17-200 Upper Cache River Watershed Monitoring Project
Final Report
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1. Executive Summary

The objective of this project was to measure the input from 12 main tributaries of the Upper Cache River (HUC 08020302) to determine the main source of contaminants entering the river and the efficacy of best management practices implemented in the subwatersheds in the monitoring plan.

The Cache River Watershed (HUC# 08020302) begins in Southeast Missouri with >90% of the watershed located in the Delta Ecoregion of Eastern Arkansas. The watershed covers a total of 1,956 mi^2 and land-use consists primarily of row crop agriculture (67.6%) and 19.2% of the watershed is forested, however landuse varies within the subwatersheds (Arkansaswater.org) (Table 1). The Upper Cache River is highly channelized with few remaining intact wetlands creating a challenge to control sediment and nutrients entering the Cache River, however, the subwatersheds located on Crowley's Ridge support greater forested land (Figure 1).

Table 1. HUC units and landuse for sampling sites in the Upper Cache River Basin Watershed.

Site name	Site code	HUC	% Urban	% Forest	% Agricultural
Big Creek Ditch	BCDI	080203020503	16.92	27.90	47.36
Beaver Dam Ditch	BDDI	080203020207	3.10	0.31	92.45
Big Gum Lateral	BGLA	080203020202	3.37	0.31	88.47
East Slough	EASL	080203020105	4.20	0.04	88.69
Kellow Ditch	KEDI	080203020208	3.84	0.12	94.65
Lost Creek Ditch	LCDI	080203020502	17.84	17.13	59.80
Little Cache River Ditch	LCRD	080203020102	6.48	24.08	66.75
Number 26 Ditch	NTSD	080203020301	5.64	18.68	71.72
Scatter Creek	SCCR	080203020601	5.91	66.24	24.81
Skillet Ditch	SKDI	080203020401	5.85	0.56	88.66
West Cache River Ditch	WCRD	080203020303	4.05	0.13	92.10
Willow Ditch	WIDI	080203020305	2.75	0.55	90.65
Cache River Ditch # 1*	CRDO	08020302	5.19	0.00	91.50

The Cache River Watershed has many different uses. The watershed offers year-round recreational activities including hunting, fishing, hiking, kayaking, birding and camping. Many large farms operate at a high level of resource management in this watershed. The Cache River Watershed was chosen as a target watershed for the MRBI project and cited in this project as a source of nutrients and suspended solids contributing to the hypoxia in the Gulf of Mexico. Recent monitoring (see Middle Cache Monitoring 13-500 final report) has noted the contaminant contributions from subwatersheds of the Cache River. MRBI and NRCS projects have recently been initiated on the Cache River Watershed. Designated uses in the watershed include fisheries, aquatic life, agricultural and industrial water supply (ADEQ, 2018).

According to the 303(d) list, the major causes of the impairment are listed as excessive turbidity, total dissolved solids, and lead (ADEQ, 2018) and include the main channel of the Cache River, which can be contributed to an accumulation of upstream agriculturally dominated watersheds. Agriculture activities within the watershed are thought to be the major source of the contamination. The alluvial soil associated with the Delta Ecoregion is very erodible and soil disturbances as part of row-crop agriculture contribute to the suspended sediment in this watershed. In addition, silt and total suspended solid inputs during storm events from the unpaved farm roads, construction sites and other land disturbances are adding a significant loading and increasing in-stream turbidity concentrations during and following storm events.

Sampling sites were established by Arkansas Natural Resource Commission and A-State ERF personnel for 14 sites within the Upper Cache River Basin. Twelve sampling sites were located within subwatersheds in the Cache River Watershed and two sites were located in the main stream of the Cache River (Table 2; Figure 2).

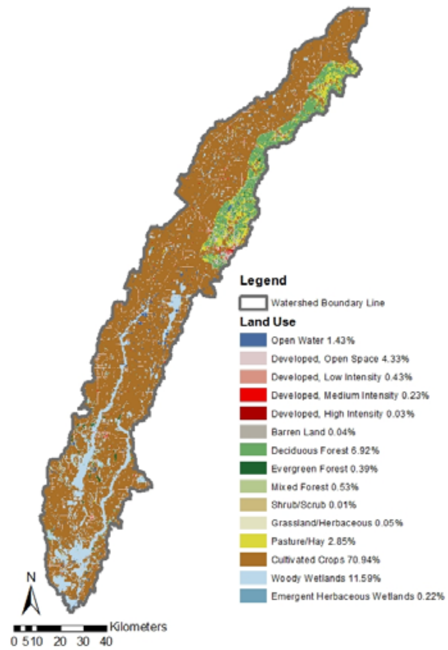

Figure 1. Land use of the Cache River Watershed based on the most recent U.S. Geological Survey's National Land Cover Data (Homer et al., 2015).

Table 2. Site names, abbreviations, HUC, drainage area, and GPS coordinates for sampling sites in the Upper Cache River Basin.

Site name	**Site code**	**HUC**	**Drainage area (km^2)**	**GPS coordinates**
Big Creek Ditch	BCDI	080203020503	69.52	35.840562, -90.801823
Beaver Dam Ditch	BDDI	080203020207	100.17	36.098562, -90.852454
Big Gum Lateral	BGLA	080203020202	117.41	36.236742, -90.643902
East Slough	EASL	080203020105	130.89	36.333792, -90.479669
Kellow Ditch	KEDI	080203020208	63.33	36.056942, -90.878115
Lost Creek Ditch	LCDI	080203020502	153.31	35.843959, -90.748421
Little Cache River Ditch	LCRD	080203020102	105.87	36.399976, -90.390031
Number 26 Ditch	NTSD	080203020301	134.28	35.984784, -90.808143
Scatter Creek	SCCR	080203020601	50.40	36.222839, -90.538103
Skillet Ditch	SKDI	080203020401	76.10	35.636723, -91.122271
West Cache River Ditch	WCRD	080203020303	48.66	35.874142, -90.911071
Willow Ditch	WIDI	080203020305	113.71	35.752668, -91.060279
Cache River Ditch No. 1*	CRDO	08020302	64.25	36.477347, -90.324775
Cache River at Egypt*	CREG	08020302	1815.58	35.857779, -90.933262

*Cache River Ditch No. 1 and Cache River at Egypt are the Cache River proper. All locations, except SKDI and WIDI drain into the Cache upstream of CREG.

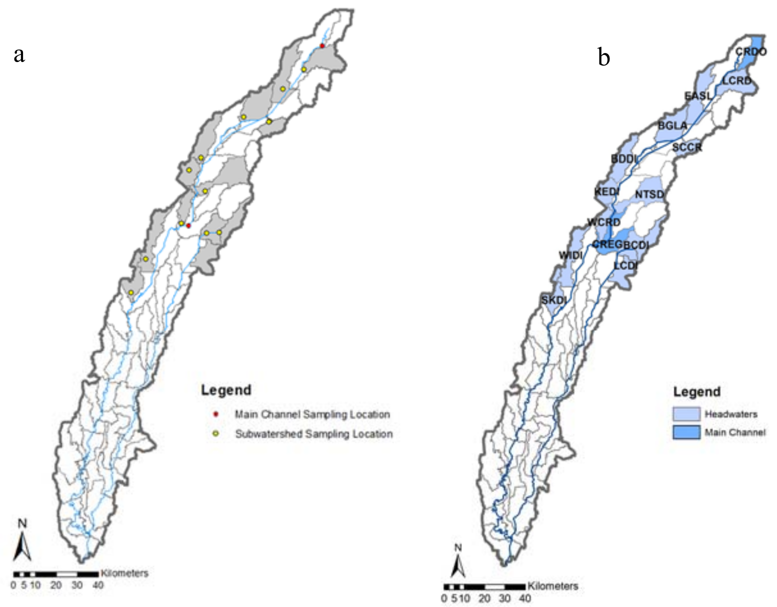

Figure 2. Sampling locations and subwatersheds in the Cache River Watershed.

The A-State Ecotoxicology Research Facility (ERF) began measuring weekly water quality parameters on October 2, 2017, and completed 156 water quality sampling dates on September 24, 2020. These analytes included total suspended solids (TSS), turbidity, dissolved oxygen, pH, conductivity, dissolved nitrates, nitrites, orthophosphates, and total nitrogen (N) and phosphorus (P).

Mean dissolved and total nutrients were greatest at BCDI (Big Creek Ditch) (Figure 3). Three-year mean dissolved NO_3 was 5.48 mgNO_3/L as compared to all other subwatershed sites, which ranged from 0.86 – 1.69 mgNO_3/L. Main channel sites had 3-year mean NO_3 of 1.91 and 1.13 mgNO_3/L, upstream and downstream, respectively. Mean dissolved PO_4 at BCDI was an order of magnitude greater than all other sites (2.33 mgPO_4/L), including main channel sites (0.20 – 0.43 mgPO_4/L). Three-year mean total nutrients were also much greater at BCDI (TN – 1.40 mgN/L; TP – 1.03 mgP/L) than all other sites (TN range 0.40 – 1.04 mgN/L; TP range 0.22 – 0.35 mgP/L).

The greatest 3-year mean turbidity and TSS were measured in EASL (East Slough); 3-year mean values at this site were 339 NTU and 190 mg/L, turbidity and TSS respectively. BCDI had the second lowest turbidity and TSS mean values greater only than SCCR (Scatter Creek). Main channel sites had similar 3-year mean turbidity and TSS values; upstream site, FTSL, had turbidity = 210 NTU and TSS = 137 mg/L and downstream site, CREG, had measured turbidity = 212 NTU and TSS = 150 mg/L.

This project was funded at $1,118,122 with 43.5% match from A-State ($486,653) and federal funds from the ANRC ($631,469).

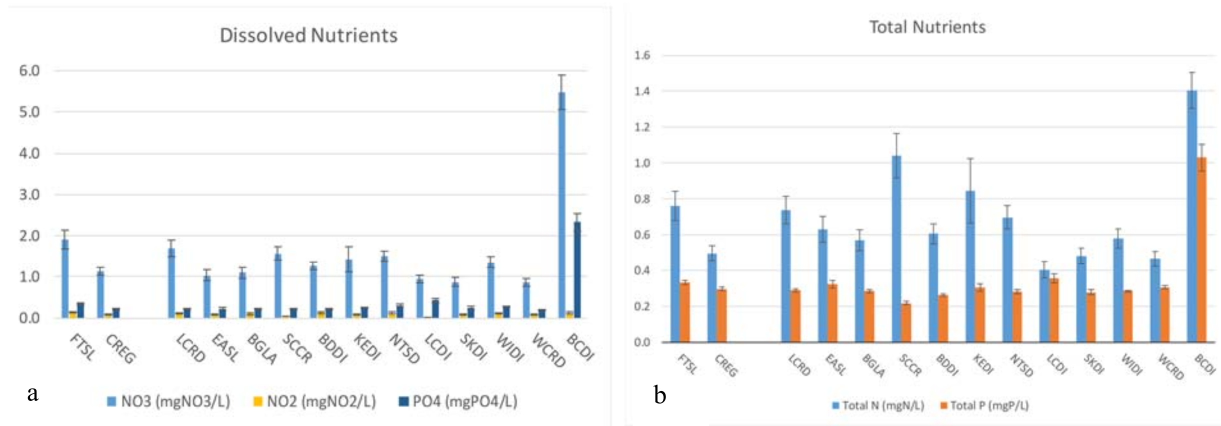

Figure 3. Dissolved (a) and Total Nutrients (b) in the Cache River Watershed.
FTSL and CREG are upper and lower main channel sites.

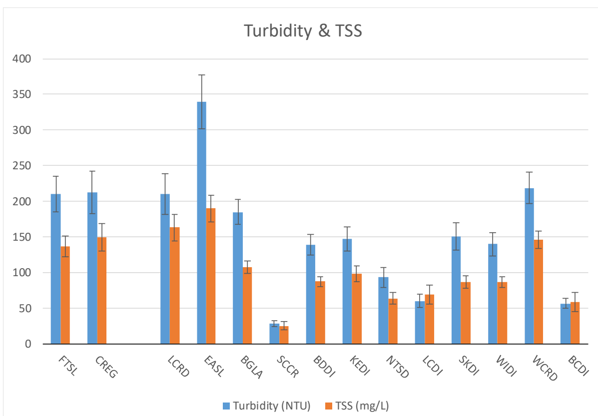

Figure 4. Turbidity and TSS in the Cache River Watershed. FTSL and CREG are upper and lower main channel sites.

2. Project Chronology

Following sampling site selection, weekly collections began on October 2, 2017. Samples were collected from each site using a bucket rinsed in the respective site water, followed by filling the acid-washed sample bottles (1-L Nalgene bottles) as recommended by the ERF Standard Operating Procedure (SOP) and based on American Public Health Association methods (APHA, 2005). Filtered samples for nutrient analyses were accomplished on-site with a syringe and 0.45 µm filter filling two 15-mL centrifuge tubes and unfiltered samples were collected in a 50-mL conical tube for Total N and P. All samples were immediately labeled with site name, collection date and time, and initials of person(s) collecting sample; samples were then placed immediately on ice. Upon returning to the ERF, samples were warmed to room temperature and tested for TSS and turbidity while filtered samples for dissolved nutrients and unfiltered 50-mL subsamples for total N and P were frozen until analyzed. TSS was measured in triplicate using the filtration technique and 100-mL of sample and nutrients were measured using the Skalar SANS++ nutrient analyzer. All water quality tests followed the American Public Health Association (APHA, 2005) guidelines.

Quality control and quality assurance was accomplished in this project as outlined in the QAPP and the ERF SOP. The ERF is EPA certified (AR#00917) for TSS and nutrients (nitrate, nitrite, orthophosphates) and certification requires bi-annual unknowns by the Arkansas Department of Environmental Quality (ADEQ). Annual re-certification requires reporting acceptable results on EPA unknowns for these parameters.

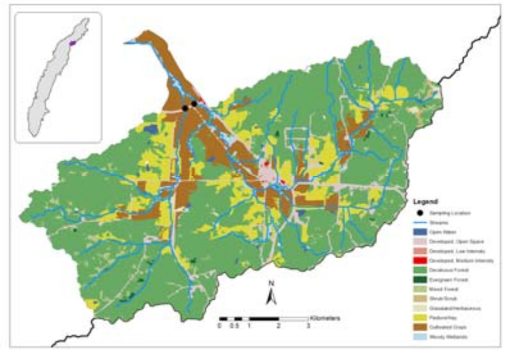

Figure 5. Land use in Scatter Creek subwatershed.

3. Results & Discussion

The 3-year mean TSS and turbidity were lowest at SCCR (Scatter Creek site) (28.4 NTU and 25.3 mg/L turbidity and TSS, respectively). This subwatershed is the smallest in area and has the greatest forested land cover (66%)(Figure 5). Conversely, the greatest 3-year mean turbidity and TSS were measured in EASL (East Slough) with mean values of 339 NTU and 190 mg/L, turbidity and TSS respectively. EASL subwatershed supports <1% forested land and 88.7% agriculture (Figure 6). It is well documented that forested subwatersheds offer more water quality protection while the conversion of forests into agricultural landuse increases sediment loading into the adjacent waterways (Kleiss, 1996; Rosado-Berrios and Bouldin, 2016). The main channel sites did not differ significantly from upstream to downstream in mean turbidity and TSS values, indicating that input from highly agricultural subwatersheds did not significantly add to the total downstream loading (Figure 4).

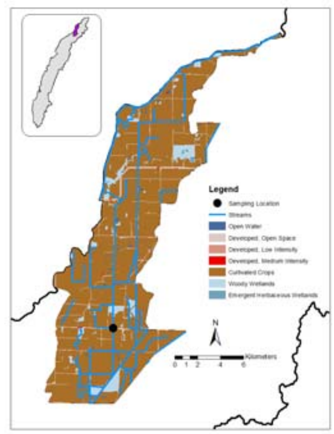

Figure 6. Land use in East Slough subwatershed.

The most notable nutrient values were measured in BCDI, Big Creek Ditch subwatershed. Three-year mean dissolved NO_3 was 5.48 $mgNO_3/L$ and 3-year mean dissolved PO_4 was 2.33 $mgPO_4/L$ (Figure 3a). Total N and P were also significantly greater at this site than all other sites (1.40 mgN/L and 1.03 mgP/L, respectively) (Figure 3b). Landuse in this subwatershed is distributed among urban, forested, and agriculture (Table 1)(Figure 7). Interestingly, turbidity and suspended sediments were not as high in BCDI as in any other sampling sites other than SCCR, Scatter Creek. Although some woody wetlands are indicated in Figure 7, the channelized ditch in BCDI may benefit from the filtering effects to reduce suspended sediments, but may not have the ability to decrease the nutrient loading measured at this site. Historic data from Big Creek reports dissolved and total nutrient data in the same range as those reported in this study (Christian et al., 2003).

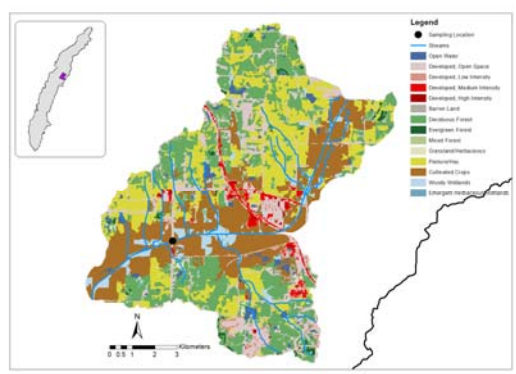

Figure 7. Land use in Big Creek Ditch subwatershed.

ArcGIS (10.3.1) was used to delineate land use (agricultural, forested, or urban) of each subwatershed using the most recent U.S. Geological Survey's (USGS) National Land Cover Data (NLCD) satellite imagery. Based on the percentage of agricultural land use above the sampling location, sites fell into four levels of agricultural intensity (Figure 8): low (n=2), low moderate (n=3), moderate high (n=4), and high (n=3). Agricultural intensity of 40% or below was classified as low, 41-70% as low moderate, 71-90% as moderate high, and 91% and up as high intensity. Agricultural intensity was determined by the following equation:

$$Agricultural\ Intensity = 100\ x \frac{Agricultural\ Land\ Use\ Upstream}{(Total\ Drainage\ Area - Non\ Ag\ Area\ Downstream)}$$

Annual averages were calculated by Agricultural Intensity to offer insight on differences per year and input in low vs. high rowcrop intensity. Turbidity and TSS were greatest in the moderate high classification for all three years with the exception of year 1 TSS in which subwatersheds classified as 'high' had the greatest mean TSS (Figure 9). Annual means were lower in year 2, but similar in years 1 and 3 for all classifications.

Total nutrient annual means were calculated without the low-moderate watershed BCDI as the nutrients for this subwatershed were extremely high. These data are shown in Figure 10 and indicate less variance, especially for total P when classified by agricultural intensity. Total nutrients include dissolved and particulate nutrients, thus input of organic matter, whether from agricultural fields or riparian buffers, will increase these concentrations. Total N was lower for all classifications in year 2, but increased in year 3. Year 3 data indicates a greater mean especially in subwatersheds classified as low intensity. Total P values decreased for all agricultural intensity classifications over the three years. This parameter also showed less variance among the agricultural intensity classifications.

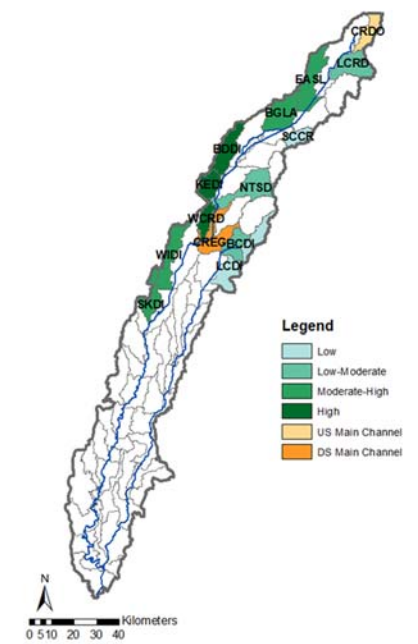

Figure 8. Agricultural intensities of the sampled subwatersheds of the Upper Cache River Watershed.

4. Lessons Learned

As indicated from the results of this monitoring, the intensity of agriculture in many of these subwatersheds drives the need for management practices to control sediment input from these activities. Subwatershed EASL (East Slough) which is 88.7% agriculture and 1% forested, has a great deal of sediment input. Not only is the farmland in this subwatershed losing topsoil, but the sediment input also carries associated contaminants (e.g. phosphorus and pesticides) which contribute to the degradation of the Cache River and ultimately the hypoxia in the Gulf of Mexico.

The agricultural intensity of the subwatersheds illustrates that moderately high and high intensity subwatersheds lack the ability to filter sediment and dissolved nutrients due to the lack of intact wetlands. Natural systems will contribute total nutrients in the form of leaf litter from riparian buffers and connected wetlands, but dissolved nutrients from many of these subwatersheds is attributed the agricultural activity in the area.

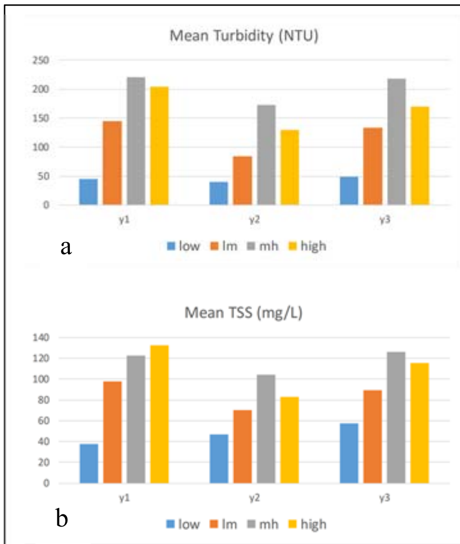

Figure 9. Mean annual turbidity (a) and TSS (b) by agricultural intensities of subwatersheds of the Upper Cache River Watershed.

BCDI (Big Creek Ditch) subwatershed warrants further investigation as the extremely high nutrient values could be attributed to several sources due to the diversity of landuse in this drainage area. This subwatershed drains much of downtown Jonesboro, AR, the city's baseball/softball and soccer complex, and much agriculture land. Dividing this subwatershed to measure below these input areas may provide additional information to reduce these nutrient inputs. Historical data measured in 2002, also recorded high nutrient values for this waterway (Christian et al., 2003).

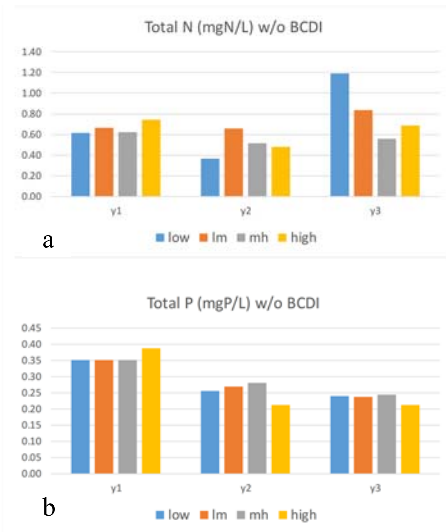

Figure 10. Mean annual Total N (a) and Total P (b) by agricultural intensities of subwatersheds of the Upper Cache River Watershed. Means for BCDI is excluded from these calculations.

5. Technical Transfer

Results from this data is part of Amelia Atwell's PhD dissertation. These data have been presented at local, regional and national/international meetings including the Arkansas Soil & Water Conservation meeting, Create@AState, MidSouth SETAC, SETAC North America, and Southeast Fisheries Council annual meeting. Publications are in preparation for these data as well as Amelia's dissertation completion. As part of her dissertation research, Amelia has also performed fish community assessments and compared them to The Nature Conservancy's historical data for the same stream segments.

All data from this project has been entered into WQX and thus is available through that website.

6. EPA Feedback Loop

To provide a complete assessment of this study and the biological surveys performed, data will be available in publications, WQX, and PhD dissertation at A-State. Data analyses will be available through these publications and a fish community assessment are important as providing and protecting natural habitat also protects our waterways for other aquatic life and recreation.

7. Conclusions / Outcomes

This project monitored changes in water quality parameters over a 3-year period. During this time, various flow and weather regimes were sampled. The overall goal is to reduce non-point source contamination and supply these data for modeling of the monitored watersheds. A few subwatersheds stand out with measured increased sediment movement and nutrient at many of the sites.

BCDI (Big Creek Ditch) subwatershed warrants further investigation and study into the input into this stream upstream from the monitoring site. Other subwatersheds can be pinpointed as receiving input from agricultural activity, however BCDI has variable landuse other than agriculture. By far, it had the greatest dissolved and total nutrient values of any sampling site.

Subwatersheds located on Crowley's Ridge are afforded water quality protection as the slopes do not allow the agricultural intensity as the Delta Ecoregionand thus have remaining intact forested landcover. Intact riparian areas in subwatersheds such as Scatter Creek reduce erosion and thus the amount of sediment entering the stream.

The Cache River Watershed is an important ecological and economic value to the State of Arkansas. The Cache River along with the Lower White River form one of the most important ecological areas in the state and is home to many endogenous fauna and flora found nowhere else in Arkansas. It is also home to recreation including boating, hunting, bird watching and fishing, and is ecologically important as well. Protection of these large watersheds must be accomplished on the subwatershed level. These data provide insight on which streams and subwatersheds are in most need of remediation.

8. References

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Appendix 1.

Excel spread sheet of all measured water quality parameters (attached).