PHYSICAL, CHEMICAL AND BIOLOGICAL

ASSESSMENT OF THE

MIDDLE FORK LITTLE RED RIVER WATERSHED

Searcy, Stone Van Buren, and Cleburne Counties, Arkansas

ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY
Water Division

June 2006
WQ-06-06-01

Etheostoma moorei, the yellow cheek darter is endemic to the South, Archey, Middle, and Devils Forks of the Little Red River. (Photo by Erica Shelby)

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http://www.adeq.state.ar.us/water
Cover Photo: Middle Fork Little Red River, central AR

STATE OF ARKANSAS

DEPARTMENT
OF
ENVIRONMENTAL QUALITY

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OF THE
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2006

WATER DIVISON, PLANNING SECTION

Mr. Martin Maner, P.E. is currently the Chief and Mr. Steve Drown is the Assistant Chief of the Water Division. Both are actively involved with many of the activities of the Water Quality Planning Branch. The Water Quality Planning Branch consists of ten biologists/ecologists and two geologists. This branch deals with a variety of issues related to surface and ground water. Among the numerous activities is the management of the State Water Quality Monitoring Network for both surface and subsurface waters. Included in the network is routine monitoring as well as intensive, special investigations of watersheds and/or aquifers. The data generated from these activities are used to prepare the biennial "Integrated Water Quality Monitoring and Assessment Report (305B)" and the "List of Impaired Waterbodies, (303(d) list)", and to develop Total Maximum Daily Loads (TMDLs) for impaired water bodies. The data are also used to develop water quality standards and criteria for designated use assessment.

The staff continues to develop and/or enhance ecoregion-based, biological assessment criteria for both fish and macroinvertebrates. The staff additionally is active in the development and updating of water quality standards and technical review and administration of the National Pollutant Discharge Elimination System Permits Biomonitoring Program. Ground-water issues of concern in recent years have included the investigation of pesticides in ground water, potential impacts from confined animal operations, saltwater intrusion in southeastern Arkansas, and most recently the development of groundwater standards. Various staff members represent the Department on numerous Federal, State, local, and watershed-based advisory boards and technical support groups.

Current staff includes:

Martin Maner, P.E., Chief, Water Division
Steve Drown, Assistant Chief, Water Division

Planning Branch

Bob Singleton, Technical Assistance Manager (Section Manager)
Jim Wise, Technical Assistance Manager
Sarah Clem, Water Quality Resources Specialist
Erica Shelby, Water Quality Resources Specialist
Mary Barnett, Program Coordination Section Manager
Jill Glenn, Ecologist II
Sam Lackey, Ecologist II
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John Fazio, Senior Geologist

Education and Outreach Branch

Ellen McNulty, Program Support Manager
Philip Osborne, Program Coordinator
Rob Beadel, Ecologist II
Cyndi Porter, Administrative Assistant II

To learn more about the Water Division and other divisions of the Arkansas Department of Environmental Quality, and to view a list of publications by the Planning Branch of the Water Division, visit http://www.adeq.state.ar.us/water or call at (501) 682-0660.

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INTRODUCTION

The Middle Fork Little Red River originates in southern Searcy County, Arkansas south of Marshal. It flows through four counties and enters Greers Ferry Lake southeast of the City of Shirley. The entire watershed is in the Boston Mountains ecoregion.

There are 224,487 acres in the Middle Fork Little Red River watershed. Land use activities have been estimated to be 78% silviculture, 21% agriculture, and less than one percent (<1%) other. Silviculture activities are limited to small, privately-owned parcels; some of which are being converted to pasture. Agriculture activities historically included confined animal operations and pasture for cattle grazing and hay production. However, most of the confined animal operations were inactive during this survey. Other land uses include forestry for firewood production and the mining of slab rock for building and landscaping material. Recreation - mainly hunting, fishing, and canoeing - occurs throughout the watershed. There are several state and federally listed "endangered species" and/or "species of concern" occurring in the Middle Fork Little Red River. The two most critically listed species are the Yellow Cheek darter and the Speckled Pocketbook mussel (US FWS 2001, 1989). Also, the Longnose darter and an additional 15 mussel species are listed as "species of concern" by the U.S. Fish and Wildlife (C.L. Davidson, US FWS, 2005, personal communication). The Yellow Cheek darter is listed as the number one fish species for conservation management by the Arkansas Game and Fish Commission (2005).

Arkansas' 2004 Integrated Water Quality Monitoring and Assessment Report (305(b)) identified 99 stream miles in the watershed, of which 75.3 were assessed. The report identified two stream segments, 20.8 stream miles, as only partially supporting the aquatic life use because of low dissolved oxygen concentrations, and the same 20.8 stream miles as not supporting the primary contact recreation use because of high fecal coliform bacteria concentrations.

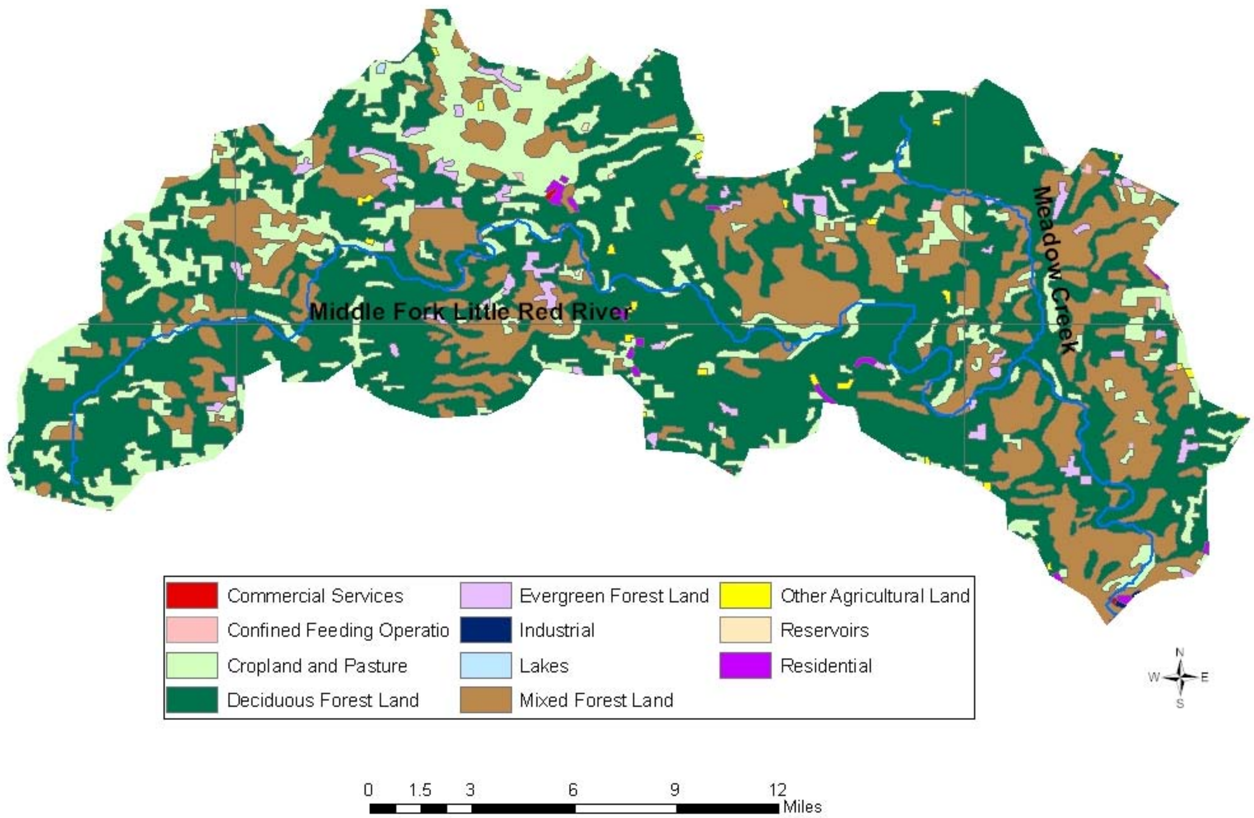
The designated uses for the Middle Fork Little Red River include: 1) Extraordinary Resource Waters; 2) Ecologically Sensitive Waterway; 3) Primary Contact Recreation; 4) Secondary Contact Recreation; 5) Domestic, Industrial and Agricultural Water Supply; and 6) Seasonal and Perennial Boston Mountains Ecoregion Fisheries.

GEOLOGY

The physiography of the lower Boston Mountains is characterized by dissected undulating plateaus, low mountains and high rounded hills. Mountaintops and hills are capped by resistant sandstones and limestones, and sideslopes are generally underlain by less resistant interbedded siltstones, sandstones, and shales (Woods et al., 2004).

The drainage basin of the Middle Fork of the Little Red River is underlain by Paleozoic strata ranging from Late Mississippian (Chesterian) to Early Pennsylvanian (Morrowan) in age (Glick, 1973a-c) (Figure 2). The Chesterian Series in north-central Arkansas is composed chiefly of shale, limestone and minor sandstone and generally reflects deposition in deep- to shallow-marine environments.

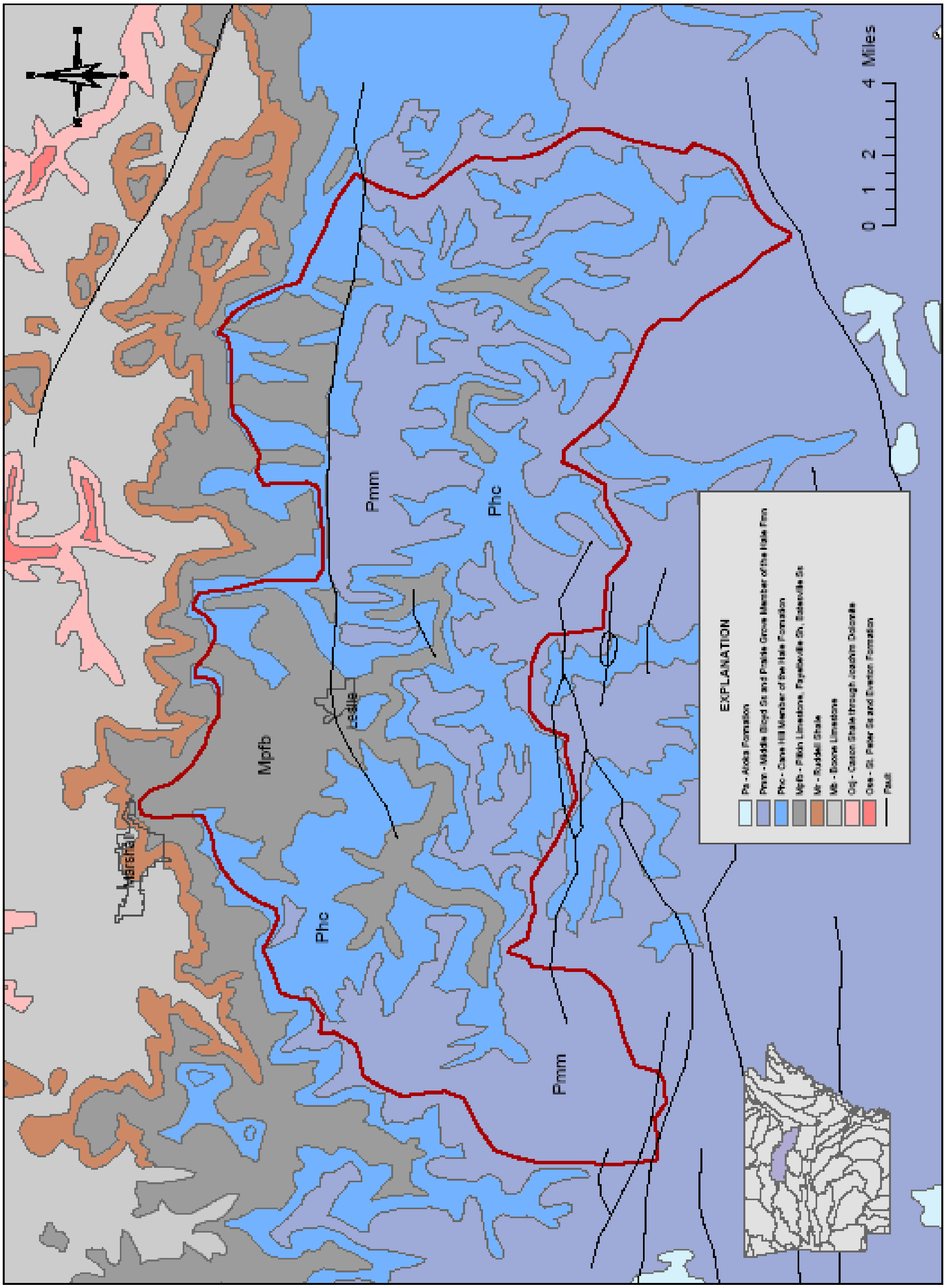
Figure 1: Watershed Land Use



The Morrowan Series is dominated by shale and sandstone with minor limestone units. These Pennsylvanian strata contrast in character from the Late Mississippian limestones, reflecting a change from carbonate platform deposition to near shore and strandline conditions. The Morrowan terrigenous clastic sediments were derived from extensive ancestral Mississippi River deltaic deposits that were swept from the main delta front by longshore currents and transported westward along the continental shelf and deposited. Fluctuations of the shoreline over these deposits produced a composite of terrestrial and shallow-marine sediments and associated unconformities (Sutherland and Manger, 1979).

Strata in this region dip gently to the south, resulting in progressively younger exposures of strata as one traverses south. Morrowan strata are found at the highest elevations throughout the study area, while Chesterian units are exposed along the lower reaches of the Middle Fork of the Little Red River and its tributaries, as well as on some hilltops in the northern part of watershed. A strike-oriented, down-to-the-south normal fault bisects the majority of the northern portion of the watershed, and a series of east-west trending normal faults are proximal to the southern boundary of the watershed (Haley et al., 1993) (Figure 2).

Figure 2: Middle Fork Little Red Watershed Geology



The Chesterian strata in this region consists of, in ascending order, the Batesville Sandstone, the Fayetteville Shale, and the Pitkin Limestone formations (Glick, 1973a-c). The Batesville Sandstone is a flaggy, fine- to coarse-grained, cream-colored to brown quartzarenite with thin shales. The basal contact is unconformable and often marked by a chert conglomerate. The thickness of the Batesville Formation is quite variable in northern Arkansas, ranging from a feather edge to over 200 feet.

The Fayetteville Shale conformably overlies the Batesville Sandstone and is a black, fissile, concretionary, clay shale. Dark-gray, micritic limestone beds are interbedded with the shales in north-central Arkansas. Fossils are abundant in some intervals and in local areas. The Fayetteville Shale ranges in thickness from 10 to 400 feet in northern Arkansas.

The Pitkin Limestone Formation is most commonly a bluish-gray, fine- to coarse-grained, oolitic, bioclastic limestone. The basal contact is considered conformable with the Fayetteville shale.

Fossils are common and include various invertebrates, conodonts, and shark teeth. The bryozoan *Archimedes* is a good index fossil for this unit, but also occurs in subjacent formations (McFarland, 1998). The average formation thickness in the study area is about 200 feet (Glick, 1973a-c).

An upper Mississippian age sequence mapped on the Geologic Map of Arkansas as the lower part of the Cane Hill Member, Hale Formation, in north-central Arkansas has been offered as a separate unit called the Imo Formation (Gordon, 1964). This sequence is a fossiliferous, gray to black shale with some fine-to coarse-grained, phosphatic sandstone and conglomeritic limestone. Uppermost Mississippian age fossils are common in some intervals and include invertebrates, palynomorphs, and plant material. The upper boundary is poorly defined and may be a shale on shale contact, while the lower contact appears conformable with the Pitkin Limestone. This formation thickness in northern Arkansas ranges from 200-340 feet (McFarland, 1998).

The Morrowan strata in the study area are represented by the Hale Formation and strata assigned to the Bloyd Formation (Glick, 1973a-c). The Hale Formation is made up of a lower Cane Hill Member and an upper Prairie Grove Member. The Cane Hill Member is typically composed of dark gray, silty shale interbedded with siltstone and thin-bedded, fine-grained limestone with some locally calcareous lithologies and isolated thick to massively bedded sandstones. The lower contact of the Cane Hill Member marks the Mississippian-Pennsylvanian boundary in north Arkansas.

The Prairie Grove Member of the Hale Formation is composed of thin to massive, often cross-bedded, frequently pitted, light-gray to dark-brown, limy sandstone or variously sandy limestone with lenses of relatively pure, crinoidal, highly fossiliferous limestone and oolitic limestone. Fossils are common but fragmental, and include a variety of invertebrates and microfossils. Formation thickness ranges from a few feet to more than 300 feet in northern Arkansas (McFarland, 1998).

The Bloyd Formation in the study area is undifferentiated, and is mapped collectively with the Prairie Grove Member of the Hale Formation as middle Morrowan (Glick, 1973a-c). The interval of Bloyd strata is represented by 30-100 feet of massive cross-bedded pebble-bearing sandstone (Sutherland and Manger, 1979). Sedimentary structures include large-scale tabular cross-bedding, conglomerate beds, ripple-laminated beds, and clay drapes. These suites of sedimentary structures together with paleocurrent measurements derived from the tabular foresets suggest that the sand and gravel was deposited in a southward flowing fluvial environment subsequently transgressed by a marine sandstone (Glenn, 1972). This unit is informally referred to as the middle Bloyd sandstone. Its lower contact is unconformable with the Hale Formation in the study area (McFarland, 1998).

GOALS AND OBJECTIVES

The main objective of this survey was to assess the waters of the Middle Fork Little Red River (USGS HUC 11010014) to confirm and better identifying the areas of water quality impairment, the causes and sources of the impairments, and to delineate impairments, if any, by sub-basin in order to better facilitate corrective actions.

The goals of this survey were:

1) Develop water quality and biological data to better assess the designated use attainment within the watershed;
2) Identify, if any, the causes and sources of any designated use non-attainment;
3) Suggest corrective action measures to restore designated uses to full attainment.

ASSESSMENT SURVEY WORK PLAN

This two year assessment of the Middle Fork Little Red River utilized three major activities: 1) a watershed land use survey; 2) a synoptic water quality, macroinvertebrate and fish community survey; and 3) a stream bank, riparian zone habitat survey.

Sample stations (Table 1) were located at the base of the major sub-basins, along the main stem of the river, and at other strategic points to determine background conditions and loadings from both point and nonpoint pollution sources. Macroinvertebrate and fish communities were sampled at selected stations to obtain a representative data base throughout the watershed. Storm flow grab samples were collected from all of the sites to determine nonpoint source inputs. Water quality parameter analyses, Table 2, included the routine water quality indicators, in-situ parameters including flow determination, metals, and *Escherichia coli* bacteria. In addition, a USGS flow gauging station was utilized to determine stream flows.

Table 1: Middle Fork Little Red River Monitoring Stations

SITE ID	WATER BODY (stream) / LOCATION (Sec., Township, Range)	County	WS	Samples W	M	F	O	Latitude Longitude
WHI0180	Little Red Creek Co. rd south of Canaan off Hwy 333 (Sec 35, T14N, R16W)	Searcy	14.5	X				35 48 43.84 92 38 53.19
WHI0181	Middle Fork Little Red River Co. rd 40 south of Canaan off Hwy 333 (Sec 36, T14N, R16W)	Searcy	56.3	X	X	X	X	35 48 28.21 92 38 43.31
UWMFK01	Middle Fork Little Red River At US Hwy 65 south of Leslie (Sec 35, T14N, R15W)	Searcy	71.8	X	X		X	35 48 58.73 92 32 57.92
WHI0182	Cove Creek Hwy. 66 at Leslie (Sec 26, T14N, R15W)	Searcy	32	X	X			35 49 30.63 92 33 29.94
WHI0183	City of Leslie WWTP WWTP located south of Leslie off Hwy 66	Searcy		X				35 49 28.99 92 33 20.59
WHI0176	Cove Creek south of Leslie WWTP off HWY. 66 (Sec 26, T14N, R15W)	Searcy	32.5	X	X		X	35 49 17.28 92 33 05.69
WHI0177	Middle Fork Little Red River 2 mi. south of Leslie off US HWY. 65 (Sec 35, T14N, R15W)	Searcy	105	X	X	X	X	35 48 16.31 92 32 30.87
WHI0178	Middle Fork Little Red River Co. rd. north of Arlberg (Sec 29, T13N, R13W)	Stone	184	X	X	X		35 44 04.12 92 23 22.60
WHI0153	Meadow Creek Co. rd. north of Arlberg (Sec 15, T13N, R13W)	Stone	41	X	X			35 46 10.51 92 20 51.81
WHI0043	Middle Fork Little Red River Hwy. 9 at Shirley (Sec 25, T12N, R13W)	Van Buren	302	X	X	X	X	35 39 07.11 92 19 10.97
WHI0179	Weaver Creek Hwy. 16 south of Hwy. 9 intersection (Sec 25, T12N, R13W)	Van Buren	31.5	X	X	X		35 38 52.50 92 19 01.19

W - water sample site
M - macroinvertebrate sample site
F - fish community sample site
O - diurnal dissolved oxygen sample site
Co. Rd. - county road
RF1 - river reach one
WS - watershed size (mi^2)

str seg - stream segment
Sec. - section number
Tnsp. - township
Rng. - range

Table 2: Water Quality Parameters

In-Situ & Lab Analyses		Metals, Dissolved	
pH	Sulfates	Aluminum	Iron
Dissolved Oxygen	Total Dissolved Solids	Barium	Lead
Temperature	Total Suspended Solids	Beryllium	Manganese
Flow	Total Hardness	Boron	Nickel
Ammonia Nitrogen	Turbidity	Cadmium	Potassium
Nitrate-Nitrite Nitrogen	Total Organic Carbon	Calcium	Sodium
Total Phosphorus	Biochemical Oxygen Demand	Chromium	Vanadium
Ortho-Phosphorus	*Escherichia coli*	Cobalt	Zinc
Chlorides	Copper		

WATER QUALITY STANDARDS

Table 3 outlines the water quality standards applicable to the Middle Fork Little Red River. Specific numeric standards for temperature, pH, in stream minimum dissolved oxygen concentration based on watershed size, minerals, and in stream turbidity dependent on flow are established. Specific numeric criteria for *Escherichia coli* and fecal coliform bacteria concentrations are also established. Narrative criteria exist for taste, odor, color and other aesthetics characteristics. Narrative criteria addressing nutrients based on excessive algae growth states that "Materials stimulating algal growth shall not be present in concentrations sufficient to cause objectionable algal densities or other nuisance aquatic vegetation or otherwise impair any designated use of a waterbody" (ADEQ, 2004). In addition, algae growth in a waterbody shall not be of a magnitude that would cause other numeric criteria not to be attained, such as the dissolved oxygen standard.

Table 3: Water Quality Standards*

Boston Mountains Ecoregion

Dissolved Oxygen (mg/L)	Primary	Critical
< 10 sq. mi. watershed	6	2
10 - 500 sq. mi. watershed	6	6
> 500 sq. mi. watershed	6	6

Chlorides	17 mg/L
Sulfates	12 mg/L
Total Dissolved Solids	92 mg/L

Temperature (C)	31

Turbidity		
	Primary	10 NTU
	Storm	19 NTU

*Critical Season standards apply when water temperatures reach 22 (C), usually between May and September.

ASSESSMENT CRITERIA

When assessing water quality data for designated use attainment decisions, one must take into consideration the possibility of one-time anthropogenic or naturally occurring disruptions that may cause exceedances of a standard, but which should not result in a designated use being evaluated as impaired. Exceedances resulting from *Naturally Occurring Excursions* (NOE), or determined to be *Natural Background* conditions, as defined in Reg. 2.106, will not be assessed as impaired, provided supporting rationale is included.

Bacteria

Primary Contact Waters - Between May 1 and September 30, the *Escherichia coli* counts shall not exceed a geometric mean of 126 col/100 ml or a monthly maximum value of not more than 298 col/100 ml. During the remainder of the calendar year, these criteria may be exceeded, but at no time shall these counts exceed the level necessary to support secondary contact recreation.

Secondary Contact Waters – The *Escherichia coli* values shall not exceed the geometric mean of 630 col/100 ml, or a monthly maximum of 1490 col/100ml.

Assessment – For assessment of ambient waters as impaired by bacteria, the above listed applicable values shall not be exceeded in more than 25% of samples in no less than eight (8) samples taken during the primary contact season or during the secondary contact season.

In April 2004, ADEQ began using *Escherichia coli* bacteria data to evaluate the attainment of contact recreational uses of the States' water bodies. Prior to April 2004, fecal coliform bacteria data was used.

Dissolved Metals – Dissolved metals standards are based on ecoregion hardness values.

* State of Arkansas Pollution Control & Ecology Commission, Regulation No. 2, April 23, 2004

The percent exceedance criteria as shown in the Assessment Criteria, Table 4, are calculated using the total number of samples. The number of data points exceeding the criteria which are necessary for an assessment decision will be calculated and rounded up to the nearest whole number; e.g. 25% of 38 data points = 9.5, therefore ten exceedances equal 25%. Therefore, ADEQ will use the 'round up to the next whole number' process to determine exceedances.

An evaluated assessment can be made for adjacent stream segments or in similar watersheds to monitored waters if there is reason to believe that the segments are similar with respect to the potential cause and magnitude of impairment. Unless documentation suggests otherwise, an evaluated assessment in the absence of data, but with general knowledge of the waterbody and watershed conditions, may be made as attainment of a use.

Table 4: Designated Use Assessment Criteria Boston Mountains Ecoregion Streams

Parameter	Support	Non-Support
Temperature	≤ 10%	> 10%
Dissolved Oxygen	≤ 10%	> 10%
pH	≤ 10%	> 10%
$CL/SO_4/TDS$		
Drinking Water	≤ 10%	> 10%
Ecoregion Criteria	≤ 50%	> 50%
Escherichia coli		
Primary Contact	≤ 25%	> 25%
Secondary Contact	≤ 25%	> 25%
Turbidity		
Primary flow	≤ 25%	> 25%
Storm flows	**≤ 20%**	> 20%

It is important to remember that the assessment methodology and criteria utilized in this survey was developed to evaluate water quality data associated with ADEQ's Ambient and Roving Water Quality Monitoring Networks. The goals and objectives, and the sampling methodology of these monitoring networks are different from those of this survey. Sample collection associated with this survey targeted extreme conditions, critical- and storm-flows, unlike the sample collection frequency of the monitoring networks. Samples collection from the monitoring networks follows a routine sampling protocol which may or may not include extreme conditions.

HISTORICAL WATER QUALITY DATA

Ambient Water Quality Monitoring Network Station (WHI0043)

Water quality data has been collected from the Middle Fork Little Red River at Arkansas Highway 9 at Shirley, Arkansas in Van Buren County for more than 20 years. Data from this site between October, 1998 and September, 2003 (Table 5) indicate that dissolved oxygen concentrations fell below the Boston Mountains Ecoregion water quality standard of 6 mg/L (Table 3) in approximately 20% of the samples collected during the primary season, and in approximately 35% of the samples collected during the critical season. The lowest dissolved oxygen concentration reading during that time was 4.1 mg/L. The majority of the dissolved oxygen readings below the standard occurred in either August or September. Three fecal coliform samples collected during the primary contact recreation season had concentrations above the standard, including one with a concentration of greater than 2664 col/100 ml.

Table 5: WHI0043 Middle Fork Little Red River Near Shirley
Water Quality Data Collected Between October 1998 and September 2003

Parameter	Data Points	Mean	Minimum	Maximum	% Samples not attaining standards
CS Dissolved Oxygen (mg/L)	21	6.84	4.10	17.40	35
PS Dissolved Oxygen (mg/L)	33	8.02	5.06	12.20	20
BOD_5 (mg/L)	56	0.9	0.00	3.32	
pH (standard units)	54	7.17	6.26	9.50	2
Total Organic Carbon (mg/L)	54	2.7	1.2	5.23	
Ammonia as N (mg/L)	58	0.01	<0.005	0.08	
NO_2+NO_3 as N (mg/L)	59	0.08	<0.01	0.58	
Orthophosphate as P (mg/L)	58	0.01	<0.005	0.06	
Total phosphorus as P (mg/L)	54	0.04	0.01	0.14	
Total hardness (mg/L)	29	40.45	21	114.00	
EC - Chloride (mg/L)	59	2.38	1.54	5.17	0
DW - Chloride (mg/L)	59	2.38	1.54	5.17	0
ER - Sulfate (mg/L)	58	5.74	2.64	14.90	2
DW - Sulfate (mg/L)	58	5.74	2.64	14.90	0
ER - Total dissolved solids (mg/L)	46	59.29	43	91.00	3
DW - Total dissolved solids (mg/L)	46	59.29	43	91.00	0
Total suspended solids (mg/L)	45	5.81	<1.0	25.00	
Turbidity (NTU)	57	6.89	1.7	25.00	4
Fecal Coliform Bacteria*	8		~22	>2664	38

CS – Critical Season PS – Primary Season
DW – Drinking Water EC – Ecoregion Criteria
*Bacteria assessment based on fecal coliform data collected from April through September, 2003.

Roving Water Quality Monitoring Network Station (UWMFK01)

There were four dissolved oxygen samples collected from this site during the critical season between October, 1998 and September, 2003. Two of those samples had concentrations (4.4 mg/L and 5.8 mg/L) below the 6.0 mg/L Boston Mountains ecoregion standard. Likewise, two bacteria samples collected during the primary contact recreation season had concentrations above the standard. An assessment of non-attainment cannot be based on such a small sample size. Table 6 tabulates the historical water quality data from the Middle Fork Little Red River (UWMFK01) south of Leslie, Arkansas.

Table 6: UWMFK01 Middle Fork Little Red River near Leslie

Water Quality Data Collected Between October 1998 and September 2003

Parameter	Data Points	Mean	Minimum	Maximum	% Samples not attaining standards
CS Dissolved Oxygen (mg/L)	4	5.55	4.40	6.32	50
PS Dissolved Oxygen (mg/L)	12	10.41	7.50	15.20	0
BOD_5 (mg/L)	15	0.644	0.1	1.19	
pH (standard units)	15	7.56	6.58	8.91	
Total Organic Carbon (mg/L)	17	2.219	<1.0	3.8	
Ammonia as N (mg/L)	17	0.021	<0.01	0.027	
NO_2+NO_3 as N (mg/L)	17	0.086	<0.01	0.367	
Orthophosphate as P (mg/L)	16	0.008	<0.005	0.02	
Total phosphorus as P (mg/L)	15	0.056	<0.01	0.394	
Total hardness (mg/L)	16	46.93	17	162	
ER - Chloride (mg/L)	17	3.87	1.68	13.9	0
DW – Chloride (mg/L)	17	3.87	1.68	13.9	0
ER - Sulfate (mg/L)	17	7.53	3.59	30.3	12
DW - Sulfate (mg/L)	17	7.53	3.59	30.3	0
ER - Total dissolved solids (mg/L)	17	77.62	40	204	18
DW - Total dissolved solids (mg/L)	17	77.62	40	204	0
Total suspended solids (mg/L)	17	4.459	1.0	55.8	
Turbidity (NTU)	16	9.744	0.82	59	
Fecal Coliform Bacteria*	7		7	2664	29

CS – Critical Season
PS – Primary Season
*Bacteria assessment based on fecal coliform data collected during the primary contact seasons of 1999 and 2003.

Based on the above data, Arkansas' 2004 Integrated Water Quality Monitoring and Assessment Report (305(b)) identified two stream segments in the watershed as only partially supporting the aquatic life use because of low dissolved oxygen concentrations. In addition, these two segments were assessed as not supporting the primary contact recreation use because of high fecal coliform bacteria concentrations.

WATER QUALITY ASSESSMENT

Seventeen water quality sampling events were completed from October 2004 to April 2006. The sampling events targeted seasonal storm-flow and low-flow events. Figure WQ-1 is a map identifying the water quality sample site locations. The water quality data collected during the project can be downloaded from ADEQ's on-line searchable database at http://www.adeq.state.ar.us.

<u>WATER CHEMISTRY DATA</u>

Fewer storms of less than average rainfall and below normal intensity occurred throughout 2005 and into the spring of 2006. Stream flows were reduced to zero at sites that would routinely have some flow throughout the year. Flow conditions in the main stem of the river at Shirley (WHI0043) during the survey ranged from less than 5 cfs to over 4000 cfs. The historical peak flow for the river occurred during the flood of December 1982. The river peaked at approximately 241,000 cfs (USGS, Stream flow statistics). On average, the river has an annual peak flow of about 29,000 cfs.

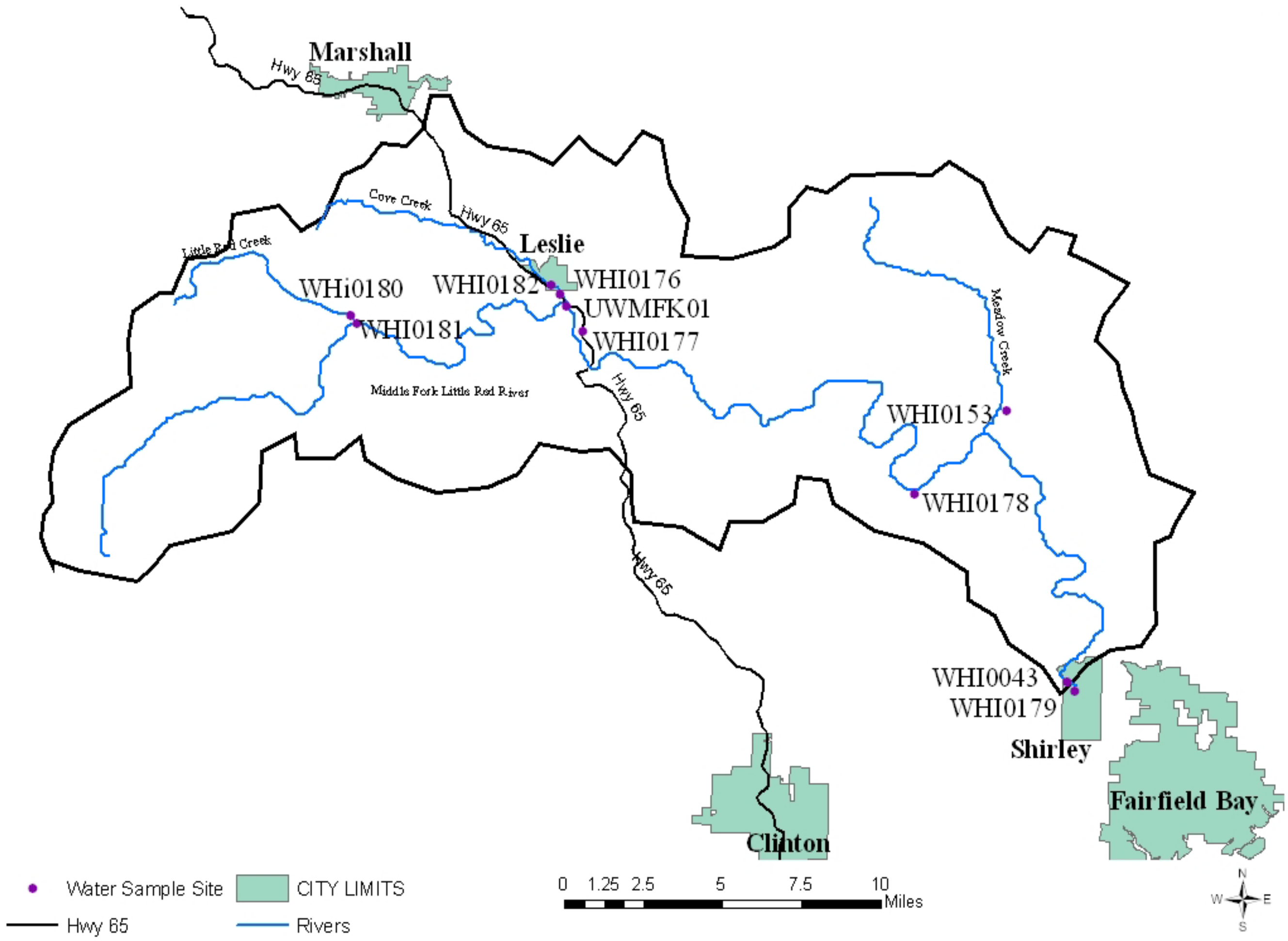
<u>Dissolved Oxygen</u>

The dissolved oxygen standard ranges from 2.0 mg/L, for sites with less than 10 mi^2 watersheds, to 6 mg/L during the critical season, for sites with watersheds greater than 10 mi^2. However, none of the sites sampled during this survey had watersheds smaller than 10 mi^2 (Table 1 – Middle Fork Little Red River Monitoring Stations). The dissolved oxygen concentration during the rest of the year is 6.0 mg/L (Table 3 – Water Quality Standards). The greatest dissolved oxygen fluctuation (~5.0 mg/L) during the survey occurred at WHI0043. The majority of all other concentrations were between 6.0 mg/L and 11.0 mg/L. The lowest value was 3.47 mg/L and was recorded during the January 2005 sampling event at the City of Leslie waste water treatment facility. The plant was in a conversion phase of switching to a new facility. Flow through the plant was minimal. All other in-situ dissolved oxygen readings throughout the watershed were above 5.33 mg/L. There were twelve (12) dissolved oxygen concentrations that were less than 6 mg/L on stream segments having a 6 mg/L dissolved oxygen standard. Of these, seven occurred during the July, August, and September 2005 sampling events at various sites. Four of the 12 occurred at the Leslie Waste Water Treatment Facility (WHI0183).

<u>Turbidity and Total Suspended Solids</u>

Turbidity values ranged from <2.0 NTU to 497 NTU. The assessment criteria for turbidity states that if more than 25% of the samples collected between June 1 and October 31 exceed 10 NTU, or if 20% of the samples from the entire data set exceed 19 NTU, the stream will be evaluated as not attaining the turbidity criteria. All sites were attaining both of these criteria during the survey. However, most of the sites had one or two samples that had extremely high turbidity values. These samples were taken during a major spring time storm event. The upper main stem sites generally had higher turbidity values during storm events than did the lower sites, and the Cove Creek tributary generally had higher turbidity values than the other tributaries in the watershed.

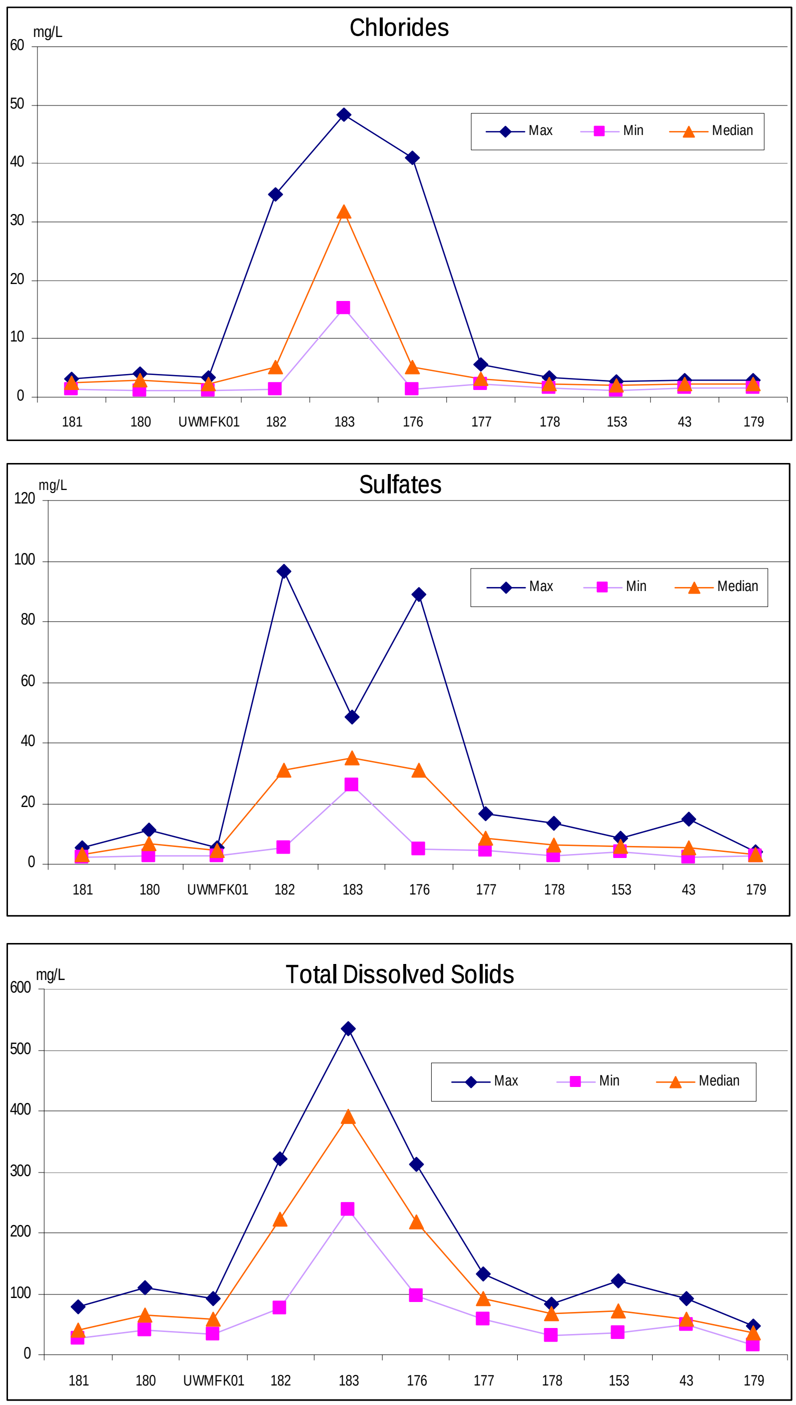
Figure WQ-1: Water Quality Monitoring Station Map



Chlorides, Sulfates and Total Dissolved Solids

Chloride concentrations ranged from a low near 1.0 mg/L at several sites, to a maximum of 48.4 mg/L at WHI0183, the City of Leslie waste water treatment facility. The sites in Cove Creek above, WHI0182, and below, WHI0176, the waste water treatment facility, both had maximum chloride concentrations that were about ten times higher than those of the other sites in the watershed, Figure WQ-2. Likewise, sulfate concentrations in Cove Creek were approximately ten times greater than the concentrations at the other sites throughout the watershed. The total dissolved solids concentrations of these sites reflect the chloride and sulfate concentrations. Median values for each of these parameters are also elevated above those of the other sites in the watershed. In addition, minimum values occur during storm events at these sites instead of during low flow events as with the other sites in the watershed. This is indicating that the source is either a nonpoint source, most likely septic tanks that are not functioning properly, or is perhaps failures in the point source collection system of the city. Additional investigation is needed to better identify the source of the minerals in Cove Creek above the City of Leslie waste water treatment facility.

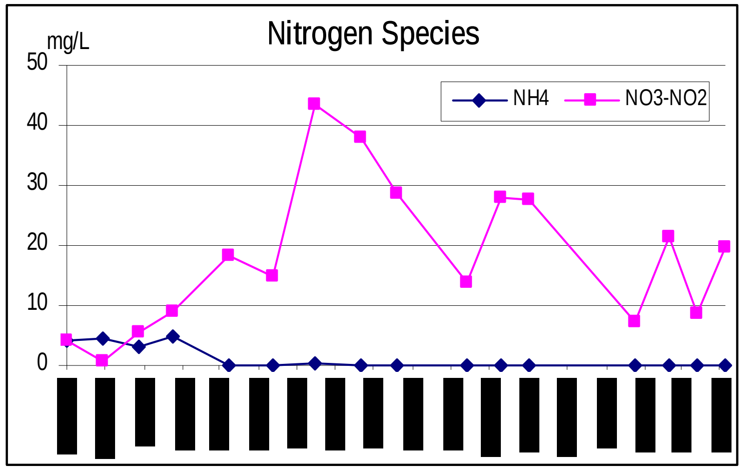
Figure WQ-2: Minerals



Nutrients

There were only 24 ammonia-nitrogen (NH_4-N) detections throughout the survey. The majority of the detections were at the City of Leslie waste water treatment facility. The highest NH_4-N concentration was 4.59 mg/L. There was a noticeable decrease in the concentrations of NH_4-N from the facility once the new waste water treatment facility became operable in February 2005. Concentrations were all less than 0.19 mg/L instead of usually being greater than 4.0 mg/L. However, there was a noticeable increase in the nitrate+nitrite-nitrogen (NO_3+NO_2-N) concentrations in the effluent after the new facility was brought on line. Concentrations were generally less than 5.0 mg/L before the new facility starting operating but were greater than 9.0 mg/L, with a peak concentration of 43.5 mg/L, since the new system has begun operating. This is typical of waste water treatment facilities that use activated sludge and aeration treatment options.

Figure WQ-3: Nitrogen Species



Nitrate+nitrite-nitrogen concentrations at the other sites in the watershed ranged from 0.33 mg/L at WHI0177, the site downstream of Cove Creek, to less than the detection limit. Most median concentrations were less than 0.10 mg/L.

Total phosphorus (TPHOS) and ortho-phosphorus (O-PHOS) concentrations were highest at the waste water treatment facility and in Cove Creek below the facility. Concentrations ranged from near 4.5 mg/L to numerous readings less than the detection limit. All phosphorus concentrations at the stream sites increased during the storm events. Except for the Cove Creek sample sites, the median phosphorus concentrations were all less than 0.03 mg/L. Cove creek median phosphorus concentrations were less than 0.08 mg/L.

Escherichia coli Bacteria

In April 2004, ADEQ began using *Escherichia coli* bacteria data to evaluate the attainment of contact recreational uses of the States' water bodies. Prior to April 2004, fecal coliform bacteria data was used. The switch was made for two primary reasons: *Escherichia coli* bacteria is a much better indicator of bacteria contamination from warm-blooded organisms; and certain soil bacteria will present as fecal coliform, thus giving false positive readings which can lead to incorrect evaluations.

Escherichia coli bacteria samples were collected on 21 occasions from most sites. Eight samples were collected during 2005 primary contact recreation (swimming) season. On a couple of occasions there was no water present at a few sites, thus these sites will have fewer samples. Assessment criteria states that if more than 25% of the samples collected exceed either the primary or secondary contact recreation standard (Table 3) the swimming use is assessed as impaired.

Bacteria concentrations ranged from less than 4 col/100ml to greater than 4000 col/100ml. The intent of this survey was to determine designated use attainment and not to quantify maximum bacteria concentrations; thus a three milliliter dilution was used as the smallest dilution. All of the sample sites were evaluated as maintaining the primary and secondary contact recreation designated uses based on the assessment criteria described in Table 4. Although, the sites on Cove Creek had some very high concentrations during the spring storm events. Likewise, the other tributary sites of Little Red Creek and Weaver Creek, along with Cove Creek, had higher median concentrations than at the other survey sites. This is perhaps a reflection of the more concentration non-point source activities, mainly cattle grazing, in their respective watersheds.

Total Hardness and Metals

Total hardness values ranged from 8 mg/L at the upper Middle Fork Little Red River site, WHI0181, to 275 mg/L at WHI0182, Cove Creek above the Leslie waste water treatment facility. The median total hardness values ranged from 184 mg/L above the plant to 165 mg/L below the plant. In addition, the median total hardness value of Meadow Creek was 113 mg/L, compared to less than 60 mg/L at all other sites. Cove Creek and Meadow Creek drain an area of the Pitkin Limestone. The other portions of the watershed drain mostly shale, accounting for differences in hardness values in these two tributaries.

None of the metals detected were determined to be present in any toxic levels. The majority of the concentrations recorded during the survey were typical of Boston Mountains ecoregion streams, even though there was an occasionally higher than normal value.

72-Hour Dissolved Oxygen Profiles

Dissolved oxygen (DO), pH, and temperature profiles were recorded for a 72-hour period from September 19th to September 22nd, 2005 at the following sites: WHI0181, UWMFK01, WHI0176, and WHI0043. Figures WQ-4 through WQ-7 illustrate the data.

Diurnal dissolved oxygen data at the upper main stem site, WHI0181, indicates that the Boston Mountains dissolved oxygen standard of 6.0 mg/L is not being maintained (Figure WQ-4). The concentration drops to near 4.0 mg/L around midnight each night and does not recover until near noon each day. The meter was placed in small, shallow pool during a period of almost no-flow; less than 0.5 cfs. The diurnal fluctuation was not excessive, generally 3.0 mg/L per day.

Figure WQ-5 illustrates that there is little diurnal DO fluctuation at the Middle Fork Little Red River site at Arkansas Highway 65 (UWMFK01). This meter was deployed at the upper end of a large shallow pool. Stream flow was minimal; less than 1.0 cfs. The diurnal dissolved oxygen concentration dropped below the 6.0 mg/L Boston Mountains dissolved oxygen standard, with a low of ~ 4.2 mg/L. Diurnal fluctuations were less than 3.0 mg/L. This pool receives minimal direct sunlight because of the well vegetated riparian zone and the large hill on the south side of the west-to-east flowing river.

Figure WQ-4: WHI0181 Diurnal Dissolved Oxygen

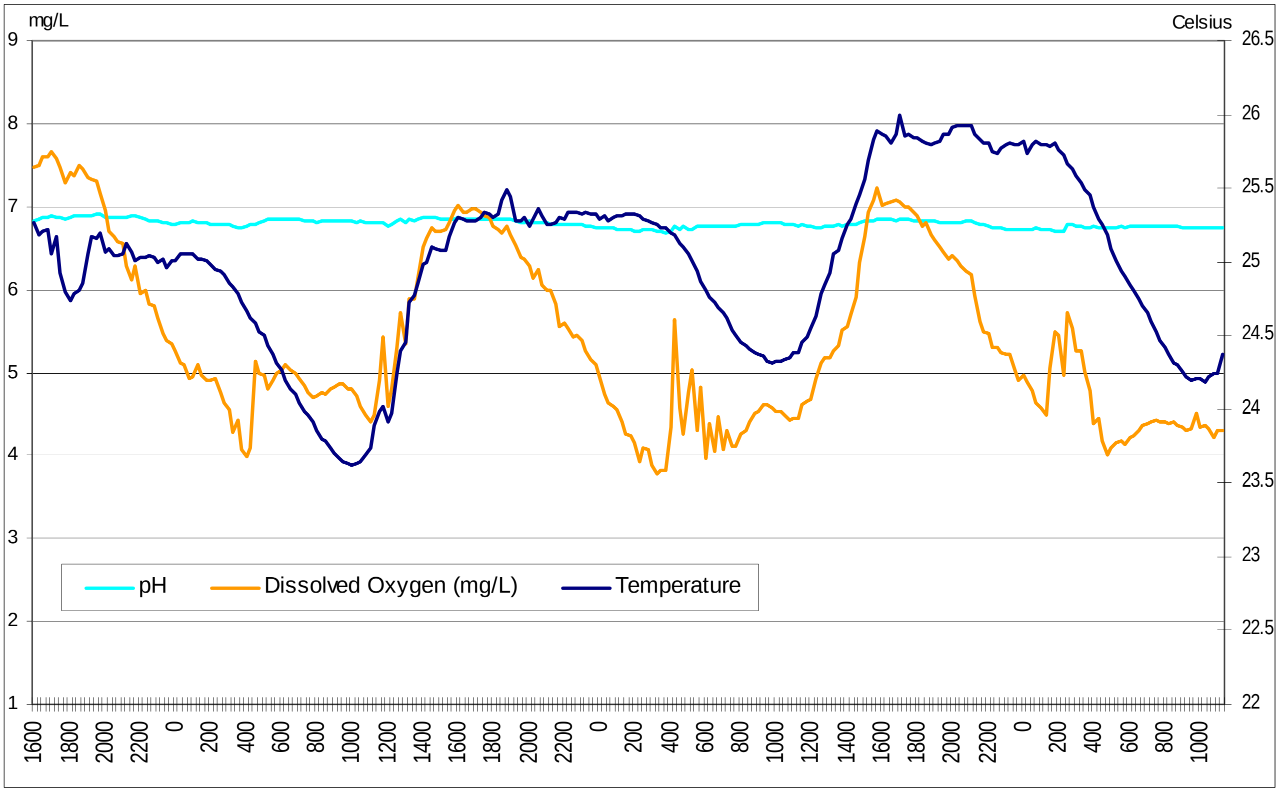
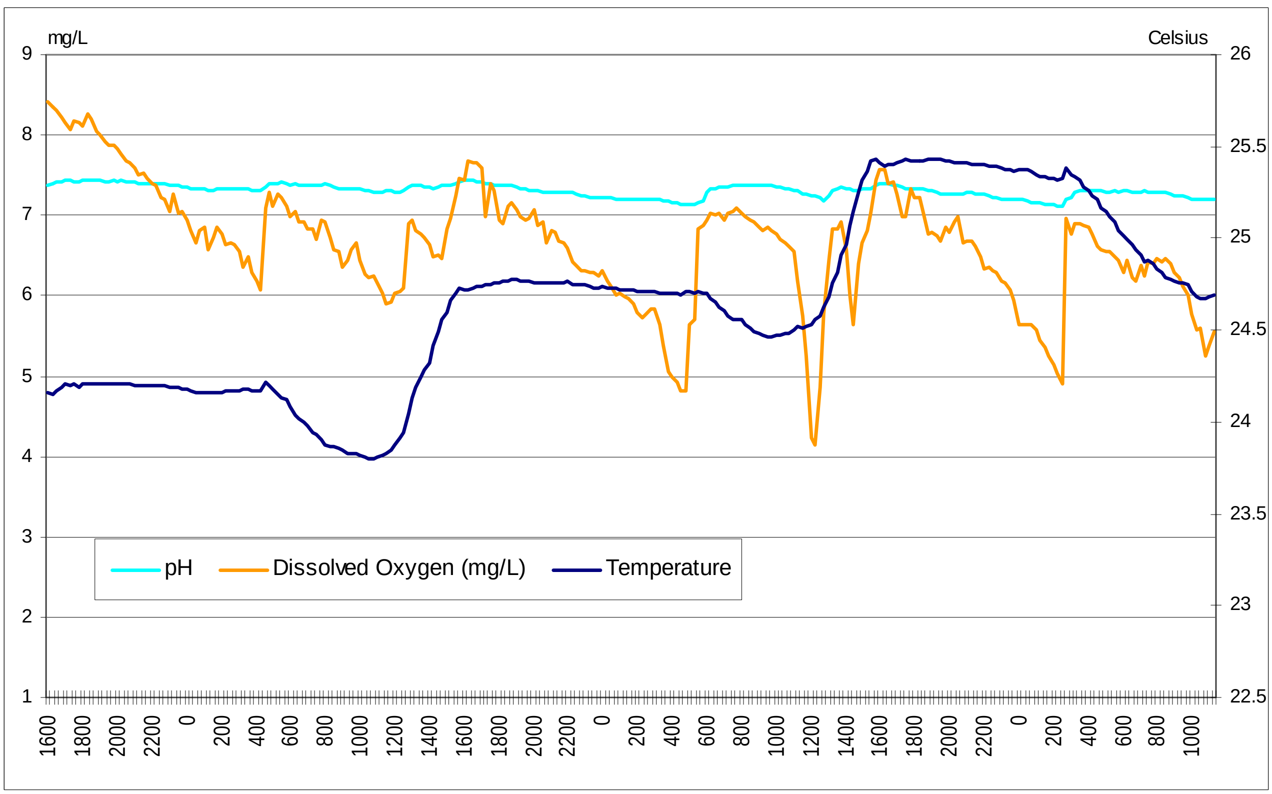
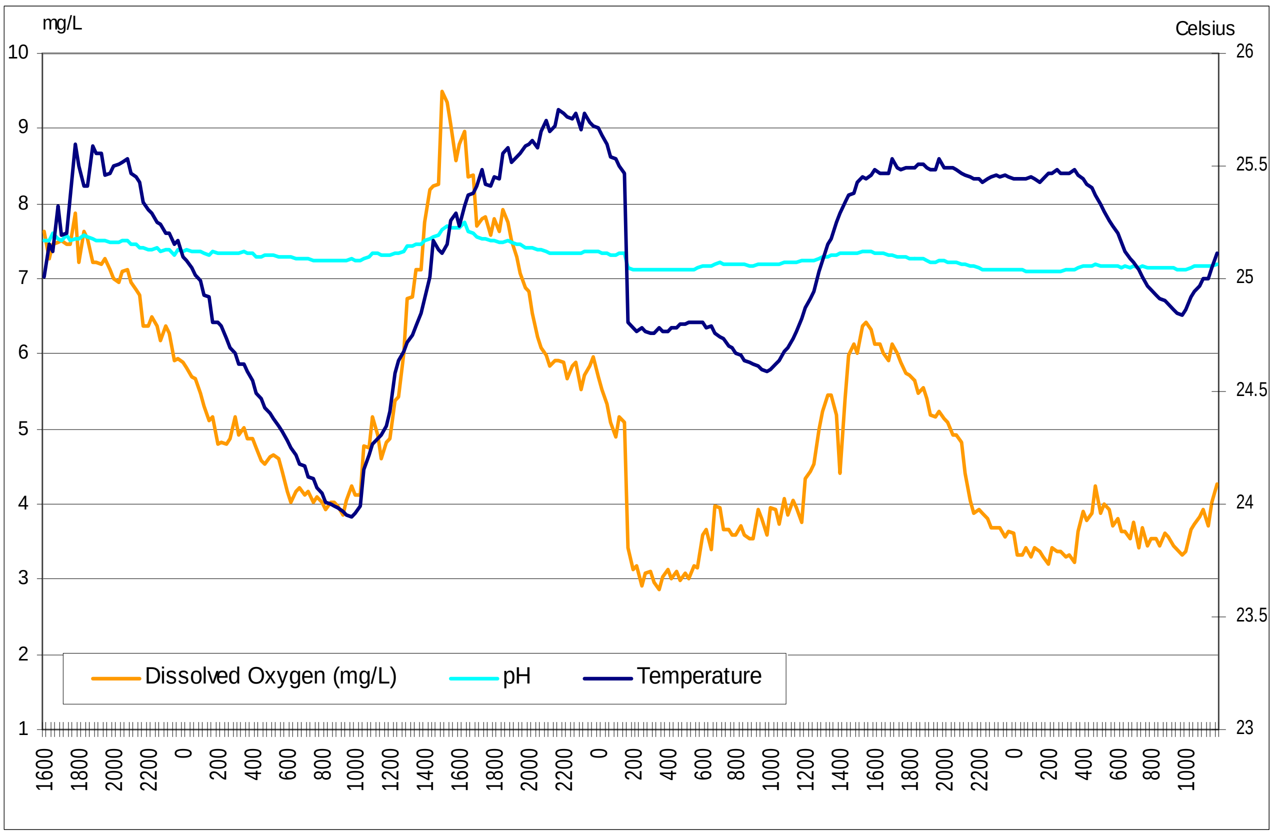


Figure WQ-5: UWMFK01 Diurnal Dissolved Oxygen



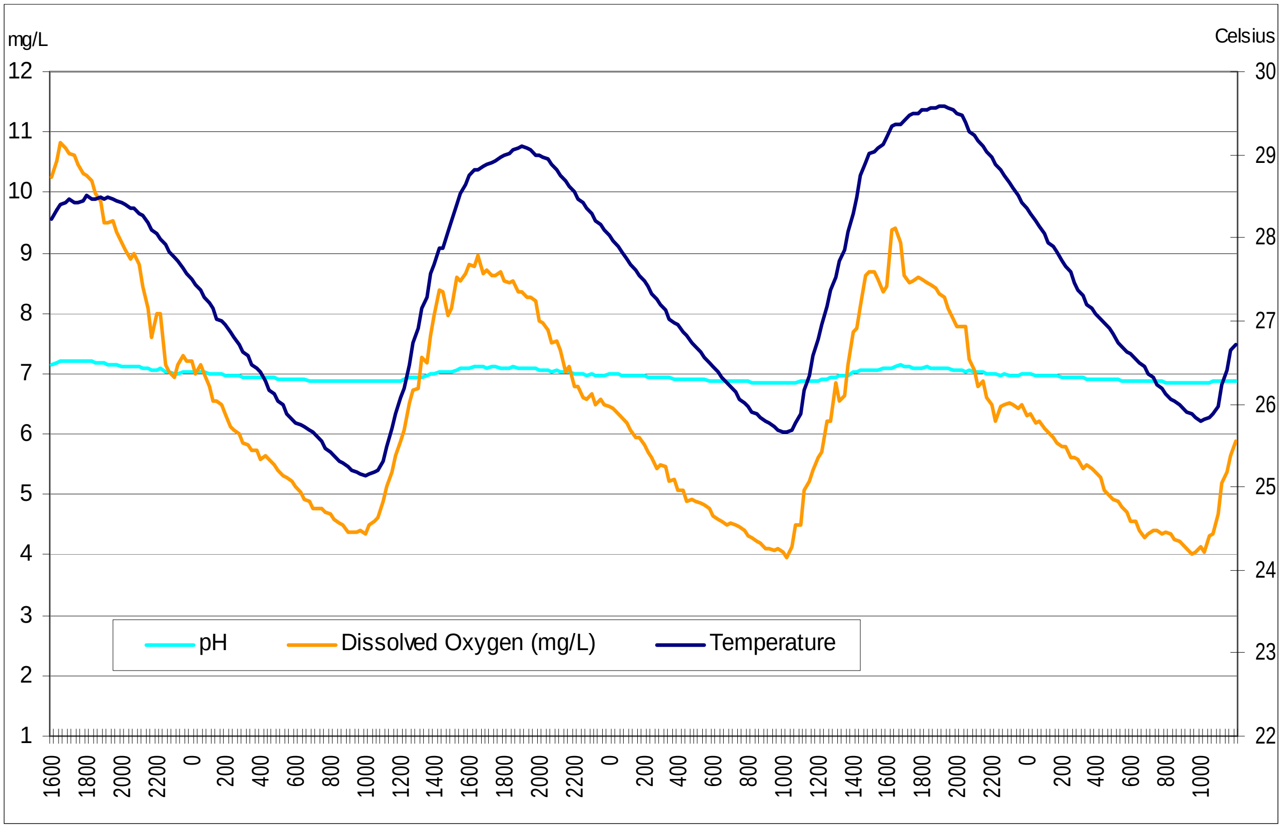
The Cove Creek site (WHI0176) below the City of Leslie Waste Water Treatment Facility (WWTF) had the largest diurnal fluctuations of any of the sites. The diurnal dissolved oxygen concentration fluctuated 3.0 mg/L to 6.0 mg/L each night, as depicted in Figure WQ-6. The concentration also dropped to near 3.0 mg/L on two nights. Because this is a small watershed, approximately 30 square miles, the creek above the WWTF was dry. Downstream flow during the critical season was dominated by the WWTF effluent and was generally less than 1.0 cfs. These conditions are typical of small Boston Mountains streams with effluent dominated stream flows. However, what was not expected was the influence the watershed land use above the facility is having on the stream. The grab sampling data indicates that Cove Creek above the WWTF is being influenced by nonpoint sources, perhaps animal agriculture and pasture maintenance activities, and septic tanks from the City of Leslie.

Figure WQ-6: WHI0176 Diurnal Dissolved Oxygen



The lower Middle Fork Little Red River site near Shirley, Arkansas (WHI0043) had diurnal dissolved concentrations generally ranging from near 10.0 mg/L to 4.0 mg/L, Figure WQ-7. Normally, the diurnal fluctuation was near 4.0 mg/L each night. The diurnal dissolved oxygen concentration dropped below the 6.0 mg/L Boston Mountains dissolved oxygen standard for approximately 12 hours each day. This is the same pattern shown at the other three main stem sites. This meter was located in a small, shallow pool below a riffle that had minimal flow, approximately 1.0 cfs.

Figure WQ-7: WHI0043 Diurnal Dissolved Oxygen



When examining the diurnal dissolved oxygen data from this survey, it is important to keep in mind the abnormally dry and hot conditions that existed during the survey. Many sites experienced no-flow conditions when normally there would be some flow. Because of this, the retention time of the water in the pools was elevated above normal conditions. The greater diurnal swings and lower than expected early morning dissolved oxygen concentrations were in part the result of the ambient conditions, which exacerbated the impacts of the agriculture and urban activities in the watershed.

SUMMARY

Stream flows throughout the watershed during the study were well below average because of recent drought conditions. This influenced the dissolved oxygen concentrations at the sample sites. However, there were only twelve (12) dissolved oxygen concentrations recorded during the survey that were below 6.0 mg/L standard. Of these, seven occurred during the July, August, and September 2005 sampling events at various sites; and four of the twelve (12) occurred at the Leslie Waste Water Treatment Facility (WHI0183).

Turbidity values ranged from <2.0 NTU to 497 NTU. The upper main stem sites generally had higher turbidity values during storm events than did the lower sites; and the Cove Creek tributary generally had higher turbidity values than the other tributaries in the watershed. However, all of the sites were evaluated as meeting water quality standards and assessment criteria.

Minerals and nutrients were elevated below the City of Leslie waste water treatment facility in Cove Creek. The creek above the facility is reduced to shallow pools with no flow during the critical season. Below the facility, the flow is dominated by the treatment facility. During high flow events, total suspended solids and turbidity concentrations are elevated, indicating impacts from nonpoint sources.

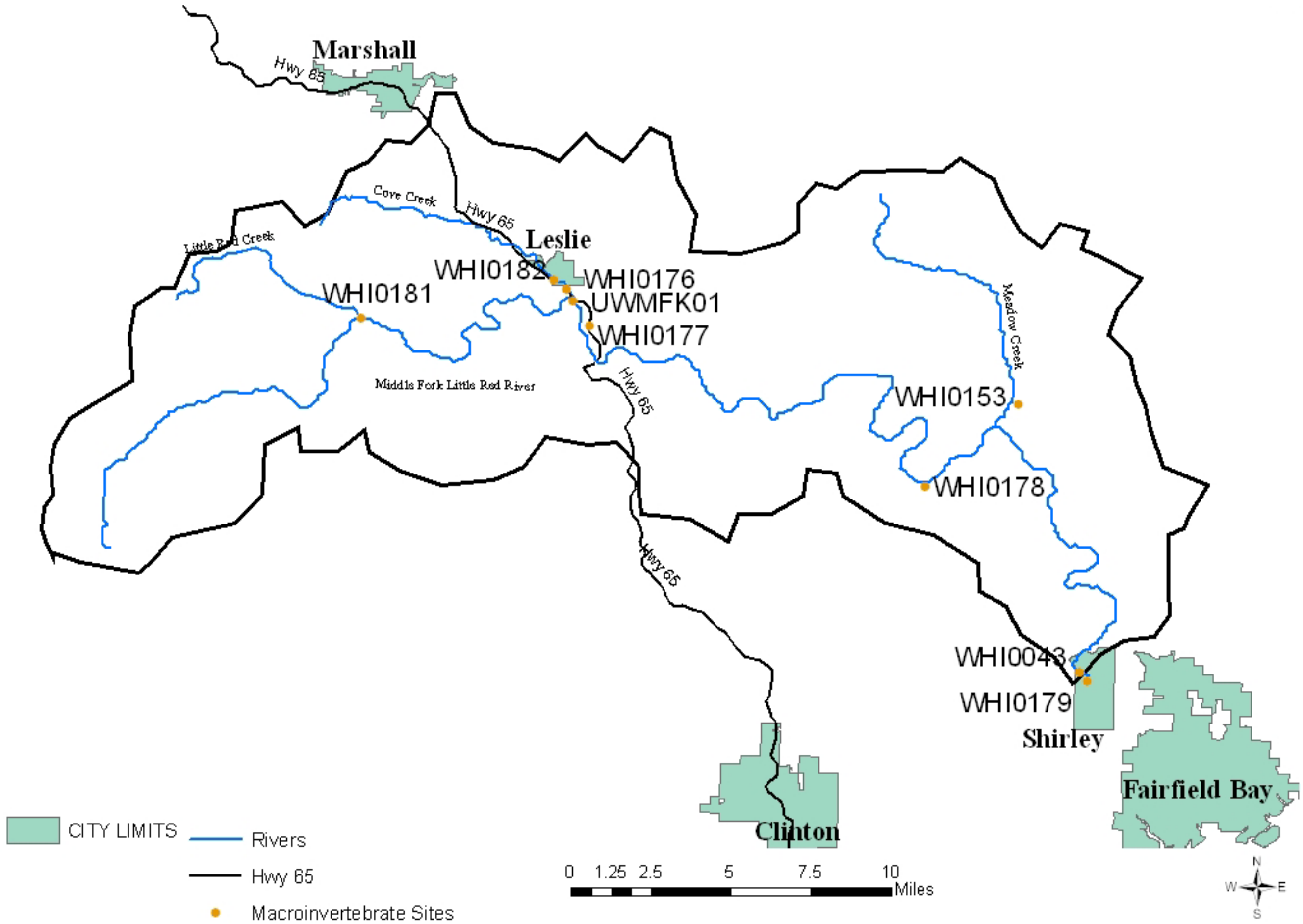
Bacteria concentrations are elevated during the early spring, high-flow events, indicating impacts from nonpoint sources. However, all the stream segments are supporting the assigned contact recreation designated uses.

Diurnal dissolved oxygen swings fluctuated from 3 mg/L per night at the main stem sites, to almost 6 mg/L at the site below the waste water treatment facility. Many sites experienced no-flow conditions when normally there would be some flow. Because of this, the retention time of the water in the pools was elevated above normal conditions. The greater diurnal swings and lower than expected early morning dissolved oxygen concentrations were in part the result of the ambient conditions, which exacerbated the impacts of the agriculture and urban activities in the watershed. In addition, the site below the City of Leslie waste water treatment facility displayed typical effects of an effluent on a small, headwater, Boston Mountain stream.

AQUATIC MACROINVERTEBRATE ANALYSIS

The aquatic macroinvertebrate community was surveyed during the spring and fall of 2005 at the stations illustrated in Figure M-1.

Figure M-1: Macroinvertebrate Sampling Locations Map



METHODOLOGY

A Turtox® D-frame dip net with shroud (500 multifilament) was used to collect samples. The samples were cleaned of larger debris in the field before preservation, preserved in 70% ethanol and labeled with the appropriate identifying information. Samples were collected during Spring 2005 and Fall 2005. Fall sampling periods for aquatic macroinvertebrates is defined by ADEQ as September 15 to October 31. The spring sampling period is defined as April 1 to June 15. Insufficient or excessive flow prevented collections from occurring at some sites during fall sampling periods, therefore sampling was performed later in the season when flows were at sufficient levels.

Aquatic macroinvertebrates were collected using the traveling kick method. The net was placed downstream while the substrate was disturbed upstream. A five-minute kick sample was taken along diagonal transects enabling all microhabitats present to be sampled. Two riffles were sampled per station. (Maxted et al. 2000; Barbour et al. 1996).

A subsample of approximately 100 organisms was picked in the laboratory. A 4-inch diameter metal ring was randomly tossed into the tray and organisms within the ring removed for the subsample. Subsampling continued until a minimum of 95 organisms was removed. The sample may exceed 100 organisms, but should not be less than 95 (Davidson and Clem, 2003). Subsamples were identified to the proposed minimum levels for taxonomic resolution.

<u>Physical Habitat Assessment</u>

A two-tier approach was employed for all streams. This approach employs more quantitative data collection, which allows for a higher level of precision when comparing sites. Physical habitat data was used to calculate metrics on the following attributes: wetted width and mean channel depth; bank characteristics; substrate mean diameter, embeddedness; substrate stability; in-channel cover; channel habitat types; and riparian vegetation structure, complexity and disturbance. The close connectivity of various parameters should impact multiple metrics if habitat alteration is occurring.

Tier one is an observational (qualitative) approach to assessing various habitat parameters which assigns a numeric score (0-20) to each parameter (EPA 1999; Appendix FS). Scores are separated into four broad categories/conditions consisting of poor, 0-5; marginal, 6-10; sub-optimal, 11-15; and optimal, 16-20. Habitat parameters assessed in all streams are epifaunal substrate/available cover, sediment deposition, channel flow status, channel alteration, bank stability, vegetative protection, riparian vegetative zone width, frequency of riffles (or bends), velocity/depth regime and embeddedness.

Tier two combines both a qualitative (visual estimates) and quantitative (in-stream measurements) approach to developing a habitat profile for each sample reach based on several broad categories. These categories include measurements/estimates of the in-channel cover, substrate, canopy cover, large woody debris within bankfull width, flow, visual riparian quality, and human influence estimates.

A two-person team conducted all assessments. This method reduced bias and subjectivity between assessors. No physical habitat activities were conducted in the stream until all biological collection was completed. Physical habitat characterization includes conducting a pebble count in each of two riffles once per year.

Any deviations from the previously mentioned methods were noted in the project field notebook. All information was recorded in the field on appropriate data forms. A photograph was taken at each site.

Aquatic Macroinvertebrate Community Evaluation Method

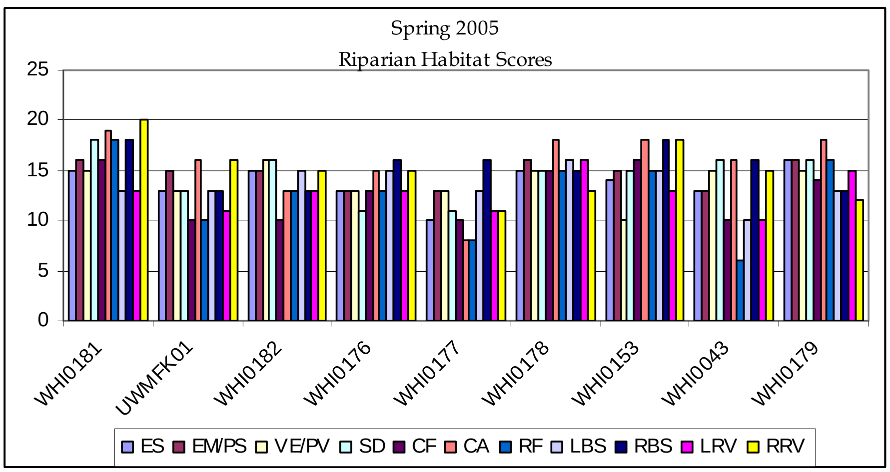
Spring aquatic macroinvertebrate communities in small watersheds (≤ 40 mi^2) were evaluated by comparing the community structure at each site to the community structure of least-disturbed, Ouachita Mountain ecoregion reference streams of similar watershed sizes.

RESULTS

Spring 2005

Sites with sufficient flow to permit sampling were sampled during April 26-27 and May 23-24. Riparian habitat was sub-optimal for most sites, with the exception of WHI0181, WHI0178, and WHI0153, which were optimal. Riparian Habitat scores ranged from 124 at WHI0177 to 181 at WHI0181. Flows were also variable, ranging from 9.96 cfs at WHI0176 to 118.83 cfs at WHI0178. Other channel characteristics, such as mean depth, canopy and wetted width, were variable.

Figure M-: Riparian Habitat Scores - Spring 2005



Site Description:

WHI0181 was a long riffle with a pool located upstream. The left bank had several areas with short filamentous algae as well as eroding stream banks located in areas with cattle access. WHI0177 sample area was below a fjord in stream with some in-stream mining and had an average filamentous algae length of 3-4 mm. WHI0182, at the time of sampling, was very turbid and showed signs of fine sediment deposition. WHI0179 substrate had a very thin layer of periphyton visible. WHI0180 had a small amount of sediment in the slower areas of the riffle, as well as severe to moderate erosion in some areas. WHI0178 had higher flow than seen at most other sites; therefore, samples were taken from one accessible riffle. WHI0176 was located in an area with obvious gravel mining resulting in turbid water. WHI0043 had an obvious layer of periphyton ranging from 5 to 20mm in thickness.

Total taxa identified within the Middle Fork Little Red River ranged from 16 at WHI0177 and WHI0043, to 33 at WHI0153 (Meadow Creek). Total organisms ranged from 228 at WHI0177 to 100 at WHI0043. Appendix M-1list the totals for the metrics evaluated.

Dominant or co-dominant taxa included Chironomidae (midgefly larvae), *Maccaffertium (Flathead mayfly larvae)*, *Stenelmis (riffle beetle)*, *Lirceus (aquatic Isopod), Ephemerella (Spiny crawler mayfly), Simulidae (Black fly larvae), Tricorythodes (triangular gilled mayfly), and Cheumatopsyche (free-living caddislfy),* and comprised between 16% and 46% of the community. Samples at WHI0181 were collected upstream of the bridge on Little Red Creek. At WHI0181 the dominant and co-dominant taxa were Chironomidae (19%) and *Lirceus* (16%), respectively. Little Red Creek is influenced by a gravel mining operation causing increased turbidity and sediment. At WHI0182, above the Leslie WWTP, the dominant and co-dominant taxa are Chironomidae (29%) and *Stenelmis* (15%), respectively. At WHI0176, below the Leslie WWTP, the dominant and co-dominant taxa are Chironomidae (41%) and Simulidae (8%), respectively. At UWMFK01, the dominant and co-dominant taxa were Stenelmis (46%) and Cheumatopsyche (11%). At WHI0177, the dominant taxa was Chironomidae (38%) while co-dominant taxa was Tricorythodes (19%), which indicates a slight increase in sedimentation. At WHI0178, above the confluence of Meadow Creek, the dominant taxa was Ephemerella (16%) while co-dominant taxa was Lirceus (14%).

At WHI0153, Meadow Creek, the dominant taxa was Maccaffertium (27%) while co-dominant taxa was Chironomidae (19%). At WHI0043, the dominant taxa was Stenelmis (42%) and co-dominant taxa was Chironomidae (14%). In Weaver Creek, WHI0179, the dominant taxa was Maccaffertium (25%) and co-dominant taxa was Chironomidae (26%).

EPT richness and composition were usually dominated by Ephemeroptera (mayfly) and Plecoptera (stonefly) taxa. Tricoptera (caddisflies) were present, but dominated by Hydropsychidae taxa. Percent EPT ranged from 20% at WHI0043 to 62% at WHI0179. When assessing the components of the EPT metrics, it was observed that a high percentage of Tricoptera consisted of Hydropsychidae taxa. Hydropsychidae taxa generally have a tolerance value of seven, which is significantly higher than most other Tricoptera, therefore excluded from the EPT metrics to avoid the misinterpretation of EPT data. Hydropsychidae prefer area with high densities of detritus material or high algal areas. Some Hydropsychidae become very abundant in streams subjected to moderate levels of pollution from organic wastes or nutrients.

WHI0178 had the highest percentage of intolerant taxa (32.62%), while WHI0043 had 6% intolerant taxa. WHI0181 has the highest percentage of tolerant taxa (15.87%), while WHI0177 had the lowest percentage (0%).

Hilsenhoff Biotic Indices (HBI) ranged from 4.06-very good at WHI0178, to 5.61-fair at WHI0177.

Table M-1: Hilsenhoff Biotic Index Water quality Degree of Organic Pollution

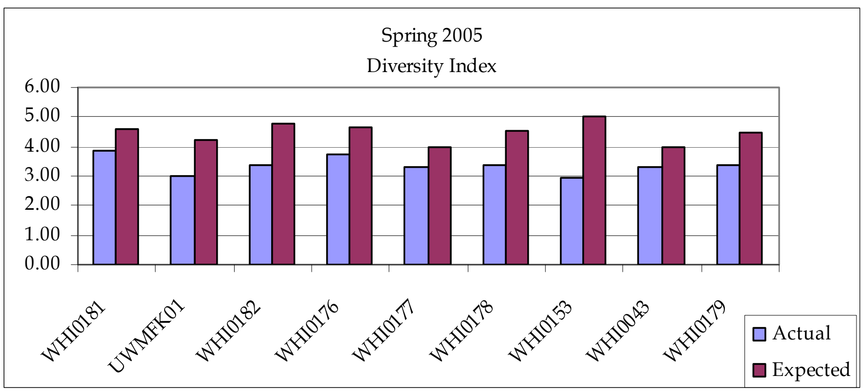
0.00–3.50	Excellent:	No apparent organic pollution

3.51–4.50	Very good:	Possible slight organic pollution
4.51–5.50	Good:	Some organic pollution
5.51–6.50	Fair:	Fairly significant organic pollution
6.51–7.50	Fairly poor:	Significant organic pollution
7.51–8.50	Poor:	Very significant organic pollution
8.51–10.0	Very poor:	Severe organic pollution

Herpobenthos (burrower + sprawler) were greatest at WHI0181 on Little Red Creek (18.44%), WHI0177 (19.47%) and WHI0178 (14.25%). This would indicate that the substrate has a greater amount of fines, soft sediments or slippery forms of algae, bacteria, or fungi.

The difference in the actual Simpson's Diversity index versus the maximum score possible with the given number of taxa for each site was elevated at WHI0153, indicating that the community expected to be present did not exist to its fullest potential. This is possibly due to recent bridge maintenance resulting in drastic habitat alterations. (Figure M-)

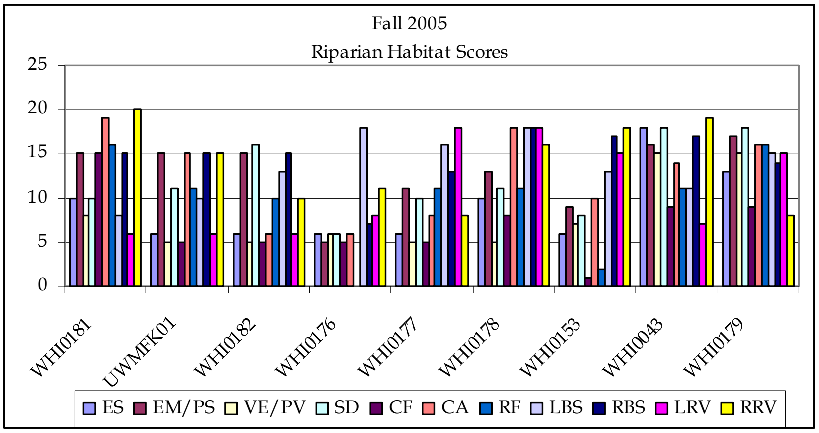
Figure M-: Spring 2005



Fall 2005

Sites with sufficient flow were sampled on October 26-27, and November 8. Riparian habitat was sub-optimal for most sites, with the exception of WHI0182, WHI0176, and WHI0153, which were marginal. Riparian Habitat scores totaled between 78 at WHI0176 to 156 at WHI0179 (Figure M-13). Flows were very low, ranging from 1 to 3 cfs. Other channel characteristics, such as mean depth, canopy, and wetted width, were variable.

Figure M-: Fall 2005



[Habitat scores defined: ES- epifaunal substrate; EM/PS- embeddedness/ pool substrate characteristic; VE/PV- velocity depth regime/ pool variability; SD- sediment deposition; CF- channel flow status; CA- channel alteration; RF- riffle frequency; LBS-left bank stability; RBS- right bank stability; LRV- left bank riparian protection; RRV- right bank riparian protection]

Total taxa identified ranged from 16 at UWMFK01 to 28 at WHI0176. Total organisms ranged from 223 at WHI0182 to 109 at WHI0179.

Dominant or co-dominant taxa included Chironomidae, *Maccaffertium, Chimarra*, *Psephenus, Heterelmis*, *Stenelmis*, *Caenis,* and Viviparidae. Samples at WHI0181 were collected upstream of the bridge on Little Red Creek. At WHI0181 the dominant and co-dominant taxa were Psephenus (30%) and Chironomidae (23%), respectively. Little Red Creek is influenced by a gravel mining operation causing increased turbidity and sediment. At WHI0182, above the Leslie WWTP, the dominant and co-dominant taxa were *Stenelmis* (35%) and Heterelmis (16%).

At WHI0176, below the Leslie WWTP, the dominant and co-dominant taxa were Psephenus (13%) and Viviparidae (12%), respectively. At UWMFK01, the dominant and co-dominant taxa were Stenelmis (32%) and Maccaffertium (19%). At WHI0177, the dominant taxa was Caenis (61%) while co-dominant taxa was Stenelmis (12%), which indicated an obvious increase in sedimentation. At WHI0178, above the confluence of Meadow Creek, the dominant taxa was Stenelmis (26%) while co-dominant taxa was Heterelmis (10%). At WHI0153, Meadow Creek, the dominant taxa is Psephenus (21%) while co-dominant taxa were Chironomidae (19%). At WHI0043, the dominant taxa was Stenelmis (42%) and co-dominant taxa was Chironomidae (18%). On Weaver Creek at WHI0179, the dominant taxa was Maccaffertium (23%) and co-dominant taxa was Chimarra (17%).

EPT richness and composition were usually dominated by Ephemeroptera (mayfly) and Tricoptera (caddisfly) taxa. Plecoptera (stoneflies) were present, but dominated by Perlidae taxa. Percent EPT ranged from 5% at WHI0176 to 69% at WHI0177, and was dominated by Caenis. After removing the Caenis taxa from the percent EPT metric, only 7% of the EPT were taxa other than Caenis.

When assessing the components of the EPT metrics, it was observed that a high percentage of Tricoptera consisted of Hydropsychidae taxa. Hydropsychidae taxa generally have a tolerance value of seven, which is significantly higher than most other Tricoptera, therefore excluded from the EPT metrics to avoid the misinterpretation of EPT data. Hydropsychidae prefer area with high densities of detritus material or high algal areas. Some Hydropsychidae become very abundant in streams subjected to moderate levels of pollution from organic wastes or nutrients.

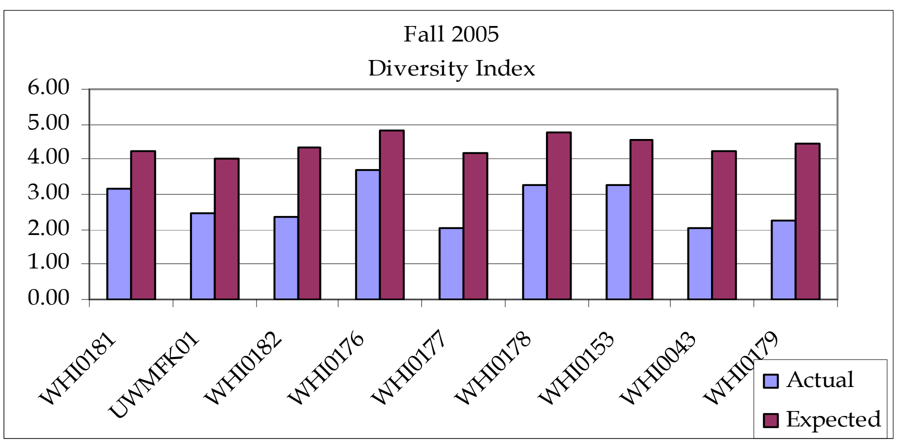
WHI0179 had the highest percentage of intolerant taxa (21.1%) while WHI0177 and UWMFK01 had 0% intolerant taxa. WHI0176 had the highest percentage of tolerant taxa (29.46%) while WHI0182 had the lowest percentage (0.90%).

Hilsenhoff Biotic Indices (HBI) ranged from 3.49-excellent at WHI0179 to 6.33-fair at WHI0177. WHI0177 had the lowest HBI score for two consecutive sampling seasons.

Herpobenthos (burrower + sprawler) were greater at WHI0177 (63.43%) and WHI0176 (20.65%). This would indicate that the substrate has a greater amount of fines, soft sediments or slippery forms of algae, bacteria, or fungi.

Figures M- depicts the differences in the actual Simpson's Diversity index scores versus the maximum expected score for each site. The maximum expected score assumes an equal distribution of specimens among all the taxa collected at a site. The more taxa present, the higher the score.

Figure M-: Fall 2005



DISCUSSION

TEMPORAL PERSISTENCE: SEASONAL AND INTER-ANNUAL VARABILITY

Figure M- illustrate the similarity of habitat scores during the course of this study in the Middle Fork Little Red River and tributaries. Riffle habitats in the sample areas scored predominantly in the sub-optimal category annually, but a few scored optimal during the spring sample and a few scored marginal during the fall sample.

Figure M-: Instream Riparian Habitat - Total Score

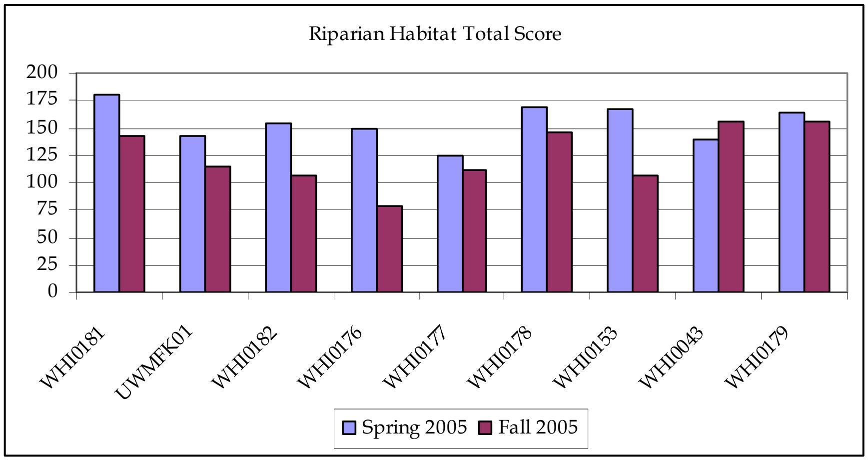


Figure M-: Percent EPT

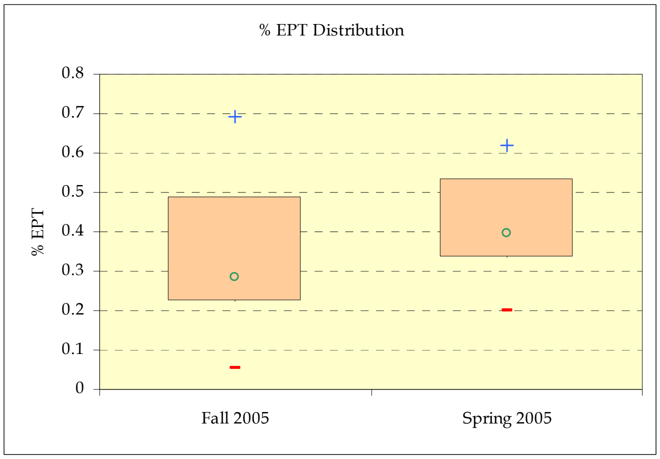


Figure M-: Percent EPT: Hydropsychidae

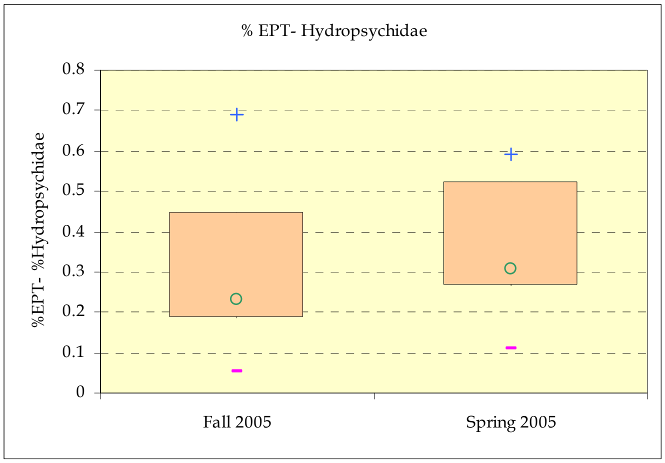


Figure M-: Percent Intolerant

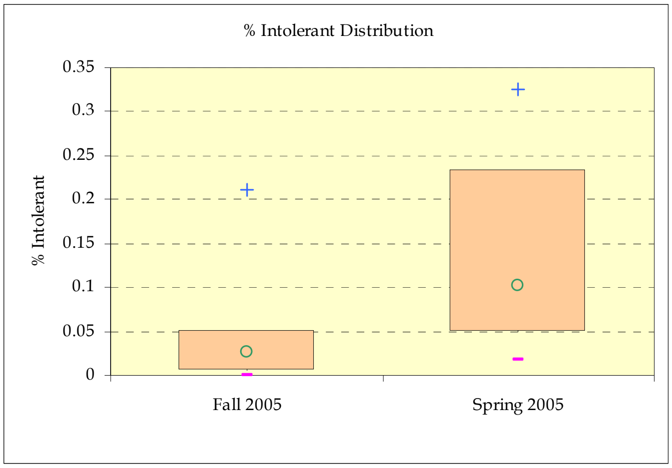


Figure M-: Percent Tolerant

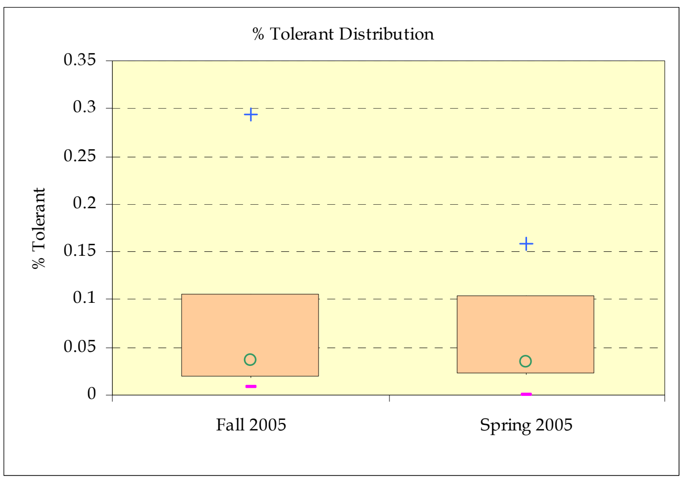


Figure M-: Hilsenhoff Biotic Index

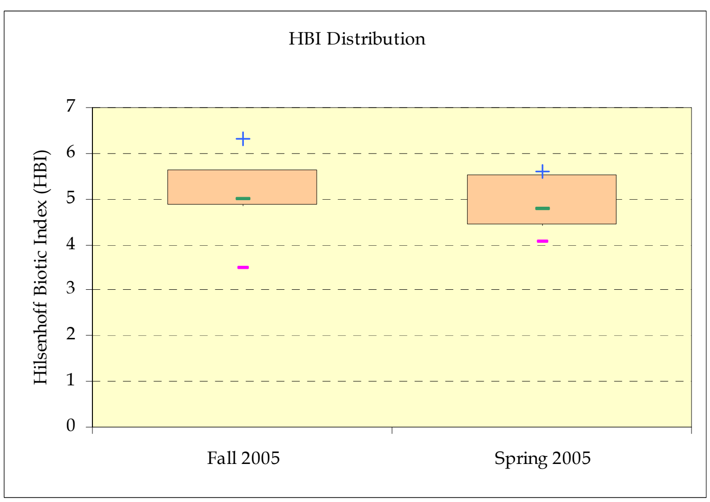


Figure M-: Hilsenhoff Biotic Index Graph

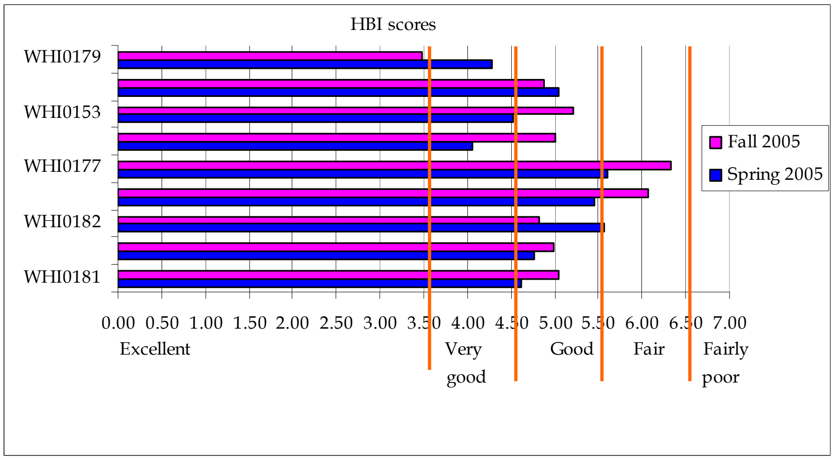


Figure M-: Total Taxa

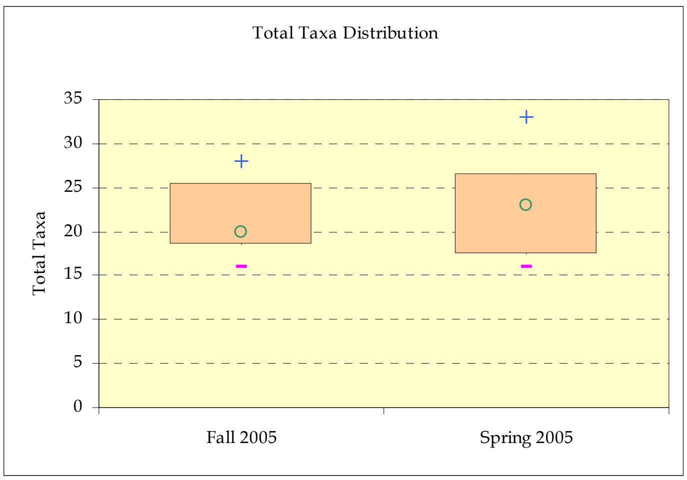
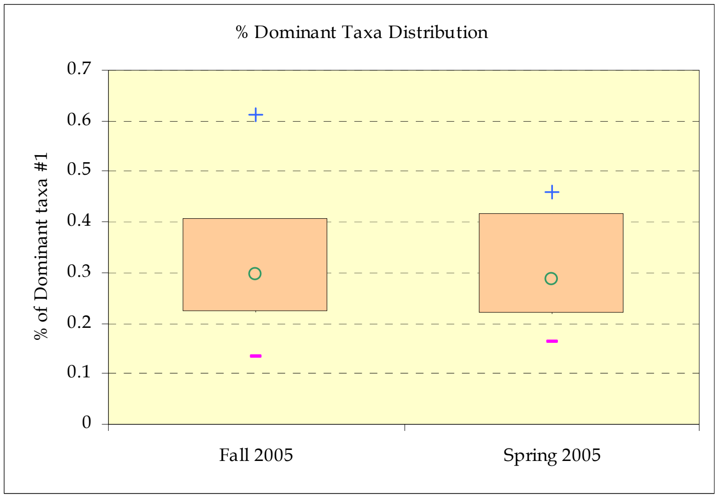


Figure M-: Dominant Taxa



Metrics that showed the greatest improvement included total taxa. Box and whiskers for percent dominant taxa and HBI slightly overlapped with spring 2002, but did improve during 2003.

The total number of organisms collected (all sites) were variable from spring to fall, except for WHI0182, which increased in the fall, while WHI0176 and WHI0177 showed a significant decrease in the fall. This change also was not as evident when examining total taxa.

Percent tolerant taxa shows a sharp decline from the spring sample to the fall sample, although WHI0176 has an obvious increase in tolerant taxa during the fall sample period.

SITE AND WATERSHED EVALUATION

Middle Fork Little Red River and Tributaries

Natural stream stability is achieved by allowing the stream to develop a stable dimension, pattern and profile, such that, over time, channel features are maintained and the stream system neither degrades nor aggrades (Rosgen and Silvey 1996). Any minor disturbances may alter nearby habitats (i.e. riffles) and thus nearby biological community structure, but not necessarily stream stability. Improper grazing strategies and the removal of riparian buffer strips lead to bank erosion and channel instability.

The aquatic macroinvertebrate communities at WHI0181, WHI0176, and WHI0177 appeared to be slightly impacted by increased sedimentation, possibly due to the instream gravel mining, habitat alterations, adjacent pastures and unrestricted cattle access. Instream habitat at these sites was comprised of larger gravel and smaller cobble with numerous interstices that possibly provided the most suitable habitat (i.e. greater number of microhabitats) when compared to other sites, but the increased sedimentation may be filling these interstices making the habitat less suitable for less tolerant organisms.

Effects of sedimentation on the aquatic macroinvertebrate habitat and biota are dependent on measured levels and persistence of sediment load (Henley et al. 2000). High and sustained levels of sediment may cause permanent alterations in community structure, diversity, density, biomass, growth and rates of reproduction and mortality. Impacts on the aquatic community are expressed through alterations in food webs (i.e. sediment transport can have an abrasive quality that reduces periphyton standing crop on stream substrata) and habitat (i.e. aquatic macroinvertebrate density and diversity are directly related to substrate diversity). As sediment settles, interstitial spaces between coarse substrata are filled, which reduces available habitat.

SUMMARY AND RECOMMENDATIONS

A summary of threats and impacts to the aquatic macroinvertebrate community inhabiting the Middle Fork Little Red River is provided below:

1. Unrestricted cattle access, eroding stream banks adjacent to pastures without riparian buffer strips (i.e. trees) and non-point source runoff from pastures were the primary threats to the aquatic macroinvertebrate community structure in the Middle Fork Little Red River. The greatest threat posed from eroding stream banks (sedimentation) is loss of habitat and food availability.

2. Altered community structure at WHI0181 and WHI0153 appears to be a result of gravel mining and significant habitat alteration. Over time these sites may show signs of recovery due to the cessation of these short term activities.

3. Unrestricted cattle access is causing streambank erosion at several locations within the Middle Fork Little Red River, which will lead to increased turbidity and sedimentation, as well as other adverse changes to the biological communities.

Turbidity and sedimentation can have profound influences on the local ecology of lotic systems at the individual, population and community levels. Reductions in food availability, environmental quality and habitat can directly affect growth, recruitment and mortality rates at multiple trophic levels. A major effect of riparian vegetation is the retardation of erosion by decreasing surface water velocity which allows deposition of eroded material in the riparian zone before it enters the lotic environment. In addition to sediment entrapment, riparian zones also filter nutrients from run-off for storage in plant material. They provide bank stabilization and in-stream thermal regulation through shading. Lush riparian zones can facilitate consistency in annual flow patterns by storing large volumes of water and then releasing it in a more even manner. It has been well documented that sites with riparian strips have higher species richness, diversity, density and IBI’s (Henley et al. 2000).

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FISH COMMUNITY ANALYSIS

Fish community surveys were conducted at the stations listed below in July 2005. Figure F-1 depicts the sites where fish community collections were made. Data presented in this section may be accessed via the ADEQ website, http://www.adeq.state.ar.us/water/data_edas/edas.asp.

STATION LOCATION

WHI0181 – Middle Fork Little Red River near Canaan
WHI0177 - Middle Fork Little Red River south of Leslie
WHI0178 - Middle Fork Little Red River north of Arlberg
WHI0043 - Middle Fork Little Red River at Shirley
WHI0179 – Weaver Creek south of Shirley

METHODOLOGY

A Smith-Root model 15-B backpack electrofishing device with pulsed DC current and a barge electrofishing unit with pulsed DC current were used. The devices were used in the pools while wading upstream and dipping the stunned fishes from the water with dip nets. The riffles were collected by posting a twenty foot seine near the toe of the riffle and while working the electrofisher in a downstream direction through the riffle, the bottom substrate was disrupted and the fish were herded into the seine or washed in by the current.

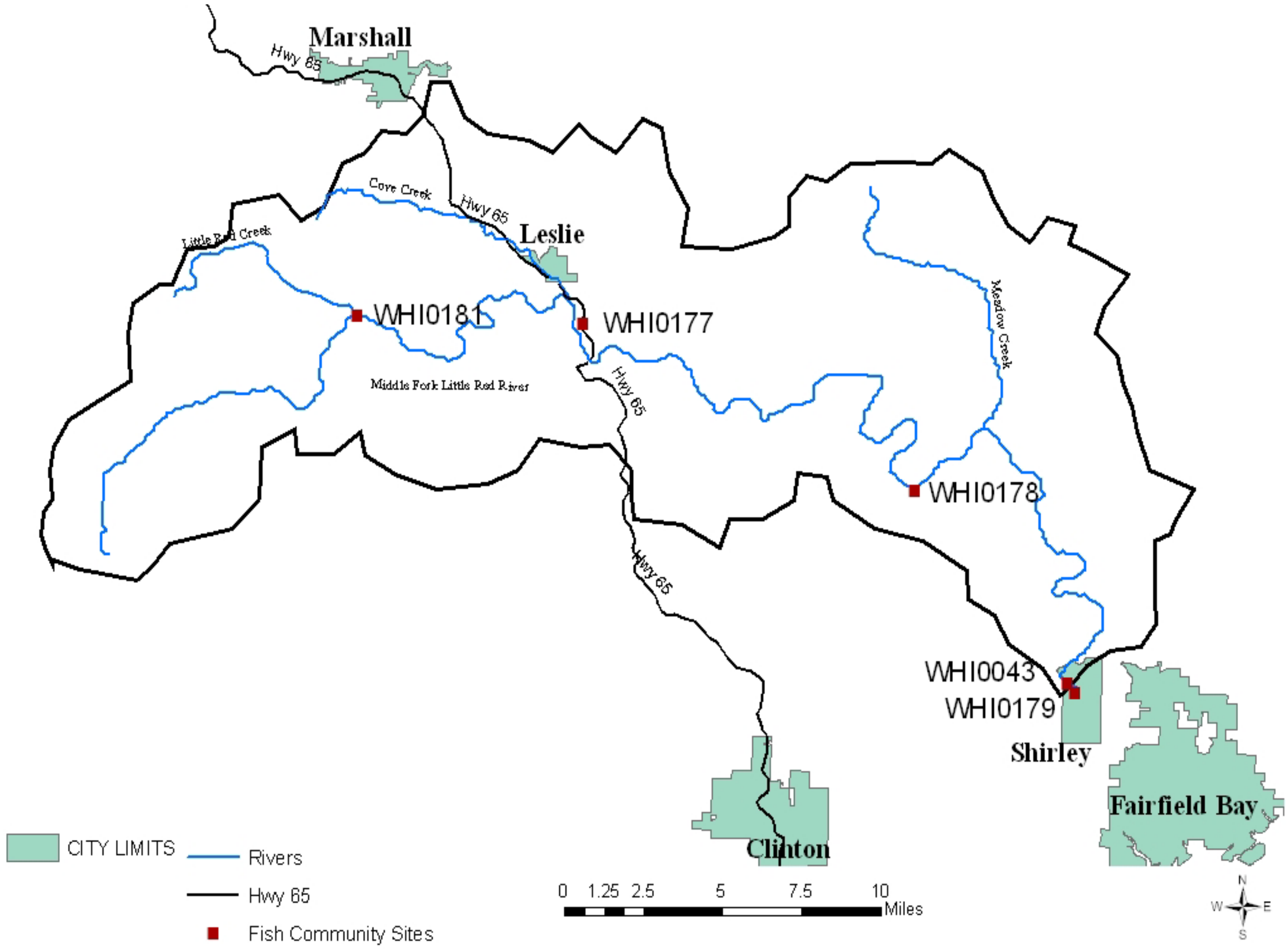
Fish species of all types were collected from all available habitats within the sample area until a fully representative sample of the species in the area was thought to be obtained. Larger specimens were field identified and released. The smaller specimens and those needing further identification were preserved in a ten percent formalin solution and returned to the lab.

HABITAT EVALUATION

Habitat evaluations were performed at all sites and were comprised of five parameters each consisting of three to seven variables. These parameters included: 1) habitat type; 2) habitat quantity; 3) quantity of substrate type based on fish use; 4) quantity of instream cover; and 5) sediment on substrate. Each parameter for substrate type and instream cover was given a score depending on its abundance. The scores given to the substrate parameters were multiplied by a factor to adjust these scores based on how they relate to fish habitat quality. Habitat type length, depth and width measurements were estimated for each habitat type and recorded in feet. The sediment on substrate parameter was scored according to the degree of embeddedness.

A total score for each habitat type was calculated by summing the scores for the substrate type, instream cover and sediment on substrate. The scores from similar habitat types were averaged for each sampling station. The lengths of each habitat type were also summed. The total habitat type lengths were divided by 100 and multiplied by the average habitat type score. This score is the Ichthyofauna Habitat Index (IHI).

Figure F-1: Fish Community Collection Sites Map



FISH COMMUNITY EVALUATION METHOD

The fish communities were evaluated by directly comparing the community structures at each site to the fish communities of least-disturbed, Boston Mountains ecoregion reference streams of similar watershed sizes. A fish community structure index (CSI) was calculated using these parameters based on ecoregion reference stream data to generate the scoring criteria (Table F-1). Seventeen different parameters were compared between each of the communities and the reference streams.

The final determination of support is derived by utilizing all of the indices, the overall fish community, and the habitat and stream characteristics. Best professional judgment is also used in those unique situations when the metrics can not properly delineate the status of the fish communities based on the data collected.

The Community Structure Index is determined by the sum of the scores for each metric for each fish community. The relative scores were developed from average values from data collected from least disturbed ecoregion reference streams. The different scores are based on one and two standard deviation units from the average.

Table F-1: Boston Mountains Fish Community Biocriteria

Metric (% community, except Diversity Index)	SCORE		
	4	2	0
Cyprinidae	25 - 60	15 – 25 or 60 - 75	<15 or >75
Ictaluridae	>4[1]	2 - 4[1]	<2[1]
Centrarchidae	10 - 40[2]	6 - 10 or 40 - 55[2]	<6 or >55[2]
Percidae	>10	6 - 10	<6
Sensitive Individuals	>30	30 - 16	<16
Primary TFL	<35	35 - 45	>45
Key Individuals	>35	25 - 35	<25
Diversity Index	>3.15	3.15 - 2.85	<2.85

1 – no more that 1% bullheads 2 – no more than 18% Green sunfish

RESULTS

Fish community samples from all of the sites were collected in July, 2005. There were 44 fish species collected during this survey. There were 31 species collected from WHI0181, 30 from WHI0177, 31 from WHI0178, 37 from WHI0043, and 20 from WHI0179. Table F-2 is a complete species list per site. Table F-3 depicts the community structure from each site as percent community composition of each family and the Community Structure Index (CSI) parameters; sensitive species, Key species, primary trophic level species, the diversity index (Shannon-Wiener, log base 10), and the catch per unit effort (in minutes). Key Individuals are "Fishes which are normally dominant species within the important groups such as fish families or trophic feeding levels" (ADPC&E, 2004). The community structure metrics discussed below are depicted in Figures F-2 and F-3.

The fish community at the Upper Middle Fork Little Red River site (WHI0181) was dominated by longear sunfish. This species accounted for more than 45% of the overall community. More than half of the community was comprised of sunfishes. The minnow family accounted for 29% of the community, with 15% of the minnow family being comprised of stonerollers. There were eight darter species collected, comprising more than 12% of the community. The rainbow darter accounted for almost 5% of the community. Over 22% of the community was comprised of Sensitive Individuals, and almost 60% of the community was comprised of Key Individuals. Primary feeders made up almost 22% of the community. The diversity index was 2.96, and the catch per unit of effort was 13.78 fish per minute. One pool habitat, one riffle, and one run habitat were sampled, totaling approximately 980 feet of stream. The substrates varied from mostly a gravel/rubble in the riffle, to more bedrock and gravel/sand in the pool and run. In stream cover was abundant in the pool, but was somewhat sparse in the run and riffle. Overall, the instream habitat was good.

The Middle Fork Little Red River site south of Leslie (WHI0177) was also dominated by the longear sunfish. This species accounted for almost 38% of the overall community and the sunfish family accounted for almost 51% of the entire community. Over 16% of the community was comprised of bluntnose minnows. The minnow family accounted for almost 36% of the overall community. Seven darter species were collected, which accounted for over 8% of the community. Primary feeders

Table F-2: Fish Species and Number Collected (WHI**)**

SCIENTIFIC NAME	COMMON NAME	1	2	3	0181	0177	0178	0043	0179
Ichthyomyzon sp.	Ammocoetes		P					1	
Lepisosteus osseus	Longnose gar						1	1	
Dorosoma cepedianum	Gizzard shad		P					1	
Campostoma anomalum	Stoneroller		P		221	119	316	147	250
Cyprinella whipplei	Steelcolor shiner	S			1	51	5	153	
Luxilus pilsbryi	Duskystripe shiner	S				60	6	776	17
Lythrurus umbratilis	Redfin shiner							1	
Notropis boops	Bigeye shiner	S		K	102	121	384	558	16
Notropis greenei	Wedgespot shiner	S			9	6	42	75	
Pimephales notatus	Bluntnose minnow		P		96	294	895	854	16
Semotilus atromaculatus	Creek chub	S							6
Erimyzon oblongus	Creek chubsucker				7				5
Hypentelium nigricans	Northern hogsucker	S			9	8	3	10	7
Moxostoma carinatum	River redhorse	S						2	
Moxostoma duquesnei	Black redhorse	S		K	28	21	28	97	
Moxostoma erythrurum	Golden redhorse				18	22	29	74	10
Ameiurus natalis	Yellow bullhead				10	2	10	8	5
Noturus albater	Ozark madtom	S				5	17	1	
Noturus exilis	Slender madtom	S		K	10	1	27	4	53
Pylodictus olivaris	Flathead catfish						2		
Fundulus olivaceus	Blackspotted topminnow				17	17	12	20	18
Gambusia affinis	Mosquitofish					7		1	
Labidesthes sicculus	Brook silverside				4	7	13	29	
Ambloplites ariommus	Shadow bass	S			2	4	13	26	
Lepomis cyanellus	Green sunfish				33	190	121	95	19
Lepomis gulosus	Warmouth sunfish				4	1	9	2	
Lepomis macrochirus	Bluegill sunfish				4	8	31	38	4
Lepomis megalotis	Longear sunfish			K	336	687	672	856	79
Lepomis microlophus	Redear sunfish				1				
Lepomis miniatus	Redspotted sunfish				1				
Micropterus dolomieui	Smallmouth bass	S		K	28	7	1	5	
Micropterus punctulatus	Spotted bass				1	17	26	9	
Micropterus salmoides	Largemouth bass				2	7	9	11	
Etheostoma blennioides	Greenside darter	S		K	35	60	168	74	2
Etheostoma caeruleum	Rainbow darter	S			62	52	118	183	59
Etheostoma euzonum	Arkansas Saddle darter	S						4	
Etheostoma moorei	Yellow cheek darter	S					3	8	

Etheostoma punctulatum	Stippled darter	S			33				
Etheostoma stigmaeum	Speckled darter	S					3	3	
Etheostoma whipplei	Redfin darter				5	3			2
Etheostoma zonale	Banded darter	S			1	2	38	22	
Percina caprodes	Logperch				33	31	85	113	6
Percina maculata	Blackside darter	S			1	2		8	
Percina nasuta	Longnose darter	S			7	3	11	1	
Number of Species					31	30	31	37	19
Total Specimens					1449	1815	3102	4271	581
Level of Effort (sec)					6308	4052	4626	8255	4429

1 – Sensitive species 2 – Primary trophic feeders 3 – Boston Mountains Ecoregion Key species

Table F-3: Community Structure (percent community)

Parameter	WHI0181	WHI0177	WHI0178	WHI0043	WHI0179
Cyprinidae	29.61	35.97	53.20	60.09	52.68
Catostomidae	4.28	2.54	1.94	4.19	3.80
Ictaluridae	1.38	0.44	1.81	0.30	9.67
Centrarchidae	51.07	50.88	28.37	24.42	17.62
Percidae	12.22	8.45	13.85	9.75	13.13
Total Species	31	30	31	37	20
No. Sen. Species	14	15	16	19	9
No. Sen. Inds.	328	403	870	2006	171
% Sens. Inds.	22.64	22.27	28.08	47.01	29.53
No. Primary Inds	317	413	1211	1003	266
% Primary Inds	21.88	22.82	39.09	23.51	45.94
No. Key Inds.	867	897	1280	1594	154
% Key Inds.	59.83	49.56	41.32	37.39	26.60
Diversity Index	2.96	3.14	3.23	3.39	2.93
Catch/Unit Effort	13.78	26.80	40.18	31.01	7.80

Figure F-2: Fish Community Composition Family Metrics

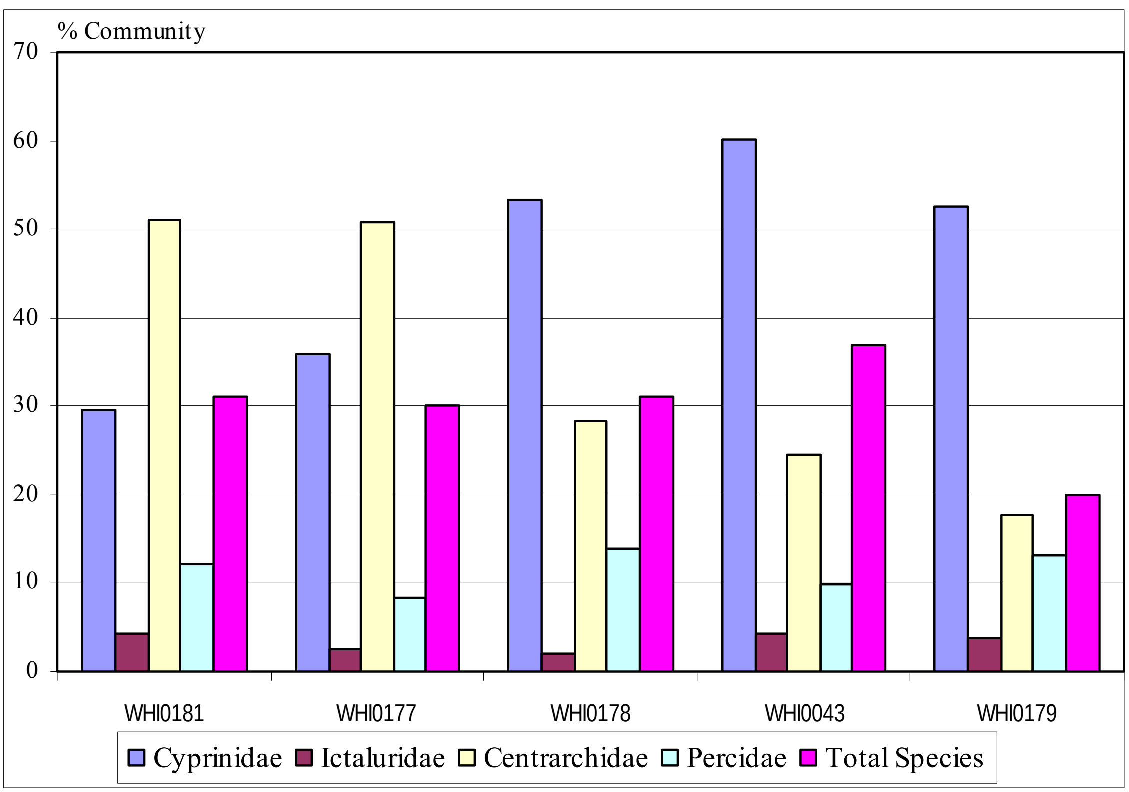
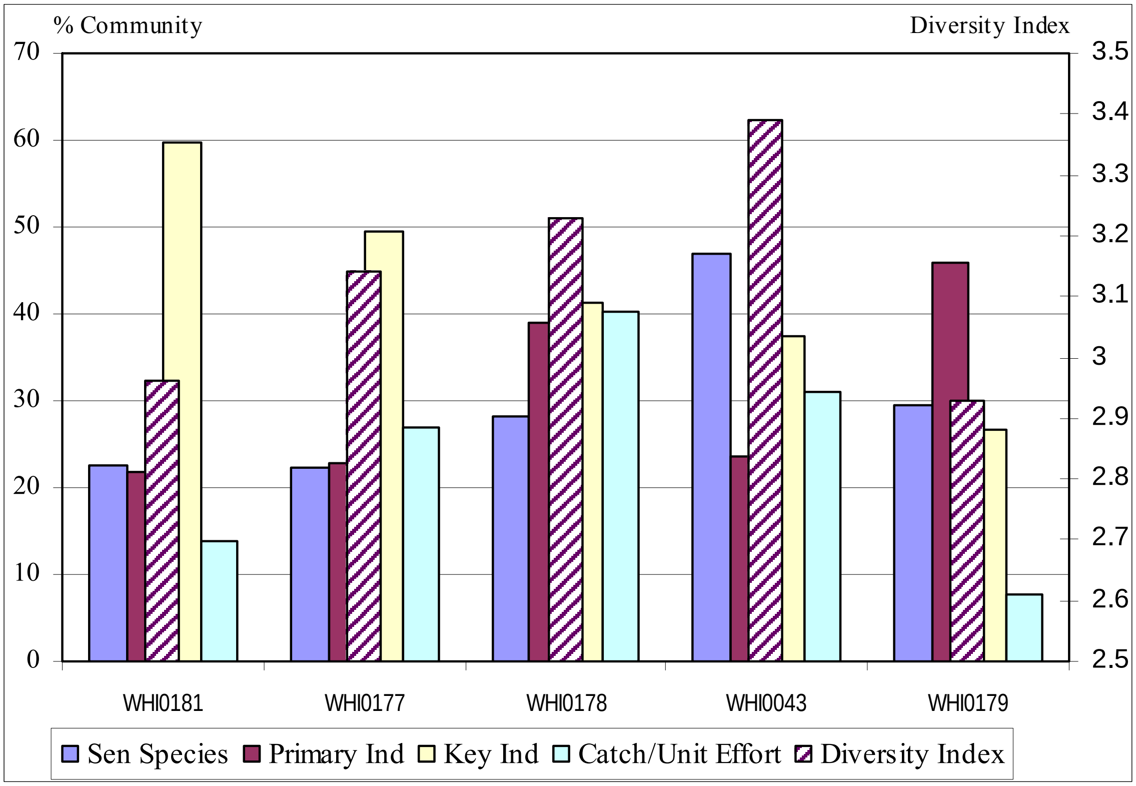


Figure F-3: Fish Community Composition Ecoregion Metrics



accounted for almost 23%, Key Individuals for almost 50%, and Sensitive Individuals for over 22% of the community. The diversity index was 3.14, and the catch per unit effort was 26.80 fish per minute. Two pool and three run habitats were sampled, totaling approximately 560 feet of stream. The substrate varied from rubble/gravel in the runs to a boulder/rubble/gravel with bedrock substrate in the pools. In stream cover was excellent in the pools, but somewhat lacking in the runs. Overall, the instream cover was good.

The collection at the Middle Fork Little Red River site at Alberg included 31 species. The bluntnose minnow dominated the community comprising almost 29% of the community. The minnow family accounted for over 53% of the total community. The longear sunfish was the next most dominant species comprising almost 22% of the community. The sunfish family accounted for over 28% of the total. Seven darter species were collected, comprising almost 14% of the community. The greenside darter was the most abundant darter collected. Primary feeders accounted for over 39%, Key Individuals for over 41%, and Sensitive Individuals for over 28% of the community. The diversity index was 3.23, and the catch per unit effort was 40.18 fish per minute. Two pool, one riffle, and three run habitats were sampled, totaling approximately 1520 feet of stream. The substrate varied from small boulders to rubble/gravel in the riffles, to a boulder/rubble/gravel substrate in the runs, and a bedrock substrate covered with gravel/sand/silt on the pools. Instream habitat was excellent in the pools, but consisted of only small boulders runs. Riffle instream cover was limited. Overall, the instream cover was good.

The site near Shirley (WHI0043) was dominated by the minnows, comprising 60% of the community, with the bluntnose minnow and duskystripe shiner accounting for 29% and 18% of the total, respectively. The longear sunfish also comprised 20% of the community, but the sunfish family as a whole only accounted for 24% of the community. The darter family accounted for almost 10% of the community, with the rainbow darter comprising over 4% of the community. Over 23% of the community was primary feeders and over 37% were Key species. Nineteen sensitive species were collected, accounting for over 47% of the community. The diversity index was 3.39 and the catch per unit effort was over 31 fish per minute. One long pool, one long run, and a short riffle habitat were sampled, covering almost 2720 feet of stream. The substrate in the riffles was mainly gravel and rubble. Instream cover was limited to some undercut banks and aquatic vegetation. Most of the substrate in the runs and pools was gravel/rubble, but some larger boulders were present. Instream cover was abundant, ranging from just a little aquatic vegetation, to an abundant mixture of undercut banks, root wads, woody debris, and aquatic and hanging vegetation. Overall, the instream habitat was excellent.

The Weaver Creek fish community south of Shirley (WHI0179) was dominated by the stoneroller, which accounted for more than 43% of the community. The minnow family accounted for almost 53% of the overall community. The sunfishes comprised almost 18% of the community, with the longear sunfish making up most of the sunfish community. Darters comprised over 13% of the community, with the rainbow darter accounting for over 10% of the total. This site had the largest madtom collection by percentage and number of specimens. Over 9% of the community was madtoms. There were nine sensitive species collected, which comprised almost 30% of the community. Almost 46% of the community was primary feeders and 27% of the community consisted of Key Individuals. Two pool, one riffle, and one run habitat were sampled, covering 425 feet of stream. The substrate in the riffle was mostly rubble/gravel with some sand. Instream cover was sparse. The substrate in the run was a mixture of rubble and gravel, with some areas of sand and bedrock. Instream cover was limited. The substrate in the pools was mostly gravel, with some boulders and bedrock. Instream cover was abundant, and offered a variety of instream cover. Overall, instream habitat was excellent.

SUMMARY AND CONCLUSIONS

Fishes were collected from five sites in the Middle Fork Little Red River watershed in July 2005. Because of the presence of the Yellowcheek darter, *Etheostoma moorie*, an Arkansas listed species of concern, sampling of preferred habitat types had to be scaled back. This lowered the percent abundance of riffle habitat species. Although the communities were assessed using the previously outlined assessment methodology, best professional judgment was employed to fully assess the communities.

There were 44 species collected from the five fish community sites. Robison and Buchanan, 1992, report 47 species of fish as occurring in the watershed--two of which are records from pre-1960 data. This survey collected four species from the River that were not previously reported as occurring in the river by Robison and Buchanan, 1992. They include the creek chubsucker, *Erimyzon oblongus*; mosquitofish, *Gambusia affinis*; warmouth sunfish, *Lepomis gulosus*; and the Arkansas saddled darter, *Etheostoma euzonum*. The goal of this project was not to determine the complete species list from the river, but to determine the assemblages of the watershed fish communities.

All of the sites sampled are supporting a Boston Mountains ecoregion fishery (Table F-4). However, there was one metric score that indicated a drastic departure from what would be expected. The Ictaluridae parameter, which is mostly a reflection of the percent of madtoms present in a community, scored zero for four of the five sample sites. Two factors are probably influencing this score. First, the amount of riffle and shallow run habitat that was sampled was greatly reduced to avoid collecting the Yellowcheek darter. Second, because the Middle Fork of the Little Red River is an upper watershed stream, stream flow is greatly reduced during the critical season, thus reducing the amount of preferred habitat for madtoms. Thus, each of the communities, except Weaver Creek, scored zero for this parameter. This reduction in madtoms collected also reduced the number of sensitive species collected, lowering the "percent sensitive individuals" parameter score. These two factors probably lowered the Fish Community Structure Index scores by two to four points for the four Middle Fork Little Red River sites. This may be the reason these sites are listed as "generally similar" instead of "highly similar" to Boston Mountains Ecoregion reference streams.

Table F-4: Fish Community Structure Index

Parameter	WHI0181	WHI0177	WHI0178	WHI0043	WHI0179
Cyprinidae	4	4	4	2	4
Ictaluridae	0	0	0	0	4
Centrarchidae	2	2	4	4	4
Percidae	4	2	4	2	4
% Sens. Inds.	2	2	2	4	2
% Primary Inds	4	4	2	4	0
% Key Inds.	4	4	4	4	2
Diversity Index	2	2	4	4	2
Total Score	22	20	24	24	22
Degree of Similarity	GS	GS	GS	GS	GS

Degree of Similarity	Boston
Highly Similar	25 – 32
Generally Similar	24 – 17
Fairly Similar	16 - 9
Not Similar	8 - 0

STREAMBANK SURVEY

A stream bank stability survey was conducted throughout the watershed by visually identifying stream banks that were unstable. A float trip on the main stem of the Middle Fork Little Red River, combined with a watershed reconnaissance survey, was used to locate the unstable stream banks. Fifty-four stream banks, totaling over four linear miles, within the watershed were identified as unstable. This is by no means a comprehensive survey of all the unstable stream banks in the watershed. These are only the stream banks that were identified during float trips when the river and its tributaries were accessible, and by accessing the stream banks across private property.

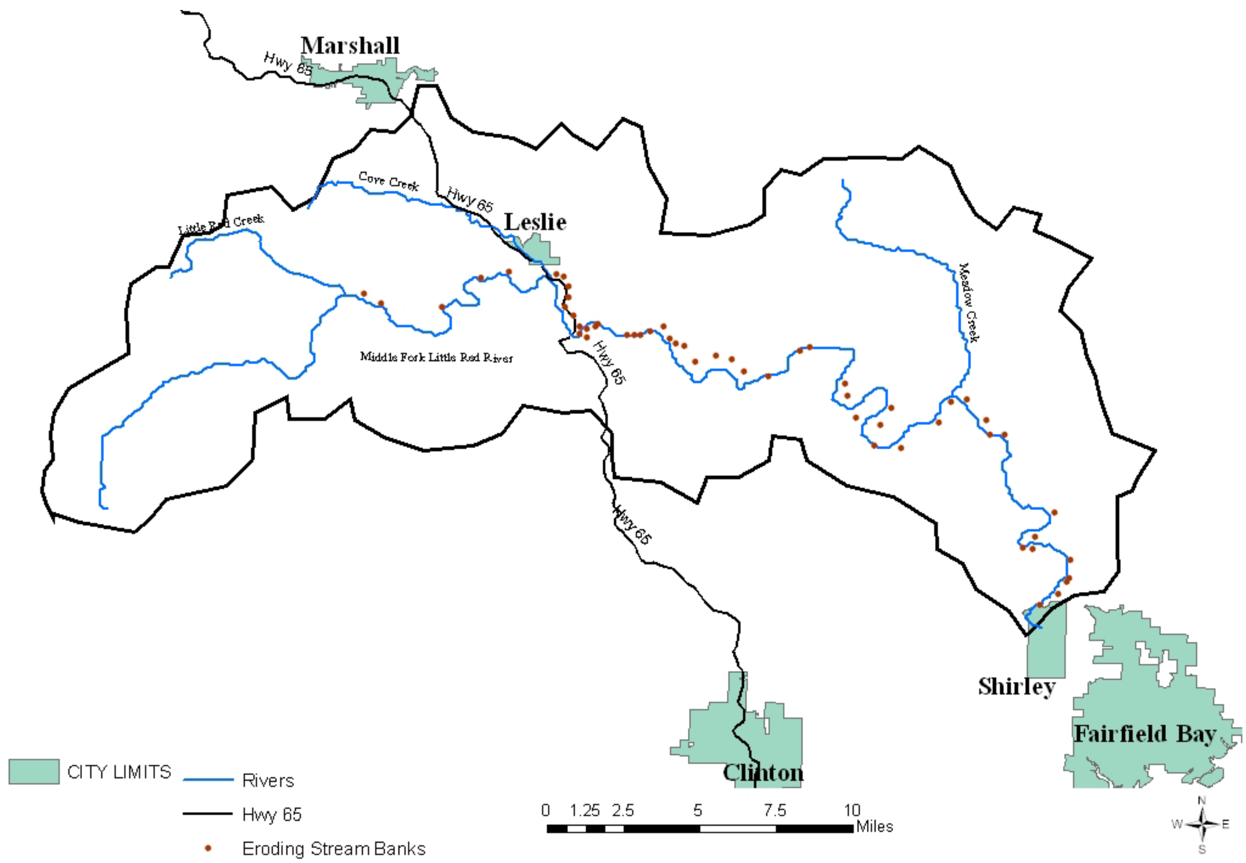
The locations of the unstable stream banks in the watershed are depicted in Figure SB-1. Appendix SB-1 lists the stream banks, briefly outlines some key characteristics of each, and gives the general location of each.

INTENSIVE STREAMBANK SURVEY

A stream bank located south of the city of Leslie, MFLLR-15, Picture SB-1, was chosen for a more in-depth survey. Three transects across the channel were established to help determine the degree of annual stream bank erosion. Transect pins were set at each end of the three transects. In addition, a pin (set pin) was set on top of the stream bank at a distance far enough back from

Picture SB-1: MFLRR-15 Streambank

Figure SB-1: Location of Eroding Stream Banks



the face so as not to be lost to erosion during storm events. A temporary bench mark (TBM) was established with an arbitrary height of 100 feet above mean sea level. Stream bed cross-sectional elevations, relative to the TBM, were measured along each transect. Elevations were measured to the nearest 0.01 feet with a SOKKIA SET5F Total Station and a 25 foot target rod. The total length of the stream bank was measured in addition to the distance between the corner pins on opposite sides of the stream.

The study reach was approximately 186 meters (615 feet) in length on the river right bank. The first transect was located approximately 12 meters (40 feet) downstream from the beginning of the point of bank instability. There was approximately 58 meters (189 feet) between transects one and two, and 43 (142 feet) between transects two and three. It was 37 (121 feet) from the last transect to the downstream portion of the river right bank that was determined to be stable. Figure SB-2 depicts the location of the transects in relation to the study area.

PUT Figure SB2 Here

The bank erosion potential for this bank was determined to be “high.” This rating was determined by using Rosgen’s Stream Bank Erosion Potential method (Rosgen Applied Fluvial Geomorphology). Numerous factors are used to determine this ranking, including bank height, root depth, root density, bank angle, bank material, soil stratification, and surface area protection. The soils throughout the stream bank were sand/silt/clay with little to no gravel or cobble. This whole structure is over bedrock which is exposed in the thalweg. There was no root or surface area protection along the bank, and the bank height was generally more than twice the bank full depth.

There were approximately four meters (13.1 feet) of height from the thalweg to the top of the right bank at Transect 1. The upper 1.6 meters (5.4 feet) had an almost 90º vertical face. It gradually sloped off for the next 2.2 meters (7.2 feet) to the waters edge, and then sloped gently for approximately 0.36 meters (1.2 feet) to the depth of the thalweg (Figure SB-3). The total transect distance from the river-left transect pin to the river-right transect pin was 56.9 meters (188 feet). There was only a 2.3 meter (7.6 feet) rise from the thalweg to the height of the left bank. There was a gentle rise of 1.9 meters (6.3 feet) to the top of the left bank full shelf. This bank was well vegetated.

Transect 2 had a total distance of 58.6 meters (193 feet) between the left bank pin and the right bank pins. There were approximately 5.4 meters (17.8 feet) of height from the thalweg to the top of the right bank. The upper 1.8 meters (5.9 feet) had an almost 90º vertical face. It sloped another 2.2 meters (7.3 feet) to the waters edge. From here, the river bed sloped for approximately 1.4 meters (4.6 feet) to the depth of the thalweg (Figure SB-3). There was only a 1.3 meter (4.3 feet) rise from the thalweg to the height of the left bank. There was a gentle rise of 2.2 meters (7.3 feet) on the left bank to the top of the bank full shelf. This bank was well vegetated, but had a steeper slope than the Transect one left bank.

There were 66 meters (217.8 feet) between the left bank and right bank pins of Transect 3. The right bank had a vertical exposed bank approximately 2.5 meters (8.25 feet) in height (Figure SB-4). The bank dropped another 0.7 meters (2.3 feet) in height over a short distance. It decreased in height another 0.7 meters (2.3 feet) to the waters edges on the right bank, and then decreased another 0.5 meters (1.7 feet) to the depth of the thalweg. The total height difference from the thalweg to the top of the right bank was 4.4 meters (14.5 feet), approximately 1.0 meter (3.3 feet) less than the upstream transects. There was a gentle rise of 3.3 meters (10.9 feet) on the left bank to the top of the bank full shelf. This bank was well vegetated.

Figure SB-3

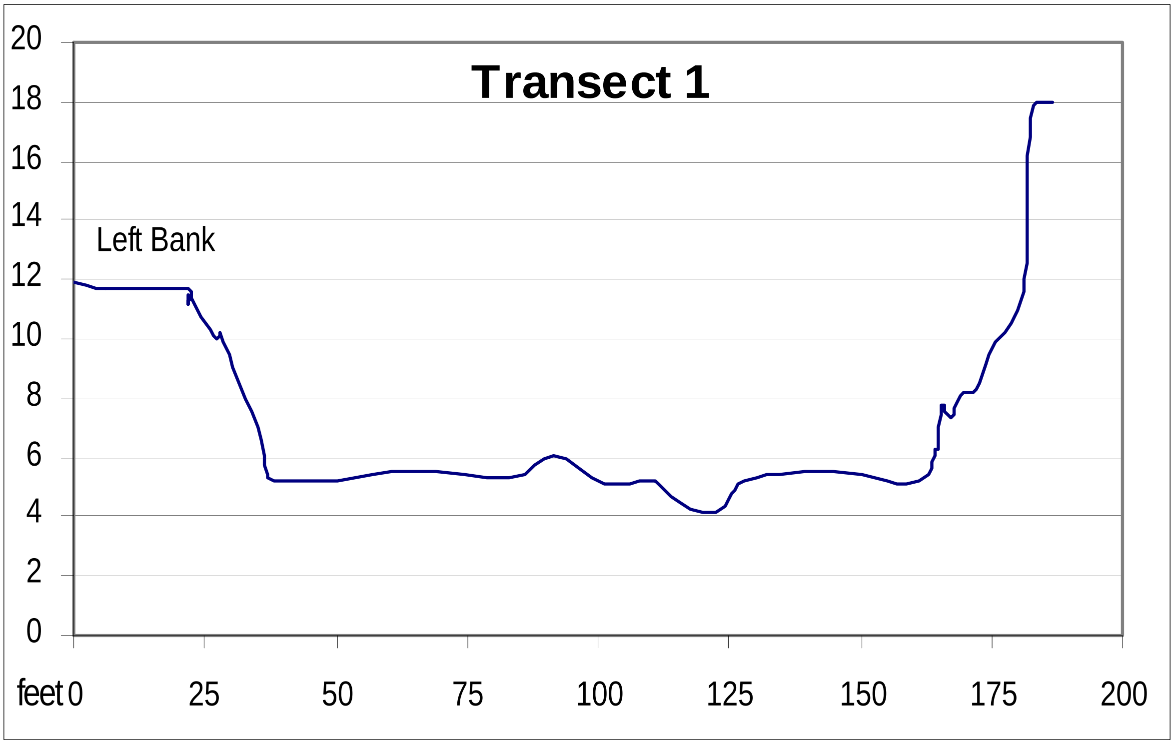


Figure SB-4

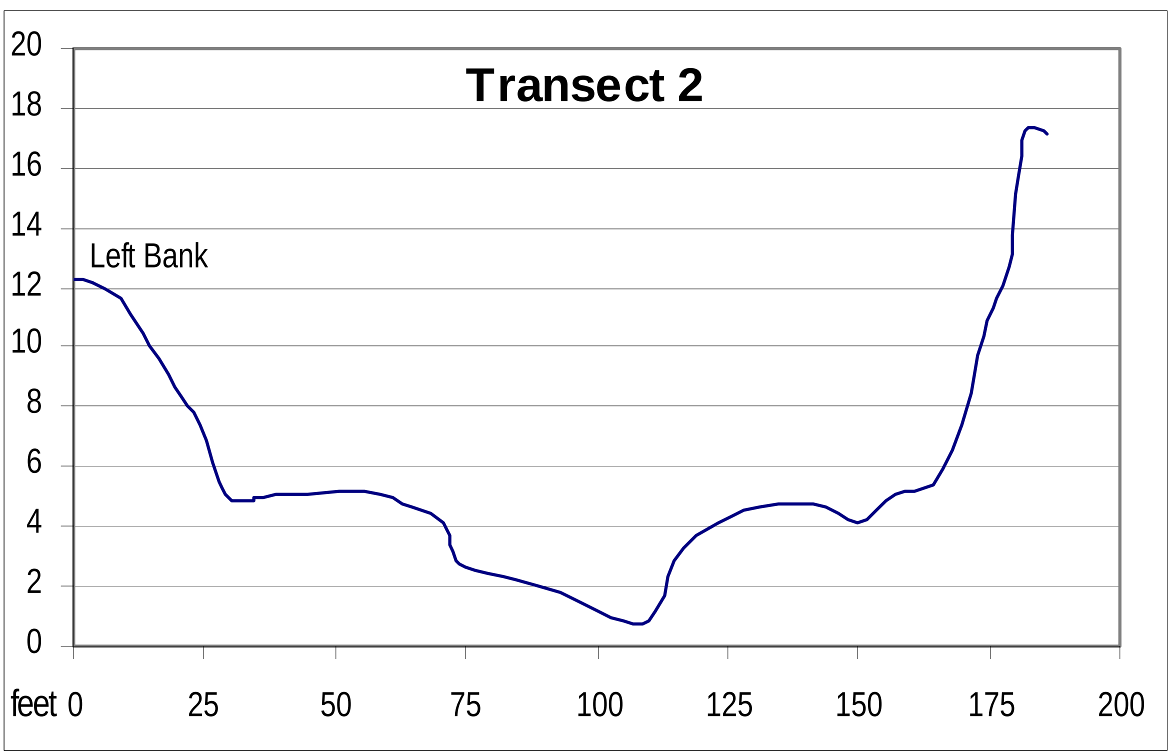
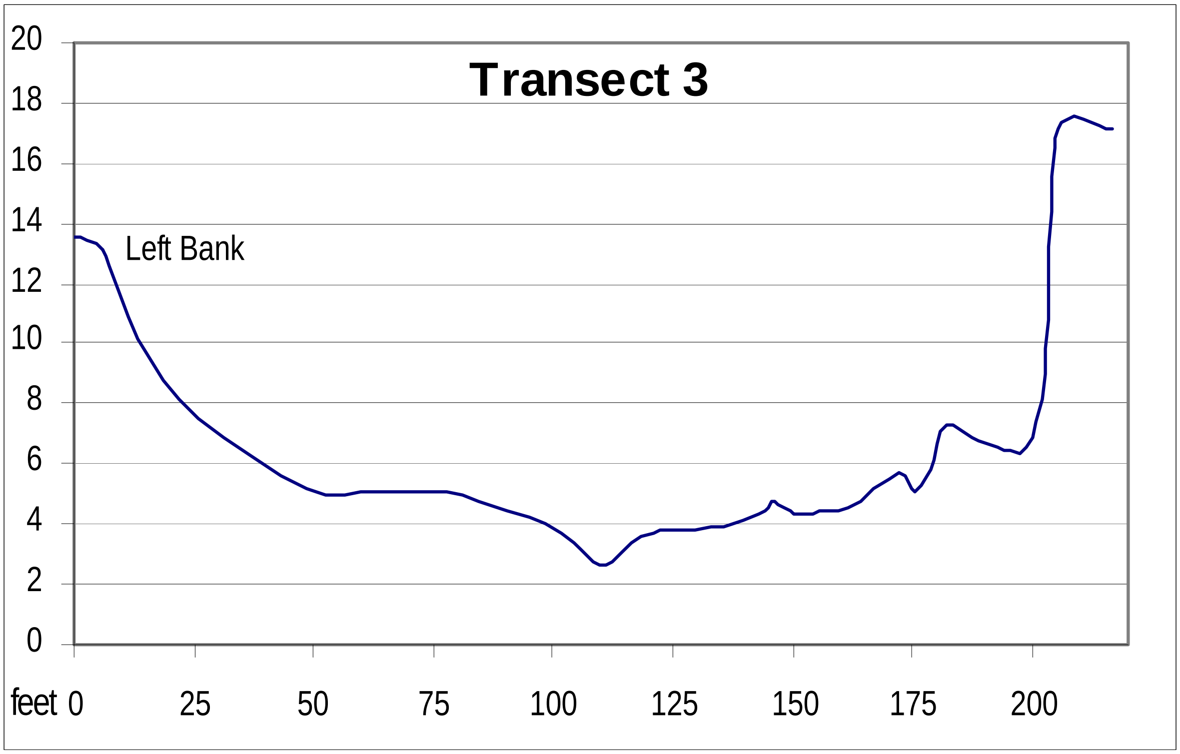


Figure SB-5



Transect 3
Left Bank
20
18
16
14
12
10
8
6
4
2
0
feet 0
25
50
75
100
125
150
175
200

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CONCLUSIONS

Water quality data has been collected from the Middle Fork Little Red River at Arkansas Highway 9 at Shirley, Arkansas in Van Buren County for more than 20 years. Data from this site between October, 1998 and September, 2003 indicate that dissolved oxygen concentrations fell below the Boston Mountains Ecoregion water quality standard of 6 mg/L in 20% of the samples collected during the primary season, and in 35% of the samples collected during the critical season. The majority of the dissolved oxygen readings below the standard occurred in either August or September.

Based on the above data, Arkansas' 2004 Integrated Water Quality Monitoring and Assessment Report (305(b)) identified two stream segments in the watershed as only partially supporting the aquatic life use because of low dissolved oxygen concentrations. In addition, these two segments were assessed as not supporting the primary contact recreation use because of high fecal coliform bacteria concentrations.

The data generated from this survey indicate that the Middle Fork of the Little Red River is fully attaining all water quality standards and fully supporting all its designated uses. However, low dissolved oxygen concentrations do exist in some areas during periods of low-flow and summer-time ambient temperatures. There are also some areas of concern relating to the point source discharger in the watershed, the elevated turbidity concentrations during periods of high runoff caused by the large, spring-time storm events, and the damage to in-stream habitat caused by short-term gravel removal activities.

The water quality and macroinvertebrate community of Cove Creek, which drains a 33.2 square mile area in the north-central portion of the watershed, is influenced by point and nonpoint sources of pollution, as well as natural occurring conditions. Geologic outcrops in the watershed increase sulfate and total dissolved solids concentrations during run-off events above those found in other portions of the watershed. Elevated turbidity and total suspended solids concentrations are perhaps a result of the geology in the watershed, as well as the land use practices. Also, a shift in the macroinvertebrate community structure, and a decrease in water quality in Cove Creek from just upstream of the City of Leslie to its mouth are perhaps attributed to leaking septic tanks, an increase in nutrients from the waste water treatment facility, and extreme critical season low-flows.

Two tributaries in the watershed, Little Red Creek and Meadow Creek, experience routine habitat destruction from gravel mining operations. Even though the Middle Fork of the Little Red River is protected from gravel mining because it is listed as an Extraordinary Resource Waterway, neither of these tributary streams is protected. The removal of gravel from these tributaries is causing stream bank and stream bed instability. This is elevating instream turbidity concentrations and could have a detrimental affect on the biology of these tributary streams, and in the Middle Fork of the Little Red River.

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Appendices

Appendix M-1: Macroinvertebrate Metrics

		Spring 2005						
	Numbers will either increase or decrease due to increased perturbation	WHI0181	UWMFK01	WHI0182	WHI0176	WHI0177	WHI0178	WI
Total Organisms	decrease	126	133	156	207	228	141	
Total Taxa	decrease	24	19	28	25	16	23	
No. Total EPT	decrease	64	51	51	71	90	73	
No. of Ephemeroptera Taxa	decrease	44	29	16	26	66	56	
No. of Plecoptera Taxa	decrease	13	3	22	30	2	15	
No. of Trichoptera Taxa	decrease	7	19	13	15	22	2	
% EPT	decrease	51%	38%	33%	34%	39%	52%	5
#Hydropsychidae		0	15	11	13	20	1	
% Hydropsychidae	either	0%	11%	7%	6%	9%	1%	
%EPT- %Hydropsychidae	decrease	51%	27%	26%	28%	31%	51%	5
%Isopoda	increase	16%	2%	6%	4%	0%	14%	
% Chironomidae	increase	19.05%	3.76%	28.85%	41.55%	38.16%	7.09%	19
% Diptera	either	22.22%	5.26%	33.97%	49.76%	40.79%	9.93%	22
% CLG	either	50.79%	16.54%	41.03%	57.97%	64.91%	41.13%	58
% SC	decrease	4.76%	52.63%	23.08%	6.76%	19.30%	20.57%	13
% CF	increase	7.14%	15.79%	10.26%	14.49%	11.40%	4.96%	2.
% Crawler:	decrease	14.29%	5.26%	16.03%	11.59%	1.75%	28.37%	13
% Clinger	decrease	38.10%	78.20%	32.05%	34.78%	38.60%	46.10%	53
% Burrowers:	increase	23.02%	5.26%	32.05%	45.41%	39.04%	9.93%	22
% Herpobenthos (BU+SP)	increase	18.44%	9.81%	9.18%	7.95%	19.47%	14.25%	5.
% Haptobenthos (CR+CLG)	decrease	65.08%	21.80%	57.05%	69.57%	66.67%	69.50%	72
Hilsenhoff Biotic Index (HBI)	increase	4.61	4.77	5.56	5.46	5.61	4.06	4
HBI Interpretation		good	good	fair	good	fair	very good	g
% Tolerant	increase	15.87%	2.26%	5.77%	4.35%	0.00%	14.89%	2.
% Intolerant	decrease	23.81%	3.76%	6.41%	10.14%	1.75%	32.62%	13
Dominant Taxa #1		**Chironomidae**	**Stenelmis**	**Chironomidae**	**Chironomidae**	**Chironomidae**	Ephemerella	**Macca**
% of Dominant taxa #1		**19%**	**46%**	**29%**	**41%**	**38%**	16%	**27%**
Dominant Taxa #2		**Lirceus**	**Cheumatopsyche**	**Stenelmis**	**Simulidae**	**Tricorythodes**	Lirceus	**Chiron**
% of Dominant taxa #2		**16%**	**11%**	**15%**	**8%**	**19%**	14%	**19%**

		Fall 2005						
		WHI0181	UWMFK01	WHI0182	WHI0176	WHI0177	WHI0178	WHI0153
Total Organisms	decrease	122	112	223	112	172	163	208
Total Taxa	decrease	19	16	20	28	18	27	24
No. Total EPT	decrease	30	32	72	6	119	51	42
No. of Ephemeroptera Taxa	decrease	24	30	32	5	118	35	35
No. of Plecoptera Taxa	decrease	4	0	6	1	0	4	1
No. of Trichoptera Taxa	decrease	2	2	34	0	1	12	6
% EPT	decrease	25%	29%	32%	5%	69%	31%	20%

#Hydropsychidae		2	2	29	0	0	7	5	
% Hydropsychidae	either	2%	2%	13%	0%	0%	4%	2%	
%EPT- %Hydropsychidae	decrease	23%	27%	19%	5%	69%	27%	18%	
%Isopoda	increase	1%	1%	0%	4%	0%	0%	1%	
% Chironomidae	increase	22.95%	12.50%	2.24%	8.93%	5.23%	6.75%	18.27%	
% Diptera	either	31.15%	14.29%	3.59%	9.82%	8.14%	6.75%	28.85%	
% CLG	either	43.44%	34.82%	12.56%	18.75%	75.58%	28.22%	33.17%	
% SC	decrease	36.07%	53.57%	62.33%	41.96%	17.44%	58.90%	28.85%	
% CF	increase	4.10%	3.57%	16.14%	1.79%	1.74%	4.91%	2.88%	
% Crawler:	decrease	7.38%	0.89%	5.38%	4.46%	2.33%	12.27%	13.94%	
% Clinger	decrease	59.84%	79.46%	70.40%	33.04%	24.42%	65.64%	47.60%	
% Burrowers:	increase	30.33%	16.07%	4.48%	12.50%	9.30%	7.36%	35.10%	
% Herpobenthos (BU+SP)	increase	2.71%	3.71%	6.30%	20.65%	63.43%	11.09%	2.09%	
% Haptobenthos (CR+CLG)	decrease	50.82%	35.71%	17.94%	23.21%	77.91%	40.49%	47.12%	
Hilsenhoff Biotic Index (HBI)	increase	5.04	4.99	4.82	6.08	6.33	5.00	5.21	
HBI Interpretation		good	good	good	fair	fair	good	good	
% Tolerant	increase	8.20%	1.79%	0.90%	29.46%	2.33%	4.29%	12.98%	
% Intolerant	decrease	4.92%	0.00%	2.69%	0.89%	0.00%	4.91%	1.92%	
Dominant Taxa #1		**Psephenus**	Stenelmis	Stenelmis	**Psephenus**	**Caenis**	**Stenelmis**	**Psephenus**	St
% of Dominant taxa #1		**30%**	32%	**35%**	**13%**	**61%**	**26%**	**21%**	
Dominant Taxa #2		**Chironomidae**	Maccafertium	**Heterelmis**	**Viviparidae**	**Stenelmis**	**Heterelmis**	**Chironomidae**	H
% of Dominant taxa #2		**23%**	19%	**16%**	**12%**	**12%**	**10%**	**18%**	

Appendix M-2: Riparian Habitat Analysis Data by Date

		Instream/Riparian Habitat												
Date	**Site**	**ES**	**EM/PS**	**VE/PV**	**SD**	**CF**	**CA**	**RF**	**LBS**	**RBS**	**LRV**	**RRV**	**TS**	**Score**
Spring 2005	WHI0181	15	16	15	18	16	19	18	13	18	13	20	**181**	**Optimal**
	UWMFK01	13	15	13	13	10	16	10	13	13	11	16	**143**	**Suboptimal**
	WHI0182	15	15	16	16	10	13	13	15	13	13	15	**154**	**Suboptimal**
	WHI0176	13	13	13	11	13	15	13	15	16	13	15	**150**	**Suboptimal**
	WHI0177	10	13	13	11	10	8	8	13	16	11	11	**124**	**Suboptimal**
	WHI0178	15	16	15	15	15	18	15	16	15	16	13	**169**	**Optimal**
	WHI0153	14	15	10	15	16	18	15	15	18	13	18	**167**	**Optimal**
	WHI0043	13	13	15	16	10	16	6	10	16	10	15	**140**	**Suboptimal**
	WHI0179	16	16	15	16	14	18	16	13	13	15	12	**164**	**Suboptimal**
Date	**Site**	**ES**	**EM/PS**	**VE/PV**	**SD**	**CF**	**CA**	**RF**	**LBS**	**RBS**	**LRV**	**RRV**	**TS**	**Score**
Fall 2005	WHI0181	10	15	8	10	15	19	16	8	15	6	20	**142**	**Suboptimal**
	UWMFK01	6	15	5	11	5	15	11	10	15	6	15	**114**	**Suboptimal**
	WHI0182	6	15	5	16	5	6	10	13	15	6	10	**107**	**Marginal**
	WHI0176	6	5	6	6	5	6	0	18	7	8	11	**78**	**Marginal**
	WHI0177	6	11	5	10	5	8	11	16	13	18	8	**111**	**Suboptimal**
	WHI0178	10	13	5	11	8	18	11	18	18	18	16	**146**	**Suboptimal**
	WHI0153	6	9	7	8	1	10	2	13	17	15	18	**106**	**Marginal**
	WHI0043	18	16	15	18	9	14	11	11	17	7	19	**155**	**Suboptimal**
	WHI0179	13	17	15	18	9	16	16	15	14	15	8	**156**	**Suboptimal**

Appendix SB-1: Unstable Stream Bank Characteristics

Site ID	Latitude	Longitude	Length (ft)	Height (ft)	Stability (Lt)	Stability (Rt)	
MFLLR A	35.80889	-92.63669	46	10.5	unstable		
MFLRR B	35.80447	-92.62867	96	11		unstable	
MFLRR C	35.80276	-92.60000	300	11	unstable		
MFLRR01	35.81641	-92.58157	90	13	moderately unstable	stable	Limited cattle access on W. Spring Hollow trib &
MFLRR02	35.81926	-92.56805	120	11	stable	moderately unstable	sloughing bank w/some vegetative cover; fence a
MFLRR03	35.81809	-92.54571	471	28	stable	moderately unstable	former cattle access; RB d/s of access w/moderate
MFLRR04	35.81682	-92.54247	186	12	unstable	moderately unstable	RB gravel bar modified for road crossing; RB cle
MFLRR05	35.81226	-92.54020	333	7	unstable	moderately unstable	channel altered by dozing, ford, cattle access both
MFLRR06	35.80729	-92.54026	231	7.5 - 11.1	stable	unstable	badly eroding bank w/cattle access, collapsing tre
MFLRR07	35.80224	-92.54153	441	10	moderately unstable	stable	additional 120 yds d/s of riffle/run similar status a
MFLRR08	35.79862	-92.53798	270	11	unstable	stable	cattle access at pasture u/s of Payton Creek conflu
MFLRR09	35.79311	-92.53493			unstable	stable	same area as MFLRR08
MFLRR10	35.79001	-92.53472	867	9	moderately unstable	moderately unstable	bank w/no riparian trees, grassy to edge; cattle ac
MFLRR11	35.78831	-92.53151	255	5 - 12	moderately unstable	stable	none
MFLRR12	35.79191	-92.53129	489	7.5	stable	moderately unstable	eroding section
MFLRR13	35.79308	-92.52737	80	5	moderately unstable	moderately unstable	short eroding section on RB; taller moderately sta
MFLRR14	35.79416	-92.52622	225	12 - 15	moderately unstable	stable	healthy riparian forest on eroding bank
MFLRR15	35.78914	-92.51259	480	12	stable	unstable	none
MFLRR16	35.78919	-92.50858	306		moderately unstable	moderately unstable	eroding RB, shorter moderately stable on LB
MFLRR17	35.78923	-92.50607	405		stable	unstable	occassional cattle and vehicle access on RB upstr
MFLRR18	35.79097	-92.50150	1113	6	moderately unstable	moderately unstable	cattle access both sides d/s margin
MFLRR19	35.79343	-92.49486	423		moderately unstable	moderately unstable	none
MFLRR20	35.78765	-92.49229	972		moderately unstable	unstable	126 ft on LB, 198 ft on RB; cattle access
MFLRR21	35.78527	-92.48909	321		moderately unstable	stable	none
MFLRR22	35.78411	-92.48531	282		unstable	stable	RB of R braided channel also eroding (168 yds);
MFLRR23	35.77647	-92.47984	282		stable	moderately unstable	vertical bank behind 10 ft vegetated ground 1 ft a
MFLRR24	35.77929	-92.47025	135		stable	moderately unstable	none
MFLRR25	35.77795	-92.46291	633	20	moderately unstable	stable	LB 133 yd; eroding bank d/s of Hurrricane Cr co
MFLRR26	35.77169	-92.45673	630		stable	moderately unstable	none
MFLRR27	35.76976	-92.44544	750	20	stable	unstable	actively eroding bank
MFLRR28	35.78195	-92.43018			stable	stable	cattle access RB and LB at head of riffle
MFLRR29	35.78339	-92.42600	162	8	unstable	stable	vertical LB; raw areas w/clay, gravel; ~150 m d/s
MFLRR30	35.76587	-92.40907			stable	moderately unstable	cattle access RB; rebar bridge 75 m d/s of cattle a
MFLRR31	35.76056	-92.40783	186		stable	unstable	RB eroding in R channel of braid; lots of woody
MFLRR32	35.75007	-92.40383	186	5	moderately unstable	stable	vertical bank on L braid at d/s convergence; well
MFLRR33	35.75449	-92.38738			stable	stable	cattle access RB; road crossing

MFLRR34	35.74644	-92.39238	261		moderately unstable	stable	cattle access both banks; recently cut trees along s
MFLRR35	35.73676	-92.39544			stable	moderately unstable	cattle access RB for ~ 1/4 mile
MFLRR36	35.73558	-92.38258	120		moderately unstable	stable	LB eroding, some cobble armoring
MFLRR37	35.74794	-92.36489	204	8	unstable	stable	vertical LB comprised of gravel and clay; high wa
MFLRR38	35.75761	-92.35860	1,410	8 - 12	stable	unstable	Pool, riffle, run, riffle alternating eroding banks
MFLRR39	35.75891	-92.35128	1,302		moderately unstable	moderately unstable	alternating eroding streambanks, RB lg trees falli
MFLRR40	35.74888	-92.34203	669	3 - 4	unstable	stable	vertical to slightly sloping bank w/exposed scars,
MFLRR41	35.74213	-92.34053	405	2 - 3	stable	moderately unstable	vertical RB w/exposed roots and trees near falling
MFLRR42	35.74212	-92.33363			stable	stable	cattle access at road and u/s along LB in pool
MFLRR43	35.70475	-92.30974	990	8	unstable	stable	alternating eroding banks, numerous trees falling
MFLRR44	35.69316	-92.31881	1,015	8	stable	unstable	eroding RB, some trees falling in river, bank com
MFLRR45	35.68849	-92.32480	144	15	stable	unstable	RB eroding next to private road; fixing to lose roa
MFLRR46	35.68773	-92.32022	306		stable	moderately unstable	none
MFLRR47	35.68248	-92.30207	273	8	moderately unstable	stable	vertical LB eroding, minor undercutting, moderat
MFLRR48	35.67356	-92.30271	324		unstable	stable	vertical LB eroding, gravel at toe - sediment on ro
MFLRR49	35.67191	-92.30392	144	12	stable	unstable	vertical RB eroding, lg chunks of clay falling in r
MFLRR50	35.66610	-92.30826	135	15	stable	moderately unstable	cattle access; vertical RB eroding; poor riparian m
MFLRR51	35.66132	-92.31686	356	8	stable	unstable	vertical RB eroding