

Niangua River

Watershed and Inventory Assessment

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64735

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Introduction

Water is the ultimate integrator. Water quality and biodiversity in aquatic ecosystems are reflections of the environmental quality of the watershed, the subsurface geohydrology, and the atmosphere. Land use and land cover in the watershed, and terrestrial and airborne pollution problems all impact water quality. Water is a universal solvent. It carries dissolved gases, nutrients, and minerals, and at least trace amounts of almost every substance it comes in contact with, from the air to the ground, and into streams and groundwater aquifers. Although the primary focus of this inventory and assessment is aquatic habitats and communities, we have attempted to view the Niangua Watershed as an ecosystem. The land, air, and water are interconnected and must be managed with mutual consideration. The creation of this document was considered a secondary objective of our planning effort for the Niangua Watershed. Our primary objective was to thoroughly inventory and organize information about the watershed for day-to-day use and for future planning.

Data Inventory and Management

The inventory for this document included compilation of a large amount of data and creation of twenty-four databases (Table 1). These databases have been incorporated in a Geographical Information System (GIS) featuring ArcView® software. Databases were structured to be as compatible as possible with available source databases, yet satisfy our needs. Data was obtained from numerous sources in various formats including hard copies of reports and computer printouts, database files and ASCII text files, and from personal communication. In order to easily determine whether sites described by legal description are located within the watershed, a diagram showing the sections within the watershed was created (Appendix A). Unique, four-character labels were assigned to each site including a letter code (A-Z) that is unique for each feature (e.g. A = animal waste point source). These labels are used to locate sites on maps, and can be used to relate records in multiple databases. Site labels were frequently included in the records extracted from these databases to create tables. In order to obtain UTM coordinates and produce maps, sites were plotted on 7.5 minute topographic maps and marked with the site labels. Then Missouri Department of Conservation's (MDC) Design and Development Division digitized these sites with AutoCad® software to produce layers for each feature. These layers were combined with layers including streams, roads, county boundaries, and other layers as necessary. MDC's Design and Development Division provided the Universal Transverse Mercator (UTM) coordinates for each site and they were added to the watershed database files. These were used to create XY. event tables in ArcView®, to produce coverages for each feature, and to create most of the maps in this document.

Many of the databases must be updated periodically to add new information (e.g. Section 404, permits and fish collections). This process will hopefully be facilitated by increased coordination between agencies to maintain databases in compatible formats and to improve accessibility. The MDC Fisheries Biometrics and two multi-agency groups, the Missouri Resource Assessment Project (MoRAP) and the Missouri Spatial Data Information System (MSDIS) are addressing this problem.

Location

The Niangua River (NR) is a sixth order tributary of the Osage River in west central Missouri. It originates in northern Webster County, at the confluence of its East and West Forks, about 7 miles north of Marshfield. In this document, the mouths of the Niangua and Little Niangua rivers are considered to be where they originally joined the Osage River before the Lake of the Ozarks was created. The mouths of all inundated tributaries to the Niangua and Little Niangua rivers are considered to be at the pre-inundated locations. The river meanders 120 miles to the north where it joins the Osage River (Osage Arm, Lake of the Ozarks, Figure 1). The largest tributary of the NR is the Little Niangua River (LNR), a fifth order stream which drains about one third of the entire watershed. The LNR originates in central Dallas County, near the town of Pumpkin Center. It meanders to the north and east 59 miles before joining the NR near stream mile 6 (SM 6). The lower 21 miles of the NR and lower 10 miles of the LNR were inundated in 1931 by Lake of the Ozarks (LOZ). The Niangua Watershed includes portions of six counties. Since only 500 acres of Benton County is within the watershed and includes negligible population and development, it is not included on many of the enclosed tables. The most detailed maps (Appendix B) divide the watershed into three subwatersheds as described below. The relative position of the three subwatersheds are shown in Figure 2.

Figure 1. Base map of the Niangua River Watershed with stream names and springs.

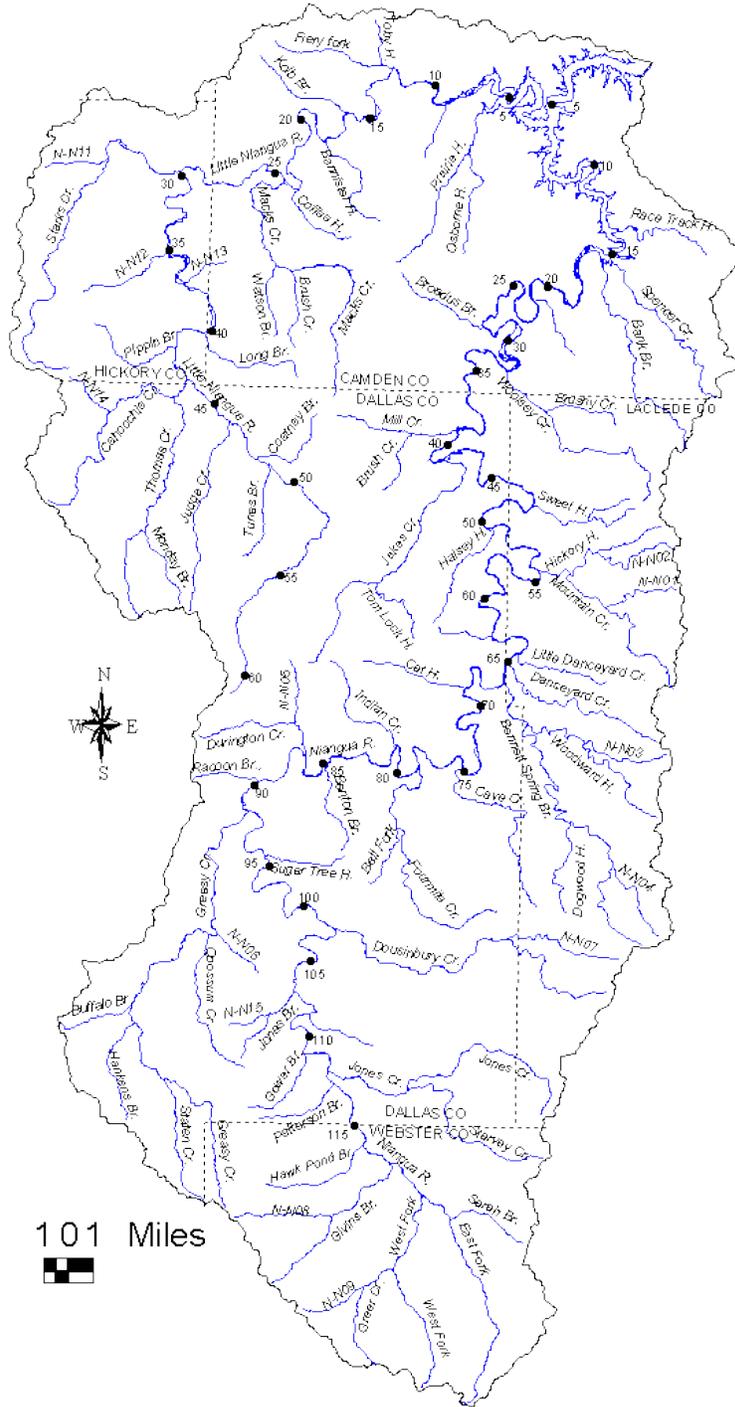
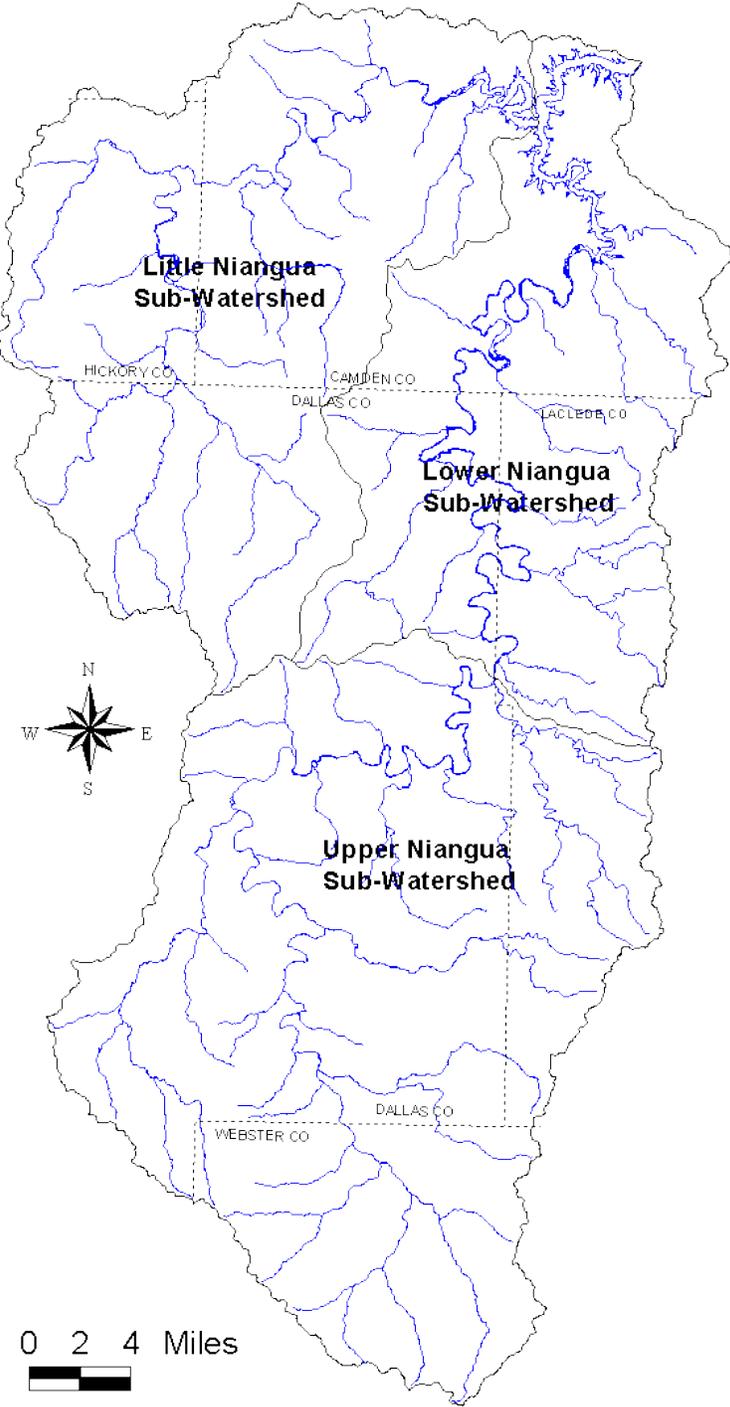


Figure 2. Lower Niangua, Upper Niangua, and Little Niangua River sub-watersheds.



Geomorphology

Physiographic Region/Geology/Soil Type

The Niangua Watershed lies in the Salem Plateau subdivision of the Ozark Plateau physiographic region. The watershed is underlain with several hundred feet of Ordovician and Cambrian rock, largely dolomite (Harvey et al., 1983). The edges of the watershed lie in Jefferson City-Cotter dolomite, while streams cut into progressively older Roubidoux, Gasconade, and Eminence formations (MDNR, 1984). There is considerable subsurface movement of water in the watershed through solution dissolved channels in the fractured and jointed dolomite. As a result, karst features such as caves, sinkholes, losing streams, and springs are abundant. Streams which incise into the middle or lower Gasconade have well sustained base flows even during dry periods, due to ample groundwater supplies (MDNR, 1984). Streams which incise into the Roubidoux formation are frequently losing streams and sinkholes are common (Harvey et al., 1983). Soils in the watershed are classified as residual, alluvial, colluvial, and loess (Harvey et al., 1983). Residual soils consist primarily of material weathered from cherty dolomite, dolomite, and sandstone, and occur on the surface of steep slopes. When they develop in uplands from Roubidoux formations, and Jefferson City - Cotter dolomites, an impervious fragipan usually occurs 18 to 24 inches below the surface. Colluvial soils, which are soils deposited on lower valley slopes by erosion from more elevated sites, are limited in abundance. Alluvial soils are those transported by streams and deposited on level or gently sloping areas in flood plains. They range in size from silt to gravel. Loess soils are silty, windblown material which commonly occur on ridgetops.

Watershed Area

The watershed area of the entire watershed is 1,040 square miles. The LNR watershed is 320 square miles, which is approximately one-third of the drainage of the entire watershed. Watershed areas for all fourth order and larger streams and some third order streams are shown in Table 2. The watersheds of fourth order streams are delineated in Figure 3. Approximately 500 acres of the Niangua Watershed is within Benton County, 164,000 within Camden County, 279,000 within Dallas County, 49,000 within Hickory County, 96,000 within Laclede County, and 69,000 within Webster County.

Stream Order

Stream order was determined from 7.5 minute topographic maps for all streams in the watershed. The NR has two fifth order and 14 fourth order tributaries. The LNR has one fifth order and six fourth order tributaries. Table 2 lists all third order and larger streams in the Niangua Watershed. Table 3 lists the total mileage of third order and larger streams, and the portions inundated by LOZ and Lake Niangua.

Channel Gradient

Stream gradients were determined for all third order and greater streams from the 7.5 minute topographic maps shown in Figure 4 and a table of elevations and average gradients is presented in Appendix C. Gradient plots were also created, but they are not included in this document. The average gradient of the Lower Niangua River is 3.9 feet per mile, the Upper Niangua River is 5.4 feet per mile, and the Little Niangua River is 9.4 feet per mile.

Figure 3. Watersheds of fourth order streams within the Niangua River Watershed.

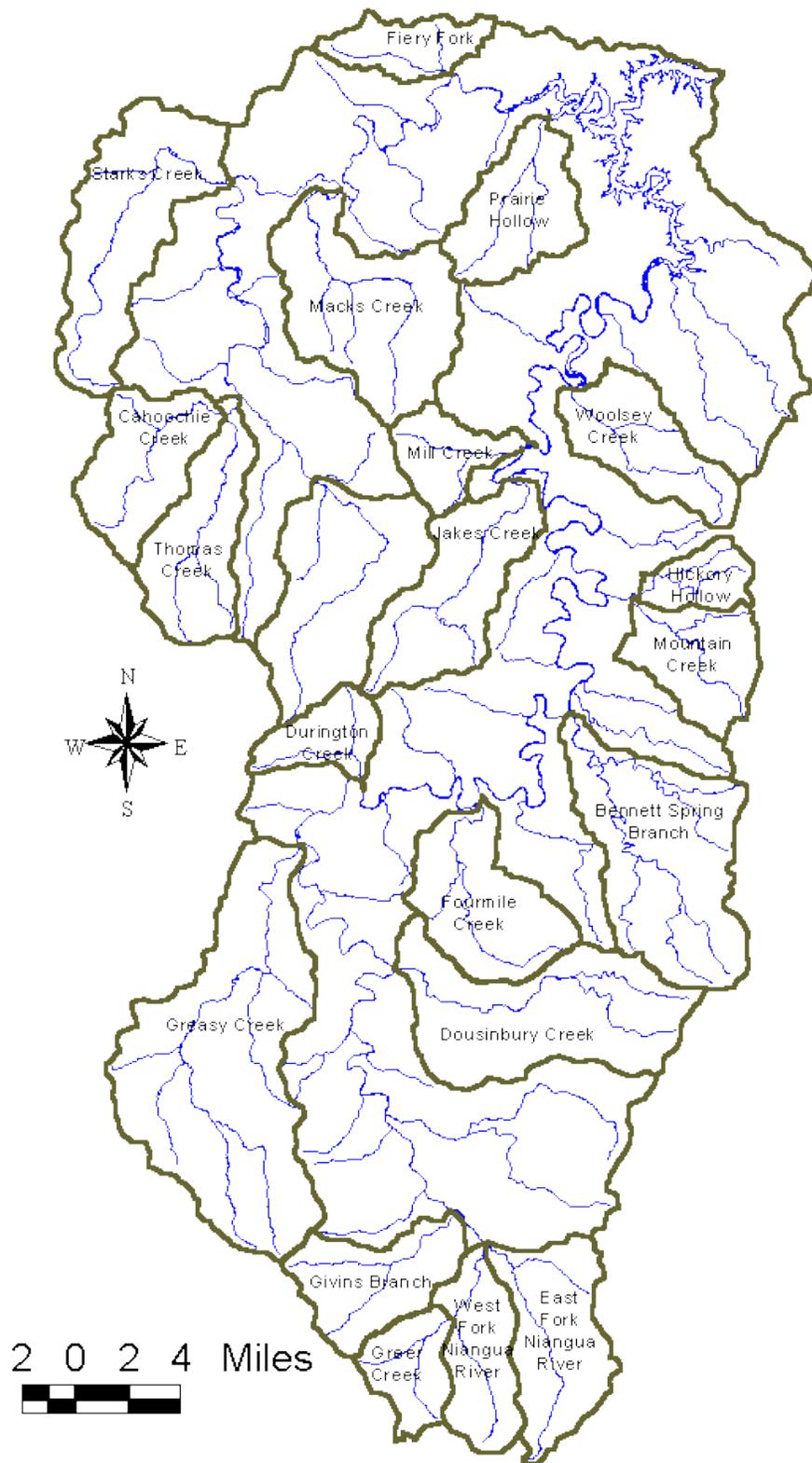


Table 2. Stream code, name, order, length, watershed area, and location for third order and larger streams within the Niangua Watershed.

Code Number	Stream	Order	Length	Length to Headwater	Watershed Area	Receiving Stream	Stream Mile	Length Intermittent
44300000	Niangua River	6	54.4	129	1,040.00	Osage River	—	0
44312000	Racetrack Hollow	3	4.5	6.8	7.9	Niangua River	13.6	4.2
44314000	Spencer Creek	3	2.8	7.5		Niangua River	15.2	0
44315000	Bank Branch	3	6.8	9.5		Niangua River	15.4	0
44318000	Broadus Branch	3	2.1	3.4		44318000	27.4	0
44321000	Woolsey Creek	4	2.1	9.4	19.7	Niangua River	32	0
44321000	Woolsey Creek	3	5.1	6.7		Woolsey Creek	0	0
44321100	Brushy Creek	3	0.9	2.8		Woolsey Creek	2.1	0
44323000	Mill Creek	4	2.4	5.1	12.1	Niangua River	38.7	0
44323000	Mill Creek	3	1.8	5.5	2.3	Mill Creek	0	0.7
44323200	Brush Creek	3	1.1	2.6		Mill Creek	2.4	0.1
44324000	Jakes Creek	4	7.3	12	27.1	Niangua River	41.2	0
44324000	Jakes Creek	3	1.8	4.6		Jakes Creek	0	0
44324100	Tom Lock Hollow	3	0.7	2.8	2.4	Jakes Creek	7.3	0
43250000	Sweet Hollow	3	2.4	4.4	8	Niangua River	47.3	0
44326000	Halsey Hollow	3	1.3	4.8	5.2	Niangua River	50.3	0
44320000	Niangua River	5	64.7	64.7		Niangua River	0	0
44327000	Mountain Creek	5	1.5	9.6	27.7	Niangua River	54.4	0
44327000	Mountain Creek	4	2.2	7.6	23	Mountain Creek	0	0
44327000	Mountain Creek	3	3.4	4.9		Mountain Creek	0	0
44327200	N_N01	3	2.2	3.7		Mountain Creek	3.7	2.1
44327100	Hickory Hollow	4	2	4.7	6.1	Mountain Creek	1.5	1.9
44327100	Hickory Hollow	3	0.9	2.7		Hickory Hollow	2	0.9
44327110	N_N02	3	1.9	4.3		Hickory Hollow	2	1.9
44331000	Little Danceyard Creek	3	0.9	3.8	7.9	Niangua River	64.6	0.2
44332000	Danceyard Creek	3	4.7	8.2	8.9	Niangua River	65	4.2
44334000	Bennett Spring Branch	4	12.2	15.8	37.7	Niangua River	65.9	10.6

Code Number	Stream	Order	Length	Length to Headwater	Watershed Area	Receiving Stream	Stream Mile	Length Intermittent
44334200	Woodward Hollow	3	3.5	7	9.2	Bennett Spring Branch	2.3	3.5
44334210	N_N03 3		2.7	3.7		Woodward Hollow	3.5	2.7
44334300	Dogwood Hollow	3	1	3.7		Bennett Spring Branch	9.2	0
44334310	N_N04	3	1.4	4.1		Bennett Spring Branch	12.2	1.4
44334100		3	2.1	4.5		Bennett Spring Branch	0	2.1
44339000	Cat Hollow	3	1.5	4.1		Niangua River	68.9	1.5
44336000	Cave Creek	3	2.3	8.6	13.3	Niangua River	75.1	0.3
44337000	Fourmile Creek	4	3.5	10	25.3	Niangua River	78.8	0
44337000	Fourmile Creek	3	3.4	6.4		Niangua River	0	1.7
44337100	Bell Fork	3	1.7	2.7		Fourmile Creek	3.5	1.7
44338000	Indian Creek	3	3.4	5.4	7.4	Niangua River	81.3	3.4
44341000	Benton Branch	3	0.4	3.6		Niangua River	84.8	0.4
44342000	Durington Creek	4	1.7	5.6	9.2	Niangua River	86.6	0
44342000	Durington Creek	3	0.5	3.8		Durington Creek	0	0
44342100	N_N05	3	1	2.4		Durington Creek	1.7	0
44343000	Raccoon Branch	3	1.4	2.6		Niangua River	89.7	0
44344000	Greasy Creek 4	14.8	21.8	71.2		Niangua River	91.4	0
44344100	N_N06	3	0.4	2.3		Greasy Creek	6.2	0
44344200	Opossum Creek	3	3.7	6.2		Greasy Creek	6.3	0
44344300	Buffalo Branch	3	1.4	3.1		Greasy Creek	11.3	0
44344400	Hankens Branch	3	1.9	4.7		Greasy Creek	12	0
44344500	Staten Creek	3	2.8	5.4		Greasy Greasy Creek	14.8	0
44344000	Greasy Creek	3	5.5	6.7		Greasy Creek	0	1.3
44346000	Sugartree Hollow	3	1	3.3		Niangua River	94.5	0
44347000	Dousinbury Creek	4	8.7	14.7	42.3	Niangua River	101.7	2.7
44347000	Dousinbury Creek	3	4	5.9		Dousinbury Creek	0	1.7

Code Number	Stream	Order	Length	Length to Headwater	Watershed Area	Receiving Stream	Stream Mile	Length Intermittent
44347200	N_N07	3	4.3	5.3		Dousinbury Creek	8.7	0
44351000	Jones Branch	3	1.7	3.9		Niangua River	106.5	0
44351500	N-N15	3	0.4	1.6		Jones Branch	1.4	0
44352000	Gower Branch	3	0.3	3.6		Niangua River	110.7	0
44353000	Jones Creek	3	6.7	7.3		Jones Creek	0	2.7
44353100	Starvey Creek	3	7.1	7.9	13.3	Jones Creek	3.5	4.8
44358000	Patterson Branch	3	2.5	3.9		Niangua River	113	1.8
44354000	Hawk Pond Branch	3	3.2	4.5	5.8	Niangua River	115.9	0
44355000	Givins Branch	4	3.4	7.2	20	Niangua River	117.3	0
44355100	N_N08	3	1.2	3.8		Givins Branch	3.4	1.2
44355000	Givins Branch	3	2.6	3.8		Givins Branch	0	0
44357000	West Fork Niangua River	4	3.3	8.3	28.3	Niangua River	119.1	0
44357000	West Fork Niangua River	3	2.5	4.6		West Fork Niangua River	0	0
44357100	Greer Creek	4	1.4	4.9	9.7	West Fork Niangua River	3.3	0
44357100	Greer Creek	3	0.7	3.3		Greer Creek	0	0
44357110	N_N09	3	0.4	2.6		Greer Creek	1.4	0
44356000	East Fork Niangua River	4	1.5	9.9	25.1	Niangua River	119.1	0
44356000	East Fork Niangua River	3	5.2	8.3		East Fork Niangua River	0	0
44356100	Sarah Branch	3	2.4	3.8	5	East Fork Niangua River	1.5	0
44360000	Little Niangua River	5	43.6	60.8	320.4	Niangua River	5.7	0
44361100	Prairie Hollow	4	2.5	8.2	21.1	Little Niangua River	4.7	0
44361100	Osborne Hollow	3	3.5	5.7		Prairie Hollow	0	0
44361110	Prairie Hollow	3	1.8	4.8		Little Niangua River	1.8	0

Code Number	Stream	Order	Length	Length to Headwater	Watershed Area	Receiving Stream	Stream Mile	Length Intermittent
44361400	Fiery Fork	4	0.3	5.5	11.3	Little Niangua River	12.2	0
44361400	Fiery Fork	3	2.3	5.1		Fiery Fork	0	0
44361410	Toby Hollow	3	1.3	2.3		Fiery Fork	0.3	0
44361600	Kolb Branch	3	1.7	3.7		Little Niangua River	15.8	0
44361900	Bannister Hollow	3	2.7	4.9		Little Niangua River	17.5	0
44361900	Coffee Hollow	3	1.2	2.8		Little Niangua River	23.7	0
44361800	Macks Creek	4	8.1	11.4	36.7	Little Niangua River	24.2	0
44361820	Watsons Branch	3	0.8	3.2		Macks Creek	5.2	0
44361830	Brush Creek	3	0.4	4		Macks Creek	5.8	0
44361840	N_N10	3	0.2	2		Macks Creek	8.1	0
44361800	Macks Creek	3	3.1	3.1		Macks Creek	0	0
44362200	Starks Creek	4	4.1	15.2	36	Little Niangua River	29.8	0
44362200	Starks Creek	3	8.4	11.7		Starks Creek	0	0
44362210	N_N11	3	1	3.9		Starks Creek	4.1	1
44362300	N_N12	3	2.6	3.9		Little Niangua River	35.1	2.6
44362800	N_N13	3	0.5	2		Little Niangua River	37.4	0.5
44362500	Long Branch	3	1.8	4.9		Little Niangua River	40.1	1.8
44362600	Pippin Branch	3	2.6	4.1		Little Niangua River	42	2.6
44362700	Thomas Creek	5	0.9	10.9	43.4	Little Niangua River	43.6	0
44362710	Cahoochie Creek	4	4.7	9.1	20.1	Thomas Creek	0.9	0
	Cahoochie					Cahoochie		
44362710	Creek	3	1.6	5.1		Creek	0	0
44362711	N_N14	3	6	2		Cahoochie	4.7	0
44362700	Thomas Creek	4	6.1	10	14.5	Thomas Creek	0	0
44362700	Thomas Creek	3	2.6	4.2		Thomas Creek	0	0

Code Number	Stream	Order	Length	Length to Headwater	Watershed Area	Receiving Stream	Stream Mile	Length Intermittent
44362720	Monday Branch	3	0.7	3.3		Thomas Creek	7	0.7
44360000	Little Niangua River	4	5	17.3	101.3	Little Niangua River	0	0
44363400	Coatney Branch	3	1.4	3.3		Little Niangua River	48.2	0
44360000	Little Niangua River	3	9.2	12.2		Little Niangua River	0	0
44363500	Tunas Branch	3	0.8	3.9		Little Niangua River	48.6	0.9

Stream code - From stream classification system (Pflieger, 1981). **Length** - Length in miles of segment of specific order.

Length to Headwater - Length in miles to origin.

Watershed Area - Square miles drained by listed streams watershed.

Stream mile - Distance from mouth of receiving stream to downstream end of described segment.

Length intermittent - Length of the segment shown as intermittent on topographic maps.

Table 3. Mileage of third order and larger streams, including inundated sections within the Niangua Watershed.

Stream Order	Number of Streams	Total Length (mi)	Inundated Lenth¹ (LOZ)(mi.)	Inundated Lenth² (Lake Niangua)(mi.)
3	80	189.4	1.1	
4	23	104.3	0.8	
5	4	110.7	10.1	
6	1	54.4	19.8	2.3

¹Total length inundated by Lake of the Ozarks (impounded in 1931).

²Total length inundated by Lake Niangua (impounded in 1929).

Land Use

Human Use

Indian occupation and European settlement of the Niangua Watershed are described in *The Big Niangua River* by Glenn "Boone" Skinner (1979). The first native Americans that French and Spanish explorers, traders, and trappers encountered in the watershed were the Osage (Circa 1780). Skinner reported that many Osage villages were strategically placed throughout the watershed, often where tributaries joined the main stem. The Osage were forced from Missouri to Oklahoma and relinquished their homeland by treaty in 1808. Soon Algonquin tribes, who were fleeing settlers to the east, moved into the area until they were evicted by treaty in 1820. Skinner related that the first permanent European settlers in the watershed established their home at the mouth of the Niangua River sometime between 1827 and 1833. Only poor roads existed so subsequent settlers poled rafts upriver to settle upstream sites in the watershed. The Buffalo area was settled in 1837 and Marshfield between 1834 and 1838. Early settlers located their homes close to the river because that was the main mode of transportation. They also sought locations near springs and forests for domestic water and building materials. Later immigrants settled on ridgetops where major roads were constructed. An Indian trail in Laclede and Webster Counties became Wire Road, which later became Route 66.

The 1994 estimated human population of the watershed was 34,679 based on U.S. Bureau of Census and Rand McNally data for each county and various communities. Population estimates by decade for counties that include the Niangua Watershed are shown in Table 4. Low-density and fairly stable populations were evident between 1930 and 1970. Since then populations of all five counties have increased, with Camden County more than doubling. The estimated population growth of Dallas County was the fourth greatest in the state between 1990 and 1994, and Camden County was ninth greatest.

Land Cover and Use

Land cover in the Niangua Watershed before settlement was a mosaic of prairie, savanna, and forest. The undissected uplands were dominated by patches of prairie and savanna with high grasses and large post oaks (Schroeder, 1983). Large patches of prairie were confined to the Buffalo Head Prairie which included the southwestern portion of the watershed in the upper reaches of the LNR and NR (McCarty, 1995). Areas of greater relief and narrow ridgetops were dominated by oak-hickory forest with occasional patches of prairie in the bottomland (Schroeder, 1983). Savannas were believed to be common in the Springfield Plateau which includes the Niangua Watershed (Nelson, 1985). They depended on fires started by lightning or native Indians every five to ten years to prevent encroachment by less fire-tolerant trees (Nelson, 1985). Drastic changes in land cover have occurred since European settlement. Prairies have been destroyed by plowing, overgrazing, and fire control, and are now primarily replaced by pasture (Schroeder, 1983). Savannas have been similarly altered and good examples are only found in Ha Ha Tonka and Bennett Springs state parks (Leach and Ross, 1995).

Approximately 50% of the original forest in the state was converted to pasture by 1947 (MDC, 1980). Conversion to pasture is most prevalent in areas with low relief, such as headwater reaches and wide valleys. In the five counties that include the Niangua Watershed, forested acres declined 24% between 1947 and 1972, while forested acres in the entire Ozark Region declined by 13% (MDC, 1980). These declines were attributed to high cattle prices in the 1960s that prompted farmers, who owned over 50% of the commercial forest in Missouri, to convert forest

to pasture (MDC, 1980). Further declines were not documented in these counties between 1972 and 1989, although differences in reporting methods "make comparison uncertain" (Smith, 1990). In areas of high relief, such as the LNR and lower NR, slopes tend to be maintained in woodland and valleys are cleared (Harvey et al., 1983).

Agriculture and tourism are major industries throughout the watershed. Primary agricultural activities include dairy and beef cattle production. A limited amount of hog and poultry production also occurs. Important tourist activities include fishing, canoeing, and boating. A major challenge in managing the watershed is to allow these industries to co-exist without adversely impacting each other or the environment.

Land use on farms in several categories is shown in Table 5. These data were obtained from Agri-Facts for each county (MDA, 1995) and from USDA (1992). In 1992 approximately 51% of the watershed was used for cropland. This consisted mostly of hay fields of which more than half was also used for pasture. Woodland pasture and other pasture occupied 39% of the watershed and ungrazed woodland occupied less than 9%. Grazed and ungrazed woodland included approximately 27% of the watershed. Notable changes evident in Table 5 between 1929 and 1992 include a decrease in harvested cropland (40%), a decrease in pastured woodland (55%), and an increase in other pasture (126%). The total amount of pasture has remained fairly constant. Most woodland was grazed, and ungrazed woodland was a small percentage (9%-10%) of the watershed between 1978 and 1992.

Soil Conservation Projects

The U.S. Department of Agriculture, through the Natural Resources Conservation Service (NRCS), began the Upper Niangua Animal Waste Project (UNAWP) in 1991 as part of its nationwide Water Quality Initiative (Smale et al, 1995). The UNAWP supports a number of activities with the common goal of minimizing the undesirable effects of agriculture on water quality in the Upper Niangua Watershed. Some of the project activities, such as outreach programs conducted through the local University Agricultural Extension offices and the completion of Farmstead Assessment Systems, are educational or information gathering in nature and difficult to quantify in terms of their effects on water quality. Other activities, including the monitoring of wells and capping of abandoned wells, are directed at preventing groundwater pollution. The main emphasis of the project has been the design and construction of a number of animal waste treatment facilities throughout the watershed.

The treatment facilities are designed to intercept and process manure and prevent nutrients from contaminating the NR and its tributaries. Manure is retained in the facilities so that it can be broken down by natural decomposition and applied to farmland. Smale et al (1995) estimated the nutrients saved in 1995 by processing this manure were valued at over \$49,000 and could be expected to produce over 3,800 tons of hay. As of October 1996, there were 29 completed facilities and seven more under design.

The agencies involved with the UNAWP have educated landowners about nutrient enrichment and the need for such facilities, and provided technical assistance and cost-share funds for their construction. Inspection and certification of the facilities is conducted by the Missouri Department of Natural Resources (MDNR). To evaluate the effectiveness of this project, the U.S. Geological Survey (USGS) was contracted to monitor water quality throughout the Upper Niangua River watershed. In addition, the Missouri Cooperative Fish and Wildlife Research Unit at the University of Missouri monitored fish and invertebrate communities and evaluated habitat conditions.

Public Lands

All public use areas are listed in Table 6 and mapped in Figure 5. Both state parks, a multi-purpose lake access, three large MDC frontage tracts with stream access, six other MDC stream accesses, and three access points near Tunnel Dam provide water-oriented recreational opportunities. Recreational use on the NR, LOZ, and at Bennett Spring State Park is very high. At least ten outfitters provide canoes, rafts, kayaks, and tubes; and shuttle customers between the public access sites and other sites on the NR. MDC agents have reported a significant increase in the number of boaters and associated violations in recent years, especially between Bennett Spring State Park and Prosperine Access (John Hoskins (MDC), pers. comm.). They estimate that over 1,000 canoes use that section on a typical busy summer day. Campground owners and canoe outfitters have also complained about littering, noise, and alcohol/drug abuse by boaters in recent years.

Bennett Spring State Park is located in Laclede and Dallas Counties at the confluence of Bennett Spring Branch and the NR (Appendix D). The 3,095 acre park is operated by the MDNR, but includes a cold-water hatchery operated by the MDC. It features a put-and-take trout fishery as well as camping and cabin facilities. Bennett Spring CA is a MDC access on the NR adjacent to the park. The Stream Management Plan for the park was prepared by the Bennett Spring Trout Park Task Force Committee in March 1990 and revised in February, 1992 (BSTPTFC, 1992). The Trout Park Task Force is comprised of two representatives from the MDNR and two representatives from the MDC. The plan outlines concerns and activities related to Bennett Spring Branch, and its stream corridors and watershed. Several described stream improvement projects have been completed. These include rock jetties to decrease gravel deposition in the main channel; bank stabilization with strategic cedar tree revetments and corridor revegetation; and boulder habitat structures. Structures to improve bank fishing access such as walkways on rock jetties and stream banks with wheelchair access have also been completed. A rock wall for bank stabilization on the NR at the mouth of Bennett Spring Branch was recently constructed, and tree plantings to reduce flood-plain erosion have been completed in most of the planned locations (Craig Fuller (MDC), pers. comm).

Lead Mine CA is located in Dallas County on the NR (SM 41.5) (Appendix D). The area includes 7,743 acres and is 90 percent forested. It contains the lower 3.6 miles of Jakes Creek to its confluence with the NR, and approximately 3.0 miles of Niangua River frontage. The area plan, which is currently being revised, was completed in June, 1984. In addition to area plans, a Riparian Management Zone Plan for Lead Mine State Forest - Jakes Creek, and a Bank Stabilization Project Plan for Lead Mine State Forest - Jakes Creek were both approved in December 1990 (see Habitat Conditions section).

Barclay Springs CA (389 acres) was acquired on the Niangua River in 1997 (Appendix D). The tract is located 6 mile north of Bennett Spring. Water resources include 1.7 mile of Niangua River frontage designated as trout management waters, a large spring, and 0.4 mile of spring branch. The tract has 55 acres of open bottomland, 58 acres of upland fields (hay and pasture), 269 acres of timber, and 5 acres of river, and buildings sites. The site is suitable for access development, riparian corridor improvements, protection of the spring and spring branch, and fisheries habitat improvements.

Mule Shoe CA encompasses 2,390 acres in three separate areas in Hickory County, including 9.2 miles of stream frontage (Appendix D). The most significant stream on the property is 2.9 miles of the Little Niangua River which is critical habitat for the Niangua darter. Other waterways on the area include Starks Creek and two unnamed tributaries. A 200-foot riparian zone will be

created and maintained on the LNR by 2003 and a 100-foot riparian zone will protect the tributaries. Nearly 80% of the area is forested. The area is managed by MDC personnel from the West Central Forestry Region in cooperation with the West Central Fisheries Region. A major reason for acquisition of the area was to protect habitat for the Niangua darter.

Charity CA is the most upstream access on the NR (SM 112) (Appendix D). It is approximately 18 miles upstream from Big John CA (SM 94). Charity CA currently includes 320 acres. Four significant springs upstream from the access and a spring within one-half mile to the east of the access combine to produce cold-water conditions in the NR in the vicinity of the access. The aquatic resources of the area will be managed for the benefit of the native fish and fauna.

Fiery Fork CA in Camden County includes 1,606 acres on the LNR (SM 12.5) (Appendix D). The area contains 1.5 miles of the LNR, and the lower 0.9 miles of Fiery Fork Creek, and 1.0 miles of Toby Hollow Creek. Five springs and numerous permanent ponds (mostly fishless) provide water for wildlife and essential breeding habitat for amphibians. The LNR access is popular with fishermen, floaters, and swimmers (Brown and Ronk, 1983). Fiery Fork is managed primarily for recreational values and as a model in forest management and wildfire suppression (Brown and Ronk, 1983). The area includes 1,401 acres (87% of total area) of forest (oak-hickory), glade, and savanna; 184 acres (11%) of crop/old field; 11 acres (1%) of water/stream bed; and 10 acres (1%) of campgrounds/roads (Jones et al., under review). In addition to the area plan, a Riparian Zone Plan for Fiery Fork CA was completed in July of 1992. This plan resulted in curtailed cultivation and haying operations in 1992 and placed a high priority on expanding riparian corridors to 200 feet on all streams by 1998 (Stoner, 1992).

Corps of Engineers Jurisdiction

Waters of the Niangua Watershed are under the regulatory jurisdiction of the Kansas City District of the U.S. Army Corps of Engineers (COE). The district assumes responsibility for all streams which appear on county highway maps prepared by the Missouri Highway and Transportation Department (MHTD). Portions of the watershed impounded by LOZ are listed as navigable waters of the United States pursuant to Section 10 of the Clean Water Act, while all other streams are regulated under Section 404. Nationwide permits are normally issued for qualifying Section 404 activities upstream of the point where the median annual flow of any stream is less than 5 cfs. Proposed activities within Niangua darter range before 1995 were usually reviewed by the MDC and USFWS, and normally not authorized by nationwide permits. In December 1995, a general permit, MKP-GP34M, was enacted for sand and gravel excavation in Missouri streams. This permit includes conditions formulated by the MDC, MDNR, U.S. Fish and Wildlife Service (USFWS), and COE to minimize environmental impacts. In stream activities are prohibited during spring and/or fall seasons on designated segments of some streams (Table 7, Figure 6). The COE automatically includes the prohibitions on general permits within these segments. Prior to 1997, most Section 404 activities involving sand and gravel removal were authorized by this permit unless unusual conditions required individual permits, or a nationwide permit could be applied.

In January, 1997 a federal court reversed a 1993 ruling that was the basis for COE authority to regulate in stream sand and gravel excavation. In 1993, the Tulloch Rule found that "incidental fallback", small amounts of material that inevitably fall back in the stream when sand and gravel are excavated, was "fill" as regulated under Section 404 of the Clean Water Act. Several months after the 1997 ruling, the court issued a stay, pending appeal that reinstated COE authority over "incidental fallback", so the COE began issuing permits and enforcing its authority. However,

the court again removed COE authority in July 1998. Currently, the COE does not regulate sand and gravel removal that results in "incidental fallback". However, COE permits are required for activities that include grading or pushing gravel in the stream channel; stockpiling, sorting, or crushing gravel in the stream channel or on gravel bars; access roads through the stream; and disposal of oversized material within the stream channel.

Any commercial sand and gravel removal within stream channels or flood plains requires a permit from the MDNR Land Reclamation Program. Environmental conditions imposed on these permits are usually much less restrictive than those in the General Permit (MKP-GP34M), and the lack of adequate personnel in the Land Reclamation Program limits enforcement. Non-commercial operations, such as those by individuals for personal use, or city, county, and state governments are exempt from Land Reclamation permitting requirements. The MDNR is in the process of developing guidelines similar to those in the General Permit (MKP-GP34M) which may be included in Land Reclamation permits in the future.

Table 4. Human populations of counties that include the Niangua Watershed.

County	1930	1940	1950	1960	1970	1980	1990	(estimate)	Rank¹
Camden	9,142	8,971	7,861	9,116	13,315	20,017	27,495	30,594	9
Dallas	10,541	11,523	10,392	9,314	10,054	12,096	12,646	14,233	4
Hickory	6,430	6,506	5,387	4,516	4,481	6,367	7,335	8,044	12
Laclede	16,320	18,718	19,010	18,991	19,944	24,323	27,158	28,682	34
Webster	16,148	17,226	15,072	13,753	15,562	20,414	23,753	25,965	14
Totals	58,581	62,944	57,772	55,690	63,356	90,909	98,387	107,278	

¹State rank in estimated population growth between 1990 and 1994.

1930 thru 1990 data are from U.S. Census Bureau.

1994 estimates are from the Missouri Office of Administration.

Table 5. Land use in acres within the Niangua Watershed between 1929 and 1992.

Year	Cropland			Woodland ⁴		Other Pasture ⁵	All Other Land ⁶
	Harvested ¹	Other ²	Pastured ³	Pastured	Not Pastured		
1929	133,684	13,986	87,605	162,591	—	32,721	12,156
1934	104,550	26,789	98,473	—	—	—	49,037
1939	104,102	10,756	106,563	—	—	—	57,306
1944	111,948	4,425	28,513	158,802	—	160,069	14,577
1949	96,672	12,002	80,669	156,695	—	81,419	17,218
1954	77,072	9,054	82,451	183,133	—	79,176	12,318
1959	67,215	16,111	85,857	162,729	—	66,515	13,307
1964	61,691	21,984	81,644	—	—	—	12,633
1969	51,778	16,345	126,954	—	—	—	8,934
1974	61,072	7,261	118,570	—	—	—	9,672
1978	67,686	7,457	130,449	83,062	32,083	58,228	15,045
1982	70,964	6,044	112,070	78,426	34,275	62,155	14,993
1987	72,754	8,401	108,303	83,062	31,614	76,265	13,043
1992	80,064	6,150	110,285	71,903	32,891	74,969	12,005

All data from 7/95 Camden, Dallas, Hickory, Laclede, Webster County Agri-facts, and from 1992 Census of Agriculture, Missouri State and County Data, U.S. Department of Commerce Economics and Statistics Administration, Bureau of the Census.

¹- All land from which crops were harvested or hay was cut, and all land in orchards, citrus groves, vineyards, and nursery and greenhouse crops.

²- Cropland used for cover crops, legumes, and soil-improvement grasses, but NOT harvested and Not pastured; cropland on which all crops failed; cropland in cultivated summer fallow; and/or cropland idle.

³- Rotation pasture and grazing land that could have been used for crops without additional improvements.

⁴- Woodlots and timber tracts and cutover and deforested land with young timber growth.

⁵- Pastureland and rangeland other than cropland and woodland pastured.

⁶- Land in house lots, ponds, roads, wasteland, etc.

— Data not available.

Table 6. Public use areas with size, stream, and type of boat access within the Niangua Watershed.

Area (Ownership ¹)	Acres	Frontage (mi)	Major Streams	Boat Access	Topographic Map
Bennett Springs Access	178	0.5	Niangua River	Yes	Bennett Springs
Bennett Springs State Park (MDC, MDNR)	40	1.5	Bennett Sprg Br	Yes	Bennett Springs
Berry Bluff CA²	159	0	Niangua River	No	Eldridge West
Big John Access	16	0.3	Niangua River	Yes	Buffalo
Branch Towersite	40	0	None	No	Branch
Camdenton CSC³	46	0	None		Green Bay Terrace
Charity Access	163	0.2	Niangua River	Yes	Long Lane
Coffin Cave CA	60	0	None	No	Bennett Springs
Fiery Fork CA	1606	1.5	Little Niangua River	Yes	Barnumton
Flatwood Church CA	71	0	None	No	Bennett Springs
Goose Creek SF	1,040	0	None	No	Long Lane, Phillipsburg
Ha Ha Tonka State Park (MDNR)	2,953	1.3	Niangua Arm (LOZ)	Yes	Ha Ha Tonka
Lake Niangua Accesses (SME)⁴	1	0.1	Lake Niangua		Ha Ha Tonka
Lead Mine CA	6,473	2.3	Niangua River	Yes	Lead Mine
Moon Valley Access	3	0.2	Niangua River	Yes	Windyville
Mule Shoe CA	1,850 540	2.2 0.8	Little Niangua River Starks Creek	Yes No	Branch Climax Springs
Gale CA	194	0.2	Niangua Arm (LOZ)	Yes	Green Bay Terrace
Niangua CA	837	0.4	Trib. East Fork Niangua River	No	Beach, Niangua
Plad Towersite	2	0	None	No	Windyville
Proserpine Access	8	0.1	Niangua River	Yes	Eldridge West
Williams Ford Access	40	0.2	Niangua River	Yes	Windyville

¹MDC = Missouri Department of Conservation, unless otherwise indicated; MDNR = Missouri Department of Natural Resources; SME = Sho-Me Power Corporation. ²CA = Conservation Area.

Figure 6. Stream segments protected by spring and fall spawning prohibitions within the Niangua Watershed.

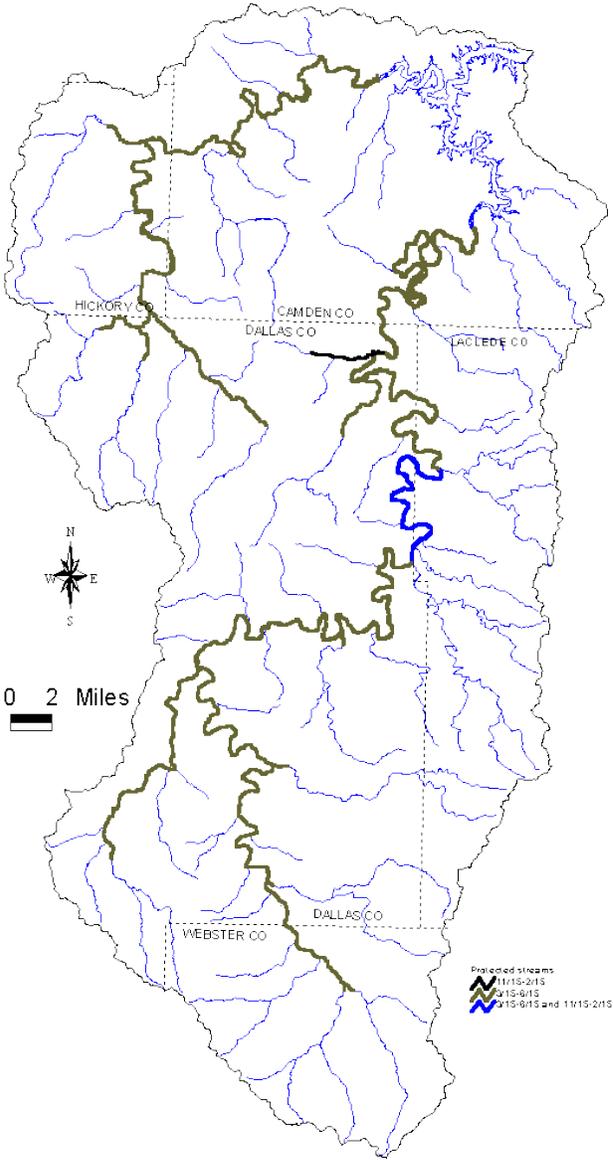


Table 7. Stream segments where Section 404 instream activities are prohibited during Spring and Fall Periods within the Niangua Watershed.

Closed March 15 Through June 15					
Waterbody	Miles	From	To	Counties	Criteria ¹
Niangua River	59	Lake of the Ozarks (9,37N,17W)	Hwy K (8,34N,18W)	Camden, Dallas, Laclede	3,5,6,7
Niangua River	40	Hwy K (8,34N,18W)	Conf. Of E. and W. Forks (33,32N,18W)	Dallas, Webster	1
East Fork Niangua River	0.5	Conf. of Niangua River (33,32N,18W)	T32 - T31 Line (33,32N,18W)	Webster	1
West Fork Niangua River	0.3	Conf. of Niangua River (33,32N,18W)	T32 - T31 Line (33,32N,18W)	Webster	1
Greasy Creek	12.9	Conf. with Niangua River (17,34N,19W)	South Section Line (34,33N,20W)	Dallas	2
Jakes Creek	4.5	Conf. with Niangua River (15,36N,18W)	First Co. Rd. Crossing (33,36N,18W)	Dallas	6
Dousinbury Creek	0.7	Conf. with Niangua River (11,33N,19W)	First Co. Rd. Crossing (12,33N,19W)	Dallas	2
Jones Creek	0.4	Conf. with Niangua River (2,32N,19W)	First Co. Rd. Crossing (11,32N,19W)	Dallas	2
Fourmile Creek	0.7	Conf. with Niangua River (4,34N,18W)	Hwy P(9,34N,18W)	Dallas	2
Little Niangua River	18.5	Lake of the Ozarks (3,38N,18W)	East Section Line (33,38N,20W)	Camden, Hickory	3 5 6 7
Little Niangua River	22.5	East Section Line (33,38N,20W)	East Section Line (26,36N,19W)	Camden, Dallas, Hickory	1
Starks Creek	2	Conf. with Little Niangua River (23,38N,20W)	North Section Line (22,38N,20W)	Hickory	2, 3
Thomas Creek	2.7	Conf. with Little Niangua River (36,37N,20W)	South Section line (12,36N,20W)	Dallas, Hickory	2, 3
Cahoochie Creek	2.5	Conf. with Thomas Creek (2,36N,20W)	West Section Line (3,36N,20W)	Dallas	2,3
Closed November 15 through February 15					
Mill Creek	3.5	Conf. With Niangua River (10,36N,18W)	West Section Line (8,36N,18W)	Dallas	6
Niangua River	12	Bennett Spring (25,35N,18W)	Prosperine Access (5,35N,17W)	Laclede, Dallas	6

¹Criteria for justifying spawning season prohibition are as follows:

1. Critical habitat for Niangua darter.
2. Area considered critical to the maintenance or recovery of one or more of the following sensitive species; Niangua darter, bluestripe darter, blacknose shiner, Topeka shiner, eastern hellbender, pink mucket, southern brook lamprey, blue sucker, and pallid sturgeon.
3. Stream reach which supports seasonal concentrations of spawning, incubating or rearing fishes of management interest including one or more of the following; walleye, sauger, white bass, rock bass, smallmouth bass, suckers, trout, and the above mentioned sensitive species.
4. Remnant example of historic habitat in which the surrounding streams or stream reaches have been severely degraded by human activities.
5. Designated Outstanding National or State Resource Water (or candidate for such designations) which supports a biological resource subject to damage from sand and gravel removal during periods of spawning, incubation, or rearing.
6. Agency management area (special trout or black bass management area), candidate for special management, or agency owned area.
7. Area containing a unique fish community or unexpectedly high biodiversity due to the presence of species considered atypical to the area.

Hydrology

Precipitation

Average annual precipitation for the Niangua Watershed is 40-42 inches per year (MDNR, 1986). The mean monthly precipitation at the Buffalo weather station, which is located near the center of the watershed, is shown in Figure 7. The wettest months are typically May, June, and September and the driest are December, January, and February.

Gaging and Water Quality Stations

Gaging and water quality stations are listed in Table 8 and mapped in Figure 8. There have been six (United States Geological Survey) gaging stations and two low flow stations in the Niangua Watershed. In addition, 19 water quality stations and one gaging station were monitored by the USGS for the Upper Niangua Animal Waste Project (UNAWP) between 1991 and 1995. Five water quality stations were monitored in 1989 and 1990 by a private contractor, Environmental Science and Engineering (ESE), to satisfy Federal Energy Regulatory Commission (FERC) requirements for Tunnel Dam relicensing (ESE, 1990). Sho-Me Electric Corporation helped fund the installation and maintenance of a new gaging station in November 1995 immediately below Tunnel Dam (NR) to monitor flow.

Stream Flow

The most downstream USGS station on the NR near Decaturville (G026) indicated a median flow of 325 cfs between 1929 and 1969. The drainage area for this station is 627 square miles. A flow duration curve for the Decaturville station is shown in Figure 9. The low 10:90 ratio (ratio of the discharge exceeded 10% of the period of record to that exceeded 90% of the period of record) of 8.8 indicates that flows are not highly variable. This value is at the low end of the range exhibited at other stations with similar drainage areas throughout the state (Skelton, 1976). Although no quantitative data is available, the median flow of the LNR as it enters the lake is usually noticeably less than that of the NR. The most downstream station on the LNR, near Macks Creek (G025), was operated as a low flow and crest station between 1962 and 1971 so median flow is not available. The only continuous record station in the LNR watershed was on Starks Creek (G024), a third order tributary. The Starks Creek flow duration curve (Figure 10) with a 10:90 ratio over 400 indicates highly variable flows at this station. This station is in the headwaters of Starks Creek (SM 12) where the average gradient is 30.8 feet per mile.

The magnitude and frequency of low-flows at several stations in the watershed are shown in Table 9. The low flow is the lowest average flow over a 7-day period that is likely to occur during a given recurrence interval. These can be useful for evaluating the impacts of effluent discharges or water withdrawals and droughts during critical periods of low flow. In Missouri low flows usually occur during August, September, and October (Skelton, 1976). Skelton also explained that Ozark streams usually have the best sustained low flows in the state, due to large underground reservoirs in the solution dissolved carbonate bedrock. However, solution channels can also divert groundwater before it reaches streams, and drain surface water from losing streams in some areas. In many of the watershed's streams, considerable water flows in the gravel beneath the stream bed during drought. Fourth order and larger reaches of most tributaries sustain permanent flow throughout the year. Maximum and minimum discharges for four gaging stations are shown in Table 10. Small streams in the watershed are flashy, with high flows after

significant rainfall. Flood discharges at gaging stations with sufficient data are shown in Table 11.

Springs

The Niangua Watershed contains numerous springs (Table 12; Figure 11). Some of the springs listed in Table 12 were found in historical records (Skinner, 1979) or on 7.5 minute topographic maps so their current status is unknown. Skinner (1979) reported that many strong flowing springs went dry following agricultural development in the watershed. Some landowners have also reported that small permanent springs have ceased flowing in the last 50 years (Bob Schulz (MDC), pers. comm.). The largest springs in the watershed are Bennett Spring, the fourth largest in Missouri, and Ha Ha Tonka Spring, the twelfth largest in the state (Vineyard and Feder, 1982). Bennett Spring practically doubles the flow where it joins the NR at SM 65.9. Bennett Spring is supplied by an extensive recharge area (Figure 11) which has recently been delineated by an MDNR study (Vandike, 1992). The recharge area includes portions of the Dry Glaiize and Gasconade watersheds (Vandike, 1992). Ha Ha Tonka Spring flows about 1.4 miles to a cove on the Niangua Arm of LOZ. Many karst features and the dramatic faults evident in the vicinity of Ha Ha Tonka Spring suggest that a large underground reservoir may supply the spring (Vineyard and Feder, 1982). In response to concerns about steady increases in nitrates and phosphates in the late 1960s, a thorough study of potential contamination sources in the vicinity of Ha Ha Tonka Spring was conducted (Vineyard and Feder, 1982). To eliminate pollution sources in the vicinity, several nearby resorts were purchased and an extensive sewer system was installed. Several other springs of the Niangua Watershed are hydrologically connected to losing streams outside the watershed (Figure 11).

Losing Streams

Nineteen losing streams have been delineated in the Niangua Watershed (Table 13; Figure 11). A losing stream is a stream segment that loses 30% or more of its flow through permeable geologic materials into a bedrock aquifer. Low flow measurements or dye tracings are used to identify losing stream segments, and the MDNR Water Pollution Control Program maintains a list of identified segments. Wastewater discharges within two miles upstream of a losing stream must meet more stringent effluent limitations due to the potential for groundwater pollution. Thirty additional stream segments within the watershed have been identified as losing streams in recent dye tracings (Vandike, 1992), and are awaiting approval for the MDNR list. In addition, several losing streams have been identified in the spring recharge area that lies outside the watershed (Figure 11).

Impoundments

Eighteen small impoundments are shown in Figure 12. Most of these were included in a database maintained by the MDNR. Impoundments with dams over 35 feet high are required to obtain a permit. However, many of the impoundments recorded in the MDNR database are not that large, and were registered voluntarily. Several additional impoundments over ten acres were located on 7.5 minute topographic maps. Lake Niangua (L010) is the largest impoundment in the watershed (360 acres).

Dam and Hydropower Influences

Two hydropower projects impact the Niangua Watershed. Bagnell Dam was completed in 1931 on the Osage River approximately 31 miles downstream from the mouth of the NR. It is owned and operated by Union Electric Company of St. Louis, MO. The facility has eight turbines with a maximum generating capacity of 215,000 kilowatt (kw). It is normally run as a peak load facility, meaning most of the power Union Electric Company of St. Louis, MO. The facility has eight turbines with a maximum generating capacity of 215,000 kilowatt (kw). It is normally run as a peak load facility, meaning most of the power is generated during periods when there is high demand for electricity. Bagnell Dam impounds 55,000-acre LOZ, which includes the lower 21 miles of the NR and lower 10 miles of the LNR. Nearly the entire shoreline of the lake is privately owned. The Niangua and Little Niangua arms are typical of much of the rest of the lake - highly developed with numerous private dwellings and recreational businesses. Because the lake was constructed primarily for hydropower production rather than flood control the magnitude of water level fluctuations is much less than that of nearby COE lakes constructed primarily for flood control. Detailed information regarding LOZ can be obtained from the Lake of the Ozarks Management Plan (Stoner, 1999).

Tunnel Dam was completed in 1929 on the NR (~SM 29) creating 360 acre Lake Niangua, a very shallow impoundment which extends upstream 2.3 miles. The storage capacity of Lake Niangua is 2,650 acre-feet at normal pool elevation (711.5 feet MSL). The watershed of the reservoir is approximately 600 square miles. The project was originally operated by the Missouri Electric Power Company, but Sho-Me Power Corporation of Marshfield, MO, purchased the facility in 1944. The project is licensed by the Federal Energy Regulatory Commission (FERC). The facility has two turbines with a maximum generating capacity of 2,650 kw. It is a run-of-the-river facility and derives head for generation by diverting river flow from Lake Niangua through a tunnel to the power plant. This diversion results in greatly reduced flow in the bypass reach, approximately 6.5 miles of river between the dam and the powerhouse.

The Tunnel Dam project was recently relicensed for 30 years beginning June 1, 1994 by the FERC (1994). Requirements of the relicensing include:

- 1) Minimum flows are to be released in the by-pass reach as follows: 60 cfs during March 15 - June 15; 40 cfs the rest of the year, or natural inflow, whichever is less.
- 2) The project will continue to operate run-of-river, but Sho-Me Power Corp. has authorization to operate in a peaking mode under the following conditions: peaking can only occur in July and August; it cannot exceed two hours per day; fluctuations in the reservoir surface elevation cannot exceed 0.5 feet; and the resource agencies must be notified.
- 3) A continuous-monitoring gage recorder is required in the bypass reach and the sluice gate will be calibrated to indicate discharge level.

In November 1995, the USGS installed a continuous record gage below Tunnel Dam with financial support from Sho-Me Power Corporation. Provisional data supplied by the USGS indicated that between December 5, 1995 and December 4, 1996, the daily mean discharge was below the required minimum on 111 of 356 days. The minimum mean daily discharge of 28 cfs was recorded on two separate days. The measured discharge was below the minimum flow requirement (60 cfs) during the spawning season (March 15 to June 15) on 51 of 93 days in 1996.

Figure 07. Mean monthly precipitation at Buffalo, Missouri between 1930 and 1995.

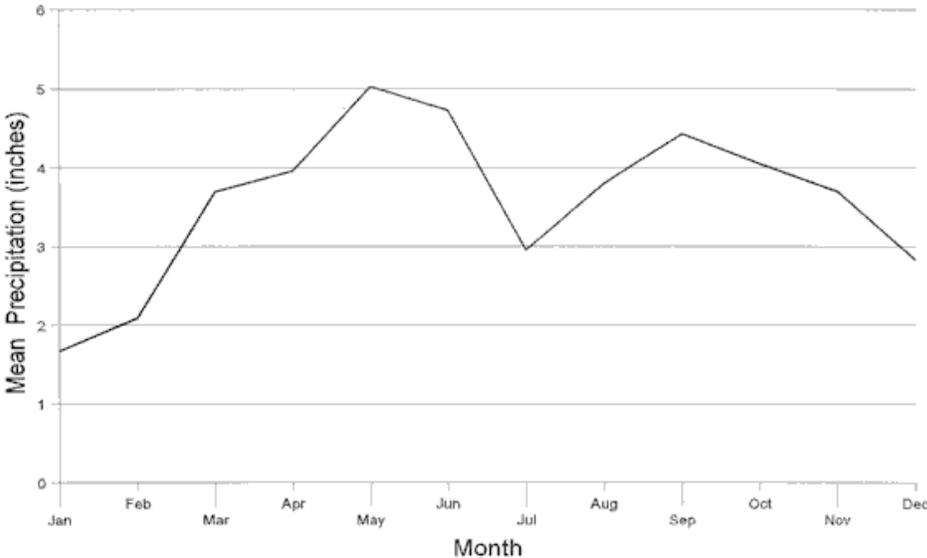


Figure 8. Gaging and water quality stations within the Niangua River Watershed.

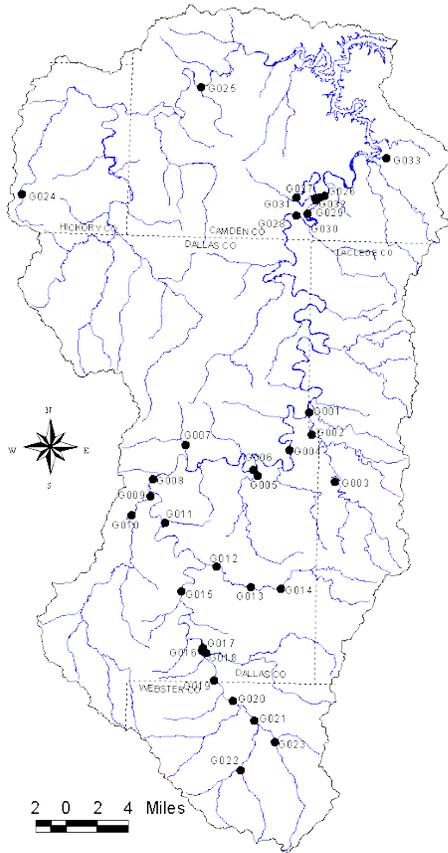


Table 8. Water quality and gaging stations within the Niangua Watershed.

Site Number	Station Number	Station Name	Location	Period of Record	Drainage Area (mi ²)	Type of Station ³
G001	6923700		Lat 37°44'17" Long 92°51'37" SESE S25, 35N, 18W at bridge on Hwy 64	'82-'88 '91- Date		WQ only
G002	6923500	Bennett Spring	Lat 37°43'03", 92°51'26"NW S1, 34N, 18W;1 mile upstream Niangua R	16-'20 '28-'41 '65-'95	100	
G003	6923400	Spring Creek above Bennett Spring	Lat 37°40'22" Long 92°49'47" SESW	'91-'95		WQ only
G004	6923300	Niangua River above Bennett Spring	Lat 37°42'07" Long 92°52'53" NWSW	'91-'95		WQ only
G005	6923255	Four Mile Creek near Windyville	Lat 37°40'41" Long 92°55'11" NWSW S9, 34N, 18W at Hwy P	'91-'95		WQ only
G006	6923250	Niangua River at Windyville at Hwy K	Lat 37°41'03" Long 92°55'27" NWSW S8, 34N, 18W	54,'67,'71 '75,'76,'80 '91-Date	377	Contin.
G007	6923242	Durington Creek near Wood Hill	Lat 37°42'27" Long 93°00'15" NESW S3, 34N, 19W	'91-'95		WQ only
G008	6923240	Niangua River near Buffalo	Lat 37°40'30" Long 93°02'27" NENW S17, 34N, 19W	'91-'95		WQ only
G009	6923237	Greasy Creek below Buffalo	Lat 37°39'33" Long 93°02'41" NW S20, 34N, 19W	'91-'95		WQ only
G010	6923235	Greasy Creek at Hwy 32 near Buffalo	Lat 37°28'27" Long 93°04'03" SWNW	'91-'95		WQ only

Site Number	Station Number	Station Name	Location	Period of Record	Drainage Area (mi ²)	Type of Station ³
G011	6923200	Niangua River at Hwy 32 near Buffalo	Lat 37°38'04" Long 93°01'39" SW	'91-'95		WQ only
G012	6923150	Dousinbury Creek on JJ near Wall Street at downstream edge of bridge	Lat 37°35'38" Long 92°58'00" SWNE	'91- Date	35.7	Gaging & WQ
G013	6923140	Dousinbury Creek near Long Lane	Lat 37°34'28" Long 92°55'42" SE S17, 33N, 18W	'91-'95		WQ only
G014	6923135	Dousinbury Creek near Earnestville	Lat 37°34'50" Long 92°53'34" SE S15, 33N, 18W	'91-'95		WQ only
G015	6923130	Niangua River near Spring Grove	Lat 37°34'13" Long 93°00'28" NW S22, 33N, 19W	'91-'95		WQ only
G016	6923120	Niangua River near Charity	Lat 37°31'12" Long 92°58'59" SE S2, 32N, 19W	'91-'95		WQ only
G017	6923110	Johnson-Wilkerson Spring near Charity	Lat 37°31'08" Long 92°59'01" NWSE S2, 32N, 19W	'91-'95		WQ only
G018	6923100	Jones Creek near Charity	Lat 37°30'50" Long 92°58'46" NENE S11, 32N, 19W	'91-'95		WQ only
G019	6923088	Jake George Spring near Thorpe	Lat 37°29'20" Long 92°58'09" NWSE S31, 32N, 19W	'91-'95		WQ only
G020	6923070	Niangua River below Forkner's Hill	Lat 37°28'08" Long 92°56'58" NE S30, 32N, 18W	'91-'95		WQ only

Site Number	Station Number	Station Name	Location	Period of Record	Drainage Area (mi ²)	Type of Station ³
G021	6923060	Niangua River on Hwy Y	Lat 37°27'01" Long 92°55'25" SWNW S33, 32N, 18W	'91-'95		WQ only
G022	6923050	West Fork Niangua River near Bermott	Lat 37°24'16" Long 92°56'37" NWSW S17, 31N, 18W	'91-'95		WQ only
G023	6923040	East Fork Niangua River near Samson	Lat 37°25'48" Long 92°54'00" NESESW S3, 31N, 18W	'91-'95		WQ only
GO24	69252001	Starks Creek 1 mi east of Preston	Lat 37°56'27" Long 93°11'48" SWNW S24, 37N, 21W at Hwy 54 bridge	'56-'78	4.18	Contin.
G025	69252501	Little Niangua River near Macks Creek	Lat 38°02'30" Long 92°59'05"N S14, 38N, 19W; Co Rd N-165, at Bannister Ford	'62-'71	338	Low & Crest
G026	69240001	Niangua River near Decaturville	Lat 37°56'20" Long 92°50'30" NWNE S19, 37N, 17W	'29-'69	627	Contin.
G027	6923950	Niangua River at Tunnel Dam near Macks Creek	Lat 37°56'13" Long 92°51'05" SWNWNW S19, 37N, 17W	'95- Date		Contin.
G028	WQ12	Niangua River First riffle upstream from Lake Niangua	Lat 37°55'17" Long 92°52'25" SENE S26, 37N, 18W	'89-'90		WQ only
G029	WQ2A2	Lake Niangua Mid-channel, approx. ~ 200' upstream of Dam	Lat 37°56'10" Long 92°51'01" SWNW S19, 37N, 17W	'89-'90		WQ only

Site Number	Station Number	Station Name	Location	Period of Record	Drainage Area (mi ²)	Type of Station ³
G030	WQ2B2	Lake Niangua Upper Portion of Lake	Lat 37°55'23" Long 92°52'27" NWNE S25, 37N, 18W	'89-'90		WQ only
G031	WQ32	Niangua River Hwy U bridge approx.~ 2 mi downstream of Dam	Lat 37°56'19" Long 92°52'27" NENE S23, 37N, 18W	'89-'90		WQ only
G032	WQ42	Niangua River~100yds downstream from powerhouse discharge from Lake Niangua	Lat 37°56'18" Long 92°50'47" NENW S19, 37N, 17W	'89-'90		WQ only
G033	6924500	Ha Ha Tonka Spring at Ha Ha Tonka State Park	Lat 37°58'26" Long 92°45'04" SESW S2, 37N, 17W '23-'25 '64- '66,'71	'93-Date		WQ only
G034	6923000	Niangua Branch at Marshfield	Lat 37° E20'50" Long 92E54'45" SENE S4, 30N, 18W	'51-'58 '60-'79	0.82	Gaging

¹Discontinued United States Geological Service USGS stations.

²Environmental Science & Engineering, Inc. 1990. Niangua River Water Quality and Fisheries Survey. Prepared for BVMCA, Kansas City, MO.

³All stations are USGS operated unless otherwise indicated.

WQ - Stations at which periodic water quality measurements are made. Contin - Stations at which continuous discharge measurements are made.

Low flow - Stations at which discharge measurements were made only during low flow periods.

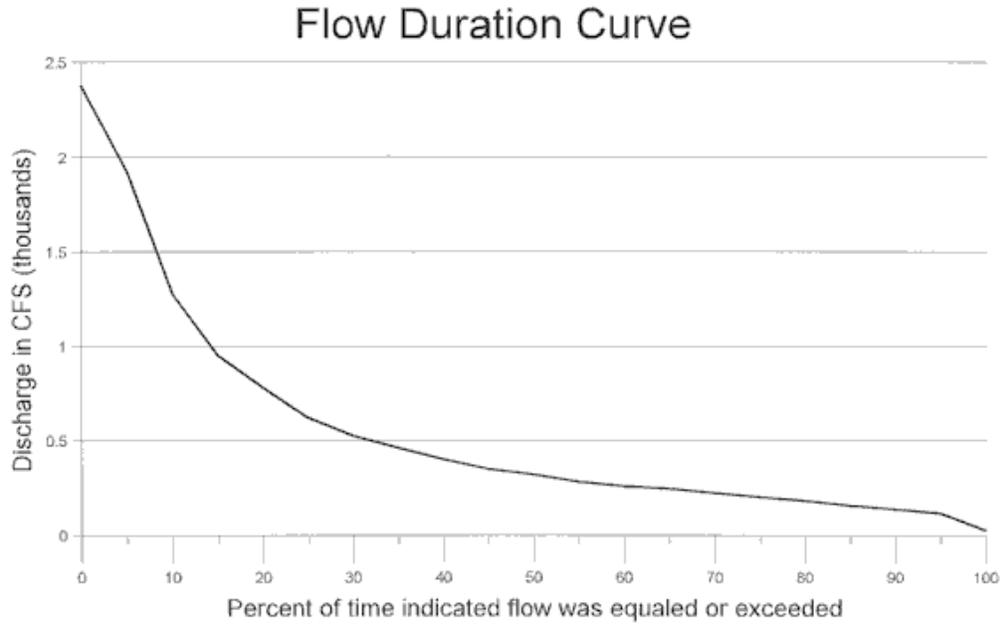
Gaging- Stations at which discharge measurements were made on a daily basis.

Crest- Stations at which peak discharge are recorded for a given time interval.

Table 9. Magnitude and frequency of annual low-flows for select stations within the Niangua Watershed (Skelton, 1976).

Site Number	Station Number	Station Name and Location	Period of Record	Drainage Area (mi ²)	Period (days)	Annual Low-Flow (cfs) for Indicated Recurrence Interval				
						2	5	10	20	50
G011	6923200	Niangua River near Buffalo, Dallas County	'54, '62-'65, '70	—	7	17	—	8	—	—
G002	6923500	Bennett Spring at Bennett Spring State Park, Dallas County	16-'20, '28-'41, '65-'72	—	7	80	—	62	57	—
G033	6924500	Ha Ha Tonka Spring at Ha Ha Tonka State Park, Camden County	'23-'25, '64-'66, '71	—	7	48	—	40	—	—
G024	6925200	Starks Creek at Preston, Hickory County	'58-'72	4.18	7	0	0	0	0	0
G006	6923250	Niangua River near Windyville, Dallas County	'54	377	7	—	14.1	—	—	—
G025	6925250	Little Niangua River near Macks creek, Camden County	'62-'64, '67, '70-'71	—	7	10	—	3.6	2.8	—

Figure 09. Flow duration curve for the Niangua River near Decaturville (G024).



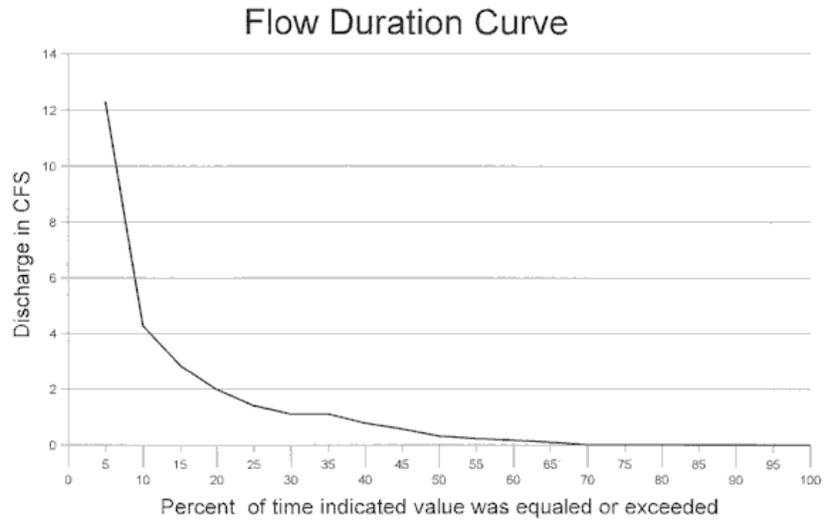


Figure 10. Flow duration curve for Starks Creek near Preston (G024).

Table 10. Maximum and minimum discharges at continuous record stations within the Niangua Watershed

Number	Number	Discharge ²	Discharge ²	Discharge ³	Exceeds ⁴	Exceeds ⁴	Exceeds ⁴	(ft.)
G006	6923250	44,700 (10/01/86)	17 (08/23/93)	424 (206.0- 583.0)	799	186	33	24.4
G006	6923500	14,400 (10/01/86)	55 (11/13/34)	180 (93.4- 306.0)	306	140	90	11.1
G026	6924000	33400 (05/19/43)	6 (10/05/30)	—	1,246.40	320.4	141.7	21.8
G024	6925200	2200 (10/12/69)	0	—	4.3	0.3	0	10.8

*Cubic feet per second

— No data available.

¹Period of record in parentheses.

²Date of record in parentheses.

³Range in parentheses.

⁴Flow that is exceeded for given percent of period of record.

Table 11. Flood discharges at select gaging stations within the Niangua Watershed.

Site Number	Station Number	Flood discharge (ft ³ /s) for indicated recurrence interval in years						
		2-	5-	10-	25-	50-	100-	500-
G034	6923000	201	313	394	505	592	682	911
G026	6924000	11600	20500	27100	35800	42600	49500	66100
G024	6925200	768	1200	1490	1890	2190	2490	3220

Table 12. Significant springs with reference map, location, average flow, and receiving stream within the Niangua Watershed.

Site Number	Spring Name	Topographic Map	Average Flow				
			Twp	Rng	Sec	(cfs)	Receiving Stream
S001	Allgire Spring	Macks Creek	36	18	8	4.54	Trib to Mill Creek
S002	Barclay Spring	Eldridge West	35	18	12		Barclay Spring Branch
S003	Bennett Spring	Bennett Springs	34	18	1	180	Bennett Spring Branch
S004	Blue Spring	Barnumton	38	18	7	4.32	Little Niangua River
S005	Burndt Mill Spring	Climax Springs	38	19	10	1.15	Little Niangua River
S006	Conn Spring	Bennett Springs	35	18	25	4.84	Niangua River
S007	Cullen Spring	Ha Ha Tonka	38	17	35	0.76	Racetrack Hollow
S008	Eadsons Spring	Barnumton	38	18	11		Prairie Hollow
S009	Famous Blue Spring	Bennett Springs	35	18	36	2.97	Niangua River
S010	Green Ford Spring	Climax Springs	38	19	27	3.12	Little Niangua River
S011	Ha Ha Tonka Spring	Ha Ha Tonka	37	17	2		Niangua Arm
S012	Jake George Springs	Beach	32	19	13		Niangua River
S013	Johnson-Wilkerson Spring	Long Lane	32	19	2		Trib to Niangua River
S014	Jordan Spring	Cross Timbers	38	20	20	0.02	Starks Creek
S015	King Spring	Leadmine	36	17	30		Jakes Creek
S016	Mills Spring	Ha Ha Tonka	37	18	36		Red Cap Hollow
S017	Mint Spring	Eldridge West	36	18	24		Niangua River
S018	Morrow Spring	Green Bay Terrace	38	17	29	1.09	Niangua Arm
S019	Mosier Spring	Ha Ha Tonka	37	7	17		Darby Hollow
S020	Moulder Spring	Green Bay Terrace	38	17	19	0.03	Trib to Niangua River
S021	Poe Spring	Barnumton	38	18	9		Prairie Hollow
S022	Sweet Blue Spring	Eldridge West	36	17	30	13.17	Niangua River
S023	Vineyard Spring	Marshfield	31	18	28		West Fork (Niangua R)
S024	Webster Springs	Leadmine	36	18	15		Jakes Creek
S025	Gunter Spring	Beach	32	18	17		Trib to Starvey Creek
S026	Springs?	Niangua	31	18	24		East Fork (Niangua R)
S027	Unknown	Beach	31	18	6		Trib to Givins Branch
S028	Sarah Spring?	Beach	31	18	10		East Fork (Niangua R)
S029	Unknown	Beach	32	18	16		Trib to Starvey Creek
S030	Flowing well?	Macks Creek	36	18	8		Mill Creek
S031	Starling Spring	Green Bay Terrace	38	17	18		Niangua Arm (LOZ)
S032	Indian Spring	Beach	32	18	19		Trib to Niangua River

Table 13. Losing stream segments within the Niangua Watershed with reference map, location, and length.

Site Number	Stream	Counties	Topographic Map	Length	Legal Start	Legal End
D001	Libby Hollow	Camden	Green Bay Terrace	2	SESWSE 15,38N,17W	NESWSW 2,38N,17W
D002	Prairie Hollow	Camden	Barnumton	2	NWNWNW 27,38N,18W	NWNENW 14,38N,18W
D003	Racetrack Hollow	Camden	Decaturville Ha Ha Tonka	5.5	NENWNW 9,37N,16W	SWSWNW 35,38N,17W
D004	Racetrack Hollow	Camden	Camdenton or Decaturville Ha Ha Tonka	1.5	SWSENW 25,38N,17W	SWSWNW 35,38N,17W
D005	Bennett Spring Branch	Laclede Dallas	Bennett Springs	10.8	NENENE 34,34N,17W	SENENE 1,34N,18W
D006	Dogwood Hollow and trib	Laclede	Phillipsburg- Bennett Springs	2.5	NWNWSE 32,34N,17W	NENWNW 21,34N,17W
D007	Trib to Dousinbury Creek	Laclede Dallas	Phillipsburg	3.1	SESWSE 8,33N,17W	SWNWSE 12,33N,18W
D008	Mountain Creek	Laclede	Lebanon- Eldridge West	7.6	NENENW 31,35N,16W	SWSESW 4,35N,17W
D009	Dousinbury Creek	Laclede Dallas	Phillipsburg	2	NESENE 18,33N,17W	SWNWSE 12,33N,18W
D010	Trib to Woodward Hollow	Laclede	Lebanon- Bennett Springs	3.8	SESE 1,34N,17W	SESWSE 4,34N,17W
D011	Woodward Hollow	Laclede	Bennett Springs	6.8	SWSENW 11,34N,17W	NWSWNW 6,34N,17W
D012	Woolsey Creek	Laclede Camden	Eldridge East- Ha Ha Tonka	10	SWSESE 24,36N,17W	SWNENE 36,37N,18W
D013	East Fork	Webster	Beach	1	NWNENW 3,31N,18W	SESWSW 33,32N,18W
D014	Givins Branch	Webster	Beach	3.6	SWSWNW 1,31N,19W	SESWNW 29,32N,18W
D015	Hawk Pond Branch	Webster	Beach	2.1	NWNENE 35,32N,19W	NWSWSW 19,32N,18W
D016	Niangua River	Webster	Beach	0.4	SESWSW 33,32N,18W	SESWNW 33,32N,18W
D017	West Fork	Webster	Beach	0.9	SESWNW 4,31N,18W	SESWSW 33,32N,18W

Site Number	Stream	Counties	Topographic Map	Length	Legal Start	Legal End
D018	West Fork	Webster	Beach	0.4	NWNWSE 28,31N,18W	NWSENW 28,31N,18W
D019	Trib to West Fork	Webster	Beach	0.5	NESENE 28,31N,18W	SWSWNE 28,31N,18W

Water Quality and Use

Beneficial Use Attainment

The MDNR maintains a list of beneficial uses for classified streams of Missouri. Beneficial uses and classifications of streams within the Niangua Watershed are shown in Table 14. Aquatic life protection, fishing, and livestock and wildlife watering are designated beneficial uses of all classified streams within the watershed. LOZ, Lake Niangua, and most of the NR and LNR are also classified for whole body contact recreation and boating. Three segments within the watershed are designated cold-water fisheries. These include 6.0 miles of the NR, 2.0 miles of Bennett Spring Branch, and 1.5 miles of Mill Creek.

Many streams are designated for cool-water fishing. A portion of LNR is classified as an "Outstanding State Resource" which is conferred upon "high quality waters that may require exceptionally stringent water quality management requirements to assure conformance with the antidegradation policy" (MoCSR, 1991). According to the Missouri Water Quality Watershed Plan all stream uses were being maintained in 1984 with the possible exception of aquatic life protection in a two mile section of the NR below the Marshfield Sewage Treatment Plant (MDNR, 1984).

A study of the Grand Glaize Arm of LOZ in the early 1980s revealed high levels of fecal coliform bacteria in residentially developed coves (Mitzelfelt, 1985). The high levels were attributed to septic systems and other individual onsite systems; point sources including small treatment systems and municipal treatment plants; and occasional pleasure boat discharges of untreated sewage. Many of the samples exceeded the state standards for whole body contact recreation of 200 colonies per 100 ml.

Samples from highly developed coves exceeded the standards on two-thirds of the sampling dates in both years of the study. Samples in moderately developed coves occasionally exceeded the standards and those in undeveloped and slightly developed coves did not exceed the standards. Bacteria levels correlated with tourist traffic on major roads and peaked during, or on the day after, holidays. This study was followed by one in 1984 by the Lake of the Ozarks Council of Governments and one in 1990 by the MDH and MDNR (MDNR, 1996). Although higher levels of bacteria were detected in developed coves than in less-developed coves, the state bacteria standards for whole body contact were not exceeded in any coves. The MDC and MDH are currently conducting a similar, multi-year study. Jones and Kaiser (1988) reported that nutrients, algae, and turbidity were all greater in the Niangua Arm than in the Grand Glaize or Gravois arms, which they attributed to higher numbers of domestic wastewater discharges. Recently enacted legislation that allows for creation of special zones for planning and zoning ordinances may help reduce these problems. A temporary committee was appointed by the Camden County Commission in July 1996 to study this option and recommend boundaries for a "lake zone", an area around the lake with special zoning regulations, which will eventually need to be approved by public vote.

Water quality in Lake Niangua, and in the NR immediately upstream and downstream from the lake, was well within the requirements for protection of aquatic life in all eight of the ESE samples obtained during 1989 and 1990, and was comparable to the water quality in other Ozark streams (ESE, 1990). Fecal coliform concentrations exceeded 200 colonies/100 ml, the Missouri Water Quality Standard for recreational use, in four samples (ESE, 1990). One of these instances occurred in Lake Niangua, one in the bypass reach, and two in the NR downstream from the powerhouse discharge. These violations all occurred in samples taken after heavy rainfall in

August 1989 and June 1990. Similar violations were recorded occasionally in the UNAWP sampling (1994-1995) after rainfall events (Smale et al., 1995).

Chemical Quality of Stream Flow

The most thorough water quality monitoring in the watershed was completed in the Upper Niangua Subwatershed for the UNAWP between 1991 and 1995. A summary of the data for select parameters is shown in Appendix E. Based on the accumulated data, water quality in the upper Niangua was described as average (Smale et al., 1995). The data did not indicate consistently high levels of nutrients or pathogens at any of the 20 sites monitored. There were, however, high levels of nitrates, phosphates, and fecal bacteria and fecal viruses detected during high flow events. This pattern is typical of Ozark streams where the main source of contaminants are non-point sources such as agricultural and storm water runoff. It is likely that aquatic plants utilize abundant nutrients during these events to increase growth and the excess nutrients are flushed downstream rapidly. This could result in excessive algae growth even though high levels of nutrients are not detected during normal flows. The average nitrate levels were relatively high at the Bennett Spring station (G002) and at Jake George Springs (G019). However, higher levels are typically measured at springs (Smale et al., 1995).

Select water quality criteria from the Missouri Code of State Regulations (MoCSR, 1995) are exhibited in Table 15. Only common pollutants are listed and the criteria for metals are those for chronic levels that apply to general warm-water fisheries (GWFF). For some metals more stringent criteria apply to cool- or cold-water fisheries and less stringent values may apply for acute levels.

Stream Teams and Water Quality Monitors

Trained volunteers have assisted in the protection of streams throughout the state. The Stream Team program was initiated in 1989 by three sponsors, the MDC, the MDNR, and the CFM. Over 1700 volunteers in Missouri have completed water quality monitoring classes offered by the program.

Twenty-seven Stream Teams and Volunteer Water Quality Monitors have been active in the Niangua Watershed (Table 15). Projects have included litter clean-up, water chemistry and macroinvertebrate sampling, tree planting for bank stabilization, stream inventories, and educational exhibits. Figure 12.5 shows locations where Stream Teams have reported activities. A total of 141 activities have been reported. Six additional Stream Teams (#s 161, 231, 267, 377, 423, 670) have formed within the watershed, but not reported activities. Fifteen monitors have submitted water quality monitoring data, many from multiple sites on many occasions. Thirteen teams have conducted litter pickups, the second most popular activity statewide. The Stream Team Program also supplies thousands of litter bags to canoe and boat liveries in the watershed which they provide to renters for their trash.

Volunteer data are reviewed by MDC and MDNR staff and entered in a statewide database. Recently data have been made available to the public on the Stream Team website (~). Agencies have used these data to determine baseline conditions of Missouri streams, identify impaired watersheds, and educate and inform the public. Volunteers have used their data to raise community awareness and help their communities solve problems and plan wisely. These volunteer efforts are likely to become more important in the future as awareness about stream issues and monitoring capabilities increase.

Chronic Fish Kill Areas

Documented fish kills and water pollution events are listed in Table 16 and mapped in Figure 13. MDC records indicate five fish kills have occurred in the watershed since 1979 (Table 16). One chronic fish-kill area is located downstream from the Marshfield sewage treatment facility. Fish mortalities in this area have been attributed to low dissolved oxygen, due to a combination of high nutrient inflow, low stream flows, and high water temperatures (MDNR, unpublished). Marshfield's recent efforts to upgrade their facility are discussed in the Point Source Pollution section. Petroleum product spills from ruptured pipelines have occurred at several sites and been responsible for at least one fish kill. One fish kill was documented at Lake Niangua in 1988. This event was attributed to rapid drawdown of surface water in August that stranded fish in shallow areas with high temperatures and low dissolved oxygen levels. To prevent similar events, the recently approved relicensing agreement limits fluctuations in lake levels to 0.5 feet and requires notification of MDC personnel.

Fish Contamination Levels/Health Advisories

Since 1987, annual tissue samples have been obtained from several fish species in LOZ to monitor select contaminants. None of the Niangua Arm samples (Table 18) exceeded action levels set by the Food and Drug Administration (FDA). During this period, the action level for chlordane (300 ppb) was exceeded in paddlefish from the Osage Arm in several years between 1988 and 1994. This resulted in health advisories issued by the Missouri Department of Health (MDH) to limit consumption of paddlefish from LOZ to one pound per week. Paddlefish caught anywhere in the Ozarks were removed from the health advisory in July 1995. The MDH also issued a health advisory in 1994 warning that sturgeon caught anywhere in Missouri should not be eaten due the high levels of chlordane and polychlorinated biphenyls (PCB's). However, sturgeon have not been observed in LOZ since the 1970s and may have been extirpated. There are currently no health advisories for LOZ or Niangua Watershed fishes. However, MDH fish advisories (MDH, 1994; MDH, 1996) have included the statewide warning, "Pregnant or nursing females and young children may be at higher risk from eating contaminated fish, and should eat less than one pound a week of the fatty species". The warning cautions that many contaminants become concentrated in fatty tissue and eggs of fatty species such as catfish, carp, buffalo, drum, suckers, and paddlefish. Current plans include sampling Niangua Arm fish every 3 years beginning in 1998.

Pipelines

Five buried pipelines cross the Niangua Watershed (Figure 14). Pipelines pose a threat to groundwater as well as streams in the watershed, because they pass through several karst areas with sinkholes and losing streams inside and outside the watershed (Figure 11). Three of the pipelines are used for transporting crude oil, diesel fuel, and fertilizer. The 10-inch Shell pipeline is currently not in use but may be reactivated in the future. The Williams pipeline was reportedly being considered for use as a fiber optics conduit (Vandike, 1992). At least four pipeline ruptures have resulted in water pollution problems and fish kills since 1979 (Table 17). In addition, pipelines have become exposed by streambed erosion at three sites in the past four years (Dousinbury Creek SM 5.5, Greasy Creek SM 11.5, NR SM 100.2). Recent gravel excavation had occurred near all three of these sites, and the resulting headcuts and destabilized channels may have created the erosion problems. Most of the pipelines in the watershed do not appear on 7.5 minute topographic maps, so it has been difficult to determine

whether proposed 404 activities may impact pipelines in the vicinity. The recently enacted general permit (MRKGP-34M) includes conditions that should minimize headcutting and channel destabilization. However, COE authority to regulate in stream gravel excavation has been severely limited by a recent court ruling (see 404 Activities section). Nationwide permits, however, are not as restrictive, and frequently the MDC is not consulted or informed of their issuance. The COE apparently does not check on the location of pipelines when considering applications.

Point Source Pollution

All wastewater discharges which are considered point sources are required to obtain National Pollution Discharge Elimination System (NPDES) permits. The MDNR issues and monitors these permits throughout the state, and the Springfield Regional Office is responsible for the Niangua Watershed. All NPDES permitted discharges as of December 13, 1995 are shown in Figure 15.

Municipal Sewage Treatment Plants

Four municipal sewage treatment plants (STPs) have been issued NPDES permits to discharge wastewater into surface waters of the Niangua Watershed. The City of Camdenton STP has had problems on several occasions which have resulted in discharge of pollutants to tributaries of the Niangua Arm (LOZ). These included mechanical failures of lift stations and the intentional release of sludge from an abandoned sewage lagoon. No fish kills or long lasting pollution problems have been documented from these incidents. The lagoon has been filled in and the lift station problems corrected (Ed Sears (MDNR), pers. comm.). Camdenton constructed a new treatment facility in 1989 featuring an oxidation ditch and ultraviolet disinfection which releases 0.35 million gallons per day (MGD) into Racetrack Hollow. This tributary flows approximately 0.6 miles to the Niangua Arm (LOZ). Recent volunteer monitoring has revealed a degraded invertebrate community near the mouth (Bob Schulz (MDC), pers. Comm.).

The treatment system in Marshfield is an extended aeration facility with a sludge storage pond and discharges approximately 0.6 MGD. A second outfall at the facility releases storm water and effluent when flows exceed the capacity of the main treatment system. The excess flow receives primary filtration and chlorination. Both discharges flow into a tributary within 0.5 miles of its confluence with the West Fork of the NR. In stream surveys of the tributary and the West Fork have indicated low dissolved oxygen, sludge deposits, and pollution tolerant benthic organisms for approximately 1.5 miles downstream from the discharges (unpublished data, MDNR). Four water pollution or fish-kill events have been documented below this facility. The presence of toxic metals in the wastewater discharges from area industries has been a concern in Marshfield, and more stringent limits for metals have been included in a recently revised permit (Ed Sears (MDNR), pers. comm. 10/96). The West Fork is classified as a losing stream for 0.4 miles beginning within 1.0 mile of the Marshfield discharge, so more stringent discharge limits are included in its NPDES permit. The MDNR is currently reviewing an engineering report that proposes to upgrade the collection system and treatment facility to extend their usefulness another 20 years, however, plans do not include increased capacity (Dave Ehlig (MDNR), pers. comm. 10/96).

Conway's treatment system consists of two lagoons which discharge approximately 0.05 MGD into Jones Creek approximately 10.5 miles from its confluence with the NR. The treatment system is not meeting discharge limits, and the MDNR has advised them to make improvements

(Ed Sears (MDNR), pers. comm. 10/96). About 0.4 miles of Jones Creek is impacted by this discharge, exhibiting pollution tolerant animals and heavy algae growth (MDNR, 1995). Jones Creek is unclassified in this area. The City of Urbana discharges 0.045 MGD from two lagoons into the East Branch of Cahoochie Creek, an unclassified stream, about 7.0 miles from the LNR. The system is currently in compliance with permit limits (Ed Sears (MDNR), pers. comm. 10/96).

The City of Lebanon is outside the surface watershed of the Niangua, but the STP discharges to Dry Auglaize Creek, a losing stream within the recharge area for Bennett Spring. The facility is not capable of treating storm water runoff, and the city has been in litigation with the MDNR for several years (Ed Sears (MDNR), pers. Comm. 10/96). During storm water events untreated sewage is released in Goodwin Hollow and Dry Auglaize Creek, both losing streams within the Bennett Spring and Sweet Blue Spring recharge areas.

Buffalo, the third largest town within the watershed, discharges wastewater into the Lindley Creek watershed outside the Niangua Watershed. Some sludge from the Buffalo STP is applied on agricultural land within the watershed. The City of Niangua STP, a small oxidation ditch, discharges to a tributary of the Osage Fork of the Gasconade River. This stream is outside the Niangua Watershed and is not known to be hydrologically connected to the watershed.

Sludge Application Sites

There are nine sites within the Niangua Watershed where sludge from municipal sewage treatment plants has been applied to agricultural land (Table 19; Figure 16). These sites are all within twenty miles of the treatment plants and are permitted through the NPDES permits for each municipality. These sites are self-monitored by the municipalities who must furnish annual reports to the MDNR on the location, landowner, application dates, and amounts. Various parameters, including metal concentrations, nitrates, phosphates, and percent solids must be monitored; and individual and cumulative levels must be within limits. The MDNR has not documented any environmental problems at any of the sludge application sites in the watershed (Robert Magai (MDNR), pers. comm.).

There are probably sites within the Niangua Watershed where private haulers dispose of sludge from private septic systems and other wastewater treatment systems. These may include land application sites or anaerobic lagoons. Private haulers have only recently been required by sludge regulations to obtain licenses and report their activities, and no information is currently available from the MDNR.

Non-POTWs

There are 48 permitted non-POTWs (non-public owned treatment works) within the watershed. Thirty-one discharge into either the Niangua Arm or the Little Niangua Arm (Figure 17). These facilities are mostly extended aeration treatment systems with chlorinated effluent and flows in the range of 1,000 to 55,000 gallons per day (GPD). They are self-monitored quarterly, semiannually, or annually depending on the flow and site conditions. The number of permits for non-POTWs releasing effluent to LOZ has increased dramatically in recent years. Occasional violations of water quality standards have been reported in highly developed coves (Mitzelfelt, 1985). Due to the neglect of proper maintenance and the infrequent monitoring of these facilities, their contribution to nutrient loading and pathogen contamination of the lake is probably considerable.

The Bennett Spring Fish Hatchery uses about 20 percent of the average flow from Bennett Spring for trout production prior to discharging the water into the Niangua River. There have been no known problems with this discharge, except occasional complaints by anglers of excess turbidity when raceways are flushed to remove accumulated sediment. Most of the sediment laden effluent is now applied to MDC land at Bennett Spring CA.

Other wastewater from Bennett Spring State Park is treated in three lagoons and then land applied on the Bennett Spring CA. Historic ponding effluent and excess runoff problems have been reduced by increasing the land area for application. Lagoon effluent is occasionally drained directly into the Niangua River during high flows to increase storage capacity. These incidents have reportedly been reduced by eliminating some of the storm water that had been draining to the lagoons.

Storm Water Discharges

NPDES permits for storm water runoff have been issued for 15 discharges within the watershed. These include a closed landfill that discharges into a tributary to Durlington Creek about 1.5 miles from the NR and a quarry that discharges to a tributary within 0.2 miles of the NR. Most of the permitted storm water discharges receive no treatment, although some may incorporate settling basins.

Landfills

All five municipal sanitary landfills located within the Niangua watershed have been closed (Table 20; Figure 16). The Lebanon Sanitary Landfill (B001) was active between 1977 and 1980, when all available space was exhausted. The underlying soils are poor and the site is in a karst area with a sinkhole nearby, so groundwater contamination is a concern (Jim Gross (MDNR), pers. comm.). A leachate collection system that discharges to the Lebanon STP has been installed, but on at least one occasion, leachate overflowed from a manhole to a nearby stream, a tributary to Goodwin Hollow (Jim Gross (MDNR), pers. comm.). Although this site lies outside the surface watershed of the Niangua Watershed, it and Goodwin Hollow are within a karst area that is hydrologically connected to Bennett Spring and Sweet Blue Spring. The Dallas County Landfill near Buffalo includes two sites. One (B002) was active between 1976 and 1986, and the other (B005) was active between 1980 and 1986. The landfill did not meet its closure conditions until December 1995 due to problems with surfacing leachate and inadequate vegetative cover. These problems have been corrected, but there is still concern that leachate may pass through the porous soil and fractured bedrock underlying the site into groundwater aquifers (Jim Gross (MDNR), pers. comm.). The Ed Mehl Landfill near Camdenton includes two different sites (B003 and B004) active from 1979 through 1991. It was officially closed in 1995. No water contamination problems have been reported at the site (Kevin Johnson (MDNR), pers. comm.). A private landfill located in a karst area near Lebanon contains sawdust and other wood waste, and poses a potential threat to groundwater resources. This facility is outside the watershed, but within the Bennett Spring recharge area. No permit or monitoring is required for this facility because a 1990 revision of the Solid Waste Law exempts wood waste (Jim Gross (MDNR), pers. comm.).

There are numerous small dump sites, including municipal, county, and private sites, which were never permitted and cannot be utilized legally. There are no known water pollution problems associated with these sites.

Toxic Waste Sites

Eighteen sites with potential toxic or hazardous waste problems have been identified (Table 17; Figure 16). They are all sites regulated and monitored by the MDNR under several programs. The Leaking Underground Storage Tank Program maintains a list of known leaking, buried tanks containing substances which have known or potential water pollution problems. The Underground Storage Tank Program maintains a list of registered buried tanks that are not known to leak. Owners of these sites were required to register these tanks by August 28, 1996 to become eligible for insurance which limits their liability to \$10,000 for future pollution problems. The Toxic Release Inventory (TRI) contains detailed information about parties that release, store, or process toxic materials such as heavy metals and pesticides. Many listed facilities in the watershed are not included in Table 21 because they discharge to municipal sewage treatment plants. In these cases, the toxins are usually retained in the sludge, and are regulated by the NPDES permit for the treatment plant. In addition, the MDNR maintains a list of Superfund sites, those which are candidates under investigation, or eligible for federal Superfund assistance to remove or otherwise control toxic wastes.

Quarries

Five limestone quarries have been permitted by the Land Reclamation Program (MDNR) (Table 22; Figure 16). One facility (Q001) is currently being investigated by the MDNR. The owner has a NPDES permit that limits suspended solids in its discharges and is responsible for self-monitoring them twice per year. A MDNR inspection in September 1996 revealed that sediment buildup in two detention basins could result in highly turbid discharges during storm runoff (Kevin Hess (MDNR), pers. comm.). The owner has been advised to clean out the basins.

404 Activities

Seventy-seven known permits were issued for 404 activities within the watershed between July 1992 and June 1996 (Appendix F; Figure 18). Only COE permits are listed for most of the sites. MDNR land reclamation permits were also issued for many of these sites, but are only included if no COE permit was recorded. The vast majority of permits (51) were issued for gravel removal. Eleven permits were issued for bridge construction or repairs, and six for bank stabilization. One permit was issued for pipeline armoring. MDC Fisheries Management personnel formally reported twenty violations to the COE during the same time period. Seventeen of these were associated with sand and gravel removal, including eight unpermitted sites and eleven occasions with one or more permit violations.

In January 1996, a general permit (MRKGP-34M) was enacted for gravel excavation in Missouri. Conditions formulated by the MDC, MDNR, and COE are included to minimize stream degradation. Excavation is prohibited in select streams identified by Fisheries Division personnel to protect spawning habitat of some species (Table 7). One hundred sixty-seven miles of Niangua Watershed streams are recommended for protection during the spring spawning season, March 15 through June 15, and fifteen miles are recommended for protection during the fall season (November 15 through February 15). The General Permit and recent changes in COE authority to regulate in stream excavation are discussed in greater detail in the Corps of Engineers Jurisdiction section. These changes could result in serious degradation to Missouri streams if alternate means to reduce environmental problems associated with sand and gravel removal are not adopted.

Animal Waste Point Sources

Seventy-one animal waste point sources are currently permitted within the watershed (Figure 19). As shown in Table 23, 51 of the 71 animal waste point sources are dairies, 11 are swine operations, and four are poultry operations. The total human population equivalent (PE) of the permitted facilities, for which PE data is available, is 113,766 (Table 18). This is far greater than the estimated 1994 human population of the watershed (34,679) and only includes animals in confinement facilities which have point discharges. Facilities which do not have permits or for which PE data is not available are not included, so this is a conservative estimate. Livestock in pastures, which occur in much greater numbers in the watershed, are considered in the following section. Most of the point sources are dairy farms with less than 300 animal units, and many have received UNAWP assistance for installing waste treatment systems. The University Extension Office in Dallas County estimates that 28 percent of the total manure production within the upper Niangua watershed is now being treated by facilities installed through UNAWP (Charles Shay (UMC Extension), pers. comm.). The USDA estimates that approximately 55,000 pounds of nitrogen and 10,000 pounds of phosphorus in 1994; and 113,000 pounds of nitrogen and 32,000 pounds of phosphorus in 1995, were intercepted and treated rather than flushed into streams (Smale et al., 1995). Nitrogen and phosphorus, fecal bacteria, and other contaminants, were monitored at 23 stations on the NR and its tributaries from summer 1991 to winter 1995. Preliminary results indicate that there were no detectable reductions in nutrient or pathogen levels that could be attributed to these installations (Smale et al, 1995). The inability to detect improvements may be due to the difficulty of monitoring water chemistry in streams because they are so dynamic, or the presence of other contaminant sources, such as cattle in pasture (see the following section).

In addition, ten sites within the study area were designated as intensive study sites, where sampling included: fish collections once per year; invertebrate collections twice per year using rapid bioassessment techniques; and a limited collection of associated physical and habitat data. Limited preliminary results indicate that invertebrate communities may be more sensitive than fish communities and both may be more sensitive to riparian conditions than to nutrient loading (Smale et al, 1995).

Non-point Source Pollution Agricultural Runoff

The main non-point pollution source in the watershed is probably runoff from dairy and beef cattle pastures. Cattle on pasture in the watershed produce waste equivalent to an estimated human population of over 1.2 million (Table 19). This estimate was derived from data from several sources. The number of cattle in counties within the watershed was obtained from statistics available from the Missouri Agricultural Statistics Service (MDA, 1995). The total numbers of beef cattle and dairy cattle in the watershed were calculated based on the assumption that both were equally distributed throughout the watershed. The estimated numbers within the watershed were multiplied by the population equivalents - PE=14 per 1,000 lbs for beef cattle, PE=20 per 1,000 lbs for milk cows (MDNR, 1989), and by 0.8, assuming the average weight of cattle in the watershed is 800 pounds (MDA, 1995). Finally, the estimated PE of cattle on pasture (1,230,914) was determined by subtracting the PE of NPDES permitted dairies in the watershed (Table 18) from the PE for total cattle in the watershed (Table 19).

Since some animal waste in pastures decomposes in place, and some nutrients are filtered out and absorbed by vegetation before they enter the surface or groundwater, the effects of this amount of waste on water quality and aquatic life, and the possible risks to human health, are

difficult to predict. This diffuse reservoir of nutrients and pathogens may account for the high levels of fecal bacteria, nitrates, and phosphates reported by Smale et al, (1995) during the UNAWP after rainfall events. These non-point sources may contribute nitrates to groundwater reservoirs and springs, and explain why significant improvements were not detected under normal flow conditions during the UNAWP after point sources had been intercepted and treated.

Septic Systems

Septic systems and most other individual onsite wastewater treatment systems are intangible non-point sources that are difficult to pinpoint or quantify. This is especially true in most of rural Missouri because, until recently, permits were not necessary to install these systems. This lack of regulation is compounded by the fact that the thin, porous soils and shallow, fractured bedrock, that are common throughout the watershed, do not provide adequate soil treatment for conventional septic systems. Impervious soil types, such as clay hardpan and fragipan, are also common in the watershed. When installed improperly or in porous soils, the leachate can percolate rapidly through the soil to contaminate aquifers that supply springs and wells. In impervious soils, poorly treated leachate can surface and enter the nearest stream. Contamination from septic systems and other onsite systems has almost certainly been the major cause of elevated nutrient and pathogen levels in developed coves of LOZ (Mitzelfelt, 1985). In less highly developed areas away from the lake malfunctioning systems can contaminate small springs and streams in local areas, but the cumulative impacts of widely dispersed small systems are difficult to ascertain. A new statewide septic system regulation that went into effect in September 1995 should reduce these problems. It requires that permits be obtained for installation or major repair of septic systems on parcels less than three acres. In addition, minimum standards, based on expected use and site conditions, must be met. A soil percolation test or soil morphology examination must be completed by a licensed technician, and the system must be approved by a licensed engineer if less than minimal site conditions are detected. The regulation is administered by the Missouri Department of Health (MDH), but counties are encouraged to adopt ordinances as strict or more so, and to administer the permitting program themselves. Most counties within the Niangua Watershed have done so.

Camden County has enacted an ordinance that adopts the state standards and has opened the Camden County Wastewater Department in Camdenton. The ordinance includes restrictions that require permits for all lake front lots and that systems be set back at least 50 feet from the shoreline. Thousands of aerobic onsite treatment systems at private homes around the lake reportedly pose a continuing pollution problem (Craig Reichert (Camden County Sanitarian), pers. comm.). The new regulation does not affect existing systems unless contamination problems are documented or the system needs major repairs or replacement. Aerobic systems do not function properly without a fairly continuous flow of waste to maintain high numbers of aerobic decomposers. Therefore, they often fail to provide adequate treatment at homes around the lake that are only used seasonally or infrequently (Craig Reichert (Camden County Sanitarian), pers. comm.). This problem is often compounded by poorly designed or constructed soil absorption fields, which are especially important for infrequently used aerobic systems. Dallas, Hickory, and Webster counties have also enacted ordinances equally or more strict than the statewide regulation. Dallas and Hickory Counties have local sanitarians, while Webster County is currently served by the Springfield Office (MDH). Laclede County has not enacted a local ordinance, so permits are issued by the Central Division Office (MDH).

Soil Erosion and Sedimentation

Although soil erosion in the watershed is considered to be fairly low at 2.5-5.0 tons per acre (MDNR, 1984), streambank erosion is a serious problem. Bank erosion is probably the main cause of excessive sediment bedload that is common throughout the watershed, and probably contributes to excessive turbidity and nutrification. Bank erosion frequently occurs because riparian woodlands have been cleared for pasture or are otherwise degraded. These problems are compounded by the fact that a high percentage of the watershed has been converted from woodland to pasture, and the runoff from pasture is much greater than the runoff from woodland.

Fire Disturbance

Manmade and natural fires are a common occurrence in the watershed during dry seasons and may increase runoff and erosion. MDC and rural fire department records were analyzed to determine the number of acres disturbed by fires between 1993 and 1995 (Table 20). The number of acres impacted is underestimated because high percentages of the reported fires did not include site descriptions (35-55%), so the watershed in which they occurred could not be determined. In addition, fire reports for Hickory and Webster counties were not included in the analysis. Most of the fires during this period occurred on forested land. Fires destroy the leaf litter and understory trees and brush that help reduce runoff and erosion in forests. Since most forest land occurs on sites with slopes too great to be cleared for pasture and most fires occur during January and February when trees are bare, severe erosion is likely to occur after fires. MDC foresters have reported that some areas within the watershed, including the Tunnel Dam and Lead Mine areas, experience relatively large numbers of fires each year (Dennis Rhoades (MDC), pers. comm.). Spatial analysis of fire data was not performed for this inventory and assessment.

Water Use

The known major groundwater and surface water users in the watershed and within spring recharge areas are shown in Table 21 and Figure 20. There are no public water supply withdrawals from surface waters in the watershed. There are only four surface water users on record. The first, Sho-Me Power Corporation (R005) operates the Tunnel Dam Project for hydroelectric power generation. All of the water used for power generation is returned to the river 6.5 miles downstream from the dam. Since most of the flow of the NR during normal flows is used, this user can have a dramatic effect on water quality and aquatic life especially in the bypass loop. The utility must allow minimum flows in the bypass loop to maintain aquatic life (see Hydrology Section).

The MDC (R015) diverts water from Bennett Spring Branch for the Bennett Spring Trout Hatchery, and all the water is returned to the spring branch. Although there have been occasional complaints of turbid discharges due to periodic flushing of the raceways at the hatchery, no water quality problems have been documented. The two other surface water users, private landowners, are relatively minor users and there have been no documented problems associated with the identified use, farm irrigation.

The known groundwater users listed in Table 21 are mostly municipal water supply wells. They are included because of their potential impact on springs within the watershed. Some of these wells are located outside the surface watershed of the Niangua Watershed, but within recharge areas of watershed springs. (see Figure 11).

Tunnel Dam/Lake Niangua is the only hydropower facility operating within the watershed, however operation of Bagnell Dam (LOZ) can also impact this watershed. Sudden changes in water level when fish are spawning may reduce reproductive success. Changes in pool level are usually not of sufficient magnitude to seriously impact fish populations or recreational users during the remainder of the year.

Air Quality

There are no known air quality problems in the Niangua Watershed. The closest sources of industrial air contaminants are Springfield (40 miles to the southwest) and Kansas City (80 miles to the northwest).

Prevailing winds could carry contaminants from either of these sources. The high alkalinity of watershed streams and lakes protects them from acidification due to acid rain. The MDNR Toxic Release Inventory (TRI) does not include any significant sources of airborne contaminants within the watershed.

Table 14. Water quality classification and beneficial uses of classified streams and lakes within the Niangua Watershed.

Stream	Class	Start	End	Length	County	Beneficial Use
AB Creek	C	Mouth	32,37N,18W	3	Dallas_Camden	W,L
Bank Branch	C	Mouth	35,37N,17W	5	Camden	W,L,F
Bannister Hollow	C	Mouth	36,38N,19W	4	Camden	W,L,C
Bennett Spring Branch	P	Mouth	Bennet Spring	2	Laclede	W,L,F,C
Benton Branch	P	Mouth	11,34N,19W	0.5	Dallas	W,L
Benton Branch	C	11,34N,19W	11,34N,19W	1	Dallas	W,L
Broadus Branch	C	Mouth	15,37N,18W	1.5	Camden	W,L
Cahoochie Creek	C	Mouth	9,36N,20W	4	Dallas	W,L
Cat Hollow	C	Mouth	33,35N,18W	2	Dallas	W,L
Cave Creek	C	Mouth	14,34N,18W	3	Dallas	W,L
Coatney Creek	P	Mouth	15,36N,19W	2	Dallas	W,L
Dousinbury Creek	P	Mouth	17,33N,18W	3.5	Dallas	W,L
Dousinbury Creek	C	17,33N,18W	15,33N,18W	2	Dallas	W,L
Durington Creek	C	Mouth	06,34N,19W	4	Dallas	W,L
E. Fork Niangua River	C	33,32N,18W	25,31N,18W	6	Webster	W,L,R
Fiery Fork	C	Mouth	36,39N,19W	2	Camden	W,L
Fourmile Creek	C	Mouth	29,34N,18W	5	Dallas	W,L
Goose Creek	C	Mouth	15,32N,18W	3	Dallas	W,L
Gower Branch	C	Mouth	09,32N,19W	2	Dallas	W,L
Greasy Creek	P	Mouth	31,34N,19W	4	Dallas	W,L,F
Greasy Creek	C	31,34N,19W	11,32N,20W	10.5	Dallas	W,L,F

Stream	Class	Start	End	Length	County	Beneficial Use
Greer Creek	C	Mouth	25,32N,19W	3	Webster	W,L
Halsey Hollow	C	Mouth	2,35N,18W	2	Dallas	W,L
Jakes Creek	C	Mouth	24,35N,19W	10	Dallas	W,L
Jarvis Hollow	C	Mouth	23,38N,17W	1.5	Camden	W,L
Jerktail Branch	C	Mouth	11,34N,19W	0.5	Dallas	W,L
Jones Branch	C	Mouth	32,33N,19W	3	Dallas	W,L
Judge Creek	C	Mouth	19,36N,19W	3	Dallas	W,L
Kolb Branch	C	Mouth	2,38N,19W	2	Camden	W,L
Little Niangua River	P	Mouth	26,36N,19W	43	Camden Dallas	W,L,R,B,O
Little Niangua River	C	26,36N,19W	20,35N,19W	7	Dallas	W,L,R,B,O
Long Branch	C	Mouth	33,37N,19W	3	Camden	W,L
Macks Creek	P	Mouth	Hwy. 54	8	Camden	W,L
Macks Creek	C	Hwy. 54	23,37N,19W	2.5	Camden	W,L
Mill Creek	P	Mouth	9,36N,18W	1.5	Dallas	W,L,C,R
Mill Creek	P	9,36N,18W	8,36N,18W	1.5	Dallas	W,L
Mountain Creek	P	Mouth	23,35N,17W	6	Laclede	W,L
Niangua River	P	Mouth	Power Plant	5	Camden	W,L,R,B
Niangua River	C	Power Plant	Tunnel Dam	6	Camden	W,L,R,B
Niangua River	P	Dallas County Line	11,35N,18W	24	Dallas	W,L,R,B,F
Niangua River	P	11,35N,18W	Bennett Spring Branch	6	Dallas	W,L,R,B,F,C
Niangua River	P	Bennett Spring Branch	33,32N,18W	51	Dallas-Webster	W,L,R,B,F

Stream	Class	Start	End	Length	County	Beneficial Use
Lake Niangua	L3	35,37N,18W		360 Ac	Camden	W,L,R,B
Lake Of The Ozarks	L2	SE 19,40N,15W		59520 Ac	Camden	W,L,R,B
Prairie Hollow	P	Mouth	04,37N,18W	7	Camden	W,L
Sarah Branch	C	Mouth	01,32N,18W	3	Webster	W,L
Spencer Creek	C	Mouth	14,37N,17W	2	Camden	W,L
Spring Hollow	C	Bennett Spring	27,34N,17W	10	Laclede	W,L
Starvey Creek	C	Mouth	15,32N,18W	3	Dallas	W,L
Sweet Hollow	C	Mouth	27,36N,17W	3	Laclede	W,L
Thomas Creek	C	Mouth	3,35N,20W	7	Hickory Dallas	W,L
Trib W. Fork. Niangua R.	P	Mouth	19,31N,18W	1.5	Webster	W,L
Trib Mill Creek	C	Mouth	14,37N,15W	1.5	Camden	W,L
Trib Greasy Creek	C	Mouth	33,33N,20W	1	Dallas	W,L
Trib Lake Niangua	C	Mouth	19,37N,17W	1	Camden	W,L
Trib Macks Creek	C	Mouth	6,37N,18W	1	Camden	W,L
Trib Niangua River	C	Mouth	17,37N,17W	1	Camden	W,L
Trib Thomas Creek	C	Mouth	26,36N,20W	0.5	Dallas	W,L
Tunas Branch	C	Mouth	33,36N,19W	3	Dallas	W,L
W. Fork Niangua River	P	33,32N,18W	33,31N,18W	7	Webster	W,L
Woolsey Creek	C	Mouth	5,36N,17W	4	Camden_Laclede	W,L,R,B

Class:

C - Streams which may cease flow in dry periods but maintain permanent pools which support aquatic life.

P - Streams that maintain permanent flow even in drought periods. L2 - Major reservoirs.

L3 - Other lakes.

Beneficial Use:

I - irrigation of cropland.

W - watering for livestock and wildlife. L - protection of aquatic life.

C - cold-water fishery.

R - whole-body-contact recreation.

B - boating and canoeing with limited body contact. D - drinking water supply.

P - industrial processing or cooling water. O - Outstanding state resource.

F - cool-water fishing.

Table 15. Stream Teams and Volunteer Water Quality Monitors with adopted reaches within the Niangua River Basin and known activities.

Location Number	Team Number	Stream	Reported Activities	Years Reported
51	313	Little Niangua River	INV, WQM	1996-1997
104	478	West Fork Ninagua	LPU, MTG, PLT, PRE, WQM	1996-1998
230	770	Niangua River	WQM	1996
231	770	Little Niangua River	ART, EDU, LPU, MED, MTG, OTH, PRE, WKS, WQM	1996-1997
234	772	Little Niangua River	MTG, PLT, WQM	1996-1999
247	807	Niangua River	INV, LPU, MTG, WKS	1996-1997
273	869	Dousinbury Creek	ART, LPU, PLT, WQM	1996-1997
344 ¹	945	Niangua River	LPU	1997
426	994	Little Niangua River	ART, LPU, MED, OTH, WKS, WQM	1996-1998
428	331	Spencer Creek	INV, LPU, WQM	1997-1998
436	869	Niangua River	OTH, WQM	1997
719	313	Little Niangua River	INV, WQM	1997-1998
867	994	Little Niangua River	LPU	1998
897	1157	Mill Creek	FOR, LPU, MTG	1998
1027 ²	994	Little Niangua River	DIS, OTH	1998
1040	1171	Niangua River	INV, LPU	1998
1233	9997	Niangua River	WQM	1997
1300	1157	Mill Creek	INV, LPU	1999
1409	1293	Niangua River	WQM	1999
1445	266	Niangua River	EDU, LPU, OTH	1999
1466	135	Niangua River	INV, LPU, WQM	1990-1996
1467	678	Greer Creek	LPU, PLT	1996
1808	9997	Greasy Creek	WQM	1996

¹Precise location unknown

²Non-site specific activities

Activity Codes:

ART = News article

OTH = Other

EDU = Educational project

PRE = Presentation at public or governmental meeting

LPU = Litter pickup

WKS = Attended training workshop

MED = Media interview
WQM = Water quality monitoring
MTG = Stream Team meeting

Figure 12.5. Stream Team activity sites within the Niangua Watershed.

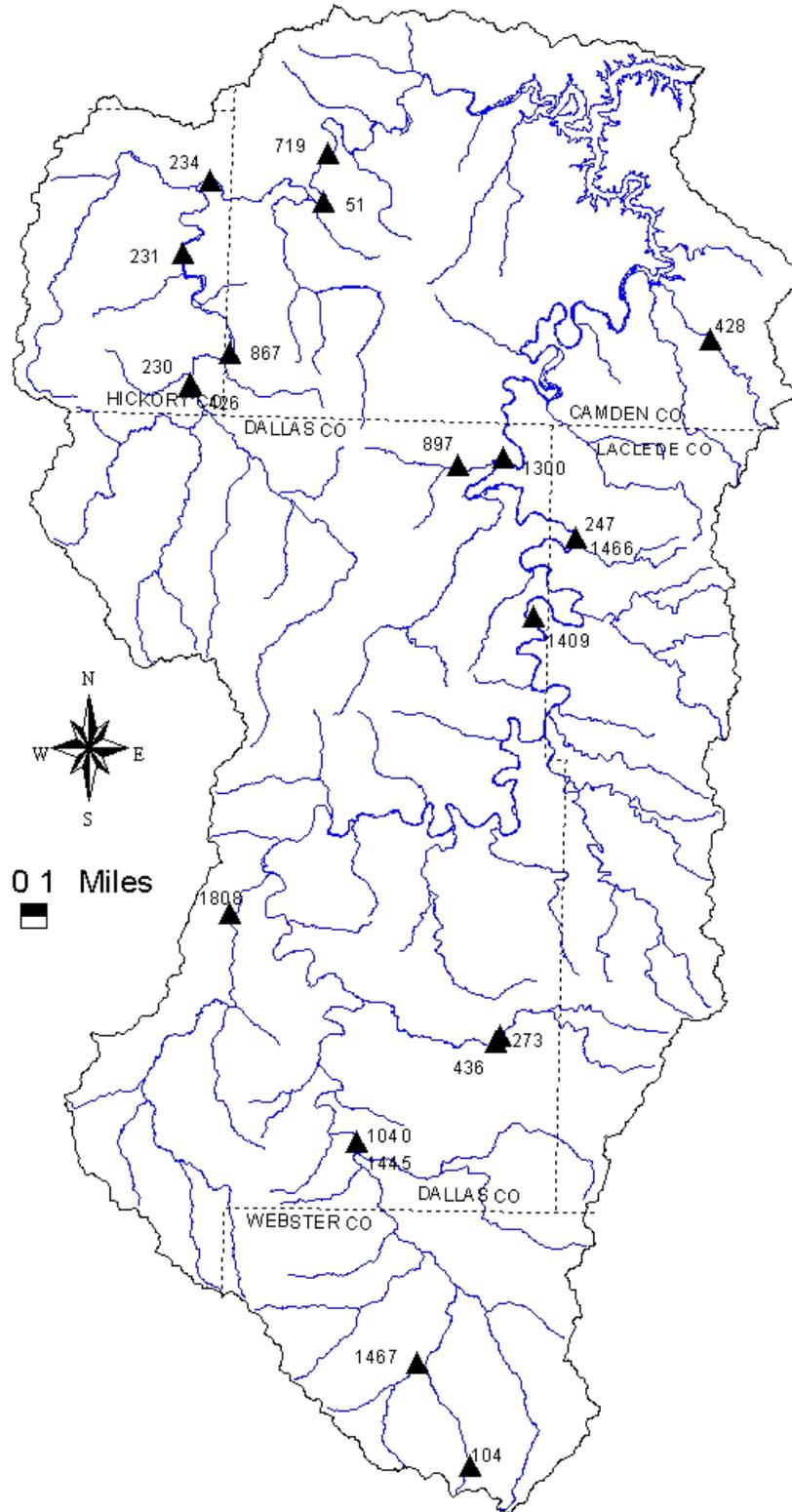


Table 16. Documented fish kills and water pollution events within the Niangua Watershed.

Site Number	Date	Stream	Problem	Length Affected	Number Fish Killed
K001	4/9/79	Hankens Branch	Crude oil pipeline rupture impacted	—	—
K002	10/21/79	Niangua River	Chromic acid & hydrogen peroxide truck	—	—
K003	5/30/80	?	Oil spill, pipeline leak resulted in avian mortal	0	0
K004	4/2/84	West Fork Niangua	Municipal sewage bypass-unknown area	—	0
K005	10/24/84	Hankens Branch	Herbicide transportation spill	0	0
K006	5/11/86	West Fork Niangua	Industrial: petroleum	—	0
K007	6/11/86	West Fork Niangua	Municipal: sewage	—	0
K008	5/13/87	Starks Creek	Other: Petroleum products	—	0
K010	8/12/88	Niangua River	Other: Drawdown of Lake Niangua	2	50
K011	4/29/90	East Fork Niangua	Industrial: petroleum	—	0
K012	7/2/90	Niangua Arm (LOZ)	Municipal: sewage	—	—
K013	7/7/91	West Fork Niangua Trib	Raw sewage discharge due to blocked manhole	1	12,420
K014	7/26/91	Racetrack Hollow	Camdenton STP sludge released from lagoon	1	0
K015	10/5/93	Bennett Spring Branch	Other: excess trout feed and waste	0	0
K016	3/14/94	Trib Dousinbury	52,000 tires burned - Bennett Spring	0	0
K017	10/5/95	Racetrack Hollow	Concrete dumped in stream	0.1	>4
K018	11/26/84	Dousinbury Creek	Diesel fuel pipeline break	—	—

Site Number	Date	Stream	Problem	Length Affected	Number Fish Killed
K019*	10/18/84	Dousinbury Creek Trib	Dousinbury Creek Diesel fuel pipeline rupture	0.1	Small number
K020*	10/24/85	West Fork Niangua River	Unknown problem	—	2558
K021*	7/2/90	Niangua Arm (LOZ)	Periodic sewage discharge private facility	—	0
K022*	12/4/92	Greasy Creek	Undetermined problem	—	—

— unknown length effected or number killed.

* sites were not mapped because locations could not be determined (K019-K022).

Figure 13. Documented fish kills and water pollution events within the Niangua River Watershed and spring recharge area.

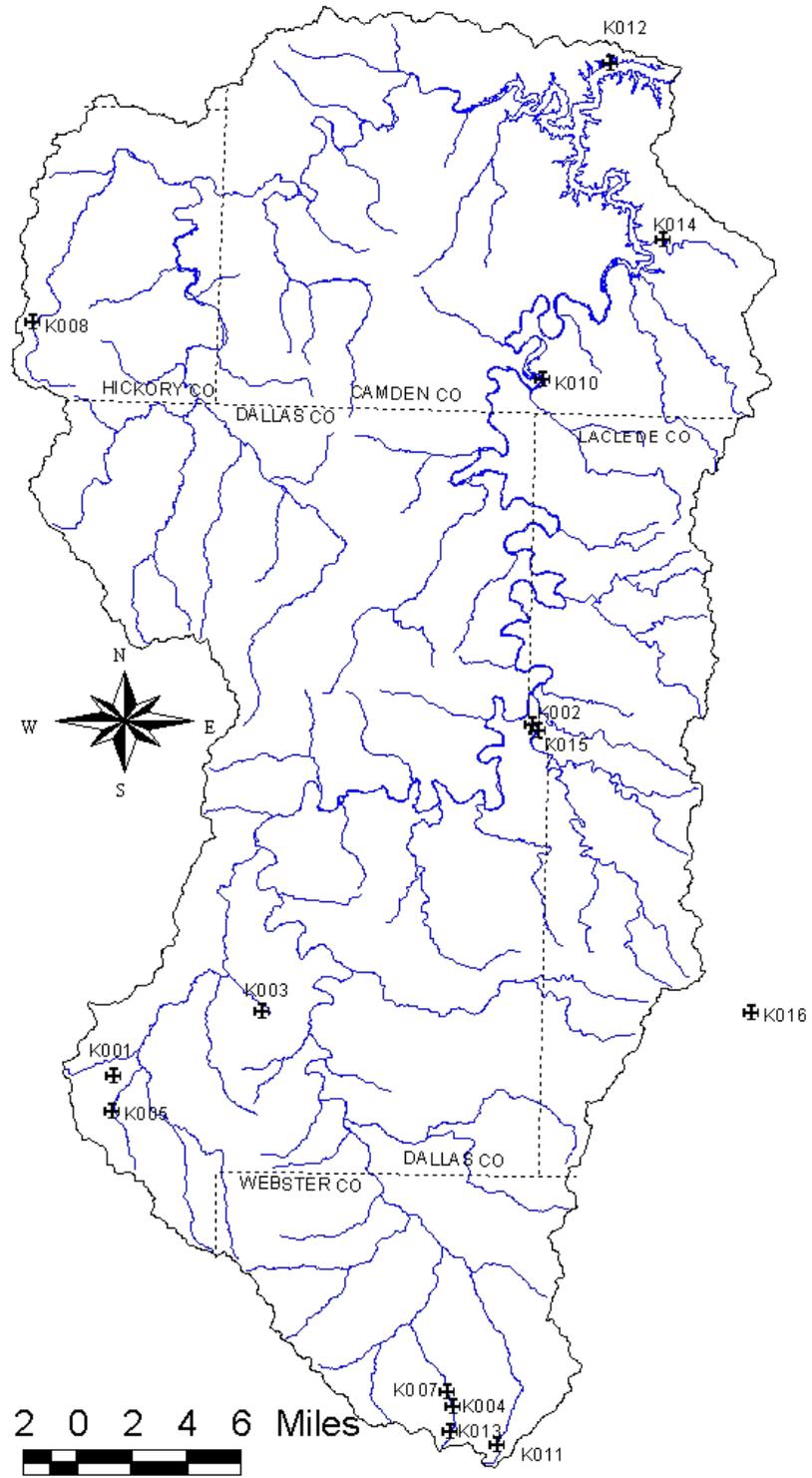


Table 18. Numbers and human population equivalents (PE) of NPDES permitted animal waste facilities within the Niangua Watershed.

Operation Type	Total Number	Number with PE data	PE
Dairy cows	51	38	80,955
Poultry layers or pullets	2	2	17,100
Swine finishing	3	0	—
Swine nursery	1	1	1,536
Sows, boars, and sow and litter	5	0	—
TOTALS	62	41	113,766

NPDES - National Pollution Discharge Elimination System.

— no PE data available

Figure 14. Buried intrastate pipelines that cross the Niangua Watershed.

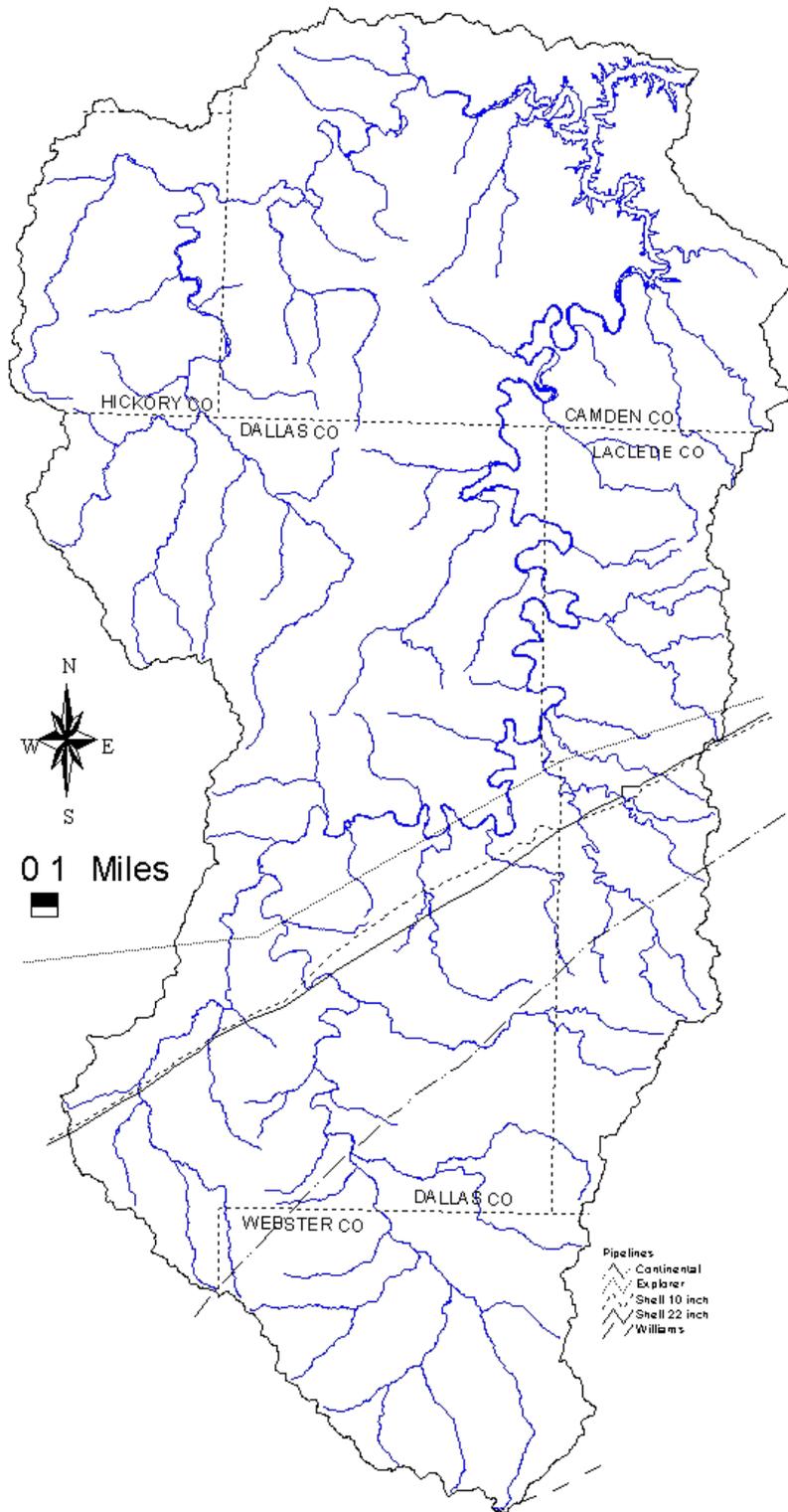


Table 17. Potential toxic or hazardous waste sites within the Niangua Watershed.

Site Number	Owner	Location	Type	Problem
T001	Case Real Estate	Marshfield, MO	UST	unknown toxins, unknown impacts
T002	Wal-Mart Store #78	Marshfield, MO	LUST	unknown toxins, unknown impacts
T003	Gier Oil Company	Marshfield, MO	LUST	unknown toxins, unknown impacts
T004	Tyler Coupling Company	Marshfield, MO	TRI in onsite landfill	several metals, unknown impacts
T005	York Quality Caskets	Marshfield, MO	TRI in onsite landfill	several metals, unknown impacts
T006	Fast Trip #28	Marshfield, MO	LUST	unknown toxins, unknown impacts
T007	Mt. Zion Baptist Church	Charity, MO	LUST	petroleum products Groundwater contamination
T008	Burlington Northern RR	Phillipsburg, MO	buried tanker spill	red and yellow phosphorus soil contamination, potential groundwater contamination
T009	Shell Pipeline Company	Dallas County	Superfund site (cleaned)	petroleum sludge, unknown impacts, sludge removed from site 1/95 to Buffalo STP.
T010	Bird Moving and Storage	Lebanon, MO	LUST	unknown toxins, unknown impacts
T011	Lebanon Site	Lebanon, MO	UST, LUST	fumes in sewers and buildings Bennett Spring recharge area
T012	R H Mini Serve		LUST	
T013	Lebanon Special Road District	Lebanon, MO	LUST	unknown toxins, unknown impacts
T014	Wal-Mart Store	Lebanon, MO	LUST	unknown toxins, unknown impacts
T015	Detroit Tool	Lebanon, MO	LUST	unknown toxins, unknown impacts
T016	Phillips 66 / Thompson Station	Roach, MO	LUST	unknown toxins, unknown impacts

Site Number	Owner	Location	Type	Problem
T017	Magic Chrome	Camdenton, MO	UST, Superfund	various metals and chrome, soil and unknown groundwater contamination, metal plating
T018	Modine Heat Transfer, Inc.	Camdenton, MO	TRI, Superfund site (proposed)	TCE, 1,11,-TCA, PCE, vinyl chloride, soil and groundwater contamination

UST = Underground storage tank with leaking status undetermined.

LUST = Leaking underground storage tank.

TRI = Toxic Release Inventory maintained by MDNR.

(All data obtained from MDNR)

Figure 15. NPDES wastewater discharges on streams, excluding animal waste discharges within the Niangua River Watershed.

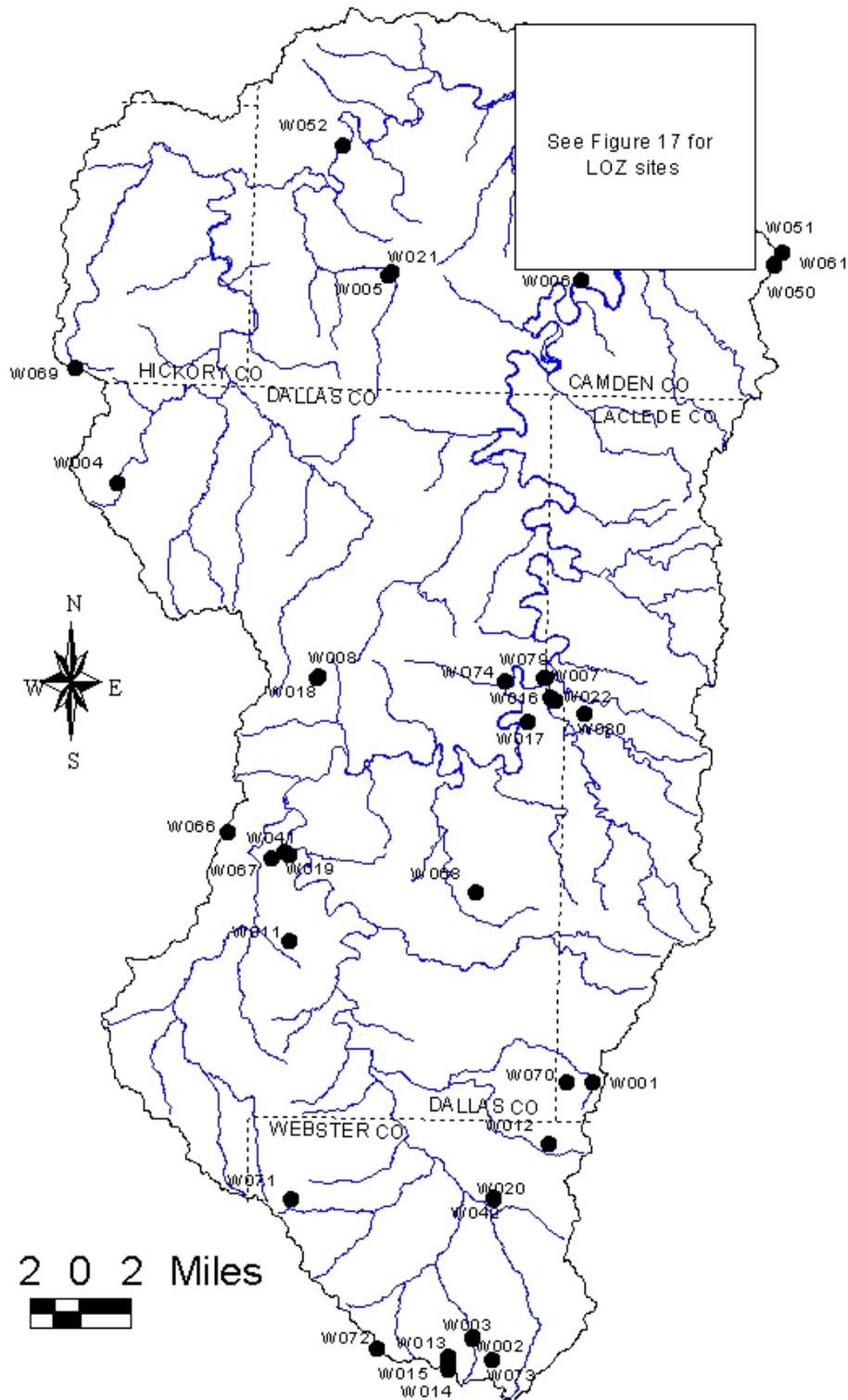


Table 19. Estimated numbers and human population equivalent (PE) of all cattle within the Niangua Watershed by county.

County	Number in Watershed			Population Equivalent in Watershed			
	Milk Cows	Other Cattle ¹	Total Cattle	Milk Cows	Other Cattle ¹	Total Cattle	Total Cattle in Pasture ²
Camden	417	8,945	9,362	8,346	125,227	133,574	
Dallas	5,796	40,817	46,613	115,929	571,435	687,365	
Hickory	355	6,693	7,049	7,105	93,707	100,812	
Laclede	1,810	12,337	14,146	36,198	172,712	208,910	
Webster	2,296	12,007	14,303	45,922	168,097	214,020	
Total	10,675	80,799	91,474	213,500	1,131,180	1,344,680	1,230,914

¹Other Cattle includes all cattle except milk cows.

²Total Cattle less those reported in NPDES facility permits in confined facilities (calculated for total watershed only).

Figure 16. Landfills, quarries, sludge disposal application sites, and toxic waste sites within the Niangua River Watershed and spring recharge area.

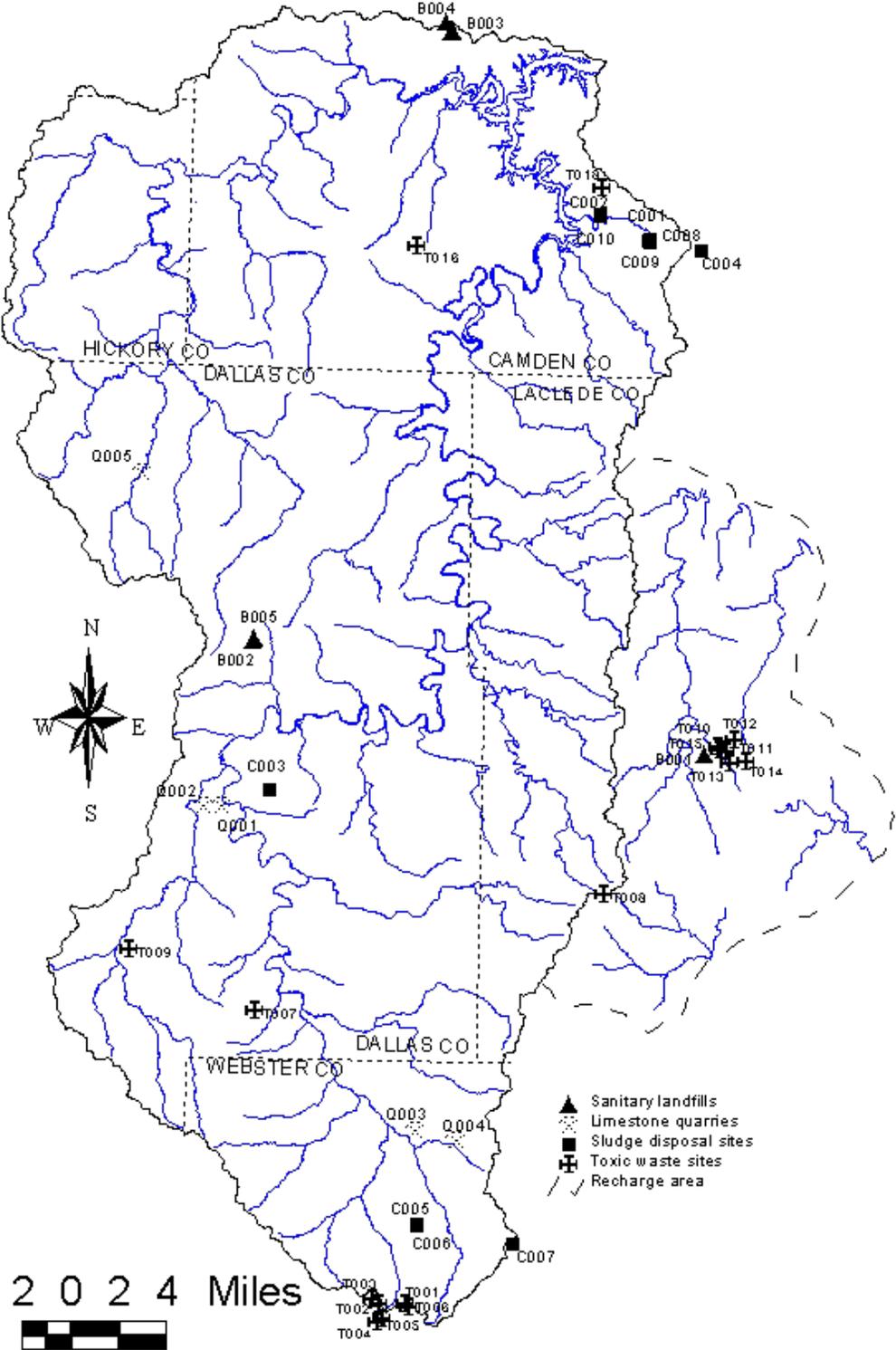




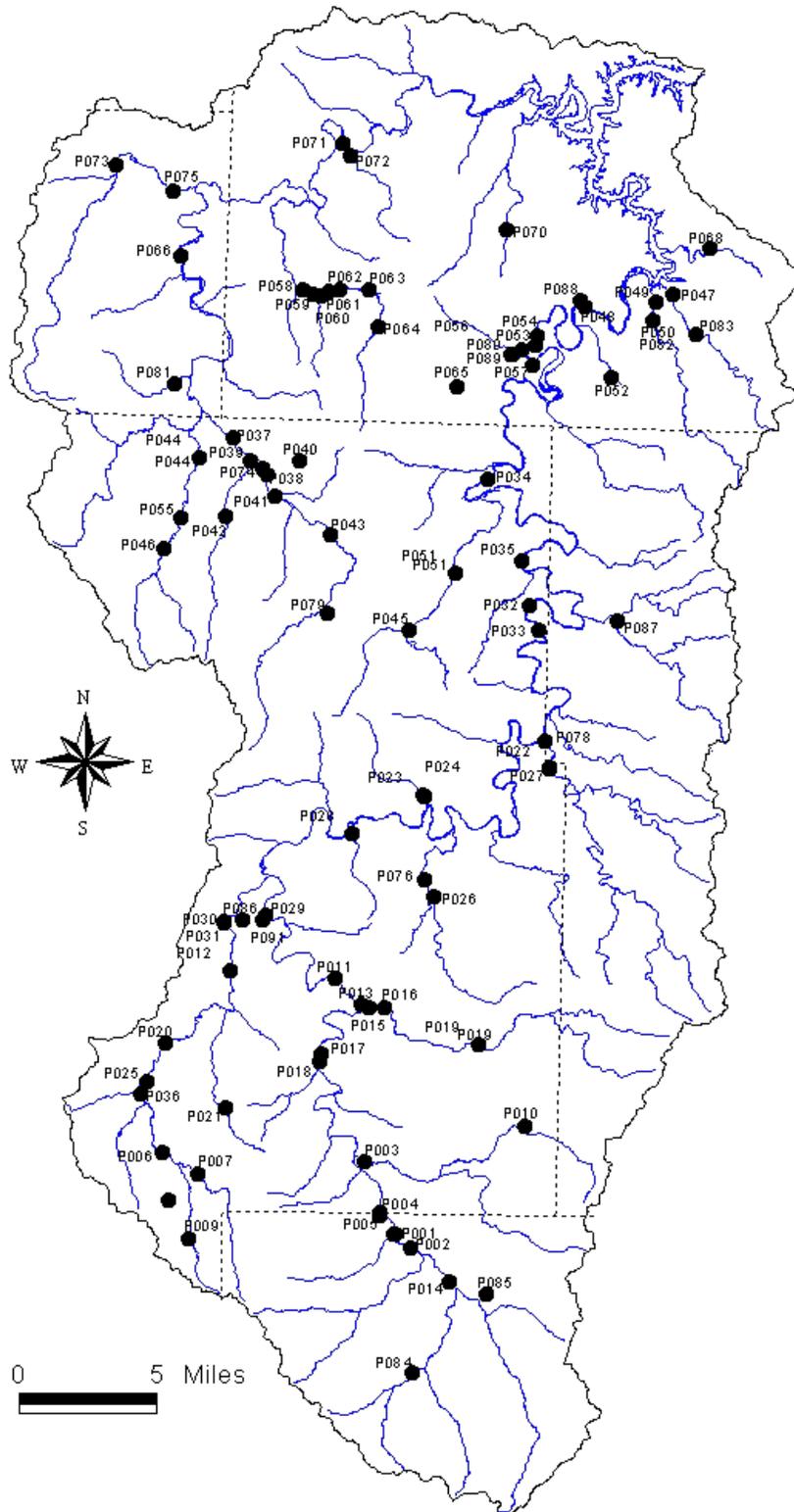
Figure 17. NPDES permitted waste water discharges on Lake of the Ozarks.

Table 20. Documented number of acres disturbed by fire between 1993 and 1995 within Camden, Dallas, and Laclede Counties.

Year	Forest Acres	Other Acres	Total Acres	Percent of Watershed Burned	Percent of Unidentified Sites ¹
1993	2,893	753	3,646	0.5	40.4
1994	6,802	2,309	9,111	1.4	55.4
1995	9,109	1,821	10,930	1.6	34.6

¹Percent of sites for which the watershed could not be determined due to missing legal descriptions.

Figure 18. USCOE and MDNR permitted instream activities and violations within the Niangua River Watershed.



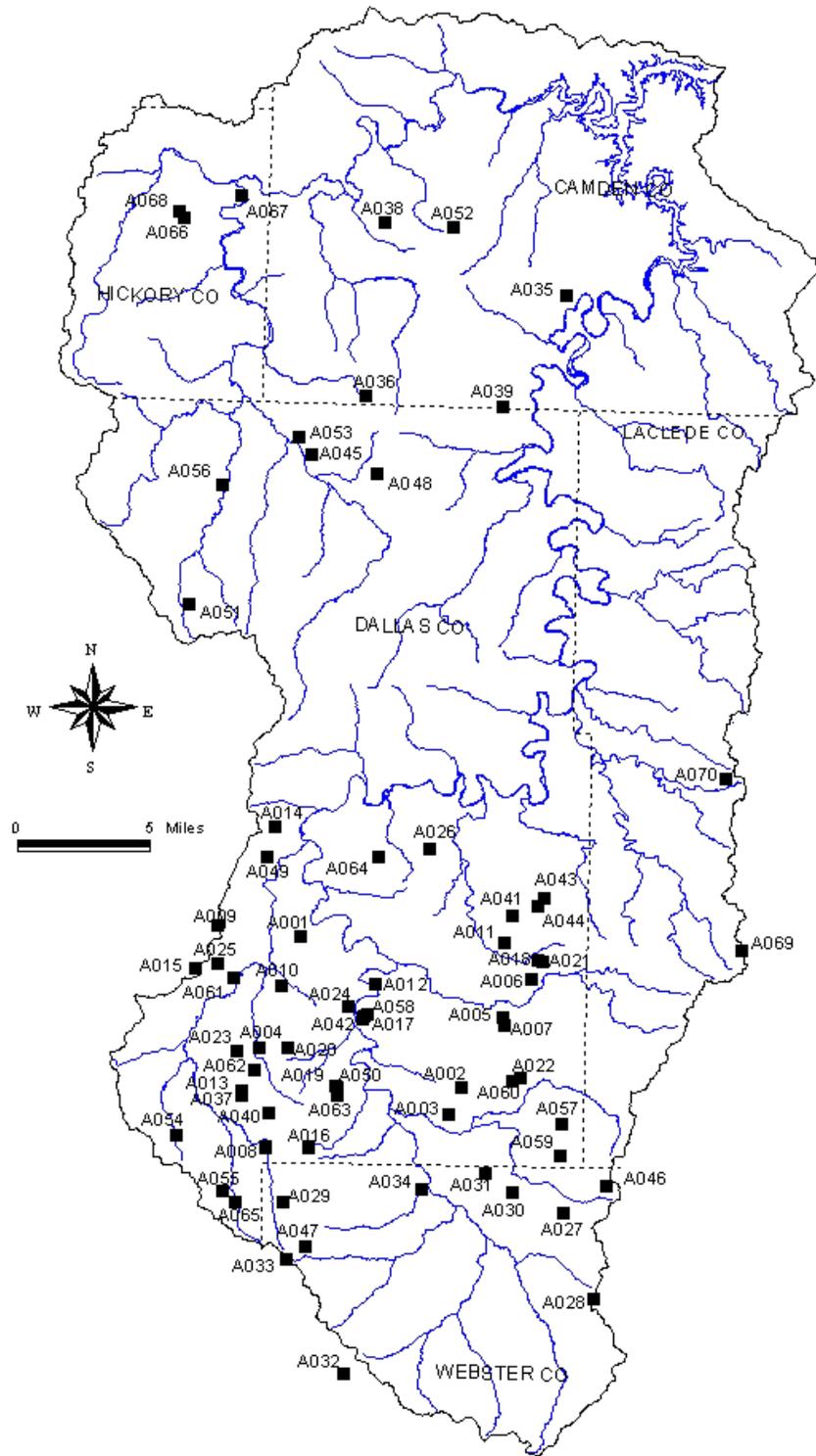


Figure 19. NPDES animal waste sites within the Niangua River Watershed.

Table 21. Major groundwater and surface water users within the Niangua Watershed and spring recharge area.

Site Number	User	Use	Twp	Rng	Sec	Topographic Map
R001	City/Camdenton (Rodeo)	Municipal Water Supply ²	38	17	26	Green Bay Terrace
R002	City/Camdenton (Blair)	Municipal Water Supply ²	38	17	26	Green Bay Terrace
R003	City/Camdenton (Mulberry)	Municipal Water Supply ²	38	17	25	Green Bay Terrace
R004	Lake View Care Inc.	Domestic Water Supply ²	38	17	14	Green Bay Terrace
R005	Show-Me Power Electric Cooperative	Electric Power Generation ¹	37	17	19	Ha Ha Tonka
R006	Robert P. Brown	Domestic Water Supply ²	35	19	19	Tunas
R007	Laclede Co. PWSD #1	Municipal Water Supply ²	34	16	6	Lebanon
R008	Laclede Co. PWSD #1	Municipal Water Supply ²	34	16	2	Lebanon
R009	Laclede Co. PWSD #1	Municipal Water Supply ²	33	17	1	Brush Creek
R010	Laclede Co. PWSD #1	Municipal Water Supply ²	34	16	3	Lebanon
R011	Laclede Co. PWSD #1	Municipal Water Supply ²	34	17	2	Bennett Spring
R012	Laclede Co. PWSD #1	Municipal Water Supply ²	36	16	30	Eldridge East
R013	Laclede Co. PWSD #1	Municipal Water Supply ²	35	16	23	Eldridge East
R014	Laclede Co. PWSD #1	Municipal Water Supply ²	33	16	7	Brush Creek

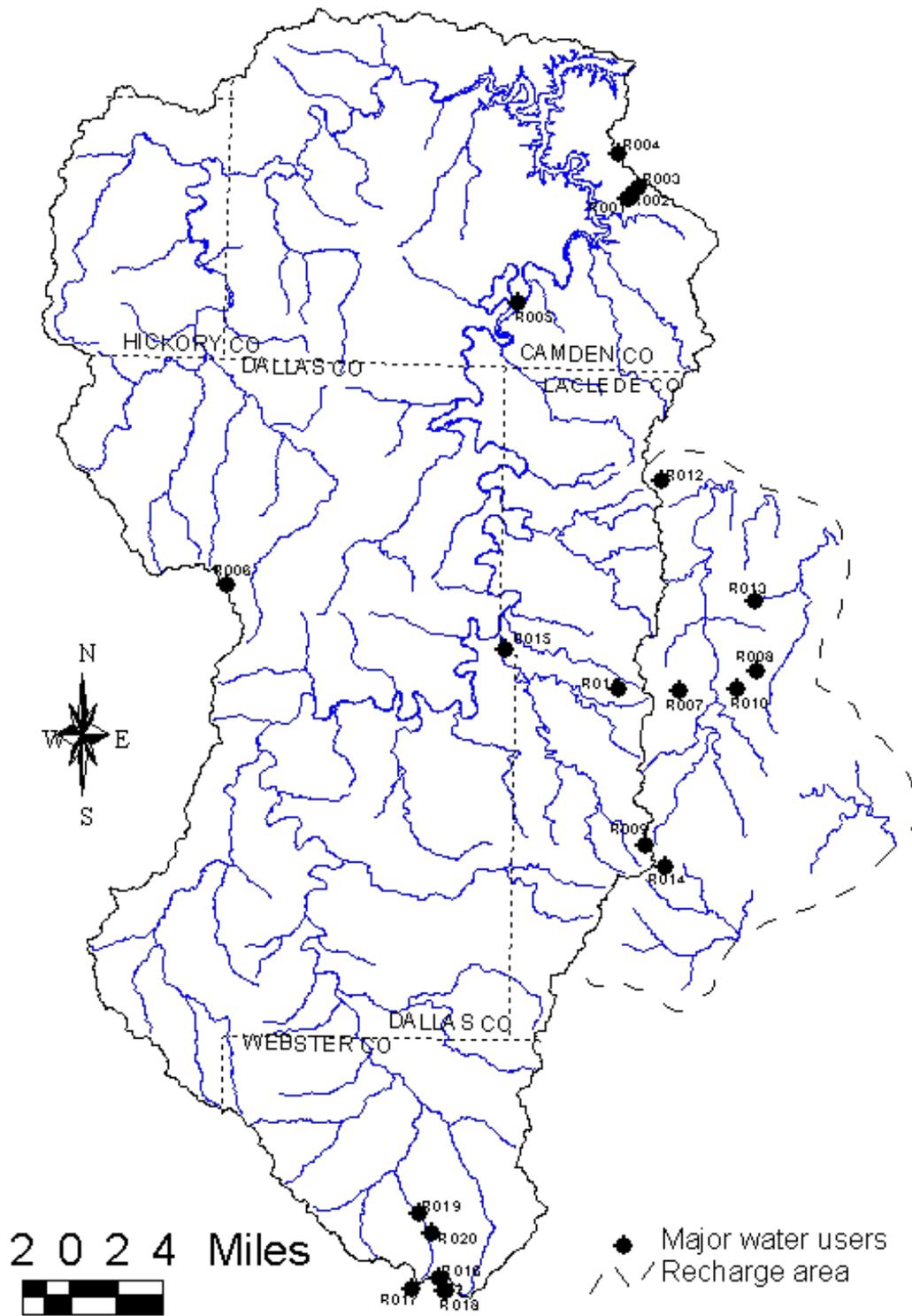
Site Number	User	Use	Twp	Rng	Sec	Topographic Map
R015	State of Missouri	Fish culture ¹	35	17	31	Bennett Spring
R016	City of Marshfield	Municipal Water Supply ²	30	18	3	Marshfield
R017	City of Marshfield	Municipal Water Supply ²	30	18	9	Marshfield
R018	City of Marshfield	Municipal Water Supply ²	30	18	10	Marshfield
R019	Ralph Vineyard	Farm irrigation ¹	31	18	28	Beach
R020	Ralph Vineyard	Farm irrigation ²	31	18	33	Marshfield
R021	Gilbert Lee	Farm irrigation ¹	36	18	10	Leadmine

¹Surface water use

²groundwater use

All data except R021 were obtained from the MDNR Water User Database.

Figure 20. Major water users listed by the MDNR within the Niangua River Watershed and spring recharge area.



Habitat Conditions

Widespread channelization has not been a problem in the Niangua Watershed, although some small channelization projects have been attempted by individual landowners. Occasionally permit applicants have proposed channelization projects in Section 404 applications. In all recent cases the MDC has recommended denial due to the potential negative impacts on aquatic habitat, and the COE has denied these proposals. However, recent changes have occurred in COE authority to regulate excavation in streams including channelization (see Corps of Engineers section).

Unique Habitat

Natural Features Inventories have been completed for counties of the Niangua Watershed by MDC, USFWS, and The Nature Conservancy (Currier, 1989; Currier, 1991; Ryan, 1992). These inventories are ongoing efforts to identify and rank outstanding examples of natural communities, rare or endangered species habitat, and other significant features. The most outstanding of the identified features are subsequently entered in the MDC Natural Heritage Database. A summary of identified aquatic features was prepared for this inventory and assessment (Table 22). The lack of high quality bottomland forest in the watershed is evident. Only one site was classified as "Significant" and four were classified as "Notable". Nine proposed bottomland forests were rejected due to recent logging or overgrazing. Only one wetland feature, a small pond shrub swamp, was identified as "Significant". No wetlands were considered "Exceptional", and six sloughs were considered "Notable".

Ninety miles of known range was designated as "critical habitat" for the Niangua darter, *Etheostoma nianguae*, when it was listed as a federally threatened species in 1985 (Pflieger, 1989c). The designated critical habitat did not include all of the known range at the time, and its range has been extended by new observations since 1985. The Niangua watershed includes 85 of the 226 miles of current known range for the darter. There are only eight known populations of Niangua darters, all within the northwestern Ozarks. Two of these populations are within the Niangua Watershed, one in the upper NR and the other in the LNR. The Niangua darter typically inhabits medium-sized streams with moderate gradients and clean gravel/rubble substrates. Within the NR, darters have been observed in the main stem and in Greasy Creek. In the LNR, they have been observed in the main stem, Thomas Creek, Cahoochie Creek, and Starks Creek. Reservoir construction, sedimentation, nitrification, and introduction of non-native species are perceived to be the greatest threats to the Niangua darter (Pflieger, 1989c). Recovery efforts have emphasized habitat restoration and preservation as the best means of saving this species in the Niangua Watershed and throughout its range. These efforts have included public education, cost share programs to control streambank erosion and nutrient runoff, thorough review of proposed Section 404 permits, and acquisition or easements for stream frontage in critical areas. A condition prohibiting excavation during the spawning season, March 15 through June 15, is included in all general permits issued in Niangua darter range. In the past three years, several stream improvement projects have been completed in Niangua darter habitat; donated and purchased stream frontage has been added to the Mule Shoe CA; and a protective easement has been obtained opposite the Mule Shoe CA.

Large springs provide cold-water habitat on 15.5 miles of streams in the Niangua Watershed. Two miles of Bennett Spring Branch; 6.0 miles of the NR; and 1.5 miles of Mill Creek are classified as cold-water fisheries (Table 14). Approximately 12 miles of the NR support trout populations, and trout are occasionally observed at Charity CA. Water temperature was

monitored in the NR in 1994, 1995, and 1996 to determine maximum temperatures attained. In 1994, four sites between 6.6 miles (SM 72.5) and 9.2 miles downstream from Bennett Spring Branch were monitored. The maximum temperatures recorded between July 22 and August 23 ranged from 70.0EF at the most upstream site to 72.0EF at the most downstream site. Two sites were monitored in 1995 between August 18 and November 8. The highest temperature recorded at SM 75.1 was 72.6E and at SM 77.3 it was 74.0EF. The data from 1996 was not available at this printing. In 1990, monitors were placed at three locations in the vicinity of Charity CA to access the site for the possible introduction of trout. The monitors were checked weekly to determine the maximum and minimum temperatures recorded between July 2 and August 20. The maximum recorded at the most upstream station (SM 111.5) was 85 °F and temperatures in the upper 70s were recorded at the downstream sites (SM 114.2 and SM 115.1). Since summer temperatures were marginal for trout and because the Niangua darter, an endangered species, could be found near this site, the area is managed for native species. On LOZ, Ha Ha Tonka Spring provides a plume of cool water in the Niangua Arm that attracts striped bass and hybrid striped bass.

There are numerous shallow, fishless ponds on public lands that offer otherwise scarce habitat for amphibians, and also provide wildlife watering. Many amphibians require such ponds for successful reproduction. Fishless ponds on public lands include: two ponds on the Niangua CA in Webster County; one at the Gale CA; 17 ponds at Muleshoe CA in Hickory County completed, and 21 ponds at Lead Mine CA.

Lake of the Ozarks Habitat

The upper parts of the Niangua and Little Niangua arms of LOZ are stream-like in nature with well-defined channels, continuous current, and pool-riffle sequences when the lake is at or below normal level (660 feet). These areas contain a much greater amount of large woody cover than do areas further downstream. This stream character rather abruptly changes to a delta-like area which is characterized by a poorly-defined channel and sluggish current. These areas are typically wide and shallow, and contain a fair amount of woody structure. They are greatly affected by elevational changes in LOZ with a high percentage exposed during winter drawdown. Areas downstream from the deltas can be considered typical "lake" habitat. Main channel depth ranges from eight to ten feet upstream to 40-50 feet at the junction of the Niangua and Little Niangua. The majority of banks in this area are steeply sloping and covered with coarse gravel or chunk rock. Several vertical rock bluffs are present. In recent years, water level fluctuations have ranged from six to eight feet. At the lower levels the shallow back ends of most coves are exposed. The majority of the standing timber was removed from the LOZ watershed prior to impoundment, so a great deal of woody structure (brush piles) has been added by anglers. The brush piles are composed of cedars or hardwood branches that are typically anchored in place with rocks or cinder blocks. In some areas, trees near the shore have been cut and allowed to fall into the water. Some of the trees in LOZ wash in from tributaries or fall into the water along the shore.

Stream Habitat Assessment

Following Bovee (1982), sites were selected by fisheries management staff for stream habitat assessment in the Niangua Watershed (Table 28, Figure 21). Assessments were completed between August 1990 and September 1991 and are summarized below. Complete habitat summaries for the NR main stem, LNR, and Jakes Creek are also provided in Appendix F.

Streambank erosion was a problem in all streams sampled in the Niangua Watershed. There were no clear differences in the pattern of bank erosion between upstream or downstream reaches. Stream reaches with the most extensive bank erosion problems were usually areas with little or no wooded riparian zone and poorly vegetated banks. Areas bordering riparian zones with little or no woody vegetation were usually pasture. Cattle grazing was evident at many survey sites, and in grazed riparian zones the woody vegetation was usually limited to mature trees with little undergrowth. In stream fish cover in pools consisted mainly of snag habitat such as rootwads and logs. Woody cover was limited along those reaches where there was little or no riparian zone present. Boulders were present in most of the NR mainstream sites and many of the downstream LNR sites. Riffle areas offered cobble and boulders, as well as water willow, as primary cover types. Undercut banks, including overhanging bedrock shelves, were present at some sites and appeared to be providing quality fish habitat. Stream depths in pools were rated fair at almost all habitat sampling sites. Increased depth associated with snags and boulders was documented at several sites. However, at many sites pool depth appeared to be lacking due to a heavy gravel bedload. The maximum depth at most sites was six feet or less.

Gravel and cobble were the predominant substrate at all sample sites. Cobble was predominant in riffle areas. Little silt or other fine substrate was found, and when it did occur, it was usually in a strip near the bank, in pools, or in backwater areas. Streambeds were unstable and uniform along areas associated with in stream activities such as gravel excavation. Only two sampling sites showed any sign of channel alterations, both were old mill dams. Gravel excavation was not evident at any of the 35 sampling sites, although gravel excavation is known to occur throughout the Niangua Watershed.

Most stream habitat sampling sites had no apparent water quality problems. At sites where overgrazing was evident water clarity was poor and an abundance of algae was noted. In general, water was clear with limited algae during the sampling period as might be expected from Ozark border streams. NR sites within a few miles downstream from Buffalo exhibited a milky turbidity that may be attributed to runoff from a limestone quarry within 0.5 miles of the river.

Habitat Improvement Projects on Public Lands

Several stream improvement projects have been completed on public lands to treat erosion problems and improve fish habitat (Table 23, Figure 22). These visible projects promote environmentally sound stream management practices as part of the MDC Streams for the Future goals. In April 1990, 13 boulders were installed to improve fish habitat in Bennett Spring Branch, approximately 0.25 miles downstream from Bennett Spring, within Bennett Spring State Park in Dallas County. A single boulder was installed along with two clusters of three boulders and one cluster of six boulders. The boulders (three to four feet in diameter) were placed in a reach approximately 200 feet long using a dragline. The smoothest surface of each boulder was pointed upstream. The clusters were set in a "Y" configuration with the point facing upstream. Boulders in the clusters were spaced from two to six feet apart. To avoid causing streambank erosion, a minimum of six feet was maintained between the boulders and the nearest streambank. The main purpose of the boulder installations was to enhance trout habitat by providing in stream cover and diversifying water depths and velocities in the reach. Other objectives of this project included: evaluating boulders as a habitat enhancement practice for use in cold-water and warm-water streams; diversifying angling opportunities in the area; discouraging future bedload deposition in the reach during high flow events; and reducing the frequency and extent of dredging required in this reach. Inspections in August 1994 revealed that most installations were

performing the desired functions although a few boulders had been undercut by scouring or covered by gravel deposition to the extent that they were ineffective. In March 1995, a 120-foot cedar tree revetment, and two gully plugs were installed in Bennett Spring Branch within the State Park in Laclede County. The revetment was installed in Zone 3, approximately 1.0 miles downstream from Bennett Spring. A single row of 15- to 20-foot cedar trees were anchored at the toe of the bank to slow streambank erosion and allow woody vegetation to become established on the bank. Cedar trees were also anchored in two gullies adjacent to the revetment. Gully plugs help control down cutting and create sediment deposition by decreasing velocity. The vegetated riparian zone will also be improved by moving a parking lot and planting trees. Future projects proposed in the Stream Management Plan include the installation of gravel traps in Bennett Spring Branch, upstream from Bennett Spring. These will help catch excess bedload before it reaches the park, thereby reducing the need for periodic gravel removal to maintain trout habitat and diversify angling opportunities.

In June 1991, five cedar tree revetments totaling 495 feet, and a 50 foot-long rock rip-rap revetment were completed on Jakes Creek within MDC's Lead Mine Conservation Area in Dallas County. Each cedar tree revetment consisted of a single row of 15- to 20-foot cedar trees anchored at the toe of the bank to slow streambank erosion and allow woody vegetation to become established on the bank. Rip-rap was placed on a 2:1 slope to stop erosion and allow woody vegetation to become established on the bank.

These installations are performing satisfactory with minor maintenance and provide demonstration areas promoting stream enhancement practices related to the MDC's Streams For The Future Program. The width of vegetated riparian zones in the area has been increased to at least 100 feet to provide root systems that will ultimately hold the streambanks and provide long-term streambank stability.

Streambank stability will continue to be monitored on state lands. Appropriate streambank stabilization techniques, including cedar tree revetments, rip-rap, log barbs, rock barbs, willow staking, riparian zone expansion, and tree planting, will be used to control future erosion problems as necessary.

Habitat Improvement Projects on Private Lands

MDC assistance to stream side landowners within the Niangua Watershed has included: technical assistance; Technical Assistance With Cost Share, a three year (1991-1993) pilot program; Equipment Loan Projects; Landowner Cooperative Projects (LCPs); an Upper Niangua Demo-Farm Project; Partners for Wildlife (PFW) projects, a joint project between the MDC and USFWS in Niangua darter habitat; and the Streams for the Future Landowner Incentive Program. These programs and thirteen projects initiated within the watershed (Table 30; Figure 22) are described in the following sections.

The first private landowner stream contact in the Niangua Watershed was made in June 1989. Since that time numerous contacts have been made with stream-side landowners in the watershed. As of February 1997, 68 landowner contacts have been made with onsite visits culminating in site-specific recommendations. The vast majority (90%) of the contacts were initiated due to concerns about bank erosion. Other contacts have included developing Alternative Watering Systems (AWS) (6%), creating trout habitat (3%), and addressing flooding problems (1%).

The leading cause of bank erosion on private lands in the watershed has been the loss of quality riparian zones. The most common recommendations to landowners have included: establish and

maintain riparian zones (typically 100 feet wide); exclude livestock from riparian zones and the stream channel; and revegetate stream banks. In a few cases when conditions were favorable, cedar tree revetments were recommended to protect banks until woody vegetation was established.

Technical Assistance Projects

Technical assistance was provided for three projects that landowners completed with their own resources (sites H007, H008, H010; Table 30). At least one landowner completed a stream improvement project without agency assistance - bank back sloping and revegetation (site H009). It is likely that there are other similar projects that remain undocumented.

Technical Assistance With Cost Share Projects

Technical Assistance With Cost Share was a cooperative pilot program between the MDC and the MDNR. It was an incentive program designed to determine if landowners would install stream improvement structures when provided appropriate financial incentives. The goal was to offer a financial incentive to create stable, healthy stream channels and stream riparian zones to benefit all Missourians.

Dallas County was one of six counties in the state to offer the program for three years (1991-1993). During the three years, 132 stream-side landowners were contacted by either direct mailing or telephone calls, to increase awareness and offer assistance through this program. Seventy of the landowners were located along the NR, 61 on the LNR, and one on Dousinbury Creek. Five of the seven landowners that responded applied for the program, and three actually signed agreements to implement the recommended practices (sites H001-H003; Table 30). All three participating landowners are located within federally designated critical habitat of the Niangua darter on the NR. Collectively, 2.7 miles of stream were directly protected by the improvement practices. In addition, as a result of the mailing, 0.25 miles of stream frontage was acquired on the LNR (Mule Shoe CA) to protect Niangua darter habitat. The pilot program provided experience necessary for formulating the statewide incentive program which was initiated in October 1996.

Equipment Loan Projects

Equipment Loan Projects were available to landowners needing specialized equipment to implement recommended stream improvement practices. One landowner within the Niangua Watershed participated with Equipment Loan assistance (site H006; Table 30). The project also included volunteer help by a local Stream Team (ST #313) to plant a 100 foot-wide, and 1,080 foot-long riparian zone along the LNR.

Landowner Cooperative Projects (LCPs)

LCPs are stream improvement projects that are jointly installed by the MDC and private landowners and are available statewide. The goal of LCPs is to create demonstrations of stream improvement practices that encourage stable, healthy stream channels and stream riparian zones, and are available for viewing by agricultural agencies, other landowners and educational groups. Two landowners, within the Niangua Watershed have participated in LCPs (sites H004 and H005; Table 30). Both projects have included the installation of cedar tree revetments, livestock exclusion and revegetation of riparian zones, and one included the installation of a solar watering system for cattle.

Partners for Wildlife Projects

In Fall 1995, the MDC and the USFWS entered into a cooperative agreement that included the Partners for Wildlife (PFW) Project. Through the project, cost share incentives are available for eligible practices in Niangua darter range, including livestock exclusion, planting or revegetation of riparian zones, and alternative watering sources for livestock. By March 1997, two such projects (H011 and H012) had been completed, an additional agreement had been recently signed, and a fourth agreement was being negotiated.

Upper Niangua Demo-Farm Projects

Five farms in the Upper Niangua Watershed were picked to demonstrate good land stewardship practices. Four of the farms do not include stream frontage, so MDC assistance was not provided. The largest Demo-Farm (H013) included MDC and NRCS (DSP3 incentives) assistance to install a Management Intensive Grazing (MIG) system. The project included the installation of: 7,300 feet of fencing for livestock exclusion and establishment of a riparian zone (18 acres); a well using existing utilities; 9,650 feet of pipeline; nine hydrants; and eight frost-free water tanks. The project will protect 0.6 miles of the Niangua River within Niangua darter critical habitat and 0.8 miles (both sides) of an unnamed tributary.

Streams for the Future Landowner Incentive Program

A comprehensive statewide MDC incentive program was initiated in July 1996 to help landowners install stream improvement practices. The program consists of three parts. Stream Watershed Restoration Projects (SWRP) are available in targeted watersheds selected by fisheries management personnel, often including SALT or EARTH project areas. These projects may include incentives for setting aside riparian management zones; small wetland development; alternative watering systems; and stream restoration such as tree or rock revetments, grade control structures, habitat structures, rock or log barbs, and back sloping. Alternative Watering Sources for Planned Grazing Systems (PGS) are available in any county offering SWCD DSP3 incentives, and can include pond construction and reconditioning, solar water systems, hydraulic ram pumps, and conventional wells, as well as fencing for livestock exclusion. Stream Stewardship Agreements (SSA) can provide yearly payments for ten years for perpetual easements that protect good quality stream corridors. Initial landowner and agency participation in these incentives, especially the PGS incentive, suggests that this program will be popular in the Niangua Watershed.

Tunnel Dam Habitat Improvement

Habitat in the bypass loop below Tunnel Dam and in Lake Niangua has been improved by new requirements included in the 1994 FERC relicensing agreement. Sho-Me Power Corporation is required, except during emergencies, to maintain a minimum flow of 60 cfs during the spring spawning season and 40 cfs the balance of the year. The utility is also required to limit draw down of the lake level to 0.5 feet to avoid low dissolved oxygen conditions.

Table 22. Summary of Natural Features Inventories within a Niangua Watershed

Significant aquatic features	
Streams with Niangua darter habitat (Niangua River, Little Niangua River, Starks Creek, Thomas Creek, Cahochie Creek)	5
Gray bat roosts	5
Springs (Bennett Spring, Ha Ha Tonka Spring)	2
Mesic Bottomland Forest	1
Great blue heron rookery	1
Pond shrub swamp	1
TOTAL	15
Exceptional aquatic features	
Great blue heron rookeries	4
Springs and spring branches	3
Streams with Niangua darter habitat (Greasy Creek)	1
TOTAL	8
Notable aquatic features	
Sloughs	6
Great blue heron rookeries	5
Springs and spring branches	4
Mesic bottomland forests	4
Waterfalls	1
Caves	1
TOTAL	21

Significant features= Biologic or geologic element of such high-quality size and/or rarity that it is of statewide importance

Exceptional features= High-quality natural communities, extant rare species sites, or other special features which increase the preservation value of an area, but are of regional rather than statewide importance.

Notable features= Sites of local interest only, and by themselves are not targeted for preservation.

Figure 21. SHAD survey sites within the Niangua River Watershed.

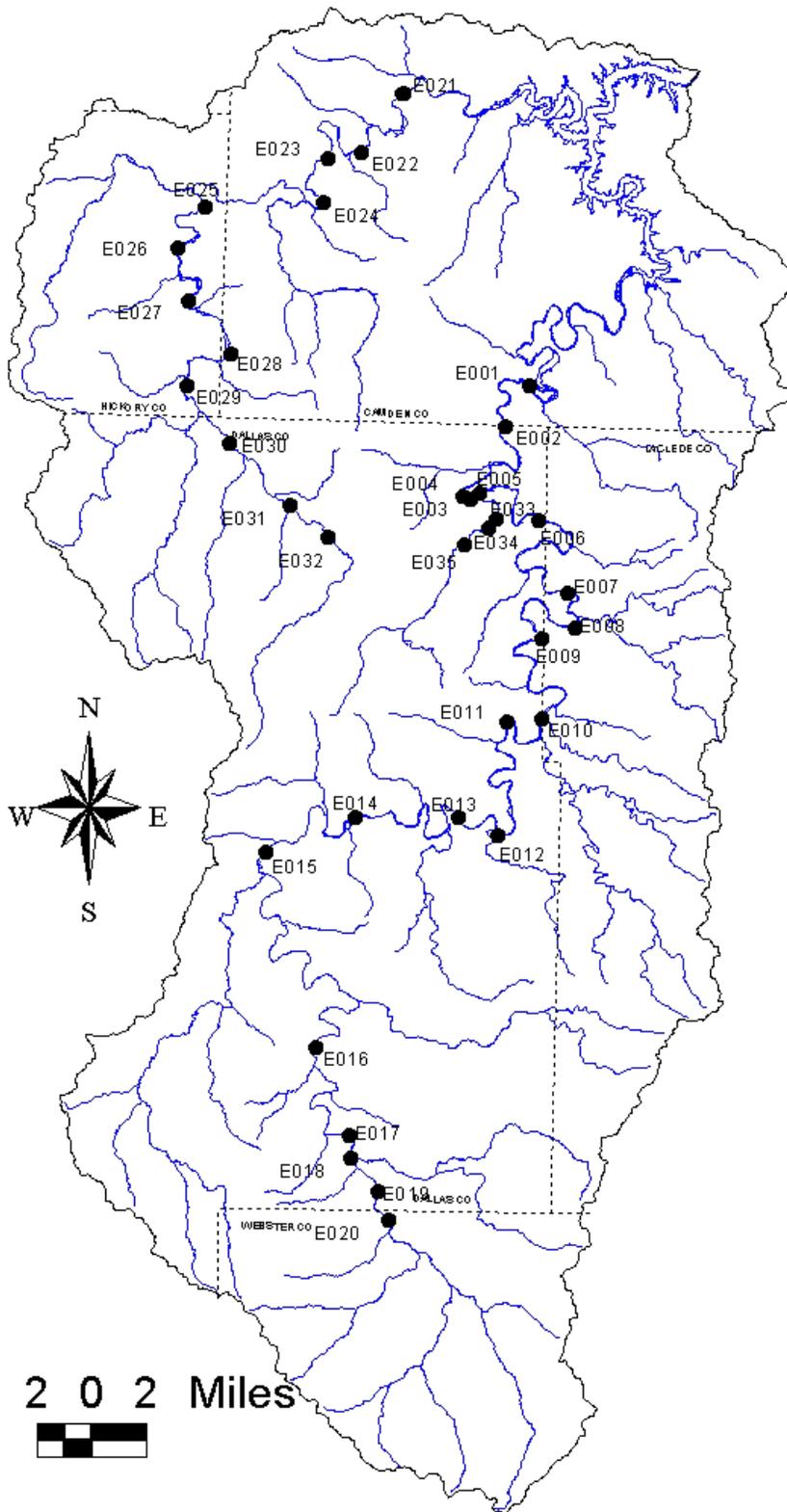


Figure 22. Stream improvement projects on public and private land within the Niangua River Watershed.

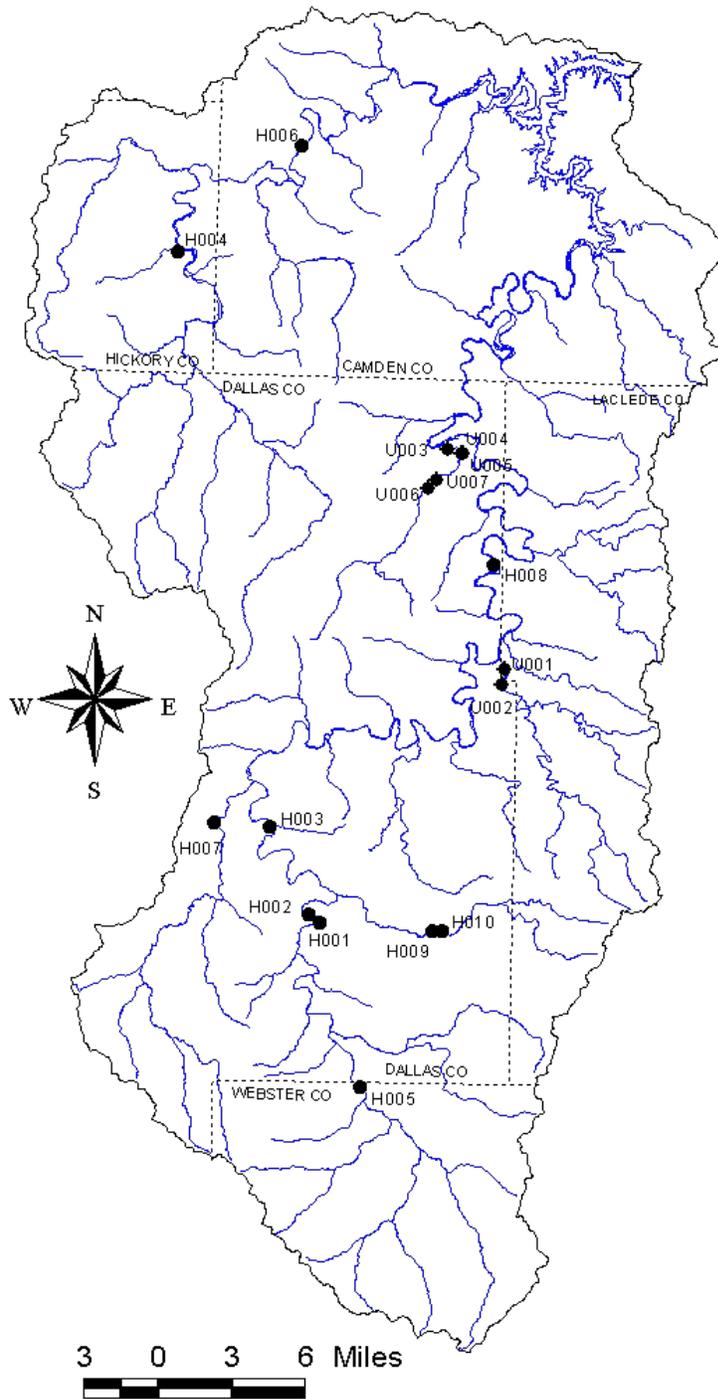


Table 23. Stream improvement projects on public lands within the Niangua Watershed.

Site	Date	Stream	Twp	Rng	Sec	Practices	Miles Affected
U001	3/8/95	Bennett Spring Branch	35	17	31	Revetment and 2 gully plugs	0.05
U001	4/9/90	Bennett Spring Branch	34	18	1	Boulder placement	0.05
U003	6/21/91	Jakes Creek	36	18	15	Cedar tree revetment Rip-rap	*
U004	06/21/91	Jakes Creek	36	18	14	Cedar tree revetment	*
U005	6/21/91	Jakes Creek	36	18	15	Cedar tree revetment	*
U006	6/21/91	Jakes Creek	36	18	22	Cedar tree revetment	*
U007	06/21/91	Jakes Creek	36	18	28	Cedar tree revetment	*

*0.1 total for five revetments

Biotic Community

Fish Communities

Ninety-nine species of fish have been recorded in the Niangua Watershed (Table 24). Diverse aquatic habitats, good water quality, sustained base flows, and stable lake levels support diverse fish communities composed mostly of species associated with the Ozark faunal region (Pflieger, 1989a), but including some riverine species in LOZ. The watershed is well known for the varied fishing opportunities it offers; from stream fishing for smallmouth bass, rock bass, rainbow and brown trout, and suckers, to reservoir fishing for largemouth and spotted bass, crappie, catfish, white bass, paddlefish, and walleye.

Fish populations within the Niangua Watershed have been sampled from four different perspectives including: fish community sampling; snorkeling for Niangua darters; sport fish sampling; and angler surveys. Two fish community samples have been conducted on the LOZ portion of the watershed, and community samples obtained during black bass and crappie sampling. Species lists were completed for many of the Niangua darter samples to obtain faunal index values as described by Pflieger (1978). These were considered limited community samples, because snorkeling in pools were limited by visibility, and the number of individuals was not recorded.

Stream Community Sampling

Fish communities have been sampled at 58 stream sites in the Niangua Watershed (Table 32; Figure 23). The most extensive community sampling of streams throughout the watershed (19 sites) was conducted by Pflieger (MDC) as part of a statewide survey in 1975-1977. Earlier, less comprehensive surveys were conducted by Salyer in the early 1930s and Harry in the 1940s. A thorough survey of the Upper Niangua Subwatershed was conducted by Smale (UMC) for the Upper Niangua Animal Waste Project (UNAWP) between 1991 and 1995. Twenty-three sites were sampled, most, every year for five years. A private contractor, Environmental Science and Engineering (ESE), sampled six sites in the vicinity of Lake Niangua three times in 1989 and 1990 for Tunnel Dam relicensing. All community samples were analyzed to determine species distribution, relative abundance, and occurrence rates. The watershed was partitioned into three subwatersheds of approximately equal area for comparison. The Upper Niangua Subwatershed includes the main stem and tributaries upstream from the mouth of Bennett Spring Branch and the branch itself. The confluence of Bennett Spring Branch was chosen as a dividing point between subwatersheds because it doubles the flow of the NR and creates cold-water conditions for approximately 12 miles downstream. The Lower Niangua Subwatershed includes the main stem and all tributaries downstream from Bennett Spring Branch. The Little Niangua Subwatershed includes the LNR and its tributaries. Stream habitat on the LNR is isolated from that on the NR by LOZ. The lower NR is a sixth order stream for most of the subwatershed. The NR is fifth order in the Upper Niangua Subwatershed and the LNR is fifth order in its subwatershed. Summary data on relative abundance (percent of the total number of individuals) and rates of occurrence (percent of sites) for the subwatersheds and entire watershed are shown in Appendix H. The most abundant fish in the entire watershed was the central stoneroller (22%) with the bleeding shiner a close second (19%). The Ozark minnow, bluntnose minnow, and rainbow darter each comprised about 5% of the community samples. The central stoneroller was most abundant in the Upper Niangua (29%), and much less abundant in the Lower Niangua

(2%), and Little Niangua (3%). The bleeding shiner was the most abundant fish in the Little Niangua (23%) and Lower Niangua (10%), and the second most abundant in the Upper Niangua (22%).

The communities in the Upper Niangua and the Little Niangua Subwatersheds were very similar (Table 33). The four most abundant fish in the Upper Niangua were also most abundant in the Little Niangua, although in different order. Six species appear in the top ten for both subwatersheds. The Lower Niangua community was quite different than the other two subwatersheds sharing only three species of the top ten with the Upper Niangua and three with the Little Niangua (Table 25). The fish community is also more diverse in the Lower Niangua. The five most abundant species comprise 35% of the community while the five most abundant in the other subwatersheds comprise over 65% of the communities. Eighty different species were collected in the Lower Niangua, 67 in the upper Niangua, and 58 in the Little Niangua. Relatively high numbers of species (41-50) were collected at the six ESE sites near Lake Niangua. This high diversity could be attributed to a combination of three factors:

- (1) Exceptionally thorough sampling was conducted - including kick and drag seining, electrofishing, trapnetting, and gillnetting;
- (2) Three samples were grouped for these analyses (August 1989, Sept 1989, and June 1990);
- (3) The area's downstream position in the watershed (SM 29) and its habitat diversity, including lentic and lotic habitat, are expected to result in greater fish diversity.

Pflieger's (1989a) designations for ecological guilds were evaluated to further describe stream samples in the watershed and subwatersheds (Table 26). Sixty-four percent of the total number of fish collected in stream community samples were nektonic species. The relative abundance of the three guilds were similar in the Upper Niangua and Little Niangua subwatersheds with nektonic species comprising roughly two-thirds of the community. The community was quite different in the Lower Niangua Subwatershed where 55% of the community consisted of large species, 38% nektonic, and only 8% benthic.

Pflieger designated 43 Missouri fish species as "intolerant" meaning they were the first species likely to be affected by stream degradation (Norman, 1994). Nineteen (22%) of the species collected in watershed streams are so designated (Table 26). In the entire watershed, 17% of the total number of fish collected were intolerant species. The relative abundance of intolerant fish collected in the Lower Niangua Subwatershed was high compared to those of the other two subwatersheds (31% vs 13% and 10%). This might be expected in any watershed due to the more stable and diverse habitat normally found in downstream sections with greater streamflow. In addition, the Lower Niangua Subwatershed includes Lake Niangua and LOZ which also provides relatively stable and diverse habitat.

As shown in Table 35, no single intolerant species comprised more than 7.6% of the community in any subwatershed. However, watershed wide, seven species occurred at more than 50% of the sites. The percentage of intolerant species was determined for all community samples (Appendix I). Although no quantitative measure of habitat degradation was available, relatively low percentages of intolerant species at several sites may indicate some correlation with degraded habitat. Most of the samples with values less than 20 percent were located on streams which are generally believed to be degraded, including the East Fork, the West Fork, Dousinbury Creek, and Greasy Creek. These data suggest that the percentage of intolerant species at a given site may be inversely correlated with habitat degradation, such as high temperature, low dissolved oxygen, nitrification, or sedimentation. Further analysis, including statistical methods, is necessary to determine whether this index has potential for monitoring streams.

LOZ Community Sampling

Most of the fish sampling on the Niangua Arm LOZ has targeted sportfish for management purposes, including black bass, white bass, and crappie. Community samples were obtained by Borges in 1947 and Dent in 1977 using rotenone and gill nets in coves (Table 36). In Borges' samples, numbers of individuals were not recorded and some species were lumped together (i.e. redhorse spp.). Some estimation of the LOZ community has been provided by records of the bycatch obtained during electrofishing surveys for largemouth bass and trapnetting for crappie at the sites listed in Table 37.

These data are lumped together for five year periods including 1985-1989 and 1990-1994 (Table 36). The electrofishing surveys were conducted during the spring at sites B101-B109, and the trap netting during the fall at sites C001-C018 (Table 37, Figure 24). Additional data has been obtained from angler surveys conducted from 1970 to date. Several species were not reported in any MDC samples since 1947 (Borges, 1950) including: paddlefish, goldeye, mooneye, emerald shiner, bluntnose minnow, northern studfish, blackstripe topminnow, and orangespotted sunfish. However, paddlefish are commonly caught by anglers, and goldeye and mooneye were reported in angler surveys.

Fish species of the large ecological guild dominated all samples (Table 36). This was probably due largely to the bias of the sampling methods and management objectives. Electrofishing yielded one nektonic species (brook silverside) and one benthic species (Ozark logperch). Borges' methods (rotenone and gill nets) yielded five additional nektonic species (emerald shiner, bluntnose minnow, northern studfish, and blackstripe topminnow), as well as brook silversides. No nektonic species were collected in Dent's rotenone samples, but one benthic species (Ozark logperch) was recorded.

Species characteristic of the four faunal regions in Missouri are indicated in Table 36. Seven species among the collections are characteristic of the Ozark Faunal Region and three of the River Faunal Region. Seven Ozark species were collected in numerous locations throughout the watershed. No species characteristic of the Prairie or Lowland faunal regions were recorded in these LOZ samples.

Ten intolerant species were collected in the LOZ samples (Table 36). Mooneye were only recorded in the 1947 survey, but were still occasionally reported by anglers until the mid-1970s in LOZ angler surveys.

Two other intolerant species, paddlefish and walleye are fairly common in the lake, but probably have limited spawning success because Truman Dam blocks their spawning migration. They are both cultured at MDC hatcheries for periodic stocking in LOZ, paddlefish annually and walleye biannually. Brook silverside are very common, and Ozark logperch are fairly common.

Smallmouth bass are collected infrequently in LOZ. Golden and shorthead redhorse suckers are common in LOZ, while black, silver, and river redhorse suckers and northern hognose suckers are collected infrequently by electrofishing and trapnetting (Greg Stoner (MDC), pers. comm.). In years with adequate flows, white bass, hybrid striped bass, paddlefish, and walleye make spawning migrations out of LOZ into the NR bypass reach, sometimes as far as Tunnel Dam. MDC Conservation Agents have reported that, historically, large numbers of fish including walleye and white bass congregated below the dam in the spring when discharge from the turbines were discontinued during large portions of the day and flows over the dam were substantial (Ed Webb (MDC retired), pers. comm.). White bass normally spawn in concentrated areas considerably downstream from the dam (Mike Colvin (MDC), pers. comm.), but have been observed spawning within 2.0 miles of the dam (Bob Schulz (MDC), pers. obs.). Tunnel Dam

provides a physical barrier to fish and it is unlikely that fish migrating upstream are able to proceed beyond the dam. Although walleye may spawn successfully below the dam in some years, it is unlikely that suitable habitat paddlefish spawning.

Angler Surveys

Roving angler surveys have been conducted on the Niangua Arm from 1951-1954, in 1956, and every year since 1967. Samples have been conducted from SM 7 to SM 15 on 11-13 days per month between March and November. All species are recorded, and the results have been used to evaluate recreational use including angling effort and catch rates. Some species that have not otherwise been collected in the watershed, were recorded in these surveys. Additional angler surveys have been conducted during April and May between SM 17 and SM 20 on the Niangua Arm. The primary objective of these surveys has been to evaluate white bass catches, but all species were recorded. For further information, consult The Lake of the Ozarks Management Plan (Stoner, 1999).

Sportfish Sampling on the Niangua River

Funk and Fleener (1966) sampled the NR between 1951 and 1962 to evaluate the impact of a closed season for smallmouth bass between December 1 and May 30. The harvest was greater during the closed season trial period (1951-1956). They attributed this to a strong 1952 year-class, and fishing pressure was too light in later years to gauge the full effect of the year-round open season. They reported that growth of smallmouth bass in the NR was near the statewide average for headwater streams.

Cool-water species were sampled in the summer of 1996 at three sites on the NR by electrofishing. At HiCo Ford (SM 106) a high density of small smallmouth bass was observed (catch rate (CR) \$ 7 inches was 23/hr; PSD(12)=3). Only 3 largemouth bass and one spotted bass \$ 8 inches were sampled. A low density rock bass population was observed (CR (\$4")=3.5/hr). Williams Ford CA (SM 93) had a medium-density smallmouth population (CR (\$7")=8/hr). A low-density rock bass population of mostly small fish (5-6") was present. The Lead Mine CA site (SM 42) exhibited a medium-density smallmouth population (CR (\$7")=6.6/hr; PSD(12)=32). The Lead Mine area also supports a medium-density rock bass population (CR (\$4")=18/hr; PSD(7)=47). The Lead Mine results are similar to those obtained by Legler in 1985. Trout have been sampled by electrofishing on the NR in 1986, 1990, 1993, 1995, and 1996. Data for three samples in 1995 and 1996 are presented in Table 38. Approximately 11 miles of the NR was sampled between Bennett Spring Branch and Prosperine CA. Fall sampling (1996) produced the greatest catch per unit effort (CPUE) for both species. Prior to 1995, brown trout were stocked when available to increase angling diversity in Bennett Spring and occasionally the Niangua River. The first major brown trout stocking of the Niangua River occurred in 1995.

Rare, Threatened, and Endangered Species

Eleven Niangua Watershed fish have been classified as state or federally rare or endangered (Table 28). The most notable of these is the Niangua darter which was so named when it was first discovered at the type locale (NR, SM 118.7) in 1884 (Pflieger, 1978). The Niangua darter is the only federally listed, threatened fish species in the watershed, and two of the eight extant populations are in the watershed (NR and LNR). It was assigned federal protection in 1985 under the Endangered Species Act; the recovery plan was approved in July 1989 (Pflieger, 1989c); and

the federal Niangua Darter Recovery Team was appointed in 1991. The species will be considered recovered when two criteria are met:

1. Eight known populations must be made secure by reducing existing and potential threats to the greatest extent possible and population size is stable or increasing.
2. Viable populations have been discovered or established in four additional stream drainages (Pflieger, 1989c).

Thirty-one sites within the Niangua Watershed have been sampled specifically for Niangua darters, including many sites established for monitoring Niangua darter distribution and population status. Pflieger sampled 16 of these sites between 1975 and 1976, many more than once. Based on these samples and numerous collections in other watersheds, Pflieger (1978) produced the definitive study on Niangua darter life history and status. Very limited sampling was conducted in the 1980s. Pflieger sampled one site (NR) and Charles Taber (SMSU) sampled one site (NR) on numerous occasions between 1976 and 1989. Regional fisheries personnel have sampled numerous sites within the watershed by snorkeling, including three sites in 1991, 13 in 1992, six in 1993, 11 in 1994, and two each in 1995 and 1996. The main objective of most of these samples was to document presence or absence, or to observe spawning behavior. Pflieger sampled three sites in the Niangua Watershed during a cursory survey of Niangua darter status in April 1992. Hayden Mattingly (UMC) surveyed numerous sites on the LNR between 1994 and 1996 as part of an MDC funded research project to investigate Niangua darter habitat preferences and reproductive behavior. Population densities, microhabitat use, and several physical habitat variables were documented. Limited data for several samples at five sites have been included in analyses for this inventory and assessment.

All of the known Niangua darter range on the NR is included within the Upper Niangua Subwatershed. The Smale survey for the UNAWP (1991-1995) included the entire range of known Niangua darter habitat on the NR. Sampling was completed at 23 sites, many once per year, for a total of 64 samples. No Niangua darters were collected during the five years of sampling, despite the fact that four of the sites had previously yielded darters and several sites were located between sites where Niangua darters were found. The data suggest that the LNR Niangua darter population is probably stable while the NR population may be declining. However, sampling on the NR was limited in 1995 and 1996, and sampling results between 1991 and 1994 were inconclusive. In 1994, observations at two sites extended the known range on Greasy Creek by 6 miles, however, only one darter was observed at each site, and habitat on Greasy Creek is considered poor. There is also reason for concern about the NR population because two previously occupied sites have failed to yield darters in recent years and no darters were found in the Smale survey. The LNR population has probably been one of the largest and stable of the eight extant populations. There is some need for concern though, because the population at the most frequently sampled site declined dramatically after a flood in April 1995 and continued to be depressed in 1996.

Pflieger also expressed concern about the LNR population based on cursory sampling in 1992 (William Pflieger (MDC), pers. comm.).

Habitat requirements and distribution for the Niangua darter and the other fish in Table 28 are described by Pflieger (1978). Five fish have Missouri distributions confined to the Ozarks (mottled sculpin, least darter, Niangua darter, and bluestripe darter). Two are only found in Missouri (Niangua darter, bluestripe darter). Six are limited to small or medium sized streams (blacknose shiner, plains topminnow, mottled sculpin, least darter, Niangua darter, and bluestripe darter). This concurs with a study of threatened and endangered fish of the United States that found a high proportion of the species were stream fish and that darters were among the most

vulnerable (Williams et al, 1989). Small streams are probably more susceptible to degradation, and darters, being less mobile than other fish, are probably less likely to escape. In Missouri, the paddlefish is distributed throughout the Missouri and Mississippi rivers, including some major tributaries, and the lower Osage River, including LOZ. Lake sturgeon are also found in the Missouri and Mississippi rivers. They occurred in the Osage River prior to construction of Bagnell Dam, and were recorded in Niangua Arm angler surveys in the early 1970s, but have probably been extirpated. Mooneye range is statewide, and the highfin carpsucker is most common in large Ozark reservoirs.

The current status of most of these listed species in the watershed is precarious. Lake sturgeon were observed in the Niangua Arm shortly after impoundment and several 33- to 55-inch fish were caught by fishermen in the Niangua Arm in the mid-1970s (LOZ Angler Survey). Paddlefish are still fairly common in the Niangua Arm (LOZ) due to MDC stocking (refer to Fish Stocking section). Mooneye were collected in Borges' sampling in 1947 and were reported in angler surveys as recently as 1988. The only recent observation (1989) of the highfin carpsucker was two individuals in Lake Niangua (ESE, 1991).

The plains topminnow was apparently extirpated from the watershed by 1971 (Pflieger, 1971) and has not been observed since. Mottled sculpins have been observed at two sites on the NR in recent years by snorkeling. They were fairly common at both sites. Niangua darter populations have been monitored closely, as discussed earlier, and appear to be fairly stable in the LNR and questionable in the NR. The bluestripe darter appears to be declining in the watershed. One was collected on the LNR in the 1950s, but none were detected at the same site in 1977. At one site on the NR, Pflieger collected seven darters in two samples in the 1970s, but Smale collected only one among four samples (1991-1994). At another NR site, Pflieger collected three in 1977, while Smale collected one in four samples (1991-1994). There have only been two snorkeling observations of the least darter in recent years but due to its small size and indistinct appearance, it is probably easily overlooked. Blacknose shiners were collected in Ha Ha Tonka Spring Branch in 1940 and have not been documented since. One southern cavefish was observed in Bennett Spring by Harry in 1940.

Several unlisted species have been rarely observed in the watershed. Borges collected emerald shiners in the mid-1940s in the Niangua Arm. Northern brook lampreys were observed by Pflieger in the 1950s and 1960s at two sites, by ESE in 1990 near Tunnel Dam, and in two unconfirmed snorkeling observations on Starks Creek in 1995 and 1996 (Bob Schulz (MDC), pers. obs.). Solitary blackstripe topminnows have been observed at two sites in the 1990s and suckermouth minnows at two sites in 1991 (Craig Fuller (MDC), pers. comm.).

Introduced and Exotic Species

A draft MDC policy provides guidelines for introducing aquatic species to waters of the state (MDC, 1996). Stocking guidelines are designed to protect native aquatic species and ecosystems from negative impacts through competition, disease introduction, and genetic introgression. Several exotic species, which are defined as those not native to Missouri, have been introduced to the Niangua Watershed. Rainbow trout were introduced to Mill Creek at the turn of the century and a naturally reproducing population persists. Muskellunge were introduced in 1967 and 1968, and the state record fish was caught in the Niangua Arm in 1981 (41 lbs., 2 oz.). Reports from anglers about catching bighead carp in LOZ have increased in recent years (Greg Stoner (MDC), pers. comm.). Grass carp have also been widely introduced in ponds and lakes for aquatic vegetation control, and probably occasionally escape to other waters. European rudd

were found at several bait shops in the LOZ area in the early 1990s, although there have been no reports of their presence in the lake.

Two exotic invertebrates were discovered in Missouri in 1992, the zebra mussel (*Dreissena polymorpha*) and the spined water flea (*Daphnia lumhotzi*) (Alan Buchanan (MDC), memo, 5/19/92). Zebra mussels have not been found in LOZ but spined water fleas have. Both species present threats to natural communities through unchecked competition. The zebra mussel can encrust and smother native mussels and deplete plankton and other suspended food sources that native mussels and other filter feeders rely on. They can also clog intake pipes for water supplies and cooling systems. The possible impacts of expanding populations of the spined water flea are unknown, but they may alter zooplankton and phytoplankton communities and their predator populations including young fish and filter feeders (John Havel (SMSU), pers. comm.).

Several species have been intentionally introduced in the Niangua River and in LOZ to provide added forage, supplement fish populations with poor reproductive success, and add variety to the number of sport fishes available to anglers. Fish stocking in watershed streams and in LOZ is summarized in Table 29. In 1931, a new fishery began in the watershed when trout fishing first opened in Bennett Springs State Park. As fishing pressure increased with the onset of this new fishery, fish were stocked to help balance the increased harvest and poor reproductive success of trout in these waters. The majority of fish stocked have been rainbow and brown trout. The MDC operates the cold-water fish hatchery in the state park and produces trout for the park and NR stocking. Each year, 11-13 inch rainbow trout (ave. = 12 inch) are stocked in Bennett Spring Branch, including 436,000 in 1995. Between 1981 and 1996, approximately 10,000 rainbow trout were stocked annually in the NR below the state park as much as 12 miles downstream. Prior to the initiation of the NR brown trout regulation in 1995, 2,090 brown trout were stocked between SM 56 and SM 65. In the spring of 1996, 7,500 brown trout were stocked between SM 54 and SM 62, and in the fall, 2,500.

Several fish species have been occasionally or periodically stocked in LOZ. Striped bass were introduced in 1967 and have been stocked periodically to provide a unique angling experience, and hybrid striped bass have been stocked since 1982. Threadfin shad were introduced in 1975 and were stocked periodically until 1983 to provide additional forage, but apparently have been unable to reproduce successfully. Spotted bass, which are native to the Bootheel and southeastern Ozarks, were probably introduced to the Osage Watershed prior to 1940 (Pflieger, 1975). Rock bass may also have been introduced to the upper Osage Watershed, since they were not collected in early surveys (Pflieger, 1975). Annual paddlefish stocking is necessary because migration to the only known spawning habitat for the LOZ population was blocked by Truman Dam in 1977. Most of the historic walleye spawning habitat was also blocked by Truman Dam, so periodic stocking is necessary. The Lake of the Ozarks Management Plan (Stoner, 1999) describes the following plans for future stocking: Paddlefish - annually; walleye and hybrid striped bass - alternate years; and striped bass every fifth year.

Aquatic Invertebrates

Invertebrates have been sampled at 44 sites within the watershed (Table 41, Figure 25), including 21 in the Upper Niangua, eight in the Lower Niangua, and five in the Little Niangua subwatersheds. The most thorough and extensive surveys were completed by Richard Duchrow (MDC) and Eric Nelson (UMC). Duchrow sampled six sites (Duchrow, 1984) distributed throughout the watershed in 1975 and 1976.

Nelson sampled 21 sites in the Upper Niangua Subwatershed for the UNAWP annually between 1991 and 1995. None of the Duchrow sites were sampled during the UNAWP. The taxa collected in these surveys are listed in Appendix J. In addition, Stream Teams have sampled at least twelve sites in the watershed, and two sites in the Upper Niangua were sampled annually from 1993 to 1995 as part of the long-term National Water Quality Assessment Program (NAWQA) by the USGS.

Table 30 lists all the known mussel species collected in the watershed. It includes those listed by Al Buchanan (pers. comm. 2/96) and others from Oesch (1984). Three are listed as rare in the state and two of those had been candidates for federal listing, until the method of listing was changed in 1996. This list portrays a diverse mussel community, however, the current status of mussels in the watershed is unknown due to lack of sampling. Mussels are considered sensitive indicators of water contamination (Cummings and Mayer, 1992). They filter large quantities of water to remove fine suspended sediment that may contain high levels of contaminants. They are also sensitive to streambed erosion and changes in substrate composition.

Pflieger collected three of the five crayfish species listed in Table 31 in the watershed (Pflieger, 1996). The *Cambarus* and *Procambarus* species are burrowing crayfish that may be found in flood plain burrows. Pflieger did not collect the burrowing species in his aquatic samples, but was confident they were in the watershed (pers. comm. 2/96). This is a surprising low number of species for a watershed with such a diverse aquatic fauna, however, the entire Osage River Watershed has a low diversity of crayfish (Pflieger, 1996). According to Pflieger, the northern crayfish has a wide distribution throughout Missouri and occurs in other states; the golden crayfish is widely distributed in the Ozarks; and the Salem cave crayfish is limited to the east central Ozarks. The Salem cave crayfish was reported from Ha Ha Tonka Spring, which is typical of its reported habitat (Pflieger, 1996).

Figure 23. Fish collection sites on streams within the Niangua River Watershed.

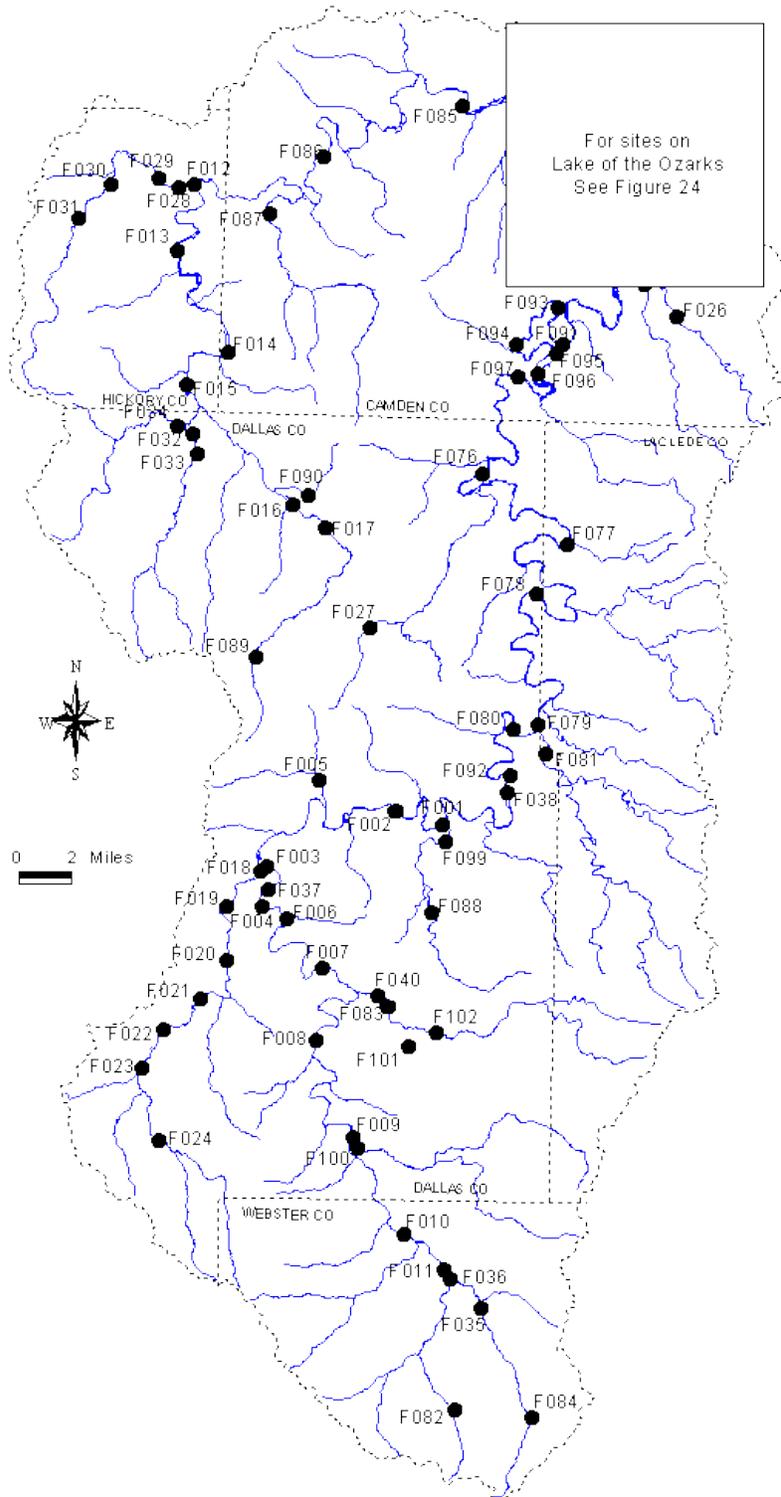


Table 24. Fish species collected within the Niangua Watershed.

Scientific Name	Common Name	Federal Status	State Status	State Rank	Global Rank
Lampreys					
Chestnut lamprey	<i>Ichthyomyzon castaneus</i>				
Northern brook lamprey	<i>I. fossor</i>				
Sturgeons					
Lake sturgeon	<i>Acipenser fluvescens</i>	E		S1	G3
Paddlefishes					
Paddlefish	<i>Polyodon spathula</i>			S3	G4
Gars					
Longnose gar	<i>Lepisosteus osseus</i>				
Shortnose gar	<i>L. platostomus</i>				
Herrings					
Gizzard shad	<i>Dorosoma cepedianum</i>				
Threadfin shad	<i>D. petenense</i>				
Mooneyes					
Goldeye	<i>Hiodon alosoides</i>				
Mooneye	<i>H. tergisus</i>		R	S3?	G5
Trouts					
Rainbow trout	<i>Oncorhynchus mykiss</i>				
Brown trout	<i>Salmo trutta</i>				
Pikes					
Muskellunge	<i>E. masquinongy</i> ¹				
Minnnows					
Central stoneroller	<i>Campostoma anomalum</i>				
Largescale stoneroller	<i>Campostoma oligolepis</i>				
Goldfish	<i>Carassius auratus</i> ¹				
Grass carp	<i>Ctenopharyngodon idella</i> ¹				
Red shiner	<i>Cyprinella lutrensis</i>				
Common carp	<i>Cyprinus carpio</i> ¹				
Gravel chub	<i>Erimystax x-punctatus</i>				
Striped shiner	<i>Luxilis chrysocephalus</i>				
Bleeding shiner	<i>L. zonatus</i>				
Redfin shiner	<i>Lythrurus umbratilis</i>				
Hornyhead chub	<i>Nocomis biguttatus</i>				
Golden shiner	<i>Notemigonus crysoleuca</i>				
Bighead carp	<i>Hypophthalmichthys nobilis</i> ¹				
Black carp	<i>Nylopharyngodon piceus</i>				
Emerald shiner	<i>Notropis atherinoides</i>				
Wedgespot shiner	<i>N. greeniei</i>				
Blacknose shiner	<i>N. heterolepis</i>		R	S2	G5

Scientific Name	Common Name	Federal Status	State Status	State Rank	Global Rank
Ozark minnow	<i>N. nubilus</i>				
Rosyface shiner	<i>N. rubellus</i>				
Sand shiner	<i>N. stramineus</i>				
Southern redbelly dace	<i>Phoxinus erythrogaster</i>				
Bluntnose minnow	<i>Pimephales notatus</i>				
Fathead minnow	<i>P. promelas</i>				
Creek chub	<i>Semotilus atromaculatus</i>				
Suckers					
Suckermouth minnow	<i>Phenacobius mirabilis</i>				
River carpsucker	<i>Carpiodes carpio</i>				
Quillback	<i>C. cyprinus</i>				
Highfin carpsucker	<i>C. velifer</i>			S2	G4G5
White sucker	<i>Catostomus commersoni</i>				
Northern hog sucker	<i>Hypentelium nigricans</i>				
Smallmouth buffalo	<i>Ictiobus bubalus</i>				
Bigmouth buffalo	<i>I. cyprinellus</i>				
Black buffalo	<i>I. niger</i>				
Silver redhorse	<i>Moxostoma ansurum</i>				
River redhorse	<i>M. carinatum</i>				
Black redhorse	<i>M. duquesnei</i>				
Golden redhorse	<i>M. erythrurum</i>				
Shorthead redhorse	<i>M. macrolepidotum</i>				
Catfishes					
Black bullhead	<i>Ameiurus melas</i>				
Yellow bullhead	<i>A. natalis</i>				
Blue catfish	<i>Ictalurus furcatus</i>				
Channel catfish	<i>I. punctatus</i>				
Slender madtom	<i>Noturus exilis</i>				
Stonecat	<i>N. flavus</i>				
Flathead catfish	<i>Pylodictus olivaris</i>				
Cavefishes					
Southern cavefish	<i>Typhlichthys subterraneus</i>				
Killifishes					
Northern studfish	<i>Fundulus catenatus</i>				
Blackspotted topminnow	<i>F. olivaceus</i>				

Scientific Name	Common Name	Federal Status	State Status	State Rank	Global Rank
Plains topminnow	<i>F. sciadicus</i>			S3	G3
Blackstriped topminnow	<i>F. notatus</i>				
Livebearers					
Mosquitofish	<i>Gambusia affinis</i>				
Silversides					
Brook silverside	<i>Labidesthes sicculus</i>				
Sculpins					
Mottled sculpin	<i>Cottus bairdi</i>				
Banded sculpin	<i>C. carolinae</i>				
Ozark sculpin	<i>C. hypselurus</i>				
Temperate Basses					
White bass	<i>Morone chrysops</i>				
Striped bass	<i>M. saxatilis</i> ¹				
Striped bass hybrid	<i>M. saxatilis x M. chrysops</i> ¹				
Sunfishes					
Rock bass	<i>Ambloplites rupestris</i>				
Green sunfish	<i>Lepomis cyanellus</i>				
Warmouth	<i>L. gulosus</i>				
Orangespotted sunfish	<i>L. humilis</i>				
Bluegill	<i>L. macrochirus</i>				
Longear sunfish	<i>L. megalotis</i>				
Redear sunfish	<i>L. microlophus</i>				
Smallmouth bass	<i>Micropterus dolomieu</i>				
Spotted bass	<i>M. punctulatus</i>				
Largemouth bass	<i>M. salmoides</i>				
White crappie	<i>Pomoxis annularis</i>				
Black crappie	<i>P. nigromaculatus</i>				
Perches					
Greenside darter	<i>Etheostoma blemmioides</i>				
Rainbow darter	<i>E. caeruleum</i>				
Striped fantail darter	<i>E. flabellare lineolatum</i>				
Least darter	<i>E. microperca</i>			S2	G5
Niangua darter	<i>E. nianguae</i>	T	E	S2	G2
Johnny darter	<i>E. nigrum</i>				
Stippled darter	<i>E. punctulatum</i>				
Northern orangethroat darter	<i>E. spectabile</i>				

Scientific Name	Common Name	Federal Status	State Status	State Rank	Global Rank
Missouri saddled darter	<i>E. tetrazonum</i>				
Banded darter	<i>E. zonale</i>				
Ozark logperch	<i>P. caprodes fulvitaenia</i>				
Bluestripe darter	<i>P. cymatotaenia</i>	*		S2	G2
Slenderhead darter	<i>P. phoxocephala</i>				
Gilt darter	<i>Percina evides</i>				
Walleye	<i>Stizostedion vitreum</i>				
Drums					
Freshwater Drum	<i>Aplodinotus grunniens</i>				

¹Introduced species Federal Status

E = Endangered T = Threatened

C = Candidate for listing

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E = Endangered

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State Rank

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Global Rank

Numerical ranking of relative endangerment for the species worldwide. The categories are similar to those listed above for State Rank.

Table 25. The ten most abundant fish species collected from streams by subwatershed.

Upper Niangua Subwatershed		Lower Niangua Subwatershed		Little Niangua Subwatershed	
Species	Relative Abundance	Species	Relative Abundance	Species	Relative Abundance
Central stoneroller	29.3	Bleeding shiner	10	Bleeding shiner	22.8
Bleeding shiner	21.8	Black redhorse	7.6	Ozark minnow	15.7
Ozark minnow	6.3	Golden redhorse	6.7	Rainbow Darter	15
Rainbow darter	5	Gizzard shad	5.9	Central stoneroller	7.4
Ozark sculpin	3.9	Bluegill	5.5	N. orangethroat darter	5.9
N. orangethroat darter	3.4	Longear sunfish	5.4	Striped fantail darter	4.1
Striped shiner	3.1	Largescale Stoneroller	5.2	Greenside darter	3.8
Bluntnose minnow	3.1	Rock bass	4.8	Largescale stoneroller	3.4
Northern studfish	2.7	Green sunfish	4.8	Hornyhead chub	2.1
Longear sunfish	2.6	Bluntnose minnow	4.6	Bluntnose minnow	1.8
	81.2		60.5		82

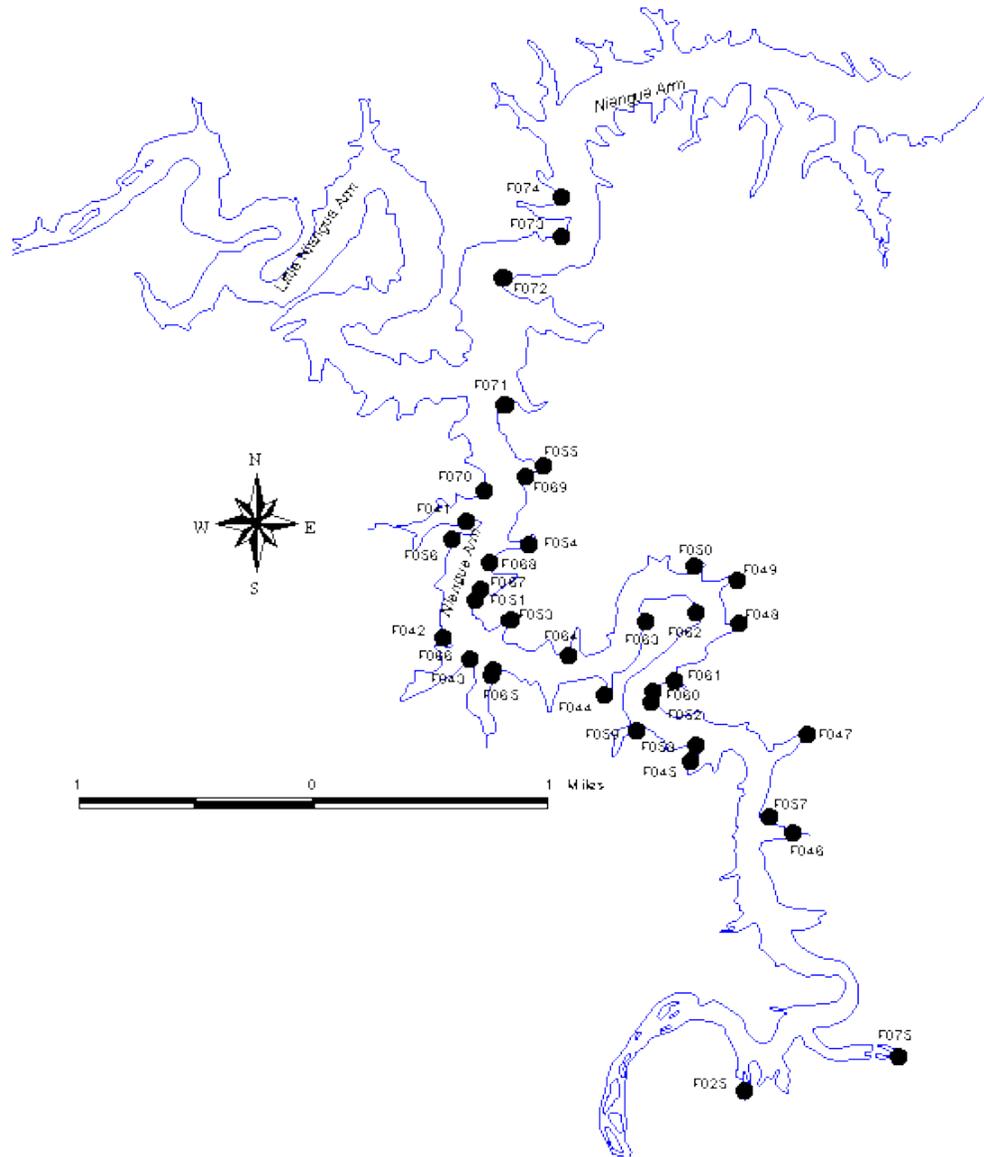
Relative Abundance - Percent of total number of fish collected.

Table 26. Ecological guild, faunal region association, and intolerant species summary for fish community samples from streams within the Niangua River Watershed.

	Upper Niangua Subwatershed			Lower Niangua Subwatershed			Little Niangua Subwatershed			Entire Niangua Watershed		
	Fish	RA*	Species	Fish	RA*	Species	Fish	RA*	Species	Fish	RA*	Species
Ecological Guild:												
Large	10,659	11.2	27	17,921	54.7	39	444	5.4	23	29,024	21.4	39
Nektonic	69,760	73.3	22	12,321	37.6	21	4,947	60.4	19	86,755	63.9	22
Benthic	14,707	15.5	18	2,500	7.6	18	2,799	34.2	15	20,006	14.7	19
Faunal Region:												
Ozark	50,060	52.8	28	15,909	48.6	26	5,751	70.2	20	71,720	52.8	29
River	0	0	0	3	<0.1	1	0	0	0	3	<0.1	1
Prairie	0	0	0	3	<0.1	1	1	<0.1	1	4	<0.1	1
Lowland	0	0	0	0	0	0	0	0	0	0	0	0
Intolerant Species	12,251	12.9	15	10,077	30.8	18	863	10.5	14	23,191	17.1	19

RA* Relative Abundance

Figure 24. Map of fish collection sites on Lake of the Ozarks.



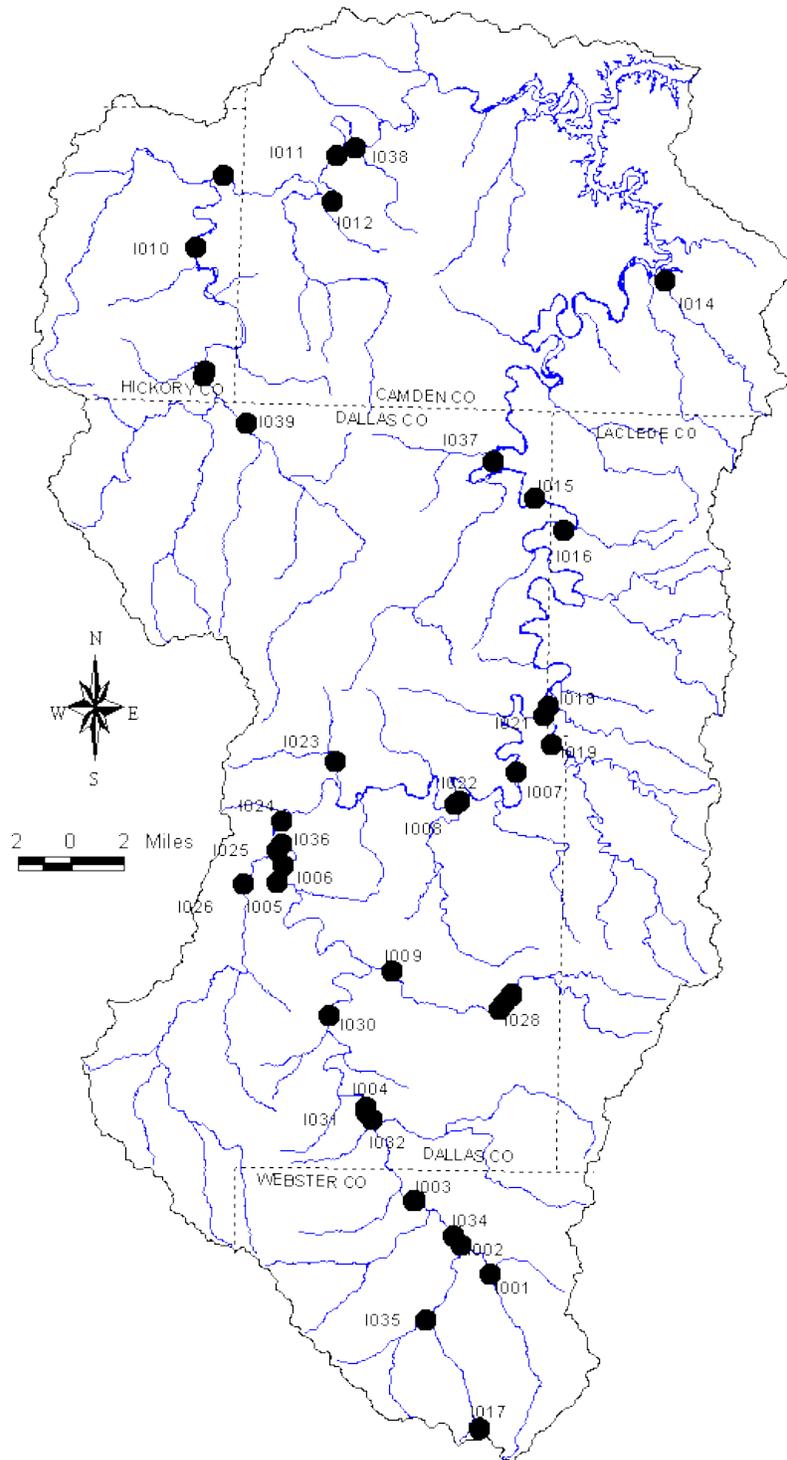


Figure 25. Map of invertebrate collection sites within the Niangua River Watershed. Fish collection sites on Lake of the Ozarks.

Table 28. State or federal listed endangered animal species found within the Niangua Watershed.

Common Name	Scientific Name	Federal Status	State Status	State Rank	Global Rank
Lake sturgeon	<i>Acipenser fulvescens</i>		E	S1	G5
Blacknose shiner	<i>Notropis heterolepis</i>			S2	G5
Paddlefish	<i>Polyodon spathula</i>			S3	G4
Mooneye	<i>Hiodon tergisus</i>			S2	G5
Highfin carpsucker	<i>Carpionodes velifer</i>			S2	G4G5
Southern cavefish	<i>Typhlichthys subterraneus</i>			S1S2	G3
Plains topminnow	<i>Fundulus sciadicus</i>			S3	G3
Least darter	<i>Etheostoma microperca</i>			S2	G5
Niangua darter	<i>Etheostoma nianguae</i>	T	E	S2	G2
Bluestripe darter	<i>Percina cymatotaenia</i>	*	S2	G2	
Cooper's hawk	<i>Accipiter cooperii</i>			S3	G5
Great blue heron	<i>Ardea herodias</i>			S5	
Gray bat	<i>Myotis grisescens</i>	E	E	S3	G3
Indiana bat	<i>Myotis sodalis</i>	E	E	S1	G2
Black-tailed jackrabbit	<i>Lepus californicus</i>		E	S1	G5
Eastern hellbender	<i>Cryptobranchus alleganiensis</i>			S4	G4T4
Ringed salamander	<i>Ambystoma anulatum</i>			S3	G4
Four-Toed salamander	<i>Hemidactylium scutatum</i>			S3	G5
Flat floater	<i>Anodonta suborbiculata</i>			S2	G5
Western fanshell	<i>Cyprogenia alberti</i>			S2?	G2
Snuffbox	<i>Epioblasma triquetra</i>			S1	G3
A perlid stonefly	<i>Neoperla carlsoni</i>			S3?	G?

¹¹Introduced species Federal Status

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Global Rank

Numerical ranking of relative endangerment for the species worldwide. The categories are similar to those listed above for State Rank.

Table 30. Mussel species collected in the Niangua Watershed.

Scientific Name	Common Name	Federal Status	State Status	State Rank	Global Rank
<i>Actinonaias l. carinata</i>	Mucket				
<i>Alasmidonta marginata</i>	Elk toe	*		S2?	G4
<i>Alasmidonta viridis</i>	Slipper shell				
<i>Amblema plicata</i>	Threeridge				
<i>Anondata grandis</i>	Giant floater	R			
<i>Anondata suborbiculata</i>	Flat floater			S2	G5
<i>Corbicula fluminea</i>	Asian clam 1				
<i>Cyclonaias tuberculata</i>	Purple wartyback				
<i>Cyprogenia aberti</i>	Western fanshell	*		S2?	G2
<i>Elliptio dilatata</i>	Ladyfinger				
<i>Epioblasma triquetra</i>	Snuffbox	*		S1	G3
<i>Fusconaia flava</i>	Wabash pigtoe				
<i>Lampsilis radiata</i>	Fat mucket				
<i>Lampsilis reeviana</i>	Britts shell				
<i>Lampsilis ventricosa</i>	Pocketbook				
<i>Lasmigona costata</i>	Fluted shell				
<i>Lasmigona complanata</i>	White heelsplitter				
<i>Leptodea fragilis</i>	Fragile papershell				
<i>Ligumia subrostrata</i>	Pond mussel				
<i>Megalonaias nervosa</i>	Washboard				
<i>Obliquaria reflexa</i>	Three horn				
<i>Pleurobema sintoxia</i>	Round pigtoe				
<i>Potamilus alatus</i>	Pink heelsplitter				
<i>Potamilus ohioensis</i>	Pink paper shell				
<i>Ptychobranchus occidentalis</i>	Kidney-shell	*		S2S3	G3G4
<i>Quadrula metanevra</i>	Monkeyface				
<i>Quadrula pustulosa</i>	Pimpleback				
<i>Quadrula quadrula</i>	Mapleleaf				
<i>Strophitus undulatus</i>	Squawfoot				
<i>Toxolasma parvus</i>	Lilliput				
<i>Tritogonia verrucosa</i>	Buckhorn (Pistol-grip)				
<i>Truncilla truncata</i>	Deertoe				
<i>Truncilla donaciformis</i>	Fawns foot				
<i>Venustaconcha ellipsiformis</i>	Ellipse				

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Global Rank

Numerical ranking of relative endangerment for the species worldwide. The categories are similar to those listed above for State Rank.

Table 31. Crayfish species collected in the Niangua Watershed.

Scientific Name	Common Name	Federal Status	State Status	State Rank	Global Rank
Northern crayfish	<i>Orconectes virilis</i>				
Golden crayfish	<i>Orconectes luteus</i>				
Salem cave crayfish	<i>Cambarus hubrichti</i>			S3	G4
Devil crayfish	<i>Cambarus diogenes</i>				
Grassland crayfish	<i>Procambarus gracilis</i>				

¹Introduced species Federal Status

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Global Rank

Numerical ranking of relative endangerment for the species worldwide. The categories are similar to those listed above for State Rank.

Management Problems and Opportunities

The goals and objectives for the Niangua River Watershed Inventory and Assessment were developed to address the problems and opportunities for conserving the aquatic resources within the watershed. The Missouri Department of Conservation's strategic plan, the Fisheries Division Operational Plan, Stream Areas Program Plan, and the Stream Access Acquisition Plan and the West Central Regional Management Guidelines indicate areas of future expanded resource management, public awareness, and access needs and helped guide development of this document.

The following text describes the management objectives and strategies in five major areas: water quality and quantity; habitat; biotic community; public awareness and recreational use; and data inventory and maintenance. Completion of these objectives will depend upon their status in overall Department, Division and Regional priorities and the availability of personnel and funds. Many of the objectives rely on interagency coordination.

Goal 1: Protect and improve water quality and quantity in the Niangua River Watershed so that all streams are capable of supporting native aquatic communities.

Status: Data were compiled for all known potential sources of water pollution in the watershed. Extensive water quality and biological monitoring were conducted for the UNAWP in the Upper Niangua Subwatershed. The beneficial uses and classifications of most third order and greater streams were evaluated, and numerous streams were recommended for upgraded classification in 1993 and 1996.

Pollution Sources

Objective I.1: Continue to identify potential pollution sources within the watershed and within the recharge areas of watershed springs; evaluate their potential impacts on water quality and aquatic communities, and implement management strategies to monitor the potential impacts and reduce these threats.

Pipelines

Problem/Opportunity: Pipelines in the vicinity of streams and other water bodies pose serious threats to water quality and aquatic life. Greater head pressure of pipelines increases the likelihood of ruptures at stream crossings. Exposure due to stream erosion, followed by corrosion or physical damage by flood debris, can increase this risk. Current policies are inadequate for protecting streams from pipeline accidents. Detailed maps are not readily available, buried pipelines are frequently not marked at stream crossings; pipeline companies are occasionally complacent about protecting and repairing pipelines; and 404 permits are frequently issued without identifying pipeline locations or with disregard for their presence.

- Determine the locations of pipelines within the watershed and plot on 7.5 minute topographic maps.
- Incorporate pipeline locations in a GIS database.
- Check above for pipelines at all sites proposed for 404 activities or where 404 violations are reported.
- Recommend new policies for controlling pipeline activities to MDNR and the COE to protect stream water quality.

Sewage Treatment Plants

Problem/Opportunity: Sewage treatment plants in Marshfield, Lebanon, and Conway are chronically discharging poorly treated wastewater to the watershed.

- Encourage MDNR to monitor compliance with permit limitations, and comment on plans to upgrade these facilities.
- Assure that receiving streams are appropriately classified for protection of aquatic resources.
- Encourage Stream Teams to monitor sites below these facilities.

Sludge Application

Problem/Opportunity: Wastewater sludge stored in lagoons or applied to farmland can pose a threat to water quality. Application sites for municipal sludge seem to be adequately monitored by the MDNR and no problems have been reported in the Niangua Watershed. Private haulers have only recently been required to obtain licenses and file reports, so limited information is available. There are a large number of private treatment systems in the watershed, especially around LOZ, that depend on private haulers for sludge disposal. Locations of disposal sites within the watershed need to be determined.

- Obtain records for private haulers from MDNR, create a database, and plot sites on 7.5 minute topographic maps.
- Obtain annual reports each year and evaluate whether haulers are in compliance. Encourage compliance through MDNR.

Non-POTWs (Non-public owned treatment works)

Problem/Opportunity: There are large numbers of these systems in the LOZ area that handle considerable amounts of waste. They pose a significant threat to water quality if they are not monitored and properly maintained. The number of these systems is expected to increase with continuing development around the lake because many sites will not meet the requirements of the new regulations for conventional septic systems.

- Recommend strict permit review and compliance monitoring for these facilities by MDNR. Highlight this need in the LOZ Management Plan.

Animal Waste Point Source

Problem/Opportunity: Most of the permitted animal waste facilities in the watershed are relatively small dairies. However, there are at least one hog confinement facility and four fairly large poultry operations with a total human population equivalent of over 30,000. Facilities this large generate the waste equivalent to a small city, yet their waste handling and treatment systems are seldom comparable to the average municipal STP.

- Encourage Stream Teams to monitor water quality and aquatic communities in the receiving streams below large facilities.
- Support legislation that reduces potential pollution of the surface and groundwater resources from the application of poultry, hog, and cattle wastes.

Landfills

Problem/Opportunity: The Lebanon Sanitary Landfill occasionally discharges leachate to Goodwin Hollow, a losing stream that is hydrologically connected to Bennett Spring and Sweet Blue Spring.

- Recommend that the MDNR inspect this facility, and ensure maximum water quality protection.

Quarries

Problem/Opportunity: Discharges of excessively turbid stormwater runoff from settling basins at a limestone quarry near Buffalo are probably degrading the Niangua River within Niangua darter critical habitat. The MDNR has investigated this problem and has advised the owner to remove accumulated sediment from the basins.

- Monitor turbidity and sediment accumulation in the NR below the quarry.
- Request confirmation from the MDNR that remedial measures have been completed.

Septic Systems

Problem/Opportunity: Poorly designed and constructed septic systems and other individual treatment systems often contribute to elevated levels of nutrients in highly developed coves of LOZ.

- Refer complaints about septic systems to County Wastewater Departments.
- Support adoption of a "Lake Zone" for planning and zoning in surrounding lake counties.

Agricultural Runoff

Problem/Opportunity: Wastewater of greater than 300 animal units from dairies and poultry and hog confinement facilities are regulated by the MDNR as point sources. They must meet minimum standards, and operations within the watershed appear to be gradually coming into compliance. Livestock in pasture are non-point sources that are less tangible and may represent a considerable source of contaminants. The amount of stream contamination can be reduced by good pasture management, erosion control, and providing filter strips in riparian corridors.

- Promote good pasture management, erosion control, revegetation of corridors, and livestock exclusion throughout the watershed.
- Offer PFW and new Streams For The Future cost share incentives for projects within the targeted LNR watershed.
- Cooperate with NRCS to implement alternative water systems incentive agreements throughout the watershed.
- Utilize other state and cost share programs such as AgNPS, EQIP, WHIP, and CRP to address non-point agriculture pollution problems in the watershed.

Water Quality Monitoring

Objective I.2: Ensure that water quality and aquatic communities are monitored adequately to provide early detection of stream and lake degradation and to evaluate possible effects of watershed and stream improvement projects.

Problem/Opportunity: Water quality monitoring during the UNAWP indicated that high levels of nutrients and pathogens were occasionally present at most monitoring stations. It was estimated that construction of animal waste treatment facilities reduced nutrient input from these sources to the NR by 20% during the project. Even so, no significant improvements were detected in water quality, fish communities, or invertebrate communities during the first four years of the five year project (Smale et al., 1995). Efforts to secure funding for continued water quality monitoring have not been successful.

Two sites within the project area (G006, G012) may be monitored occasionally by the NAWQA project (USGS).

- Review the final UNAWP report when completed.
- Support continued water quality monitoring efforts in the Upper Niangua Subwatershed to document improvements from animal waste treatment facilities installed by the UNAWP and from continuing efforts to reduce agricultural runoff.

- Encourage Stream Teams to adopt strategic sampling sites in the Upper Niangua Watershed.

Fish Kills

Problem/Opportunity: Several fish kills have been documented in the watershed. Most have been associated with municipal sewage discharges from the Marshfield sewage treatment plant.

- Assist state and federal agencies with enforcement of water pollution laws by cooperating with pollution and fishkill investigations.
- Cooperate with MDNR to minimize future threats from the Marshfield STP and other municipalities within the watershed and spring recharge areas.

Fish Contamination

Problem/Opportunity: Although no Niangua Arm (LOZ) samples have yielded action levels of contaminants, some Osage Arm (LOZ) paddlefish samples showed elevated chlordane levels.

- Initiate collection of redhorse suckers from the NR in 1999 for contaminant analysis by MDH; sample at Bennett Spring Branch and Leadmine CA in 1999, then alternate sites in subsequent years.
- Continue to collect LOZ fish for contaminant analysis by MDH including fish from the Niangua Arms every other year.
- Cooperate with MDH in informing the public about health advisories and the impacts of fish contamination.

Beneficial Use Attainment

Objective I.3: Evaluate all classified streams to assure that appropriate beneficial uses are being attained and recommend upgraded classifications as necessary.

Problem/Opportunity: Some third-order streams in the watershed remain unclassified and other streams may qualify as cool-water fisheries.

- Identify appropriate classifications and beneficial uses for remaining unclassified streams and recommend upgraded classification to MDNR.

Problem/Opportunity: Efforts to protect Niangua darter habitat with a special classification have failed to win Clean Water Commission approval. Classification could be used to require stricter limitations in NPDES Permits that discharge to streams within critical habitat.

"Outstanding State Resource" classification would also provide better protection for these streams.

- Propose, once again, that Niangua darter known range be given special classification "Critical Habitat for Rare and Endangered Aquatic Species," or alternatively, "Outstanding State Resource."

Problem/Opportunity: Bennett Spring and Ha Ha Tonka Spring are among the largest springs in the state and both are featured resources at state parks. Recent MDNR dye tracings and geological investigations have established extensive recharge areas for these springs and this assessment has identified numerous water quality threats within them.

- Propose special classification for Bennet Spring and Ha Ha Tonka Spring and the losing streams within their recharge areas.
- Propose that the Spill Emergency Plan for Bennett Spring State Park be approved.

Objective I.4: Promote programs that enhance groundwater recharge in the watershed and spring recharge areas.

Springs

Problem/Opportunity: Springs are the main source of sustained flow in streams during periods of low precipitation. Since aquatic communities can experience great stress under these

conditions (low dissolved oxygen and high temperatures), adequate flow and good water quality are essential. Springs in the watershed have not been monitored sufficiently to determine current conditions or detect change over time.

- Compile existing data on springs within the watershed.
- Cooperate with the USGS and MDNR to develop a plan to monitor strategic springs.

Watershed Projects

Problem/Opportunity: The amount of rainfall that percolates through the soil to recharge aquifers and maintain base flows is affected by land use and the amount of vegetation. Ungrazed, uneven-aged, woodland allows optimal percolation, and well managed pastures improve the quality of runoff events.

- Promote watershed practices that improve groundwater recharge, including cattle exclusion from woodlands, good pasture management, timber stand improvement, and conversion of pasture and open fields to woodland.

Water Quantity

Objective I.5: Support the enactment of a State Water Law and other legislation that will prevent negative downstream impacts from single or cumulative withdrawals.

Problem/Opportunity: Since there is no water law in Missouri, downstream users and government agencies have little recourse to regulate upstream water users and prevent them from withdrawing water that may impact aquatic organisms.

- Cooperate and support MDNR in preparing a Missouri Water Law which restricts water removal from streams for crop irrigation and other uses.
- Work with MDNR and COE, to protect or enhance stream flows through oversight and enforcement of existing water withdrawal permits.

Goal II: Protect and improve aquatic habitat conditions of the Niangua River Watershed to meet the needs of native aquatic species while accommodating society's demands for water and agricultural production.

Objective II.1: Insure that instream projects within the watershed do not interfere with natural stream processes.

Channel Alterations

Problem/Opportunity: Many landowners still believe that channelization is an appropriate solution to bank erosion and flooding problems. Although some short-term reduction in bank erosion may be achieved, the negative side effects can be severe, including loss of habitat diversity, accelerated upstream and downstream erosion, headcutting upstream, and channel destabilization.

- Meet with landowners who propose channelization projects to discuss their concerns and inform them about stream processes and the negative impacts of channel alterations, and recommend more appropriate remedies.
- Disseminate MDC literature and other information that describe the offers alternative techniques to channelization.

404 Activities

Problem/Opportunity: A large number of Section 404 applications for instream construction and excavation are submitted for streams within the Niangua Watershed. Since a large portion of Niangua darter habitat occurs in the watershed, MDC reviews many of these.

- Review all 404, gravel excavation, bridge construction and other development projects that may impact streams and recommend appropriate action to maintain, improve or protect aquatic habitats.
- Recommend denial of 404 permits that require repeated stream crossing or recommend conditions that include installation of a temporary crossing under MDC supervision.
- Encourage Stream Teams to comment on 404 permits.

Problem/Opportunity: The general permit for sand and gravel removal (GP-34) has greatly simplified the application and approval process for applicants, the COE, the MDNR, and MDC. Unfortunately, it has also reduced a very important component which has been beneficial in the past, direct contacts with landowners and permittees. These contacts provide opportunities to inform the interested parties about stream processes and the meaning and justification for the permit conditions; learn about their experiences, techniques, and concerns; and otherwise establish a cooperative, mutually beneficial relationship. In addition, greater involvement provided opportunities to make site visits and document pre-permit conditions, monitor compliance, and observe possible impacts. Now, when a general permit is issued, the MDC is usually not consulted and frequently the COE makes no site inspection. Nationwide permits are usually issued with inadequate conditions to protect aquatic resources and without MDC input.

- Review 404 applications and inspect proposed sites whenever possible.
- Encourage the COE to provide opportunities for regional fisheries personnel to comment on 404 applications that include requests for variances, crossing streams, or channelization including those in NWP segments.
- Recommend that MDC Policy Coordination request changes in procedures to COE General and Nationwide Permits. Include careful scrutiny of locations of proposed activities, onsite inspections where violations have occurred, and MDC notification of proposed activities.

Objective II.2: Determine minimum flows necessary to sustain native communities of fish and other aquatic life, and to provide adequate spawning habitat for white bass, walleye, and other species.

Problem/Opportunity: Truman Dam prevents migration of LOZ white bass, walleye, paddlefish and other species to historic spawning sites upstream. White bass spawn in the Niangua River and Little Niangua River. While some walleye may spawn in both rivers, it is doubtful that they contribute to annual recruitment in LOZ. Neither river provides suitable spawning conditions for paddlefish.

- Conduct fish sampling and spawning habitat assessment on the Niangua River and the Little Niangua River for walleye; follow-up on results of the current research project on white bass.
- Develop recommendations for maintaining adequate flows for white bass and walleye using approved instream flow methodologies as recommended by Fisheries personnel. Such flows might also enhance paddlefish migration and susceptibility to anglers.

Problem/Opportunity: MDC is required to monitor the new USGS gage at Tunnel Dam to ensure that minimum flows required by the recent relicensing agreement are sustained. Recent data indicate that over a one-year period through December 4, 1996, minimum required flows were not sustained 31% of the time. During the spawning season (March 15 through June 15), mean daily flows were below the required minimum flow of 60 cfs 55% of the time.

- Inform Show-Me Power Corporation and FERC of non-compliance and assure that minimum flows are attained.

- Monitor flows to assure compliance by obtaining data periodically from the USGS.

Objective II.3: Implement habitat improvement projects on public and private land.

Habitat Improvement Projects on Private Land

Problem/Opportunity: Riparian corridors are in poor condition on many watershed streams and cattle frequently have access to corridors and streams. The vast majority of stream frontage in the watershed is in private ownership.

- Implement landowner incentive programs through existing or new state or federal incentive program or assist county SWCDs to obtain federal or state grant money through: 319 Environmental Protection Agency grants, Rural Clean Water Program, Water Quality Improvement Practices (WQIP), AgNPS projects and MDC stream incentive programs.
- Develop landowner cooperative projects (LCPs) on the LNR. Target the LNR watershed for promoting cost shares.
- Promote the adoption of streambank erosion control and riparian corridor establishment or protection practices for approval by the county Agriculture Executive Committee of FSA or the SWCD administered through the MDNR Soil and Water Conservation Program.
- Encourage landowners and urban residents to form their watershed committees.
- Provide technical assistance and information to all landowners who request assistance and on-site consultation to those willing to establish and maintain stream corridors guidelines.

Problem/Opportunity: The three-year pilot stream incentive program in Dallas County, the recently initiated PFW project, and increased cooperation with NRCS to install alternative water systems, have stimulated interest in stream improvement in the watershed. Promotional and educational efforts are necessary to inform landowners about these programs and encourage participation.

- Promote and advertise stream improvement projects on Department areas and LCPs for demonstration purposes using Neighbor to Neighbor or SWCD Field Day events.
- Advertise and promote available stream habitat cost share programs through traditional and agricultural media; emphasize word-of-mouth advertising by neighbors.
- Sponsor a stream and watershed workshop for landowners, NRCS, FSA, COE, and city and county officials which highlights problems and strategies for correcting them.
- Increase landowner awareness of MDC private stream programs through SWCD and Farm Bureau cooperative programs at the county level. Emphasize the economic benefits of well-managed streams.
- Cooperate with the MDC Outreach and Education Division to develop stream habitat improvement materials for use by local Vocational Agricultural instructors, FFA chapters, and 4-H clubs.

Habitat Improvement Projects on Public Lands

Problem/Opportunity: Area Plans are prepared periodically for MDC conservation areas.

- Inspect these areas and recommend corridor expansion or bank stabilization projects as necessary to correct problems and serve as demonstration sites.
- Include monitoring and habitat improvement strategies for streams on these areas to correct problems.

Problem/Opportunity: The newly acquired Barclay Springs CA is in the beginning stages of planning and development. This diverse area encompasses 389 acres with 1.7 miles of Niangua River frontage and a sizeable spring that provides an excellent opportunity for managing these aquatic resources.

- Inspect this area and recommend corridor expansion, bank stabilization projects, and fish habitat improvements to correct problems and serve as demonstration sites.

Problem/Opportunity: Several habitat improvement projects have been completed at Bennett Spring State Park, Leadmine CA, and Mule Shoe CA. Since these serve as highly visible demonstration sites for effective stream improvement practices, they should be carefully monitored and properly maintained.

- Continue to monitor these projects and complete maintenance as necessary.
- Use these projects to demonstrate good stream management to the general public and agency personnel as appropriate.

Unique Habitat

Objective II.4: Identify and protect unique habitat in the watershed

Problem/Opportunity: Very little high quality bottomland forest was identified in the Natural Features Inventory of the Niangua Watershed. This is the result of one or more of the following common practices: clearing of bottomlands up to the stream edge; allowing cattle to graze the intact forests; and repeated logging of forests. These forests are important and necessary components of the stream ecosystem. They provide essential habitat, help prevent streambank erosion, filter surface runoff and groundwater flow, reduce water temperatures by shading streams, and contribute woody debris and organic matter.

- Encourage Little Niangua River landowners with bottomland forests or sites naturally suited for bottomland forests to protect and manage them.

Problem/Opportunity: Very few high quality wetlands were identified in the Natural Features Inventory. Wetlands were probably always a scarce resource in the watershed historically and many have been developed for pasture or cropland.

- Identify, protect, and enhance wetland habitat through purchases, easements, LCPs, PFW, or other agreements.
- Recommend wetland creation at suitable sites on public lands.
- Implement management strategies outlined in the MDC Guidelines for Promoting Fishery Resources in Missouri Wetlands on all public areas and privately owned wetlands.
- Assist the West Central Region Wildlife personnel with workshops for other agency staff and landowners on the importance of managing wetlands for fish and other aquatic organisms.
- Assist West Central Region personnel with workshops for loggers and landowners regarding proper methods of logging timber from riparian corridors and bottomland forests.

Problem/Opportunity: Two of the eight extant Niangua darter populations occur in the watershed.

Habitat degradation is apparently still negatively impacting the Niangua darter. Nutrification and sedimentation are believed to be the most serious threats to the darter, as well as the rest of the natural fauna.

- Support continued habitat and water quality monitoring efforts in the Upper Niangua and Little Niangua subwatersheds.
- Encourage Stream Teams to adopt monitoring sites in Niangua darter range.
- Identify, protect, and enhance Niangua darter habitat through purchases, easements, LCPs, PFW, or other agreements. Highlight expansion priorities identified in the Mule Shoe CA draft area plan.

Habitat Assessment

Objective II.5: Inventory aquatic habitat throughout the watershed to provide descriptions of habitat conditions in representative reaches and quantify various parameters for comparisons between subwatersheds and with other Missouri watersheds.

Problem/Opportunity: Insufficient numbers of SHADs were conducted to adequately characterize the entire watershed. Most of the SHADs were completed in 1991, so it would be desirable to repeat them if surveys are conducted at additional sites. The Habitat Assessment Committee investigated possible alternatives to the SHAD that would provide more useful quantitative data from a watershed wide perspective. Analyses of remote sensing data, including aerial photography, digital orthophotography, and satellite imagery, are promising alternatives, however, current data on a sufficiently large scale is not readily available. A method for evaluating riparian corridors has been developed by Tom Groshens (MDC), using aerial photographs. Photographs were on hand for only a small portion of the watershed, so this method was not pursued for this plan. Another emerging method is digital image analysis of high quality helicopter videos or low altitude digital photographs.

- Implement the habitat assessment methodology recommended by the habitat assessment committee for streams within the watershed.
- Incorporate site specific habitat observations on all Niangua darter snorkeling trips.

Goal III. Maintain the diversity and abundance of aquatic communities and improve the quality of the sport fishery.

Objective III.1: Protect and improve the status of threatened and endangered species, and implement state or federal recovery plans.

Problem/Opportunity: Niangua darter populations appear to be fairly stable in the Little Niangua River but declining in the upper Niangua River. Sampling in both subwatersheds needs to be expanded and compared to Mattingly's (UMC) sampling on the Little Niangua River. Although limited targeted sampling was conducted, thorough community sampling of the Upper Niangua River by Smale during the UNAWP failed to yield Niangua darters. No thorough, comparable survey has been conducted throughout Niangua darter range since Pflieger's in the 1970s and recent sampling procedures have been inconsistent.

- Conduct a thorough search of the Upper Niangua River for the Niangua darters distribution.
- Recommend to the MDNR that all known range of the Niangua darter be classified as "Critical Habitat for Rare and Endangered Aquatic Species," or failing that, as "State Outstanding Resource Waters."
- Conduct a multi-district survey of known range to evaluate current status and consider elevation of federal status to "Endangered."
- Target the Little Niangua River watershed for intensive promotion of stream incentive programs and SSA.
- Identify, protect, and enhance Niangua darter habitat through purchases, easements, and cost shares. Highlight expansion priorities of the Mule Shoe CA draft area plan, as per Objective II.4.
- Carry out recommendations in the Niangua Darter Recovery Plan and actively participate on the Niangua Darter Recovery Team.
- Adopt a standardized monitoring plan for Niangua darters and maintain a statewide database.

Problem/Opportunity: The blueshrike darter is only found in a few streams in the Missouri Ozarks and appears to be declining in the watershed. Its status in other watersheds is unknown.

- Inform the USFWS, MDC Natural History, and other MDC Regions within historic range of the blueshrike darter of its apparent decline in the Niangua River Watershed and consider elevating its state and federal status.

Objective III.2: Maintain the diversity and abundance of fishes and invertebrates at or above current levels.

Problem/Opportunity: Thorough fish community samples have not been conducted in the Lower Niangua River Subwatershed or the Little Niangua River Subwatershed since Pflieger's surveys in the mid-1970s.

- Conduct periodic, thorough fish community sampling at historic collection sites in both subwatersheds.

Problem/Opportunity: Comprehensive invertebrate sampling has not been conducted in the Lower Niangua Subwatershed or Little Niangua River Subwatershed since the mid-1970s. Thorough collections were completed during the UNAWP from 1991-1995 in the Upper Niangua Subwatershed.

- Encourage Stream Teams to assist with sampling.

Problem/Opportunity: A diverse mussel community historically occupied the watershed. In consideration of mussel decline throughout the Midwest and the lack of recent watershed sampling, a thorough mussel survey is warranted.

- Conduct a mussel survey of all fifth-order and greater streams in cooperation with the statewide mussel survey that Fisheries Research will be conducting.

Problem/Opportunity: The Niangua and Little Niangua Rivers offer opportunities for producing high quality fisheries.

- Identify and prioritize the native sportfish most suitable for increased management emphasis in the Niangua River and implement a plan for sampling.
- Give special consideration to a special smallmouth bass management area on the Niangua.
- Assess the impacts of Tunnel Dam and Lake Niangua on sportfish populations, .
- Continue the Special Management Area for brown trout in the Niangua River by annual stocking of 10,000 ten-inch brown trout with special harvest regulations.
- Continue to serve on the Bennett Spring Management Task Force.
- Continue to manage Bennett Spring State Park as a "put and take" rainbow trout fishery.

Problem/Opportunity: Management actions targeting one or more game species can have unexpected negative impacts on non-game fishes and invertebrates. Several listed rare, threatened, and endangered species are found in limited number in the watershed.

- Evaluate the potential impacts of sportfish management activities on non-game fishes and invertebrates before and after implementation.
- Avoid special management areas in designated critical habitat for state or federally listed rare, threatened or endangered species.

Problem/Opportunity: The Niangua and Little Niangua rivers are important components of the fisheries and aquatic ecosystems of LOZ.

- Implement all strategies of the LOZ Management Plan and this plan so they complement one another.
- Be aware of problems which arise in LOZ which may negatively impact the Niangua and Little Niangua rivers (exotic species introductions; distributional changes of zebra mussels or spine water fleas; etc.)

Goal IV. Increase access and MDC ownership within the Niangua Watershed.

Objective IV.1: Provide additional MDC owned access to the Niangua River between Bennett Spring and the Camden County line.

Problem/Opportunity: There is a demand for at least one stream access on the lower Niangua River to increase user convenience and encourage more uniform use throughout the watershed.

- The recently purchased Barclay Springs CA will provide additional access upstream from the Lead Mine CA. An additional access between Leadmine CA and Lake Niangua is recommended.
- Priority should be given to land acquisitions in the Niangua Watershed that include stream frontage for access development and corridor protection/development.

Objective IV.2: Enhance accessibility at all MDC access and frontage areas within the watershed.

Problem/Opportunity: Area Plans have been or are being developed for five stream areas. There are no disabled user facilities at MDC stream areas in the watershed.

- Include public use objectives, including some disabled user facilities, in MDC area plans for public lands along streams in the watershed.

Objective IV.3: Implement expansion plans as outlined in MDC area plans; focus on key expansions at Mule Shoe CA and Leadmine CA.

Problem/Opportunity: Area Plans have been or are being developed for several stream areas.

- Highlight expansion needs and stress the need to fund these expansion areas.

Objective IV.4: Work with other divisions and agencies to address problems associated with increased public use in the watershed.

Problem/Opportunity: There has been a significant increase in canoeing, rafting, tubing, and kayaking on the Niangua River in recent years. Litter, noise, and controlled substance violations have also increased. Owners of boat liveries and campgrounds have complained about these problems and may be cooperative allies for planning management actions.

- Cooperate with MDC Protection Division to organize a task force to develop an action plan to address these problems. Include the Missouri State Water Patrol, MDNR, and local sheriff departments on the task force.

Goal V: Address information and education opportunities within the watershed.

Objective V.1: Inform other agencies, local government officials, land developers, landowners, and the general public of water quality conditions and problems in the watershed.

Problem/Opportunity: Sound watershed management depends on our ability to increase public awareness and educate the general public, landowners, city and county officials, and industrial and residential developers on the importance of improving water quality, and generate an interest in water quality problems and solutions.

- Include the Niangua Watershed as a high priority for private landowner assistance within the West Central Region Private Land Plan.
- Coordinate private landowner assistance with Agricultural Services, NRCS, FSA, The Nature Conservancy, COE and MDNR to cultivate mutual interests and concerns for land and stewardship issues.
- Incorporate information on Best Management Practices into MDC stream management workshops presented to local SWCDs, private industry, city and county governments and other agencies.
- Attend public meetings regarding highway construction, development projects, 404 permits, and state or federal watershed projects to inform the public about local water quality and watershed issues and the importance of reporting all pollution incidents to the MDNR and MDC.
- Write articles for local newspapers, Farm Bureau, University Extension, local SWCD, NRCS, and FSA newsletters, and conduct radio or TV programs concerning proper land use and local water quality problems and solutions.
- Work with MDC Outreach & Education Consultants to incorporate information into teacher workshops concerning watershed and stream issues, particularly the need to promote advocacy of these resources and the importance of local citizen involvement to solve local problems by forming Stream Teams.

- Seek opportunities to involve citizens and organizations in planning activities.
- Publicize the acquisition, development and opening of new public access sites.
- Promote the adoption of watershed streams by Stream Teams.
- Promote the education of youth in the watershed by coordinating aquatic education opportunities for schools in the watershed with MDC Outreach & Education Consultants.
- Write a Missouri Conservationist article on the PFW project.
- Produce a video promoting the resources and public use opportunities, and stream ecology and preservation in the watershed.
- Emphasize stream ecology, good stream stewardship and the MDC Streams for the Future program (using watershed models and the stream trailer where applicable) during presentations at adult and youth organizations, adult service clubs and sportsman's groups, Boy Scouts of America, Girl Scouts of America, Future Farmers of America, 4-H and Vo Ag youth groups, schools in the watershed, and fairs or other special events.
- Promote stream ecology in MDNR (Ha Ha Tonka, Bennett Spring and LOZ state parks) brochures and at their visitor centers.
- Promote the adoption of this plan by the Missouri Department of Natural Resources Non-point Pollution Program responsible for writing watershed plans for the state of Missouri.
- Include questions on water quality, water quantity, habitat conditions, biotic community access and public awareness issues in telephone or mail surveys to the public residing in the watershed.
- Incorporate these goals and objectives into the Regional Management Guidelines.
- Enhance awareness among all resource and government agencies by providing copies of this inventory and assessment to MDNR offices at Ha Ha Tonka, Bennett Spring and LOZ state parks; U.S. Army Corps of Engineers in Kansas City and the project office in Warsaw; the USFWS office in Columbia; SWCD, NRCS and FSA offices in Benton, Camden, Dallas, Hickory, Laclede, and Webster counties; MDC employees who work in the Niangua River Watershed; Environmental Protection Agency, The Nature Conservancy, USGS, city and county officials, state and federal legislators, and county libraries.
- Provide copies of this plan to Stream Teams within the watershed.
- Keep Stream Teams informed about water quality problems and other significant stream issues.
- Include this inventory and assessment on the MDC watershed web page.

Goal VI. Manage Niangua River Watershed databases to provide accurate and up-to-date data, easy accessibility, and compatibility with other districts, divisions and agencies.

Objective VI.1: Organize watershed databases to improve accessibility and compatibility.

Problem/Opportunity: Numerous databases were created and a large amount of data were compiled during the inventory for this plan. These databases must be readily accessible for general use and updating. They should also be compatible with those of other regions, divisions, and agencies to facilitate exchange of data.

- Prepare documentation for all watershed databases.
- Insure that watershed databases are compatible with comparable statewide databases.
- Incorporate these data into MoRAP and the Statewide Resource Assessment and Monitoring Plan.

Objective VI.2: Update watershed databases periodically to include the most current, accurate information.

Problem/Opportunity: Many of the watershed databases must be updated periodically to include the most recent data (e.g., 404 permits, fish collections). MoRAP is coordinating data

preparation and maintenance of some databases throughout the state to increase compatibility and efficiency.

- Develop a plan for updating watershed databases periodically.
- Cooperate with MoRAP to improve database compatibility between agencies.

Angler Guide

The watershed is well known for the varied fishing opportunity it offers - from stream fishing for smallmouth bass, rock bass, trout, and suckers, to reservoir fishing for largemouth and spotted bass, crappie, paddlefish, catfish, white bass, and walleye. In 1988, more than twice as many angler-days were spent fishing LOZ than the second most popular large reservoir in the state (Weithman, 1991).

Bennett Spring Trout Park

Year-round 55 degrees F. water from Bennett Spring provides habitat for trout in 1.5 miles of Bennett Spring Branch and in approximately 12 miles of the NR downstream of Bennett Spring Branch. Flow from Bennett Spring averages approximately 100 million gallons per day, and the branch doubles the flow of the NR. The spring and the branch below it are owned by the MDNR and managed as a state park. The MDC owns and operates a trout hatchery within the park, and rainbow and brown trout are stocked annually in the park and the NR (see the Introduced and Exotic Species section). From March through October, the trout park is open daily and the trout fishery is managed on a put-and-take basis. There is no length limit on rainbow trout, and the daily limit is five. The spring branch is separated into three zones, each with different lure restrictions (flies, artificials without soft plastic or synthetic substances, and bait or soft plastic/synthetic substance lures). From the second weekend in November through the second weekend in February the park is open on Fridays, Saturdays, and Sundays. The fall/winter season is catch and release and only flies and artificial lures without soft plastic or synthetic substances may be used. The MDNR reported that in 1997 approximately 188,000 trout tags were sold including 2,200 during the fall/winter season.

Since January 1996, the trout fishery in the NR and its tributaries, including Bennett Spring Branch and the trout park, has been managed under an 18" minimum length limit for brown trout. The regulation also places a daily limit of five trout in the Niangua Watershed, and only one may be a brown trout. Brown trout will be stocked annually in the NR downstream from Bennett Spring Branch to establish and maintain a quality brown trout fishery (Table 27).

Lake of the Ozarks

Most of the information included in this section was obtained from the Lake of the Ozarks Fisheries Management Plan (Stoner, 1999), which can be consulted for more details. In January 1976, a minimum length limit of 15" was imposed on all black bass species in a successful attempt to increase overall bass densities, increase catch rates of bass of all sizes, and to more effectively utilize the existing food supply. As a result, the CPUE of largemouth bass over 12" doubled during the first year in electrofishing samples. The average growth rate of largemouth bass has remained stable since the regulation went into effect, and the legal catch and harvest rates for black bass on the Niangua arm have remained stable since 1987. In 1988, the catch rate for largemouth bass (0.61 fish/hour) on LOZ was second only to Table Rock Lake among Missouri reservoirs (Weithman, 1991).

Two crappie regulations were enacted during the 1980s based on trapnetting conducted by MDC Fisheries Research (Colvin and Vasey, 1986). These included a daily and possession limit of 15 crappie in 1984, and a 9" minimum length limit in 1989. Recent trapnet and angler data indicate that following the 9" regulation, survival increased for age-one plus and age-two plus crappie. Catfish have been the 3rd or 4th most popular fish as a group on the Niangua Arm since 1981. However, fishing effort for catfish declined to less than 4 hours/acre in 1992 and 1993, compared

to an average of 10 hours/acre in the early- to mid-1980's. Harvest and catch rates, along with average size harvested, remained stable during this period. Efforts to manage catfish have been hampered by lack of effective sampling methods.

The walleye fishery in LOZ declined after Truman Dam was closed in 1977. A six-year tagging study initiated in 1977 revealed that the majority of LOZ spawning walleye concentrate in the Truman Dam tailwater area in the spring. No other significant spawning runs are known to exist, and spawning below the dam is probably not very successful due to erratic water releases. Since minimum flows have been maintained below Tunnel Dam, increasing numbers of walleye have been observed there.

In 1991, MDC Fisheries Research initiated a study of white bass population dynamics in the Niangua Arm and Pomme de Terre Lake. In 1992, white bass were the most sought after species with angler effort at 18.2 hours per acre. Tagging studies of fish larger or equal to 11 inches conducted between 1992 and 1995 indicate that approximately 25% of the fish tagged in the spring on the Niangua Arm are caught during that same calendar year. Initially, many tag returns came from the spawning area immediately upstream from the LOZ border.

Striped bass were first stocked in the lake in 1967 to provide a unique trophy fishery and to utilize the surplus of large gizzard shad. A 20-inch minimum length limit and a daily limit of four went into effect in 1978, a daily limit of 15 Morone sp. in the aggregate with only four greater than or equal to 18 inches was enacted in 1987. The plume of cool water from Ha Ha Tonka Spring provides the desired thermal refuge for this species and has been a popular fishing location. Although the harvest of striped bass has remained low, a number of trophy size fish have been caught.

Hybrid striped bass were first stocked in LOZ in 1982 (Table 29), although fish entered LOZ prior to that time from stockings at Montrose Lake. In recent years, MDC has concentrated stocking efforts on hybrid striped bass rather than striped bass due to their better hatchery survival and higher angler catch. Notable hybrid fisheries have developed near Ha Ha Tonka Spring on the Niangua Arm, and near the lake boundary in the Niangua Arm during April and May.

Paddlefish were listed as sportfish in 1968, with a statewide 45-day spring season in 1979, and a statewide 24-inch (eye-to-fork of tail) minimum length limit in 1987. Beginning in 1992, paddlefish caught by sportfishing methods could not be possessed on waters of the state except during the spring snagging season. Since 1982 paddlefish have been annually stocked LOZ (Table 40). Paddlefish still attempt to make a spawning run up the Osage Arm of LOZ, but are unable to reach their historical spawning ground which has been inundated by Truman Lake. Some paddlefish were observed in the Niangua River in April of 1988 and 1994 during high water. High water conditions must persist for several days to promote a successful spawn, and an extensive stretch of open river is required for larval survival. Apparently, the stretch of Niangua River between Tunnel Dam and LOZ does not meet these conditions as there has been no documented recruitment in the Niangua River.

Sport Fisheries on Lake Niangua

The Tunnel Dam area is a popular recreational site for angling, canoeing, and swimming. During the spring spawning runs and on summer nights, anglers can be found fishing below the dam, along the bypass reach, and at the powerhouse. Few anglers fish Lake Niangua, but use is expected to increase since improved access was provided in 1995. Several conditions of the

recently approved FERC relicensing agreement will benefit recreational users and water quality. These conditions include:

- 1) A recreational access facility will be provided in the bypass reach on the NR, immediately below the dam;
- 2) Vehicles will be allowed access to the powerhouse boat ramp;
- 3) Directional and informational signs will be installed from the nearest paved roads to access facilities at Lake Niangua, the bypass reach, and the powerhouse;
- 4) One hundred-foot riparian zones will be protected, and all wetland timber and all shallow water habitat on Tunnel Dam project land will be protected;
- 5) Two year-long recreational use studies will be conducted, one 10 years after relicensing, and another 20 years after, to assess use of the reservoir and bypass reach. The first two of these conditions have been fulfilled.

Pond Fisheries

Many of the public use areas within the watershed have small ponds that offer fishing opportunities. Charity Access in southern Dallas County has one 0.4 acre fishing pond containing channel catfish, largemouth bass, bluegill, and green sunfish. The pond receives moderate fishing and frogging pressure. Branch Towersite in southwestern Camden County has a 0.25 acre fishing pond containing largemouth bass, bluegill, channel catfish and green sunfish. Access to the pond is available by trail. There are two fishable ponds on Gale CA in central Camden County. One is 0.5 acre, shallow, and contains bluegill and green sunfish. The other is 0.25 acre and contains hybrid bluegill, channel catfish, and largemouth bass. Three fishable ponds approximately 0.23 acre on Fiery Fork CA contain bluegill and green sunfish and largemouth bass.

Table 27. Trout sampling results from the Niangua River in 1995 and 1996.

Parameter	Brown Trout			Rainbow Trout		
	1995	1996 (Summer)	1996 (Fall)	(Fall)	1996 (Summer)	1996 (Fall)
N	3	91	219	30	26	92
Effort (hours)	3.2	13.6	13.6	3.2	18.6	13.6
N<11 inches (TL)	3	17	157	9	2	32
N>11 inches (TL)	0	74	62	21	24	60
PSD (15)	0	1.4	25.8	4.8	4.2	1.7
RSD (20)	0	0	0	0	0	0
Wr (average)	86.1	105.1	83.7	97.3	100.1	93.7

N = Number collected.

TL = Total length from tip of snout to tip of tail.

PSD (15) = Proportional Stock Density - The percentage of sample fish greater than or equal to the minimum stock length that were greater than or equal to 15 inches in total length.

RSD (20) = Relative Stock Density - The percentage of sample fish greater than or equal to the minimum stock length that were greater than or equal to 20 inches in total length.

Wr = Index of condition or relative weight (Wr) -index that compares the actual weight (W) of a fish with a standard weight (Ws) of a given length.

Table 29. Fish stocked in the Niangua River and Lake of the Ozarks.

Species	Years	Number (size)	Location
Hybrid striped bass	1982-83	20,000 (2")	LOZ
	1985-87	176,500 (2")	LOZ
	1988 ¹	133,000 (2")	LOZ
	1989 ²	115,000 (2")	LOZ
	1990 ³	117,700 (2")	LOZ
	1991-96	615,900 (1-5")	LOZ
Paddlefish	1982-88	111,800 (10-14")	LOZ
	1989	10,100 (12-19")	LOZ
	1990-1994	39,000 (10-14")	LOZ
	1995	10,100 (10-14")	LOZ
Striped bass	1967-74	819,000 (2")	LOZ
	1976-79	308,000 (2")	LOZ
	1980-85	958,000 (2")	LOZ
	1986	1,000 (6")	LOZ
	1990,93,95	339,300 (2")	LOZ
Walleye	1985-86	176,000 (2-4")	LOZ
	1991	1,117,300 (fry-5")	LOZ
	1992-96	3,224,000 (fry-4")	LOZ
Blue catfish	1991,95	2,800 (13"+)	LOZ
Threadfin shad	1975,80,81,83	70,000 (adults)	LOZ
Muskellunge	1967,68	225 (N/A)	LOZ
Largemouth bass	1950's	N/A (12")	LOZ
Rainbow trout	1981-94	140,000 (12")	Niangua River ⁴
	1995	8,000 (12")	Niangua River ⁵
Brown trout	1995	2,100 (9")	Niangua River ⁶
	1996	7,500 (9")	Niangua River ⁷

¹6,300 marked with OTC (oxytetracycline).

²10,200 marked with OTC

³27,800 marked with OTC. stock NRO to WG.

⁴85% at Bennett Access (BA), 7% float stock BA to Winchester Gap (WG), 8% at WG Campground, 4.6% float stock NRO to WG.

⁵87.5% at Bennett Access (BA), 7.8% float stock BA to NRO Campground, 4.6% float

⁶Float stock NRO to 0.5 miles up from Prosperine Access (PA)

⁷Float stock 0.5 miles up from NRO to 0.5 miles up from PA.

Glossary

Alluvial soil: Soil deposits resulting directly or indirectly from the sediment transport of streams, deposited in river beds, flood plains, and lakes.

Aquifer: An underground layer of porous, water-bearing rock, gravel, or sand.

Benthic: Bottom-dwelling; describes organisms which reside in or on any substrate.

Benthic macroinvertebrate: Bottom-dwelling (benthic) animals without backbones (invertebrate) that are visible with the naked eye (macro).

Biota: The animal and plant life of a region.

Biocriteria monitoring: The use of organisms to assess or monitor environmental conditions.

Channelization: The mechanical alteration of a stream which includes straightening or dredging of the existing channel, or creating a new channel to which the stream is diverted.

Concentrated animal feeding operation (CAFO): Large livestock (ie. cattle, chickens, turkeys, or hogs) production facilities that are considered a point source pollution, larger operations are regulated by the MDNR. Most CAFOs confine animals in large enclosed buildings, or feedlots and store liquid waste in closed lagoons or pits, or store dry manure in sheds. In many cases manure, both wet and dry, is broadcast overland.

Confining rock layer: A geologic layer through which water cannot easily move.

Chert: Hard sedimentary rock composed of microcrystalline quartz, usually light in color, common in the Springfield Plateau in gravel deposits. Resistance to chemical decay enables it to survive rough treatment from streams and other erosive forces.

Cubic feet per second (cfs): A measure of the amount of water (cubic feet) traveling past a known point for a given amount of time (one second), used to determine discharge.

Discharge: Volume of water flowing in a given stream at a given place and within a given period of time, usually expressed as cubic feet per second.

Disjunct: Separated or disjoined populations of organisms. Populations are said to be disjunct when they are geographically isolated from their main range.

Dissolved oxygen: The concentration of oxygen dissolved in water, expressed in milligrams per liter or as percent.

Dolomite: A magnesium rich, carbonate, sedimentary rock consisting mainly (more than 50% by weight) of the mineral dolomite ($\text{CaMg}(\text{CO}_3)_2$).

Endangered: In danger of becoming extinct.

Endemic: Found only in, or limited to, a particular geographic region or locality.

Environmental Protection Agency (EPA): A Federal organization, housed under the Executive branch, charged with protecting human health and safeguarding the natural environment — air, water, and land — upon which life depends.

Epilimnion: The upper layer of water in a lake that is characterized by a temperature gradient of less than 1° Celsius per meter of depth.

Eutrophication: The nutrient (nitrogen and phosphorus) enrichment of an aquatic ecosystem that promotes biological productivity.

Extirpated: Exterminated on a local basis, political or geographic portion of the range.

Faunal: The animals of a specified region or time.

Fecal coliform: A type of bacterium occurring in the guts of mammals. The degree of its presence in a lake or stream is used as an index of contamination from human or livestock waste.

Flow duration curve: A graphic representation of the number of times given quantities of flow are equaled or exceeded during a certain period of record.

Fragipans: A natural subsurface soil horizon seemingly cemented when dry, but when moist showing moderate to weak brittleness, usually low in organic matter, and very slow to permeate water.

Gage stations: The site on a stream or lake where hydrologic data is collected.

Gradient plots: A graph representing the gradient of a specified reach of stream. Elevation is represented on the Y-axis and length of channel is represented on the X-axis.

Hydropeaking: Rapid and frequent fluctuations in flow resulting from power generation by a hydroelectric dam's need to meet peak electrical demands.

Hydrologic unit (HUC): A subdivision of watersheds, generally 40,000-50,000 acres or less, created by the USGS. Hydrologic units do not represent true subwatersheds.

Hypolimnion: The region of a body of water that extends from the thermocline to the bottom and is essentially removed from major surface influences during periods of thermal stratification.

Incised: Deep, well defined channel with narrow width to depth ration, and limited or no lateral movement. Often newly formed, and as a result of rapid down-cutting in the substrate

Intermittent stream: One that has intervals of flow interspersed with intervals of no flow. A stream that ceases to flow for a time.

Karst topography: An area of limestone formations marked by sinkholes, caves, springs, and underground streams.

Loess: Loamy soils deposited by wind, often quite erodible.

Low flow: The lowest discharge recorded over a specified period of time.

Missouri Department of Conservation (MDC): Missouri agency charged with: protecting and managing the fish, forest, and wildlife resources of the state; serving the public and facilitating their participation in resource management activities; and providing opportunity for all citizens to use, enjoy, and learn about fish, forest, and wildlife resources.

Missouri Department of Natural Resources (MDNR): Missouri agency charged with preserving and protecting the state's natural, cultural, and energy resources and inspiring their enjoyment and responsible use for present and future generations.

Mean monthly flow: Arithmetic mean of the individual daily mean discharge of a stream for the given month.

Mean sea level (MSL): A measure of the surface of the Earth, usually represented in feet above mean sea level. MSL for conservation pool at Pomme de Terre Lake is 839 ft. MSL and Truman Lake conservation pool is 706 ft. MSL.

Necktonic: Organisms that live in the open water areas (mid and upper) of waterbodies and streams.

Non-point source: Source of pollution in which wastes are not released at a specific, identifiable point, but from numerous points that are spread out and difficult to identify and control, as compared to point sources.

National Pollution Discharge Elimination System (NPDES): Permits required under The Federal Clean Water Act authorizing point source discharges into waters of the United States in an effort to protect public health and the nation's waters.

Nutrification: Increased inputs, viewed as a pollutant, such as phosphorous or nitrogen, that fuel abnormally high organic growth in aquatic systems.

Optimal flow: Flow regime designed to maximize fishery potential.

Perennial streams: Streams fed continuously by a shallow water table an flowing year-round.

pH: Numeric value that describes the intensity of the acid or basic (alkaline) conditions of a solution. The pH scale is from 0 to 14, with the neutral point at 7.0. Values lower than 7 indicate the presence of acids and greater than 7.0 the presence of alkalis (bases).

Point source: Source of pollution that involves discharge of wastes from an identifiable point, such as a smokestack or sewage treatment plant.

Recurrence interval: The inverse probability that a certain flow will occur. It represents a mean time interval based on the distribution of flows over a period of record. A 2-year recurrence interval means that the flow event is expected, on average, once every two years.

Residuum: Unconsolidated and partially weathered mineral materials accumulated by disintegration of consolidated rock in place.

Riparian: Pertaining to, situated, or dwelling on the margin of a river or other body of water.

Riparian corridor: The parcel of land that includes the channel and an adjoining strip of the floodplain, generally considered to be 100 feet on each side of the channel.

7-day Q^{10} : Lowest 7-day flow that occurs an average of every ten years.

7-day Q^2 : Lowest 7-day flow that occurs an average of every two years.

Solum: The upper and most weathered portion of the soil profile.

Special Area Land Treatment project (SALT): Small, state funded watershed programs overseen by MDNR and administered by local Soil and Water Conservation Districts. Salt projects are implemented in an attempt to slow or stop soil erosion.

Stream Habitat Annotation Device (SHAD): Qualitative method of describing stream corridor and instream habitat using a set of selected parameters and descriptors.

Stream gradient: The change of a stream in vertical elevation per unit of horizontal distance.

Stream order: A hierarchical ordering of streams based on the degree of branching. A first order stream is an unbranched or unforked stream. Two first order streams flow together to make a second order stream; two second order streams combine to make a third order stream. Stream order is often determined from 7.5 minute topographic maps.

Substrate: The mineral and/or organic material forming the bottom of a waterway or waterbody.

Thermocline: The plane or surface of maximum rate of decrease of temperature with respect to depth in a waterbody.

Threatened: A species likely to become endangered within the foreseeable future if certain conditions continue to deteriorate.

United States Army Corps of Engineers (USCOE) and now (USACE): Federal agency under control of the Army, responsible for certain regulation of water courses, some dams, wetlands, and flood control projects.

United States Geological Survey (USGS): Federal agency charged with providing reliable information to: describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect the quality of life.

Watershed: The total land area that water runs over or under when draining to a stream, river, pond, or lake.

Waste water treatment facility (WWTF): Facilities that store and process municipal sewage, before release. These facilities are under the regulation of the Missouri Department of Natural Resources.

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