Illinois River and Tributaries: Streambank Erosion Sites and Analysis 2020 Report

Prepared by Natural State Streams LLC for The Illinois River Watershed Partnership, September 2021

Natural State Streams LLC

ILLINOIS River WATERSHED PARTNERSHIP

Introduction and Executive Summary

In 2016, Natural State Streams, LLC (NSS), under contract and in partnership with the Illinois River Watershed Partnership (IRWP), conducted a streambank erosion inventory to determine the erosion potential of streambanks along 49 river miles of the mainstem and tributaries of the Illinois River. Predicted annual erosion rates were mapped and color-coded based on relative rates of predicted bank migration. These predictions were based on data relating to streambank and stream channel attributes collected by the NSS team in the field, which was then analyzed and input into a predictive model developed by the Arkansas Department of Environmental Quality for a nearby watershed- the West Fork of the White River (Van Eps et al, 2004)[1].

In 2017, as a follow-up to that inventory, NSS and the IRWP initiated a multi-year study in order to test the validity of those 2016 erosion predictions with the intent of developing a more accurate predictive model tailored specifically for the Illinois River watershed. Five study sites were established initially, where the NSS team directly measured data relating to the geomorphology of the stream channel and banks. A year later these sites were re-surveyed and ten more streambank sites were established and added to the study for a total of fifteen annual survey locations/ study sites. Semi-permanent landmarks were established at each study site in order to allow field technicians to accurately replicate survey efforts once every 12 months.

Annual streambank surveys were conducted in consecutive years spanning from 2017-2020. NSS conducted the fourth year of surveys in May of 2020. Detailed channel cross-section, bank profile and GPS data collected at each site was examined and compared to previous years' results to document stream channel conditions and determine trends for each site. Four years of measured geomorphic data (2017, 2018, 2019, & 2020) was collected for each of the five initial study sites and three years of data (2018, 2019, 2020) for the remaining ten sites. Utilizing GIS mapping software and graphical overlays of the data collected from year to year, annual erosion rates were determined for each of the study sites spanning the data collection period.

Utilizing methods developed by Dave Rosgen (2006)[2], measured average erosion rates for each study site, along with measured Near Bank Shear Stress (NBSS) and Bank Erosion Hazard Index (BEHI) ranking criteria, NSS developed a graphical model to predict annual streambank erosion rates within the Illinois River Watershed. Measured total erosion rates were also plotted by measured flood occurrences at each site and incorporated into the model to account for variable hydrology & weather. The modeling developed by NSS was compared to the previously published West Fork model. The new Illinois River model, based on analysis of three to four years of survey data at fifteen study sites, predicts erosion rates within the Illinois River watershed on average

[1] Van Eps MA, Formica SJ, Morris TL, Beck JM, Cotter AS (2004) "Using a bank erosion hazard index (BEHI) to estimate annual sediment loads from streambank erosion in the west fork white river watershed." Arkansas Department of Environmental Quality, Environmental Preservation Division, Little Rock.

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

over three times the magnitude of those calculated based on curves reported for the West Fork of the White River (Table 1).

Site #	Site Name	BEHI Score 2020	NBSS 2020	BER 2017-2018 (ft/year) @ XS	BER 2018-2019 (ft/year) @ XS	BER 2019-2020 (ft/year) @ XS	BER AVERAGE (ft/year) @ XS	BER Illinois Model 2020 (ft/yr)	BER WFWR Model 2004 (ft/yr)
1	Muddy Fork 1 FID 228	33.9	Very High	1.86	0.93	2.38	1.72	2.40	0.64
2	Muddy Fork 2 FID 67	39	Very High	4.73	1.92	5.11	3.92	3.28	0.96
3	Illinois River 1 FID 25	33.7	Moderate	0.97	1.24	0.75	0.99	1.01	0.33
4	Illinois River 2 FID 2	43.8	Extreme	13.04	8.62	32.52	18.06	14.96	13.99
5	Illinois River 2 to 412 FID 75	29	High	1.97	0.21	3.48	1.89	1.78	0.36
6	Muddy Fork 1 FID 172	7.8	Moderate		0.28	0.57	0.43	0.33	0.09
7	Illinois River 2 FID 16	22.4	Very Low		0.1	0.36	0.23	0.26	0.07
8	Illinois River 3 FID 46	27.7	High		0.39	3.26	1.83	1.65	0.32
9	Illinois River 2 to 412 FID 69	29.4	Extreme		0.13	16.32	8.23	8.52	4.22
10	Clear Creek FID 8	36.2	Extreme		0.51	14.03	7.27	11.12	7.43
11	Clear Creek FID 40	30.1	Extreme		5.55	17.47	11.51	8.76	4.47
12	Moores Creek 3 FID43	23.7	Low		0.43	0.11	0.27	0.28	0.08
13	Moores Creek 3 FID25	10.6	Moderate		0.52	0	0.26	0.37	0.11
14	Sager Creek FID 24	28.8	Low		0.15	0.71	0.43	0.42	0.13
15	Sager Creek FID 106	38.9	Moderate		0.06	2.29	1.18	1.26	0.42

Table 1. Illinois River watershed bank study sites summary table. Observed annual Bank Erosion Rates (BER) are displayed for each study site as well as annual predicted rates based on both the Illinois River and West Fork models.

After analysis, it was determined that average annual erosion rates that were observed at the fifteen study sites during the study period were more accurately predicted by the new Illinois River model than by the previously-published West Fork model. With that knowledge, NSS utilized the new Illinois River erosion model as well as new information relating to BEHI and NBSS gathered during the 2017-2020 study period to recalculate and re-evaluate predicted erosion rates that were reported by NSS back in 2016 as a result of their 49-mile Illinois River streambank erosion inventory. Since the original 2016 predictions were based off of the West Fork modeling, it is likely that these recalculated annual erosion rate predictions are more accurate and more closely representative of conditions that occurred locally within the Illinois River watershed over the past four years.

It will take careful study to effectively address the erosion and instability observed in the Illinois River watershed. Maintaining and restoring an extensive riparian and floodplain buffer of native deep-rooted vegetation is critical to the long-term success of any such plan. We have made an effort to make recommendations for each study site based on a holistic approach that addresses both the causes of instability and best opportunity for success. It does appear that a very large percentage of the volume of erosion that is occurring in the watershed is coming from a very small percentage of stream banks. Based on our modeling, restoring just the four highest-eroding study sites that were chosen for detailed observation as ‘study sites’ could reduce the total soil lost due to streambank erosion within the 49-mile study area by over 11%, while only comprising around 0.7% of the total bank length within that same area. Those four sites are Site 11 (Clear Creek FID 40), Site 10 (Clear Creek FID 8), Site 9 (Illinois River 2 to 412 FID 69), and Site 4 (Illinois River 2 FID 2). It is our hope that this study will help inform watershed planners and practitioners as we strive to understand, protect, and restore the water quality and habitat within the Illinois River watershed for generations to come.

Figure 1. 2016 overview of study sites 4 & 11. Based on the best available information at that time, erosion predictions were made for each stream bank line segment and color-coded (see Legend).

Figure 2. 2020 overview of study sites 4 & 11. Study sites have been established and erosion rates monitored for several years. Erosion predictions were recalculated based study results and color-coding updated (see Legend). Note the differences between the two Figures (1&2).

Methodology

In 2016 NSS conducted a stream bank inventory of approximately 49 river miles of the Illinois River and tributaries including Muddy Fork, Moore's Creek, Clear Creek, and Sager Creek. During that inventory, stream segments were mapped and catalogued based on stream bank and channel attributes as well as predicted erosion rates. These predicted erosion rates were calculated based on field observations which were input into a model developed by ADEQ in 2004 for a nearby watershed- the West Fork of the White River.

In 2017 and 2018 NSS established 15 permanent survey sites spread throughout the 49 mile study area to determine the effectiveness of the ADEQ model in accurately predicting erosion rates within the Illinois River Watershed. At each survey site NSS installed semi-permanent landmarks, measured the representative channel cross-section and a detailed bank profile, mapped the top of each bank using precise GPS techniques, photo-documented target banks, and installed bank pins to provide visual evidence of erosion.

All 15 site surveys were replicated in 2019 and 2020. Annual surveys at each site yield a snapshot including various information relating to channel dimensions and stream bank location, from which detailed comparisons can be made from year to year. Any erosion or other changes to the stream bed and banks that may have occurred within any given year are measured. In total we collected four years (2017,2018, 2019, & 2020) of measured erosion data for survey sites 1-5 and three years (2018, 2019, & 2020) of data for sites 6-15.

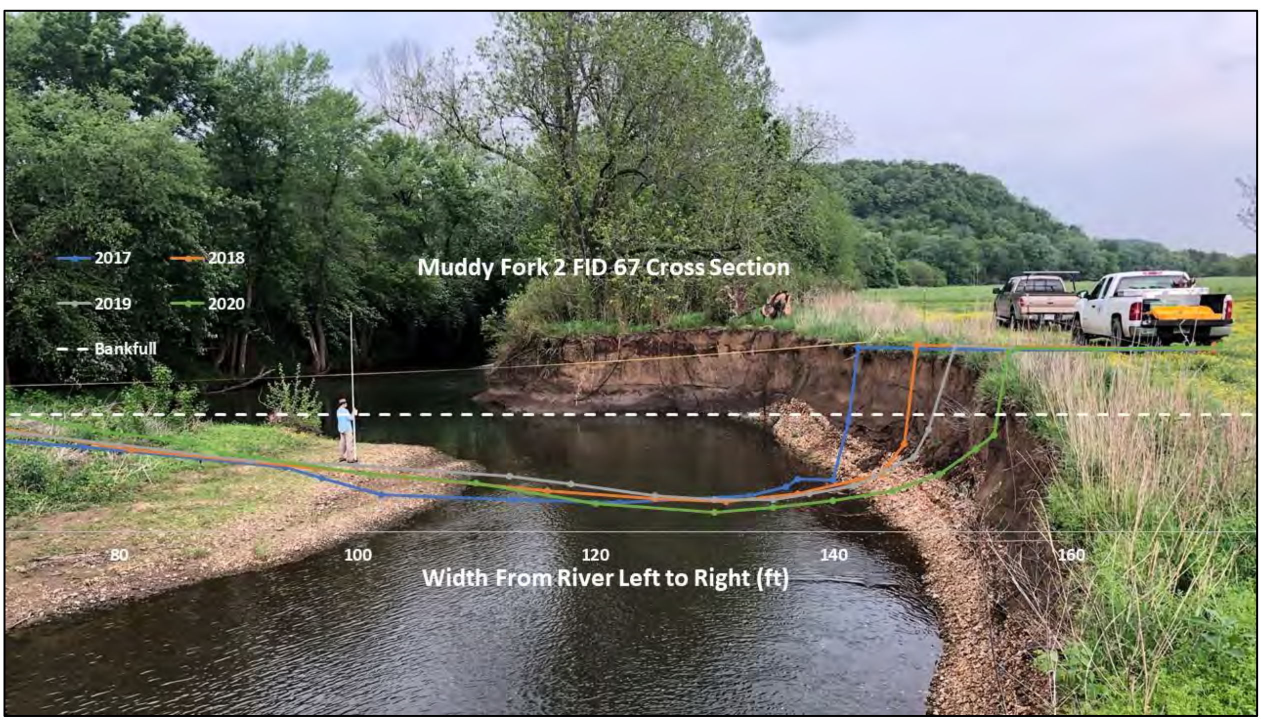

Figure 3. 2017-2020 Cross section graph and 2019 data collection photograph overlay at survey site 2.

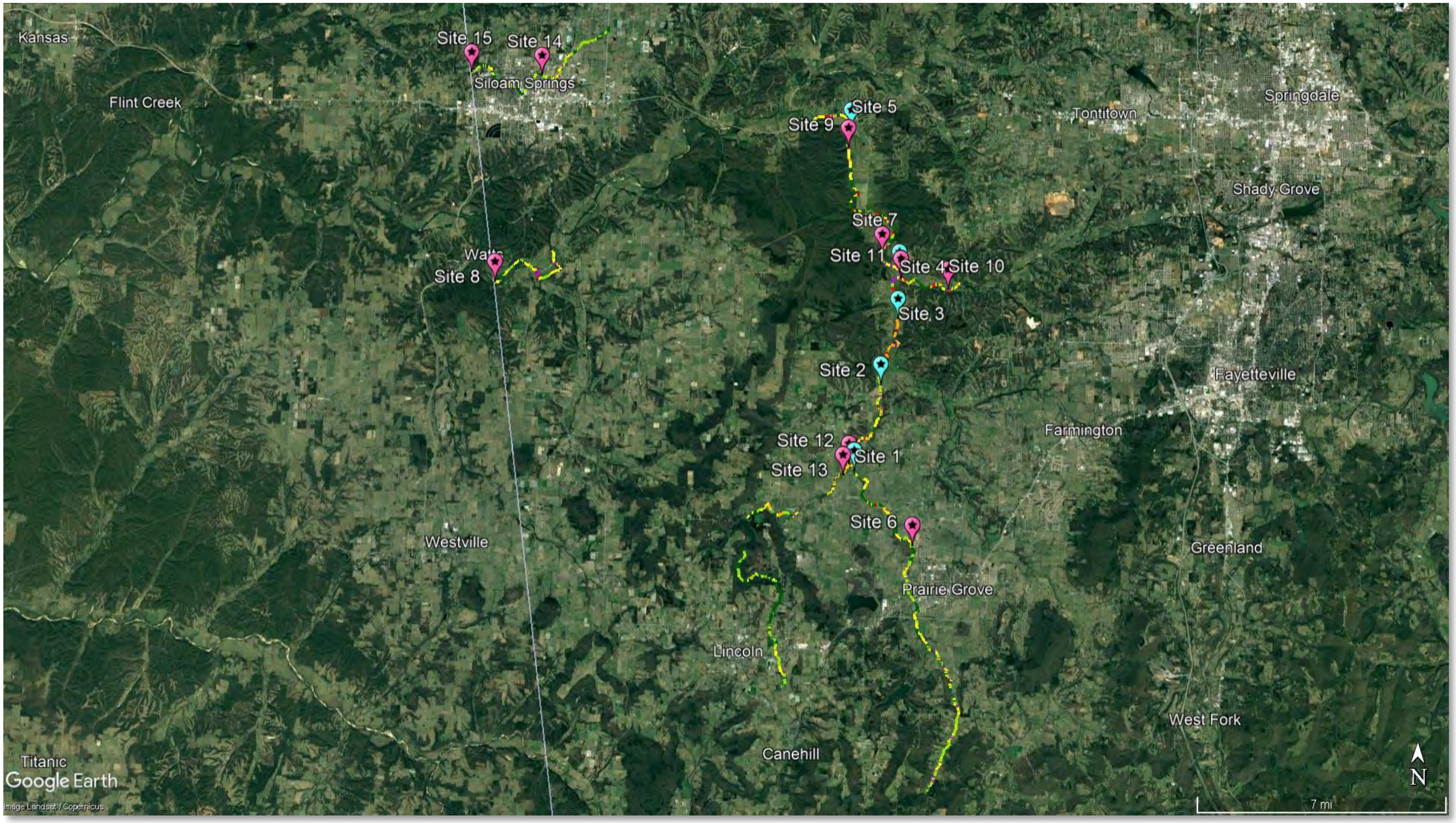

Figure 4. Map of Permanent Survey Sites 1-15. Sites 1-5 are marked with light blue icons, sites 6-15 are marked with pink icons, and the 49-mile streambank inventory is depicted as a multi-colored line (NSS, 2021).

Site 1 – Muddy Fork 1 FID 228

Site Description

This site is located approximately 0.1 mile north of the WC 62/Bethel Blacktop Rd. crossing over Muddy Fork. The river right (east side) bank was selected for monitoring. The study bank is approximately 162 feet long, 16 feet tall and has a bank angle of 51 degrees. The bank is comprised of silt & clay with very little ground cover and almost no surface protection. The location of the stream bank is along the edge of a cattle pasture. The riparian corridor was cut at some point in the past leaving only shallow non-native grasses to hold the soil in place. The landowner has fenced off the cattle about 35 ft back from the top of bank, which has helped some sparce woody vegetation start to recolonize the riparian corridor.

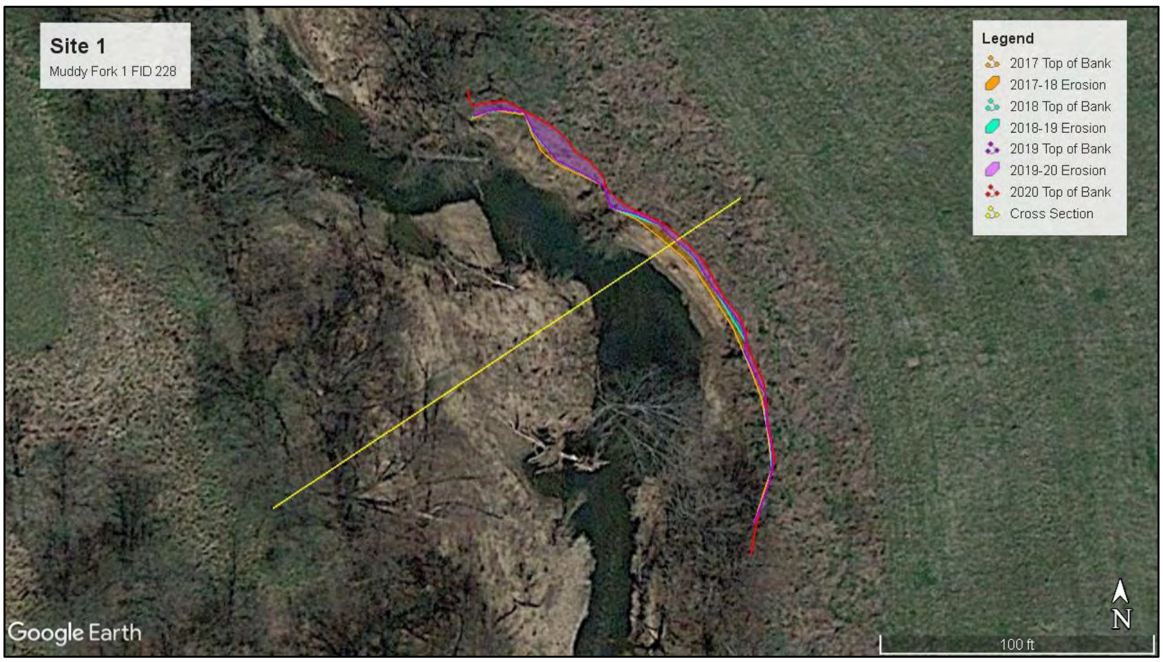

Figure 5. Planform view of the Muddy Fork 1 FID 228 annual survey site. The Creek flows generally South to North at this location. The small orange shaded area represents the bank lost to erosion from 2017-2018, while the light blue shaded area represents bank lost from 2018-2019, and the purple shaded area depicts land that washed downriver from 2019-2020. Google Earth Imagery Date: 3/4/2020.

Survey Results

Based on the 2017, 2018, 2019, & 2020 cross-section surveys, the stream bank at this location moved an average of 1.72 feet laterally across the bank profile annually, which is ranked 8th out of the 15 annual survey sites for highest annual bank erosion rate. In total, we measured 5.17 ft of lateral erosion from 6/13/2017 to 5/7/2020. (Figures 6 & 7). Annual GPS top of bank measurements corroborate these results (Figure 5). The total average measured volume of soil/sediment loss due to erosion for this stream bank segment from 2017-2020 is 4,367ft^3/year (162 yd^3/year).

Discussion & Recommendations

A small logjam just upstream from the survey site has been contributing to mid-channel and transverse bar development for years and creating a condition of elevated Near-Bank Shear Stress (NBSS). After all of the data analysis, a more thorough BEHI and NBSS investigation (2020), and utilizing the erosion prediction curves developed for the Illinois River Watershed, we have estimated that this bank will continue to erode at a rate of around 3.75 feet per year on average.

We are seeing evidence of the greatest amount of erosion migrating gradually downstream as this is a natural process described as down valley meander migration. As the area of greatest stress erodes a bit with each flood, the eroding bank slowly moves in an upstream to downstream direction. We observed areas on the most upstream portion of this cut bank to be fairly stable and starting to recolonize with vegetation, while the most active areas of erosion are on the downstream 1/3 of the study bank.

This site would be a good candidate for restoration activities. Although it is not one of the most actively eroding banks in the study, there is significant bank loss occurring and the stream appears overall in relatively poor health. Expanding the riparian corridor here with a 100 ft buffer of native hardwoods would help slow down erosion long-term, help protect water quality, and provide a corridor of shade and cover for wildlife.

Muddy Fork 1 FID 228. Aerial shot captured by drone during our most recent annual survey, 05/07/2020.

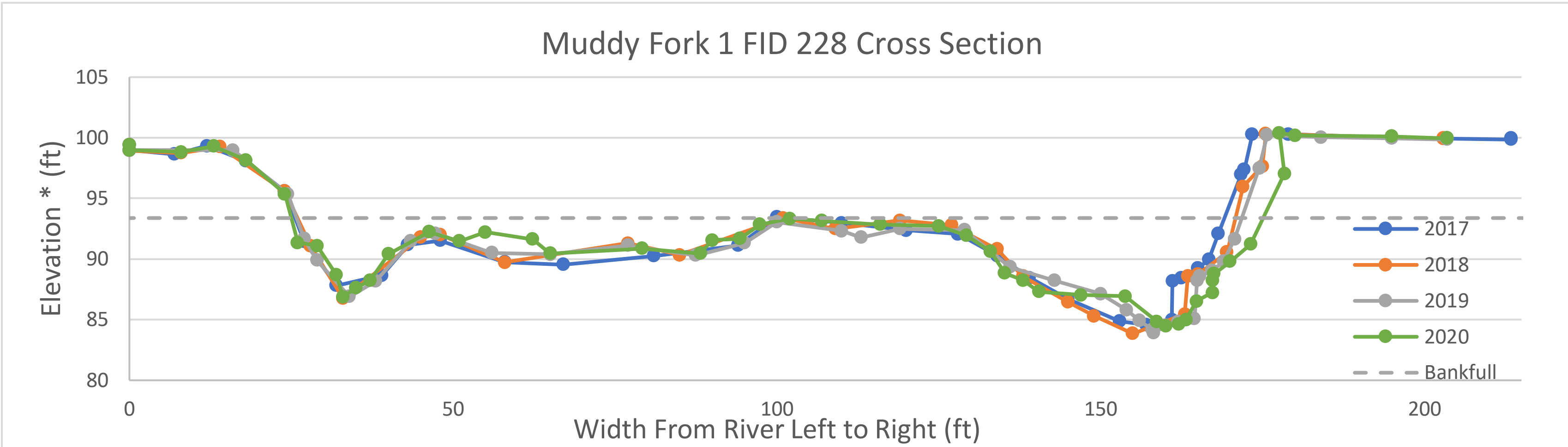

Figure 6. Site 1 Cross Section. Measurements taken 6/13/2017, 5/15/2018, 4/30/2019, & 5/7/2020. (Bankfull height: 93.38 ft) *Elevations not georeferenced

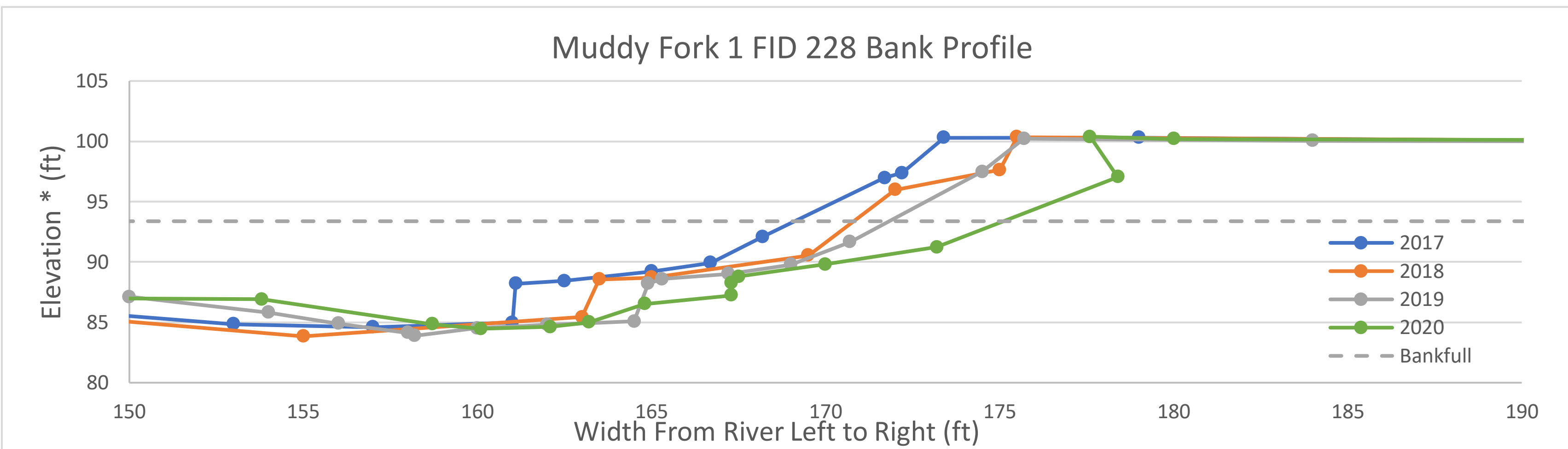

Figure 7. Site 1 Bank Profile. Measurements taken 6/13/2017, 5/15/2018, 4/30/2019, & 5/7/2020. (Bankfull height: 93.38 ft) *Elevations not georeferenced

Site 1 Photos

Muddy Fork 1 FID 228. 2017 (top) vs 2018 (middle) vs 2019 (bottom) Looking downstream.

Muddy Fork 1 FID 228, (2019) Cross Section View

Muddy Fork 1 FID 228, (2018) mid-channel bar.

Site 2 – Muddy Fork 2 FID 67

Site Description

This site is located approximately 0.1 mile north of the WC 612/Kinion Lake Road crossing of Muddy Fork. The river right (east side) bank was selected for monitoring as it is actively eroding into the landowner's cattle pasture. The bank is approximately 234 feet long, 12-13 feet tall and is near vertical or vertical throughout the study area. The bank is comprised of silt, clay and gravel layers with very little ground cover and almost no surface protection. A tight bend is forming in the river as the river is entrenched in a fairly straight channel and gravel deposition has been depositing the form of a point bar, continuing to elevate NBSS levels along the cut bank. Cattle have been fenced out of the creek, but bank erosion is occurring so rapidly that the fence has to be regularly moved so as not to fall in the stream channel.

Figure 8. Planform view of Muddy Fork 2 FID 67 annual survey site. The creek flows generally South to North at this location. The orange shaded area represents the bank lost to erosion from 2017-2018, while the small light blue shaded area represents bank lost from 2018-2019, and the purple shaded area depicts land eroded from 2019-2020. Google Earth Imagery Date: 3/4/2020.

Survey Results

Based on the 2017, 2018, 2019, & 2020 cross-section surveys, the stream bank at this location moved an average of 3.92 feet laterally across the bank profile each year from 2017 to 2020 (Figures 9 & 10). Annual top of bank measurements corroborate these results. Immediately downstream of the cross section however, erosion rates are closer to 10 feet per year according to the annual top of bank measurements (Figure 8). The calculated average annual volume of soil/sediment loss due to erosion for this stream bank segment from 2017-2020 is 10,862 ft^3 (402 yd^3).

Discussion & Recommendations

Based on the results of this investigation, we are predicting this bank segment to continue to erode at an average rate of 3.28 ft/year, continuing into the foreseeable future. There is evidence that this site may be impacted from past channelization activities in which the original meandering creek was ditched and straightened in order to help dry the land for farming. The bridge on Kinion Lake Rd is also likely causing convergence of flow during large storm events when floodwaters are forced to pass through the bridge opening rather than across an open floodplain.

Evidence of old channel scars, including an oxbow lake are now perched upon the terrace, where once Muddy Fork coursed gently back and forth across the fertile floodplain. Muddy Fork and the Illinois River, whose confluence is just downstream of this site, were likely interconnected with an expansive wetland complex fed by springs and frequent overbank flooding. It may not be feasible to restore this site to its former glory, but there are several factors that make it a very attractive site for a limited scope streambank and wetland restoration.

Firstly, a streambank stabilization would remove a large polluter of sediment and nutrients into the Illinois River. Out of the 15 banks in our study, this site is eroding at the 5th highest rate. Additionally, this site has excellent potential to provide a large ecological uplift to this reach of stream. A large, deep pool exists at this location that could be stabilized with submerged woody debris or large rock, providing instream habitat for fish as well as mussels, including the endangered Neosho Mucket which historically inhabited this stretch of creek. Finally, a riparian corridor could be established that surrounds the two remnant channel scars up on the high floodplain. These channel scars do not often flood from the creek, but do hold water most of the year. Riparian wetlands like this are seemingly becoming more and more rare each year as development encroaches upon and impacts our streams and rivers.

Muddy Fork 2 FID 67. Aerial shot captured by drone during our most recent annual survey, 05/11/2020.

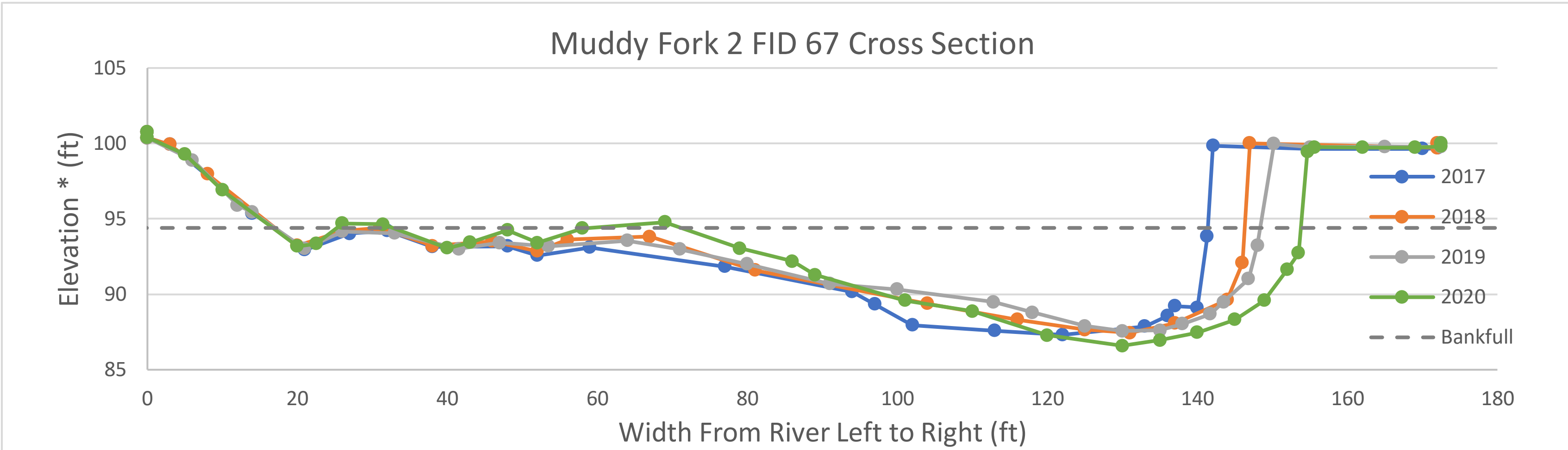

Figure 9. Site 2 Cross Section. Measurements taken 6/14/2017, 5/15/2018, 4/30/2019, & 5/11/2020. (Bankfull height: 94.4 ft) *Elevations not georeferenced

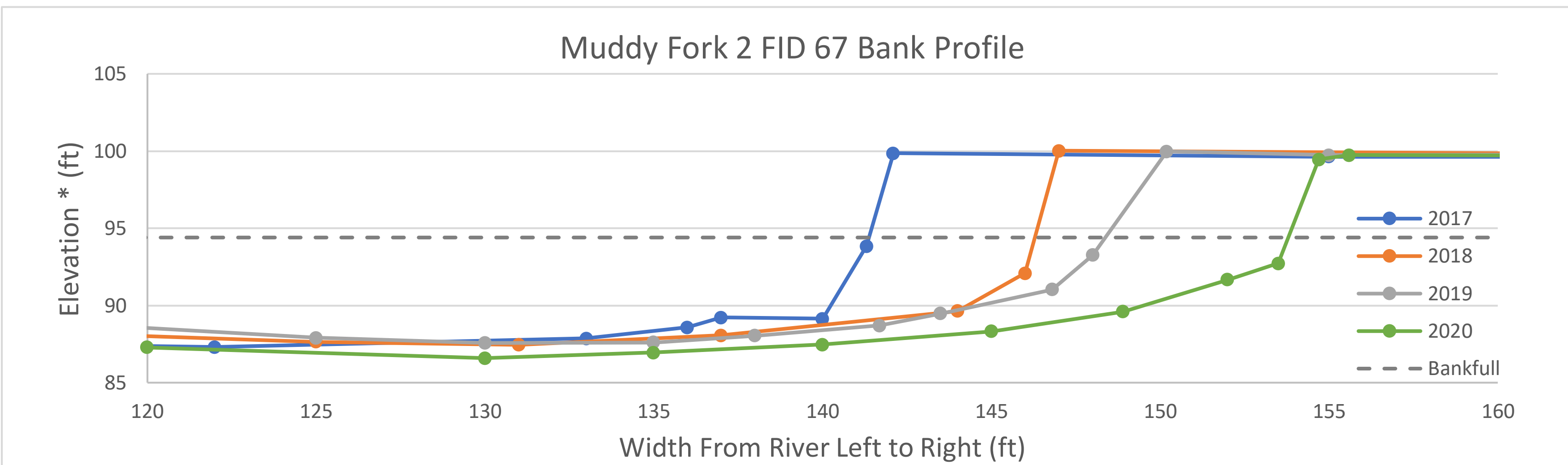

Figure 10. Site 2 Bank Profile. Measurements taken 6/14/2017, 5/15/2018, 4/30/2019, & 5/11/2020. (Bankfull height: 94.4 ft) *Elevations not georeferenced

Site 2 Photos

Muddy Fork 2, FID 67. 2017 (top) vs 2018 (middle) vs 2019(bottom), Looking Downstream.

Muddy Fork 2, FID 67 (2019) Cross Section View

Muddy Fork 2, FID 67 (2019) Actively eroding bank

Site 3 – Illinois River 1 FID 25

Site Description

This site is located on the Illinois River approximately 1 mile south of AR Hwy 16 near Savoy, AR. The left (west side) bank was selected for monitoring. The bank is approximately 238 feet long, 19 feet tall, and the bank angle is approximately 42 degrees. The bank is comprised predominately of silt and clay. The study area occurs at a very high bank on the river that has been cleared of trees resulting in a loss of rooting depth and accelerated erosion. The active land use here appears to be primarily harvesting hay from the field several times annually, during which the property is mowed very close to the edge of bank.

Figure 11. Planform view of Illinois River 1 FID 25 Permanent Survey Site. The orange shaded area represents bank lost to erosion from 2017-2018. The small light blue shaded area represents bank erosion from 2018-2019, and the purple shaded area depicts land lost to erosion from 2019-2020. Google Earth Imagery Date 3/4/2020).

Survey Results

Based on the 2017, 2018, 2019, & 2020 cross-section surveys, the stream bank at this location moved an average of 0.99 feet laterally across the bank profile annually (Figures 12 & 13). Annual top of bank measurements corroborate these results (Figure 11), although there is an area downstream of the cross section that has been experiencing much higher rates. The river has quickly been washing away a vegetated point that, until very recently, used to abruptly jut out into the river. It appears that much of the erosion relating to this flow obstruction may be complete, as the river now has developed a more natural flowpath along the bank. The average measured annual volume of soil/sediment loss due to erosion for this stream bank segment from 2017-2020 is 4,080 ft^3 (151 yd^3).

Discussion & Recommendations

The bank segment appears to be eroding badly, but looks can be deceiving. At some point in the near past it probably was actively eroding. The problem largely appears to have moved downstream, however, as the meander has widened enough to reduce the Near Bank Shear Stress down to a moderate level. Based on our most recent 2020 data and modeling, we anticipate this stream bank segment to continue eroding laterally at the modest rate of 1.01 ft/year on average.

This bank is so tall that even a relatively low erosion rate of around a foot a year quickly adds up to a large volume. Even so, we do not feel like this site would be an ideal location for a large-scale streambank stabilization or restoration project at this time. The cost would be great and would likely outweigh any realized benefits. Alternatively, it would be helpful to establish around a 75 ft or wider corridor of deep-rooted trees along the top of bank at this location that may eventually provide shade and rooting density to benefit the river and help hold soil in place.

Illinois River 1 FID 25. Aerial shot captured by drone during our most recent annual survey, 05/14/2020.

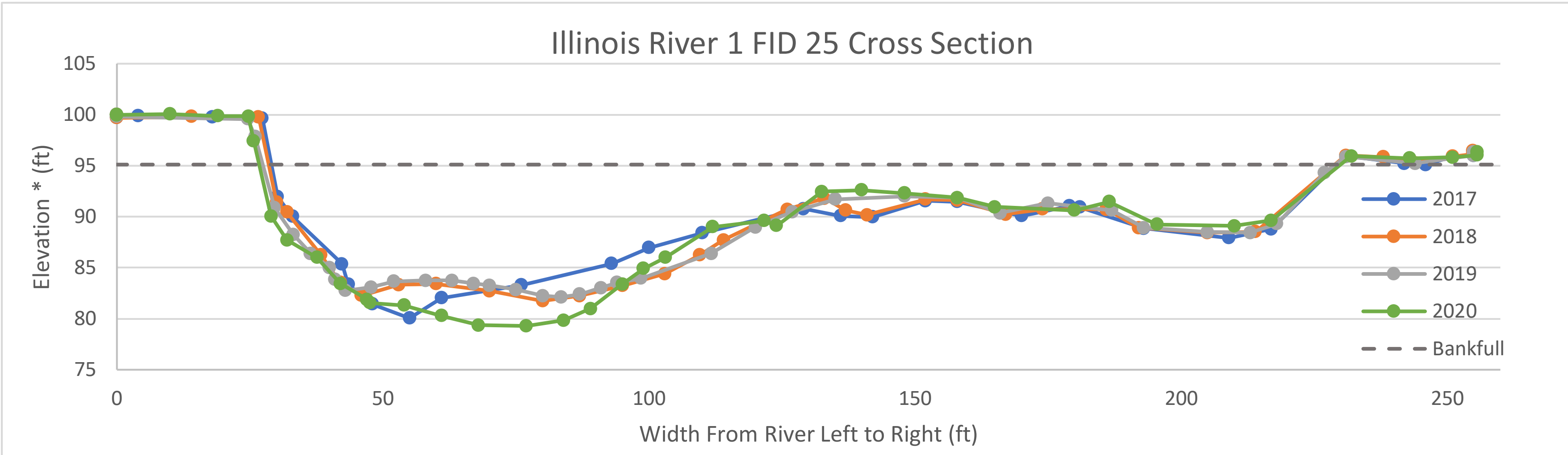

Figure 12. Site 3 Cross Section. Measurements taken 6/14/2017, 5/17/2018, 5/14/2019, & 5/14/2020. (Bankfull height: 95.11 ft) *Elevations not georeferenced

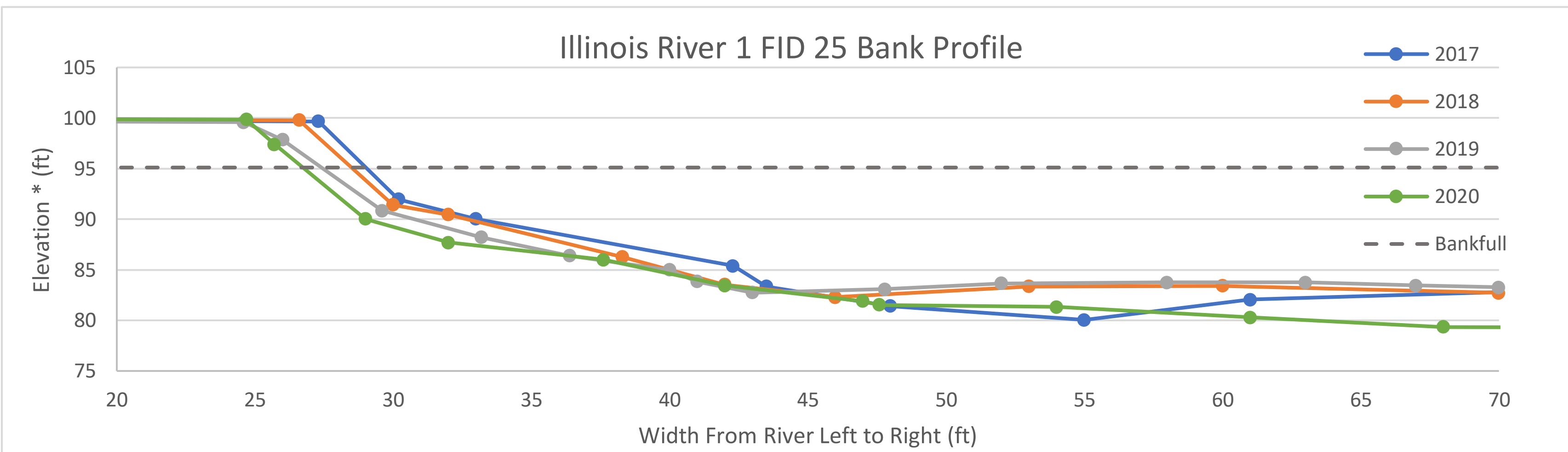

Figure 13. Site 3 Bank Profile. Measurements taken 6/14/2017, 5/17/2018, 5/14/2019, & 5/14/2020. (Bankfull height: 95.11 ft) *Elevations not georeferenced

Site 3 Photos

Illinois River 1 FID 25, 2017 (top) vs 2019 (bottom), Looking Upstream.

Illinois River 1 FID 25, (2017) Looking Downstream

Illinois River 1 FID 25, (2019) Cross Section View

Site 4 – Illinois River 2 FID 2

Site Description

This site is located approximately ½ mile north of the AR Hwy 16 crossing of the Illinois River near Savoy, AR. The river right (east side) bank was selected for monitoring. The bank is approximately 516 feet long, 16 feet tall and has a bank angle of approximately 55 degrees. The bank is comprised of silt, clay and multiple gravel layers with very little rooting depth and almost no surface protection. This site lies just downstream of a large naturally-occurring shale bedrock outcropping in the river. It appears that over many years numerous large pieces of shale repeatedly flaked off from the outcropping which formed a riffle at this location that can be observed on historic aerials. This bar has become destabilized at the study bank site causing a very large migrating transverse bar to form and increasing NBSS to extreme levels. The study bank is eroding quickly into a hay field where shallow grass offers little to no rooting protection against the erosive force of the river.

Figure 14. Planform view of Illinois River 2 FID 2 annual survey site. The river flows generally South to North at this location. The orange shaded area represents the bank/pasture lost to erosion from 2017-2018. The light blue shaded area represents widening of the river channel and land washed away from 2018-2019, while the purple shaded area depicts the river channel continuing to widen and a large area of eroded soil and grass that washed downstream from 2019-2020. Google Earth Imagery Date: 3/4/2020.

Survey Results

Based on the 2017, 2018, 2019, & 2020 cross-section surveys, the stream bank at this location moved an average of 18.06 feet laterally across the bank profile each year from 2017 to 2020 (Figures 15 & 16). Annual top of bank measurements corroborate these results (Figure 14), although the primary erosive force is continuing to migrate downstream of the cross section location. Annual top of bank measurements as well as

Google Earth aerial photography confirm that the river bank shaded in purple on Figure 12 above has eroded a staggering 135 ft laterally in just the last year alone (5/2019-5/2020). The average measured volume of soil loss due to bank erosion for the stream bank segment annually from 2017-2020 is 297,589 ft^3 (11,022 yd^3). The total volume over the last year alone from May 2019-May 2020 is 621,262 ft^3 (23,010 yd^3). To put that in perspective, **the volume of bank loss from this one site alone is nearly double of all of the other 14 study sites combined!**

Discussion & Recommendations

Through natural erosive and depositional processes, a large quantity of loose shale once accumulated in the bed of the river at this location, just downstream of a large natural bedrock outcropping of relatively flaky shale in the Illinois River. Over some period of time, this shale had been transported some 200 feet downstream of the outcropping and had built up in layers and formed an unusual but relatively stable riffle that spanned the riverbed approximately 60 feet upstream of the current cross section location. This shale layering can be observed as a stable channel feature on Google Earth from the earliest aerial in 1994 all the way up to around 2009 when it appears that a mid-channel gravel bar had begun to form on top of the riffle, extending downstream for some ways directly in the center of the river channel.

Mid-channel bars are notorious for altering flows, and this bar can be witnessed splitting flow in two separate directions, directly towards either side of the channel causing elevated Near Bank Shear Stress (NBSS) on both the left and right bank. By interpreting the Google Earth aerials it is apparent that, sometime after 2009 and before 2012, bank erosion started occurring immediately upstream and downstream of where the shale riffle met the right bank. This erosion is associated with very high NBSS caused by the formation of the small mid-channel bar that had begun to form around 2009. Only a very narrow riparian corridor was present at this location, as most of the land here was and still is maintained primarily as a hay field. By 2014 the shale riffle had become destabilized. It had migrated downstream approximately 30 feet from its previous location, and an extensive mid-channel gravel bar had formed extending for some ways downstream.

This is the point that it was evident that erosion along the right bank had flanked the shale riffle and compromised its structure. The original shale deposition did not appear to key into or extend into or under the bank at that location. The once stable shale bar completely destabilized by March of 2016 as chute cutoffs had formed around both sides of a large central transverse bar, producing extreme NBSS along an extended length of the right bank. By 2018, the head of the bar had migrated some 70 feet downstream of the cross section location, and by 2020 the transverse bar is so massive it can be a bit difficult to comprehend. Gravel appears to make up a much larger percentage of the bar than it did several years ago, but the overall form still appears to be held by thick layers of shale. Huge, chute cutoffs still exist along both banks, indicating steep slope around the near-bank region and an extreme NBSS rating. The location of the head of the bar is now some 165 feet downstream of the cross section location, and the majority of flow directed is along the right bank.

The pictures and graphs really speak for themselves on this one. There may not be another river bank on the entire Illinois River that is currently migrating at such a high rate. Our 2020 modeling yields an estimate that this river bank segment will continue to erode at 14.96 ft/year on average, which may be quite accurate for the cross section location. The highest stress, however is continuing to migrate downstream with each flood event as the shale bar is continually changing shape and still developing larger as more gravel continues to build.

Near Bank Shear Stresses at this location are off of the charts, as we are measuring most recent rates of lateral erosion well over 100 feet annually, and the rock bar continues to shift and rapidly expand. The erosion has reached a point at the downstream 1/3 of the bend where a large number of mature trees are becoming uprooted and entering the river, causing a significant log jam. Also, the problem has started to impact the descending left bank immediately downstream of the study bank, as the river is continually being redirected and adjusting to a new flow path.

In due time, without any intervention, the lateral channel migration will likely encounter bedrock to the Northeast, where a limestone outcropping forms the valley wall at the edge of the floodplain. There is a privately-owned cave at this location known to be inhabited by a population of rare and Federally Endangered Gray Bats. It is probably worth communicating with a bat expert about the possible effects of this erosion on the bats. I am merely speculating, but the loss of canopy cover and potential loss of seclusion associated with the river washing the riparian corridor away right at their doorstep may have some negative effect. Even just exposing the naturally well-hidden cave entrance to canoeists may encourage people to unknowingly disturb these sensitive animals.

Regardless of the outcome of any further discussions regarding bats, we recommend immediate action. It is truly unknown how great and long-term of an effect this large-scale disturbance could have without professional intervention. A plan should be developed as soon as possible to restore this reach of river to a state of stability and equilibrium. This will not be an easy fix, but there really are countless benefits to undertaking an endeavor like this. We could spend the next 5 years restoring every eroding bank in this study and still not come close to realizing the potential sediment and nutrient reduction impact of this one project.

Illinois River 2 FID 2. Aerial shot looking downstream at the site, 05/13/2020.

Collecting annual Top of Bank data at Illinois River 2 FID 2. (05/13/2020).

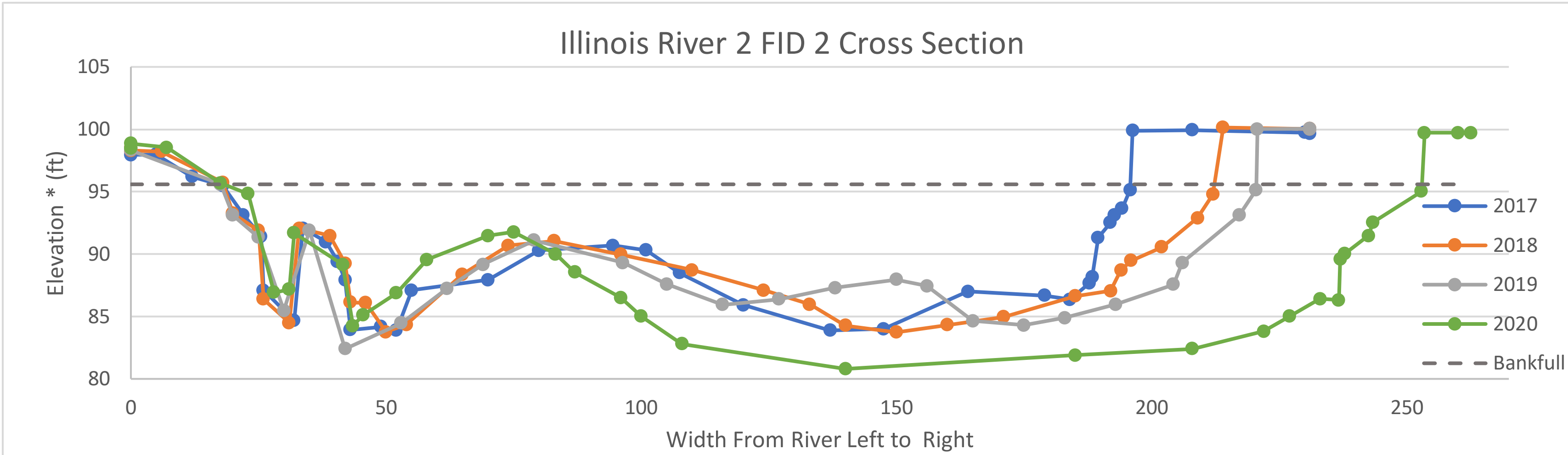

Figure 15. Site 4 Cross Section. Measurements taken 6/13/2017, 5/15/2018, 5/16/2019, & 5/13/2020. (Bankfull height: 95.59 ft) *Elevations not georeferenced

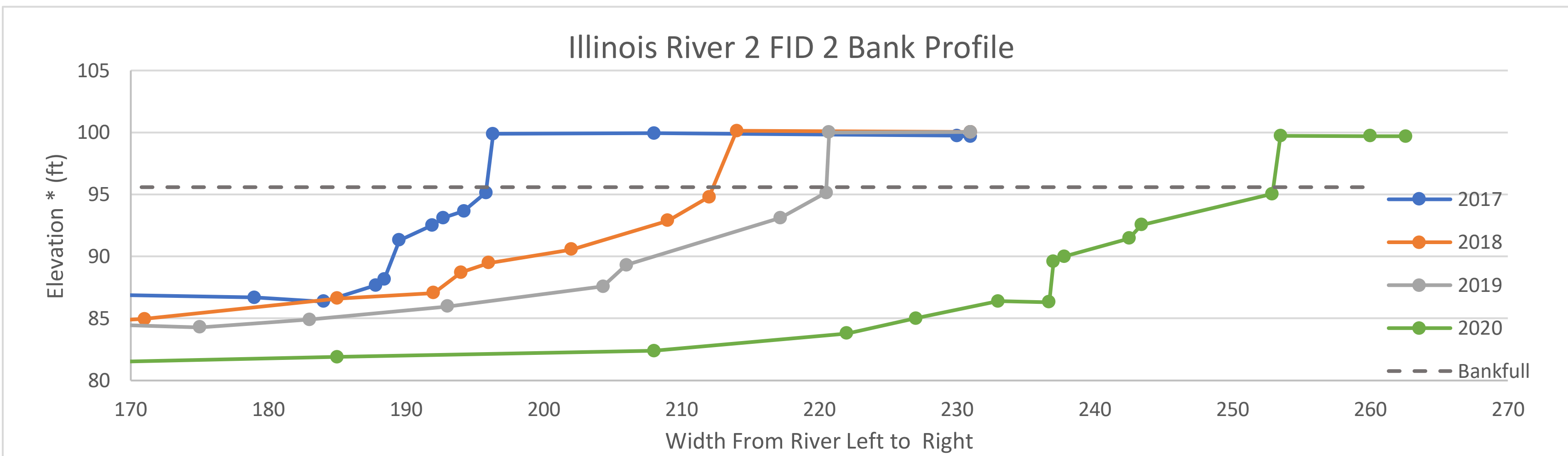

Figure 16. Site 4 Bank Profile. Measurements taken 6/13/2017, 5/15/2018, 5/16/2019, & 5/13/2020. (Bankfull height: 95.59 ft) *Elevations not georeferenced

Site 4 Photos

Illinois River 2 FID 2, 2017 (top) vs 2018 (middle) vs 2019 (bottom), Looking Downstream.

Illinois River 2 FID 2, (2017) Cross Section View.

Illinois River 2 FID 2, (2018) Looking Upstream.

Site 5 – Illinois River 2 FID 75

Site Description

This site is located approximately ¼ mile south of the AR Hwy 412 crossing of the Illinois River. The river right (east side) bank was selected for monitoring. The bank is approximately 230 feet long, 11-12 feet tall and has a bank angle of approximately 47 degrees. The bank is comprised of silt, clay and gravel layers with little ground cover or surface protection. This site falls in a relatively straight section of the river that has widened considerably over the years. The study bank location is adjacent to a mid-channel gravel bar, which is causing high NBSS and accelerated erosion. There is a narrow, but intact riparian corridor on both banks here, which is likely helping to stabilize this river bank.

Figure 17. Planform view of Illinois River 2 FID 75 annual survey site. The river flows generally South to North at this location. The orange line represents the location of the study bank in 2017. 2018 is represented as a light blue line. The purple line depicts the top of bank location on the survey date in 2019, and the red line represents top of bank in 2020. All of the lines overlap slightly, indicating that the location of the top of bank has not moved tremendously through the 3-year study period. Google Earth Imagery Date: 3/4/2020.

Survey Results

Based on the 2017, 2018, 2019, & 2020 cross-section surveys, the stream bank at this location laterally moved an average of 1.88 feet annually (Figures 18 & 19). Annual top of bank measurements corroborate these results (Figure 17). The average measured volume of soil/sediment loss due to erosion for this stream bank segment from 2017-2020 is 4,713 ft^3 (175 yd^3).

Discussion & Recommendations

Based on the latest data and modeling, predict that the bank at this site will continue to erode at an average rate of 1.78 feet laterally per year. That estimate would put this site in the top half of study sites in regards to predicted erosion potential (ft/year). Our recommendation is to keep an eye on this site over the coming years and be aware that any significant growth or migration of the mid-channel gravel bar would indicate a corresponding increase in NBSS. Any efforts to maintain and enhance the riparian corridor onsite would also be helpful. There are several small riverside hay fields that could be taken out of hay production and a now-mow regimen introduced (while maintaining river access) to encourage forest re-growth and help ensure the long-term sustainability of this beautiful spot.

Illinois River 2 FID 75. Overview of the cross section survey, 05/14/2020.

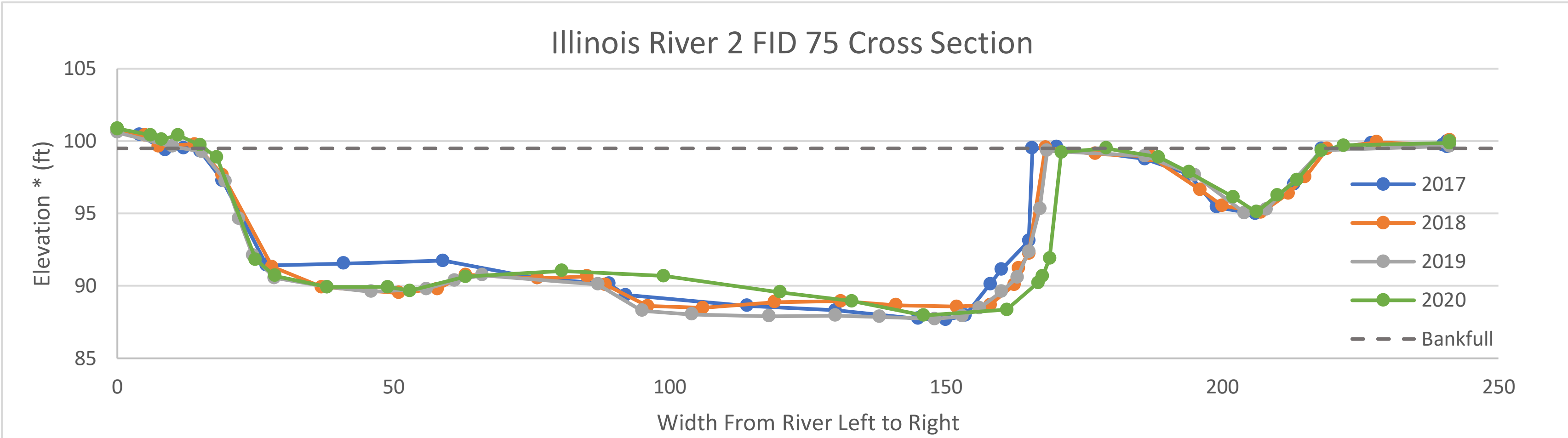

Figure 18. Site 5 Cross Section. Measurements taken 6/13/2017, 5/23/2018, 5/14/2019, & 5/14/2020. (Bankfull height: 99.5 ft) *Elevations not georeferenced

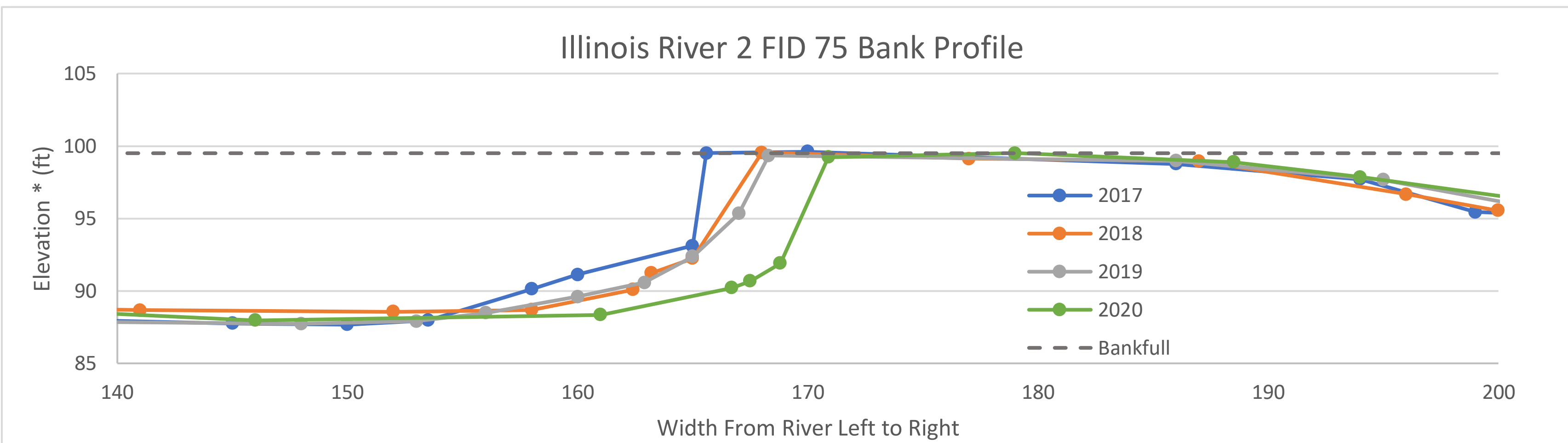

Figure 19. Site 5 Bank Profile. Measurements taken 6/13/2017, 5/23/2018, 5/14/2019, & 5/14/2020. (Bankfull height: 99.5 ft) *Elevations not georeferenced

Site 5 Photos

Illinois River 2 FID 75, 2018 (top) vs 2019 (bottom) Cross Section View.

Illinois River 2 FID 75, (2019) Critical Bank View.

Illinois River 2 FID 75, (2019) Looking Downstream.

Site 6 – Muddy Fork 1 FID 172

Site description

This site is located at the dead-end of Bonnie Scotland Rd. in northwest Prairie Grove, AR. The river right (west side) bank was selected for monitoring. The bank is approximately 818 feet long, 16-17 feet tall, and has a bank angle of approximately 60 degrees. The bank is comprised of clay with very little ground cover and almost no surface protection. There is a deep pool here, along with a public park, providing swimming and fishing recreational opportunities. Although new development is occurring in the immediate vicinity, a narrow but largely intact riparian corridor provides a level of protection on both sides of the creek.

Figure 20. Planform view of Muddy Fork 1 FID 172 annual survey site. The light blue line indicates the target top of bank location in 2018. The purple line indicates the bank location in 2019, and the red line indicate the location of the top of bank during the most recent survey in 2020. Of note is that this area is experiencing rapid development in or very close to the active floodplain and riparian corridor of Muddy Fork. A paved trail that was not here in 2019 is clearly visible on this aerial as well as new building pads directly to the north of that trail. Google Earth Imagery Date: 3/4/2020.

Survey Results

Based on the 2018, 2019, & 2020 cross-section surveys, the stream bank at this location moved an average of 0.43 feet laterally across the bank profile each year (Figures 21 & 22). Annual top of bank measurements were inconclusive due to heavy canopy cover but generally corroborate these results. (Figure 20). The average measured volume of soil/sediment loss due to erosion for this stream bank segment annually from 2018-2020 is 5,060 ft^3 (187 yd^3).

Discussion & Recommendations

Based on modeling completed in 2020, it is estimated that the cut bank at this site will continue to erode at an average rate of only 0.33 feet laterally per year. This is one of the lowest measured and predicted erosion rates for any of the 15 sites in the study. Initially it may appear that there would be more erosion occurring at this site, given that the bank is nearly vertical, quite tall and has relatively little direct protection from roots and other vegetation. It is really the bank material here that is the key to those low observed and predicted erosion rates that we are reporting. This bank is comprised almost entirely of clay. Clay is generally resistant to erosion, and therefore a bank comprised of clay (unless it has layers of sand or gravel) will generally experience low rates of erosion.

The only recommendation that we have for this site is to potentially engage with Prairie Grove Parks staff to ensure that the riparian corridor along Muddy Fork is preserved as this place continues to develop into a popular park. In addition, developers appear to be encroaching very close to the floodplain from the East of this location. There is a large tract of relatively wild land on the West side of the creek that appears to be active floodplain. From the historical aerial photos, you can see that this area was once maybe a hay or sod farm, but it appears to have laid fallow for some time now. Ensuring that low-lying properties like this do not get filled or unsustainably developed is important for preventing long-term channel instability and is also great for natural flood retention and mitigation downstream.

Muddy Fork 1, FID 172 (5/06/2020) Note nearly vertical bank comprised primarily of clay.

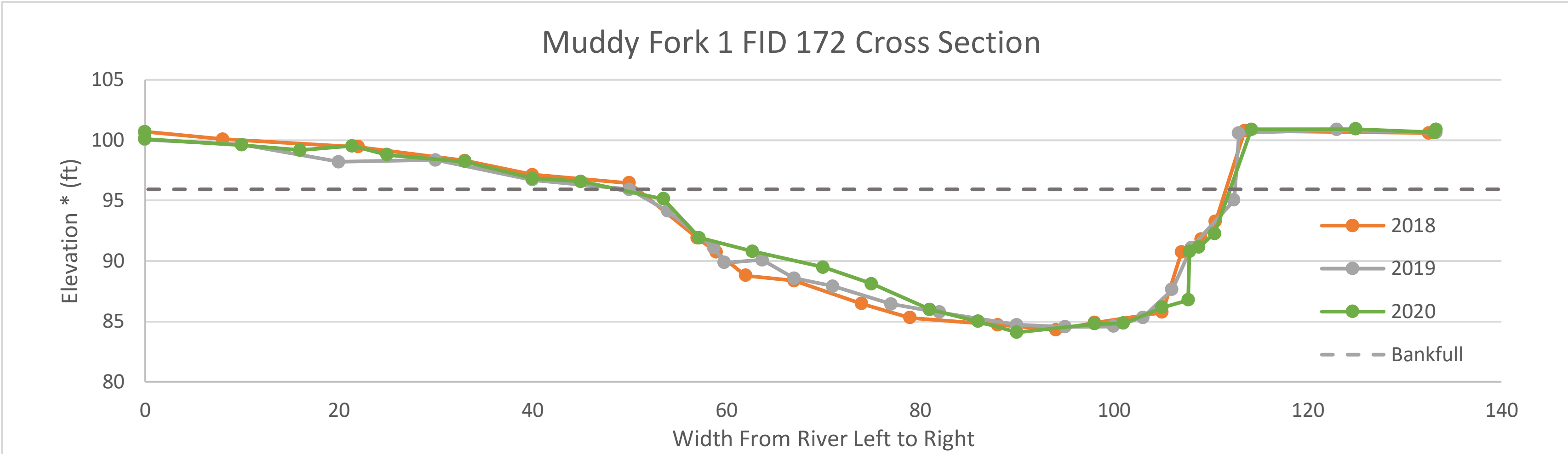

Figure 21. Site 6 Cross Section. Measurements taken 5/15/2018, 5/15/2019, & 5/6/2020. (Bankfull height: 95.93 ft) *Elevations not georeferenced

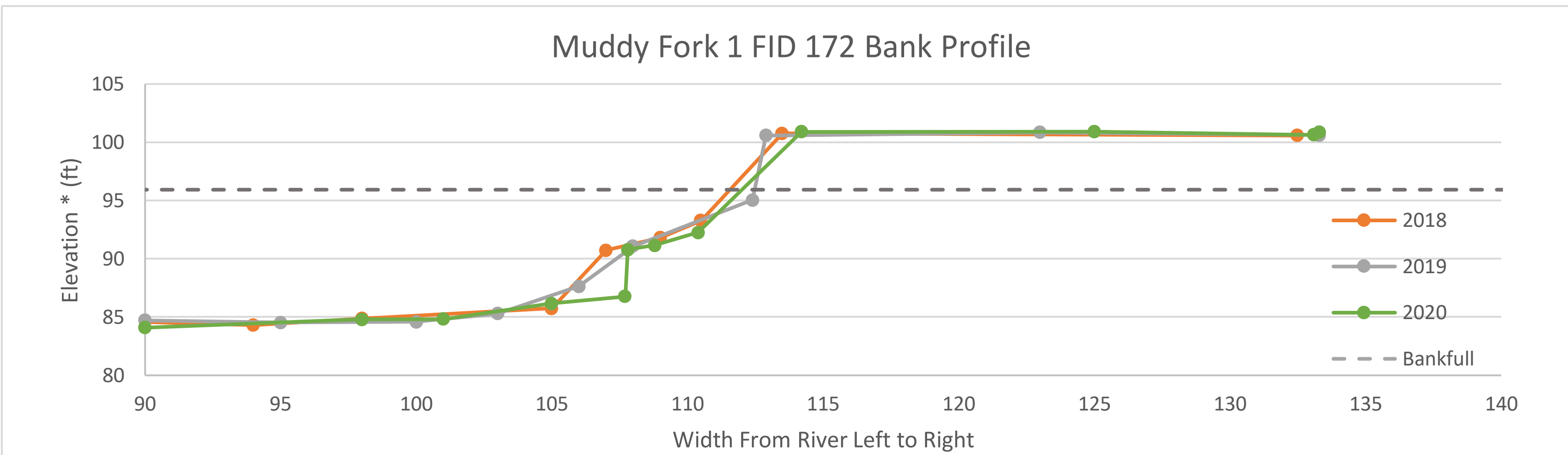

Figure 22. Site 6 Bank Profile. Measurements taken 5/15/2018, 5/15/2019, & 5/6/2020. (Bankfull height: 95.93 ft) *Elevations not georeferenced

Site 6 Photos

Muddy Fork 1 FID 172 (2019) Critical Bank View

Muddy Fork 1 FID 172 (2019) Cross Section View

Muddy Fork 1 FID 172 (2019) Upstream View

Muddy Fork 1, FID 172 Aerial View (2020)

Site 7 - Illinois River FID 16

Site description

This site is located approximately 1 mile west of the intersection of Fletcher and Lynch Rds. near Savoy, AR. The river right (East side) bank was selected for monitoring. The bank is approximately 349 feet long, 14-15 feet tall, and has a bank angle of approximately 32 degrees. The bank is comprised of silt and clay with very little ground cover and little surface protection. The opposite, West river bank is protected by natural bedrock bluffs. The bank currently experiences very low near bank shear stress (NBSS) but a mid-channel gravel bar has developed upstream of this site that may increase the NBSS on the targeted bank in the future. An expansive riparian corridor and intact active floodplain with off-channel wetlands are hallmarks of this unique and wild location.

Figure 23. Planform view of Illinois River 2 FID 16 annual survey site. The light blue line represents the location of the study bank in 2018. The purple line depicts the top of bank location on the survey date in 2019, and the red line represents top of bank in 2020. The annual top of bank lines appear to overlap at this scale, indicating that the bank has not moved tremendously through the 2-year study period. Also of note is the mature and healthy riparian corridor and unique oxbow wetland/lake few by a small tributary within the floodplain adjacent to the river. Google Earth Imagery Date: 3/4/2020.

Survey Results

Based on the 2018, 2019, & 2020 cross-section surveys, the stream bank at this location moved an average of 0.23 feet laterally per year from 2018-2020 (Figures 24 & 25). Annual top of bank measurements were inconclusive due to the heavy canopy cover but generally corroborate these results (Figure 23). The average annual measured volume of soil/sediment loss due to erosion for this stream bank segment from 2018-2020 is 893 ft^3 (33.1 yd^3).

Discussion & Recommendations

The latest modeling based on 2020 data estimates that this site will continue to erode at an average rate of 0.26 feet laterally per year, which makes this site one of the areas with the lowest both measured and predicted erosion rates included in the study. Based on these results, we conclude that Site 7 is actually very stable in terms of being able to withstand large flood events while displaying little to no change in bank and channel shape. This site is beautiful and uniquely protected, being bound on one side by a wooded, rocky hillside and on the other by a riparian zone that consists of over 500 feet of mature bottomland hardwood forested floodplain with hydrologically interconnected side channels and wetlands. Continued protection of this resource is the key to its long-term resilience and sustainability.

Illinois River 2, FID 16 Aerial View of the Cross Section location at the time of the 2020 annual survey (5/13/2020).

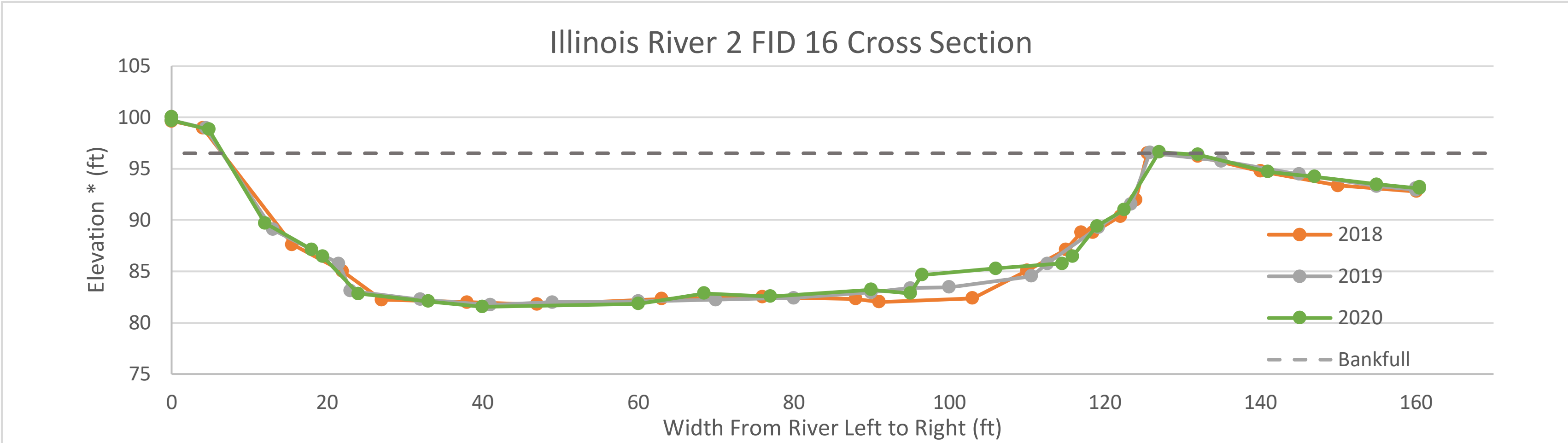

Figure 24. Site 7 Cross Section. Measurements taken 6/5/2018, 5/16/2019, & 5/13/2020. (Bankfull height: 96.51 ft) *Elevations not georeferenced

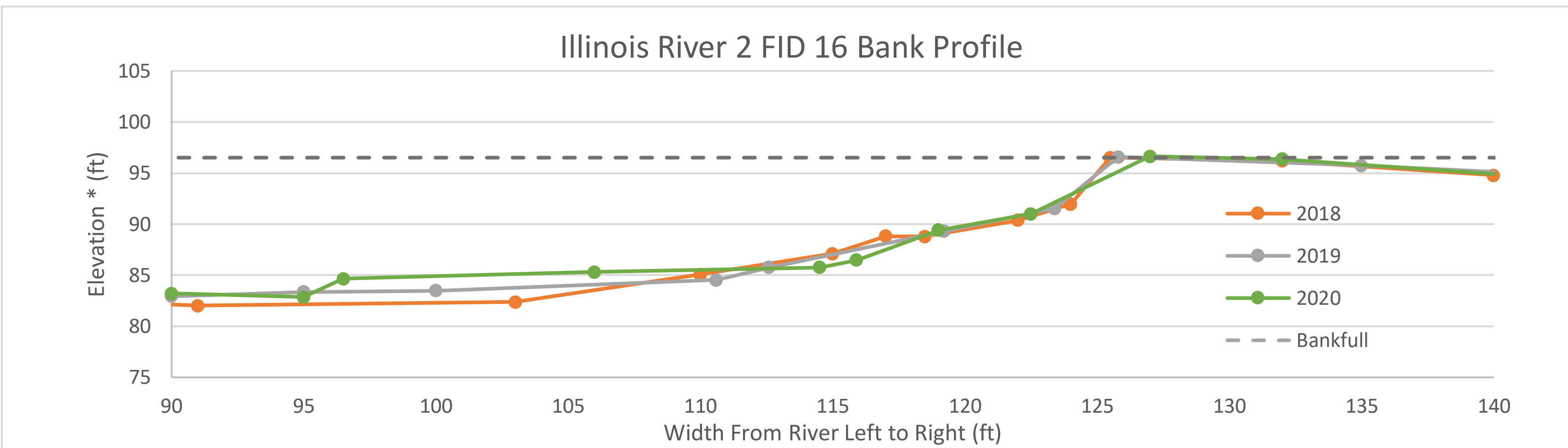

Figure 25. Site 7 Bank Profile. Measurements taken 6/5/2018, 5/16/2019, & 5/13/2020. (Bankfull height: 96.51 ft) *Elevations not georeferenced

Site 7 Photos

Illinois River 2, FID 16, 2018 (top) vs 2019 (bottom), Cross section View.

Illinois River 2, FID 16, (2019) Downstream View

Illinois River 2, FID 16, (2018) Elevations Recorded for Cross Section graphing

Site 8 - Illinois River 3 FID 46

Site description

This site is abutting the Oklahoma-Arkansas state line around 1 mile west of Hwy 59 and may be accessed via a private drive off County Rd. 801. The river left (South side) bank was selected for monitoring. The bank is approximately 503 feet long, 14-15 feet tall, and has a bank angle of approximately 54 degrees. The bank is comprised of layered silt and clay with gravel and very little surface protection. This river bank lies just over a mile upstream of the impounded Lake Frances and within one of the larger, relatively-intact wooded corridors along the Illinois River. Of note are several large, natural high-flow/side channels that provide flood relief to the mainstem Illinois during high water. This is possibly/partly a result of channel braiding that has occurred due to relatively high sediment supply and restricted flow related to the dam construction (1931) and associated impoundment of the river channel.

Figure 26. Planform view of Illinois River 3 FID 46 annual survey site. Illinois River flows generally East to West at this location. The light blue line represents the location of the study bank in 2018, while the purple line and red lines depict the top of bank location on the survey dates in 2019 and 2020 respectively. Google Earth Imagery Date: 3/4/2020.

Survey Results

Based on the analysis of 2018, 2019, & 2020 cross-section surveys, it has been determined that the stream bank at this location moved an average of 1.83 feet laterally across the bank profile each year from 2018 to 2020 (Figures 27 & 28). Annual top of bank measurements were inconclusive due to heavy canopy cover but generally corroborate these results. (Figure 26). The average annual measured volume of soil/sediment loss due to erosion for this stream bank segment from 2018-2020 is 11,422 ft^3 (423 yd^3).

Discussion & Recommendations
Updated modeling based on analysis of 2017-2020 Illinois River field data yields a predicted estimate of 1.65 feet of annual lateral bank erosion for this site. Both the observed rates and predicted rates are about middle of the pack in relation the other 14 study sites. Looking at the cross section graph (Figure 27), you can observe that both the left and right bank scoured during the 2019-2020 survey period. This is interesting, because generally there will be aggradation/deposition that occurs on the inside bend (point bar) while corresponding degradation/erosion occurs on the outside bank (cut bank).

It would not be surprising to see a cycle of aggradation and degradation that occurs on point bars and other depositional features at this location. Sediment, including fine gravel and sand is deposited here with each minor flood occurrence. This deposition gradually builds up (aggrades) and forms bars along inside bends or within slack water areas that occur in the channel during these minor floods. This site is close enough to the Lake Frances Dam that backwater effects occur here during high water. Essentially, fast moving flood waters from upstream are slowed down at this location as the dam and large floodplain levees act as a bottleneck to flood flow. Fast moving flood waters carry sand and gravel from far upstream but it may deposit at an accelerated rate at this location as the flood waters are forced to slow down and spread out across the floodplain.

It takes an especially large and more infrequent flood event to generate sufficient water velocity in the channel to remobilize this deposition and flush it downstream and through the backwater zone. This site experienced relatively low water and only one flood event (1.65 x BKF discharge) during the 2018-2019 study year whereas during the 2019 to 2020 study year this same site experienced ten flood events, one of which was quite large (5.16 x BKF discharge), a magnitude event that generally only happens once every 3-4 years. This was likely the flood event that washed away this the sandy depositional bar and caused degradation on the inside bend of the pool (Figure 27).

This site, although experiencing a moderate rate of bank erosion is not the ideal site for a riverbank restoration project. Multiple landowners each have narrow lots with waterfront acreage. The scale of the river here is quite large, so multiple landowners would need to be involved to complete a successful project on this riverbend; completing a restoration on a portion of a large eroding bend is unlikely to be successful in the long-term. In addition, there are the confounding effects of the backwater associated with the dam located downstream of the site. As long as the landowners here keep mature, deep-rooted trees growing as a buffer along the riverbank, they will be doing what they can to keep erosion at a reasonable pace of around 1-2 ft per year on average.

Illinois River 3, FID 46 (5/14/2020) Aerial View with the survey site directly below.

Illinois River 3, FID 46 (5/14/2020) Aerial View looking back across the river towards the cut bank.

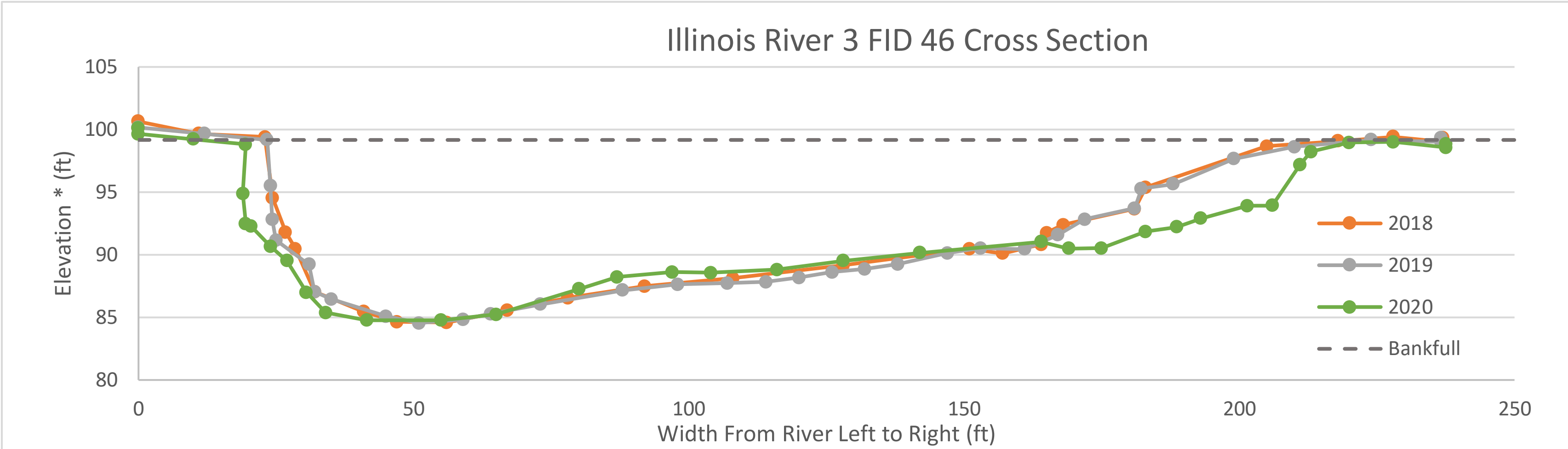

Figure 27. Site 8 Cross Section. Measurements taken 5/23/2018, 5/15/2019, & 5/14/2020. (Bankfull height: 99.17 ft) *Elevations not georeferenced

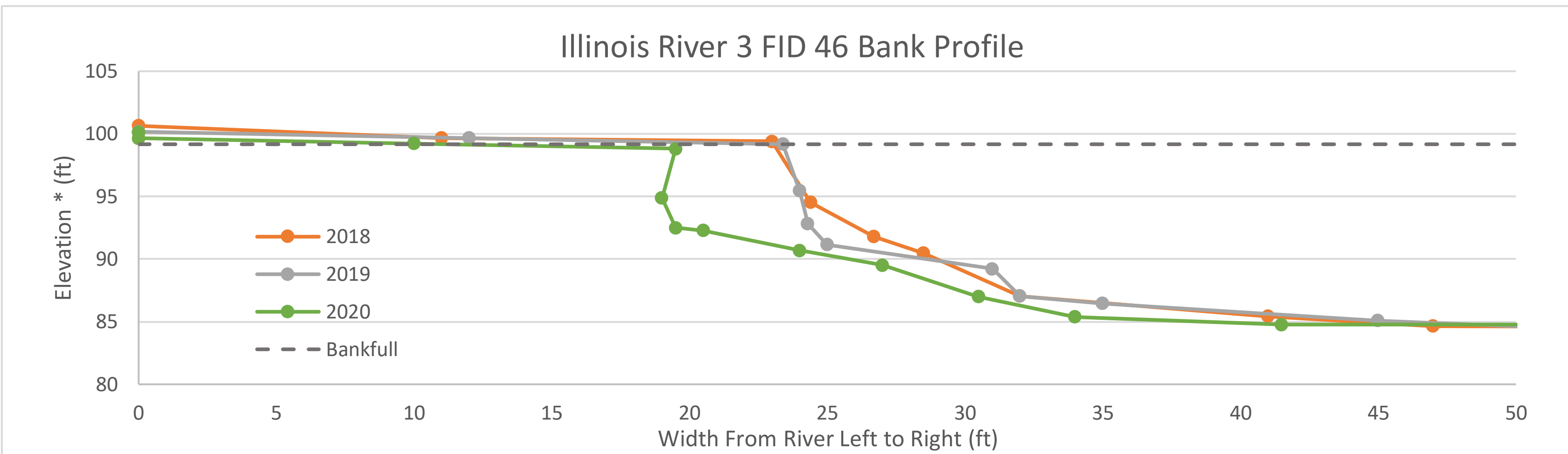

Figure 28. Site 8 Bank Profile. Measurements taken 5/23/2018, 5/15/2019, & 5/14/2020. (Bankfull height: 99.17 ft) *Elevations not georeferenced

Site 8 Photos

Illinois River 3, FID 46, 2018 (top) & 2019 (bottom), GPS marking of current top of bank position.

Illinois River 3, FID 46 (2020) Aerial Cross Section View

Illinois River 3, FID 46 (2018) Cross Section View

Site 9 - Illinois River 2 FID 69

Site description
This site is located approximately 1 mile south of the AR Hwy 412 crossing of the Illinois River. The river right (east side) bank was selected for monitoring. The bank is approximately 428 feet long, 11 feet tall and has a bank angle of approximately 65 degrees. The bank is comprised of silt and clay with very little ground covering, few trees, and almost no surface protection. A side-channel bar is located within the cross section, directly across the river from the study bank which, along with the tight radius of curvature of the new bend that is forming, is elevating Near Bank Shear Stress levels to extreme at this location.

Figure 29. Planform view of Illinois River 2 FID 69 Permanent Survey Site. The small area shaded in light blue represents erosion that took place from 2018 to 2019, while the relatively larger area shaded in purple depicts bank erosion from 2019 to 2020. Google earth Imagery Date: 3/4/2020.

Survey Results
Based on the 2018, 2019, & 2020 cross-section surveys, the stream bank at this location is moving an average of 8.23 feet laterally across the bank profile per year (Figures 30 & 31). Annual top of bank measurements also support these results. (Figure 29). The average measured volume of soil/sediment loss due to erosion for this stream bank segment annually from 2018-2020 is 49,700 ft³ (1,841 yd³).

Discussion & Recommendations

Utilizing the most recent data, and according to the updated bank erosion rate model included in this report, it is estimated that this bank segment will continue to erode at an average rate of 8.52 feet laterally per year. The measured erosions rates here as well as the model predictions indicate that this site is one of the top 3 worst offenders in terms of bank erosion out of the 15 sites selected for this study. In our opinion, this is a good site for river restoration as well.

Gaining an understanding of the underlying causes of instability at a restoration site is critical to developing a plan that is likely to lead to successful outcomes. Looking at the reach of river immediately upstream and downstream of the project site, there appears to be a pattern of side-channel bar development. This pattern includes this site as well as two banks within a mile upstream of this site and may even include study Site 5 (Illinois River 2 to 412 FID 75) not far downstream of this location as well.

Elevated bedload sediment (primarily gravel in this case) can lead to deposition in to form of mid and side-channel bar development in areas where gravel bars may not have previously occurred. This bar development directly elevates Near Bank Shear Stress on the river bank directly opposite of the bar. If the bank experiencing this elevated stress is not extremely resistant against erosion, this can quickly lead to bank loss and channel migration.

Most of this gravel in the Illinois River is very likely generated through processes of bank erosion from upstream sources. It is a compounding problem, where bank erosion leads to deposition in the form of in-channel bar development, which like will in turn lead to more bank erosion… and so on. It is possible for some gravel sources to contribute enough sediment or be situated upstream of a location especially sensitive to this type of disturbance, thereby causing cascading bank erosion and bar development for many miles downstream of the original source.

Through a quick reconnaissance utilizing Google Earth, we have identified a relatively small tributary that feeds into the Illinois River from the East approximately ¾ of a mile upstream of Site 9 which may be dumping vast amounts of gravel into the river. A large gravel bar or delta forms at the mouth of this tributary where it flows into the Illinois River. It appears that extensive bank erosion and, likely, channel incision are actively occurring for several miles along this small stream. A field reconnaissance to assess the current condition of this creek, gauge its role in gravel contribution to the river, and potentially recommend actions that could reduce the volume gravel would be a recommended action which could go hand in hand with a more direct restoration approach and plan that would need to be developed to stabilize, restore, and revegetate the cut bank at Site 9 on the Illinois.

Illinois River 2 FID 69 (5/13/2020) Looking downstream towards the site.

Illinois River 2 FID 69 (5/13/2020) Aerial looking from directly above down towards the site.

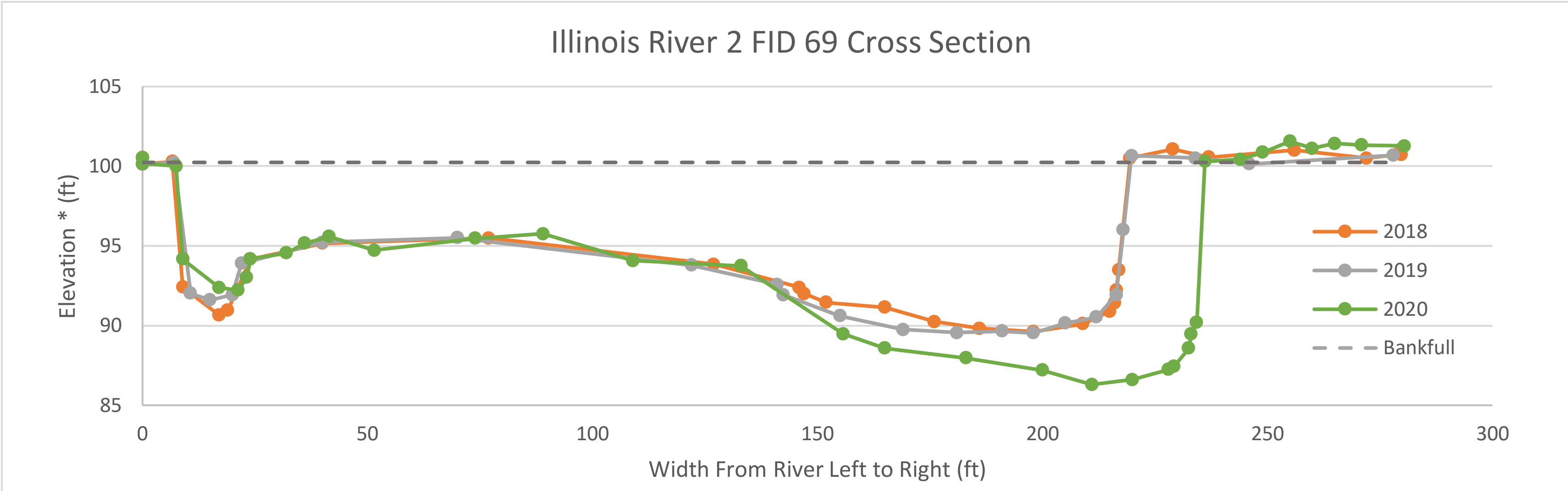

Figure 30. Site 9 Cross Section. Measurements taken 5/24/2018, 5/16/2019, & 5/13/2020. (Bankfull height: 100.24 ft) *Elevations not georeferenced

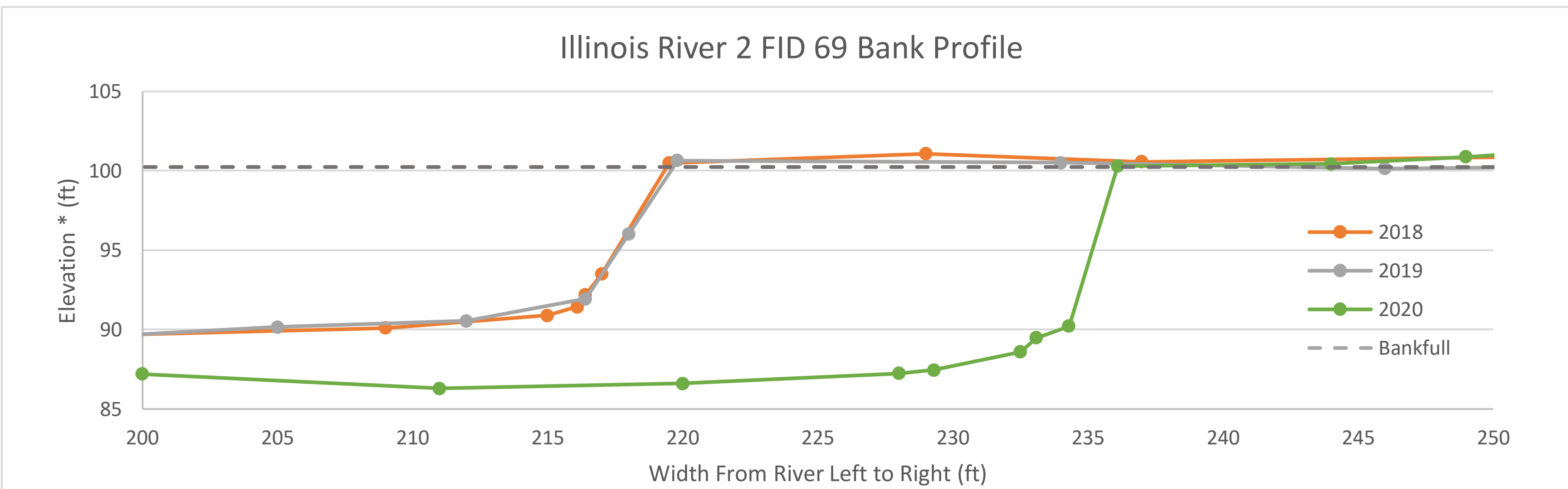

Figure 31. Site 9 Bank Profile. Measurements taken 5/24/2018, 5/16/2019, & 5/13/2020. (Bankfull height: 100.24 ft) *Elevations not georeferenced

Site 9 Photos

Illinois River 2 FID 69, 2018 (top) vs 2019 (bottom), Upstream View.

Illinois River 2, FID 69, 2018 (top) vs 2019 (bottom), Downstream View

Illinois River 2 FID 69, (2019), Cross Section View

Site 10 – Clear Creek FID 8

Site description

This site is located 0.3 miles south of Washington County Rd 86 east of Savoy, AR. The river left (west side) bank was selected for monitoring. The bank is approximately 389 feet long, 8-9 feet tall, and is near vertical or vertical throughout the study area. The bank is comprised of silt, clay, and gravel layers with no deeply rooted vegetation and almost no surface protection. The study bank is gradually eroding into the landowner's field, which is overgrown with weeds and common pasture grasses.

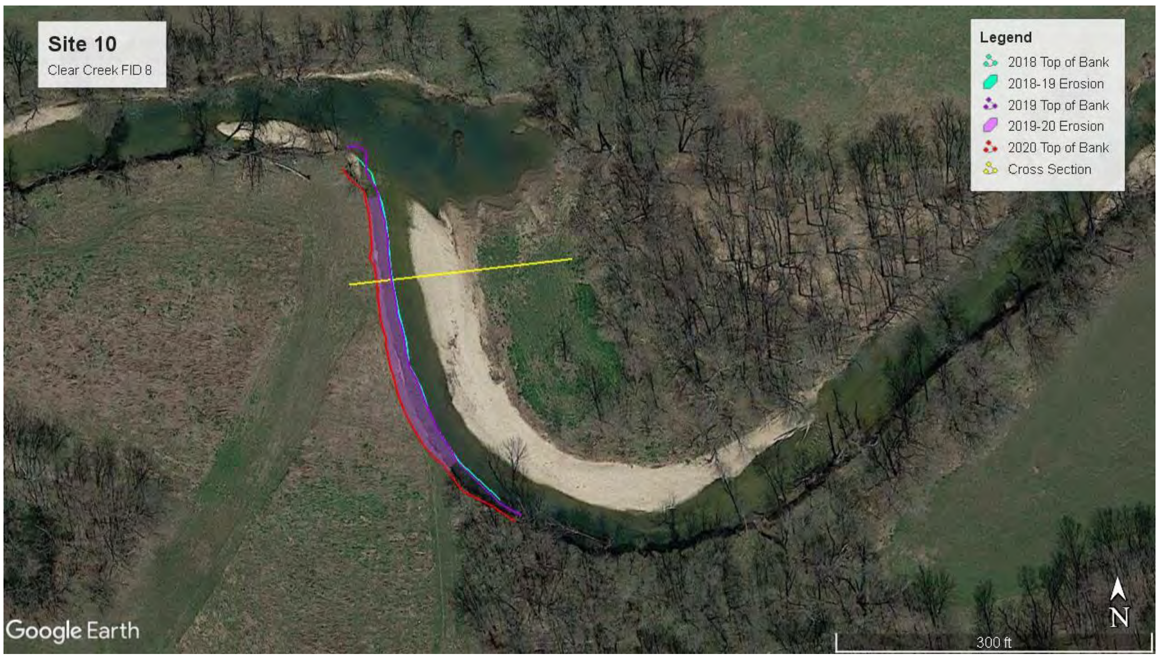

Figure 32. Planform view of Clear Creek FID 8 annual survey site. The area shaded in light blue the location of bank erosion that occurred between the 2018 and 2019 survey dates. The area shaded in purple is bank lost during the time period between 2019 and 2020. Google Earth Imagery Date: 3/4/2020.

Survey Results

Based on the 2018, 2019, & 2020 cross-section surveys, the stream bank at this location moved an average of 7.27 feet laterally across the bank profile annually throughout the study period (Figures 33 & 34). Annual top of bank measurements also support these results. (Figure 32). The average annual measured volume of soil/sediment loss due to erosion for this stream bank segment from 2018-2020 is 25,069 ft³ (928 yd³).

Discussion & Recommendations

Bank erosion modeling estimates predict that this cut bank will continue to erode at an average rate of 11.12 feet laterally per year. Both measured and predicted erosion rates for this site are among the top 5 highest of the 15 sites included in this study. The stream bank at this site, situated just beyond the end of a private drive in a picturesque valley is not unlike many other stream banks located along Clear Creek- badly eroding.

A very high percentage of banks on Clear Creek appear to be in very bad shape, with side channel gravel bar development and corresponding bank erosion occurring on many banks all the way from the Blessings Golf Club in Fayetteville, downstream to the confluence of Clear Creek and the Illinois River. It is going to take a large-scale effort to restore Clear Creek due to the prevalence of bank erosion throughout the watershed and deforestation of much of the riparian corridor, but actions in the right direction have to start somewhere. Why not here? Clear Creek is worth saving.

Any serious restoration plan for this site is going to recommend hardening the toe of the bank with a combination of wood and/or rock as well as sloping, matting and replanting the bank with native vegetation. This is a site that is going to continue to experience very high stresses, so the restoration approach needs to be very resilient to that. Changes in both the hydrologic regime due to the headwaters encompassing large parts of the city of Fayetteville as well as the sediment regime due to all of the extensive bank erosion occurring along the creek make this a unique challenge. This could be a great demonstration project, however, with a high likelihood of success. The approaches utilized here could be replicated elsewhere along Clear Creek, serving as a demonstration site which also addresses a bank that is known to have been contributing a very large volume of sediment and nutrients downstream and eventually into the Illinois River.

Clear Creek FID 8, (5/11/2020) Aerial view.

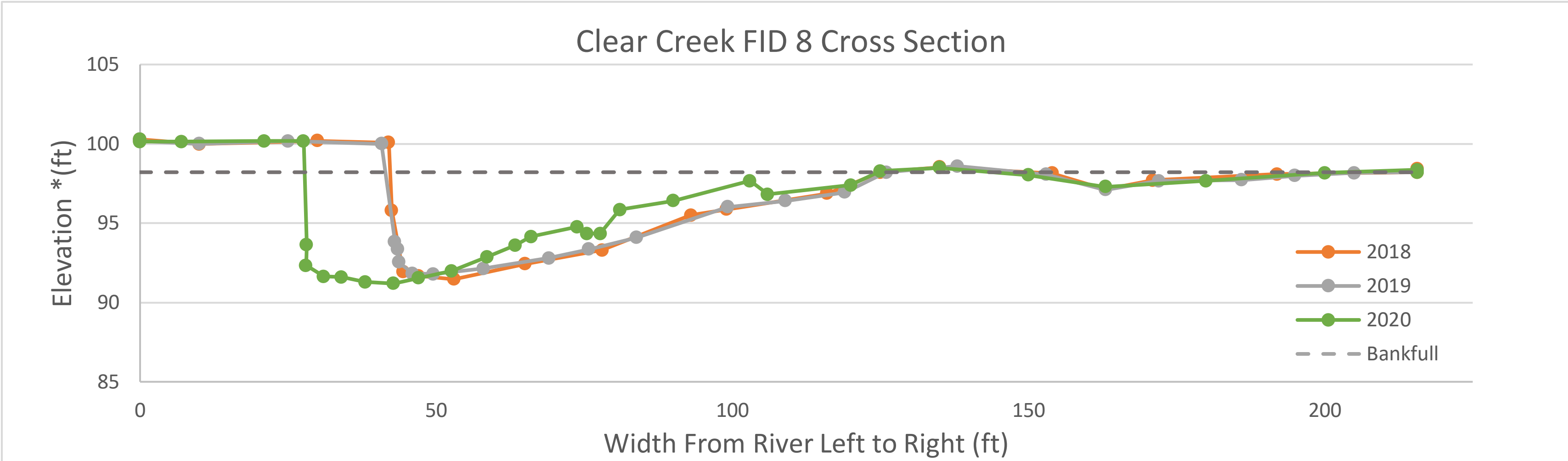

Figure 33. Site 10 Cross Section. Measurements taken 5/23/2018, 4/29/2019, & 5/11/2020. (Bankfull height: 98.21 ft) *Elevations not georeferenced

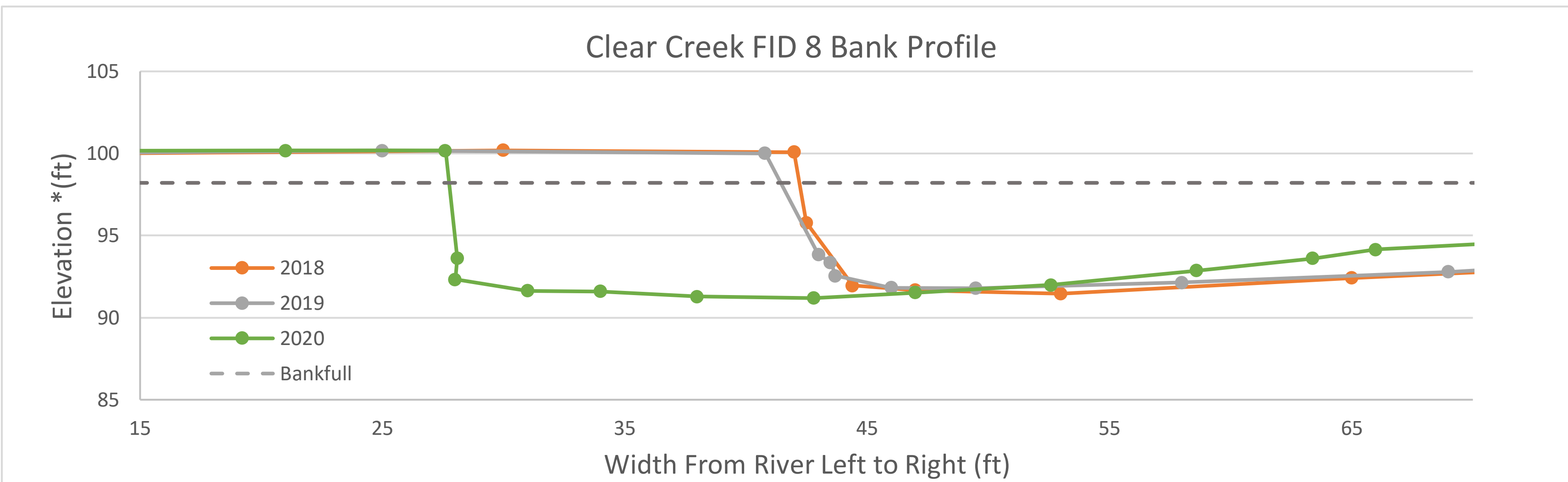

Figure 34. Site 10 Bank Profile. Measurements taken 5/23/2018, 4/29/2019, & 5/11/2020. (Bankfull height: 98.21 ft) *Elevations not georeferenced

Site 10 Photos

Clear Creek FID 8, 2018 (top) vs 2019 (bottom), Upstream View.

Clear Creek FID 8, (2019) Cross Section View.

Clear Creek FID 8 (2019) Downstream View.

Site 11 – Clear Creek FID 40

Site description

This site is located 0.35 river miles north of the Hwy 16 crossing of the Illinois River near Savoy, AR. The river left (west side) bank was selected for monitoring. The bank is approximately 370 feet long, 10-11 feet tall, and has a bank angle of 42 degrees. The bank is comprised of silt and clay with very little ground cover and almost no surface protection. Land use at this site primarily consists of traditional row crop agriculture, with a substantial amount of valuable cropland being lost to erosion with each flood event. Immediately downstream of this site is a log jam at the confluence of the Illinois River. Converging flows at this confluence as well as extensive gravel deposition have led us to conclude that Near Bank Shear Stresses at this location are often extreme.

Figure 35. Planform view of Clear Creek FID 40 annual survey site. Clear Creek flows in from east to west and confluences with the Illinois River immediately downstream of the study bank. The area shaded in light blue represents stream bank erosion that took place on Clear Creek from 2018-2019, while the area shaded in purple depicts erosion that occurred from 2019-2020. Google Earth Imagery Date: 3/4/2020.

Survey Results

Based on detailed measurements collected in 2018, 2019, & 2020 at the cross section location, we have determined that the stream bank at this location moved each year an average of 11.51 feet laterally across the bank profile from 2018 to 2020 (Figures 36 & 37). Annual top of bank measurements corroborate these results. (Figure 35). The average measured volume of soil/sediment lost annually due to erosion for this stream bank segment from 2018-2020 is 45,879 ft^3 (1,699 yd^3).

Discussion & Recommendations
Utilizing detailed site data and updated bank erosion rate modeling, we can now confidently estimate that this site will continue to erode at an average rate of 8.75 feet laterally per year. The measured and predicted erosion rates for this site are among the highest recorded in this study. The only site included in this study with higher observed erosion rates just happens to be located around 1,000 ft downstream of this site along the Illinois River (Site 4 – Illinois River 2 FID 2).

After 4 years of study in this watershed, we are gaining a better understanding of how interconnected these stream systems truly are. Clear Creek is currently experiencing some of the most dramatic erosion in the watershed, and the two sites on Clear Creek included in this study are clearly no exception to this statement. In fact, two of the four most actively eroding sites included in the 15-site study are located on Clear Creek. Development in the headwaters, construction of multiple dams on the creek, along with extensive riparian degradation and incompatible land use practices have ultimately led to a system in flux.

Vast stretches of Clear Creek now experience greatly-elevated bedload sediment transport coming in from upstream sources, extensive in-channel gravel deposition as a result of that increase in bedload, and increased bank erosion rates as a result of elevated deposition and associated NBSS. It is no great leap of logic to think that much of this gravel being transported downstream within Clear Creek eventually makes its way into the Illinois River, especially during flood when the vast majority of sediment transport, bedload deposition, and bank erosion are known to occur.

We may be documenting a direct effect of this massive input of bedload sediment into the Illinois River at Site 4 (Illinois River 2 FID 2), as we have witnessed massive transverse bar development and migration from 2017-2020 on a scale that we have not observing elsewhere in the watershed. Being only 1000 ft downstream of the confluence of the Illinois River and Clear Creek, Site 4 lies directly in the path of any bedload that does make its way into the Illinois. I suspect that there is more of a cause and effect at play here than we may have first imagined.

Clear Creek, FID 40 (05/11/2020) Aerial View.

Clear Creek, FID 40 (05/11/2020) Looking downstream towards the confluence with Illinois River.

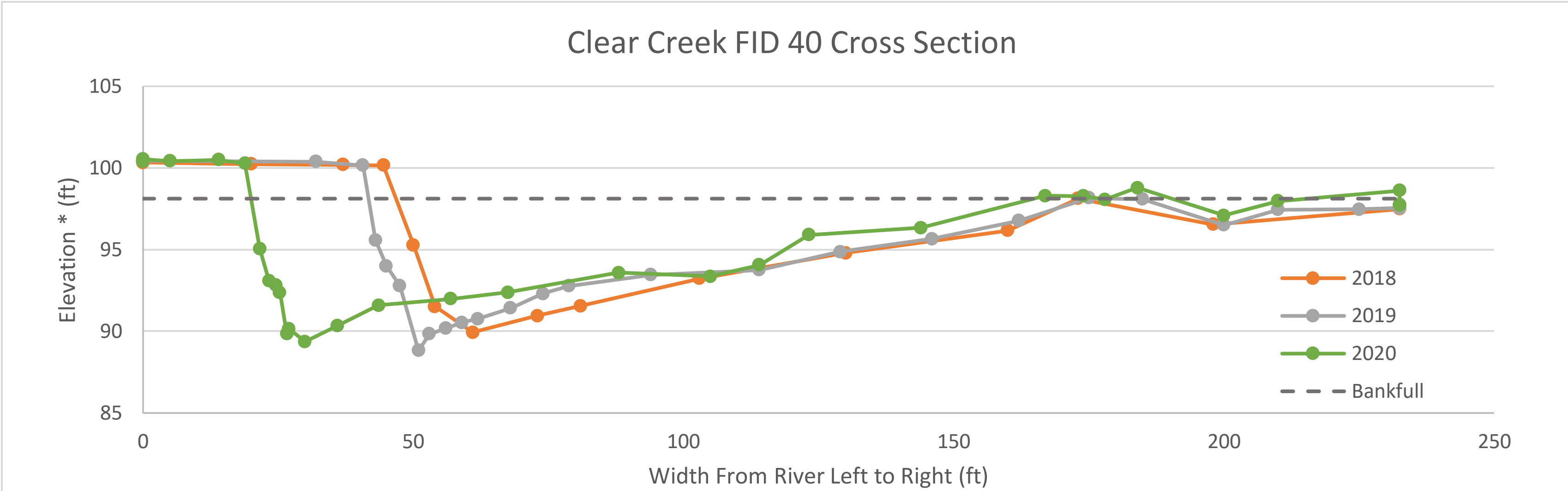

Figure 36. Site 11 Cross Section. Measurements taken 6/5/2018, 5/14/2019, & 5/11/2020. (Bankfull height: 98.12 ft) *Elevations not georeferenced

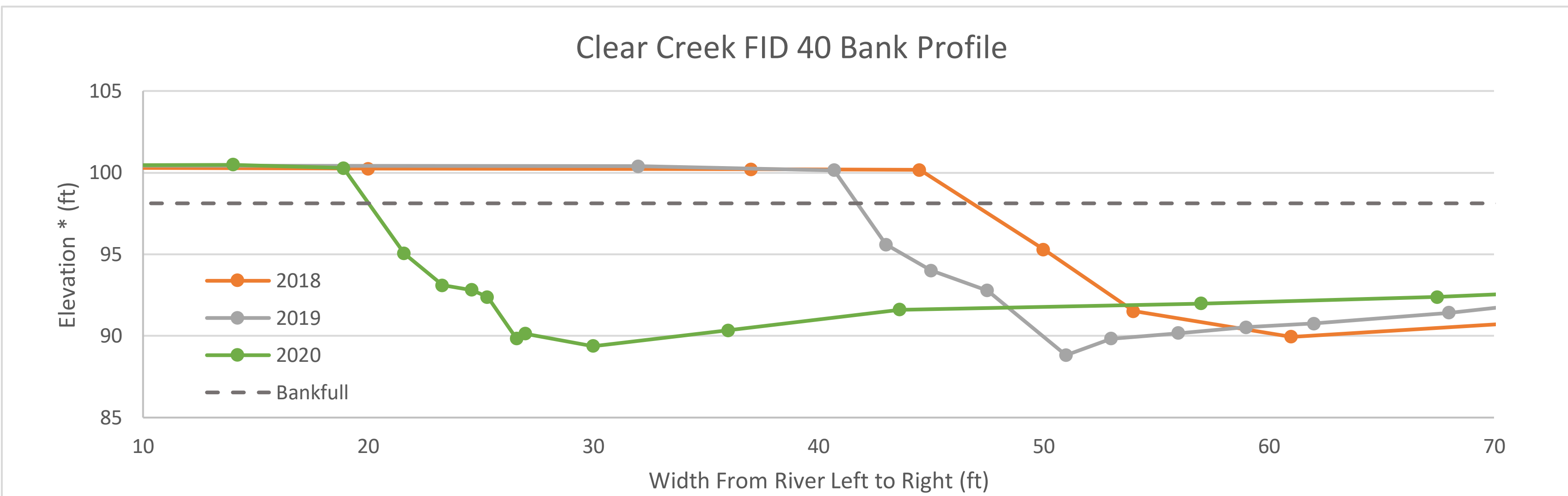

Figure 37. Site 11 Bank Profile. Measurements taken 6/5/2018, 5/14/2019, & 5/11/2020. (Bankfull height: 98.12 ft) *Elevations not georeferenced

Site 11 Photos

Clear Creek, FID 40, 2018 (top) vs 2019 (bottom), Downstream View.


Clear Creek, FID 40 (2019), Downstream View.


Clear Creek, FID 40 (2019), Cross Section View.

Site 12 – Moores 3 Creek FID 43

Site description

This site located 0.3 miles north of Hwy 62, just east of Lincoln, AR. The right (east side) bank was selected for monitoring. The bank is approximately 114 feet long, 12 feet tall and has a bank angle of approximately 48 degrees. The bank is comprised of silt and clay mix with very a moderate amount of ground covering and surface protection. A relatively healthy riparian corridor surrounds the creek at this location, which we often find corresponding with low measured bank erosion rates.

Figure 38. Planform view of Moores 3 Creek FID 43 annual survey site. The light blue line represents the location of the study bank in 2018. The purple line depicts the top of bank location on the survey date in 2019, and the red line represents top of bank in 2020. The annual top of bank lines appear to overlap at this scale, indicating that the bank has not moved tremendously through the 2-year study period. Google Earth Imagery Date: 3/4/2020.

Survey Results

Based on the 2018, 2019, & 2020 cross-section surveys, the stream bank at this location eroded an average of 0.27 feet laterally across the bank profile annually (Figures 39 & 40). Annual top of bank measurements were inconclusive due to heavy canopy cover but generally corroborate these results. (Figure 38). The average measured volume of soil/sediment loss due to erosion for this stream bank segment from 2018-2020 is 371 ft^3 (13.7 yd^3).

Discussion & Recommendations

Based on the new Illinois River curves, along with site specific BEHI and NBSS ratings, bank erosion rates were modeling for this site. It is estimated that this site will continue to erode at an average rate of 0.28 feet laterally per year. This site has one of the lowest measured and predicted erosion rates out of any of the 15 sites included in this study. With that understanding, we have determined that this may be a good location to collect reference reach geomorphic data at some point in the future. If our observations are correct, it is likely that a long reach of Moore's Creek, including several meanders upstream to Site 13 are very stable and could yield valuable information about the dimension, pattern and profile of the natural stable form. This information can be utilized as a template for the development of Natural Channel Design- based restoration approaches on projects within the Illinois River Watershed.

Moores Creek 3 FID 43 (2019) Cross Section View looking back at the very stable study bank.

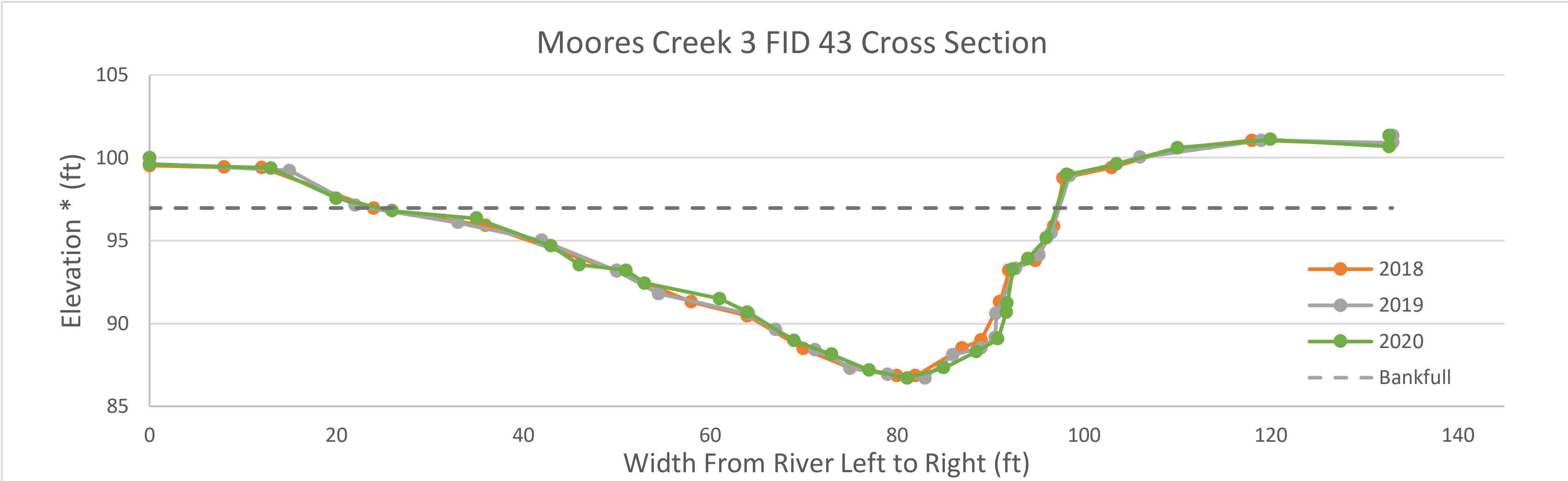

Figure 39. Site 12 Cross Section. Measurements taken 5/17/2018, 4/30/2019, & 5/7/2020. (Bankfull height: 96.97 ft) *Elevations not georeferenced

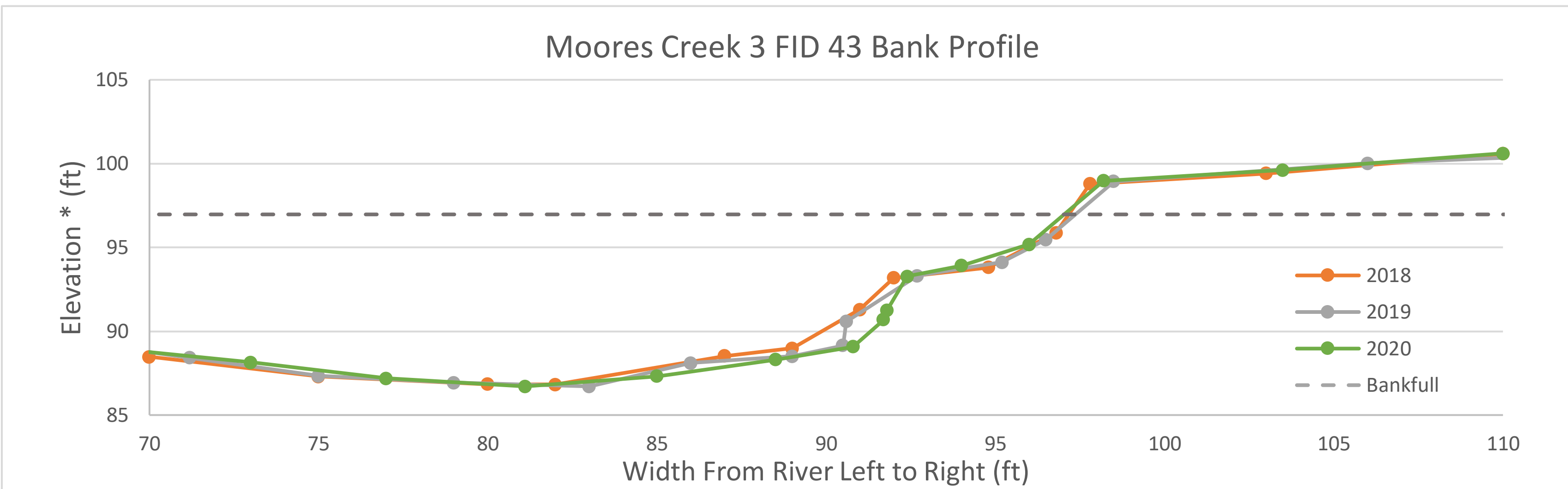

Figure 40. Site 12 Bank Profile. Measurements taken 5/17/2018, 4/30/2019, & 5/7/2020. (Bankfull height: 96.97 ft) *Elevations not georeferenced

Site 12 Photos

Moores Creek 3 FID 43, 2018 (top) vs 2019 (bottom), Cross Section View.

Moores Creek 3 FID 43 (2019), Cross Section View.

Moores Creek 3 FID 43 (2019), Upstream View.

Site 13 – Moores Creek 3 FID 25

Site description

This site is located approximately 0.1 miles west of Hwy 62. The river right (east side) bank was selected for monitoring. The bank is approximately 65 feet long, 8 feet tall and has a bank angle of approximately 52 degrees. The bank is comprised of silt and clay with vegetation covering and protecting much of the bank surface. There is a relatively narrow, but healthy riparian corridor at this location, while the field beyond the top of bank is utilized primarily for hay and cattle operations.

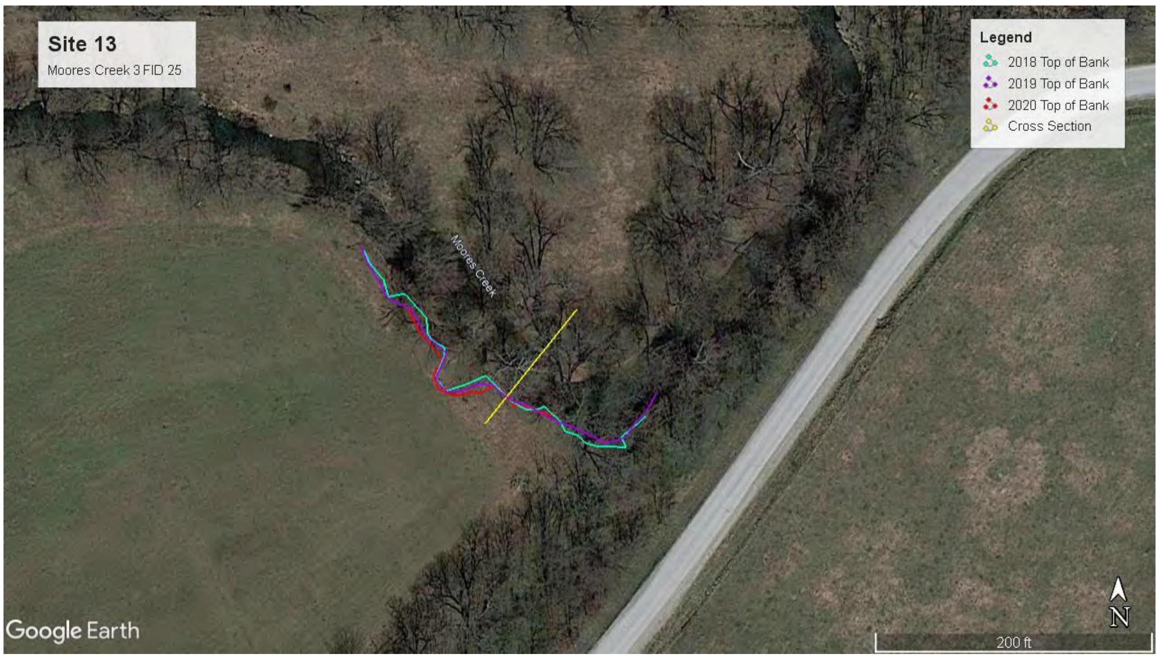

Figure 41. Planform view of Moores Creek 3 FID 25 annual survey site. The light blue line represents the location of the study bank in 2018. The purple line depicts the top of bank location on the survey date in 2019, and the red line represents top of bank in 2020. The annual top of bank lines appear to overlap at this scale, indicating that the bank has not moved tremendously through the 2-year study period. Google earth Imagery Date: 3/4/2020.

Survey Results

Based on the 2018, 2019 & 2020 cross-section surveys, the stream bank at this location moved an average of 0.26 feet laterally across the bank profile annually from 2018 to 2020 (Figures 42 & 43). Annual top of bank measurements were inconclusive because of relatively heavy canopy cover but generally corroborate these results. (Figure 41). The average measured volume of soil/sediment loss due to erosion for this stream bank segment from 2018-2020 is 21 ft^3 (0.8 yd^3).

Discussion & Recommendations
Detailed site information as well as Illinois River erosion curves were utilized to predict erosion rates for this site moving forward. It is estimated that the target bank at this site will continue to erode at an average rate of 0.37 feet laterally per year. This prediction, along with the actual measured rates of erosion, were relatively very low at this site. Therefore, we don't see any reason to recommend major restorative actions here that would involve typical bank restoration techniques. Maintaining or even enhancing the riparian buffer with a diverse mix of native, deep-rooted vegetation is probably the most important thing to do here in order to keep these sites along Moores Creek healthy with low erosion rates into the future.

Moores Creek 3 FID 25 (5/11/2020), Aerial View.

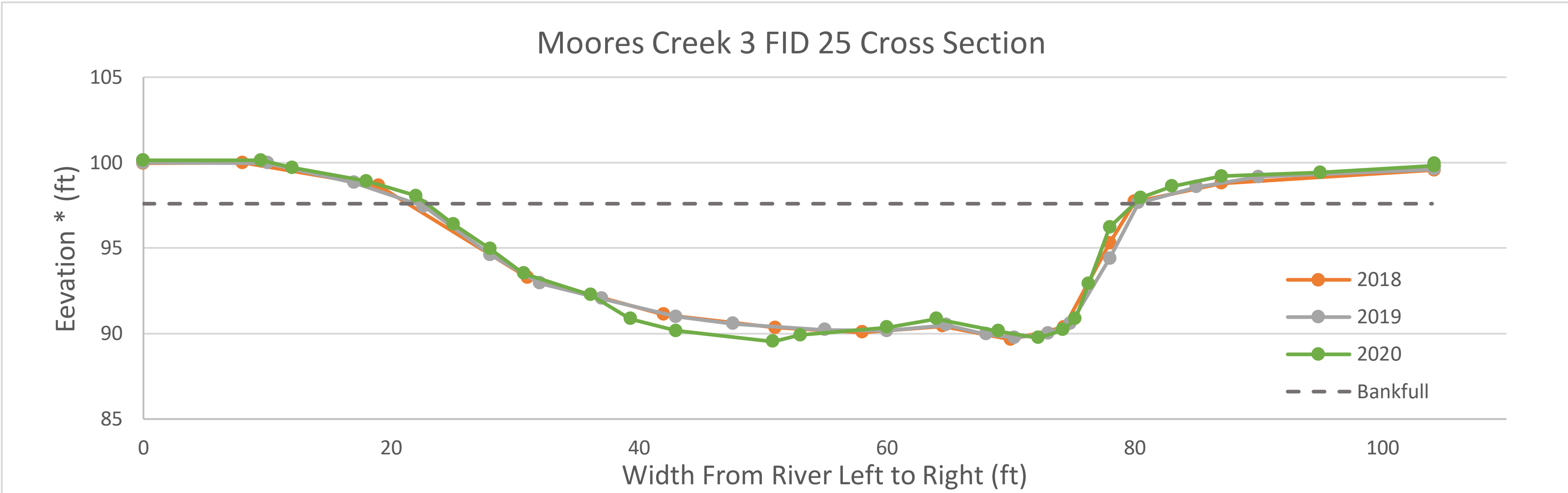

Figure 42. Site 13 Cross Section. Measurements taken 6/5/2018, 4/30/2019, & 5/11/2020. (Bankfull height: 97.6 ft) *Elevations not georeferenced

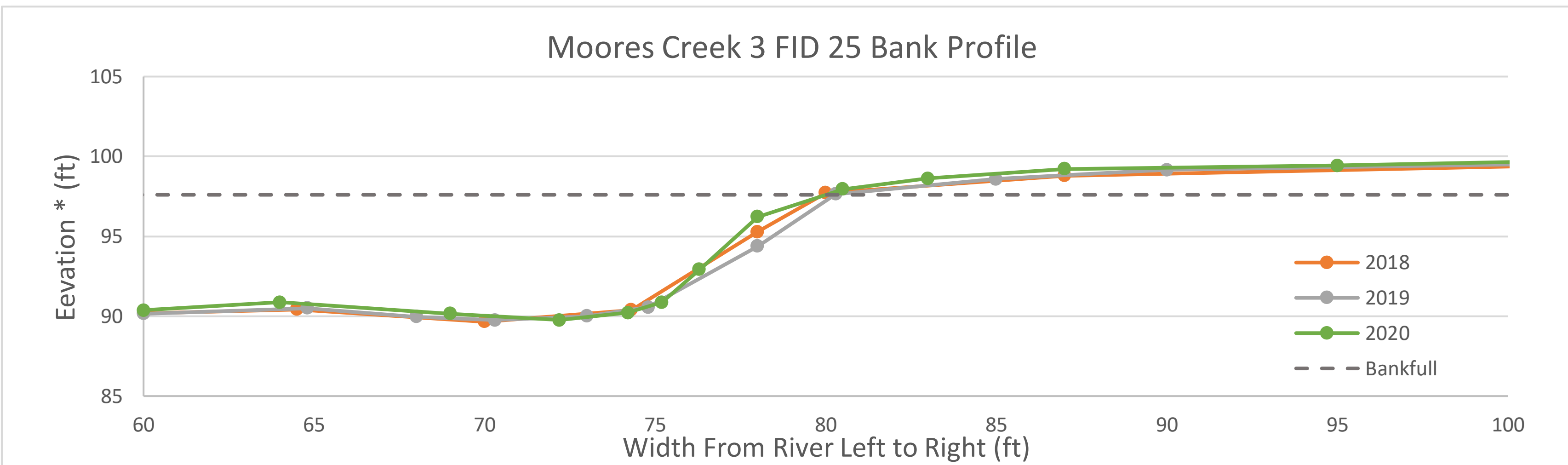

Figure 43. Site 13 Cross Section. Measurements taken 6/5/2018, 4/30/2019, & 5/11/2020. (Bankfull height: 97.6 ft) *Elevations not georeferenced

Site 13 Photos

Moores Creek 3 FID 25, 2018 (top) vs 2019 (bottom), Upstream View.

Moores Creek 3 FID 25 (2019), Cross Section View.

Site 14 – Sager Creek FID 24

Site description
This site is located in Siloam Springs approximately 0.15 miles west of N. Lincoln St. The target bank being monitored is on river left (south side). The bank is approximately 86 feet long, 5 feet tall and is near vertical or vertical throughout the study area. The bank is comprised predominately of gravel layers with moderate ground covering and surface protection. A narrow but largely intact riparian corridor extends along the creek here, providing some level of protection against the erosive force of floodwaters.

Figure 44. Planform view of Sager Creek FID 24 annual survey site. The light blue line represents the location of the top of study bank in 2018. The purple line depicts the top of bank location on the subsequent survey date one year later in 2019, and the red line represents top of bank in 2020. Google earth Imagery Date: 3/4/2020.

Survey Results
Based on the 2018, 2019 & 2020 cross-section surveys, the stream bank at this location moved an average of 0.43 feet laterally across the bank profile annually from 2018 to 2020 (Figures 45 & 46). Annual top of bank measurements corroborate these results. (Figure 44). The average measured volume of soil/sediment loss due to erosion for this stream bank segment from 2018-2020 is 139 ft^3 (5.1 yd^3).

Discussion & Recommendations
Site-specific BEHI and NBSS ratings for this site were utilized along with new Illinois River erosion curves to predict average annual erosion rates for this site. Based on those curves, it is estimated that the study bank at this site will continue to erode at an average rate of 0.42 feet laterally per year. The predictions and measured erosion rates at this site are relatively low, and we do not have any specific recommendations at this time for this site.

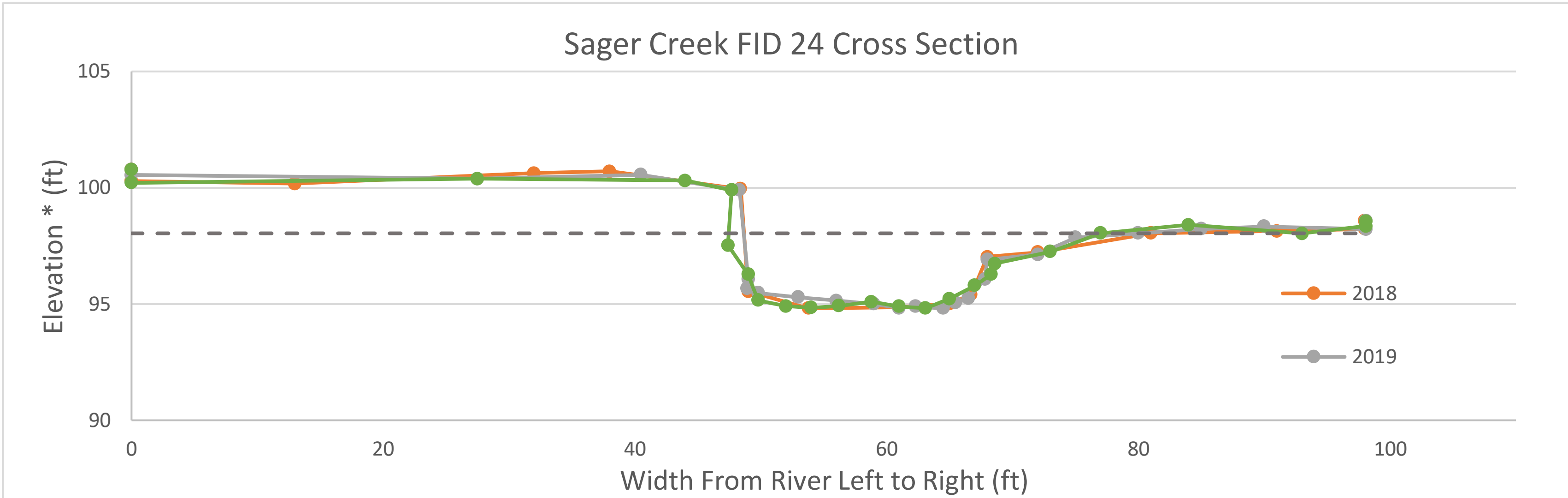

Figure 45. Site 14 Cross Section. Measurements taken 5/15/2018, 4/29/2019, & 5/6/2020. (Bankfull height: 98.04 ft) *Elevations not georeferenced

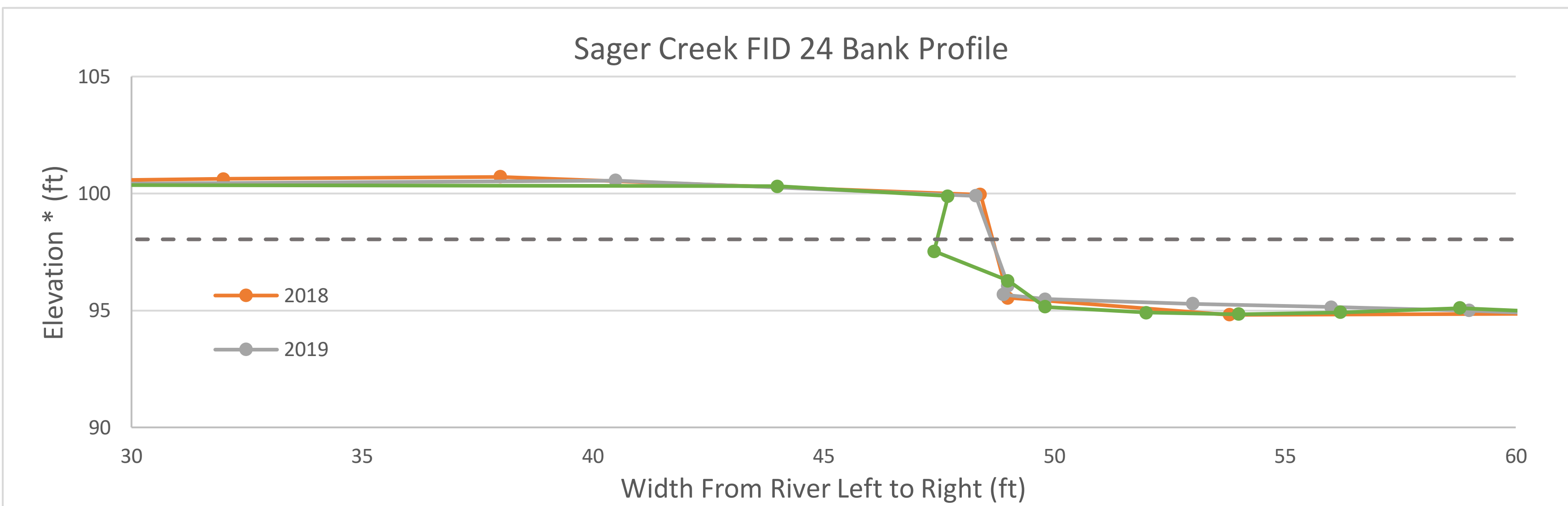

Figure 46. Site 14 Cross Section. Measurements taken 5/15/2018, 4/29/2019, & 5/6/2020. (Bankfull height: 98.04 ft) *Elevations not georeferenced

Site 14 Photos

Sager Creek, FID 24, 2018 (top) vs 2019 (bottom), Upstream View.

Sager Creek, FID 24 (2018), Down Stream View.

Sager Creek, FID 24 (2019), Riparian Buffer.

Site 15 – Sager Creek FID 106

Site description

This site is adjacent to the Oklahoma state line near the Siloam Springs water treatment facility. The river right (north side) bank was selected for monitoring. The bank is approximately 429 feet long, 10-11 feet tall and is near vertical or vertical throughout the study area. The bank is comprised predominantly of gravel layers with very little ground cover or surface protection. An expansive riparian corridor does exist at this site, most of which is dominated by mature bottomland hardwood trees.

Survey Overview

Figure 47. Planform view of Sager Creek FID 106 annual survey site. The light blue line indicates the top of bank location during the 2018 survey. The purple line illustrates the location of the bank in 2019, and the red line indicates the most recent top of bank location from the 2020 survey. Note that several large trees have recently fallen into the channel. More significant erosion is likely to occur here as a result of this disturbance. Google Earth Imagery Date 3/4/2020.

Survey Results

Based on the 2018, 2019, & 2020 cross-section surveys, the stream bank at this location moved an average of 1.18 feet laterally across the bank profile annually from 2018 to 2020 (Figures 48 & 49). Annual top of bank measurements corroborate these results. (Figure 47). The annual measured volume of soil/sediment loss due to erosion for this stream bank segment from 2018-2020 is 4,791 ft³ (178 yd³).

Discussion & Recommendations

Updated BEHI as well as NBSS ratings were utilized, along with newly-developed Illinois River regional curves, to predict erosion rates for this site. Based on that information, it is estimated that the target bank at this site will continue to erode at an average rate of 1.26 feet laterally per year. The measured and predicted erosion rates for this site are fairly close to average or middle of the road for the group of 15 study sites.

There are several large trees, however, that have recently fallen from a standing position along the top the bank and now lie in and across the stream channel downstream of the cross section location. We would not be surprised if these obstructions cause localized scour or even a debris jam, which could lead to greater than predicted actual erosion rates moving forward. The erosion rates here are relatively low, and this site has a largely intact riparian buffer, so we would not expect to have any specific restoration plans for this site. If anything, the trees lying in the channel could be removed to reduce scour potential and prevent a larger blockage from occurring.

Sager Creek, FID 106 (5/12/2020) Looking Upstream at the Cross Section Location.

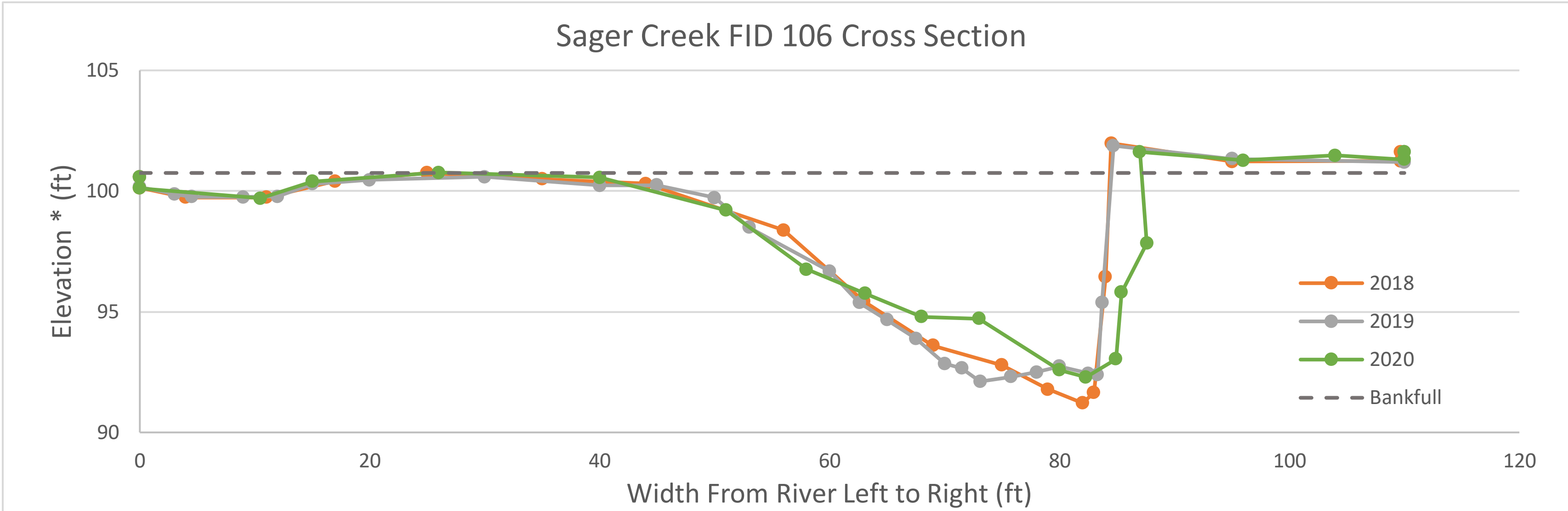

Figure 48. Site 15 Cross Section. Measurements taken 5/16/2018, 4/29/2019, & 5/12/2020. (Bankfull height: 100.75 ft) *Elevations not georeferenced

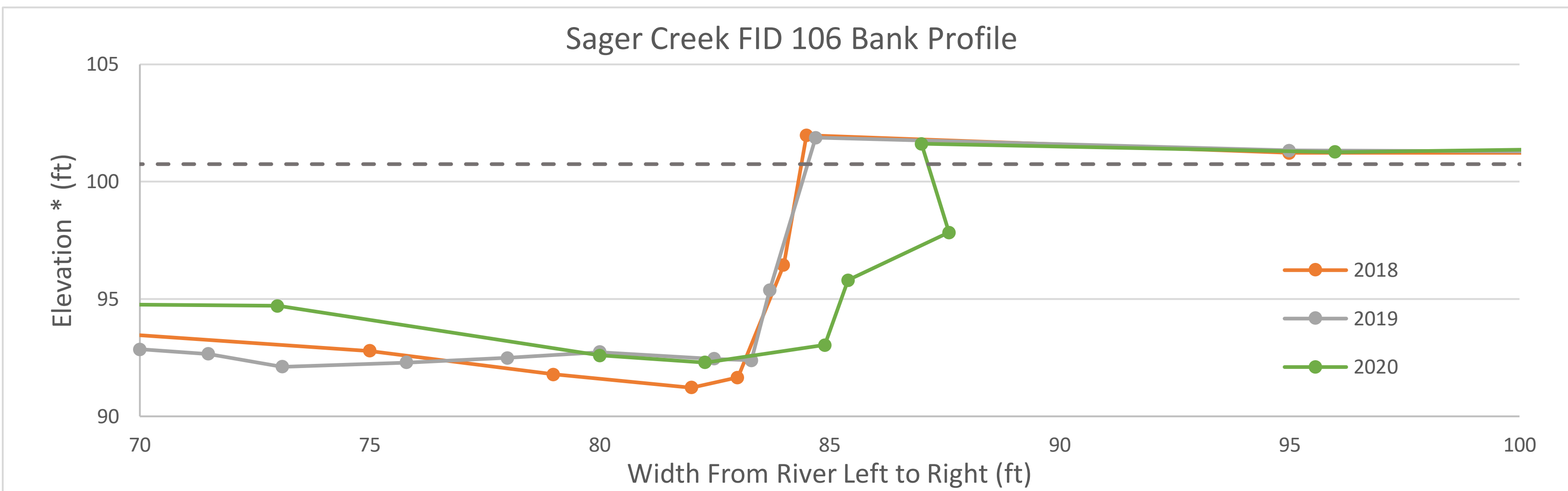

Figure 49. Site 15 Bank Profile. Measurements taken 5/16/2018, 4/29/2019, & 5/12/2020. (Bankfull height: 100.75 ft) *Elevations not georeferenced

Site 15 Photos

Sager Creek, FID 106, 2018 (top) vs 2019 (bottom), Downstream View, looking upstream.

Sager Creek, FID 106 (2018) Upstream View.

Sager Creek, FID 106 (2020) Looking Upstream at large trees in the channel that were standing in 2019.

Hydrology

We observed extremes, from very dry weather with few large storm events in the 2018-2019 study period to extremely wet and repeated flooding that occurred during the 2019-2020 study period. In order to understand how water levels at each study site relate to real-time data collection and an established long-term data set, NSS collected water surface and peak flood elevation data at numerous sites spread throughout the Illinois watershed during a widespread, overbank flood event that occurred throughout the watershed on May 1, 2019. Observations at bank study sites and various USGS stream gages during and immediately post-flood allowed NSS to correlate nearby gage data to flood water levels observed at each of the sites. Bankfull flows were approximated for 3 gages in the watershed. These include the following: Flint Creek near Siloam Springs (~630 cfs), Illinois River at Savoy (~5,130 cfs), and Illinois River at Hwy 16 near Siloam Springs (~10,700 cfs).

Observing and measuring water levels at each site and determining how they relate to nearby USGS stream gages gives the ability to approximate water levels at any given time simply by checking the appropriate gage online. Many of the 15 study sites sites are directly upstream or downstream of an established gage, and these approximations can be quite accurate. Utilizing data available online as well as information collected in the field at study sites and USGS gages, NSS estimated the frequency and timing of flood event occurrences as well as periods of low water. We have concluded that here were 5 high flow (exceeding bankfull) flood events that occurred at each of the study sites. during the 2017-2018 study year, 0 to 1 flood event (depending on the timing of our annual survey at each individual site) that occurred during the 2018-2019 study year, and 9-12 flood events that occurred at each site respectively during the 2019-2020 study year (Table 2, Figures 50-52).

Bankfull flow conditions observed at Site 10 (Clear Creek FID 8) on May 1, 2019.

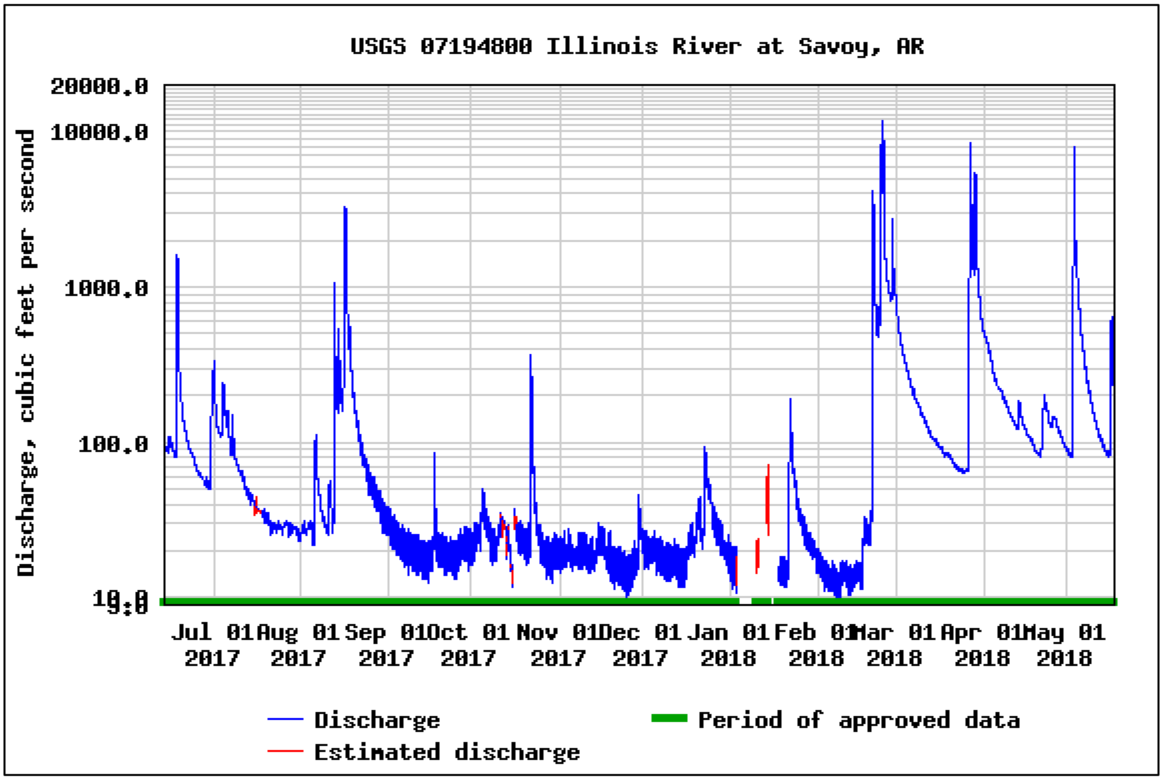

Figure 50. Hydrograph depicting the 2017-2018 study year at the USGS gage on the Illinois River at Savoy, AR. Bankfull is approximately 5,130 cfs.

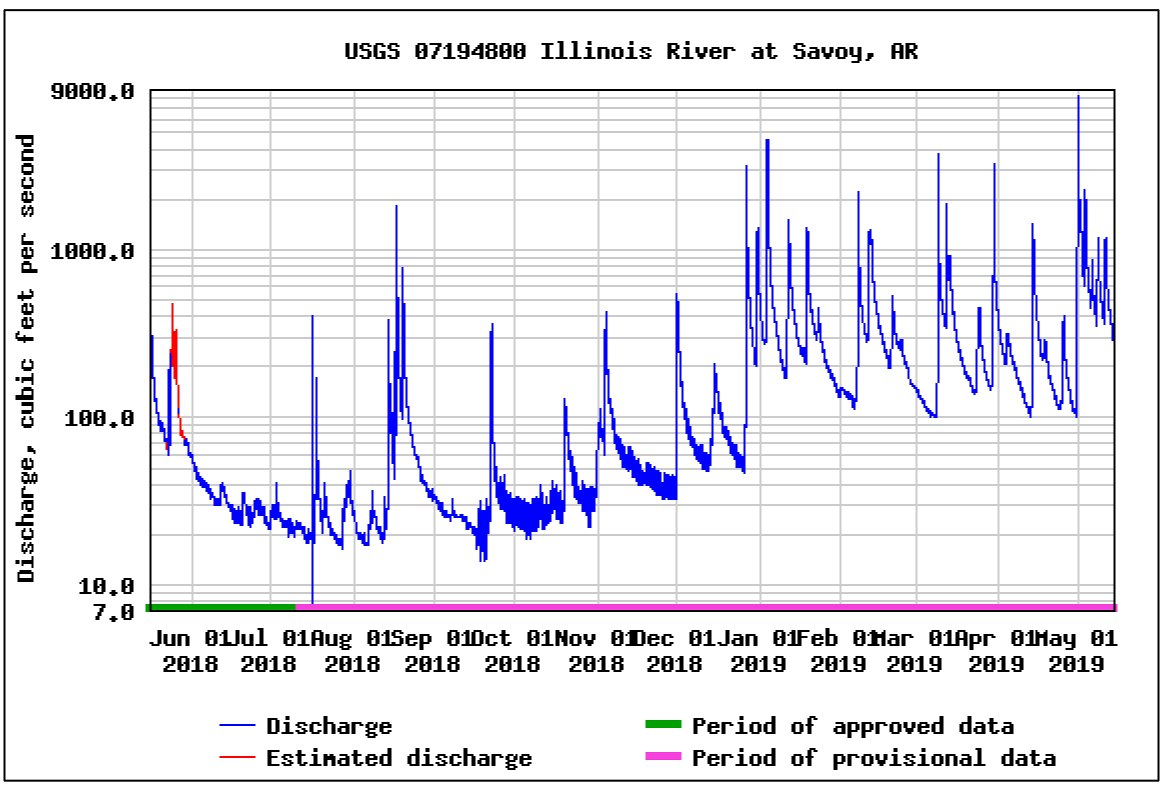

Figure 51. Hydrograph depicting the 2018-2019 study year at the USGS gage on the Illinois River at Savoy, AR. Bankfull is approximately 5,130 cfs.

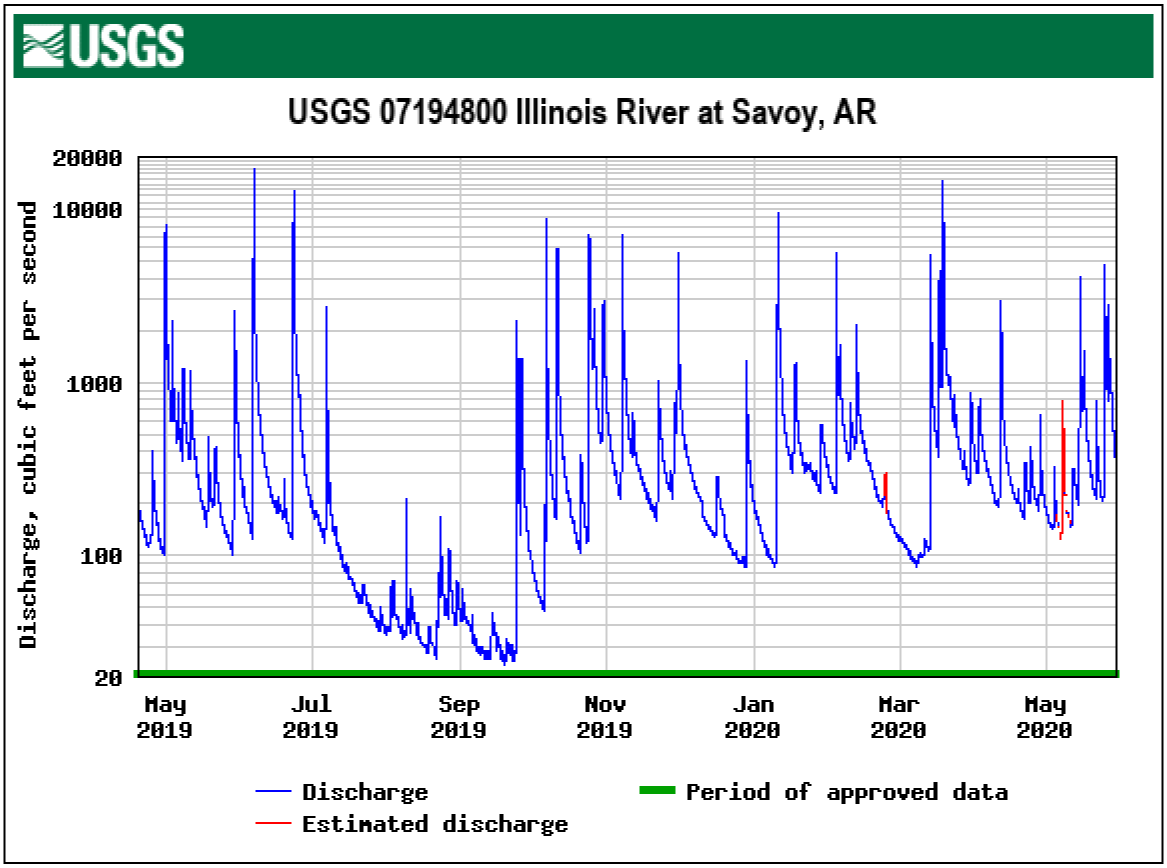

Figure 52. Hydrograph depicting the 2019-2020 study year at the USGS gage on the Illinois River at Savoy, AR. Bankfull is approximately 5,130 cfs.

Site #	Site Name	USGS Stream Gage utilized for analysis	Estimated Bankfull Discharge at Gage (cfs)	Bankfull Flood Occurrences 2017-2018 Study Period	Bankfull Flood Occurrences 2018-2019 Study Period	Bankfull Flood Occurrences 2019-2020 Study period	Bankfull Flood Occurrences during Total Study period
1	Muddy Fork 1 FID 228	07194800 Illinois River at Savoy, AR	5,130	5	0	12	17
2	Muddy Fork 2 FID 67	07194800 Illinois River at Savoy, AR	5,130	5	0	12	17
3	Illinois River 1 FID 25	07194800 Illinois River at Savoy, AR	5,130	5	1	11	17
4	Illinois River 2 FID 2	07194800 Illinois River at Savoy, AR	5,130	5	1	11	17
5	Illinois River 2 to 412 FID 75	07194800 Illinois River at Savoy, AR	5,130	5	1	11	17
6	Muddy Fork 1 FID 172	07194800 Illinois River at Savoy, AR	5,130		1	11	12
7	Illinois River 2 FID 16	07194800 Illinois River at Savoy, AR	5,130		1	11	12
8	Illinois River 3 FID 46	07195400 Illinois River at Hwy 16 Near Siloam	10,700		1	10	11
9	Illinois River 2 to 412 FID 69	07194800 Illinois River at Savoy, AR	5,130		1	11	12
10	Clear Creek FID 8	07194800 Illinois River at Savoy, AR	5,130		0	12	12
11	Clear Creek FID 40	07194800 Illinois River at Savoy, AR	5,130		1	11	12
12	Moores Creek 3 FID43	07194800 Illinois River at Savoy, AR	5,130		0	12	12
13	Moores Creek 3 FID25	07194800 Illinois River at Savoy, AR	5,130		0	12	12
14	Sager Creek FID 24	07195855 Flint Creek near West Siloam Springs, OK	630		0	9	9
15	Sager Creek FID 106	07195855 Flint Creek near West Siloam Springs, OK	630		0	9	9

Table 2. Summary hydrology data for each of the 15 study sites broken down by each study year (2017-2018, 2018-2019, and 2019-2020)

Regional Hydraulic Geometry Curves

Regional hydraulic geometry curves are plots comparing channel dimensions at bankfull discharge to site drainage areas. These curves are often watershed-specific and convey valuable information relating to stream channel widths, depths and bank heights to watershed size. Restoration professionals often utilize regional curves to design and implement Natural Channel Design on unstable reaches of streams and rivers. NSS utilized survey data from each of the 15 stream bank monitoring sites to develop preliminary regional hydraulic geometry curves for pools or cut banks within the Illinois River Watershed (Table 3, Figures 53-55).

These curves are already proving very useful in restoration planning in the Illinois Watershed. Around a half-mile stretch of Sager Creek at The Course at Sager's Crossing in Siloam Springs was completed in the Summer of 2021. The data collected in this study and these regional hydraulic geometry curves helped our team of restoration planners to design the stream channel with appropriate pattern and channel dimensions. The more we understand about this unique resource the better we can plan to preserve and restore it going forward.

Site #	Site Name	Watershed Size (acres)	Watershed Size (sq mi)	Bankfull Max Depth (ft)	Bankfull Width (ft)	Bankfull XS Area (sq ft)
1	Muddy Fork 1 FID 228	22,129.0	34.58	9.5	145	471
2	Muddy Fork 2 FID 67	45,869.5	71.67	7	128	411
3	Illinois River 1 FID 25	102,836.2	160.68	10.7	110	1462
4	Illinois River 2 FID 2	156,502.3	244.53	14.6	205	1518
5	Illinois River 2 Fid 75	164,933.2	257.71	11.8	156	1433
6	Muddy Fork 1 FID 172	18,226.0	28.48	11.5	62	497
7	Illinois River 2 FID 16	156,995.4	245.31	14.8	119	1459
8	Illinois River 3 FID 46	366,907.6	573.29	14.6	199	1778
9	Illinois River 2 FID 69	164,695.1	257.34	10.7	213	1534
10	Clear Creek FID 8	46,933.8	73.33	6.9	94	348
11	Clear Creek FID 40	49,193.6	76.86	8.75	130	551
12	Moores Creek 3 FID 43	15,693.4	24.52	10.2	74	372
13	Moores Creek 3 FID 25	15,384.2	24.04	8	59	340
14	Sager Creek FID 24	5,049.0	7.89	3.2	32	63
15	Sager Creek FID 106	7,987.2	12.48	8.5	40	185

Table 3. Site attributes utilized to develop regional hydraulic geometry curves

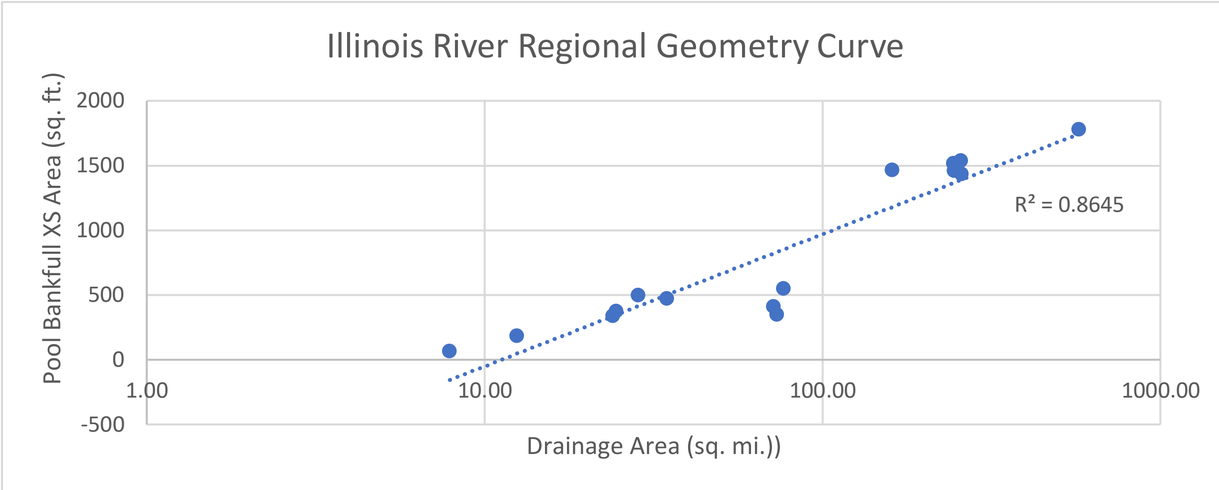

Figure 53. Plot illustrating the relationship of a stream's watershed size (Drainage Area) its channel size (XS Area).

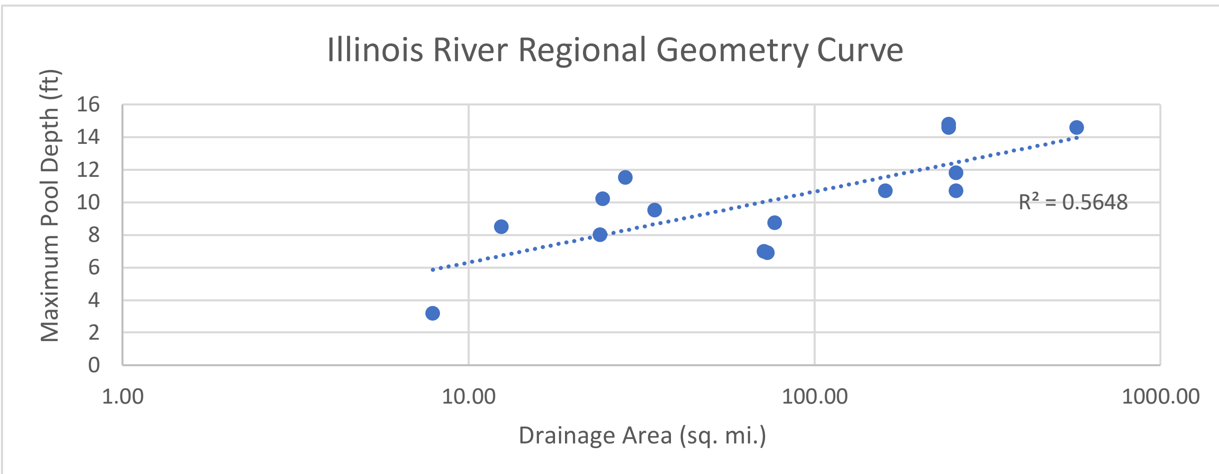

Figure 54. Plot illustrating the relationship of a stream's watershed size (Drainage Area) its depth.

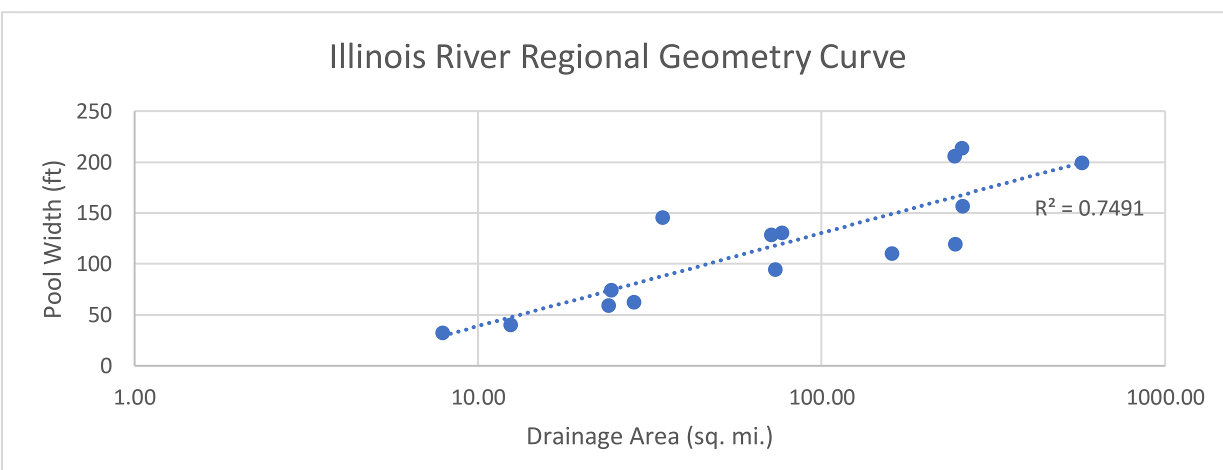

Figure 55. Plot illustrating the relationship of a stream's watershed size (Drainage Area) its width.

Erosion Modeling

Utilizing Microsoft Excel, total bank erosion was graphed and calculated for the entire multi-year study period and then divided by the number of years monitored in order to yield an average erosion rate for each site (ft/year). These rates were plotted along with each site's respective Bank Erosion Hazard Index (BEHI) rating. A strong correlation was noted even before stratifying the data, with sites that have high BEHI ratings generally having higher observed rates of erosion than those with lower BEHI ratings (Figure 56).

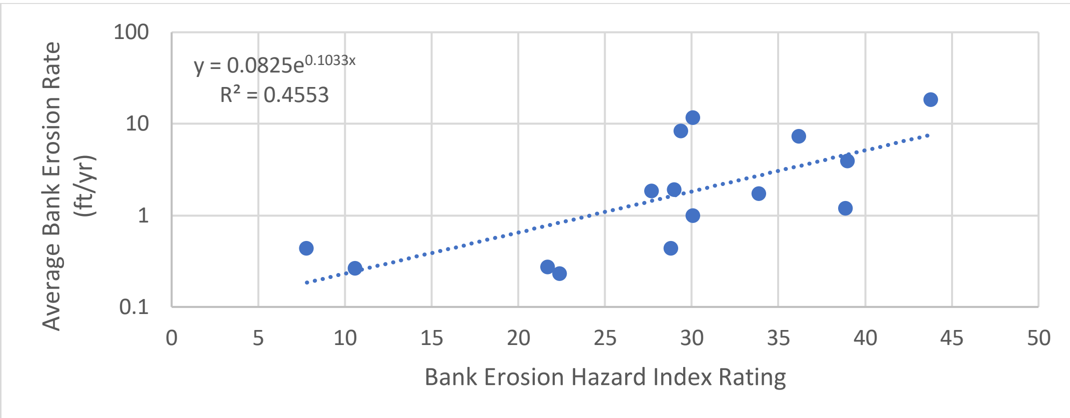

Figure 56. Averaged measured annual bank erosion rates vs. Bank Erosion Hazard Index (BEHI) scores.

Averaging the annual data at each site helped account for some years being very flood prone with very relatively high measured erosion rates while other years were relatively dry with relatively low erosion rates. We observed drastic differences in erosion rates at nearly every site when comparing a very dry year to a very wet year. We wanted look at this in another, more direct way. We knew with a high degree of certainty from observations, measurements, and USGS gage information how many bankfull flood event had occurred at each site and when each of those occurred. NSS summed total bank loss for each of the sites throughout the entire study and divided that sum by the number of bankfull flood events that had occurred at each of the sites during that same time period. We found a strong correlation here (Figure 57).

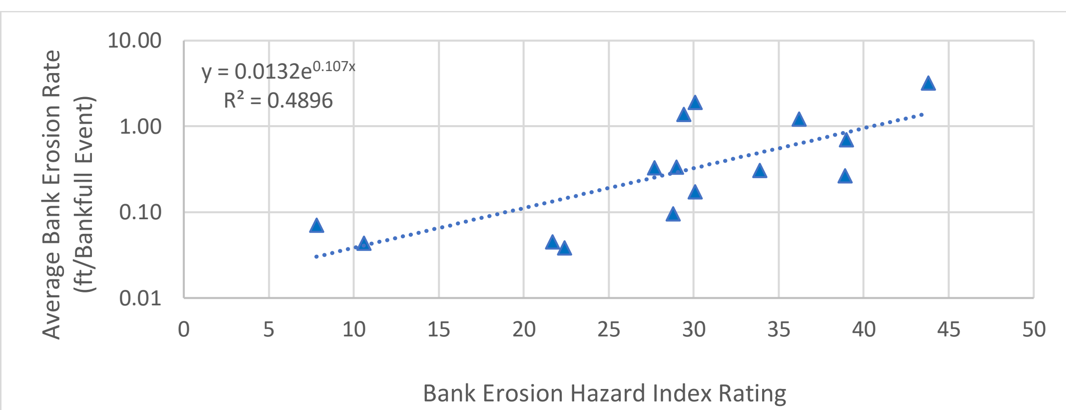

Figure 57. Total bank erosion rates per observed bankfull flood event for each of the 15 study sites vs. Bank Erosion Hazard Index (BEHI) scores.

These data were then stratified by broad Near Bank Shear Stress (NBSS) rating categories, enabling us to create an Illinois River erosion model that will allow watershed planners to map and estimate streambank erosion rates in both feet per year and feet per flood event based on easily measurable attributes (BEHI) and (NBSS). (Figures 58 & 59).

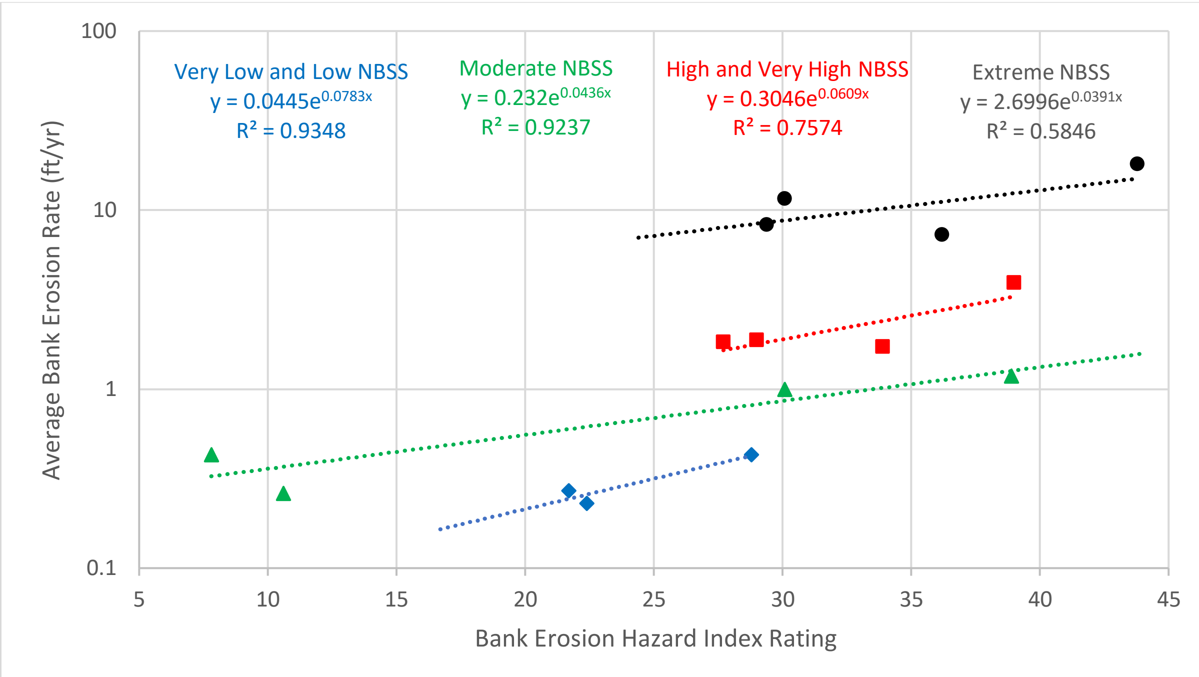

Figure 58. Averaged measured annual bank erosion rates vs. Bank Erosion Hazard Index (BEHI) scores. Data are stratified by Near Bank Shear Stress (NBSS) categories.

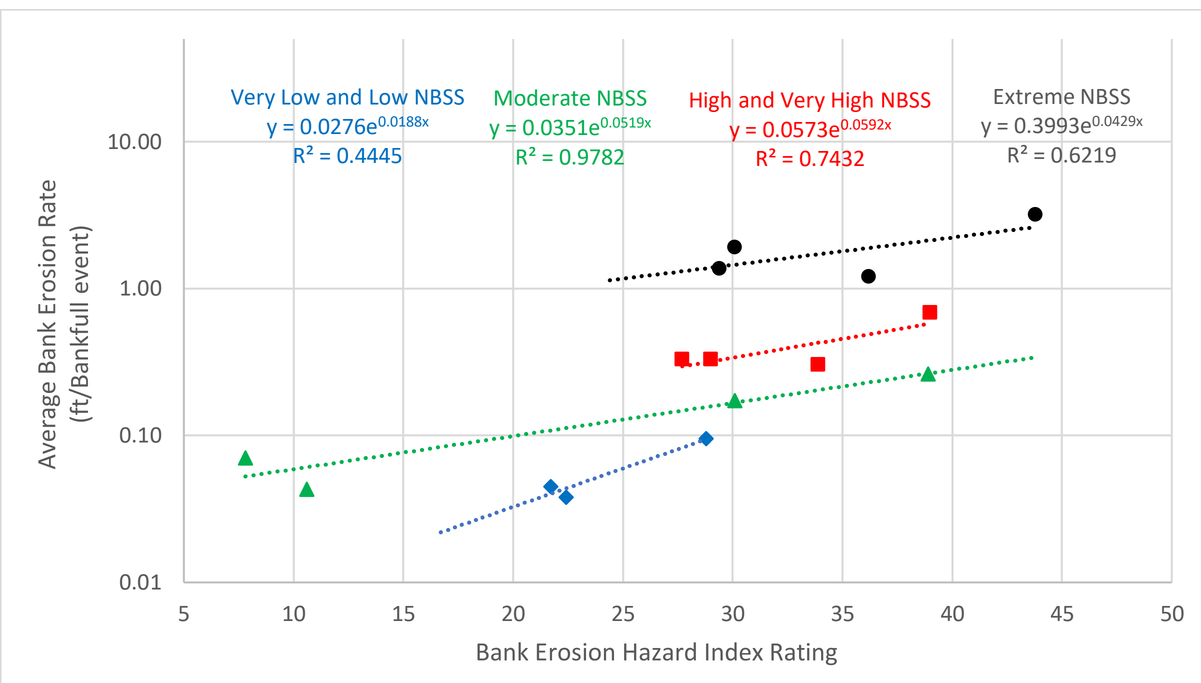

Figure 59. Total bank erosion rates divided by observed bankfull flood events for each of the 15 study sites vs. their Bank Erosion Hazard Index (BEHI) scores. Data are stratified by Near Bank Shear Stress (NBSS) categories.

WFWF Comparison

The new Illinois River model (BER/yr) was overlayed with an existing model developed in 2004 for the West Fork of the White in order to make comparisons. We have been utilizing the West Fork model for years as a tool and baseline for predicting erosion in the Illinois River Watershed. Given the West Fork's relative proximity to the Illinois River Watershed we would expect a lot of commonalities and a potential for close agreement between the respective curves.

We plotted Average Bank Erosion Rate (ft/yr) vs. Bank Erosion Hazard Index Rating stratified by broad Near Bank Shear Stress Categories for each of the models (Figure 55).
It is readily apparent that the West Fork model underestimates average erosion rates that we have measured throughout the Illinois River Watershed from 2017-2020. Across the board, we measured average streambank erosion rates in the Illinois River Watershed that were on average over 3 times the magnitude of those reported for the West Fork White River by Van Eps et al (Figure 60).

This discrepancy between the two models could mean that each model is simply better at predicting erosion rates for that specific watershed due to local factors such as geology that tend to differ between the two watersheds. An analysis of the weather and local hydrologic conditions that occurred during the West Fork study period may yield some insight as well. Erosion can be influenced by a number of factors (see the BEHI and NBSS variables) but it will always closely correlate with weather patterns and associated drought and flood cycles (Figures 57 & 59). Simply put, more flooding and more intense flooding should generally equate to more observed erosion. It would be interesting to divide the West Fork measured erosion rates by the number of bankfull flood occurrences for each study period to see if correlations between the two data sets is improved.

An extended dry study period with few flood events such as the one observed from 2018-2019 during a bank erosion study could lead to model predicting lower than average erosion rates across the board. The alternative can be said of unusually wet years, one of which we experienced in 2019-2020, potentially leading to overestimated rates. A multi-year study is always recommended, and incorporating a hydrologic variable to the analysis such as observed bankfull flood occurrences/site study period is strongly encouraged when developing these curves so that the potentially confounding effects of unpredictable weather can be minimized.

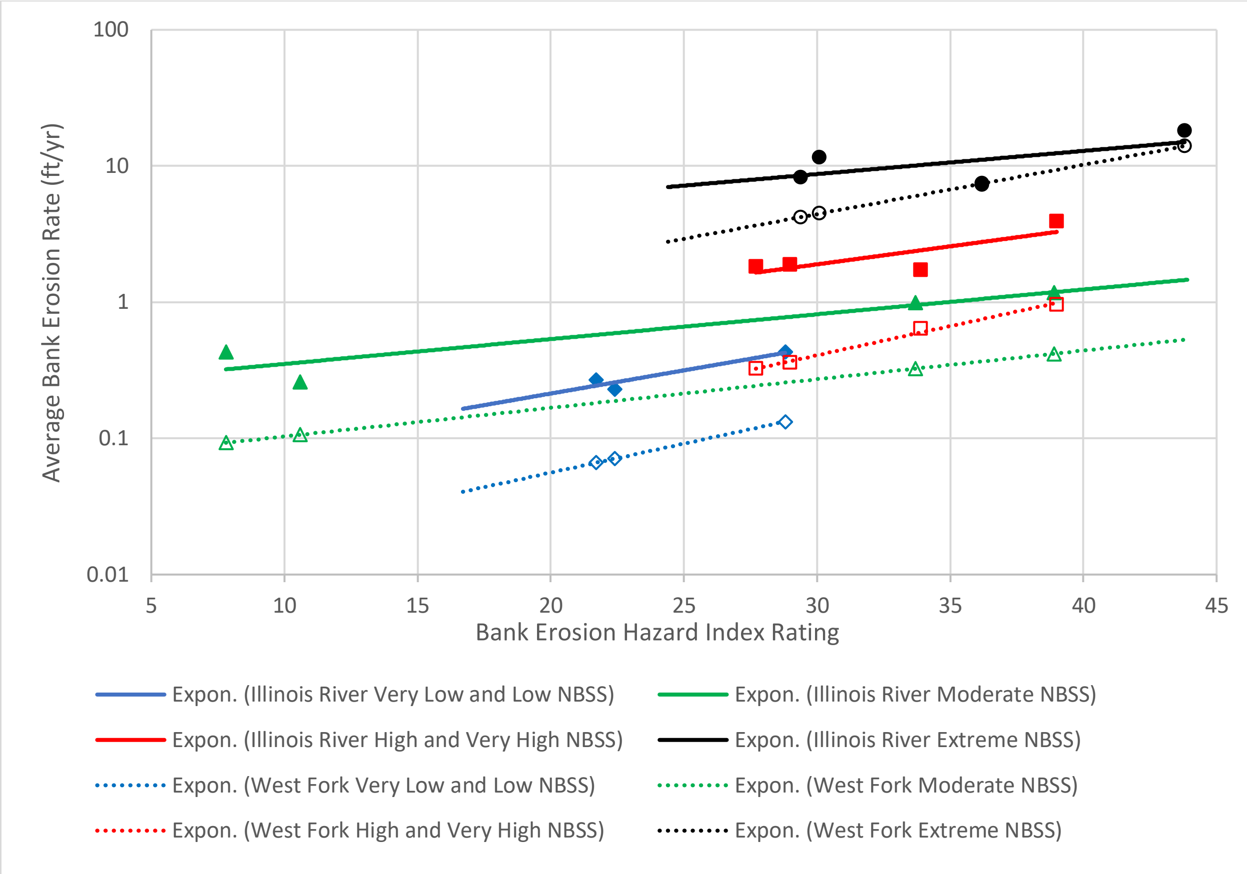

Figure 60. Annual measured bank erosion rates vs. Bank Erosion Hazard Index (BEHI) scores. Data is stratified by Near Bank Shear Stress (NBSS) category. All solid-colored points plotted and solid-colored lines represent data collected by NSS in the Illinois River watershed from 2017-2020, while the hollow-colored points along the dashed lines represents erosion predictions and curves developed for the West Fork White River (Van Eps, 2004).

Data Extrapolation

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. Approximately 49 miles of the Illinois River and tributaries were inventoried, all in Washington and Benton Counties of Arkansas.

In January 2017, Natural State Streams reported calculated predicted erosion rates for streambanks within the stream inventory area. Utilizing 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 (NBSS) ratings, along with empirical relations developed by Van Eps et al. (2004) for erosion assessment on the West Fork White River, annual rates of erosion were estimated on the surveyed reaches within the Illinois River Watershed.

Updated Data Analysis

In 2021, this stream inventory data was again analyzed, this time utilizing empirical relations described above for erosion assessment on the Illinois River and its tributaries. Attributes of each line segment were managed in Microsoft Excel, where predicted erosion rates and volumes were calculated (see Appendix XX for detailed technical description of erosion rate calculations). Corrected fields including total BEHI score and calculated erosion rates (based on Illinois River modeling coefficients) 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

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 16.44 feet/year with an average erosion rate of 1.01 feet/year for all streambanks catalogued. A total of forty one bank segments fell within the Extreme predicted erosion category (3-4 feet/year), sixty eight segments were categorized as Very High (2-3 feet/year), one hundred and sixty three segments were predicted to be within the High category (1-2 feet/year), two hundred forty four segments were predicted to be in the Moderate category (0.5-1 foot/year), one hundred eighty eight segments were predicted to be in the Low category (0.25-0.5 foot/year), and two hundred nineteen segments were predicted to be in the Very Low category (0.0-0.25 foot/year). Predicted erosion rates were also calculated as volumes (m^3/year and yd^3/year) as well as weight (tons/year), and estimated contribution on Phosphorus (lbs/year) based on as assumed rate of 1.5 pounds Phosphorus per 1 ton of soil.

Data Sharing

In an effort to make the data gathered for this report more accessible, NSS exported all of the GIS data (ArcMap shape files) into a user-friendly format that can be opened and utilized in Google Earth. The Estimated Erosion Rate data can be opened and viewed individually by stream reach or as a whole. When opened in Google Earth these .kmz files display the estimated rates of erosion by color corresponding to bank stability – green, yellow, orange, red, purple representing low to extreme predicted rates of erosion. Attributes of the stream can be viewed by selecting (clicking on) the line file anywhere on the map. A list and a description of each of the attributes of the erosion rate estimate line files can be found in Appendix XX.

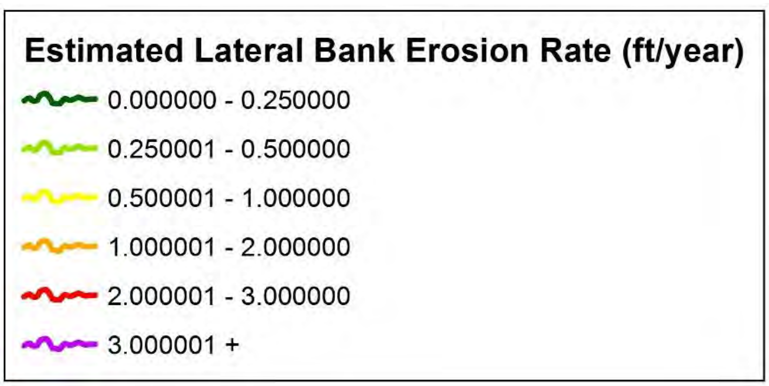

Figure 61. Google Earth map legend representing .kmz line files (erosion rate estimates).

Additional Recommendations

Now that we have developed and refined a watershed-specific model for erosion prediction in the Illinois River watershed, it would be helpful to complete streambank inventories upstream of 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.

It is also worth noting that we do not believe that all erosion or all cut-banks are bad. In fact, certain species such as belted kingfishers and bank swallows have relied upon relatively-stable cut-bank habitat for thousands of years as ideal burrowing and nesting areas. Relatively low or moderate rates of natural erosion can and do occur even in pristine areas, allowing this habitat to naturally form as fluvial channel processes gradually evolve over time. Developing a working understanding and continually refining our knowledge involving the complexities of this natural system and studying and mitigating the impacts of people and changing climate on the system is critical to maintaining the unique biodiversity of the Illinois River watershed.

Bank swallow burrow observed in relatively stable streambank at Site 3 (Illinois River 1 FID 25) on May 14, 2020.

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