UPPER WHITE RIVER BASIN MONITORING ANALYSIS

Triennial Report

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INTRODUCTION

Objectives

The upper White River basin (UWRB) is comprised of ten counties in northwest Arkansas and nine in southwest Missouri. Home to over a million people, this region has grown and developed rapidly in recent decades. But growth and development, along with changing agricultural practices, have prompted concerns about the negative impact of these trends on water quality in the region.

The objective of this monitoring and data analysis program by the UWRB is to analyze quality-controlled and technically defensible data from the USGS to determine the status and trends in ecological condition and certain targeted water quality parameters in the UWRB in order to:

- Communicate this information to the public in an annual report of the state of the water quality in the basin region;
- Understand the natural seasonal and/or annual variation in these parameters;
- Potentially identify locations or pollutants of concern to focus future targeted monitoring programs or watershed education and management;
- Potentially identify areas of high ecological quality that can focus future watershed protection efforts and serve as a reference for comparison to other sites.

Monitoring Parameters

Water quality monitoring provides data on targeted parameters of concern, including nutrients, bacteria and turbidity, as well as core field water quality parameters such as dissolved oxygen, pH and specific conductance. These data are intended to address questions about the current state and long-term trends of water quality in the watershed with respect to impacts such as urbanization, agriculture and septic tanks. The water quality data that were included in this analysis were collected by the United States Geological Survey (USGS) and were downloaded from the National Water Information System (http://waterdata.usgs.gov/nwis) , which is a public database managed by the USGS. The USGS collects

water quality data on a dozen stream sites within the watersheds of the James River, Beaver Lake and Bull Shoals Lake (Table 1).

Benthic invertebrate data were collected from 10 sites each year for three years (Table 1) and were used as a measure of ecological condition. The composition and abundance of the benthic invertebrate community is commonly used as an indicator of the overall ecological condition in streams because they reflect water quality over time as well as the habitat and ecological balance of a stream system. Benthic invertebrates were collected and identified by Dr. Michelle Evans-White at the University of Arkansas.

METHODS

Site descriptions

The following sites were used for this analysis of water quality and benthic macroinvertebrate data.

Wilson Creek near Brookline, Missouri

USGS site 07052152 is in the James River sub-basin. It receives most of its base flow from the Springfield Southwest Wastewater Treatment Plant. There is some agricultural land outside of the Springfield metropolitan area, but it is being converted to urban/suburban land use. Latitude 37°08'49.7", Longitude -93°22'31.7" (Borchelt, 2007)

James River near Boaz, Missouri

This site (07052250) receives effluent from the Springfield, Nixa, and Rogersville Wastewater Treatment Plants. It is surrounded by cattle pastures. There are also many construction projects in this area. Latitude 37°00'23.7", Longitude -93°21'52.8" (Borchelt, 2007).

Finley Creek below Riverdale, Missouri

The Finley Creek site (USGS site 07052345) is in the James River sub-basin. It is dominated by agricultural land use, mostly cattle pastures, but also has some urban area and forest land. It is also affected by five wastewater treatment facilities located near Nixa, Ozark, Sparta, Fordland and Seymour. However, the nearest municipal facility is located 7 km upstream. Latitude 36°58'29.6", Longitude -93°19'40.4" (Borchelt, 2007).

Finley Creek near Sparta, Missouri

This site (USGS site 37021555093031901) is in Christian County, Missouri. Latitude 37°02'15", Longitude 93°03'19".

James River at Galena, Missouri

USGS site 07052500 has a watershed of approximately 1/3 forest area with the remaining areas made up of grassland/pastures and urban areas. The Galena Wastewater Treatment Plant is just upstream of the sample site. Latitude 36°48'19.4", Longitude -93°27'41.7" (Borchelt, 2007).

James River south of Northview, MO

This is not a USGS-monitored site. It is located at State Hwy. B south of Northview in Webster County, Missouri. Latitude 37°26.16", Longitude 93°0".

Flat Creek below Jenkins, Missouri

This site (USGS site 07052820) is mostly agricultural with some forests and very little urban land use. It is about four miles downstream of Jenkins, Missouri. It has a median flow of 95 CFS, but the gage has only been in operation since May 4, 2007 (USGS, 2008). Jenkins has a population of 382 as of the 2000 census and therefore does not appear large enough to have a wastewater treatment plant (Wikipedia, 2008). Latitude 36°45'02", Longitude -93°37'06

Flat Creek at Hwy. C, Missouri

This is not a USGS-monitored site. It is located downstream of State Highway C below the confluence of Little Flat to the FR 2080 (1165) crossing in Barry County, Missouri. Latitude N36°48.715", Longitude 93°46.007".

Bull Creek near Walnut Shade, Missouri

This site (USGS site 07053810**)** is dominated by forest with very little urban development. It is a potential site for development due to its location near Highway 65. Latitude 36°43'03.9", Longitude -93°12'24.5" (Borchelt, 2007).

Bull Creek at Center Road, Missouri

This is not a USGS-monitored site. This site is in Christian County, Missouri, at the Center Road crossing in Mark Twain National Forest. Latitude N36°54.456", Longitude W93°8.331".

Swan Creek near Swan, Missouri

This site (USGS site 07053900) is mostly agricultural with some forests and very little urban land use. Additional information could not be found on the USGS Water Resources web page. Latitude 36°47'12", Longitude -93°03'41"

Beaver Creek at Bradleyville, Missouri

USGS site 07054080 has a large number of beef cattle operations in the watershed. There is also some gravel mining in the watershed. Latitude 36°46'46.7", Longitude -92°54'26.2 (Borchelt, 2007).

Beaver Creek at Hwy. 76, Missouri

This is not a USGS-monitored site. This site is in Douglas County, MO. Latitude N36°54.104", Longitude W92°46.001".

West Fork White River east of Fayetteville, Arkansas

This site (USGS site 07048550) is mostly forested but has some grassland/pasture and some urban land use. Latitude 36°03'14", Longitude -94°04'59"

Middle Fork White River near Fayetteville, Arkansas

This site (USGS 07047985) is in Washington County, Arkansas. Latitude 36°00'58", Longitude 94°03'59".

White River near Fayetteville, Arkansas

Forests and agriculture dominate this watershed (USGS site 07048600), however there is an increasing amount of urban residential area spreading from Fayetteville, Arkansas. Latitude 36°04'23", Longitude -94°04'52"

White River at Elkins, Arkansas

This site (USGS 07047980) is located in Washington County, Arkansas. Latitude 36°00'03", Longitude 94°00'13".

Richland Creek at Goshen, Arkansas

USGS site 07058800 has thick stands of river cane on both sides of the stream and nearly stagnant water during base-flow conditions. Land use is mainly forest with areas of grassland/pasture and some urban areas closer to Fayetteville, Arkansas. Latitude 36°06'15", Longitude -94°00'27" (Borchelt, 2007).

Richland Creek at CR 79, Arkansas

This is not a USGS-monitored site. This site is in Washington County, AR. Latitude N 36^0 02.701', Longitude W 93^0 58.064'

Richland Creek near Wesley, Arkansas

This site (AR DEQ RCH01) is at the Hwy. 303 bridge ¼ mi. south of Hwy. 74 near Wesley in Madison County, AR. Latitude N36°0.644", Longitude 93°53.242".

War Eagle Creek near Hindsville, Arkansas

This watershed (USGS site 07049000) is predominately forest with pastures in the bottom lands. Poultry production is also present. War Eagle Creek watershed also receives effluent from Huntsville municipality Wastewater Treatment Plant. Latitude 36°12'00", Longitude -93°51'18" (Borchelt, 2007).

War Eagle Creek near Huntsville, Arkansas

This site (USGS site 07048960) is located in Madison County, AR, at Highway 23 southeast of Huntsville. Latitude N 36^0 06.828', W 93^0 41.667'.

Kings River near Berryville, Arkansas

This site (USGS site 07050500) is dominated by forest with some pasture and some urban land use. The Berryville Wastewater Treatment facility discharges into the Kings River. This watershed also contains a large poultry industry. Latitude 36°25'38", Longitude -93°37'15" (Borchelt, 2007).

Kings River southwest of Berryville, Arkansas

This site is not a USGS-monitored site. It is located at Arkansas DEQ site KGS05 at the Hwy 221 bridge six miles southwest of Berryville, AR in Carroll County, Arkansas. Latitude 36°18.84", Longitude 93°39.45".

Kings River near Kingston, Arkansas

This site (USGS site 07050225) is located in Madison County, AR, on Highway 21 near Kingston. Latitude N 36^0 03.752', Longitude W 93^0 32.155'.

Osage Creek southwest of Berryville, AR

This site (USGS site 07050390) is in Carroll County, AR. Latitude 36°20'55", Longitude 93°35'28".

Yocum Creek near Oak Grove, Arkansas

This site (USGS site 07053250) has mostly pasture with some forest in the watershed. There are two small communities and several poultry and cattle operations. Latitude 36°27'15.56", Longitude -93°21'21.61 (Borchelt, 2007).

Long Creek at Denver, Arkansas

This site (USGS site 07053207) is in Carroll County, Arkansas. The drainage area is 104 square miles and the largest town nearby is Green Forest, AR. It is mostly a rural area with flat-topped mountains covered with upland oak-hickory forests and limestone bluffs. Latitude 36°23'23", Longitude 93°19'01".

Pond Creek near Longrun, Missouri

This site (USGS site 07054285) is in Ozark County, MO. It is mostly rural in the Ozark Mountains with Gainesville being the largest community. The hills are covered with oak-hickory forests. Latitude 36°39'24", Longitude 92°40'55".

Crane Creek at Hwy.AA, Missouri

This site (USGS site 365119093271601) is in Stone County, MO. I. Latitude N 36^0 51.352', Longitude W 93^0 27.371'.

Turkey Creek near Theodosia, Missouri

This is not a USGS-monitored site. It is in Ozark County, MO, east and north of Theodosia, MO, at a low water crossing on County Road 865/863. Latitude N 36^0 40.186', Longitude W 92^0 37.939'.

Bear Creek near Omaha, Arkansas

This site (USGS site 07054410) is in Boone County, AR, on Highway 14 east of Omaha. Latitude N 36^0 26.394', Longitude W 93^0 4.689'.

Water Quality Index

Data

Twelve sites were included in the calculation of the Water Quality Index (Table 1) where water quality data are available from the prior three years (since August, 2008). Some stormflow data (defined below) were not included in the Water Quality Index calculation.

Table 1. Upper White River Basin monitoring sites from 2008-2011.

USGS Site #	Sub-basin	Site name	Water Quality Index	Water Quality Trend Analysis	Biological Index
07052152	James	Wilson Creek near Brookline, MO	X	X	X
07052345	James	Finley Creek below Riverdale, MO	X	X	X
N/A*	James	Finley Creek near Sparta, MO			X
07052500	James	James River at Galena, MO	X	X	X
07052250	James	James River near Boaz, MO	X	X	X
N/A*	James	James River south of Northview, MO			X

USGS Site #	Sub-basin	Site name	Water Quality Index	Water Quality Trend Analysis	Biological Index
07052820	James	Flat Creek below Jenkins, MO	X		
N/A*	James	Flat Creek at Hwy.C, MO			X
N/A*	James	Crane Creek at Hwy.AA, MO			X
07053810*	Bull Shoals	Bull Creek near Walnut Shade, MO			X
N/A*	Bull Shoals	Bull Creek at Center Road, MO			X
07053900	Bull Shoals	Swan Creek near Swan, MO	X		
07054080*	Bull Shoals	Beaver Creek at Bradleyville, MO			X
N/A*	Bull Shoals	Beaver Creek at Hwy. 76, MO			X
07054285*	Bull Shoals	Pond Creek near Longrun, MO			X
N/A*	Bull Shoals	Turkey Creek near Theodosia, MO			X
07054410*	Bull Shoals	Bear Creek near Omaha, AR			X
07048600	Beaver	White River near Fayetteville, AR	X	X	X
07048800	Beaver	Richland Creek at Goshen, AR	X		X
07047980*	Beaver	White River at Elkins, AR			X
N/A*	Beaver	Richland Creek at CR 79, AR			X
N/A*	Beaver	Richland Creek near Wesley, AR			X
07049000	Beaver	War Eagle Creek near Hindsville, AR	X	X	X
07048960*	Beaver	War Eagle Creek near Huntsville, AR			X
07048550	Beaver	West Fork White River east of Fayetteville, AR	X	X	X
07047985*	Beaver	Middle Fork White River near Fayetteville, AR			X
07053250	Beaver	Yocum Creek near Oak Grove, AR	X		X
07050500	Beaver	Kings River near Berryville, AR	X	X	X
AR DEQ #KGS05*	Beaver	Kings River SW of Berryville, AR			X
07050225*	Beaver	Kings River near Kingston, AR			X
07050390*	Beaver	Osage Creek southwest of			

USGS Site #	Sub-basin	Site name	Water Quality Index	Water Quality Trend Analysis	Biological Index
		Berryville, AR			X
07053207*	Beaver	Long Creek at Denver, AR			X

* Not currently monitored by the USGS. N/A = No data have ever been collected at this site.

Method

The Water Quality Index score is calculated as the percentage of samples taken during the three-year index period that did not violate the thresholds (are not higher than the maximum threshold or lower than the minimum threshold; Table 2). Higher scores indicate a higher number of samples that were within the water quality thresholds. The method of calculating the Index score is as follows:

1. Scores were calculated for each parameter (dissolved oxygen, total nitrogen, total phosphorus, and *E. coli*) at each site at low and at medium discharge (streamflow; see below). The parameter score for each site in the table is the mean of the scores calculated from the low and medium discharge periods (high discharge periods were not included).
2. The average of the parameter scores were calculated to obtain a Water Quality Index score for each site.
3. A Modified Water Quality Index also was calculated for each site. The Modified WQI was calculated by curving each of the parameter scores relative to a reference site. The reference site (Buffalo River near Boxley, AR – USGS site 07055646) was selected to be indicative of a relatively undisturbed stream in the same ecoregion. The WQI scores for the reference site were 90, 91.7, 100, and 82.9 for dissolved oxygen, *E. coli*, TN, and TP, respectively. Therefore, the WQI scores for the Upper White River Basin sites were raised 10 for dissolved oxygen, 8.3 for *E. coli*, and 17.1 for TP. The raised scores are presented as Modified WQI score.

The Index was calculated using data from the preceding three years. This minimizes the importance of any particularly high or low flow year or sporadic rainfall events in any one area of the

basin in any one year. At least 30% of the data must be available for a parameter to be included in the calculation. This method does not take into account the magnitude of the violation of the threshold. Sites with the same number of violations would receive the same score whether the water quality results were slightly above the threshold or much higher. In addition, all parameters were given equal weight in the Index.

In order to determine the discharge categories, the log discharge measurements (instantaneous discharge or the mean daily discharge) were divided into three categories relative to the range of discharge. These correspond to the log intervals. For example, if the instantaneous discharge data range from 60 to 6000 cfs, the three categories were assigned as less than 100 cfs, 100 to 1000 cfs, and greater than 1000 cfs. The water quality data collected from the highest discharge category were identified as stormflow data and were not included in the calculation of the Index. When the flow at a site is stable (discharge does not vary by three orders of magnitude), the data were divided approximately equally into two discharge categories of high and low. In addition, when multiple samples were taken by the USGS over a short time period (24 to 48 hours), one sample was randomly selected to be included in the calculation of the discharge categories. However, most of these were identified as stormflow data, as described above, and subsequently were not included in the analysis.

Table 2. Minimum thresholds and maximum limits used in the calculation of the water quality index.

Parameter	Timeframe of interest	Minimum threshold	Maximum limit	Notes
Dissolved oxygen	Whole year	5 mg/L	110%	Minimum threshold based on Missouri standards for aquatic life use. Maximum threshold set for percent saturation to account for the effect of temperature (100% saturation is the amount of oxygen water can hold at a particular temperature)
E. coli	Whole year	n/a	126 per 100 ml	Maximum threshold based on Missouri standards for whole body contact recreation and losing streams
TN	Whole year	n/a	0.46 mg/L	Upper limit of EPA recommended criteria for the central and eastern forested uplands
TP	Whole year	n/a	0.01 mg/L or detection limit	The EPA recommended criteria for the central and eastern forested uplands is 0.007 mg/L. Threshold set at detection limit (normally 0.01 mg/L)

Trend analysis

Data

Trend analyses were conducted on total phosphorus, total nitrogen, dissolved oxygen, and *E. coli* at eight sites in the basin (Table 1). In order to be included in the trend analysis, water quality and mean daily discharge data from the site were current and available from the prior five years. Discharge data were necessary to develop an accurate model of the trend in a parameter over time because all of the water quality parameters were strongly dependent on discharge. This includes contemporaneous discharge (current streamflow at the time the sample was taken) as well as rolling averages of antecedent discharges. Prior frequency and intensity of storm events can affect current water quality characteristics.

Method

The trend analysis method used was similar to that of Anderson and Smith (2006). Briefly, censored regression in Minitab 15™ (Minitab, Inc.) was used to estimate a trend in water quality

concentration adjusting for season and contemporaneous and antecedent stream flow. The stream flow variables included 7-day to 5-year moving averages of mean daily discharge at the site. The entire 5-year antecedent discharge dataset was only available for a few sites, and was not included in the analysis if not available in full. The regression analysis was evaluated at 95% confidence.

Ecological condition

Data

Ten sites were selected for benthic invertebrate monitoring each year (Table 1). The monitoring protocols followed those of the National Park Service (Bowles et al., 2007) with some modifications. Briefly, two benthic invertebrate samples were collected from each of three riffles at each site from December 2008 to February 2011. The two samples from each riffle were combined to result in three samples from each site. Invertebrate samples were processed in the laboratory and were identified to the lowest possible taxon. In most cases, invertebrates were identified to genus level but some were identified only to family or order.

Method

Four benthic invertebrate community metrics were used to assess general ecological condition at each site following the Stream Condition Index of Rabeni et al., (1997).

Taxa Richness. This metric is the total number of taxa in a sample. High taxa richness reflects higher ecological condition.

EPT Richness. This metric is the total number of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) taxa in a sample. These taxa are considered

particularly sensitive to poor water and habitat quality, so high EPT richness reflects higher ecological condition.

Shannon's Diversity Index. Shannon's Diversity is a measure of evenness in the invertebrate community. Higher diversity values indicate that several taxa are well-represented in the community. Low diversity indicates that only one or two taxa dominate and this is an indication of poor ecological condition.

Biotic Index. Each taxon was assigned a pollution tolerance value that reflects its known or assumed tolerance to poor water quality, particularly organic pollution. Tolerance values range from 1 to 10, where 1 indicates an extremely sensitive taxon and 10 indicates high tolerance. These were taken from published sources (Bowles et al., 2007). The Biotic Index value is the mean of the tolerance values of all of the invertebrates in a sample.

The four metrics were calculated for each of the three samples at each site and the average of these is presented in Table 5. The metric values were assigned a score using the guidelines below (Bowles et al., 2007; Table 3). The overall Stream Condition Index score is the total of the metric scores for each site. Stream Condition Index scores range for 16 to 20 for sites that are not impaired, 10 to 14 for impaired, and 4 to 8 for very impaired.

These scoring criteria were developed by Rabeni et al. (1997) based on the scores obtained from reference stream sites (streams with little or no watershed impacts). In their study, the lower 25th percentiles of SCI scores for these reference streams were higher than 16 and the median score for sites known to be impaired was 10. The ranges for the SCI scores were selected accordingly.

Table 3. Metric scoring criteria for the Stream Condition Index.

Metric	Scores		
	5	**3**	**1**
Taxa Richness	>=14	13-12	<12
EPT Richness	>=6	5	<5
Shannon's Diversity Index	>=4.3	4.2-1.9	<1.9
Biotic Index	<=3.40	3.41-3.55	>3.55

FINDINGS

Water Quality Index

The Modified Water Quality Index scores ranged from a high of 89.4 on Swan Creek near Swan, Missouri (site 7053900), to a low of 30.4 at Wilson's Creek at Brookline, Missouri (site 7052152; Table 4). Most of the scores were in the 40's and 50's. Variation in the scores from year to year is expected and is likely associated with normal variation in water quality measurement and the error associated with calculating the scores.

Table 4. Parameter scores and Water Quality Index (WQI) scores for sites in the Upper White River Basin. The Modified WQI score is curved to the score of a reference site. Data were collected by the USGS from September 2008 through September 2011.

Site	Dissolved Oxygen	*E. coli*	TN	TP	WQI Score	Modified WQI Score
West Fork White River – Fayetteville, AR (07048550)	100	47.5	29.2	39.2	54.0	**60.3**
White River – Fayetteville, AR (07048600)	100	70.0	34.0	0.0	51.0	**57.4**
Richland Creek at Goshen, AR (07048800)	61.1	52.8	10.0	35.6	39.9	**48.7**
War Eagle Creek – Hindsville, AR (07049000)	83.8	75.0	0.0	0.0	39.7	**48.6**
Kings River near Berryville, AR (07050500)	45.0	100	30.0	0.0	43.8	**50.5**
Wilson Creek – Brookline, MO (07052152)	9.8	76.4	0.0	0.0	21.5	**30.4**
James River – Boaz, MO (07052250)	70.0	83.3	0.0	5.0	39.6	**48.4**
Finley Creek – Riverdale, MO (07052345)	61.1	86.1	0.0	45.4	48.2	**57.0**
James River – Galena, MO (07052500)	69.4	83.3	0.0	17.6	42.6	**51.5**
Flat Creek – Jenkins, MO (07052820)	53.5	87.1	7.5	60.0	52.0	**60.9**
Yocum at Oak Grove, AR (07053250)	68.0	57.4	0.0	0.0	31.3	**40.2**
Swan Creek – Swan, MO (07053900)	72.1	79.8	87.5	93.7	83.3	**89.4**

Trend analysis

A majority of the analyses showed no statistical change of a parameter at a site over time (Appendix 1). While a parameter at a particular site occasionally indicates a trend, most of these have been inconsistent due to variability from year to year. However, six trends at four sites have been consistent during the three years of analyses:

- A drop in total phosphorus in the James River at Boaz, MO, and at Galena, MO (Appendix 1, Figures 8 and 16). This is likely due to the installation of a tertiary treatment process at the City of Springfield Southwest Wastewater Treatment Plant and other non-point source phosphorus reductions in the greater Springfield area.
- A drop in total phosphorus in Finley Creek below Riverdale, MO (Appendix 1, Figure 12). This also likely can be attributed to efforts in the City of Ozark to control phosphorus.
- An increase in *E. coli* in the James at Boaz and an increase in total nitrogen in the James River at Galena (Appendix 1, Figures 6 and 15). While control of phosphorus in the wastewater treatment process has been successful, nitrogen and *E. coli* levels in the James are still indicative of wastewater discharge from a major metropolitan area.
- An increase in dissolved oxygen in the White River near Fayetteville (Appendix 1, Figure 29). This site is immediately downstream of a small impoundment. The increase in oxygen at the site likely reflects an increase of dissolved oxygen concentrations in the small reservoir. This most often is due to an increase in algae growth.

Ecological condition

The ecological condition scores for most sites in the Upper White River Basin were within the range of 'impaired' (Table 5). However, several sites, particularly in the headwater areas of the basin, received high scores for taxon richness and EPT richness, indicating a high proportion of sensitive taxa at those sites. The raw invertebrate sample data are listed in Appendix 2. Physical and chemical data that were collected concurrent to the benthic invertebrates are presented in Appendix 3.

Table 5. Metric scores and the Stream Condition Index score calculated from the benthic invertebrate samples. The metric scores are presented with standard errors. Site names in bold were sampled in 2010-2011.

Site	USGS Site Number	Taxa Richness	EPT Richness	Shannon's Diversity	Biotic Index	SCI Score
James River near Boaz, MO	07052250	13 ± 3.6	8.7 ± 2.3	0.6 ± 0.2	5.9 ± 0.0	**10 impaired**
James River at Galena, MO	07052500	14 ± 2.5	10 ± 1.2	1.6 ± 0.4	4.8 ± 0.6	**12 impaired**
James River south of Northview, MO	N/A	25 ± 3.6	13 ± 2.0	1.6 ± 0.0	5.0 ± 0.1	**12 impaired**
Finley Creek below Riverdale, MO	07052345	12.3 ± 2.4	10 ± 1.7	1.3 ± 0.3	5.0 ± 0.3	**10 impaired**
Finley Creek near Sparta, MO	Footnote*	21.1 ± 4.8	13.3 ± 2.7	1.2 ± 0.4	5.3 ± 0.4	**12 impaired**
Flat Creek below Jenkins, MO	07052820	16.3 ± 1.5	10 ± 1	1.6 ± 0.2	4.6 ± 0.3	**12 impaired**
Flat Creek at Hwy. C, MO	N/A	29.7 ± 2.2	13 ± 1.0	2.3 ± 0.0	4.8 ± 0.2	**14 impaired**
Swan Creek near Swan, MO	07053900	14.7 ± 2.0	9.3 ± 0.7	1.9 ± 0.1	4.9 ± 0.1	**14 impaired**
Bull Creek near Walnut Shade, MO	07053810	27.3 ± 2.9	15.3 ± .7	1.8 ± 0.3	5.6 ± 0.1	**12 impaired**
Bull Creek at Center Road, MO	N/A	27.0 ± 0.6	13 ± 0	2.1 ± 0.1	5.4 ±0.1	**14 impaired**
Beaver Creek at Bradleyville, MO	07054080	16 ± 2.1	12 ± 1.5	1.1 ± 0.3	5.4 ± 0.2	**12 impaired**
Beaver Creek at Hwy. 76, MO	N/A	22 ± 1.2	11.7 ± 0.3	2.0 ± 0.1	3.9 ± 0.2	**14 impaired**

Site	USGS Site Number	Taxa Richness	EPT Richness	Shannon's Diversity	Biotic Index	SCI Score
Pond Creek near Longrun, MO	07054285	23 ± 3.2	16.7 ± .9	1.7 ± 0.1	4.0 ± 0.4	**12 impaired**
Crane Creek at Hwy.AA, MO	N/A	23.7 ± 2.8	16 ± 2.2	1.8 ± 0.1	4.6 ± 0.1	**12 impaired**
Turkey Creek near Theodosia, MO	N/A	20.7 ± 1.5	12 ± 0	1.7 ± 0.1	5.2 ± 0.6	**12 impaired**
White River near Fayetteville, AR	07048600	18.7 ± 3.3	9.3 ± 1.8	1.8 ± 0.2	5.8 ± 0.1	**12 impaired**
White River at Elkins, Ar	07047980	18 ± 2.3	11.3 ± 1.9	1.8 ± 0.1	4.8 ± 0.1	**13 impaired**
War Eagle Creek near Hindsville, AR	07049000	17.3 ± 0.9	11 ± 1.5	1.6 ± 0.4	5.3 ± 0.3	**12 impaired**
West Fork White River east of Fayetteville, AR	07048550	14.7 ± 1.5	10 ± 1	1.6 ± 0.0	5.7 ± 0.1	**12 impaired**
Middle Fork White River near Fayetteville, AR	07047985	22.7 ± 1.7	10.3 ± 0.9	2.1 ± 0.1	5.0 ± 0.4	**14 impaired**
Yocum Creek near Oak Grove, AR	07053250	15 ± 1	9.7 ± 1.7	1.7 ± 0.0	5.3 ± 0.1	**12 impaired**
Kings River near Berryville, AR	07050500*	11 ± 4.5	8.7 ± 3.9	1.0 ± 0.5	5.6 ± 0.2	**8 very impaired**
Kings River SW of Berryville, AR	AR DEQ #KGS05	25.3 ± 0.3	15.7 ± 0.9	1.9 ± 0.1	4.8 ± 0.4	**14 impaired**
Kings River near Kingston, AR	07050225	23.3 ± 2.7	16 ± 1.5	1.5 ± 0.2	4.8 ± 0.3	**12 impaired**
Osage Creek SW of Berryville, AR	07050390	20 ± 2.5	12.3 ± 0.3	1.6 ± 0.1	5.1 ± 0.1	**12 impaired**
Long Creek at Denver, AR	07053207	8.7 ± 2.2	5.3 ± 2.4	1.1 ± 0.5	3.5 ± 1.7	**8 very impaired**
War Eagle Creek near Huntsville, AR	07048960	20 ± 1.2	13 ± 0.7	2.1 ± 0.2	5.2 ± 0.2	**14 impaired**
Bear Creek near Omaha, AR	07054410	9.7 ± 1.2	4 ± 1	0.5 ± 0.1	5.9 ± 0.1	**4 very impaired**
Richland Creek at CR 79, AR	N/A	17 ± 0.6	13 ± 1.2	1.2 ± 0.2	5.1 ± 0.4	**12 impaired**
Richland Creek near Wesley, AR	AR DEQ #RCH01	16.3 ± 1.2	10.3 ±1.2	1.7 ± 0.3	5.6 ± 0.1	**12 impaired**

* Finley Creek near Sparta USGS site #370215093031901

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