17-1200 White River Watershed Monitoring Project
Final Report
Submitted by Jennifer L. Bouldin
Ecotoxicology Research Facility
Arkansas State University

1. Executive Summary

The objective of this project was to obtain baseline water quality data needed for future watershed based plan development and possible entry into watershed models in the North Fork White River Watershed, Middle White River Watershed and the Bull Shoals Watershed (HUC #11010006).

Monitoring in the White River Watershed Basin took place in the major tributaries of the North Fork White River Watershed (HUC# 11010006), Middle White River Watershed (HUC# 11010004) and the Bull Shoals Watershed (HUC# 11010003). All three watersheds lie within the White River Basin in Northern Arkansas. The North Fork White Watershed is the northernmost and its headwaters and approximately 75% of the watershed is in Missouri (Figure 1). The study watersheds have similar landuse (Table 1).

Table 1. HUC units and landuse for sampling watersheds in the White River Basin Watershed.

Watershed	HUC#	Landuse		
		Forest	Grassland	Cropland
North Fork White River	11010006	57%	30%	0.0%
Bull Shoals	11010003	57%	28%	0.1%
Middle White River	11010004	65%	26%	3.0%

The White River originates in northwestern Arkansas, flows through southern Missouri and then re-enters Arkansas at the most northwestern part of Bull Shoals Lake. Three major dams impound stretches of the 1,162 kilometer White River: Table Rock Dam, Powersite Dam, and Bull Shoals Dam, all of which hold back river water to create reservoirs large enough for boating recreational activities (Bayless & Vitello, 2015). Norfork Dam, which holds back the waters of Lake Norfork, also contributes to the White River waters just before the town of Norfork, Arkansas.

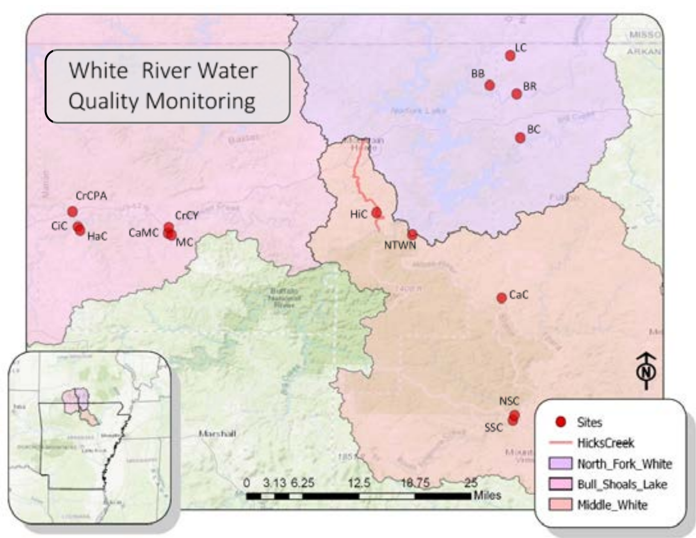

Figure 1. Map of study sites in tributaries of the White River. Sites are located in the North Fork, Bull Shoals, and Middle White watersheds in Baxter, Fulton, Izard, Marion, and Stone counties.

The White River, its tributaries, and associated watersheds support many activities for humans such as hunting, fishing, swimming, hiking, kayaking, birding, and camping. The fishing industry in particular is a multi-billion dollar industry and is internationally known for both Brown and Rainbow trout. Designated uses for the White River include primary and secondary uses (ADEQ, 2018). Six of the 15 sites in this project are listed as impaired by the ADEQ (2018). Big Creek is impaired for pH and lead; Crooked Creek at Pyatt Access, Clear Creek, and Crooked Creek at Yellville are all impaired for temperature, and Hicks Creek is impaired for pathogenic bacteria.

Sampling sites were established by Arkansas Natural Resource Commission and ASU ERF personnel for 15 sites within the White River Basin. Four sampling sites were located within the North Fork White River Watershed, six sites were located in the Bull Shoals Watershed and five sites are located in the Middle White River Watershed (Table 2).

Table 2. Watershed, site names, GPS coordinates and HUC# for sampling sites in the White River Basin.

Watershed	ID	Site Name	Latitude	Longitude	HUC#
North Fork White River	BR	Bennetts River	36.42252	-92.118333	110100060802
	LC	Little Creek	36.48026	-92.128611	110100060803
	BB	Bennetts Bayou	36.43551	-92.161944	110100060804
	BC	Big Creek	36.35724	-92.112500	110100060903
Bull Shoals	CrCpA	Crooked Creek at Pyatt Access	36.24625	-92.835000	110100030908
	CIC	Clear Creek	36.22392	-92.826389	110100030803
	HaC	Hampton Creek	36.21872	-92.822778	110100031001
	CaMC	Campground Creek	36.21422	-92.680833	110100031003
	MC	Mill Creek	36.21129	-92.675000	110100031003
	CrCy	Crooked Creek at Yellville	36.22312	-92.679722	110100031004
Middle White River	HiC	Hicks Creek	36.24477	-92.340000	110100040201
	Ntwn	Norfork Tail Water at Norfork	36.21186	-92.286667	110100040203
	CaC	Calico Creek	36.11742	-92.142500	110100040206
	NSC	North Sylamore Creek	35.93434	-92.124444	110100040305
	SSC	South Sylamore Creek	35.94170	-92.121667	110100040306

The A-State Ecotoxicology Research Facility (ERF) began measuring weekly water quality parameters on October 31, 2017, and completed 52 water quality sampling dates on March 15, 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 total and dissolved nutrients were greater in sites in the Bull Shoals Watershed. Mean dissolved nitrate values were as great as 5.935 $mgNO_3/L$ at the Crooked Creek Pyatt Access site; mean dissolved phosphorus values were as 0.878 $mgPO_4/L$ at Mill Creek site. Crooked Creek sites (Pyatt Access and Yellville) had the greatest mean TSS and turbidity in the Bull Shoals Watershed (TSS 9.06 and 9.48 mg/L, respectively; turbidity 13.23 and 9.10 NTU, respectively). High flow events on 03/29/18 and 12/1/18 resulted in high TSS and turbidity measurements in the North Fork White and Bull Shoals watersheds. These events did not increase these measurements in the Middle White River Watershed, and is most likely the reason TSS and turbidity in this more southern watershed had lower mean values as compared to the other watersheds. Mean dissolved and total nutrient values for the Middle White River Watershed were also lower than the North Fork White and Bull Shoals watersheds with the exception of Hicks Creek which had the greatest mean dissolved and total P values of all sampled sites (0.878 $mgPO_4/L$ and 0.518 mgP/L, respectively).

This present project was funded at $666,563 with 43% match from A-State ($286,437) and federal funds from the ANRC ($380,126).

2. Project Chronology

Following sampling site selection, bi-monthly collections began on October 31, 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.

3. Results & Discussion

The mean TSS and turbidity were lowest in the Middle White River Watershed (Figure 2). The lowest mean TSS and turbidity values for any site were measured in the North Sylamore Creek (1.63 mg/L and 1.08 NTU, respectively). South Sylamore Creek also has the 3rd lowest mean values (2.35 mg/L and 2.32 NTU, respectively). Forested landcover in these subwatersheds most likely contributes to the sediment control at these two sites (North Sylamore - 95.5%, South Sylamore - 78.8% forested, respectively) (Table 1) (Arkansaswater.org). Hampton Creek located in the Bull Shoals Watershed ranked 2nd lowest mean TSS and turbidity with mean TSS = 2.31 mg/L and turbidity = 1.56 NTU. Interestingly the Hampton Creek subwatershed has only 62.7% forested (Arkansaswater.org) and the site was adjacent to pasture land which most likely contributed to the high dissolved and total nitrogen values (3.417 mgNO_3/L and 0.811 mgN/L, respectively) (Figures 3 and 4).

The sites with the greatest mean TSS values were Crook Creek at Yellville and Crooked Creek at Pyatt Access (9.48 and 9.06 mg/L, respectively). Crooked Creek at Pyatt Access also had the greatest mean turbidity value (13.23 NTU). High flow events resulting in much sediment movement increased the mean values in both Crooked Creek sites on 3/29/18, 12/1/18 and 2/8/19 as is reflected in the measured values (Appendix 1).

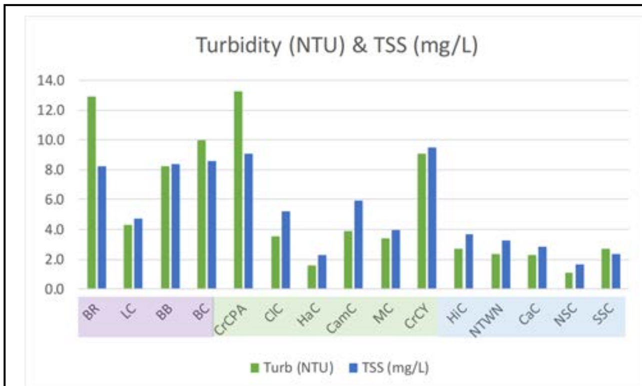

Figure 2. Mean values for TSS and turbidity from North Fork White River (purple), Bull Shoals (green) and Middle White River (blue) watershed sites.

Dissolved nutrients were greatest in the Bull Shoals Watershed sites (Figure 3). All mean NO_3 values were >3.0 mg/L in this Watershed. Crooked Creek at Pyatt Access had the highest mean NO_3 (5.935 mgNO_3/L) of all sampling sites followed by Clear Creek (5.645 mgNO_3/L). Hicks Creek in the Middle White River Watershed had the greatest mean PO_4 of all sites sampled. This mean was influenced by the first sampling event on 10/31/17, which had extremely high dissolved and total nutrient values (Appendix 1). This also resulted in a slightly greater mean total N and P for Hicks Creek. Crook Creek at Yellville and Crooked Creek at Pyatt Access had greater mean total and dissolved nutrient values in year 2 than year 1 (Appendix 1). Crooked Creek at Pyatt Access, indicating an increase over the sampling period. However, Hicks Creek had greater values in the first year of sampling.

High flow events resulting in increased TSS and turbidity values were also reflected in nutrient values (Appendix 1). Phosphorus binds to sediment and thus is transported with sediment runoff from storm events as reflected in Total P values and phosphorus dislodged from these sediment particles is also measured as dissolved PO_4. Dissolved NO_2 and NO_3 values will also increase in these events as these water-soluble nutrients are stored within the soil and will be mobilized in these storm events.

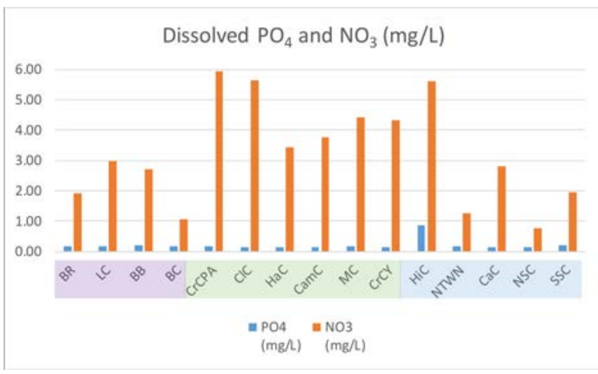

Figure 3. Mean dissolved PO_4 and NO_3 from North Fork White River (purple), Bull Shoals (green) and Middle White River (blue) watershed sites.

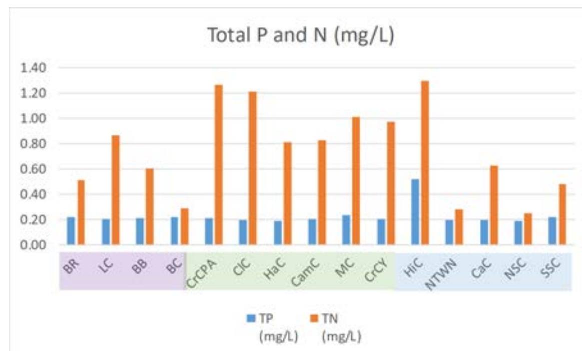

Figure 4. Mean dissolved PO_4 and NO_3 from North Fork White River (purple), Bull Shoals (green) and Middle White River (blue) watershed sites.

4. Lessons Learned

As indicated from the results of this monitoring, high flow events drove much of the sediment movement and increased nutrients in these watersheds. Clear Creek and the Crooked Creek sites in the Bulls Shoals Watershed (Crooked Creek at Pyatt Access and Crooked Creek at Yellville) are areas of concern as they had high nutrient values throughout the sampling period. Hicks Creek located in the Middle White River Watershed is also of concern as high dissolved and total nutrient values, even without the sediment movement (TSS and turbidity) measured in other sites.

The sites in these three watersheds varied in size with Norfork Tailwater, Hicks Creek and the Crooked Creek sites the largest streams in the study. Smaller streams which do not contribute the total loading to the watershed, especially those located in North Fork White River site, had lower nutrient mean values but greater TSS and turbidity than most of the larger streams in the study, with the exception of the two Crooked Creek sites.

This monitoring project provides an interesting comparison of watersheds, landuse, and stream size of the monitored sites. Consideration should be taken in monitoring Crooked Creek in the Bull Shoals

Watershed as this waterway is of concern according to the results presented here. Additionally, Hicks Creek, which is listed by the ADEQ for pathogens

5. Technical Transfer

Results from this data will be part of Jae Chester's MS thesis. These data have also been presented at local, regional and national/international meetings including the Arkansas Soil & Water Conservation meeting, Create@AState, MidSouth SETAC, SETAC North America, and the National Soil & Water Conservation meeting. Publications are planned for these data along following Jae's MS thesis completion.

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 MS theses. Data analyses will be available through these publications and are important as a 'one-size-fits-all' approach does not fit this diverse watershed which originates in the Ozark Highlands and flows into the Black River in the Delta Ecoregion.

7. Conclusions / Outcomes

This project monitored changes in water quality parameters over a 2-3-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 episodic events increased sediment movement and nutrient at many of the sites. However, these events did not tend to substantially increase the mean measured sediment and nutrient values as these sites.

A measurable difference can be noted among the watersheds in this monitoring study. Crooked Creek in the Bulls Shoals Watershed certainly needs continued monitoring and tracing the sources of the nutrient and sediment loading to this stream. Nutrient sources should be investigated in Hicks Creek in the Middle White River Watershed as the greatest mean dissolved and total phosphorus were measured at this site. It also had the greatest mean total N value and the 3rd greatest dissolved NO_3 value. Upstream pasture land may be contributing to these increased measurements.

North Sylamore Creek and South Sylamore sites appear to be protected in this highly forested subwatershed as these sites had some of the lowest mean values for nutrients and sediments. However, water quality protection as noted by low suspended sediment (TSS and turbidity) can also be accomplished in subwatersheds like Hampton Creek located in the Bull Shoals Watershed. This may have been partially accomplished by stable stream banks and rocky or slate creek beds. Dissolved and total N values should be protected from the adjacent pasture land.

The White River Watershed is an important ecological and economic value to the State of Arkansas. The watershed and the reservoirs formed from the White River serve as a drinking water source, recreation (boating 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

ADEQ. (Arkansas Department of Environmental Quality). 2018. Arkansas pollution control and ecology commission regulation no. 2, regulation establishing water quality standards for surface waters of the state of Arkansas.

APHA. 2005. Standard methods for the examination of water and wastewater. 21st ed. American Public Health Association, Washington D.C.

Bayless, M. and Vitello, C. 2015. White River watershed inventory and assessment. Retrieved from https://mdc.mo.gov/sites/default/files/watersheds/WhiteRiverWatershed390.pdf.

Appendix 1.
Excel spread sheet of all measured water quality parameters (attached).