Illinois River and Tributaries: Streambank Erosion Inventory Report

Prepared for:

Illinois River Watershed Partnership

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Introduction

Natural State Streams (NSS) conducted a stream inventory from October to December 2016 on selected reaches of the Illinois River, Moores Creek, Muddy Fork, Clear Creek and Sager Creek. The survey for Moores Creek and Muddy Fork began at their headwaters and extended downstream to their confluence with the Illinois River. The survey for Sager Creek began at its headwaters and extended downstream to the Oklahoma/Arkansas state line. A reach of Clear Creek 2.4 miles in length was surveyed immediately upstream of its confluence with the Illinois River. The Illinois River was surveyed from its confluence with the Muddy Fork downstream to Dawdy Spring off of highway 412 in addition to the last 3.4 miles upstream of Oklahoma/Arkansas state line.

The objective of this report is to document the stream bank conditions of the approximately 48.8 miles of inventoried reaches, estimate rates of erosion for specified areas in the Illinois River watershed, and outline next steps towards developing a more thorough understanding of current conditions and an action plan for the ultimate goal of improving water quality and watershed health.

Watershed Context

The Illinois River and tributaries inventoried are all found in Washington and Benton Counties in Northwest Arkansas. Land use in the areas surveyed was predominately pasture and farmland with some forested areas and urban areas. The Arkansas Department of Environmental Quality (ADEQ) has listed the Illinois River as an Ecologically Sensitive Waterbody. Stream bank erosion and agricultural practices, along with other sources, have led to high sediment and nutrient loading in the upper Illinois River. This excessive loading has required ADEQ to add approximately 125 miles of rivers and streams in the upper Illinois River Waters to the state's 2006 Clean Water Act section 303(d) list of impaired waters. In 2016 ADEQ had a provisional list of 303(d) waterbodies that included 45.7 miles of rivers and streams in the Illinois River Watershed. Those 45.7 miles of rivers and streams were the focus of this stream bank erosion inventory report.

Methodology Overview

Natural State Streams utilized the BANCS (Bank Assessment for Non-point source Consequences of Sediment) model (Rosgen 1996, 2001, 2006) which combines Bank Erosion Hazard Index (BEHI) and Near-Bank Shear Stress (NBS) ratings, along with empirical relations developed by Van Eps et al (2004) for erosion assessment on the West Fork White River to estimate annual rates of erosion on the surveyed reaches within the Illinois River Watershed. Approximately 50.3 miles of the Illinois River and tributaries were inventoried, all in Washington and Benton Counties Arkansas.

Field Methods

The inventory involved a one to two-person crew that traversed every mile of inventoried stream on foot or in canoe. Crews recorded stream channel and bank condition attributes on Trimble Geo7X handheld GPS units with Trimble TerraSync software and photographed inventoried reaches with digital cameras with geotagging capabilities (Figure 1). A total of 923 individual stream bank reaches were inventoried. Those reaches averaged a length of 288 feet each.

Figure 1. Collecting data on Illinois River.

Stream Bank Inventory Components

Natural State Streams utilized Trimble GPS Pathfinder Office software to create a BEHI and NBS 'Data Dictionary' to define specific attributes of line features collected in the field. This dictionary is then utilized within Trimble TerraSync program on the handheld GPS unit and allows the user to utilize a series of text and numeric fields and menus to manually enter data relating to stream channel and bank conditions (Figure 2).

Line features were collected for all stream miles traversed and were segmented as the GPS user observed measurable changes in channel and/or bank conditions. There are nine main components/attributes that were recorded for each stream line segment during this inventory. BEHI and NBS attributes of only the outside or cut bank were recorded for purposes of this study. For straight reaches, attributes were collected regarding the bank that appeared to be undergoing the most degradation. Channel and streambank attributes collected for each line segment included the following:

1. Bankfull Height:
In stable streams this is the incipient elevation/height on the bank where flooding begins (the flow that just fills the channel to the top of its bank and at a point where the water begins to overflow onto a floodplain). Bankfull indicators in unstable streams are more difficult to identify, but are usually less than top of bank and may include top of point bars or other depositional features that, with time, may represent the eventual formation of a floodplain.

2. Study Bank Height:
The average height of the stream bank being inventoried.

3. Stream Bankfull Width:
The average width of the stream at bankfull elevation in the reach being inventoried.

4. Root Depth:
Average depth of plant roots at on study bank being inventoried.

5. Root Density:
Where roots are present, the proportion of the stream bank surface, expressed as a percent, composed of plant roots for the study bank being inventoried.

6. Bank Angle:
The angle (degree) of the study bank being inventoried from the waterline to the top of bank.

7. Surface Protection:
The percentage of the study bank covered (and therefore protected) by sod mats or other vegetation, downed logs and branches, large rocks, revetments etc.

8. Bank Materials:
The primary makeup of material (bedrock, boulder, cobble, gravel, sand, silt/clay) of the study bank being inventoried.

9. Bank Stratification:
The presence of different layers of materials (bank material stratigraphy) making up the study bank being inventoried.

9. Near Bank Stress:
The relative distribution of stream flows on the study bank being inventoried as determined by local energy slope, width/depth ratio and position in the channel

plan-form (i.e., meander bend or straight reach)(Rosgen, 1993). High near bank stress is often associated with the outside bank of a meander bend with a low radius of curvature (a tight bend) and also may be caused by debris jams or depositional features such as mid-channel or transverse bar development. NBS was estimated for all stream segments by field staff, but could also be estimated by calculating stream channel radius of curvature to bankfull width ratios.

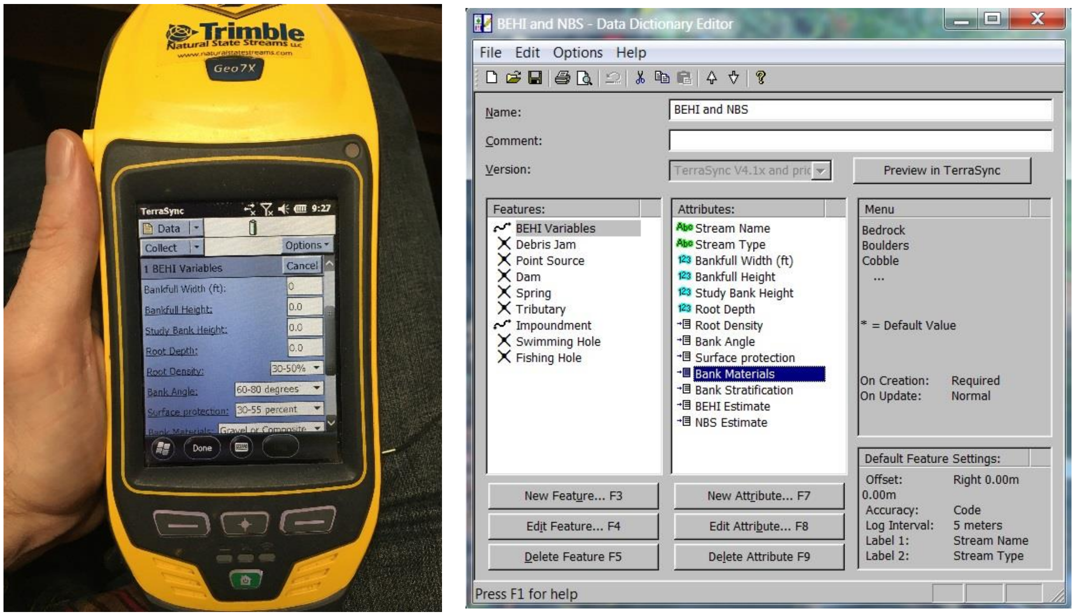


Figure 2. ‘Data Dictionary’ used for collection of channel and streambank attributes.

Data Analysis

All line segment features were imported into Trimble Pathfinder Office software, where differential correction was performed to the improve accuracy of data. Shapefiles were then created and data was post-processed utilizing Esri ArcGIS mapping software. Post-processing entailed smoothing line segments with irregular vertices and ensuring all segments link correctly without gaps or overlaps. The length of each line segment was then calculated and a unique identifier was created for each line segment.

Attributes of each line segment were then exported to Microsoft Excel and Access, where predicted erosion rates and volumes were calculated (see Appendix 2 for detailed technical description of erosion rate calculations). New fields including total BEHI score and calculated erosion rates were then joined back to the corresponding line shapefile segments in ArcMap. Line segments were color-coded based on predicted annual lateral erosion rates (ft/year) and line shapefiles were exported as KMZ files for easy sharing and viewing in Google Earth software.

Calculated predicted erosion rates were stratified by NSS staff into the following categories for visual and planning purposes:

Very Low:	0.00-0.25 feet of lateral bank erosion per year
Low:	0.250001-0.50 feet per year
Moderate:	0.500001-1.00 feet per year
High:	1.000001-2.00 feet per year
Very High:	2.000001-3.00 feet per year
Extreme:	>3.000001 feet per year

Stream Bank Inventory Results

A total of 48.77 miles streams and river were inventoried, including 923 individual stream bank segments averaging 279 feet each in length. Annual bank erosion estimates ranged from 0 to 4.95 feet/year with an average erosion rate of 0.50 feet/year for all streambanks catalogued. A total of eight bank segments fell within the Extreme predicted erosion category (3-4 feet/year), thirty eight segments were categorized as Very High (2-3 feet/year) and ninety three segments were predicted to be within the High category (1-2 feet/year). Predicted erosion rates were also calculated as volumes (m^3/year and yd^3/year) as well as weight (tons/year), but are all solely described herein in terms of lateral rates of erosion (ft/year). Each of the individual stream reaches inventoried is described in detail below.

Muddy Fork

Muddy Fork is predominately a cobble and gravel-bottomed stream characterized by broad alluvial valleys and predominately alluvium soils and banks with bedrock outcroppings. Most of Muddy Fork can be categorized as a gravelly C4 stream type based on the Rosgen classification system, while the upper reaches are more cobble-dominated. The meandering channel has defined riffle-pool sequences and point bars, although certain areas are entrenched and deeply incised, resulting in abandonment of former floodplains.

At its confluence with the Illinois River, Muddy Fork has a drainage area of 73.3 square miles (Figure 3). The watershed is characterized primarily by rural pastureland floodplains and terraces as well as steep, rocky wooded headwaters and includes a small amount of urban area including most of the town of Prairie Grove. Bob Kidd Lake as well as Lake Prairie Grove lie within the watershed and are formed by the impoundment of tributary streams to Muddy Fork. The main tributary to Muddy Fork is Moores Creek, which joins Muddy Fork approximately four miles upstream of its confluence with the Illinois River. For purposes of this study we divided Muddy Fork into two distinct reaches, one upstream of the confluence with Moores Creek and one downstream.

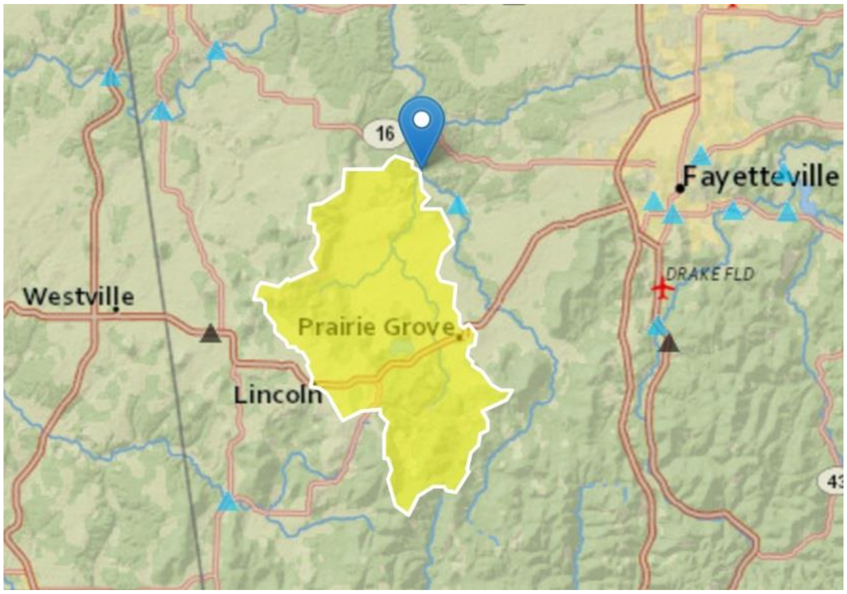


Figure 3. Muddy Fork Drainage Area. Source: streamstatsags.cr.usgs.gov

The streambank inventory of the upper reach of Muddy Fork extends from near the stream's source at North Cove Creek Rd. south of Prairie Grove, AR down to the confluence with Moores Creek. This 12.39-mile reach was traversed on foot on October 11-12, 2016. Overall stream health appeared to be degraded as evidenced by low water clarity and apparent nutrification where water was present. Degraded water quality was likely due to low flows and livestock watering directly in the creek. Much of this reach was dry at the time of our survey with water pooled intermittently in areas with relatively low gradient. Stream flow becomes more perennial in nature north (downstream) of Stonewall Rd. in Prairie Grove. It is unlikely that Muddy Fork upstream of Prairie Grove supports abundant aquatic life including a wide diversity of fishes due to the ephemeral nature of flows.

A total of 247 bank segments were inventoried on upper Muddy Fork with an average length of 265 feet each. Annual bank erosion estimates ranged from 0 to 3.36 feet/year with an average erosion rate of 0.36 feet/year for all streambanks catalogued. One streambank segment fell within the Extreme predicted erosion category (3-4 feet/year), two segments were categorized as Very High (2-3 feet/year) and twenty-two segments were predicted to be within the High category (1-2 feet/year). Areas with relatively high predicted erosion rates generally had low rooting depths and density as well as high bank height to bankfull height ratios (Figure 4).

There are several areas where it is apparent that heavy equipment has recently been in the stream, likely an attempt by landowners to clear perceived blockages to flow or repair bank erosion (Figure 5). These 'fixes' may eventually exacerbate erosion onsite or downstream of the channel modifications by destabilizing the channel bed and banks. Any attempt at channel or streambank restoration should proceed with extreme caution and with the consultation of a qualified restoration specialist.


Figure 4. High erosion on upper Muddy Fork.


Figure 5. Channel modifications on Muddy Fork.

The lower reach of Muddy Fork extends from the confluence of Muddy Fork and Moores Creek downstream to the Illinois River. This stretch is 4.01 miles in length and was surveyed by canoe on November 11 and 15, 2016. Overall stream health appeared to be fair, despite much of the reach being entrenched due to past channel bed incision. Stream flow is perennial throughout this section of Muddy Fork, and water clarity was fair, although an abundance of fine-grained substrates in the channel bed and depositional features quickly leads to elevated turbidity when disturbed. The lower Muddy Fork likely supports healthy game fish populations, with plentiful deep pools and woody debris in the stream channel (Figure 7).

A total of 89 bank segments were inventoried on lower Muddy Fork with an average length of 238 feet each. Annual bank erosion estimates ranged from 0 to 2.98 feet/year with an average erosion rate of 0.77 feet/year for all streambanks catalogued. Thirteen streambank segments were categorized as Very High (2-3 feet/year) and thirteen segments were predicted to be within the High category (1-2 feet/year). Areas with relatively high predicted erosion rates generally had low riparian and rooting cover as well as high bank height to bankfull height ratios (Figure 6).


Figure 6. Very High erosion on Muddy Fork.


Figure 7. Stable section of lower Muddy Fork.

Moores Creek

Moores Creek is predominately a cobble-bottomed stream characterized by narrow to broad alluvial valleys and predominately alluvium soils and banks with extensive bedrock outcroppings. Most of Moores Creek can be categorized as a C3 stream type based on the Rosgen classification system. The meandering channel has defined riffle-pool sequences and point bars, although certain areas are confined within relatively steep, narrow rocky valleys and display more of a step-pool morphology.

The drainage area of Moores Creek is 24.6 miles at its confluence with Muddy Fork (Figure 8). The watershed is characterized primarily by rural pastureland uplands and lowlands as well as steep, rocky wooded ravines near the area surrounding Lincoln Lake. This lake lies near the center of the basin and is formed by the impoundment of Moores Creek. Lincoln Lake acts as a sediment sink, capturing all but the finest grained sediment from upstream sources. For purposes of this study we divided Moores Creek into two distinct reaches, one upstream of Lincoln Lake and one downstream.

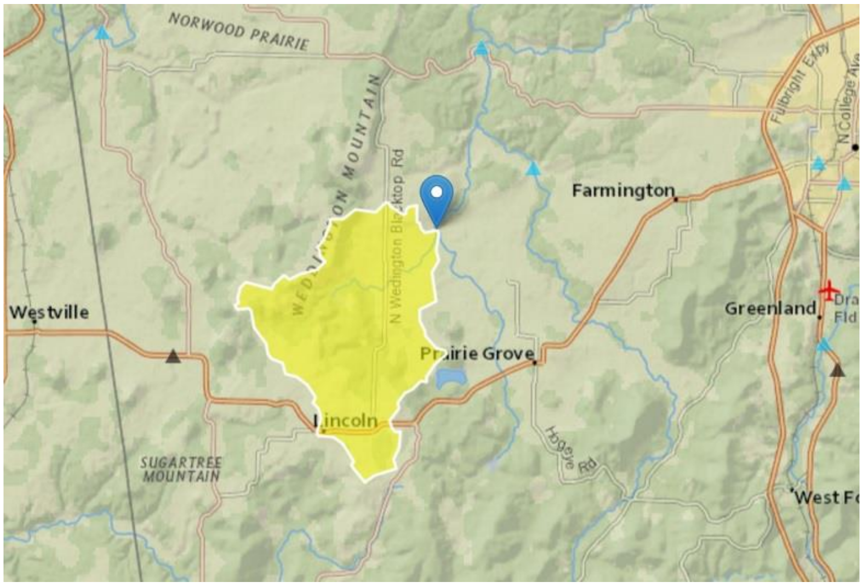


Figure 8. Moores Creek Drainage Area. Source: streamstatsags.cr.usgs.gov

The streambank inventory of the upper reach of Moores Creek extends from near the stream's source at Old Cane Hill Rd. near the town of Lincoln, AR down to Lincoln Lake. This 5.83-mile reach was traversed on foot on October 11 and November 16, 2016. Overall stream health appeared to be good although much of this reach was dry at the time of our survey with water pooled intermittently in areas with relatively low gradient. It is unlikely that this reach of Moores Creek supports abundant aquatic life including a wide diversity of fishes due to the ephemeral nature of flows.

A total of 129 bank segments were inventoried on upper Moores Creek with an average length of 238 feet each. Annual bank erosion estimates ranged from 0 to 1.66 feet/year with an average erosion rate of 0.18 feet/year for all streambanks catalogued. No streambank segments fell within the Very High predicted erosion category (2-3 feet/year) and only five segments were predicted to be within the High category (1-2 feet/year). The low erosion rates observed are likely due to high bedrock component in the stream bed and banks and a relatively intact riparian area, which all contribute to bed and bank stability.

A large wooded area just upstream of Lincoln Lake and surrounding both sides of Moores Creek potentially has high conservation value. It is currently in private ownership. The area is steep and rugged with bluffs, overhangs and interesting geology. The creek at this location would serve as a good reference reach for future restoration work as well because of its relative pristine condition (Figures 9&10).


Figure 9. Lepidodendron fossil in Moores Creek.


Figure 10. Large bluff on upper Moores Creek.

The lower reach of Moores Creek extends from the tailwaters of Lincoln Lake down to its confluence with Muddy Fork. This reach is approximately 4.77 miles in length, although a 1.22-mile section just downstream of N. Wedington Blacktop Rd. was not inventoried because we couldn't acquire landowner permission to access the creek. A total of 3.55 miles of Moores Creek was traversed by foot and canoe on November 15, 2016. This reach is characterized by perennial stream flow although water quality appeared to be less than ideal as evidenced by low water clarity, especially in areas where cattle were accessing the creek (Figure 11).

A total of 89 bank segments were inventoried on lower Moores Creek with an average length of 210 feet each. Annual bank erosion estimates ranged from 0 to 2.41 feet/year with an average erosion rate of 0.48 feet/year for all streambanks catalogued. One streambank segment fell within the Very High predicted erosion category (2-3 feet/year) and nineteen segments were predicted to have High erosion rates (1-2 feet/year). Areas with elevated erosion rates are characterized by extensive gravel point bar formation and a lack of adequate riparian corridor. The lowest 0.5 miles of Moores Creek, directly upstream of the confluence with Muddy Fork appears to be in a fairly unstable condition with bank erosion rates in the 0.5-2.0 feet/year range. Many large trees that have recently fallen into the creek have led to the formation of several large debris jams which may be exacerbating the bank erosion at this location (Figure12).


Figure 11. Cattle in lower Moores Creek.


Figure 12. Debris jam on lower Moores Creek

Clear Creek

Clear Creek is a predominately gravel-bottomed stream, characterized by broad alluvial valleys and alluvium soils and banks. It is categorized as a C4 stream type based on the Rosgen classification system. The meandering channel has defined riffle-pool sequences and point bars. The presence of significant depositional features within the inventoried reach of Clear Creek indicate that it may be an aggrading system with a high bedload component, likely from upstream sources including streambank erosion.

The drainage area of Clear Creek is 76.9 square miles at its confluence with the Illinois River (Figure 13). The watershed is characterized primarily by wooded uplands and steep ravines as well as grassy floodplain pastures and includes a highly urbanized headwaters encompassing areas of northern Fayetteville and southern Springdale. Lake Fayetteville is formed by the impoundment of Clear Creek near its source.

Figure 13. Clear Creek Drainage Area. Source: streamstatsags.cr.usgs.gov

This study focused on the lowest 2.35 miles of Clear Creek down to its confluence with the Illinois River. This reach was floated by canoe on November 16, 2016. Overall stream health appeared to be good with excellent water clarity, relatively high base flow and seemingly abundant fish populations. There is a low-head dam approximately 8 foot in height that impounds roughly 0.6 miles of Clear Creek within this reach as well as an old concrete low water crossing (Figures 14&15). Both of these structures may be acting as un-natural barriers to fish passage during normal flows.

A total of 41 bank segments were inventoried on Clear Creek with an average length of 303 feet each. Annual bank erosion estimates ranged from 0 to 2.89 feet/year with an average erosion rate of 0.68 feet/year for all streambanks catalogued. Four streambank segments fell within the Very High predicted erosion category (2-3 feet/year) and are characterized by extensive gravel point bar formation and a lack of adequate riparian corridor. Four streambank segments were predicted to have High rates of erosion (1-2 feet/year). The low-head dam is likely accelerating depositional and erosional processes directly upstream of the impoundment by creating low energy slope conditions, which can lead to aggradation of the channel bed and extensive bar formation and lateral channel migration.


Figure 14. Dam on Clear Creek


Figure 15. Low water crossing on Clear Creek

Sager Creek

Sager Creek is a cobble and gravel-bottomed stream, generally characterized by broad alluvial valleys and alluvium soils and banks. It is categorized as a C3 or C4 stream type based on the Rosgen classification system. The meandering channel has defined riffle-pool sequences and point bars and bedrock outcroppings. Sager Creek flows through the city of Siloam Springs, where extensive channel modifications including rock and concrete bank revetments and a low head dam have altered the natural stream processes throughout the downtown area.

The drainage area of Sager Creek is 13.2 square miles at the Oklahoma-Arkansas state line (Figure 16). Primarily grassy low-gradient pastures and urban areas encompassing most of Siloam Springs characterize the watershed. Sager Creek also flows through Siloam Springs Golf Course, where there are several springs that provide perennial streamflow to downstream reaches (Figure 18). Upstream of the golf course, flows are ephemeral or intermittent.

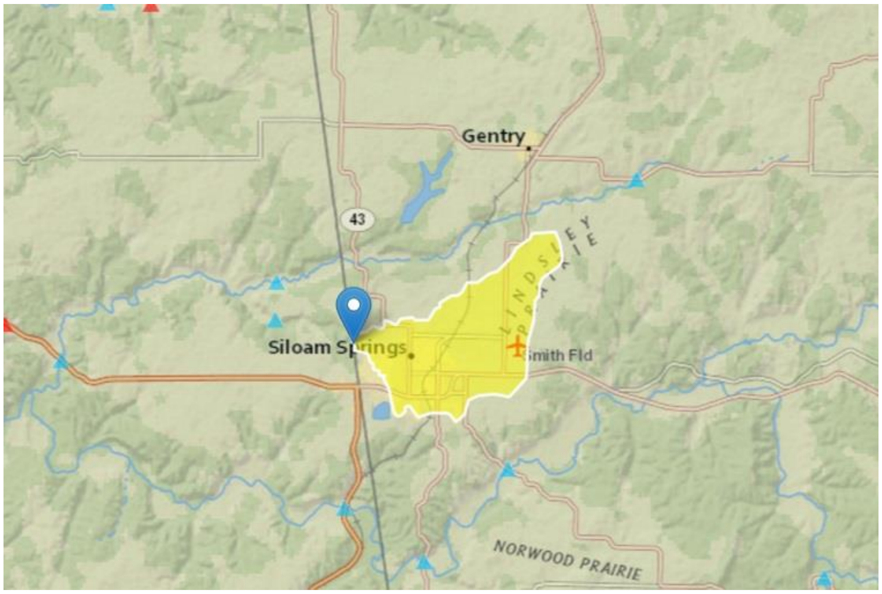


Figure 16. Sager Creek Drainage Area. Source: streamstatsags.cr.usgs.gov

This study focused on the main channel of Sager Creek from its headwaters near AR Hwy 59 down to the state line. This 6.29 mile reach was traversed by foot on November 10, 2016. Overall stream health appeared to be good where water was present, although nutrification of the creek was evident directly downstream of, and apparently caused by, effluent from the Siloam Springs Wastewater Treatment Plant (Figure 17). There is a low-head dam approximately 6 foot in height that impounds roughly 0.4 miles of Sager Creek within this reach as well as several small (1-2 ft height) concrete check dams. These structures may be acting as un-natural barriers to fish passage during normal flows.

A total of 135 bank segments were inventoried on Sager Creek with an average length of 248 feet each. Annual bank erosion estimates ranged from 0 to 1.31 feet/year with an average erosion rate of 0.19 feet/year for all streambanks catalogued. No streambank segments fell within the Very High predicted erosion category (2-3 feet/year), and only five segments were categorized within the High predicted erosion category (1-2 feet/year). The low erosion rates observed are likely due to high bedrock component in the stream bed and banks and a relatively low bedload component which minimizes bar development and associated lateral channel migration.


Figure 17. Wastewater effluent in Sager Creek.


Figure 18. Siloam Springs Golf Course.

Illinois River

The Illinois River is a predominately gravel-bottomed river, generally characterized by broad alluvial valleys, alluvium soils and banks, and bedrock outcroppings. It is categorized as a C4 stream type based on the Rosgen stream classification system. The slightly entrenched, meandering river has a defined riffle-pool sequence and a well-developed floodplain. The banks are generally composed of unconsolidated alluvial materials that are susceptible to accelerated bank erosion. Point bars and other depositional features are common.

The drainage area of the Illinois River is 575 miles at the Arkansas-Oklahoma state line (Figure 19). Low-gradient pastures, upland wooded areas, and urban areas including parts of Fayetteville, Rogers, Bentonville, and Siloam Springs characterize the watershed of the Illinois River. There are several impoundments of tributary streams within the watershed including those that form Lake Elmdale, Lake Fayetteville, Lake Prairie Grove, Bob Kidd Lake, Lincoln Lake, and Lake Wedington. The Illinois River is dammed just across the state line and forms Lake Frances. This study focuses on two distinct reaches of the Illinois- the 'Lower Illinois' near the Oklahoma-Arkansas state line and a reach further upstream that we are describing as the 'Middle Illinois'.

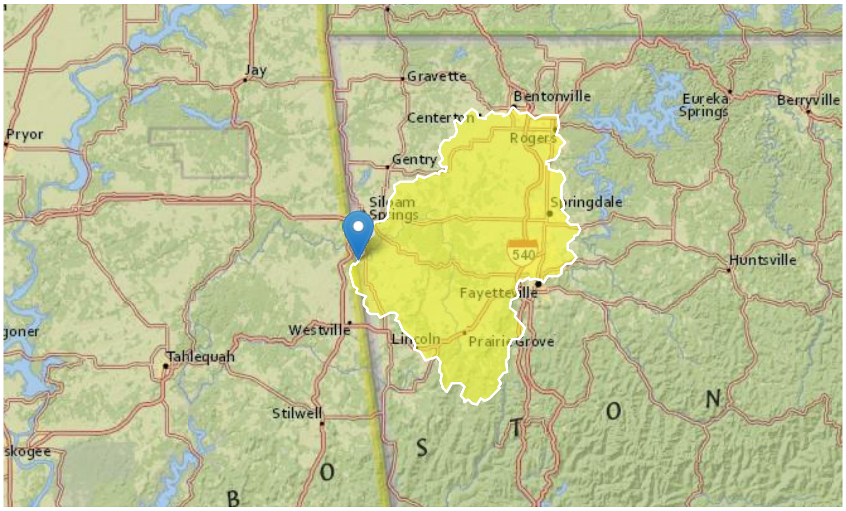


Figure 19. Illinois River Drainage Area. Source: streamstatsags.cr.usgs.gov

Middle Illinois River

The reach of the Illinois River is a predominately gravel-bottomed stream, characterized by broad alluvial valleys, alluvium soils and banks. It is categorized a C4 stream type based on the Rosgen classification system. The meandering channel has defined riffle-pool sequences, point bars and bedrock outcroppings. This section of the Illinois flows through a wide alluvial valley bordered by wooded uplands and rocky bluffs.

The drainage area of the Illinois River is 262 square miles at Dawdy Springs just north of AR Hwy 412 and includes the tributary basins of Clear Creek, Muddy Fork, and Moores Creek (Figure 20). Low-gradient floodplain and upland pastures, steep wooded uplands, bedrock outcroppings and bluffs, and urban areas characterize the watershed of the Middle Illinois.

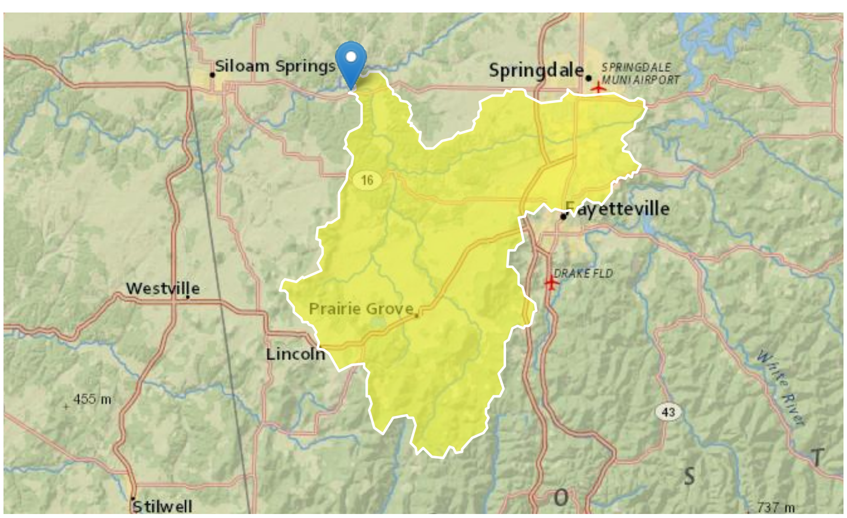


Figure 20. Middle Illinois River Drainage Area. Source: streamstatsags.cr.usgs.gov

This study focused on approximately 10.95 miles of the Illinois River from the confluence with Muddy Fork near Viney Grove Rd to Dawdy Springs just north of Hwy 412. This reach was floated by canoe on November 3-4 and 9, 2017. The overall health of the river in this section appeared fair to good with high base flows, deep pools and fair water clarity. This reach potentially has high recreational value for fishermen and boaters alike but lacks adequate public access points for parking and launching canoes or kayaks (Figure 22).

A total of 146 bank segments were inventoried on the Middle Illinois River with an average length of 396 feet each. Annual bank erosion estimates ranged from 0 to 4.95 feet/year with an average erosion rate of 0.82 feet/year for all streambanks catalogued. Six streambank segments fell within the Extreme predicted erosion category (3+ feet/year) while fourteen segments are predicted to have Very High erosion rates (2-3 feet/year) and twenty-one streambanks are predicted to have High rates (1-2 feet/year).

Those areas that are experiencing high to extreme levels of streambank erosion are characterized by extensive gravel point and transverse bar formation and a lack of adequate riparian corridor. Areas with highly vegetated and/or bedrock banks were particularly stable (Figure 21), while the Illinois River near the confluence with Clear Creek is one of the problem areas on this reach, potentially exacerbated by the influence of the dam on Clear Creek. This reach likely has elevated bedload sediment, consisting mainly of gravel and finer materials from local bank erosion and upstream sources. The deposition of these materials in the active channel and migration of gravel bars can often lead to areas with high near bank stress and, consequently, bank erosion.

Figure 21. Bedrock Outcrop on Middle Illinois

Figure 22. AHTD Riprap near Hwy 412

Lower Illinois River

The reach of the Illinois River is similar to the Middle Illinois but has a much larger watershed size and, consequently, is a larger river. The Lower Illinois is a gravel-bottomed river, characterized by broad alluvial valleys, alluvium soils and banks. It is categorized a C4 stream type based on the Rosgen classification system. The meandering channel has defined riffle-pool sequences, point bars and areas where bedrock is the dominant bed and bank material. This section of the Illinois flows through a wide alluvial valley bordered by wooded uplands and bluff-lines.

This study focused on the lower 3.41 miles of the Illinois River from about 1 mile downstream of the City of Siloam Springs Kayak Park to the Arkansas-Oklahoma state line. This reach was floated by canoe on November 3, 2016. Overall the river health appeared good with high base flows, deep pools and good water quality although several areas showed signs of accelerated bank erosion. This reach of Illinois River likely supports abundant aquatic life because of the high base flows and plentiful available habitat.

A total of 47 bank segments were inventoried on the Lower Illinois River with an average length of 383 feet each. Annual bank erosion estimates ranged from 0 to 4.0 feet/year with an average erosion rate of 0.72 feet/year for all streambanks catalogued. One streambank segments was predicted to have Extreme annual erosion rates (3+ feet/year) while four segments fell within the Very High predicted erosion category (2-3 feet/year), and four segments were categorized within the High predicted erosion category (1-2 feet/year). Areas inventoried with low predicted erosion rates were highly vegetated and/or had a high bedrock component in the banks (Figures 23&24).

Areas with high to extreme erosion are generally characterized by silt/clay and gravelly bank materials with little to no riparian cover. This reach of the Illinois is particularly susceptible to accelerated erosion because of a high bedload of gravel from upstream sources. The formation and continued growth of point bars, mid-channel, side-channel and transverse gravel bars associated with this high bedload leads to elevated water velocities and associated stress on riverbanks near those depositional features. Additionally, the low-head dam that forms Lake Frances is likely accelerating depositional and erosional processes directly upstream of the impoundment by creating low energy slope conditions, which can lead to aggradation of the channel bed and extensive bar formation and lateral channel migration.

Figure 23. Bedrock outcrop on Illinois River

Figure 24. Typical deep pool on Illinois River

Summary

Overall, Upper Moores Creek and Sager Creek were observed to have the lowest average predicted rates of erosion, followed by Upper Muddy Fork and Lower Moores Creek. The highest average predicted rates were observed on the Middle Illinois River, followed by Lower Muddy Fork, Lower Illinois River and Clear Creek. In general, erosion rates were observed to be higher with increases in watershed size (Tables 1&2). This trend is not surprising because overall channel size is smaller in headwater areas, and headwater streams inventoried tended to be well vegetated. Also, streambank erosion tends to have amplified downstream effects as elevated sediment and debris loading from upstream sources can lead to channel instability and accelerated erosion, creating positive feedback loops that lead to increasing levels of channel instability downstream.

	Stream Length (mi)	# of Stream Segments	Average Erosion Rate*	Highest Rate Observed/Predicted*
Upper Muddy Fork	12.39	247	0.36	3.36
Lower Muddy Fork	4.01	89	0.77	2.98
Upper Moores Creek	5.83	129	0.18	1.66
Lower Moores Creek	3.55	89	0.48	2.41
Clear Creek	2.35	41	0.68	2.89
Sager Creek	6.29	135	0.19	1.31
Middle Illinois River	10.95	146	0.82	4.95
Lower Illinois River	3.41	47	0.72	4.00
Total	48.77	923	0.50	4.95

Table 1: Summary of streambank inventory results. *Rates are listed in predicted feet/year of lateral bank erosion.

	Number of Banks within Predicted Erosion Category		
	Extreme (3+ ft/year)	**Very High** (2-3 ft/year)	**High** (1-2 ft/year)
Upper Muddy Fork	1	2	22
Lower Muddy Fork	0	13	13
Upper Moores Creek	0	0	5
Lower Moores Creek	0	1	19
Clear Creek	0	4	4
Sager Creek	0	0	5
Middle Illinois River	6	14	21
Lower Illinois River	1	4	4
Total	8	38	93

Table 2: Summary of streambank inventory results specifying areas of highest predicted erosion.

Potential Permanent Survey Sites

NSS, working with the IRWP, will identify five permanent survey sites (model calibration sites) based on the results of this study. NSS will complete a bank profile survey at each site, establish a semi-permanent elevation landmark (buried re-bar in a small cement-filled hole), install several bank pins to monitor erosion across the entire bank and will photo-document each area. These sites can be re-surveyed annually to record actual erosion rates and can assist in verifying and calibrating predicted erosion rates elsewhere in the Illinois River watershed.

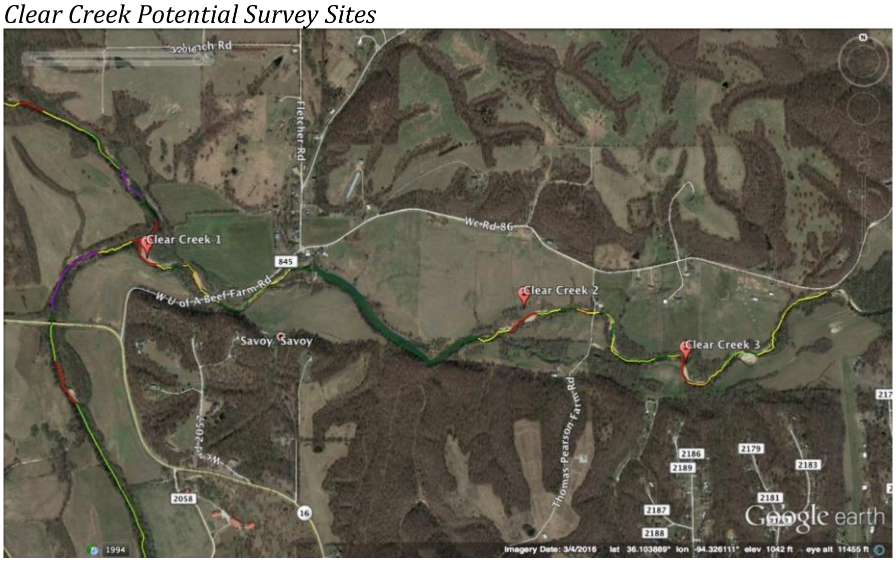
Because of the low number of sites being used across the entire area surveyed, NSS recommends picking five sites spread across the watershed that have Very High to Extreme predicted rates of erosion. Data gathered from this inventory has identified many areas of very high and/or extreme BEHI and Near Bank Stress levels that would be suitable model calibration sites.

Since these sites will be used for annual monitoring and will have a very small yet permanent landmark, landowner cooperation and access will be necessary. It is anticipated that some landowners will not want to participate in this research so we have chosen nineteen potential sites spread across the study area. Below is list of the areas for potential permanent survey sites on each reach inventoried:

Clear Creek

Three areas on Clear Creek had Very High predicted rates of erosion. (1) The streambank at the mouth of the river, (2) the streambank approximately 0.63 miles upstream of the Savoy Lake Dam, and (3) the streambank approximately 1.19 miles upstream of the Savoy Lake Dam would be ideal areas to establish permanent survey sites.

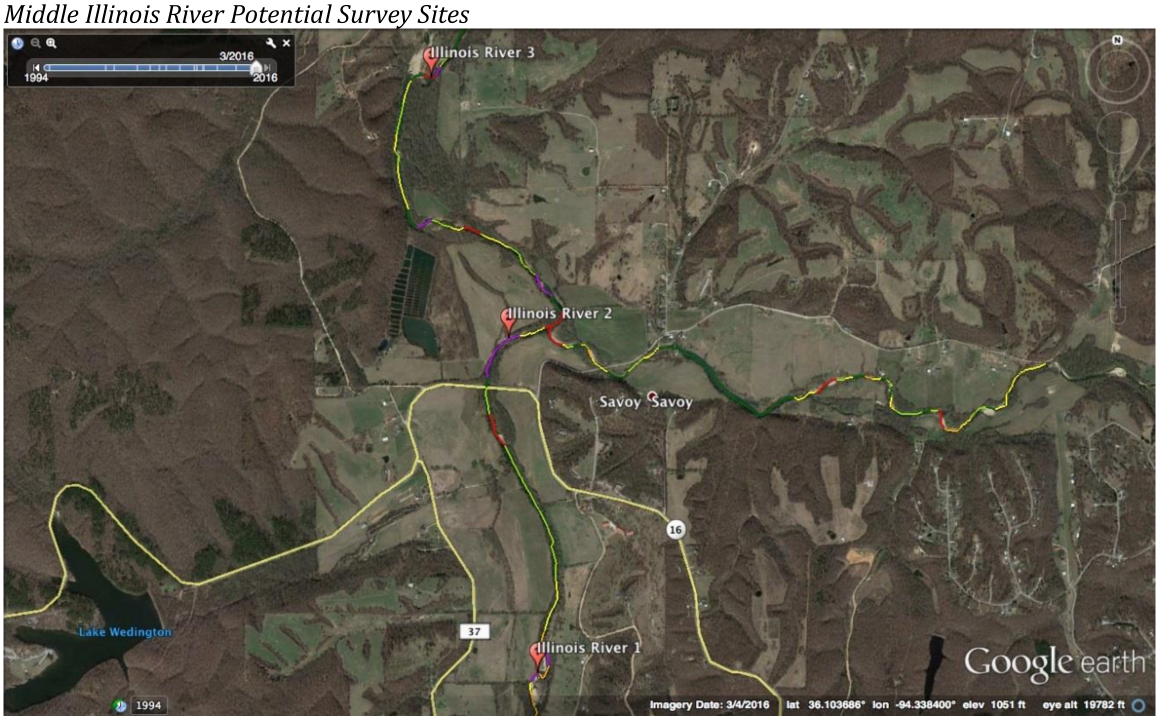
Clear Creek Potential Survey Sites



Illinois River

Several areas were identified as Very High or Extreme predicted rates of erosion on the Illinois River. The four areas with the highest rates are described below. (1) The streambank approximately 1.1 miles upstream of the Hwy 16 bridge, (2) the area immediately downstream of the Hwy 16, (3) the streambank approximately 1.7 miles downstream of the Hwy 16 bridge, (4) and the streambank approximately 0.4 miles upstream from the Hwy 59 bridge would be idea areas to establish permanent survey sites.

Middle Illinois River Potential Survey Sites

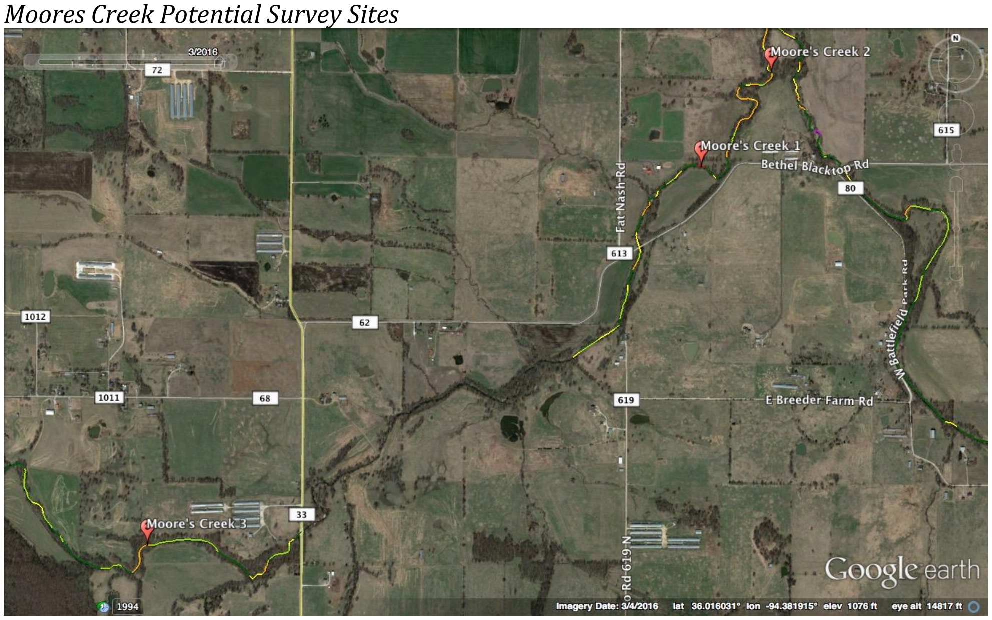


Lower Illinois River Potential Survey Sites

Moores Creek

Moores Creek had several High and Very High predicted areas of erosion that were identified during the stream inventory. (1) The streambank approximately 0.35 downstream of Bethel Blacktop Rd/Hwy 62, (2) the area just upstream from the confluence with Muddy Fork, (3) and the streambank approximately 1.32 miles downstream from the Lincoln Lake Dam would be ideal areas to establish permanent survey sites.

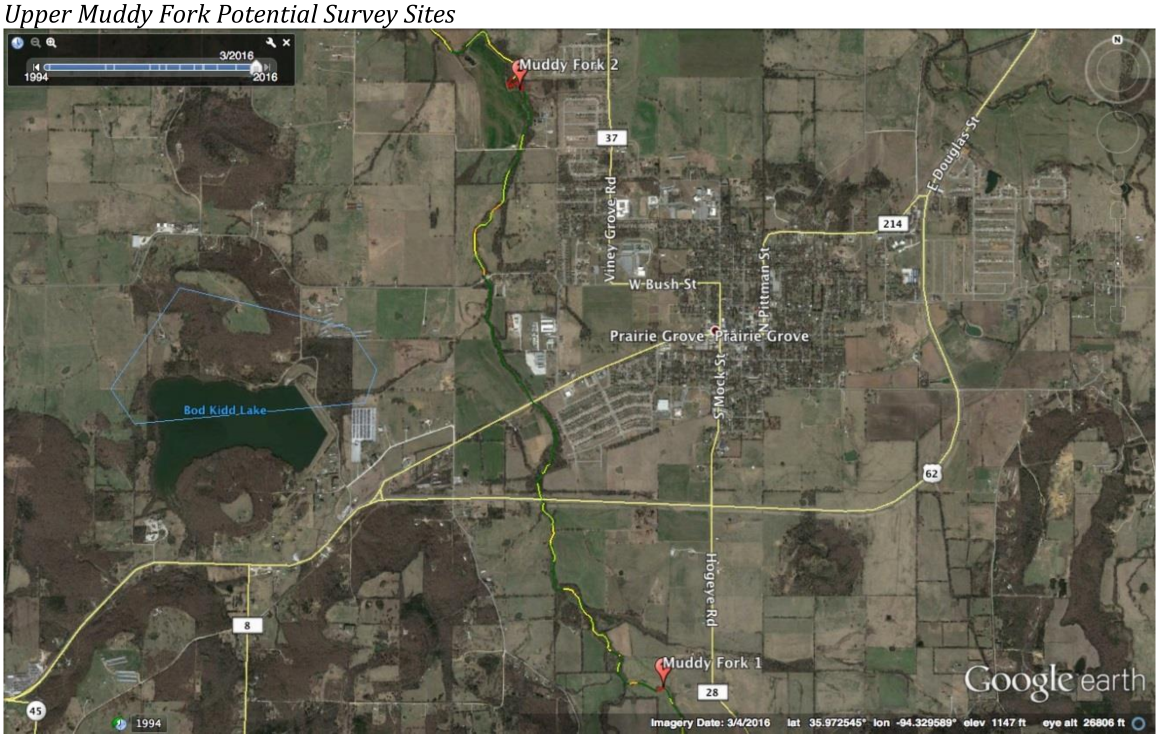
Moores Creek Potential Survey Sites



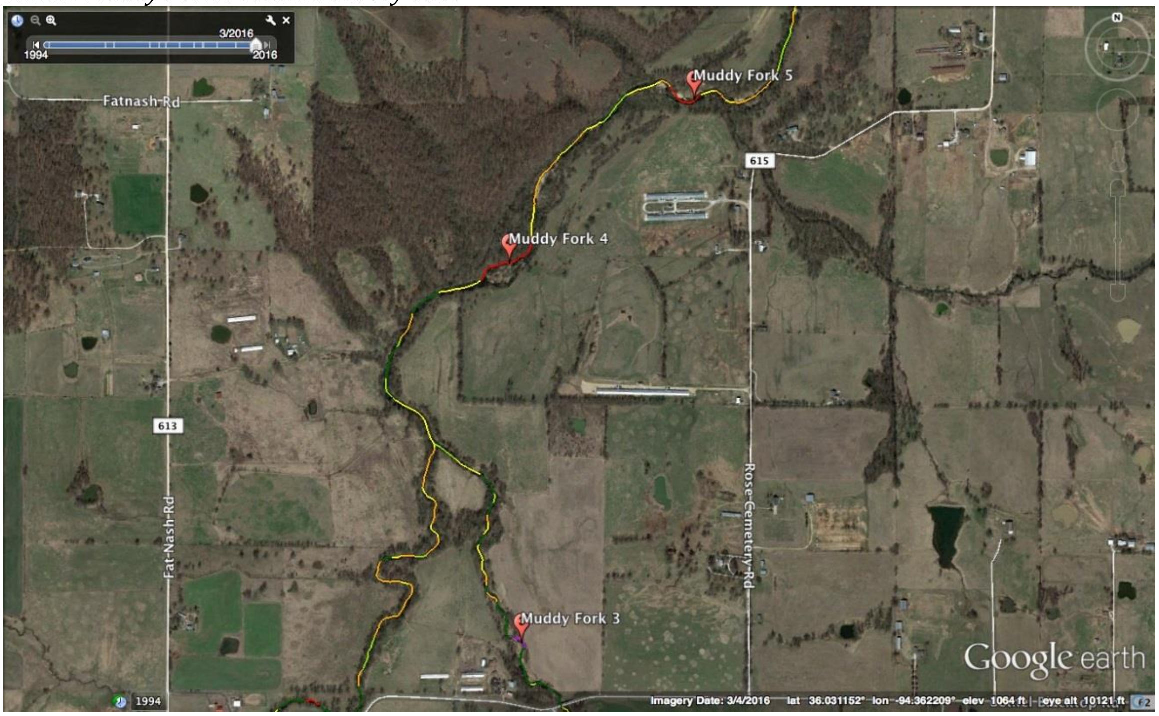
Muddy Fork

Multiple sites and areas were identified as Very High and Extreme potential erosion rates on Muddy Fork. They are described below. (1) The streambank approximately 1.25 miles upstream from Hwy 62, (2) the streambank approximately 2.27 miles downstream from Hwy 62, (3) the streambank approximately 0.14 miles downstream from Bethel Blacktop/Hwy 62, (4) the streambank approximately 1.01 miles downstream from Bethel Blacktop/Hwy 62, (5) the streambank approximately 1.54 miles downstream from Bethel Blacktop/Hwy 62, (6) the streambank approximately 0.71 miles upstream from Hwy 37, and (7) the area just upstream from the confluence with the Illinois River.

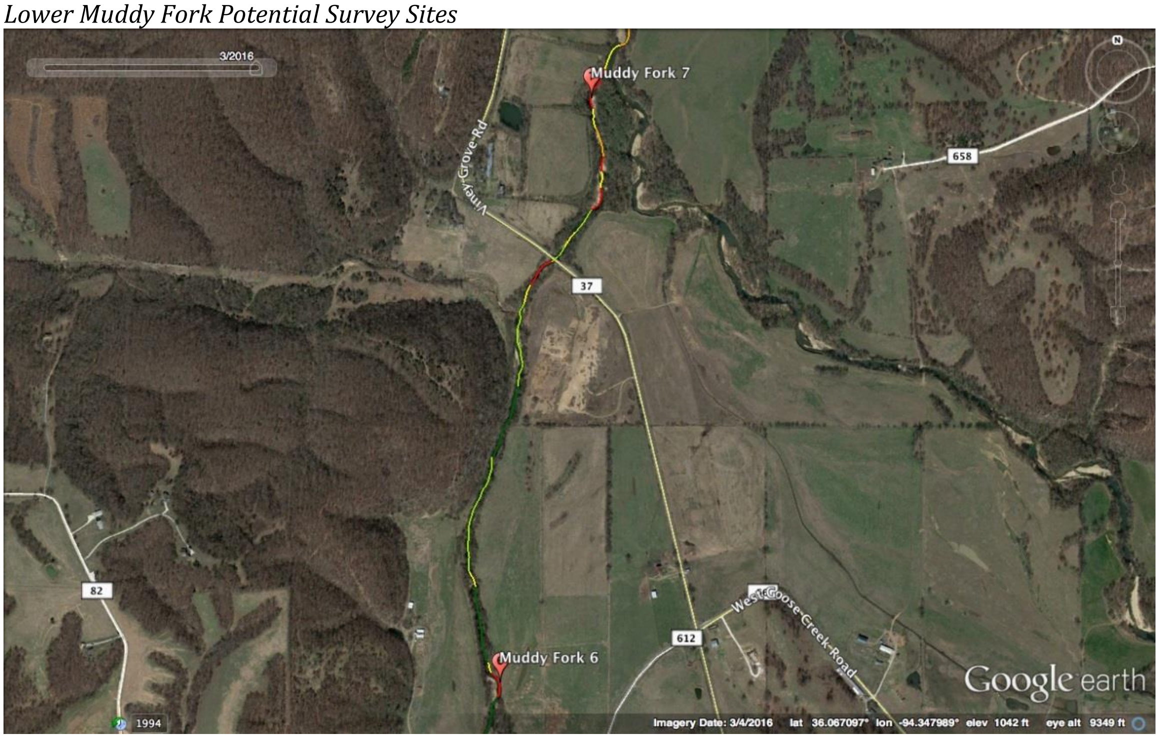
Upper Muddy Fork Potential Survey Sites



Middle Muddy Fork Potential Survey Sites



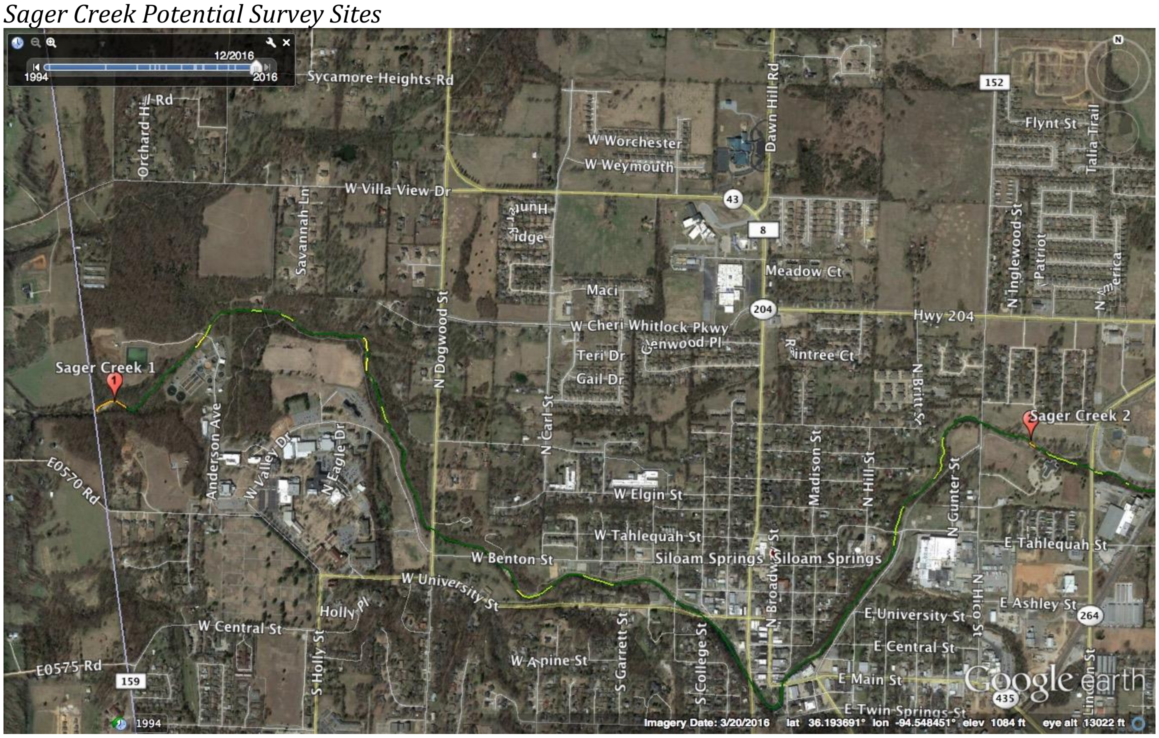
Lower Muddy Fork Potential Survey Sites



Sager Creek

Sager Creek had the fewest areas with high predicted rates of erosion. (1) The steambank just upstream from the state line and (2) the streambank approximately 0.15 miles downstream from N. Lincoln St. were identified as potential permanent survey sites.

Sager Creek Potential Survey Sites



Recommendations

Once selected and established, the five permanent survey sites should to be monitored annually to provide data to properly calibrate the predicted erosion rates throughout the watershed. It is recommendend to select and establish up to fifteen additional permanent survey sites in the watershed that include areas with lower measured BEHI and NBS scores. Monitoring actual annual erosion rates at these permanent survey sites would allow NSS to create basin-specific erosion prediction curves based on different BEHI and NBS combinations and more accurately predict future streambank erosion within the Illinois River watershed.

It would also be helpful to complete streambank inventories upstream of the reach surveyed on Clear Creek as well as the entire main-stem Illinois River and other major Illinois River tributary streams to gain a more complete understanding of all major streams and rivers in the watershed that could be contributing significant amounts of sediment to the system. The data collected to date, along with any future inventories can be used to prioritize future streambank and riparian restoration and projects

Literature Cited

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology, Fort Collins, Colorado.

Rosgen, D.L. 2001. A practical method of computing stream bank erosion rate. Proceedings of the 7th Federal Interagency Sedimentation Conference 2: 9-15.

Rosgen, D.L. 2006. Watershed Assessment of River Stability and Sediment Supply (WARSSS). Wildland Hydrology, Fort Collins, Colorado.

Van Eps, M.A., S.J. Formica, T.L. Morris, J.M. beck and A.S. Cotter. 2004. Using a bank erosion hazard index (BEHI) to estimate sediment loads from streambank erosion in the West Fork White River watershed. Proceedings of the American Society of Agricultural and Biological Engineers 2004 Conference on Self-sustaining Solutions for Streams, Wetlands, and Watersheds. Publication 701P0904: 125-132.