MERAMEC RIVER

WATERSHED

DEMONSTRATION PROJECT

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U.S. Environmental Protection Agency

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EXECUTIVE SUMMARY

Project Overview

The overall purpose of the Meramec River Watershed Demonstration Project is to bring together relevant information about the Meramec River basin and evaluate the status of the stream, watershed, and wetland resource base. The project has three primary objectives, which have been met. The objectives are: 1) Prepare an inventory of the Meramec River basin to provide background information about past and present conditions. 2) Facilitate the reduction of riparian wetland losses through identification of priority areas for protection and management. 3) Identify potential partners and programs to assist citizens in selecting approaches to the management of the Meramec River system. These objectives are dealt with in the following sections titled Inventory, Geographic Information Systems (GIS) Analyses, and Action Plan.

Inventory

The Meramec River basin is located in east central Missouri in Crawford, Dent, Franklin, Iron, Jefferson, Phelps, Reynolds, St. Louis, Texas, and Washington counties. Found in the northeast corner of the Ozark Highlands, the Meramec River and its tributaries drain 2,149 square miles. The main stem of the Meramec's 218 linear miles carries water from the lightly populated, forested, and agricultural upper watershed north easterly to the heavily populated and urbanized lower watershed to enter the Mississippi River below St. Louis. Meramec tributaries of fifth order or greater include Courtois, Crooked, Dry, Dry Fork, Huzzah, and Indian creeks and the Little Meramec River. Meramec base flows are well sustained by springs characteristic of the region's karst topography and by drainage from the Big and Bourbeuse rivers, two major tributaries large enough to merit their own basin inventory and management plans. The Bourbeuse enters the Meramec at river mile 64.0, and the Big River enters the Meramec at river mile 35.7.

Present Meramec River basin landcover consists of roughly one-half forest, one-quarter pasture, and one-quarter cropland, rural transportation, urban development, water, and other minor land uses combined. Within the upper Meramec River portion, nearly one third of the forest land is privately owned. The Mark Twain National Forest covers a large area in the remaining two thirds. Major resource uses within the Meramec River basin include grazing, logging, and mining lead, iron, sand and gravel. Earlier land-use practices have been identified as possible causes for stream morphology changes in the Meramec as well as other stream systems within the Ozarks. There is a current trend toward increasing numbers of cattle and increasing grazing density. Where cattle have free access to streams, this trend causes more stream-channel disturbance. Also, gravel mining contributes to the accelerated transport of sediments in the Meramec River basin.

Overall, water quality within the Meramec River basin is quite good. In fact, the Missouri Department of Natural Resources Clean Water Commission designated segments of Courtois Creek, Huzzah Creek, Blue Springs Creek, and the Meramec River as Outstanding State Resource Waters. Despite the basin's overall good water quality, problems do exist. In the upper and middle basin, cattle grazing on creek bottom pastures is very common. When cattle have open access to streams, damage to riparian areas and excessive nutrient loading of the streams often results. In the upper basin, impoundments containing tailings from mining operations pose a potential threat to stream water quality. The lower watershed from Eureka to Fenton is an urbanized zone that poses other threats to water quality. Sediment and pollution-laden runoff enter the lower Meramec system rapidly because of impervious surfaces from development and the channelization of tributaries.

Stream habitat quality is fair to good throughout most of the basin. Some areas, including portions of the Brazil subwatershed, Courtois, Huzzah, and Indian Creek watersheds, suffer from a more severe lack of riparian vegetation. In these and other streams the lack of adequate riparian corridors, excessive nutrient loading, streambank erosion, excessive runoff and erosion, and the effects of extensive instream gravel mining are among the problems observed. Grazing practices along many streams contribute to streambank instability, nutrient loading, and poor riparian corridor conditions. Increased land clearing and higher runoff associated with urbanization also impact stream habitat quality.

The basin has a very diverse fish assemblage of 125 fish species collected since 1930. The crystal darter, a state listed species, is present in the lower Meramec Basin. Excellent sportfishing is available on the Meramec and its tributaries, and basin streams are widely acclaimed, particularly for smallmouth bass and rock bass. Sportfishing management emphasis species are smallmouth bass, largemouth bass, rock bass, brown trout, and rainbow trout. Crawford County contains the Meramec River Smallmouth Bass Special Management Area (from Highway 8 to Scott's Ford Access), the Meramec River Special Trout Management Area (from Scott's Ford Access to Bird's Nest Access), and the Blue Springs Creek Wild Trout Management Area. The heavily fished Maramec Spring Park lies immediately adjacent to the Meramec in Phelps County. The taking of non-gamefish (mainly sucker species) by gigging is a strong tradition throughout the basin. Floating and float-fishing are highly popular, particularly on the upper Meramec, Huzzah, and Courtois. Seventeen Missouri Department of Conservation (MDC) stream access sites are located in the basin. Access to stream frontage is also provided by a mix of MDC conservation areas, Missouri Department of Natural Resources (MDNR) state parks, county parks, and United States Forest Service (USFS) lands.

Meramec mussel populations have been surveyed periodically. Relative abundances are declining, and habitat disturbances are the suspected cause. Fortunately, the endangered pink mucket (federal listing) is still maintaining a presence in the lower Meramec.

The Meramec River basin contains 8 species of crayfish and many aquatic insect groups, including pollution intolerant species that require clear, well-oxygenated, unpolluted streams. Unusual macroinvertebrates found in the Maramec Spring system include the cave crayfish (*Cambarus hubrichti*) and a caddisfly, *Glyphopsyche missouri* Ross. The cave crayfish inhabits the subterranean spring system while *Glyphopsyche missouri* is found in the spring branch. Maramec Spring is the only known location of *Glyphopsyche missouri* in the world.

GIS Analyses

The initial goal of the GIS analyses part of the project was to produce many different large-scale GIS layers for the Meramec River basin with a final objective of using the products to prioritize wetlands for protection through acquisition or voluntary stream incentive programs. Six prioritization analyses were completed to answer wetland protection objectives: stream prioritization, watershed landcover prioritization, stream landcover prioritization, fish nursery wetland identification, wetland prioritization, and fish community prioritization. Three other analyses, spectaclecase mussel distribution, slender madtom distribution, and species richness comparison, were used to guide future sampling efforts, to understand distribution of species, and to identify the effects of various human activities on the aquatic resource.

The stream prioritization analysis was performed to find stream segments near public land and near sites known to provide habitat for endangered species, or within reaches with spawning season restrictions for sand and gravel mining. The resulting selected set of 528 priority stream segments form only 5.6% of the 9,364 major stream segments for the basin. A series of seven GIS layers identifying either attractive features on or around the streams, such as springs or observed natural heritage species, or degrading features, such as chemical spill sites or mines, have been made available to further assess specific lands identified by any of the protection analyses.

Watershed landcover prioritization involved merging the project subwatershed layer with the landcover classification, and then rating the subwatersheds based on the percentages of certain landcover types, such as the Forest or Urban classes. Rated subwatersheds in order of most negatively impacted to the least negatively impacted watersheds were: Mattese Creek, Lower Lower Meramec. Lower Meramec Mainstem 5, Grand Glaise Creek, Fishpot Creek, Fishwater Creek, Dry Branch, Lower Courtois Creek, Billy’s Branch, and Upper Indian Creek. Subwatersheds with greatest area of cropland from most to least were: LowMid Meramec main stem 6, Calvey Creek, LowMid Meramec main stem 3, Dry Fork main stem 1, and Lower Meramec main stem 6. Lastly, the subwatersheds with greatest area of grasslands were from most to least: Upper Dry Fork, Dry Fork main stem 1, Little Dry Fork, Spring Creek, and Norman Creek.

Stream landcover prioritization involved merging the landcover classification with streams and a 90-meter buffer area around them to identify the landcover type percentages about the streams. The merged stream-landcover GIS layer enables the biologist or planner to identify with simple queries those places in the basin where extensive row crop agriculture is occurring in close proximity to the stream channel. The relationship between cropland and streams varies among the subwatersheds, and significant reaches of unprotected streambanks can occur in any subwatershed with cropland. This analysis produced a data set with 71.0 kilometers (44.1 miles) of streams that have a high potential for receiving sediment and farm chemicals, because they are adjacent to cropland and may have little or no corridor.

In the fish nursery wetland identification analysis, a set of potential fish nursery wetland areas were selected. The results were used to provide one of the criteria for the wetland prioritization analysis. The analysis utilized the National Wetland Inventory system of classes and modifiers to select among the many types of Palustrine wetlands. These selected wetlands were then reduced to those that have a direct connection to perennial streams to ensure juvenile fish could have access to the stream resource when they mature. Field reconnaissance further determined the accuracy of potential nursery areas. Out of these natural wetlands, only 398, or 2.5% of the total are inundated for extended periods. Out of these 398, 31 wetlands, which comprise only 0.12% of the total number of wetlands, had connectivity to perennial streams and were selected as potential fish nursery wetlands. Natural wetlands that might provide habitat for extended periods of time and have direct connection to water filled segments of the stream network, prove to be rare in the Meramec River basin.

In the wetland prioritization analysis, wetlands were rated according to a series of criteria that are based not only on the rarity or importance of the wetland type, but also on the local land use, as well as the proximity of the wetland to either beneficial areas (public land) or potentially degrading ones (encroaching urban areas). Rated wetlands had to be natural and Palustrine. Natural wetlands comprised

11.8% on public land (already protected), 43.6% within a mile of public land, 8.4% within a city limit, and 16.7% within a mile of a town. Thirteen protection area polygons (delineations) encompassed the areas with the densest clumps of highly rated wetlands. These areas were, from largest wetland clusters to smallest wetland clusters and with a polygonal (delineated) wetland rating, respectively, from 1-13: Saline Creek, Pacific, Eureka, Telegraph Road, Steelville, St. Clair, Salem, Crooked Creek, Scotts Ford/Riverview, The Eagle, Courtois/Lost Creek, Huzzah CA, and Short Bend.

The fish community prioritization analysis was done to prioritize areas for protection. Criteria used for the analysis were: 1) species richness, 2) habitat characteristics such as the presence of wetlands and springs, 3) public land, and 4) the presence of human impacts, such as mining sites or chemical dumping sites. The first analysis was a statistical analysis on the above dataset. Only weak correlations were found between the datasets. The second analysis used a ranking system (four to 18, the higher the value the more suitable the stratum) to determine which strata might be recommended for land acquisition. The highest score from the analysis was 16 for strata F. Thirteen strata received scores of 12 or below. The nine remaining strata scoring above 12 were considered.

Analyses were done to investigate the sampled range of aquatic habitat attribute values (stream order, gradient, miles to headwater) from collection sites making a "signature" for a species. These signatures were then used to select stream segments with the same attribute values in order to predict the potential range of the endangered spectaclecase mussel and the slender madtom. The spectaclecase sampled range was confined to the Meramec River from river mile 10.0 to 136.2, or a total of 126.3 stream miles. The predicted range using GIS was 167.9 stream miles, a potential range that was 32.9% greater than the length of the sampled range. The predicted range of the slender madtom was extensive, 794.8 miles, or approximately 4.5 times the sampled range, which was 176.3 miles in extent. Differences between potential range and actual range point to the need to investigate possible factors contributing to the apparent discrepancy.

Action Plan

Major goals for the Meramec River watershed are improving water quality, improving riparian and aquatic habitat conditions, maintaining diverse and abundant populations of native aquatic organisms and sportfish, providing for a high level of recreational use, and increasing public appreciation for the stream resources. Cooperative efforts with other resource agencies on water quality, habitat, and watershed management issues will be critical. Enforcement of existing water quality and other stream-related regulations and necessary revisions and additions to these regulations will help reduce violations and lead to further water quality improvements. Working with related agencies to promote public awareness and incentive programs and cooperating with citizen groups and landowners will result in improved watershed conditions, better water quality, and a healthier stream system.

TABLE OF CONTENTS

LOCATION

The beautiful Meramec River basin is in the northeastern quarter of the Ozark Highlands. We excluded the two major tributaries, the Bourbeuse and Big rivers from this watershed inventory and assessment; as major streams themselves, they will be treated in separate Missouri Department of Conservation (MDC) watershed assessments. Overall, the basin comprises the upper Meramec River, Dry Fork, Huzzah Creek, Courtois Creek (pronounced Code-away by local residents), Indian Creek, Little Meramec River, and the lower Meramec River drainages. The river flows northeast through Phelps, Crawford, Dent, Franklin, Jefferson, and St. Louis counties to join with the Mississippi River. Other counties within the Meramec's drainage are Texas, Iron, Reynolds, and Washington (Figure 1).

The entire basin, including the Bourbeuse River and the Big River, drains 3,980 square miles into the upper Mississippi River Basin (USGS 1994). The Meramec River, excluding the Bourbeuse and the Big rivers, drain 2,149 square miles (MDC Fisheries Research Section 1996). The lower drainage flows through urbanized area of St. Louis and Jefferson counties, while the upper drainage swirls through forested and agricultural areas.

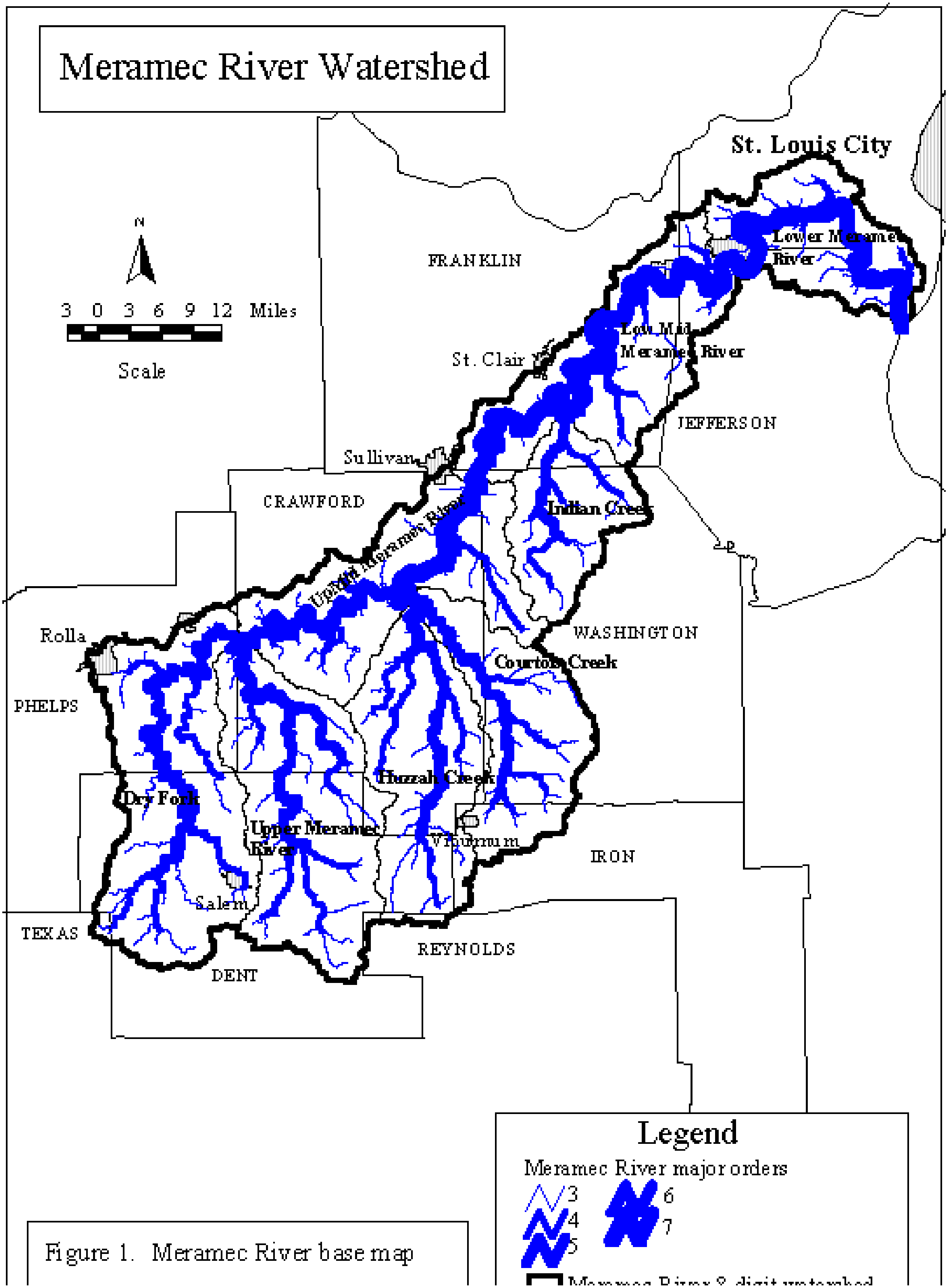


Figure 1. Meramec River base map

Source: USGS topos (streams), NRCS (24K watershed boundaries)
Created by: Todd J. Blanc

Meramec River 8-digit watershed
Meramec River 11-digit watersheds
Cities
Countyboundaries

GEOLOGY

A.

A.1. PHYSIOGRAPHIC REGION

The Meramec River basin is one of the most rugged regions of the Midwest. Most of the Meramec River basin lies within the Salem Plateau subdivision of the Ozark Plateau. The lower Meramec River lies within the Central Lowland Region.

Topography varies from wide ridges and gentle slopes to narrow ridges, steep slopes and bluffs. Gently rolling topography is found in the north and west portions. Steeply rolling topography is found in the south-central portions (USDA 1966). Land elevations range from 400 feet to 1,400 feet. Major features of the geology are Mississippian, Precambrian igneous, Ordovician Cincinnatian and Champlanian series, and Canadian series rock formations (Missouri Department of Natural Resources or MDNR 1986). Major rock types are dolomite, limestone, chert, and sandstone. Karst features such as caves, sinkholes, and underground streams are locally prominent in the Salem Plateau (MDNR 1986).

A unique feature of the karst Ozark Uplands is the presence of many springs. The Dry Fork watershed in Dent and Phelps counties is thought to contribute to Maramec Spring (Vineyard & Feder 1982; see subsection, D.2.1., Figure 13). The Dry Fork disappears or loses to reappear many miles north near the Meramec River (Pflieger 1971).

A.2. GEOLOGY

The Meramec River basin possesses a range of surface rocks varying in age from the Pennsylvanian to the Precambrian period (MDNR 1984, 1995a). The majority of the surface rock types are the Ordovician Age rock of the Gasconade and Roubidoux formations, which is underlain chiefly by limestone, dolomite to cherty dolomite with minor sandstone. To a lesser extent, the lower portions of the basin near the Mississippi River have rock of the Mississippian Age, which is a mix of St. Louis Limestone, Salem Formation, Keukok Limestone, and Burlington Limestone (MDNR 1979, 1995a). Between Gray Summit and Valley Park, the river winds through the geologically older Ordovician Age rock lain from oldest to youngest by St. Peter Sandstone, Joachim Dolomite, and Plattin Formation (limestone, shale, and chert). In the Huzzah-Courtois Creek watershed, the Cambrian rocks are overlain from oldest to youngest by the Davis (shale, dolomite, and conglomerate) Formation, Derby-Doerun Dolomite, and Potosi Dolomite at the surface (MDNR 1979, 1995a). The Potosi Dolomite is found primarily along the bottomlands of the upper and middle Meramec River, Huzzah and Courtois creeks. A fault dissects the Huzzah Creek watershed dividing the older Potosi Dolomite and the younger Gasconade and Roubidoux formations.

A.2.1. Losing Streams

Permeable geologic material of the Meramec River region allows streams to lose water to bedrock aquifers. Thirty percent or more of the stream flow must be lost to bedrock within two miles flow distance downstream of an existing discharge to be considered a losing stream (MDNR Clean Water Commission Water Quality Standards, 10 CSR 20-7.01, 1994). Most losing streams within the Meramec

River basin are found in Crawford, Phelps, Reynolds, and Dent counties, totaling 160.4 miles of streams for the listed counties (MDNR Division of Geology and Land Survey 1992). Knowledge of losing streams is useful for fish kill and pollution investigations. For example, a losing stream section of the Dry Fork had a break in an ammonia pipeline that killed cave crayfish in Maramec Spring. A list of the known losing streams is available from the Department of Natural Resources Division of Geology and Land Survey and the Water Pollution Control Program.

A.3. SOIL

The Natural Resources Conservation Service "NRCS" (formerly known as Soil Conservation Service "SCS") Soil Survey characterizes the Meramec River basin in an aggregate of soils known as the Deep Loess Hills area (Figure 2) within the northern most river portions (Jefferson and St. Louis counties), shifting to the Ozark Border and the Ozark Plateau to the southwestern extent (MDNR 1986). The Meramec River Watershed Regions and Generalized Soil Associations map (Figure 2) is based on 1991 Missouri digital soil survey data (NRCS). Associations have changed from the original SCS 1979 generalized soil references, illustrating improved information. The physiographic regions, however, have not changed and show the relative position of each region. Local variations in climate and parent material, landforms, and vegetation produce a variety of separate soil types. Based on the 1979 SCS Generalized Soils, within all major land resource areas, the Hartville-Ashton-Cedargap-Nolin Association parallels the Meramec River channel.

A.3.1. Soil Types

Within the Deep Loess Hills area, the Menfro-Winfield Association (Table 1) comprises part of the Meramec River basin (Allgood and Persinger, SCS 1979). Menfro is a deep, well-drained soil with slopes of 2 to 20%. Menfro formed in loess (wind-deposited silt, commonly accompanied by some clay and fine sand) ridge tops and side slopes. On the surface lies silt loam underlain by moderately permeable, silty clay loam subsoil. While formed, however, in the same loess ridge tops and side slopes and having the same surface and subsurface soil as Menfro, Winfield is moderately well drained with slopes of 2 to 20%.

The Ozark Border is a transitional area between the Deep Loess Hills area and the Ozark Plateau. Ridge tops have a thin mantle of loess caps and soils formed in fragipans (Allgood & Persinger 1979). Fragipans are loamy, brittle subsurface horizons, low in porosity and content of organic matter and low or moderate in clay. It appears cemented and restricts roots. Soil associations are similar to the Ozark Plateau with the exclusion of the Union and the Gasconade. The deep, cherty clayey soil is high in iron that oxidizes on exposure, giving a red color to the soils. Within the Ozark Border, two soil associations predominate: the Union-Goss-Gasconade-Peridge Association and the Hobson-Clarksville-Gasconade Association (Table 1).

Forests, scattered glades, and prairie areas are found in the Ozark Plateau. Soil types in this area are variable, generally having infertile, stony clay soils in some areas and fertile, loess-capped soils in others (MDNR 1986). Stony, cherty soils characterize much of the Ozark Plateau. Weathering of limestones, an important soil forming rock, leaves little behind except chert; as a result, soil formation is slow (Pflieger 1971). Within the Ozark Plateau four associations predominate: the Lebanon-Hobson-Clarksville Association, Hobson-Coulstone-Clarkville Association, the Captina-Clarksville-Doniphan Association, and the Hartville-Ashton-Cedargap-Nolin Association (Allgood & Persinger 1979). Possessing unique features, Lebanon is a moderately well-drained soil, holding a limited effective root zone due to the presence of a fragipan. The Clarksville, which is largely devoted to the production of trees (USDA 1966), is excessively drained and formed in cherty dolomite and limestone residuum. On the surface is a very cherty silt loam underlain by very cherty, silty clay loam (Allgood & Persinger 1979).

A.3.2. Erosion Potential

Sheet, rill, and gully erosion are the three types of upland erosion that affect the streams in the Meramec River basin (Anderson 1980). Soil scientists define rill erosion as an incision created in the land greater than 12 inches in depth. These incisions occur mostly on recently tilled soils. Sheet erosion is soil removal by raindrop splash and overland flow that does not create channels greater than 12 inches in depth. In the Meramec River basin, sheet and rill erosion contribute 24-30 tons/acre from tilled land, 5-9 tons/acre from permanent pasture, and 0.25-0.5 tons/acre from non-grazed forest land to soil losses. In a 1978 Soil Conservation Survey (SCS) Erosion Inventory Report for all upland types in the Meramec River basin combined, sheet erosion soil losses were 3.5 tons/acre/year (Anderson 1980). Also, sediment yield by stream basins was 0.9 tons/acre/year. The sediment sources are 80% sheet and rill erosion, 7% gully erosion, 3% stream bank, and 3% urban (Anderson 1980).

In comparison to other basins in this survey, the Meramec River basin was lower in actual sediment, mainly because the basin has comparatively less upper watershed development. Best Management Practices advocated by the SCS (called the Natural Resources Conservation Service, starting in 1995) are used by some landowners to reduce the impact of these forms of sedimentation (Anderson 1980). The 1979 SCS Missouri Water Quality Management Plan designated practices for erosion reduction and sediment control. Within the Meramec River basin resource area as defined by Soil Conservation Service, practices most needed were grade stabilization structures, contour farming, crop residue use, and conservation cropping systems. The watershed approach to improving streams was advocated at least as early as the 1940s. As Bill T. Crawford (1944) in AThe Meramec - St. Louis Playground@ writes, "to save the soil is to save the stream and this can be accomplished by cultivating only the gentle slopes, terracing, contour farming, strip cropping, substituting forage crops for row crops, reforesting, and preventing wood fires and overgrazing."

A.3.3. Riparian-Wetland Types

In wetland classification systems (several systems exist), water regime, soil characteristics, vegetation, and possible landscape positions are used to categorize natural Missouri wetlands into eight generalized types: swamp, shrub swamp, forested wetland, marsh, wet meadow, fens and seeps, pond and lake borders, and stream beds (Epperson 1992). For instance, fen wetlands have saturated soils from alkaline groundwater, while seep wetlands have a primary source of saturated soils from neutral, acidic, or saline groundwater. A cross-reference comparison among the generalized Missouri wetland types, the US Fish and Wildlife Services Cowardin System, the SCS Food Security Act System, and the Missouri Natural Terrestrial Communities System is presented in Missouri Wetlands: A Vanishing Resource by Epperson, 1992.

Riparian-wetland types are land adjacent to streams and are. The Missouri Department of Conservation's Natural Heritage Database contains an inventory of Missouri Natural Terrestrial Communities that are on publicly- and privately-owned land. This database also lists those rare and endangered species that are within different wetlands types or streams. The following are Missouri Natural Terrestrial Communities found within the Meramec River basin as listed in the Heritage Database: deep muck fen, fen, mesic bottomland forest, gravel wash, and wet-mesic bottomland forest (Table 2).

A.4. WATERSHED AREA

We estimated the basin's surface area from the MDC Fisheries Research GIS database (Table 3). The Meramec River basin drains a total of 2,149 square miles and 1,375,493 acres of land. The upper watersheds, the Dry Fork, the Upper Meramec River, the Huzzah Creek, and Courtois Creek, respectively, comprise 383, 345, 266, 220 square miles or 17.9, 16.1, 12.4, and 10.2% of the total basin area. The U.S. Geological Survey divides the Meramec River into the 11-digit (see Table 3 for clarification) Upper Meramec River watershed from river mile 166-218, the Upper Middle Meramec River watershed from river mile 110-166, Lower Middle Meramec River watershed from river mile 42-110, and the Lower Meramec River watershed from river mile 0-42 (see Figure 1 or Appendix A for clarification). The lower watersheds, the Lower Meramec River, the Lower Middle Meramec River, Indian Creek, and Upper Middle Meramec River, respectively, drain 234, 250, 158, and 293 square miles or 10.9, 11.6, 7.4, and 13.6% of the total watershed area.

A.5. STREAM ORDER AND MILEAGE

Stream order was determined using a system of classification that was first defined by Horton (1945) and later modified by A.N. Strahler (1952). Strahler called all unbranched tributaries first-order streams; two first-order streams join to make a second-order stream, and so on downstream to the stream mouth.

East Central Region Fisheries personnel determined stream mileage using a pair of locking dividers and U.S. Geological Survey topographic maps (Table 1-A, Appendix A) and tabulated stream mileages by name, watershed position, and mile marker confluence (Table 2-A to 9-A, Appendix A). The Meramec River has a total of 218 linear stream miles and 201 miles of permanent stream flow.

A.6. GRADIENT PLOT

Missouri Department of Conservation biologists in the East Central and St. Louis regions collected elevation and distance data from USGS 7.5 minute topographic maps (usually 20-feet contours). They tabulated gradient by stream order and watershed, measuring the vertical drop over a given distance for the number of streams that were third-order or greater (Table 2-A to 9-A, Appendix-A). Average gradient for the Upper Meramec River watershed is 34.7 feet/mile, and the average gradient for the Lower Meramec River watershed is 1.0 feet/mile.

Within a watershed, we created gradient plots for all fourth-order or greater streams, and for third-order streams that were at least 4.25 miles long (Appendix A, Figure 1-A thru 8-A). Also, a composite map of the Meramec River and tributaries was plotted (Appendix A, Figure A). In comparison, Courtois Creek is higher in elevation than Huzzah Creek, resulting in a much higher gradient (48.4 feet/mile versus 9.1 feet/mile). The Dry Fork, a losing stream, has a relatively mild stream gradient in most areas (15.3 feet/mile). The remaining tributaries, the Upper Meramec River (73.0 feet/mile) and Indian Creek (155.0 feet/mile), represent systems with the highest gradients.

Gradient plots are useful for understanding channel steepness in relation to geology. The relief of the land influences drainage, runoff, and other factors such as erosion. The average gradient of the river decreases downstream, so the long profile is a hyperbolic curve that decreases in gradient downstream (Appendix A, Figure A). For example, because the Meramec River basin did not undergo glaciation in the last glacial age, the present gradient is the result of erosional processes, structural dissection, and repeated uplift. The Salem Plateau is a very extensive landform covering most of the basin. Many streams and hollows in the Salem Plateau tilt toward north and east. The lower basin has Deep Loess Hill soil types and elevated older rocks. Also, lower basin streams cut through the Ozark uplift (dolomite and sandstone bedrock), explaining the lower stream gradient. In the upper basin, a fault crosses the path of the Huzzah-Courtois Creek watershed, thrusting up older rocks so that most of the surface rock is Potosi Dolomite in the upper Huzzah-Courtois Creek watershed, changing abruptly to Gasconade and Roubidoux Dolomite. At this point near river mile 3.0, gradient in Shoal Creek decreases abruptly.

A.6.1. Gradient Related to Distribution of Fish

Gradient data was linked with the fish community data via the stream name, river mile, and order. Searches on a species of interest and its occurrence can tell us something about that species' distribution in relation to gradient. As expected, greater numbers of occurrences of catastomids were found at the lower gradients and lesser occurrences at higher gradient. Two other catastomids, the black redhorse and the northern hog sucker, had a greater distribution across stream gradient (Missouri Department of Conservation Fisheries Research Section 1995). The black redhorse was found in gradients ranging from 1 to 22 feet/mile, and the hog sucker gradients ranging from 2 to 33 feet/mile. Among the centrarchids, the species with the widest distribution was the longear sunfish, found in gradients ranging from 2 to 67 feet/mile. The rock bass was not quite so well distributed, occupying gradients ranging from 1 to 37 feet/mile. Benthic species, such as the northern orangethroat darter, the central stoneroller, and the Ozark sculpin, occupy a large number and wide range of gradients. These three species were collected at gradients ranging from 1 to 87 feet/mile. Cyprinids (minnows and shiners), such as the striped shiner, have a wide distribution and are found in relatively unstable, high gradient areas as well as stable, low gradient areas.

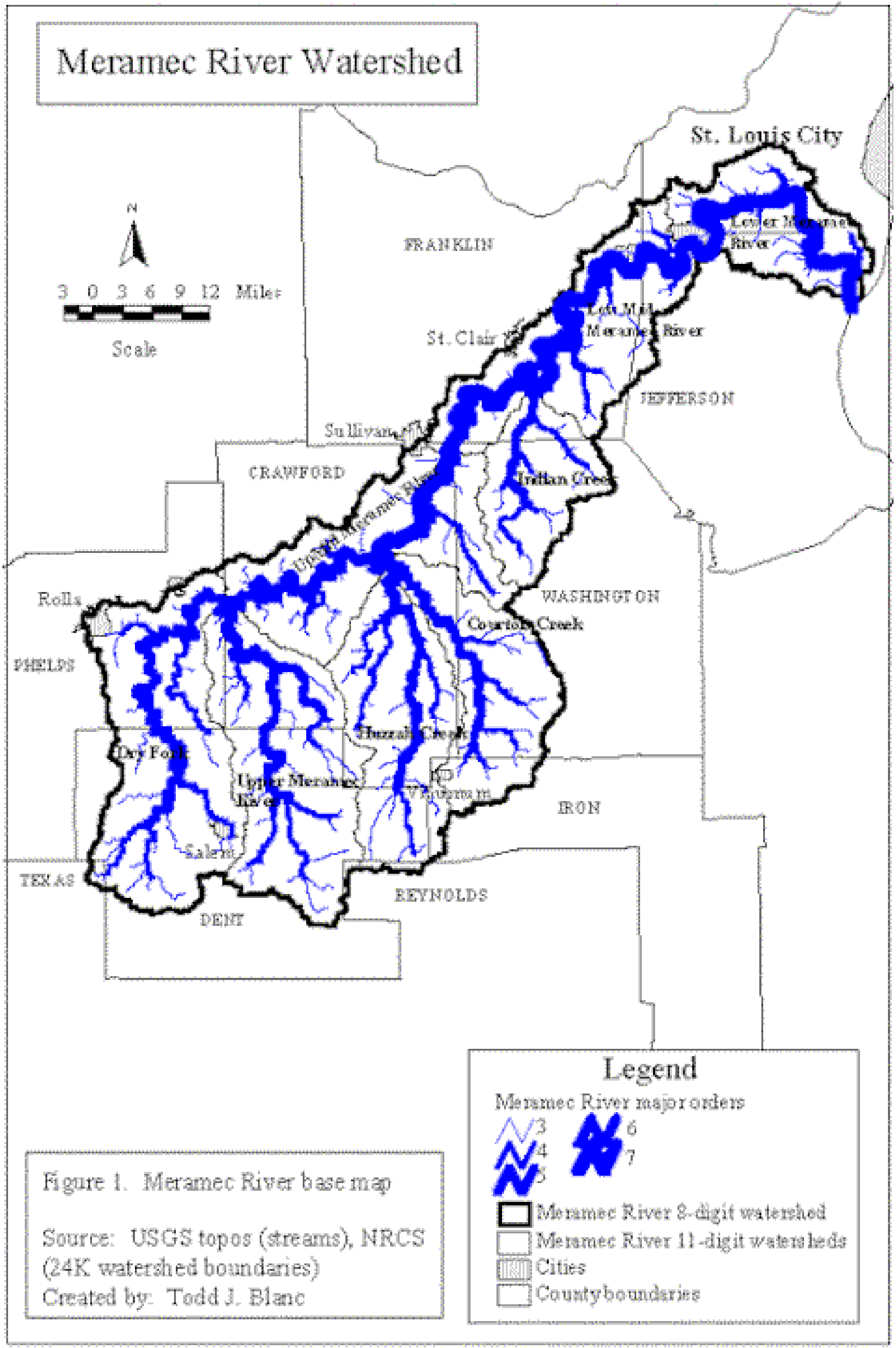


Figure 1. Meramec River base map

Source: USGS topos (streams), NRCS (24K watershed boundaries)
Created by: Todd J. Blanc

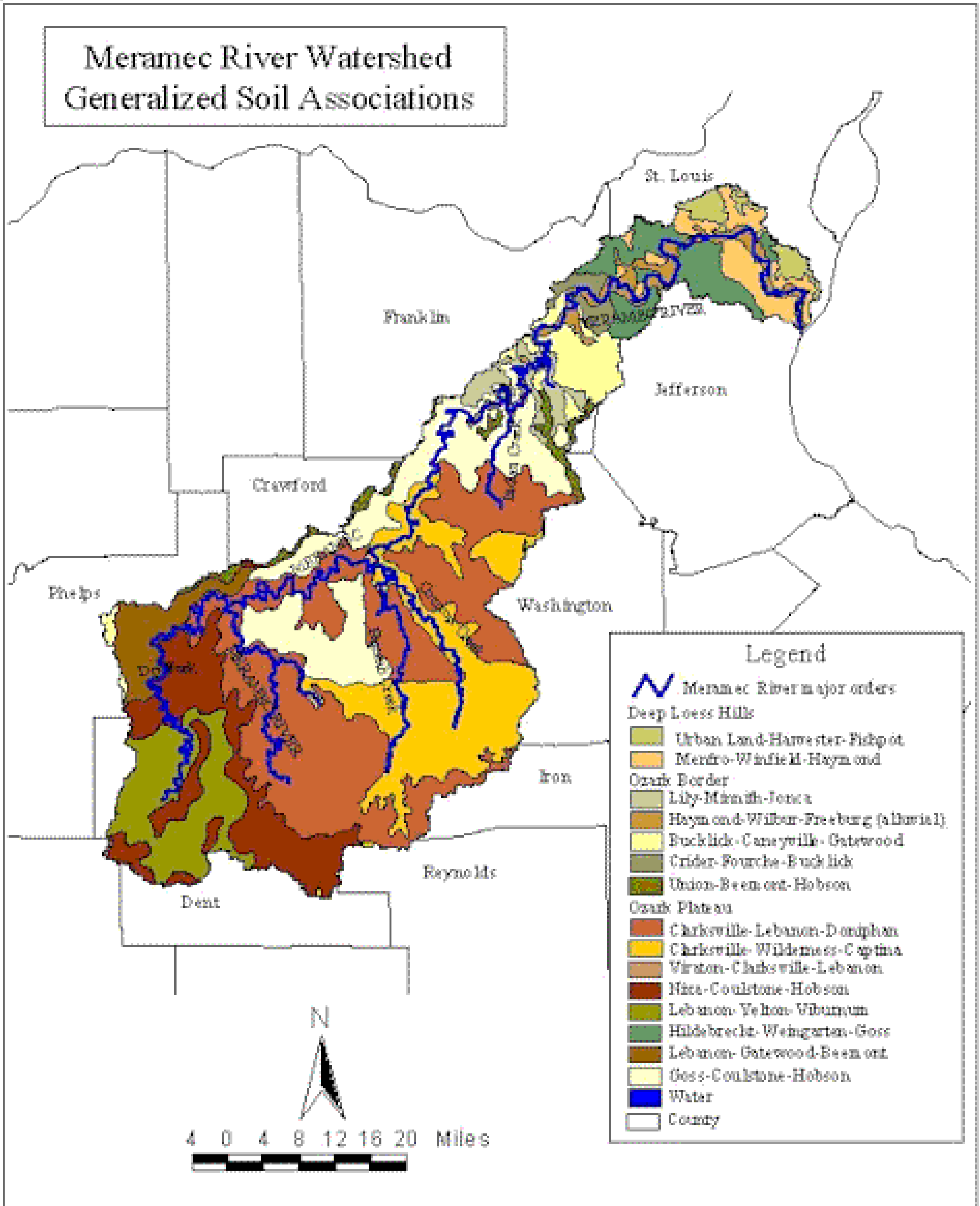


Figure 2. Generalized soils associations map for the Meramec River watershed
Data source: STATSGO, 1997 & MDC Fisheries Research -- Hydrography.

Created by: Todd Blanc, 1997

Location of the Meramec River Watershed in relation to Missouri's Natural Divisions.

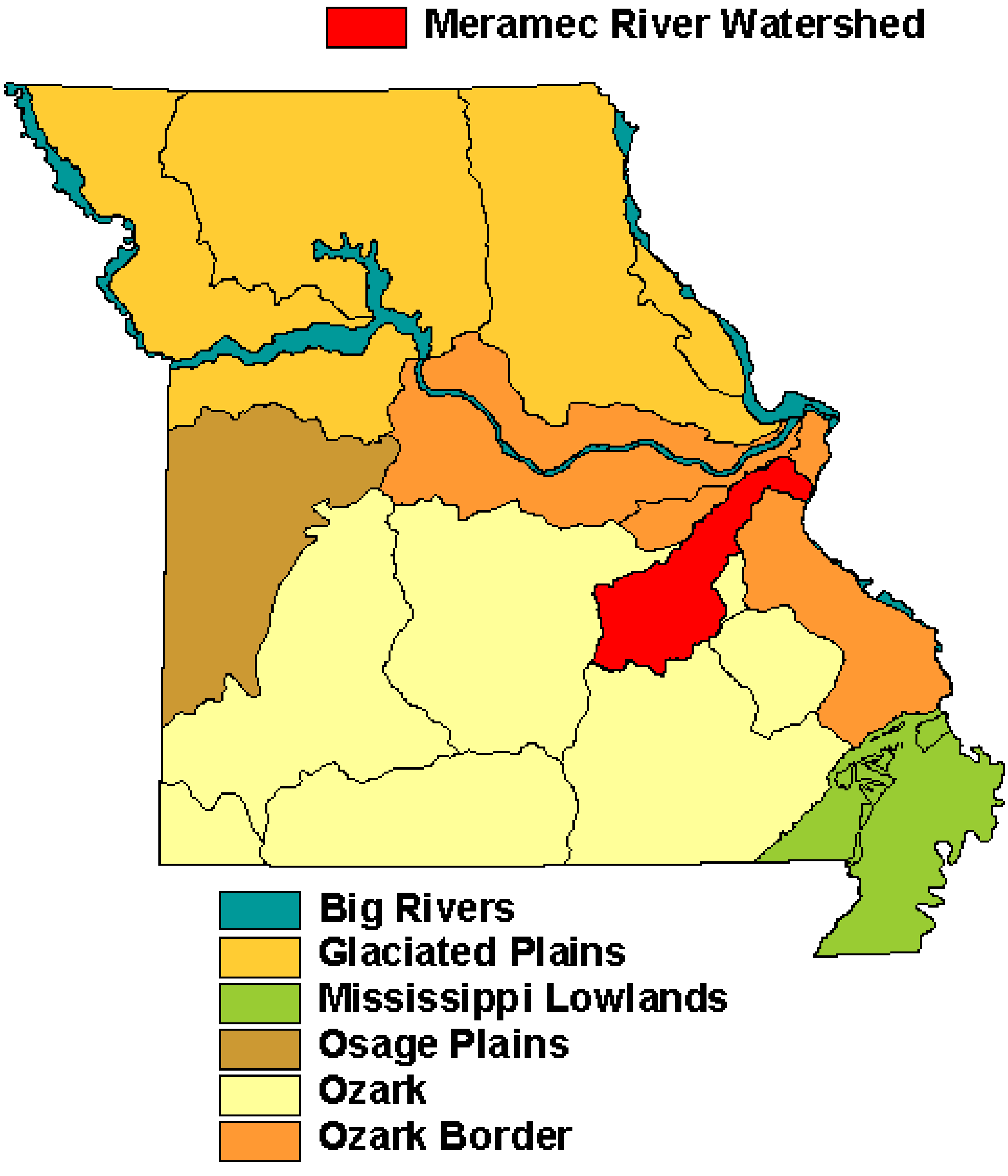


Table 1. Soil characteristics of the generalized soil associations (SCS 1979) related to hydrology, water management, erosion and runoff within the Meramec River basin (SCS Franklin Co. Soil Survey 1989, Dent Co. Soil Survey 1971, Iron Co. Soil Survey 1991, St. Louis Co. Soil Survey 1982)

	Feature Affects		Water Erosion Factors[2]		Water Features	
Soil Name	Grassed Waterway[1]	Drainage	K	T	Hydro-Soil Group[3]	Water Capacity[4]
Menfro	Erodes easily	Deep to water	0.37	5	B	0.20-0.24
Winfield	Erodes easily	Frost action(freezing and thawing of soil moisture), slope	0.37	5	B	0.20-0.24
Hartville	Erodes easily, percs slowly	Percs slowly, frost action	0.28-0.43	4	C	0.1-0.24
Union	Erodes easily, shallow root zone	Percs slowly, slope	0.43-0.43	4	C	0.11-0.21
Goss	Large stones, slope, droughty	Deep to water	0.1-0.24	2	B	0.04-0.17

Peridge	**Erodes easily**	**Deep to water**	**0.37-0.32**	**5**	**B**	**0.16-0.20**
Ashton	**Erodes easily**	**Deep to water**	**0.43-0.28**	**4**	**B[a]**	**NA**
Cedargap	**Large stones**	**Deep to water**	**0.1-.024**	**5**	**B[b]**	**0.04-0.18**
Nolin	**Erodes easily**	**Deep to water**	**0.43-0.43**	**5**	**B[c]**	**0.18-0.23**
Hobson	**Erodes easily, droughty**	**Percs slowly, slope**	**0.37-0.37**	**3**	**C**	**0.01-0.24**
Clarksville	**Large stones, slope, droughty**	**Deep to water**	**0.28-0.28**	**2**	**B**	**0.05-0.12**
Gasconade	**Large stones, slope, droughty**	**Deep to water**	**0.2-0.2**	**2**	**D**	**0.05-0.12**
Lebanon	**Wetness, erodes easily**	**Percs slowly, slope**	**0.32-0.43**	**4**	**C**	**0.02-0.22**
Captina	**Erodes easily, shallow root zone**	**Percs slowly, slope**	**0.43-0.32**	**3**	**C**	**0.14-0.16**

Doniphan	**Droughty, slope**	**Deep to water**	**0.28-0.28**	**4**	**B**	**0.08-0.10**
Coulstone	**Droughty, slope**	**Deep to water**	**0.24-0.24**	**3**	**B**	**0.06-0.09**

[1] A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.
[2] Soil erodibility factor (K) reflects the susceptibility of a soil to erode under the action of raindrop impact and water flowing over the surface (sheet and rill erosion). (T) is rating from 1 (most erodible) -10 (least erodible) on erodibililty.
[3] Refers to the soil behavior according to water infiltration, transmission, and runoff producing characteristics. The slope and the plant cover are not considered but are separate factors in predicting runoff. Group "A" has a high infiltration rate and low runoff potential. The other extreme is group "D" which has a low infiltration rate and a high runoff potential.
[4] Presented is a range in inches from surface to bottom soil layer.
The amount of water that would be maintained in soil after natural drainage in response to gravity alone. Varies with soil texture, structure, rock fragment content and other soil properties.
The available water capacity in a 60-inch profile or to a limiting layer is:
0-6 inches: Very low, 3-6 inches: Low, 6-9 inches: Moderate , 9-12 inches: High
[a] JAN-APR [b] NOV-MAY [c] FEB-MAY

Table 2. Wetland types identified by the Missouri Department of Conservation's Natural Features Inventory (MDC, 1995 printout of the Natural Heritage Database) within the Meramec River basinches

Missouri Natural Terrestrial Community	State Status	Site Name	Township Range Section	Managed Area or Private Owner
Deep Muck Fen	**E[1]**	**Cox Wet Meadow**	**T34N-R6W-S12**	**Private owner - 1979 Plat map**
Deep Muck Fen	**E**	**Spring Creek Wet Meadow**	**T34N-R6W-S02**	**Private owner - 1979 Plat map**
Fen	**R[2]**	**Bangert Seep Fens**	**T35N-R5W-S08**	**Private owner - 1979 Plat map**
Fen	**R**	**Bates Hollow Seep Fens**	**T34N-R3W-S03**	**Mark Twain NF**
Mesic Bottomland Forest	**-**	**Scott's Ford Access**	**T38N-R6W-S36**	**Scotts Ford Access**
Mesic Bottomland Forest	**-**	**Springs End Forest NA**	**T38N-R6W-S36**	**MDC**
Mesic Bottomland Forest	**-**	**Woods (Woodson K.) Memorial CA.**	**T37N-R5W-S07**	**MDC**
Gravel Wash	**-**	**Indian Trail CA-Fishwater Creek**	**T35N-R4W-S33/03**	**MDC**
Wet-Mesic Bottomland Forest	**R**	**Teszars Woods NA**	**T42N-R6E-S04**	**MDC/Private owner**

State Status [1] **Endangered** [2] **Rare**

Table 3. Drainage area of major watersheds, Meramec River basin, Missouri (MDC Fisheries Research 1996). The hydrologic unit code - 07140102 - is the prefix to the watershed (USDA) code.

USDA Code	Watershed	Maximum Order	Area (acres)	Area (sq.mi)	% of Basin
010	Dry Fork	5[1]	245,478	383.00	17.90
020	Upper Meramec River	5[2]	220,875	345.00	16.10
030	Huzzah Creek	6[3]	170,302	266.00	12.40
040	Courtois Creek	5[4]	140,801	220.00	10.20
050	Lower Middle Meramec RM 166-110	5[5]	159,792	250.00	11.60
060	Indian Creek	5[6]	101,046	158.00	7.40
070	Upper Middle Meramec RM 110-42	7[7]	187,513	293.00	13.60
080	Lower Meramec River	7[7]	149,686	250.00	10.90
	Total Meramec River basin		1,375,493	2,149.00	100.00

[1]Dry Fork [2]Crooked Creek [3]Huzzah Creek [4]Courtois Creek [5]Brazil Creek [6]Indian Creek [7]Meramec River

LAND USE

B.

B.1. HISTORICAL LAND USE

B.1.1. General

Experts at the US Geological Survey pinpoint land-use changes as possible cause for the present maladies of stream systems within the Ozarks. Changes in stream morphology have taken place within the entire Ozarks and the Meramec River basin. Written historic observations of early settlers and explorers do not suggest extensive gravel bars on Ozark streams as seen today. Nevertheless, geologists working in the late 1800s, before significant land use, describe large quantities of gravel in streambanks and beds (Jacobson and Primm 1994). Until 1920, shortleaf pine logging practices created minimal erosional processes; however, Jacobson and Primm believe the combined effects of land clearing, road construction and floods from 1895-1915 to be the beginning of upland disruption that peaked from 1920-60. Stream disturbance may have resulted from several practices in the post-timber boom period (1920-60) such as upland burning, grazing of cut-over-valley-side slopes and open land, and lastly, using marginal land for cultivated crops. Oral-history reports compiled by Jacobson and Primm (1994) reveal "flashier" streams in the period from 1960-93 than the period from 1920-60 due to changes in upland and riparian zone vegetation, resulting in decreased water storage and flow resistance. Jacobson and Primm identify destruction of riparian vegetation from livestock grazing on bottom lands as the most disrupting force on Ozarks stream channels.

B.1.2. Farming

Floodplains are well known as fertile areas, making them desirable for settlement. By the early 1800s, the land was being cleared for crops and the wood used as timber for home construction, fences, and firewood. In pre-settlement times, main-stem riparian zones were up to two miles wide on either side of the river. In upland areas different settings existed due to fires set by Native Americans, which resulted in expansive savannahs and glades that dotted the Meramec River basin.

Within Franklin, Washington, and Jefferson counties the principal agricultural crop production in 1880 was barley, buckwheat, Indian corn, oats, rye, and wheat (Goodspeed 1888). In 1850, Franklin, Crawford, and Washington counties had 42,674, 26,910, and 36,139 acres of improved land, respectively. Total improved acres were on the rise because as noted in Goodspeed, "Malaria is rapidly disappearing before the advance of civilization and improved methods of cultivating and draining the soil." Residents in Franklin County relied heavily on wheat as a money-making crop because the soil was well adapted to its growth. Prior to 1820 in all counties within the Meramec River basin, residents paid little attention to the production of wheat, because people lived on corn bread, wild game, and vegetables. Inhabitants were more attentive to mining than agriculture.

B.1.3. Grazing

As the Timber-boom period (1880-1920; see subsection B.1.6) came to a halt and large commercial interests sought more fertile grounds outside the Ozarks, the inhabitants' livestock grazed the open ranges left in cutover areas. To prevent trees and shrubs from reclaiming the range, the basin residents burned seasonally. Oral-history accounts from residents describe seasonal burning as necessary to maintain pasture. Some oral-history respondents recall extensive erosion in areas of the Ozarks due to the upland farming and grazing, and gully and sheet erosion were common sites (Jacobson and Primm 1994).

B.1.4. Recreation

In 1940, the Missouri State Planning Board estimated 834,350 persons recreated in the Meramec River basin from May 15 - September 30 (Brown 1945). Fishing, swimming, picnicking, and boating made up 85% of the recreational use. The Missouri State Planning Board calculated that flooding during this peak attendance caused losses of $1.36 per person per day. Finding a means of controlling these floods has been a concern of the Army Corps of Engineers since the 1930s. Consequently. Meramec Park Lake was advocated as a flood control reservoir as well as a recreational reservoir. The reservoir was never constructed, however, because of public opposition.

B.1.5. Mining

The original attraction to the Meramec River region was the lure of precious metals such as gold, copper, and silver. These metals were not found, but the first white settlers did find lead and iron ore (Jackson 1985). Also, highly prized for clean sand and gravel, streams in the Meramec River basin have been mined to provide construction materials.

B.1.5.1. Lead and Iron

The first lead mine was established in 1797 by Moses Austin. The site is now the town of Potosi. Several other lead mines were described by Schoolcraft (1821) in Jefferson and Washington counties (Jacobson and Primm 1994). In 1818, one mine was worked in what is now Jefferson County, Gray's Mine on the Big River. In fact, in Washington County, most lead mines mentioned in Schoolcraft (1821) were on the Big River system.

Today's Maramec Spring Trout Park was once the site of Maramec Iron Works. Thomas James and his business associate, Samuel Massey, both from Ohio, started the Maramec Iron Works in 1826. In 1847, Samuel Massey was forced to sell his interest in the company, and the son of Thomas James assumed management of the works until its closure in 1876. This operation tried hauling iron on the Meramec River, but the numerous trees, snags, and gravel riffles were major obstacles. Although the mining operations opened the Ozark wilderness to settlers, these operations caused instream pollution from tailings. Tailings were a source of sediment and toxic substances that adversely affected aquatic biota. In addition, riparian woodlands were cleared to fuel the smelting furnaces.**(*note: Maramec Spring is spelled differently than the river and the watershed).**

In Goodspeed's 1888 publication, the author reported iron mining operating within the vicinity of several creek systems between 1860-88. Sligo Iron Furnace was in operation in the Crooked Creek drainage. Near Dry Branch Creek, Booth Bank Iron Mines (Sec 27, T41, R1W) removed 2,000 tons of red hematite. The owners of Moselle Iron Furnace (Sec 14, T42, R1E) mined brown hematite ore from a deposit near Benton Creek in the Upper Meramec River watershed. The iron ore was deposited or banked into various shapes and sizes on or near the surface of the land. Banks of ore were found in isolated locations--there are no veins. As a result, today, many small depressions (pits approximately 3-15 feet deep) can be found in various locations within the Meramec River basin where mining was done.

B.1.5.2. Historic Sand and Gravel Operations

Since the early 1800s, the Meramec River has been recognized and utilized for its sand and gravel resources. Operations included the removal of sand and gravel from quarry and instream locations. Sand and gravel were, and still are, important construction materials. The quality of the sand and gravel varies among river systems, as well as between small and large streams within a system. Geologists found Meramec gravel samples to be clean and abundant. The Ozarks Region produced 20% of the state's sand and gravel during 1913, and during that same year, the Meramec River produced 17% by weight of Missouri’s total sand and gravel output (Dake 1918). In 1918, sand and gravel operations on the Meramec River were located at Valley Park, Drake, Sherman, Pacific, and Moselle (Dake 1918). Some of these sites are still active today.

In 1918, sand dredging was a continuous trade, but the freezing of wet sand hindered some methods of sand extraction during the winter. At locations near St. Louis, within-stream mining, common at this time, involved using 15-inch centrifugal dredge pumps to load material from the Meramec River into waiting barges. Other methods included loading by hand into wagons or barges towed by gasoline-powered tugs, and loading by clam-shell dredge. The severity of impacts to the stream would vary with method. Extraction by hand and wagon methods were more appropriate for smaller stream systems and dealers whose products were strictly for local use (Dake 1918).

B.1.6. Logging

The expansive Ozark Plateau had two land-use periods known as the Timber Boom (1880-1920) and the Post-timber Boom (1920-1960) that affected uplands, valley slopes, and valley bottoms. The Post-timber Boom was a time of economic depression and migration out of the Ozarks. Cutover valley slopes during the Timber Boom were converted to pasture and seasonally burned. The Great Depression placed increased pressure on the valley bottoms and uplands for subsistence farming (Jacobson and Primm 1994). From 1880-1920, timber was cut for a variety of uses. Several portable sawmills existed for home use. Because of the limited supply of shortleaf pine, builders used hardwoods for railroad ties, flooring, barrel staves, and fuel. Franklin, Jefferson, Crawford, and Washington counties had predominately hardwood species such as scrub oak, white oak, post oak, and red oak in the uplands and black walnut, hickory, maple, ash, birch, sycamore in bottom lands (Goodspeed 1888). Sources agree that until the railroad reached the Meramec vicinity in 1870, cutting was limited to small operations near river systems (Goodspeed 1888; Jacobson and Primm 1994). Large-scale producers of dairy products and cord wood shipped their goods to St. Louis via the Iron Mountain Railroad. Transport, however, was mainly for producers within the vicinity of the railroad, and it was noted in that, "Wood supply along the immediate line of the Iron Mountain Railroad was being exhausted" (Goodspeed 1888). This notation compares well with the decline in Missouri timber production in 1900 described by Jacobson and Primm (1994).

The Timber Boom apparently had not reached Crawford County in 1888 because the author Thomas Gileson noted the untapped water resources and " . . . timber that could be made into furniture and land to be cleared for agriculture" (Goodspeed 1888). At this time, many people were migrating to the Ozark area to work in the forest operations and mills. The author wrote that area streams had " . . . clear water, flowing through rich valleys that can supply water power to run mills" (Goodspeed 1888).

It is doubtful that large log drives like those that took place on the Gasconade and Little Piney rivers in the 1880s ever occurred on the Meramec River. Nonetheless, in many areas of the Ozarks, hardwood railroad ties were cut, and when water was high, transported by river. Because officials were apprehensive about dangers of loose ties and their effects on streambanks, Missouri regulated the size of drives and method of tie transport (Jacobson and Primm 1994). In the Ozarks, beginning in 1925, a tie producing company stopped river drives on the Black River from April 15 - June 1 because of fish spawning.

B.2. RECENT LAND USE

Some of the same forces affecting the past land-use periods still exist today. Recent land-use practices (1960-present) include greatly reduced intentional burning. Grazing and row cropping has increased in upland areas, and valley bottom lands are still being cleared for pasture and row cropping. Logging operations on valley slopes and uplands are better managed than during the Timber Boom and Post-timber Boom periods, but upland areas and valley slopes still have a slight increase in annual runoff, storm runoff, and upland sediment yield as compared to pre-settlement conditions (Jacobson and Primm 1994).

In general, land-use and land-cover estimates from the NRCS (1995) classify watershed areas as 4.5% cropland, 48% forest, 24% pasture, 1.3% rural transportation, 6.5% urban development, 15.7% water, minor and other land-use categories (Table 4). Within the upper Meramec River watershed, nearly one third of forest land is owned by farmers, corporations, and forest industries, and another one third by the federally owned Mark Twain National Forest, and the remaining one third by other private landowners. Only a small percentage of forest land is owned by the forest industry. In recent years, urban development in the lower Meramec has reduced the size of contiguous forest tracts.

B.2.1. Farming

Based on 1992 broad land-use estimates obtained from the NRCS, the Meramec River basin has 15,500 acres of cultivated cropland and 54,900 acres of uncultivated land (NRCS 1995). According to the Missouri Agricultural Statistics Service (MASS), most of the crop production is hay. Several of the larger counties within the basin do not produce sizable amounts wheat or corn (MASS 1995). Because of this low cash crop production, use of herbicides such as 2,4-D and Atrazine is generally low.

Crawford County Farm Information

St. Louis County Farm Information

Phelps County Farm Information

Washington County Farm Information

Dent County Farm Information

Jefferson County Farm Information

Farmers maintain approximately 375,100 acres of pasture for cattle, horses, and sheep (NRCS 1995). It is possible that more farmers will be converting land to pasture while cattle prices remain high. Cattle prices, however, have fallen from 1994 to 1995, and in all counties within the basin, total numbers of cattle produced fell from 1994 to 1995 (MASS 1995). Of the major counties within the basin, Franklin County produced the most cattle with Dent, Phelps, and Crawford counties close behind.

Hog production fell in all counties from 1993 to 1994 (MASS 1995). Franklin County had 63,000 hogs in 1992, 59,000 hogs in 1993, and 56,000 in 1995. Fortunately, no large-scale combined hog feeding operations exist within the Meramec River basin. Nevertheless, hogs in open fields create areas that are devoid of vegetation and possess large gullies occur adjacent to some streams reaches in the basin.

B.2.2. Grazing

Jacobson and Primm (1994) demonstrate a trend in the rural Ozarks toward increased populations of cattle and increased grazing density. Increased grazing density translates into greater populations of cattle per unit area. County land-use information from the Missouri Agricultural Statistics Service supports this trend (Figure 3). If this trend continues, stream-channel disturbance, caused by increased runoff and sediment supply has the potential to increase. From 1960-93, populations of cattle have increased yet total improved land in farms has decreased. Cursory observation of streams shows that cattle are noticeably impacting stream water quality.

B.2.3. Recreation

Fifteen percent of the Ozarks has been purchased (US Bureau of the Census 1990) by State and Federal agencies for recreation and timber production. Recreation represents a major land use within the Meramec River basin on public and private land. Significant impacts to streams due to recreational use have not been documented. Based on a survey of the upper and lower Meramec River, the river has more use (hours per acre) than any stream in Missouri (Fleener 1988). In a telephone survey to estimate angler effort and success in Missouri waters, the Meramec River was among the highest in days fished in three of the six years listed (Table 5).

A survey conducted from 1978-79 on a 74-mile segment of the upper Meramec River found camping, floating, swimming, and picnicking accounting for 84% of all hours spent in the area and 75% of all visits (Fleener 1988). All types of fishing made up about 10% of all visits. In the 117-mile lower segment of the Meramec River, pole-and-line fishing was popular, making up 15% of all visits to the area. According to the survey, canoeing is a very popular outdoor activity, especially on the Huzzah and Courtois creeks. The gradient and the water clarity of these streams seem to attract many outdoor enthusiasts.

B.2.4. Mining

Mining for lead, barite, iron, and sand and gravel within the upper portion of the Meramec River have the potential to adversely affect streams. Nevertheless, mining is a major industry within the basin and employs several thousand people. Recently, land restoration mining technology has been funded by the mining industry. Stricter regulation, direct taxation of mineral production, and customer awareness have also fueled water quality monitoring and waste management systems.

B.2.4.1. Lead

Doe Run Mining Company’s Viburnum 35 Lead Mine (NW NE Sec 11, T34, R2), which is within the Huzzah Creek and Courtois Creek drainages, has potential to affect aquatic biota within a tributary to Crooked Creek and Indian Creek tributaries (Table 19; Water Quality Section, D.6. Non-point Source Pollution). Although the tailings ponds have not been a problem, proper maintenance and observation are recommended to assure that the risk posed to downstream aquatic habitat and biota is held to a minimum. In addition, the Viburnum Mine operation manages a smelting operation within the vicinity of Crooked Creek.

B.2.4.2. Barite

Parole, Howell, Palmer, Politte, and Joe Smith are mine sites where barite (barium sulfate) has been extracted from the land surface (Water Quality Section, D.6. Non-point Source Pollution). Parole Mine has water-covered tailings and all others are partially water covered. Although tailings dam failures are infrequent, barite mining, centered in Washington County, has in the past buried creeks in red mud, destroying aquatic life (MDNR 1995). Barite tailings are less damaging to the aquatic environment than lead tailings because of the small-sized particles (MDNR 1995). The DNR's Dam Safety Program is responsible for monitoring tailings ponds for structural integrity.

B.2.4.3. Iron

Historically, iron mining was an important industry within the basin, and several old abandoned mining operations still impact the stream biota. Today, of the remaining two major mining operations, Pea Ridge Iron Mines and Hobo Iron Mines, only Hobo Mines has been reported to cause stream water quality problems (Water Quality Section, D.6. Non-point Source Pollution, MDNR 1995). The tailings pond are monitored by the DNR to prevent potential contamination of streams.

These mines both have tailings ponds classified by USFWS National Wetland Inventory (NWI). In the NWI map classification, Pea Ridge Iron Mines has a series of 12 polygonal wetlands; only one polygonal wetland has the spoils designation, and the remaining polygons give no indication that mine tailings are present. Hobo Mines tailings are not identified as mining spoils but as a single pond. Vegetation found on these tailings ponds is characteristic of the cattail wetland. Cattail wetland conditions reduce the tailings waste to a less reactive waste.

B.2.4.4. Sand and Gravel

The Army Corps of Engineers (COE) through Section 404 of the Clean Water Act and the Department of Natural Resources (DNR), through its Land Reclamation Program, issue permits for the mining of stream sand and gravel. Although the regulation of sand and gravel mining is in a state of flux, guidelines developed by state and federal agencies with input from the regulated community and used by the COE allow mining of gravel bars and floodplains.

The use of GIS allowed the MDC's East Central Region to store, search, and display mined stream sites, landowners, type of permit holders, and permit conditions. Seventy-one permitted sites on 11 different streams in seven counties were mapped (Figure 4). Thirty-two sites were permitted under the Missouri General Permit (GP-34M) from January 1996 to August 1996. Brazil Creek, with a relatively small watershed area, had 20 gravel mining sites, making it the most heavily mined watershed (Blanc 1997).

B.2.5. Logging

Forests in the Meramec Basin are dominated by oak species (Leatherberry 1990; Hansen 1991), but accurate percentages of upland forest types within the basin are difficult to obtain. Black-scarlet oak and white oak are the dominant upland forest types within the basin. Succession is toward white oak as climax species. White oak and red oak account for approximately 60-75% of growing stock volume on timberland (Leatherberry 1990; Hansen 1991). Softwood species such as shortleaf pine account for between 10-15% of the growing stock volume. Roughly one half of the red and white oak species' growing stock is logged annually. Of all stands within the basin, the stand size-classes (stocked forest land based on the size of the tree on the area) on tracts of land are roughly 45% saw timber, 30% pole timber, and 18-25% seedling and sapling timber (Leatherberry 1990; Hansen 1991).

B.3. NATURAL RESOURCES SOIL CONSERVATION PROJECTS

The Meramec River basin has no PL-566 projects (Small Watershed Projects) and no SALT (Special Area Land Treatment) projects (MDNR 1995; Clarence Buel, NRCS, personal communication); however, several PL-566 applications within the basin are filed with NRCS (Clarence Buel, personal communication). Thirty years ago, Congress enacted the Watershed Protection and Flood Prevention Act (Public Law 83-566). This act provides federal dollars to help plan and construct projects in small watersheds less than 250,000 acres. The program has evolved from the initial focus on flood control and erosion to water quality and wetlands, among others.

B.4. PUBLIC AREAS

The de-authorization of the Meramec Park Lake, through Public Law 97-128, allowed the state of Missouri to acquire a sizable amount of acreage. In 1969, the Army Corps of Engineers began a slow purchase of land along the Meramec River. By 1977, the federal government had purchased 25,697 acres of land. The de-authorization bill, signed into law by President Ronald Reagan in December 1981, contained several important provisions besides the de-authorization of the reservoir: 1) The state of Missouri was to receive deed to 3,382 to 5,122 acres of land, unless the state legislature disapproved; 2) Within ninety days the Corps was to appraise the remaining acreage and offer it back for sale to the original landowners first, and then at public auction; 3) The state of Missouri was deeded a perpetual 600-foot easement on privately-owned land bordering the Meramec River, Huzzah Creek, and Courtois Creek (Ruddy 1992). This easement was to provide a 600-foot natural, cultural, and visual corridor, starting at the center of the river. The legislature prohibited construction of new buildings, tree cutting, and trash deposition in the 600-foot corridor (Ruddy 1992). Presently, no state agency is designated to carry out the terms of the easement (Shorr 1995).

The state of Missouri acquired 5,122 acres for state parks and conservation areas (Figure 5-source Franklin County Tribune Map), after the Missouri House of Representatives defeated a bill denying the state’s right to the land (Ruddy 1992). Al Nilges, who represented a district near the Bourbon area, introduced the bill. After the state accepted title to the 5,122 acres, it offered 1,732 acres for resale to past owners or for a public auction. Its sale would help pay the cost of maintaining the 3,390 acres of land. The final plan for deposition of the lands allowed the state to add Onondaga Cave State Park, Campbell Bridge Access, Vilander Bluff, Blue Springs Creek, Sappington Bridge Access, and additional land to the Meramec Conservation Area (Figure 5- Franklin County Tribune Map).

The Meramec River basin has 55,257.6 acres of state-owned land (Table 6). Twenty-two MDC Conservation Areas, 17 MDC River Accesses and several other tracts of land provide opportunities for recreational activities (Figure 6). Although not considered public land, Maramec Spring Trout Park, owned by the James Foundation, is a 1,534.8-acre area offering year-round rainbow trout fishing. **(*note: Maramec Spring is spelled differently than the river and the watershed).**

B.4.1. Stream Frontage

Stream frontage miles for MDC-owned lands were provided by area managers (Table 6). An estimated total of 46.5 miles of land along streams are found within MDC-owned lands.

B.4.2. Stream Access

The Missouri Department of Conservation (MDC) maintains 17 public stream accesses within the Meramec River basin (Table 6). Nearly all of the accesses are on the main stem of the Meramec River. MDC has a long-standing program to acquire strategically located stream frontage tracts from willing sellers at market values. The Conservation Commission makes annual payments to compensate local governments and schools for lost tax revenues at assessment levels current when acquired. The objective of the program is to provide stream access at reasonable floating or motoring distances. This objective for the Meramec River basin has been largely achieved, although a few stream segments could use frontage sites, and two prior acquisitions remain undeveloped as accesses (McPherson 1994). Because of the combination of MDC, MDNR, and USFS lands, the major streams within the Meramec River basin are very accessible to the public.

B.4.3. Flood Buy Out Lands

The severity of the 1993 floods led taxpayers and government agencies to reassess the repeated payment of federal money for disaster relief. From 1995-96, a large amount of federal money from the Federal Emergency Management Agency (FEMA) in the form of grants was available to local governments to buy out damaged structures and remove them from the floodplain. These areas will become greenways for resource conservation or for recreation.

B.5. CORPS OF ENGINEERS 404 JURISDICTION

The entire Meramec River basin is under the jurisdiction of the St. Louis District of the U.S. Army Corps of Engineers. Section 404 regulation permitting, inquiries, and violation reports should be directed to the St. Louis Office: 1222 Spruce Street, St. Louis, MO 63103-2833 or call (314) 331-8575.

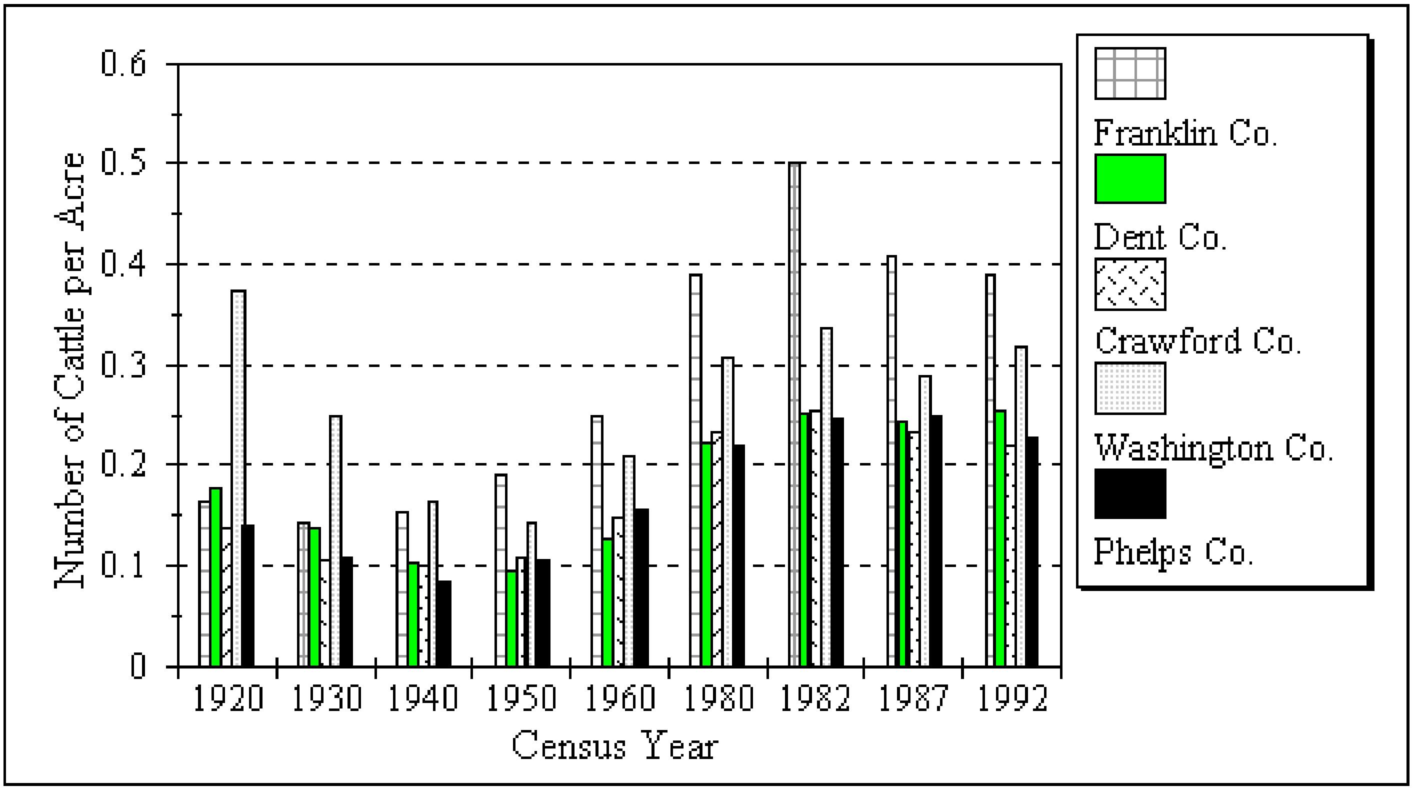


Figure 3. Cattle population per pastured acre in selected counties of the Meramec River basin (MASS 1995).

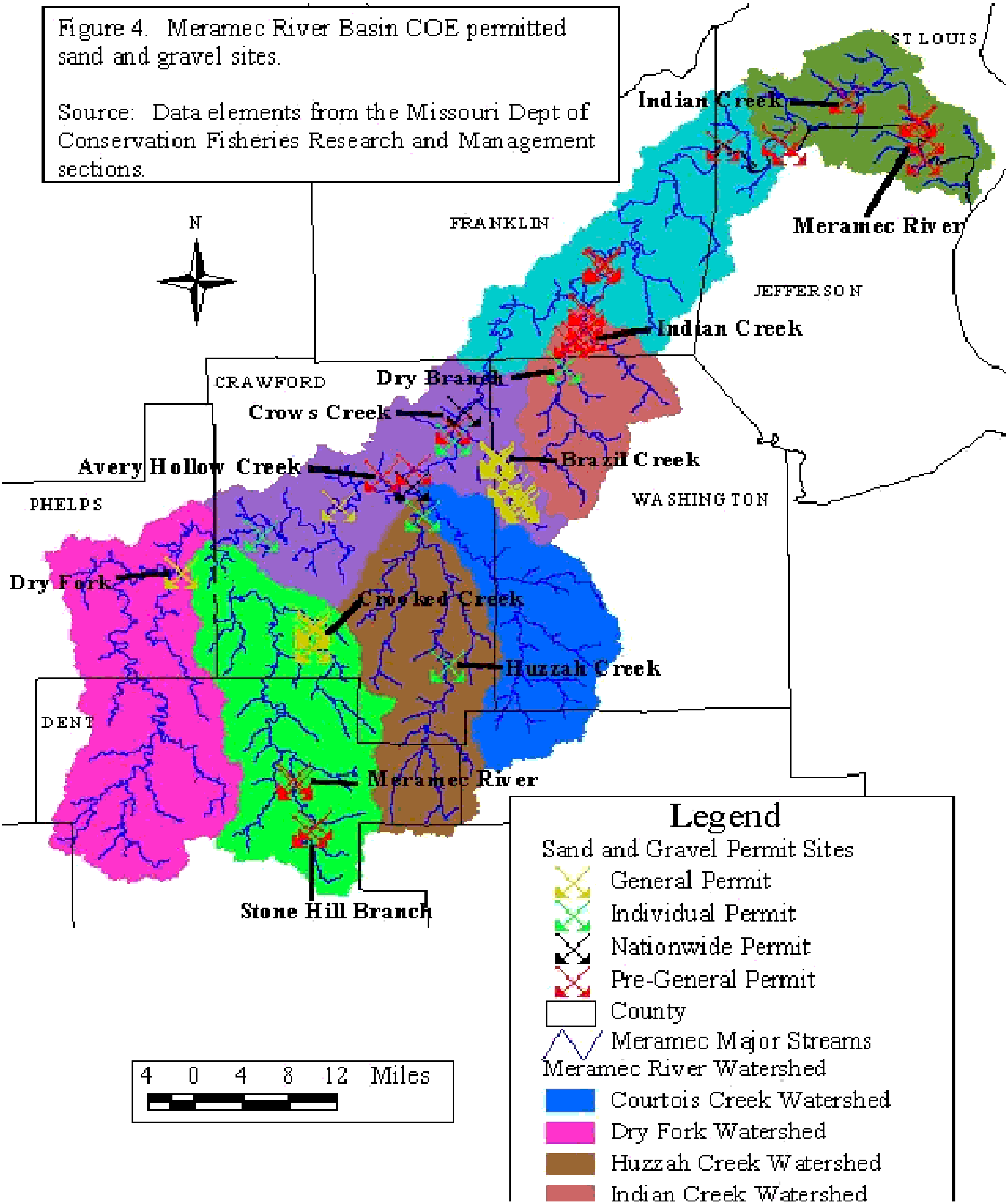
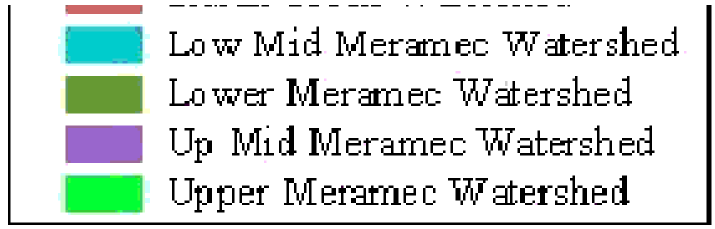


Figure 4. Meramec River Basin COE permitted sand and gravel sites.

Source: Data elements from the Missouri Dept of Conservation Fisheries Research and Management sections.


Low Mid Meramec Watershed
Lower Meramec Watershed
Up Mid Meramec Watershed
Upper Meramec Watershed

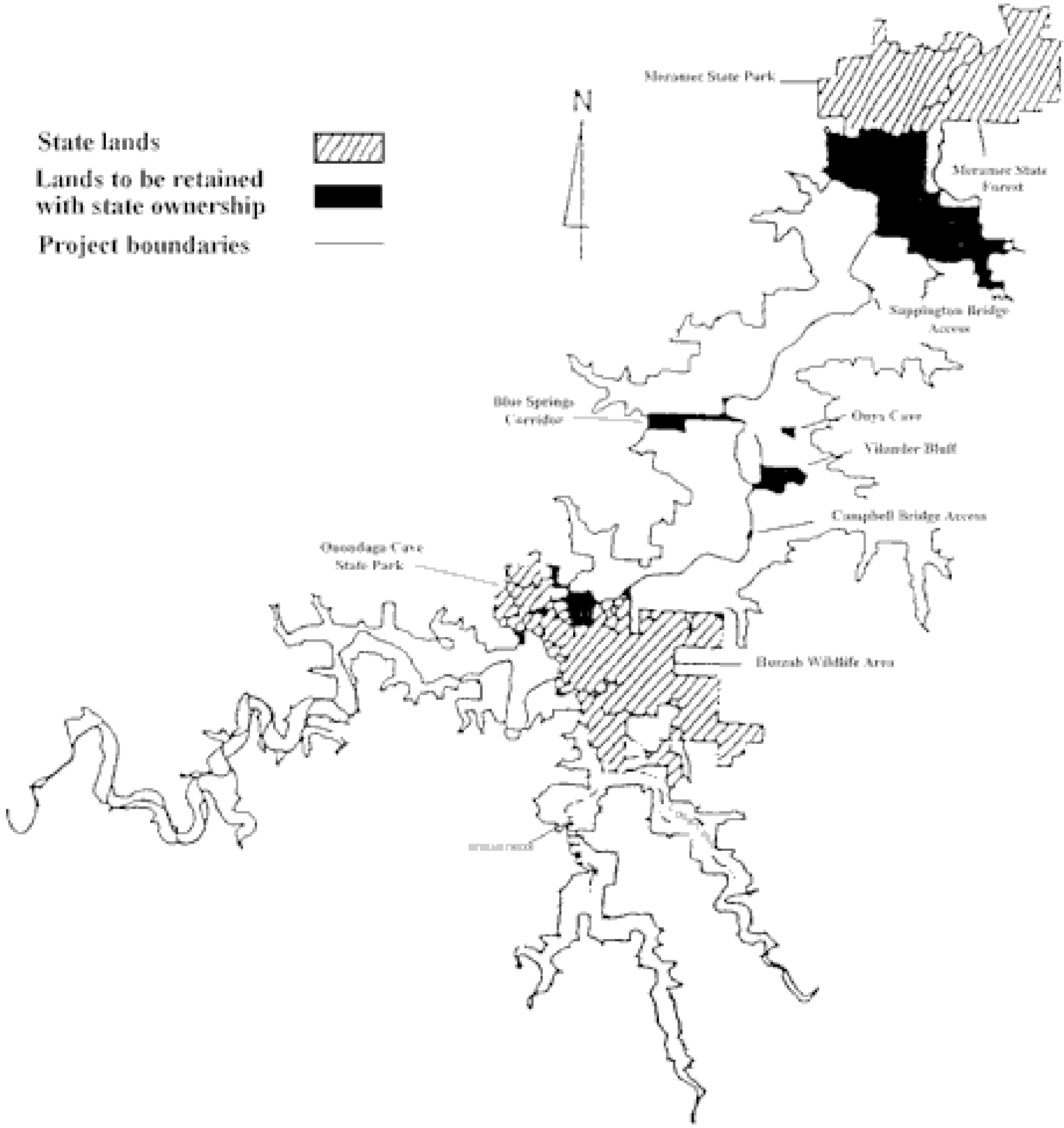
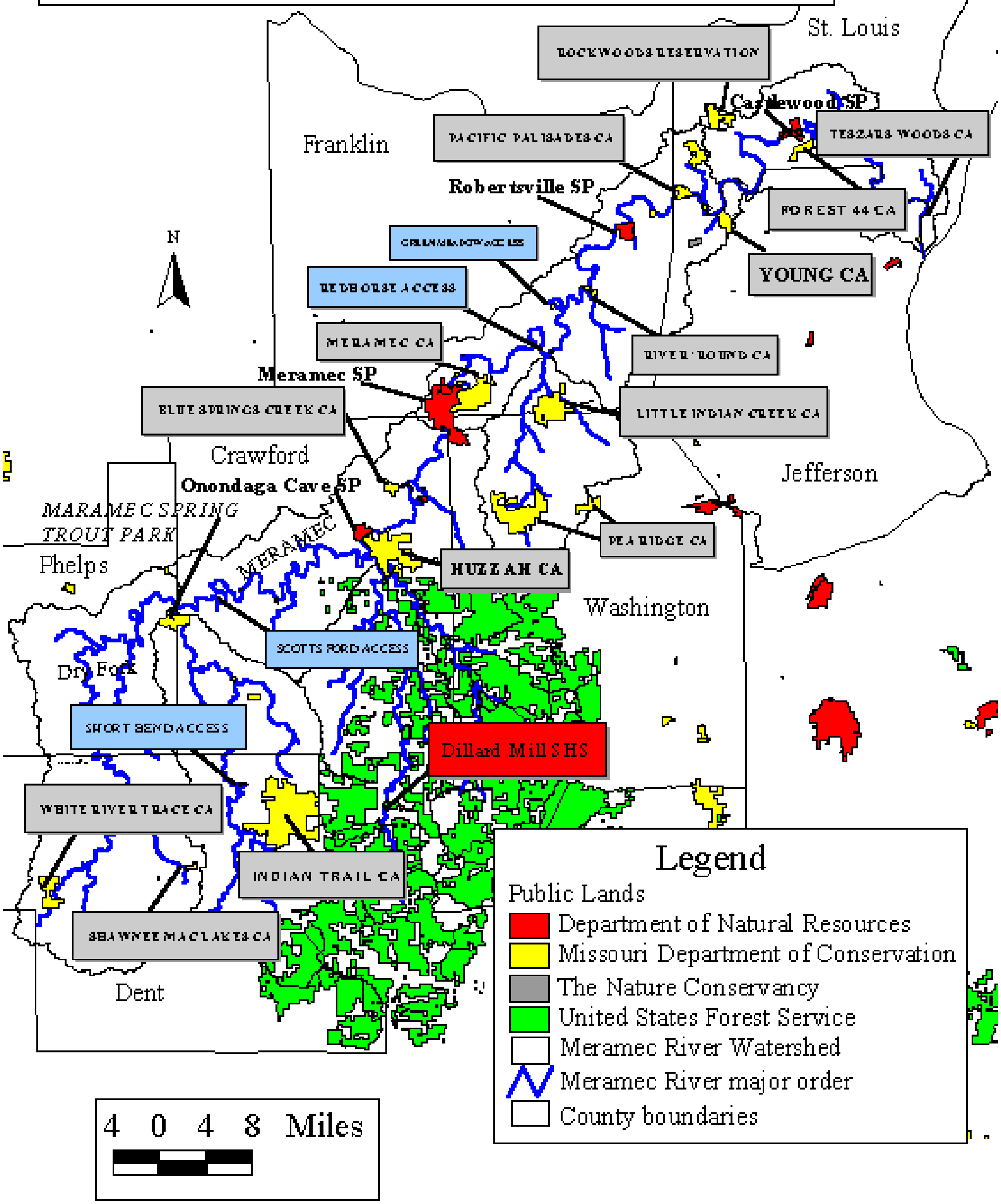


Figure 5. Public lands in the area. (source: Franklin County Tribune)

Figure 6. Meramec River watershed public lands.
Source: Public lands -- Missouri Department of Conservation Policy Coordination & Hydrography--MDC Fisheries Division 1998



Map production by Todd Blanc, MDC

Table 4. 1992 broad land-use estimates for the Meramec River basin. Based on 8-digit hydrologic units (1992 National Resources Inventory, USDA Natural Resources Conservation Service).

Broad Cover/Use	Thousands of Acres	Percent of Totals
Cropland - cultivated	15.5	.99
Cropland - noncultivated	54.9	3.51
Forest land	750.0	48.00
Miscellaneous /minor land cover/uses	19.3	1.24
Pastureland	375.1	24.01
Rangeland	0.0	0.00
Rural transportation - roads and railroads	20.5	1.31
Urban - small and large built-up	101.1	6.47
Water - census - streams >= 660 feet wide and water bodies >= 40 acres	0.6	0.04
Water - small - stream < 660 feet wide and water bodies < 40 acres	14.5	0.93
Other	210.9	13.50
Total	1,562.4	100.00

* Percentages do not add to 100 % due to decimal rounding effects.

Table 5. Estimates of angler effort (days fished) on rivers and streams in the MDC East Central Region, Missouri (Weithman 1991).

	Year					
Location[a]	1983	1984	1985	1986	1987	1988
Big	51,922	15,291	61,539	27,177	31,245	32,441
Bourbeuse	56,387	27,451	15,692	17,997	66,943	21,818
Gasconade	93,123	89,993	98,049	72,303	119,467	103,045
Meramec	*147,194*	*104,471*	*94,030*	*66,569*	*140,481*	*158,522*
Missouri	139,410	120,915	112,440	78,945	135,981	151,374
St. Francis	21,955	68,159	91,603	37,369	47,539	38,575
Total	509,991	426,280	473,353	300,360	541,656	505,775

a The estimates of effort listed for each river or stream include days of fishing on all smaller tributaries in the watershed.

Table 6. Available information on Missouri public land acreage and miles of stream frontage upon public lands within the Meramec River basin (MDC, Planning 1996). County and city public land not included.

Area Name	Acres of Public land	Frontage Miles
Missouri Department of Conservation - Accesses		
Allenton Access	7.88	0.50
Blue Spring Creek Access		
Campbell Bridge Access	10.00	
Catawissa Access		
Chouteau Claim Access	15.11	0.50
Flamm City Access	20.44	0.50
Highway 8 Access		
Redhorse Access	47.33	0.25
Riverview Access	15.15	0.10
Sand Ford Access	32.65	0.25
Sappington Bridge Access	10.00	
Scotts Ford Access	17.81	0.30
Scotia Bridge Access		
Short Bend Access	74.63	0.00
Times Beach Access	0.96	0.25
Valley Park Access	5.00	
MDC Conservation Areas		
Blue Springs Creek CA	854.14	5.00
Catawissa CA	215.03	0.50
Forest 44 CA	981.47	0.00
Huzzah CA	6,101.78	7.25
Indian Trail CA (Indian Trails Hatchery - 75 acres)	13,462.02	1.00
Klamberg (Roger) Woods CA	65.10	0.75
Little Indian Creek CA	2,958.42	1.00
Meramec CA	3,891.60	4.80
Meramec CA - Heynes (Authur G) Memorial Annex	174.27	0.00
Onyx Cave CA	37.35	0.33
Pacific Palisades CA	733.01	2.90
MDC Conservation Areas (con't)		
Pea Ridge CA	6,453.88	4.00

Possum Woods CA	**14.55**	**0.00**
Richter CA	**81.97**	**0.00**
River 'Round CA	**305.52**	**3.30**
Shawnee Mac Lakes CA	**253.93**	**0.00**
Swiftwater Bend CA	**77.35**	**0.50**
Teszars Woods CA	**95.69**	**0.50**
White River Trace CA	**1,633.92**	**0.00**
Woods (Woodson K) Memorial CA	**5,660.00**	**8.00**
Young CA	**970.00**	**1.30**
MDC Lakes		
Queeny Park Lake	**1.00**	**0.00**
Schuman Park Lake, Rolla (Community Assistance Program)	**16.76**	**0.00**
Scioto Lake, St. James [1] (Community Assistance Program)	**5.00**	**0.00**
Simpson Park Lake	**72.00**	**0.00**
Suson Park Lake	**8.00**	**0.00**
Vlasis Park Lake	**1.00**	**0.00**
Walker Lake	**2.50**	**0.00**
MDC - Towersites		
Keysville Towersite	**76.86**	**0.00**
Leasburg Towersite	**5.35**	**0.00**
Rockwoods Towersite	**9.47**	**0.00**
Rosati Towersite	**91.64**	**0.00**
MDC - Other Lands		
Dry Fork Tract	**163.00**	**0.00**
Green Meadow Access (undeveloped)	**75.66**	**0.25**
Maramec Spring Trout Park[1]	**1,534.82**	**2.50**
Maramec Spring Fish Hatchery[1]	**16.49**	**0.00**
MDC - Other Lands (con't)		
Rockwoods Range	**1,425.98**	**0.00**
Rockwoods Reservation	**1,890.52**	**0.00**
Powder Valley Conservation Nature Center	**116.41**	**0.00**
Wesco Tract	**74.60**	**0.00**
Department of Natural Resources - State Parks		

Castlewood SP	**1,192.00**	
Dillard Mill State Historic Site	**130.00**	
Meramec SP	**6,551.00**	
Onondaga Cave SP	**974.00**	
Robertsville SP	**1,129.00**	
Natural Areas		
Hyer Woods NA	**31.29**	
Meramec Upland Forest NA	**451.26**	
Roaring Spring Cave NA	**11.64**	
Spring's End Forest NA	**7.87**	
Vilander Bluff NA	**219.00**	
National Forest		
Mark Twain National Forest	**346,000.00**	
Total	**407,562.08**	

1 James Foundation

HYDROLOGY

C.

C.1. PRECIPITATION

According to the National Weather Service, the Meramec River basin has a relatively humid continental climate with much variability. Climatic influences originate from the Southwest, which carry warm moist air from the Gulf of Mexico or hot dry air from the desert Southwest. During winter, lack of barriers to the north can bring cold Canadian air, dropping temperatures into the sub-freezing range. In summer, 90 degree Fahrenheit temperatures are common for 55 to 60 days.

The National Climatic Data Center's climatological normals presented graphically are based on monthly total precipitation for each year in the 30-year period 1931-60 (Figure 7) and 1961-90 (Figure 8). The precipitation pattern illustrated in the period 1931-60 mirrors the precipitation pattern from the upper to lower basin in the period 1961-90 (Owenby and Ezell 1992). During 1931-60, normal precipitation was highest in Farmington (42.46 inches) and lowest in St. Louis (35.97 inches). Average basin precipitation in the period of 1931-60 was 39.87 inches and 40.96 inches during the period of 1961-90.

Winter months are dry with most precipitation falling in the spring, early summer, and fall months (Figure 8). From 1931-60, average precipitation was highest in May (4.75 inches) and lowest in January (2.22 inches). The same pattern was exemplified in 1961-90 with 4.38 inches during May and 1.89 inches in January.

C.2. USGS GAGING STATIONS

Meramec River basin US Geological Survey (USGS) water discharge gage stations are at Steelville, Sullivan, and Eureka (Appendix B, Figure 1-B to 8-B). These stations collect daily water discharge data, and also house National Weather Service gage-height meters. The following is a list of the location and period of record of the gage stations:

1) Gage station 07013000 in Steelville (Lat. 37 59'58", long. 91 12' 16" in NE1/4, S21, T38N, R4W, Crawford County) has recorded daily water discharge from October 1922 to the current year.

2) The Sullivan gage station, 07014500, is found on the right streambank of Sappington Bridge at river mile (RM) 117 (Lat. 38 09'30", long. 91 06'30" in SE1/4, NE1/4, S35, T40N, R2W, Crawford County). The Sullivan gage station has a period of record of September 1921 to September 1933, and October 1943 to present.

3) The Eureka gage station, 07019000, is found on the right bank, 44 feet upstream from a bridge on the north roadway of I-44 (Lat. 38 30'20", long. 90 35'30", in SE1/4, S32, T44N, R4E). This gage has a longer period of record, August 1903 to July 1906, and October 1921 to the current year.

C.3. PERMANENT AND INTERMITTENT REACHES

Permanent and intermittent stream reaches within the Meramec Basin were tabulated (Table 7) using a combination of information derived from 7.5" topographic maps by Funk (1968) and St. Louis and East Central Fisheries regions (1991). The USGS defines perennial or permanent streams as those having water 12 months of the year during normal precipitation. Permanent streams are identified on USGS maps as solid blue lines. Funk defined permanent streams as those that maintain flow even during periods of drought. The purpose of his study was to determine the miles of water that could provide angling. The geology of this area makes it a candidate for losing and intermittent streams. According to Funk (1968), the Meramec River basin has 201 miles of permanent streams capable of supporting angling.

C.4. AVERAGE ANNUAL DISCHARGE

Flows vary according to precipitation levels. For the 1921-1994 Sullivan gage period of record, representing 1,475 square miles of drainage, the highest 2,313 cfs monthly discharge is in April and the lowest 536 cfs in August (Figure 9). The average annual discharge was 1,227 cubic feet per second (cfs) for the 1921-1994 period of record (USGS 1994). The highest annual mean discharge (AMD) was 3,014 cfs recorded in 1985 and the lowest annual mean discharge, 341 cfs in 1954. Real-time discharge and stage data.

C.5. STREAM/ HYDROLOGIC CHARACTERISTICS

Information found in this section can be used for special projects (e.g., management of high-valued fisheries, instream habitat projects). In addition, this information is useful in understanding wetland functions and will aid in targeting management emphasis.

C.5.1. 7-Day Q2, Q10, Q20 Low Flows, and Slope Index

The 7-day Q2 low flow is the two-year recurrence interval of 7-day low flow. Every two years (Q2) the discharge at the St. James gage station has fallen below 22 cfs for seven days, and every ten years, below 12 cfs for seven days. A large change in flow characteristics occurs near St. James in Phelps County, where flow from Maramec Spring enters the Meramec River. Q2 and Q10 flow for the three gage stations (Steelville, Sullivan, Eureka) on the Meramec River, Huzzah Creek, and Courtois Creek until the period of record 1967 are listed in Table 8. The Q20 for the three gage stations on the main stem Meramec River for period of record 1922-94 was calculated from USGS low flow statistics.

The measure of year-to-year low flow variability is the slope index (SI); it is the ratio of the 2-year to 20-year average low flows (Q2/Q20). Large SI values suggest poor natural water supply and instability from year-to-year (Orsborn 1986). The Q2/Q20 values were determined for the seventh-order Meramec River at an upper-basin site, a mid-basin site, and a lower-basin site. The Steelville gage station, the Sullivan gage at Sappington Bridge, and the Eureka gage have slope indexes of 1.7, 2.1, and 1.9, respectively. These values show well-sustained flows and good basin conditions.

Flows are sustained by adequate precipitation, evaporation, runoff conditions, and ground water supply (sandstone and cavernous carbonate rocks rapidly transmit water from highland areas to deep river valleys where water emerges as springs). Rainfall runoff is important in the Meramec River. Twenty-five percent of rainfall in the basin drains as streamflow and is available for surface water use (UMRCBS Coordinating Committee 1972). The average annual runoff is 10.21, 11.3, 11.43 inches near Steelville, Sullivan, and Eureka, respectively (Vandike 1995). Watershed stability is measured by the influence of watershed constants such as geology, soils (soil water storage), latitude and elevation, topography, and vegetation type. These watershed constants influence the hydrological variables such as stream base flow discharge rates, groundwater levels and daily evaporation. Base flow discharge is the dry-weather discharge of the stream or the average rate of decrease during a period of no precipitation (Skelton 1970).

An estimate of the quantity of flowing water remaining in the stream 30 days after no rain at the Sullivan gage during record 1922-67 is 170 cfs (Table 9). Huzzah Creek near Steelville, in the upper basin, will retain less water after 30 days (22 cfs). Dry-weather flows are considered good within the basin.

C.5.2. Flow Duration Curves and 90:10 Ratio

Figures 10, 11, and 12 show the percentage of time that flow is equaled or exceeded (USGS 1995). Plotted points are midpoints of classes and the percentage of the time that those flows are equaled or exceeded for the given period of record (Osborn 1986). At the Steelville gage on the main stem Meramec River, 267.8 cfs is the median flow or the flow exceeded or equaled 50% of the time (Figure 10). At the Sullivan gage and the Eureka gage, the 50% (median) flow is 600.6 cfs and 1239.8 cfs, respectively (Figure 11, 12). The 90**:**10 ratio (ratio of discharge value exceeded 90% of the time to that exceeded 10 % of the time) for the Steelville gage station, the Sullivan gage station, and the Eureka gage station is 130.23 cfs**:**1,096.2 cfs or 1 to 8.42, 271.0 cfs**:**2412.2 cfs or 1 to 8.90, and 520.7 cfs**:** 6761.8 cfs or 1 to 12.97 respectively. These values suggest, as mentioned above, a lower variability in flow as compared to the Cuivre River basin that has a high ratio of 1 to 218.

C.6. FLOOD FREQUENCY

The volume and rate of discharge can be calculated using the equations from Hauth (1974). Knowing the watershed area and average watershed gradient, the magnitude of a flood event can be calculated. Relationships developed by Hauth (1970), presented in Table 10, were determined by a step-backward multiple regression technique. Hydrologists sometimes call the recurrence interval (RI) the return time measured in years. The magnitude of a flood in cfs is measured for years 2, 5, 10, 25, 50, and 100. Hydrologists derive the recurrence interval from the probability of extreme events. For example, a 100-year (RI) flood of magnitude 68,000 cfs at the Sullivan gage has a 1/100th chance of occurring within any year.

C.7. DAM AND HYDROPOWER INFLUENCES

Although Army Corps of Engineers 404 permits are often required for large impoundments and the MDNR Dam Safety Section regulates non-agricultural, non-federal dams 35 feet or more in height, up-to-date information on the number of small impoundments has been difficult to obtain. The National Wetland Inventory incorporated into this report in the GIS Section now makes this information available.

In a 1966 USDA Meramec River Basin Report, the Army Corps of Engineers advocated constructing the Meramec Park Lake Dam for several reasons: 1) Projected water supply needs for municipal use, 2) anticipated increase in water-oriented recreation use in 1980-2010, 3) the distance of travel from St. Louis, and 4) the economic gain from the resource use.

Several Army Corps of Engineers reservoir projects have been proposed in the basin, but after public review, were defeated. The Meramec Basin project originated in a plan authorized by Congress in 1938 as a means of reducing floods on the Mississippi River (RETA 1973, Vol. I). The Meramec Park Lake project on the main stem Meramec River was one of five reservoirs to be built in the basin. These reservoirs included Meramec, Union, I-38, Irondale, and Pine Ford. An inventory of the Meramec Park Lake project area and the entire river basin was completed by the Ryckman, Edgerley, Tomlinson and Associates, Incorporated (RETA) in 1973. The purpose of the inventory was intended to identify the short and long-term impacts of the proposed project. Physical, biological, cultural elements for the entire basin and the physical, biological, cultural elements for the Meramec Park Lake Study Area were compiled to assess the possible interaction between these elements and also the responses to the proposed alteration (RETA 1973).

The actual dam site was to be within Meramec State Park. The dam would have been made of earth and rockfill (see Land-use Section for more information). The lake would have had a water surface area of 12,600 acres, a total length of 33 miles, and width of 1.75 miles. By 1972, rural opponents, the Citizens Committee to Save the Meramec, encouraged by the newly-formed Ozark Chapter of the Sierra Club, formed to make the public aware of the dam issue (Jackson 1984). In September 1972, Sierra Club filed suit against the US COE, only to lose their case. This court case fueled further opposition. Concern over the loss of wildlife habitat and growing opposition lead to a call for public referendum on the dam issue. Voters residing within the 12 counties of the Meramec River basin and St. Louis decided on August 8, 1978. On that date, 64% of the voters said no to the Meramec Dam (Jackson 1984).

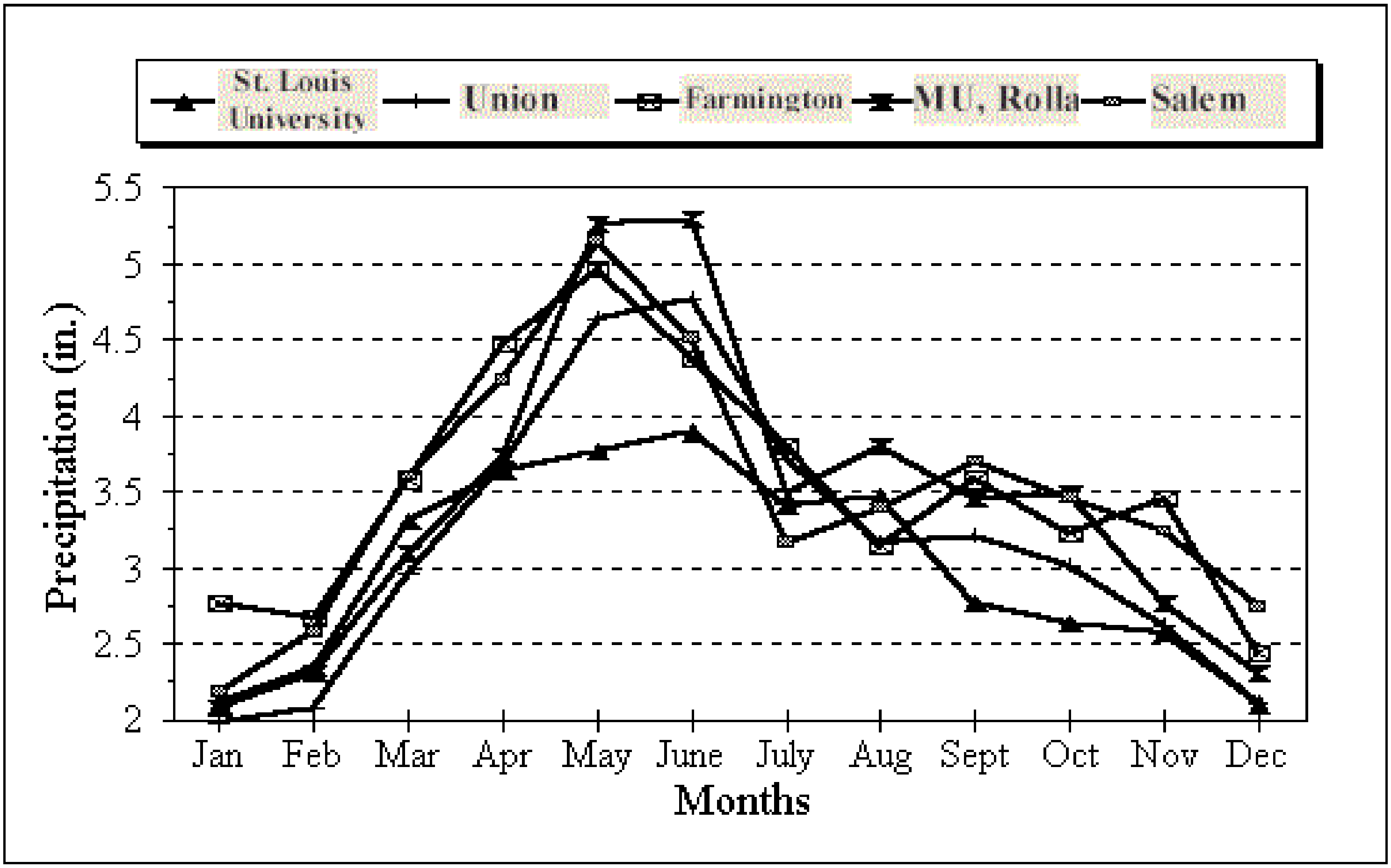


Figure 7. Normal precipitation by National Oceanic and Atmospheric Administration climatological stations within and adjacent to the Meramec Basin--30 year average (1931-1960).

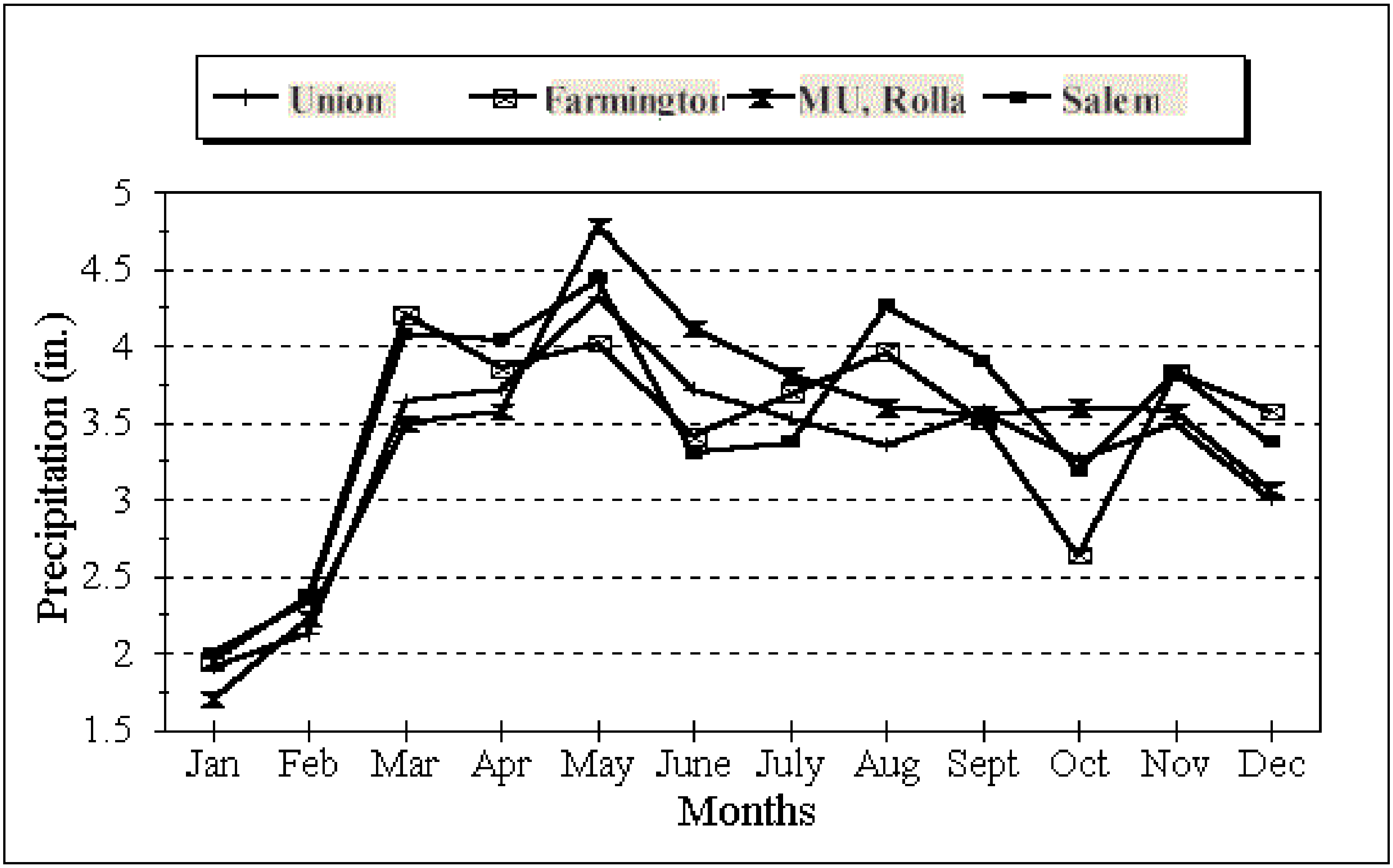
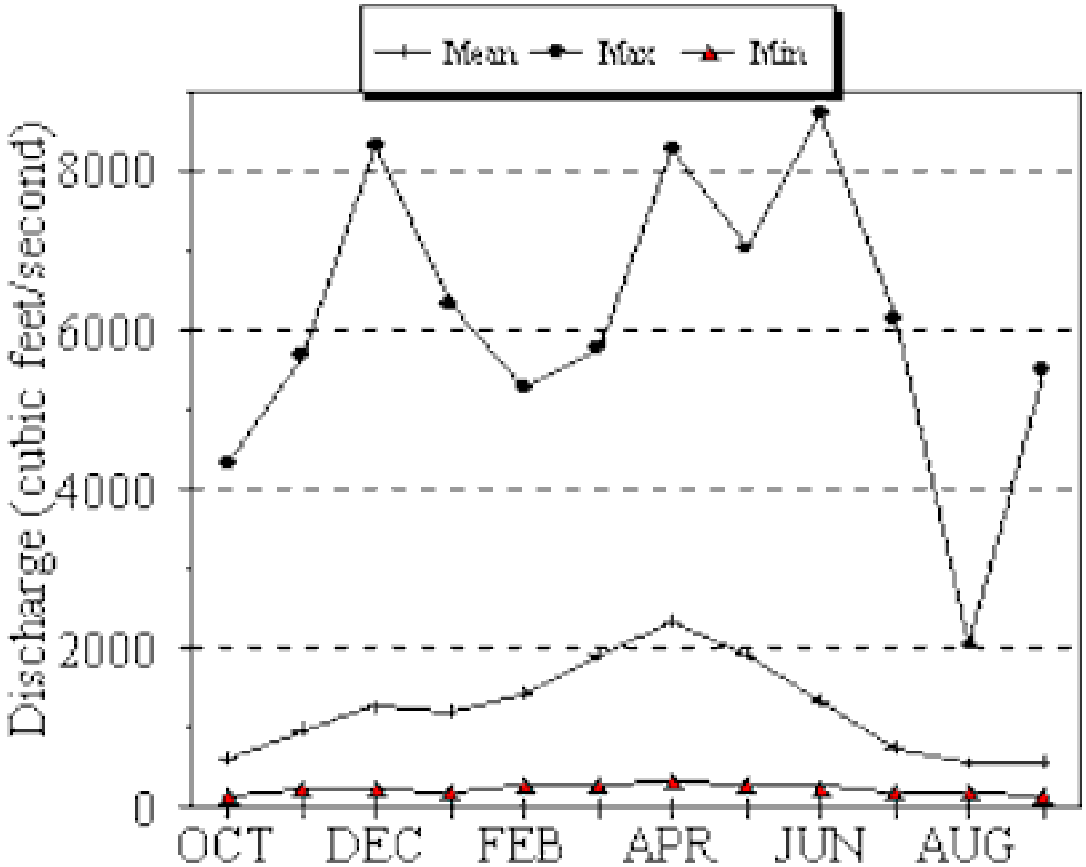


Figure 8. Normal precipitation by National Oceanic an Atmospheric Administration climatological stations within and adjacent to the Meramec Basin--30 year average (1961-1990).

Figure 9. Mean, minimum, maximum annual discharge of the Meramec River at the Sullivan gage station for period of record 1921-1994.



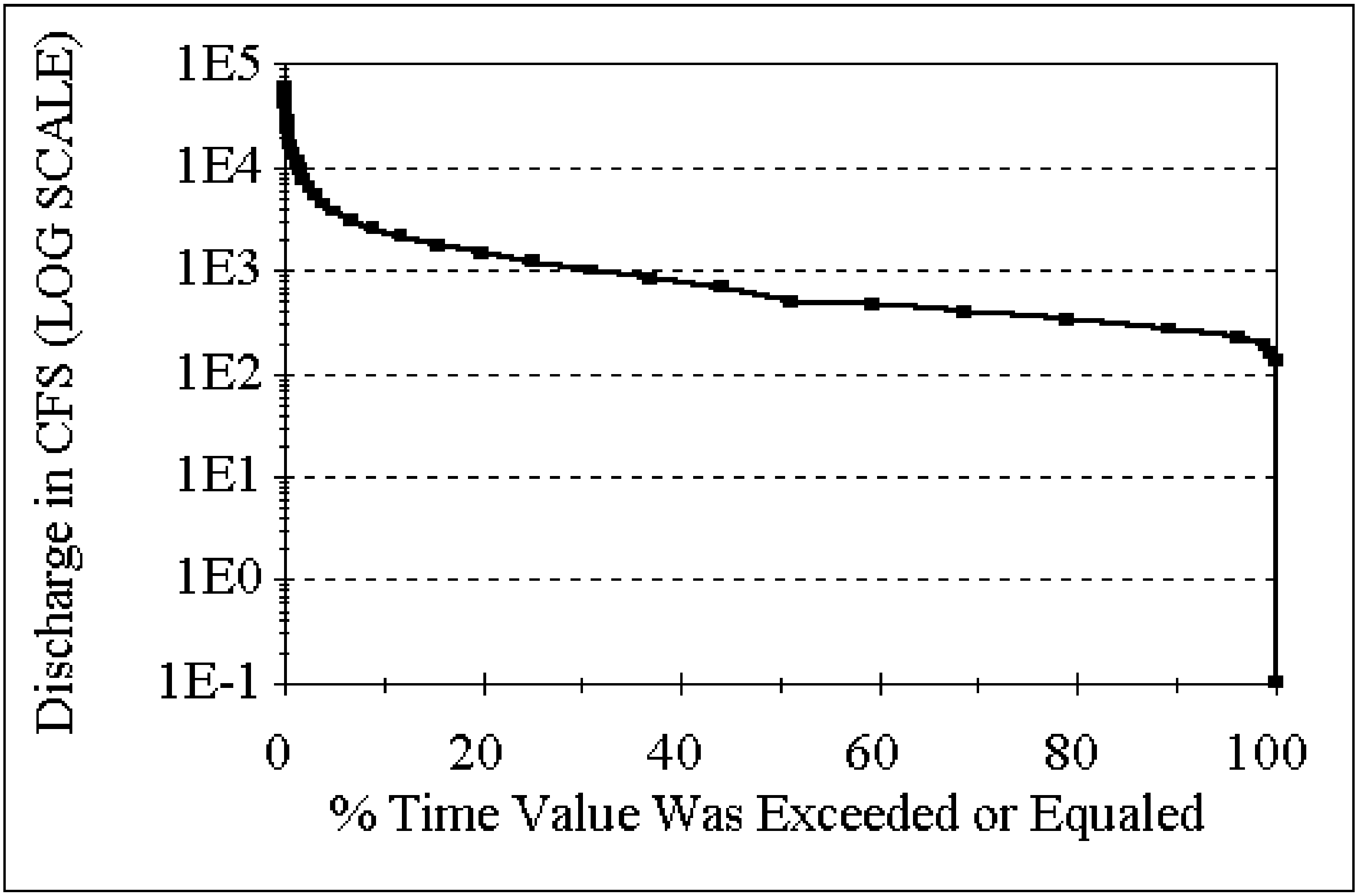


Figure 10. Low-normal duration plot for October - September on the Meramec River near Steelville, Missouri for years 1923-1994.

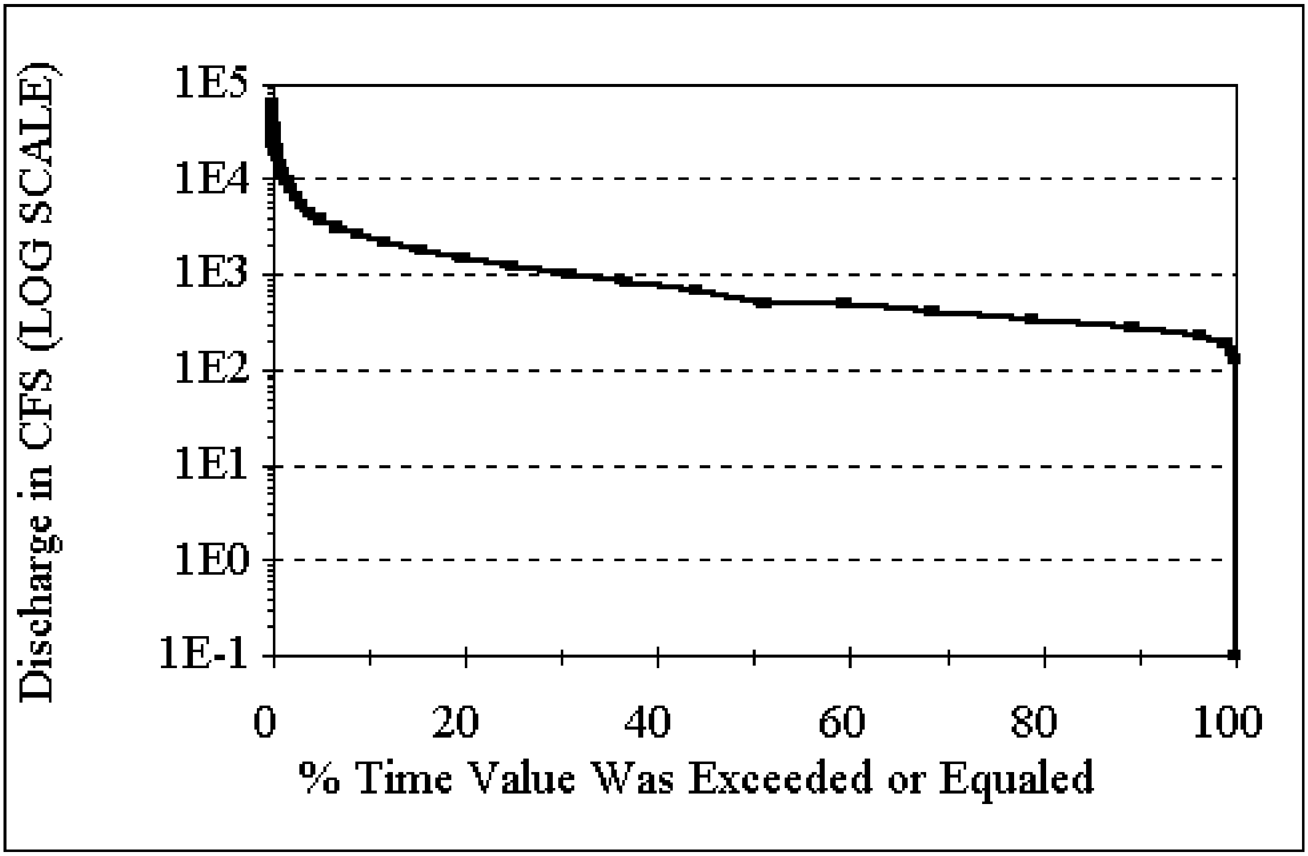


Figure 11. Low-normal duration plot for October-September on the Meramec River near Sullivan, Missouri for years 1922-1995.€€

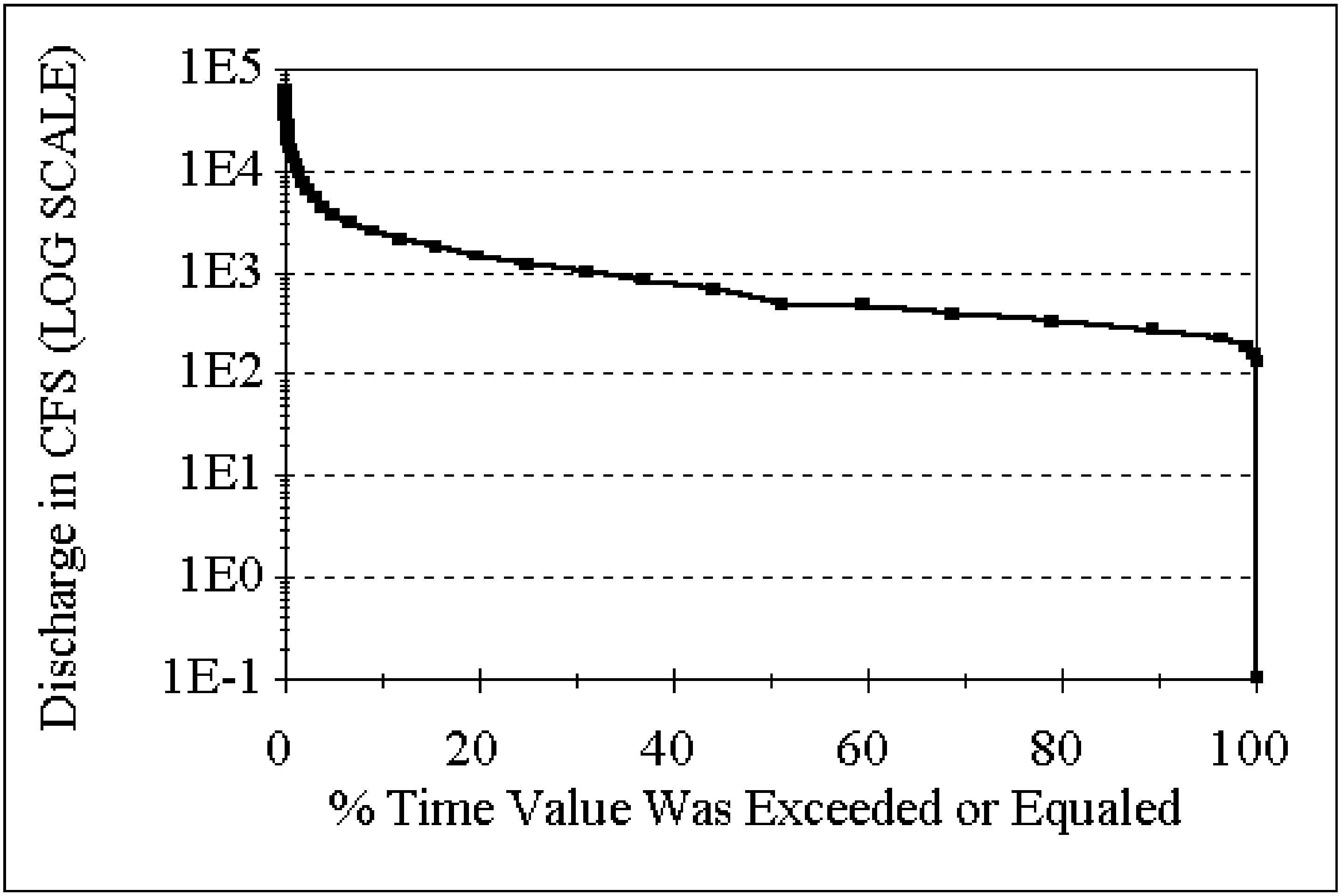


Figure 12. Low-normal duration plot for October - September on the Meramec River near Eureka, Missouri for years 1904-1995.

Table 7. Permanence of stream flow (fishable waters) in third-order and larger streams in the Meramec River basin (Funk 1968). Note: Dry reaches are not reflected in the estimates of total stream length. RM = river mile.

Stream Name	Order[1]	Permanent Stream[2] Miles	Intermittent Pools[2] Miles	Total Length Miles[3]
Dry Fork Subbasin				
Dry Fork	5	21.5	37.5	75.50
Norman Creek	4			23.85
Little Dry Fork	4	5.0	4.0	13.04
Upper Meramec Subbasin @ RM 216-166				
Benton Creek	4	6.0	2.0	9.50
West Fork Benton Creek	3		2.5	6.32
Crooked Creek	5	18.0	0.5	20.28
Yankee Branch	3	1.0	1.0	6.40
Noname Tributary	3		0.5	3.90
Noname Tributary	3		0.5	2.50
Middle Prong Crooked Creek	3	4.0	2.0	7.35
Dry Valley Creek	4		2.0	14.00
Hutchins Creek	4		1.0	8.55
Huzzah Creek Subbasin				
Huzzah Creek	6	33.0		31.30
Dry Creek	5	4.5	8.5	18.15
Cherry Valley Creek	4		3.0	14.15
Noname	3		1.5	2.50
Noname	4		0.5	2.80
Left tributary to Noname	3		1.0	1.40
Shoal Creek	4	7.5	3.0	11.10
Noname	3		0.5	2.75
Little Shoal Creek	3		1.0	4.20
Middle Fork Shoal Creek	3		1.0	3.85
Pyatt Hollow	3		1.5	4.25
Rock Branch	3		2.5	5.45
Davisville Hollow	3		2.0	4.20
Noname	3		0.5	2.70

James Branch	**3**	**2.0**	**1.5**	**4.15**
Huzzah Creek Subbasin (con't)				
Indian Creek	**3**	**1.5**	**1.5**	**5.50**
Crooked Creek	**3**	**3.5**		**8.90**
West Fork Huzzah Creek	**4**	**6.0**	**1.5**	**8.62**
Barney Creek	**3**		**4.5**	**7.37**
East Fork Huzzah Creek	**4**	**5.0**	**2.5**	**9.50**
Courtois Creek Subbasin				
Courtois Creek	**5**	**29.5**	**2.0**	**34.50**
Lost Creek	**4**	**7.0**	**5.0**	**14.20**
Clear Creek	**3**		**2.0**	**4.70**
Little Lost Creek	**4**	**2.0**		**6.60**
Hazel Creek	**4**	**8.0**	**2.0**	**11.50**
Little Hazel Creek	**3**	**1.5**	**0.5**	**3.75**
Johns Creek	**3**	**1.5**	**1.5**	**3.55**
Cub Creek	**4**	**6.5**	**0.5**	**9.75**
Trace Creek	**3**	**1.0**	**1.5**	**3.80**
Unnamed Creek	**3**		**0.5**	**3.35**
Indian Creek	**4**	**1.5**		**7.60**
Middle Meramec Subbasin @ RM 166-110				
Brazil Creek	**4**	**12.0**	**1.0**	**15.75**
Whites Creek	**3**	**1.5**	**1.0**	**4.75**
Ashley Branch	**3**	**1.0**	**1.5**	**4.80**
Little Brazil Creek	**3**	**1.5**	**1.0**	**4.00**
Blue Springs Creek	**3**	**4.0**	**1.0**	**5.85**
Hinch Branch	**3**	**1.5**	**1.0**	**4.25**
Harman Creek	**3**		**2.0**	**6.75**
Lick Creek	**4**	**2.0**	**2.0**	**6.15**
Whittenburg Creek	**4**	**2.5**	**5.5**	**12.85**
Yadkin Creek	**4**		**3.0**	**7.50**
Pruett Creek	**4**	**1.0**	**1.0**	**3.87**
Middle Meramec Subbasin @ RM 166-110 (con't)				

Hamilton Creek	**3**		**2.0**	**4.50**
Indian Creek Subbasin				
Indian Creek	**5**	**19.0**	**1.5**	**25.35**
Little Indian Creek	**4**	**8.0**	**1.0**	**10.90**
Noname	**3**		**0.5**	**2.60**
Piney Creek	**3**		**1.0**	**4.00**
Noname	**3**		**0.5**	**2.15**
Levy Hollow	**3**		**1.5**	**3.70**
Dry Branch	**4**		**5.0**	**7.70**
Little Courtois Creek	**4**	**2.0**	**2.0**	**5.25**
Mary's Creek	**3**		**0.5**	**3.75**
Middle Meramec Subbasin @ RM 110-42				
Brush Creek	**3**		**2.0**	**7.80**
Hoosier Creek	**3**		**1.5**	**4.60**
Brush Creek	**3**	**1.0**	**1.5**	**4.25**
Calvey Creek	**4**	**2.0**	**4.0**	**13.90**
Little Calvey Creek	**3**		**1.0**	**7.15**
Little Meramec River	**5**	**3.0**		**9.0**
Lower Meramec River Subbasins				
Lower Meramec River	**7**	**201.0**	**4.0**	**218.57**
Saline Creek	**3**		**2.0**	**9.39**
Sugar Creek	**3**	**1.0**	**3.0**	**6.91**
Grand Glaize Creek	**4**		**4.0**	**11.19**
Fishpot Creek	**4**		**0.5**	**9.16**
Carr Creek	**3**		**0.5**	**3.83**
Antire Creek	**3**	**1.5**	**0.5**	**7.2**

1 Stream order taken from 7.5" topographic maps.
2 Taken from Funk 1968.
3 As determined using hand dividers from 7.5" topographic maps by East Central Region and St. Louis Region Fisheries personnel.

Table 8. Estimated magnitude and frequency of annual low flow within period of record listed except where footnoted (MDNR 1995a, USGS 1995, Skelton 1970).

				Discharge(CFS)			7-Day Low Flow			
Gage No.	Stream	Site	Period of Record	Average	Maximum	Minimum	Q2	Q10	Q20[4]	Slope Index (Q2/Q20)
7-0104	Meramec River	St. James	1953,57 1962-67	-	-	-	22	12	-	-
7-0130	Meramec River	Steelville	1915, 1922-67	587[1]	1,473	177	150	98	86	1.7
7-0140[5]	Huzzah Creek	Dillard	1943-67	-	-	-	18	9.5	-	-
7-0140[5]	Huzzah Creek	Steelville	1942-67	-	-	-	50	28	-	-
7-0142[5]	Courtois Creek	Berryman	1943-67	-	-	-	30	17	-	-
7-0145	Meramec River	Sullivan	1922-67	1,227[2]	3,014	341	300	200	140	2.1
7-0170[5]	Meramec River	Robertsville	1940-50	-	-	-	450	235	-	-
7-0190	Meramec River	Eureka	1922-67	3,187[3]	7,407	751	600	315	225	1.9

Period of Record (USGS 1994)--11922-1993, 21921-1993, 31903-1906, 1921-1993. 4 Period of Record - 1922-94 (USGS 1995) 5 Skelton 1970

Table 9. Base-flow (cfs) recession characteristics. The average rate of decrease of runoff of the stream during periods of no precipitation. Recession data from the period of May through October (Skelton, 1970).

					TIME, IN DAYS				
GAGE NO.	STREAM	SITE	PERIOD OF RECORD	MEASURED FLOW (CFS)	0	10	20	30	40
7-0104	Meramec River	St. James	1953-67	10	35	24	18	14	12
7-0130	Meramec River	Steelville	1923-67	74	150	120	98	82	40
7-0140	Huzzah Creek	Dillard	1943-67	8.4	18	13	9.5	7.2	-
7-0140	Huzzah Creek	Steelville	1942-67	26	50	36	28	22	18
7-0142	Courtois Creek	Berryman	1943-67	16	30	22	17	13	10
7-0145	Meramec River	Sullivan	1922-67	131	300	240	200	170	150
7-0170	Meramec River	Robertsville	1940-50	256	450	310	235	185	150
7-0190	Meramec River	Eureka	1922-67	196	600	420	315	245	200

Table 10. Flood frequency data from stream gaging stations in the Meramec River basin (Hauth 1974).

					MAGNITUDE OF FLOOD IN CFS (X10^3), FOR YEARS					
GAGE NO.	STREAM	SITE	BASIN AREA (MI^2)	SLOPE (FT/MI)	2[1]	5[2]	10[3]	25[4]	50[5]	100[6]
7-0130	Meramec River	Steelville	781	6.29	15.4	27.9	36.7	48.1	56.5	64.7
7-0145	Meramec River	Sullivan	1475	4.89	18.6	31.8	40.8	52.0	60.0	68.0
7-0170	Meramec River	Robertsville	2670	3.83	38.7	62.8	78.7	101	-	-
7-0190	Meramec River	Eureka	3790	3.44	37.0	61.2	77.4	97.4	112	125

WATER QUALITY

D.

D.1. BENEFICIAL USE ATTAINMENT

In a statewide survey conducted by resource management professionals, river basins were ranked in terms of intensive recreational use, bank or shoreline development, sand and gravel dredging, pollution, poor land use, intensive agricultural use, environmental intrusions, channels modification, and water withdrawals. The cumulative ranking of all categories ranked the Meramec River basin as second out of thirty-eight rivers in Missouri (Bachant et al. 1992). On a scale of 1-10 (10 being the highest), the recreational value was 9.2. Professional staff of resource management agencies ranked intensive recreational use, bank or shoreline development, and sand and gravel dredging as the top three problems facing the basin. As a result, survey participants expect the river to drop one rank in recreational worth in the future.

D.1.1 Beneficial Uses

According to MDNR Water Quality Standards, all streams within the basin are designated for aquatic life protection, fishing, and livestock and wildlife watering. From the mouth of Big River to Meramec State Park, residents use the Meramec River for drinking water supply and industrial uses. Drinking water is considered adequate and only small amounts of toxins remain after treatment. Whole-body contact recreation and boating use are designated on the Meramec River, Huzzah, and Courtois Creek systems. Also, coldwater sport fishing can be found in areas on the Meramec River (Highway 8 to Scott's Ford) and in Dry Creek (MDNR 1984).

The basin is ranked first out of thirty-six watersheds surveyed (332,224 fishing trips) in a statewide fishing pressure survey (Hanson 1980). In a 1979 survey, 8.5% of the visits and 5% of the total recreational-use hours were angling (pole-and-line method) in four sections: the upper segment of the Meramec River, Indian Creek to Highway 185, the lower 13 miles of the Huzzah Creek, and the lower 15 miles of the Courtois Creek (Fleener 1988). Gigging use was also high. Two thousand eight hundred giggers harvested more than 9,900 fish. In a 1980-81 survey of the 117-mile lower Meramec River segment, pole-and-line fishing made up 15% of the visits. Catch rates were 0.38 fish per hour (Fleener 1988). More recently, in a 1988 telephone survey, angler effort (days fished) was 158,522 (Weithman 1991).

D.1.2. Threats to Beneficial Uses

Current threats to beneficial uses are excessive discharge from sewage treatment plants, cattle in streams, and dioxin and chlordane levels in sport fish. Short segments of stream near sewage treatment plants at Rolla (1993) and Salem have experienced episodes of low dissolved oxygen (MNDR 1984, 1994). Improperly maintained septic systems in the upper and middle basin have been a concern. The upper river and tributary areas experience continued problems with livestock in streams, causing localized water quality problems.

Gravel mining by large operations causes turbidity and reduction of quality aquatic habitat on reaches of the lower Meramec River. Numerous active gravel mining sites throughout the basin contribute to the accelerated transport of sediments. Permits are issued by the Army Corps of Engineers to ensure water quality, some protection of instream habitat, and to document the absence of federally threatened and endangered species.

In the upper stream segments of the basin, a threat to attainment of beneficial uses is the failure of lead or iron tailings pond dams (MDNR 1984). A number of mines in the Washington County area that affect tributaries to the Meramec River are of concern. Failure of these tailings pond dams has the potential to cause heavy metal contamination of stream waters and sediments. In the event of contamination, severe reduction in quality of aquatic habitats from sediment deposition exists. At present, dams are inspected frequently, and a dam failure is rare. Finally, in the lower segment of the Meramec River, another threat to attainment of uses would be several point and non-point discharges (see Section D5 and D6; MDNR 1984).

D.2. <u>WATER QUALITY</u>

Overall, the streams in the Meramec River basin have well-sustained base flows during dry periods, except the Dry Fork watershed, which has subsurface flows (MDNR 1984). Below Maramec Spring, base flows are well sustained due to springs and major tributaries such as Huzzah Creek, Bourbeuse River, and Big River.

The lower basin in Jefferson and St. Louis counties has a very large and concentrated number of point-source discharges (MDNR 1984). Water quality violations are not apparent in the lower main stem of the Meramec River, except during extremely low-flow conditions where point-source discharges from domestic sources overload the system.

Water quality in the lower Meramec River has improved greatly in the last 20 years. In a 1964 survey, water quality of the lower Meramec River was high (Ryck 1971). The river was relatively unaffected by man's activities as there were no recommended limitations on whole-body contact. Only a few years later, however, a 1971 survey conducted in St. Louis County by the Missouri Department of Conservation (MDC) identified Meramec River water quality as at risk. MDC identified domestic sewage as the source of much of the degradation of the lower Meramec River and its tributaries. At that point, MDC considered the river moderately polluted.

In contrast to land use in the lower Meramec River watershed, upper and middle Meramec River watersheds are primarily used for agriculture. This area is thought to be responsible for the majority of the nutrient loading in the Meramec River (MDNR 1985). Cattle frequent riparian areas and stream channels areas for food and water, often leaving behind their wastes. In addition, between $1,000 and $2,000 of chemical fertilizers per year per farm are used in some counties (MASS 1995).

D.2.1. Springs

The Meramec River basin has many moderately mineralized springs (Figure 13). Calcium, magnesium, and bicarbonate are the predominant dissolved components, but sulfate and chlorine comprise a significant portion of the dissolved solids in the water. Dissolved solids range from 116-338 mg/l (Vineyard and Feder 1982). Spring Creek in the Dry Fork watershed and the middle portion of the Upper Meramec River watershed have the highest number of springs (Figure 13).

Thirteen springs with flow rates greater than two million gallons per day (mgd) are found in the Meramec River basin. Crawford, Phelps, Jefferson, Dent, Franklin, and Washington counties have the springs with the largest flow rates. Flow rates, representing records ranging from 1924-72, are found in Vineyard and Feder (1982).

Located in Phelps County, Maramec Spring (the spelling, *Maramac*, is of Indian origin) is the largest spring in the Meramec Basin and the seventh largest in Missouri. The average flow is 93 mgd (Vineyard and Feder 1982). Industrious individuals used Maramec Spring as a water power source for iron production in the 1800s. Today, the ironworks are part of Maramec Spring Park, which is owned by The James Foundation of New York and open to the public. MDC, in cooperation with The James Foundation, manages a trout hatchery at Maramec Spring, which is one of four trout parks in Missouri. Six major springs, Evans, James, Roaring, Westover, and unnamed spring, are located in Crawford County. The largest of these is Westover Spring, producing water at approximately 8.2 mgd. Finally, four springs that arise on private land, known as Blue Springs, have a combined flow estimated to be 4.5 mgd. These springs feed Blue Springs Creek. This part of Blue Springs Creek, near Highway N south of Bourbon, is a wild rainbow trout management zone contained partially within the Blue Springs Creek Conservation Area.

D.2.2. Chemical Composition of Stream

The Meramec River is monitored by 53 STREAM TEAMs, groups, teachers, schools, and/or individuals. The Missouri STREAM TEAM is a joint venture between the Conservation Federation of Missouri, a National Wildlife Federation affiliate, the Missouri Department of Conservation, and Missouri Department of Natural Resources. A Governor's Proclamation in February 1989 inaugurated the STREAM TEAM program (Lee and Ely 1990). Some STREAM TEAM groups are involved in water quality monitoring. They collect information on water color, odor, and clarity. Other parameters collected are temperature, dissolved oxygen, pH, nitrates and ammonia, total dissolved solids (TDS), phosphate, zinc, lead, fecal coliform, and stream flow.

To aid Stream Teams, selected water quality parameters (USGS 1995) for the Meramec River basin at the Paulina Hills, Jefferson County, USGS gage station are compared with Missouri State Water Quality 1995 Standards within designated uses I, II, VI, and VII (Table 11). This station is strongly influenced by the urban environment and may not represent average conditions in the basin.

D.3. FISH KILLS, CONTAMINATION LEVELS, AND HEALTH ADVISORIES

D.3.1. Fish Kills

Stream fish kills in the basin have not been excessive, but two fish kill investigations have been costly to the resource and the responsible party. An improper application of termite pesticide to a building in Steelville caused an estimated $7,355.62 of resource damage in Yadkin and Whittenburg creeks on March 21, 1994 (Duchrow 1995b). Investigations revealed 76,986 fish were destroyed in 3.7 miles of the two streams. In another incident within the basin, a fish kill occurred sometime before August 9, 1995, as reported by an unidentified angler, on a 1,075-foot stretch of Blue Springs Creek Wild Trout Management Area. The fish died from suffocation induced by clogged fish gills from fine sediment, released from a culvert replacement project at the Highway N crossing of Blue Springs Creek. The release of unwashed limestone and fresh concrete raised the pH of the water that injured fish gills, thus contributing to fish deaths. An estimated 2,775 fish were killed, including 65 wild trout (Czarnezki

1995). Enforcement settlement totaled $7,516.38, which included a civil penalty of $5,250.00 (Duchrow 1997).

D.3.2. Contamination Levels

Since the early 1980s, MDC has conducted contaminant surveys on fish and mussels. Few people eat freshwater mussels; however, freshwater mussels are better indicators of heavy metal contamination than fish. At some locations, mussels have as much as 1,000 times more lead than edible tissue fish samples from the same locations. Fish are better indicators than mussels of chlorinated hydrocarbons, such as chlordane. Based on fish sampling and analysis performed by the Missouri Department of Conservation, the Missouri Department of Health issues annual health advisories regarding the safety of eating fish harvested from Missouri streams and impoundments.

From 1980-83, MDC analyzed freshwater mussels for lead and cadmium concentrations, finding low lead levels in the Highway W (Jefferson County) to Steelville portion but high lead levels (below the Big River) at Times Beach. Four of the five sampled sites exceeded FDA action levels for lead. For many years, landowners used chlordane for termite and general insect pest control until it was banned in 1988. This allowed chlordane, a known carcinogen, to enter the river via storm water runoff. Consequently, in the late 1980s, Missouri Department of Conservation researchers found chlordane in fish tissue in the lower 22 miles of the Meramec River (MDC 1995). Because chlordane in fish exceeds Food and Drug Administration (FDA) action levels (see below), consumption of fish is not recommended in the lower 22 miles of the Meramec River.

River conditions have greatly improved since the 1980s. Missouri Department of Conservation personnel found lower levels of chlordane, metals (ppb/l), and PCBs in fish during 1994 (Buchanan 1995). FDA and the World Health Organization (WHO) had identified action levels for chlordane as 300 ppb/l, ITOT (sum of the chlordane isomers) as 100 ppb/l, lead as 300 ppb/l, cadmium as not determined, mercury as 1,000 ppb/l, and PCBs as 1,000 ppb/l. Fish contaminant tests performed in 1994 on spotted bass in Meramec River, Winter Park, St. Louis County identified respectively, 55 ppb/l lead, < 0.6 ppb/l cadmium, and 240 ppb/l mercury. Because of the relatively low statewide mercury levels in predators such as spotted bass, Missouri Department of Conservation biologists ceased predator sampling in 1995. Contaminant tests done at the same location on carp were 103 ppb/l chlordane, 28 ppb/l ITOT, 77 ppb/l lead, 5.5 ppb/l cadmium, 77 ppb/l mercury, and 126 ppb/l PCBs (Buchanan 1995).

In July 2001, the Missouri Department of Health issued a fish consumption advisory that incorporated the U.S. Environmental Protection Agency recommendation that lowered the action level for methylmercury to 300ppb in fish tissue to protect the health of consumers of noncommercial freshwater fish. The statewide advisory recommends that women who are pregnant, who may become pregnant, nursing mothers, and children 12 years of age or younger should not eat largemouth bass more than 12 inches in length. The Missouri Department of Conservation will be sampling and analyzing black bass as well as other predator species to determine the concentration of methylmercury in their flesh (Low 2001).

D.4. WATER USE

Water use refers to water used for any purpose (MDNR 1986). Water withdrawals refer to the straight employment of surface water and groundwater taken from its natural location. According to the MDNR Water Quality Atlas, in the lower Meramec River, municipal and industrial facilities are the highest water consumers. No water withdrawals, as defined by the MDNR Basin Plan (1984), affect the upper Meramec River.

Water withdrawals, as defined by the MDNR (1984), affect the lower Meramec River. Maximum surface water withdrawal rates in two of the three public water supplies could significantly reduce water levels in the lower portions of the Meramec River. The South Water Treatment Plant (WTP) and the Meramec WTP, in St. Louis County, remove an average of 20.63 and 10.39 mgd, respectively . A lesser facility in Kirkwood removes 4.5 mgd (MDNR 1984, 1995a).

D.5. POINT SOURCE POLLUTION

Significant point-source water quality problems exist in southern St. Louis County and northern Jefferson County. Sewage treatment plant upgrading, elimination, and consolidation have been a top priority of the Missouri Department of Natural Resources Water Pollution Control Program for many years. A number of smaller inefficient treatment facilities were replaced by larger, less-polluting systems. The MDNR and local municipalities have progressed to create sub-regional treatment facilities to discharge directly in the Meramec River (Table 12). Within the lower Meramec River, the Northeast Public Sewer District in northern Jefferson County is an area of concern because of numerous small treatment systems and the local geology.

Areas from southern Jefferson to Phelps counties have several permitted discharges that are being managed to eliminate potential problems. Lead mine discharges in this area have the potential to affect receiving streams. The discharge from Viburnum Lead Mines No. 28, 29 and 35 has heavy metals and nutrients that may cause algae blooms. In addition, the AMAX Lead smelter discharges heavy metals. These non-municipal permitted discharges have settling ponds or tailings ponds. Management of these areas includes annual dam safety inspections. Latest surveys of these discharges indicate no problems with elevated levels of heavy metals (MDNR 1984, 1995a).

Seventy-five wastewater discharge facilities from the Lower Middle Meramec Watershed to the Upper Meramec River Watershed discharge from 0.1 to 10 million gallons of water per day. Grand Glaize and Fenton STP discharge directly or into a tributary to the Meramec, and water quality is good in this area (MDNR 1995a). Several wastewater facilities in the upper basin have the potential to affect water quality during low flow periods (Table 16). Steelville STP has a large discharge to Whittenburg Creek, affecting 0.1 miles of losing stream. These potential impacts can vary depending upon the extent of the facility malfunction and flow conditions. Low flow surveys were conducted in 1994 and planned for 1999 (MDNR 1995a).

D.5.1. Concentrated Animal Feedlots

As a result of the May 15, 1996, Missouri Clean Water Commission public meeting, amendments have been made to the Missouri Water Quality State Code that impact concentrated feedlot operations larger than 1,000 animal units (MDNR 1996). Sensitive areas as defined by the MDNR--watersheds of outstanding state water resources (Table E of 1996 Missouri Water Quality Standards) and watersheds of public drinking water (Table G of 1996 Missouri Water Quality Standards)--are excluded from permit consideration. Presently, only two poultry operations with nearly 30,000 animal units are found within the Meramec River basin.

D.6. NONPOINT SOURCE POLLUTION

Non-point source pollution comes from many sources in the Meramec River basin. Chlordane leaches into storm water runoff in urban areas. In addition, waste oil can cause elevated levels of dioxin in fish. Within the last 40-50 years, particularly following the construction of Interstate 44, an increasing amount of impervious surfaces has allowed more household and automobile wastes to wash into the river. Areas from southern Jefferson to Phelps counties are wooded and sparsely populated, thus non-point source pollution is small and considered as no effect. The Courtois and Huzzah watersheds in the upper end of the Meramec Basin have lead mines with tailings ponds that the MDNR monitors as point sources, having the potential to become non-point sources (Table 13). Numerous active gravel mining sites throughout the basin contribute to the accelerated transport of sediments. In Franklin County, Meramec Aggregates affects 0.2 miles of the Meramec River, while in Jefferson County, the Winter Bros. Sand and Gravel dredge in the floodplain of the river.

Significant non-point source water quality challenges exist in southern St. Louis and northern Jefferson counties (MDNR 1984, 1995a). Runoff from construction of roads, homes and businesses, and parking lots continue to affect stream habitats (MDNR 1995a). In addition, releases of toxic chemicals from landfills affect water supplies and fish. To compound the problem, losing streams in northern Jefferson County have affected groundwater. For example, tetra- and trichloroethylene (TCE), known carcinogens, already have contaminated the Meramec River alluvial aquifer at Valley Park and Kirkwood. The source is a dump at 3rd Street and Benton Street in Valley Park (MDNR 1995a).

Several other sites in St. Louis and Jefferson counties have dioxin-contaminated soils (Table 14). Times Beach is Missouri's most well known dioxin site. The area became contaminated in 1971 when dioxin-contaminated oil was sprayed on the streets to control dust. In 1983, the federal government bought the land that is now owned by the Missouri Department of Natural Resources. The U.S. Environmental Protection Agency released a study in 1986 that recommended thermal treatment to destroy the dioxin. Subsequently, the MDNR began water monitoring in the Meramec River and soil sampling around Times Beach. They also installed wells to monitor the groundwater. Demolition of abandoned buildings took place after checking them for hazardous wastes. In October 1994, remediation of the contaminated streets was completed. In September 1995, an incinerator was constructed on site (Silver 1995). After EPA, MDNR, and health agencies reviewed results from the trial burn, the production burn began in February 1996 and was completed a year later.

Table 11. Selected water quality data for the Meramec River basin at Lat. 38 27'46", Long 90 24'53", Paulina Hills, Jefferson County, Hydrologic Unit #07140102, Gage station #07019280 for water years 1964, 1973, 1983, 1994 (USGS 1995; MDNR 1994, Code of Regulations 10 CSR 20.7).

Parameter	State Standard of Uses				Water Year			
	I	III	VI	VII	1964	1973	1983	1994
Water Temperature (ºC)	32.2º Max[1] 28.9º Max[2]				1-29.0	0-28.5	0.5-31	1.5-29.5
Turbidity (mg/l)	*Contaminants should cause turbidity difference from natural appearance.				5-460	--	--	--
Specific Conductance (us/cm)	---	--	--	--	225-485	212-430	260-418	283-471
O_2, Dissolved (mg/l)	5[1],6[2]	--	--	--	4.9-15.3	6.0-10.7	5.2-14	6.8-14.2
pH	*H_2O contaminants should not cause pH fall out of 6.5-9.0 range.				7.9-8.6	7.6-8.3	7.8-8.3	7.5-8.4
Hardness, Total (mg/l $CaCO_3$)	--	--	--	--	110-230	95-190	140-210	160-200
Calcium, Dissolved (mg/l as Ca)	--	--	--	--	26-46	22-40	31-43	36-43
Magnesium, Dissolved (mg/l as Mg)	--	--	--	--	12-27	9.7-21	15-27	18-23
Fluoride, Dissolved (mg/l as Fl)	--	4	--	4	0-0.6	24-15	0-0.1	<0.1-0.2
Sulfate, Dissolved (mg/l as SO_4)	--	250	--	--	18-29	<0.1-0.3	18-25	17-23

Nitrogen, Total Ammonia (mg/l as NH_4)	--	--	--	--	--	2.0-5.6	--	2.4-4.4
Nitrate-N (mg/l N)	--	10	--	10	--	0.0-0.97	0.07-0.75	0.07-0.4
Phosphorus, Total P (mg/l as PO_4)	--	--	--	--	--	0.27-0.04	<0.05-0.16	0.03-0.1
Coliform, Fecal (colonies/100 ml)	--	--	200	--	--	--	22-440	9-510
Streptococci, fecal (colonies/100ml)	--	--	--	--	--	--	--	11-160
Dissolved solids (mg/l)	1000	200	--	300	134-262	116-213	173-221	188-217
Iron Dissolved (mg/l FE)	--	--	--	--	--	<10-230	<20-140	<3-21

I: Protection of aquatic life.

III: Drinking water supply.

VI: Whole-body-contact recreation.

VII: Groundwater

[1]For warm-water fisheries.

[2]For cold-water fisheries.

Table 12. Major sewage (<0.19 million/gallon/day) and water treatment plants in the Meramec River basin (Table 1-49, 1-52, MDNR 1995a).

Facility	Flow[1]	Receiving Stream	County
Grand Glaize WWTF*	15.64	Meramec River	St. Louis
Eureka STP (3 Lagoons)	0.50	Flat Creek	St .Louis
Eureka STP (HTank)	0.50	Flat Creek	St .Louis
Baumgartner Lagoon	3.20	Meramec River	St. Louis
MSD-Fenton WWTP*	2.44	Meramec River	St. Louis
MSD-Lower Meramec*	2.30	Trib. to Meramec River	St. Louis
MSD-Friendship Village STP	2.02	Trib. to Meramec River	St. Louis
Rolla SE WWTP	2.00	Burgher Br.	Phelps
Pacific WWTF	0.89	Meramec River	Franklin
Salem WWTF	0.63	Spring Branch	Dent
Viburnum Lagoon	0.20	Trib. to Indian Creek	Iron
Sylvan Manor- Sunset Acres	0.30	Trib. to Meramec River	Franklin
Steelville WWTF	0.19	Whittenburg Creek	Crawford

* Subregional treatment facilities

[1] Million gallons per day

Table 13. Crawford, Washington, and Iron counties mines with tailings ponds that are monitored as non-point sources in the Meramec River basin (Table 49-1, MDNR 1995a).

Site*	Tailing/Spoil (acres)	Stream
Parole Barite Mine	71/98	Stringtown Branch
Howell Barite Mine	63/222	Ishmael Branch
Palmer Barite Mine	146/233	Hazel Creek
Politte Barite Mine	87/336	Little Indian Creek
Joe Smith Barite Mine	5/35	Tributary to Little Indian Creek
Doe Run, Viburnum Lead Mine	235/0	Tributary to Crooked Creek, Indian Creek
Hobo Iron Mine	0.33/4	Tributary to Meramec River
Pea Ridge Iron Ore Co.	Not Available	Mary's Creek, Tributary to Little Courtois Creek

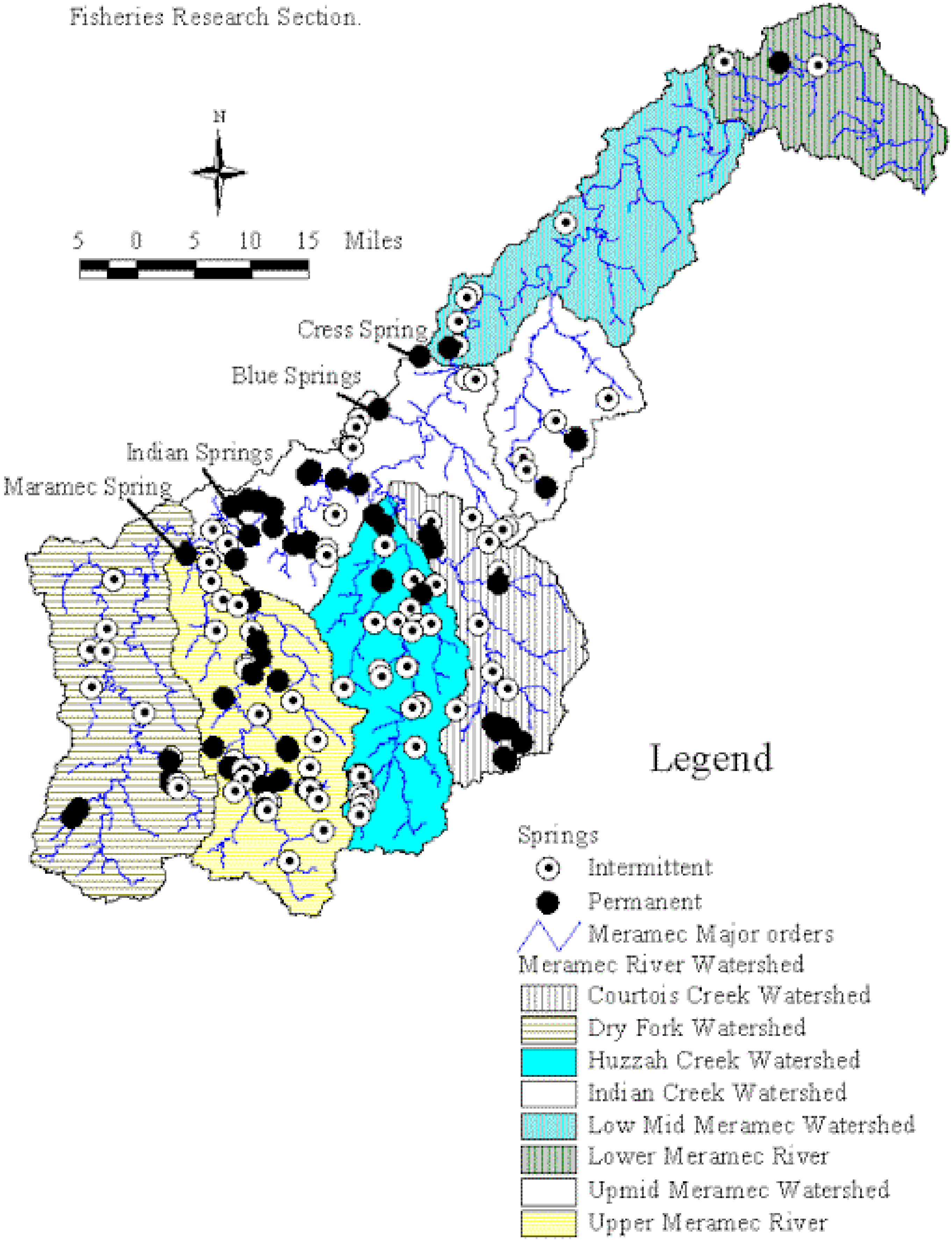
* See map

Table 14. Major sites in St. Louis and Jefferson counties with dioxin-contaminated soils in the Meramec River basin (Table 52-1, unpublished MDNR 1995a).

Site	Description	County
Times Beach	Soil - incineration	St. Louis
Saddle & Spur Stable	Reclamation site - 1989 <1 ppb	Jefferson
Romine Creek Areas	Sediment removed 1989	Jefferson
Bubbling Springs Ranch	Soil - incineration	Jefferson
Minker-stout Area	Reclamation site	Jefferson
Sontag Road Swim Club	Soil erosion to streams, reclamation site	St. Louis
Manchester Methodist	Driveway - paved	St. Louis

Figure 13. Location of springs in the Meramec River watershed.

Data elements from the Missouri Department of Conservation Fisheries Research Section.



HABITAT CONDITIONS

E.

E.1. CHANNEL ALTERATIONS

The Meramec River is the second longest free-flowing river in the state of Missouri. Within the 228 miles total length of the Meramec River, 100% is unaltered (MDNR 1986). The MDNR defines unaltered as segments that man has not channelized or submerged by impoundment. The lower Meramec River has 0.5 miles that are historically navigable as defined by the U.S. Army Corps of Engineers (MDNR 1986).

E.2. UNIQUE HABITAT

E.2.1. Natural Features Inventory

The objective of the MDC statewide Natural Features Inventory was to locate, describe, classify, and rank high quality elements of Missouri's natural habitats. Biologists graded sites for their natural quality, and ranked sites to provide a means of comparing similar features for their preservation value (Ryan 1993). The three rankings were significant, exceptional, and notable.

E.2.2. Potential Natural Feature Sites

Natural history biologists identified 43 sites as potential natural feature sites . Ryan (1993) ranked 10 sites as significant, four sites as exceptional, and 10 sites as notable natural communities in the Crawford, Dent, and Reynolds counties inventory. The remaining 19 areas were identified as special natural areas in the Franklin, Jefferson, St. Louis, and Washington counties inventory by Kurz (1981). A Missouri Natural Features Inventory for Phelps, Pulaski, and Laclede counties was done by Ryan in 1992. Two of the significant natural communities were rare seep fens. The USFS, Salem District, and private interests partially own the Bates Hollow Seep Fen. In addition, Onondaga Cave in Crawford County is a significant feature, as identified by MDC, as well as a National Natural Landmark. The Natural Heritage database lists two types of glades--dolomite and sandstone. The MDC has two dolomite glades in the Indian Trail Conservation Area, and several can be found at Meramec State Park. Also, two of the exceptional communities were endangered deep muck fens. Although not the most abundant community, these wetlands were important high quality communities. Only two of the notable natural communities, the Ver Kamp Glade and the Woodson K. Woods Mesic Bottomland Forest, were identified by Ryan. Natural history biologists identified two dolomite cliffs, Vilander Cliff on the Meramec River (owned by the Missouri DNR) and Red Bluff (owned by the USFS) on Huzzah Creek as significant geologic features. Finally, the Natural Heritage database lists nine types of forests as terrestrial communities within the Meramec River basin.

The Meramec River has the unique honor of being one of the state’s finest free-flowing waters. The upper Meramec River in Dent County was ranked as an exceptional headwater stream, and the Crawford County portions of the Meramec River was identified as a significant aquatic community in the Ryan (1993) survey. Huzzah Creek and the Courtois Creek were also identified as significant aquatic communities in the Ryan (1993) survey.

E.2.3. Rare, Threatened & Endangered Aquatic Fauna

Since 1976, MDC Natural History inventories have documented 106 rare species sites, 72 sites with watch-list species, and 63 endangered species sites within the Meramec Basin (Table 15).

E.3. IMPROVEMENT PROJECTS

MDC fisheries biologists use cedar-tree revetment, corridor reforestation, streambank revegetation, willow staking, and rock blanket (riprap) as stream fish habitat improvement techniques and streambank erosion controls for improved water quality. Since 1987 a total of 13 projects were installed in Crawford, Jefferson, and Washington counties, using these techniques. The intended projects facilitated demonstration of proper stream management techniques and correction of identified MDC land (Fantz et al. 1993).

E.4. STREAM HABITAT ASSESSMENT

E.4.1. SHAD Site Selection

Following Bovee (1982), the methodology for stream habitat evaluation site selection of segments, sub-segments and representative reaches was based on stream order, flow, and stream complexity within the eight watersheds. In Jefferson and St. Louis counties, the St. Louis Region fisheries biologists portion of the lower Meramec River and its tributaries had 55 Stream Habitat Annotation Device (SHAD) sites. St. Louis Region biologists evaluated sites at all existing electrofishing sites and on all streams greater than or equal to order three (Meneau 1991). According to Meneau (1991), his group performed SHADs on every change in order upon a stream, unless a drastic habitat change (unchannelized vs. channelized, intermittent vs. permanent flow) took place. A representative reach consisted of 75-250 feet. Lastly, when possible, SHAD sites corresponded with Pflieger's (MDC Icthyologist) sample sites. In the upper Meramec River portion, East Central Region fisheries personnel evaluated SHAD sites on all streams greater than or equal to order three. Also, in this portion, fewer SHADs were done on higher order stream segments because they were relatively less complex and less prone to change as compared to lower order segments of the systems (Austin, MDC fisheries biologist, personal communication). In addition, according to Austin, the site selection procedure consisted of: (1) constructing gradient plots of potential areas to provide variation in gradient among the sites, (2) consulting a topographic map or aerial photos for surrounding land use and access to the site, (3) viewing video tapes of the watershed areas. Final selection was based on relative difference of the areas, access to the site, and locating and determining representative sections of the area.

E.4.2. HABITAT EVALUATION

E.4.2.1. Deep Loess Hills & Ozark Border Region

E.4.2.1.1. Erosional and Land-use Conditions

Soil types, stream corridor, and land-use conditions ultimately affect the erosional characteristics of a stream. A silty loam bottomland soil type borders the main stem Meramec River from the mouth to the headwaters (Figure 2; subsection A.3. Soils). Its tributaries are contained within two generalized regions: the Deep Loess Hills Region and the Ozark Border Region. Mostly contained within the USGS Lower Meramec River watershed, the Deep Loess Hills Region is predominantly the Menfro-Winfield Association with silt loam underlain by moderately permeable silty clay loam subsoil. The Union-Goss Association within the Ozark Border has a loess and cherty limestone residuum and a fragipan. Soils are silty loams on the surface and degrade to very cherty, silty clay soils. Silty clays, silty clay loams, and silty loams have an erodibility factor of 0.24, 0.37, and 0.43, respectively, representing moderately to highly erodible soils (Table 1; subsection A.3.1.). In addition, the Deep Loess Hills Region is contained within the urban sprawl of St. Louis. Some areas within the St. Louis vicinity are classified as urban land, having bottomland soils that consist of asphalt, concrete, building, or other impervious surfaces.

Within the third-, fourth-, and seventh-order segments of the Lower Meramec River watershed (USGS Code #07140102-080), forest was the predominant SHAD site land use with development (buildings, roadways, parking lots, generally urban land soils) as a second principal land use. As a result of land use, soil, and stream corridor characteristics, St. Louis Region fisheries biologists found that approximately 43% of the corridors sampled had climax vegetation and 32% of the corridors sampled had immature trees and shrubs. Seventy-two percent of streams were at least adequately protected from streambank erosion; however, roughly 5.5% of the streambanks were unprotected from future erosion. Presently, of all stream orders combined, approximately one-half of the streambanks surveyed in the Lower Meramec River watershed had no unacceptable erosion or bank caving

E.4.2.1.2. Corridor Conditions

Future erosion can be prevented or lessened by maintaining a healthy corridor. Within the Deep Loess Hills Region and the Ozark Border Region, forests are largely oak-hickory, having fewer maple, elm, and black walnut. Also, floodplain areas have the sugar maple and butternut hickory associations (Steyermark 1996). In general, the SHAD survey of the lower Meramec River watershed shows that 44% of the third-order sampled corridors had timbered corridors with 25% of the length greater than 100 feet wide. One hundred feet of timbered corridor is generally agreed upon as the acceptable corridor width. Based on SHAD surveys conducted on the Lower Meramec River watershed, corridors on lower-order streams were poor. Within this watershed, sampled segments of Meramec River's corridor (seventh order) had 40% of the corridor length as 100 feet or greater in width. All stream orders combined, between 9-15% of the stream corridors sampled had no woody vegetation in 25% of the corridor length (Table 16).

E.4.2.1.3. Channel Conditions

Good bass fishing depends on adequate cover, especially dead trees and crevices, and pool depth development. After the 1993 and 1995 floods, fishery biologists have noted an increase in woody structure that may have influenced the present fish assemblages. Surveys in 1991 of instream cover produced many types of cover that were reduced to nine predominant types. In addition, pool depth was measured to determine available habitat for bass.

The presence and density of woody structure (Table 17)was related to channel size and high flow events. The St. Louis Region fisheries biologists found woody structure as one of the predominant instream cover types on sampled sites (17% woody structure, 33% boulder). Woody structure made up a small portion of the sites sampled on third-order and seventh-order streams. Overall, boulder, rock, asphalt, and concrete were likely to be the predominant cover. Woody structure, however, was the predominant cover on fourth-order streams.

According to Edwards, Gebhart, and Maughan (1983), adult smallmouth bass minimum depth requirements for optimal survival and growth are between 3 to 4 feet. Within the Lower Meramec River, watershed pool depth and cover were from fair to good for the fish community (Table 29). Stormwater input may be contributing to the change in pool depth in some areas. Some main-stem Meramec River reaches in the Lower Meramec river watershed have been scoured down to bedrock. Roughly 50% of the third-order pools were greater than three feet in depth. Although there are ranges of depths suitable for adult spawning, adult growth, and juvenile growth, optimal depth of all smallmouth bass during mid-summer ranges from 1.5 to 5 feet. Orders five and seven had some pools with depths that were slightly above optimal, such as sites near the mouth of the Mississippi River. These deep pools may explain the presence of bigger bass in the lower Meramec River.

E.4.2.2. Ozark Border Region to Ozark Region

E.4.2.2.1. Erosional and Land-use Conditions

Soil types in the Ozark Region are similar to the Ozark Border Region, having the Clarksville series (SCS 1979). Likewise, water erodibility factors range from 0.10 to 0.43 (see subsection A.3.1.). In the upper basin, selected SHAD sites within four watersheds, Dry Fork, Upper Meramec, Huzzah Creek, and Courtois Creek, had land uses near the SHAD sample site consisting of predominantly timber or forested areas and pasture. Soils in this area are not useful for row-crop farming. Streambanks are generally stable within these areas because of the limited human manipulation of the surrounding land. The levels of streambank erosion protection were indicative of areas that were previously disturbed either by natural events or man. Between 33% (Upper Meramec River) and 73% (Courtois Creek) of the streambanks sampled among the four watersheds were adequately protected from streambank erosion. Often streambank disturbances in this region of the basin were related to cattle grazing within riparian areas (the effects of grazing are discussed in Land Use subsection B.3.3.). Of the four watersheds, Huzzah and Courtois creeks had more streambanks (52% and 73%, respectively, of those sampled within the basin) with climax trees and shrubs, capable of full protection of the streambanks. Soils in these areas are very cherty silty loams on the surface, underlain by very cherty, silty clay loam to sandy loams (SCS 1971). Soils of this nature are highly erodible (water erodibility factor is 0.24).

Streambank protection comes from a combination of soil type and vegetative characteristics of the stream corridor. Sampled sites within the Dry Fork area had forested areas (42.1%) that had climax vegetation capable of erosion protection on 44.7% of the surveyed streambanks. As a result, erosion was minimal to moderate with 44.7% of the 38 streambanks surveyed possessing no significant erosion. Poor streambank protection, poor corridor vegetation, and predominantly pasture land uses were some characteristics that lead to moderate to massive levels of erosion within the Upper Meramec River watershed (Table 16). According to the SHAD survey, climax vegetation comprised 43% and 67% of corridors sampled in Huzzah and Courtois creeks, respectively. Courtois Creek had no erosional problems on 63% of the streambanks sampled, which was slightly higher than Huzzah Creek. Courtois Creek is a good example of a system with a healthy corridor that slows a stream’s natural sinuosity.

The Upper Middle Meramec River watershed RM (river mile) 166-110 (USGS Code #07140102-050), is different in geomorphology, watershed land use, and precipitation patterns from the Dry Fork, Upper Meramec, Huzzah Creek, and Courtois Creek watersheds. Gradient ranges from 6.25 feet/mile at RM 166 to 2.40 feet/mile at RM 110, which is distinctly different from the tributaries that enter this watershed (previously mentioned). For example, gradient in the Courtois Creek watershed ranges from 50-200 feet/mile and 50-300 feet/mile in the Upper Meramec River watershed. Differences in precipitation patterns were notable between the Upper Middle Meramec River watershed, the Lower Middle Meramec River watershed, and the Dry Fork watershed (Figure 7; Subsection C.1). Rolla and Salem both receive more rainfall than Union. Of the 32 sampled sites within the Upper Middle Meramec watershed, 22% had development as the predominant SHAD site land use. At sampled sites within the Lower Middle Meramec River , landcover was mostly timber (40%), the remaining 60% was pasture, hay meadow, row crop, and other land uses. As within the other basins, land use at SHAD sites was a combination of pasture and timber. Of all the Meramec watersheds, Indian Creek had the most sampled sites with pasture (42.3%).

Thirty percent (Indian Creek), 44% (Upper Middle Meramec River), and 46.9% (Lower Middle Meramec River) of the corridors sampled had climax trees and shrubs, capable of full protection of the streambanks. Vegetation is an important type of hydraulic roughness in a stream system. In addition, root wads are particularly good for stream energy dissipation and act to anchor soils in place. Soils in Upper Middle Meramec River and Indian Creek watersheds are similar to the Dry Fork, Upper Meramec, Huzzah Creek, and Courtois Creek watersheds with very cherty silty loams on the surface and underlain by very cherty, silty clay loam to sandy loams (SCS 1971). In contrast, the Lower Middle Meramec River watershed and part of Indian Creek watershed possess different soil complexes, containing slightly more silty clay loam and less chert.

According to the Franklin County Soil Survey, soils along the Meramec are silty, loamy alluvium to somewhat fine sandy loam subsurface layers. Soils of this nature erode easily. Soil erosion was minimal in the Upper Middle Meramec River ; approximately 56% of sampled corridors had no erosion and 31% had minimal erosion. The Lower Middle Meramec was minimal to moderate in erosion with only 18% of the corridors having moderate amounts. Indian Creek was by far the most disturbed watershed with 19% of the sampled corridors having massive erosion in isolated areas and 11% with moderate throughout the entire sample reach.

E.4.2.2.2. Corridor Conditions

Bottomland trees and riparian vegetation help protect streams against erosion especially in areas having highly erodible soils. Stream reaches with no vegetation have accelerated runoff and increased stream energy. Watershed roughness components are a vital part of the stream erosion protection. Several sites within the Upper Middle Meramec and Indian Creek watersheds have unvegetated corridors that were used for row crops. Greater amounts of vegetated sample corridors were found in the Lower Middle Meramec , although sampled stream corridors often lacked the more important corridor vegetation--trees.

In the SHAD survey, fisheries biologists were interested in determining the amount of the timbered corridor length that was at least 100-foot wide within SHAD sample sites. The five rating categories of the percent corridor length that had at least 100-foot wide corridor were 100%, 75-99%, 50-75%, 25-50%, and less than 25% (Table 16). The best corridor conditions were found in Courtois Creek. Courtois Creek, rated with the least erosional problems, had 47% of corridors with corridor lengths having a 100-foot width and 27% with less than 25% of the corridor length having a 100-foot width. Furthermore, fisheries biologists surveyed fewer stream corridors in Courtois Creek that were completely without woody vegetation and more corridors that had between 75-99% of the corridor length from 51 to 100 feet in width than any other watersheds. Approximately 40% of the Indian Creek corridors sampled had no woody vegetation and one-half had a 100% of the corridor length as 100-foot wide (Table 16). Of moderate corridor condition, Indian Creek watershed also had another 40% with less than 25% of the sampled length having a 100-foot corridor width. Of the 38 sampled corridors within the Dry Fork watershed, 40% had 100% of the sampled corridor length as 100 feet in width and another 40% with less than 25% of the sampled length having a 100-foot corridor width (Table 16).

The two watersheds with the worst corridor rating were the Upper Meramec River and Upper Middle Meramec River watersheds, both having 50% for the less than 25% category. As expected, the Upper Meramec River and the Upper Middle Meramec River watersheds had more sites that were without woody vegetation than most other watersheds. In these two watersheds, a large portion of the sampled fourth-order streams was devoid of vegetation, while a larger portion of the sampled higher-order streams had some vegetation. In the combined Lower Middle and Upper Middle corridors, the main stem Meramec River (seventh order) had six out of 22 corridors with 100-foot or greater width. Likewise in these watersheds, all orders included, between 11-25% of the stream corridors sampled have no woody vegetation in 25% of the corridor length.

E.4.2.2.3. Channel Condition

SHAD surveys from 1991-1996 of instream cover produced many types of cover that were reduced to nine predominant types. Cover types influence the fish assemblage, and system stability is indicated by the certain cover types. In addition, pool depth was measured to determine the available habitat for smallmouth bass.

Indicating the relative stability of the Courtois Creek watershed, the predominant instream cover was water willow (37%) and cobble or roots (Table 17). The lack of downed trees as fish cover suggests that the river sinuosity is stable. In contrast, the remaining watersheds (Huzzah Creek, 35%; Upper Meramec River, 32%; Dry Fork, 37%) had woody structure as the most common cover within riffles and pools. As expected, the Upper Middle and Lower Middle Meramec River watersheds also had 23% and 36% woody structure as cover. Comparatively, cover was poor in the Indian Creek watershed, having no cover in 31% of the sampled riffles and pools.

Recent studies on the Buffalo River, Arkansas, have shown that smallmouth bass macrohabitat use varies on a regional scale (Walters and Wilson 1996). At the macrohabitat level, age-0 and older fish are habitat generalists, using pools and runs. In pools of the Buffalo River, age-0 smallmouth bass utilized shallow water 0.032 to 1.1 feet in combination with cobble substrate, aquatic vegetation, and high light levels. Pool development was adequate (greater than five feet) pool depth for adult smallmouth bass, according to Edwards, Gebhart, and Maughan (1983), in the Dry Fork and Upper Meramec River watersheds. Seventy-five percent of the sites had adequate pool depth for adult smallmouth bass in both watersheds. As would be expected, seventh-order sample segments within the Upper and Lower Middle Meramec watersheds possessed pools that were at least 10 feet in depth. In four out of six fourth-order segments in the Indian Creek watershed pool depth was less than three feet. Within fourth-order streams of the Courtois Creek, 66% of the sites sampled had pool depths that were less than suitable for adult survival and growth, according to Edwards, Gebhart, and Maughan (1983). Sixty % of the fourth-order sites in the Huzzah Creek watershed were less than adequate for adult smallmouth bass.

E.4.2.3. Substrate

Streambed substrate varied somewhat from the headwaters to the mouth of the Meramec River (Figure 14). Gravel was a consistent component of the streambed within all basins. Substrates sampled in Indian Creek, Courtois Creek, and Upper Meramec River watersheds were predominantly gravel. The Regional biologists found cobble substrate in abundance within the Huzzah Creek, Dry Fork, and Upper Middle Meramec River watersheds. Dry Fork had the largest percentage of sand. Only the Lower Meramec River watershed had a high percentage of boulder substrate.

E.4.2.4. Channel Alterations

The Lower Meramec River had no major channel alterations in 11 of the 24 third- order sites, seven of the 10 fourth-order sites, three of the 16 seventh-order sites. The Meramec River had several sites with armoring of some sort to prevent bank erosion. The Meramec River RM (river mile) 15.0 had bank armoring to protect clubhouses. St. Louis Region fisheries biologists noted that downcutting and bank sloughing had happened in the past but appeared to have stabilized at that site. At Meramec River RM 20.0, the channel was downcutting and moving laterally causing bank sloughing, and the channel was paved with rock and broken concrete in many places. At Meramec River RM 48.6 the biologists observed that the channel was migrating vertically and laterally due to armoring of railroad tracks. Downcutting within the channel was most evident on the right bank (approximately five feet during an unknown length of time).

Two third-order, one fourth-order, and one fifth-order SHAD sample segments within the Meramec River basin were channelized. A fifth-order segment of Huzzah Creek RM 25.0 had a channelized loop that was greater than or equal to 1,000 feet long. Bedrock substrate was preventing massive downcutting as evidenced by the exposed bridge. Some widening occurred in the pool below the channelized area. In Pomme Creek, channel alterations were not evident, but channelization occurred 300-400 yards upstream near Highway 55 bridge. In addition, within Fishpot Creek, the stream was actively downcutting (discharge pipes exposed). Within 200 feet upstream of the reach, the channel had been straightened (2000 feet) adjacent to new homes.

No watershed other than the Lower Meramec River watershed had any natural gradient controls within a SHAD site, although many road slab crossings throughout the entire basin act as local gradient controls. On an unnamed tributary of Fishpot Creek RM 0.2, a 5-foot tall concrete grade control structure was 500 feet downstream from the SHAD sample reach. Fisheries biologists observed, "The structure had filled with gravel, making a big plunge pool below the grade control structure." Kiefer Creek RM 2.6 has downcutting due to heavy development in the watershed (high imperviousness) and a gradient control structure directly upstream of the reach. Also, in the SHAD survey, the fisheries biologist observed, "Kiefer Creek Road was not allowing natural meander of the right bank. Despite the gradient control structure, the stream would be downcutting anyway. This is a typical reach of Kiefer Creek."

Within the Dry Fork watershed, no channel alterations were noted by East Central Regional biologists. The regional biologists noted six alterations in the Upper Meramec River watershed, six in the Huzzah Creek watershed, five in the Courtois Creek watershed, five in the Indian Creek watershed, sixteen in the Upper Middle Meramec River watershed and twenty-five in the Lower Middle Meramec River watershed. Gravel reaming has been a problem for sometime within most of these watersheds. For example, within a SHAD site on Crooked Creek RM 8.4, gravel had been pushed up against banks throughout the reach. East Central Region fisheries biologist noted "gravel management techniques" on Courtois Creek RM 25.15, resulting in a shallow and wide channel. Above that SHAD site was a county slab crossing where gravel had been pushed up against each bank. On Cub Creek RM 0.2 of the Courtois Creek watershed, the SHAD site was not disturbed, but 200-300 feet above a slab had been altered with bulldozers that forced materials against the streambank. At Pruett Creek RM 0.05, fisheries biologists in the SHAD survey observed, "Heavy graveling--a mound is pushed up mid-channel and gravel in a 4-foot pile against 30 feet of the left bank. Gravel has been scraped down 2.5 feet from gravel bar height. There is significant gravel working (probably not commercial operation) from bridge down to this site."

Generally, cattle were free to use streams for watering throughout the basin. Their activities can alter the riparian area enough to cause changes in channel morphology and water quality. East Central Region fisheries biologists noted cattle use impacts at the following sites: Fox Creek RM 3.5, Crooked Creek RM 8.4, Benton Creek RM 0.6, Courtois Creek RM 20.9, Hutchins Creek RM 2.3, Hutchins Creek RM 5.7, Dry Branch RM 4.0, Huzzah Creek RM 25.0, and Indian Creek RM 1.0.

ATV and vehicle traffic was relatively moderate in the basin. Gravel bars were most often used by ATVs. Evidence of their use was noted on gravel bars at Courtois Creek RM 25.15, Indian Creek RM 19.6 and RM 18.0, Water Fork Creek RM 1.0, Huzzah Creek RM 32.0, and East Fork Huzzah Creek RM 7.0.

Gravel removal operations were observed on several streams in the basin with some incidents having severe impacts. They were particularly heavy on Indian Creek. At Indian Creek RM 1.0, a gravel removal operation adjacent to the second pool (right bank) was not digging below water line at the time of the sample. This section of stream, however, was dramatically different from 1969 USGS topographic maps, which showed the stream running against the bluff. On Indian Creek RM 5.2, there was a major commercial gravel operation. This SHAD site seemed to have adjusted, although it is probably wider now. A braided area was below downstream pool. Finally, at RM 44.3, the Meramec River channel was wildly laterally migrating due to deposition of gravel and sand. A biologist remarked that the migration was probably directly related to a gravel operation two mi. upstream, which is causing a gradient change and corresponding deposition of bed load. During a 25-year flood event, these sensitive lower Meramec River areas, in particular Eureka and Robertsville (see Table 12--Section C.6.), can receive up to twice the discharge received at Sullivan. As a result of major tributaries such as the Bourbeuse and Big rivers and Indian Creek entering the Meramec main stem, erosion potential and sediment load therefore is much higher.

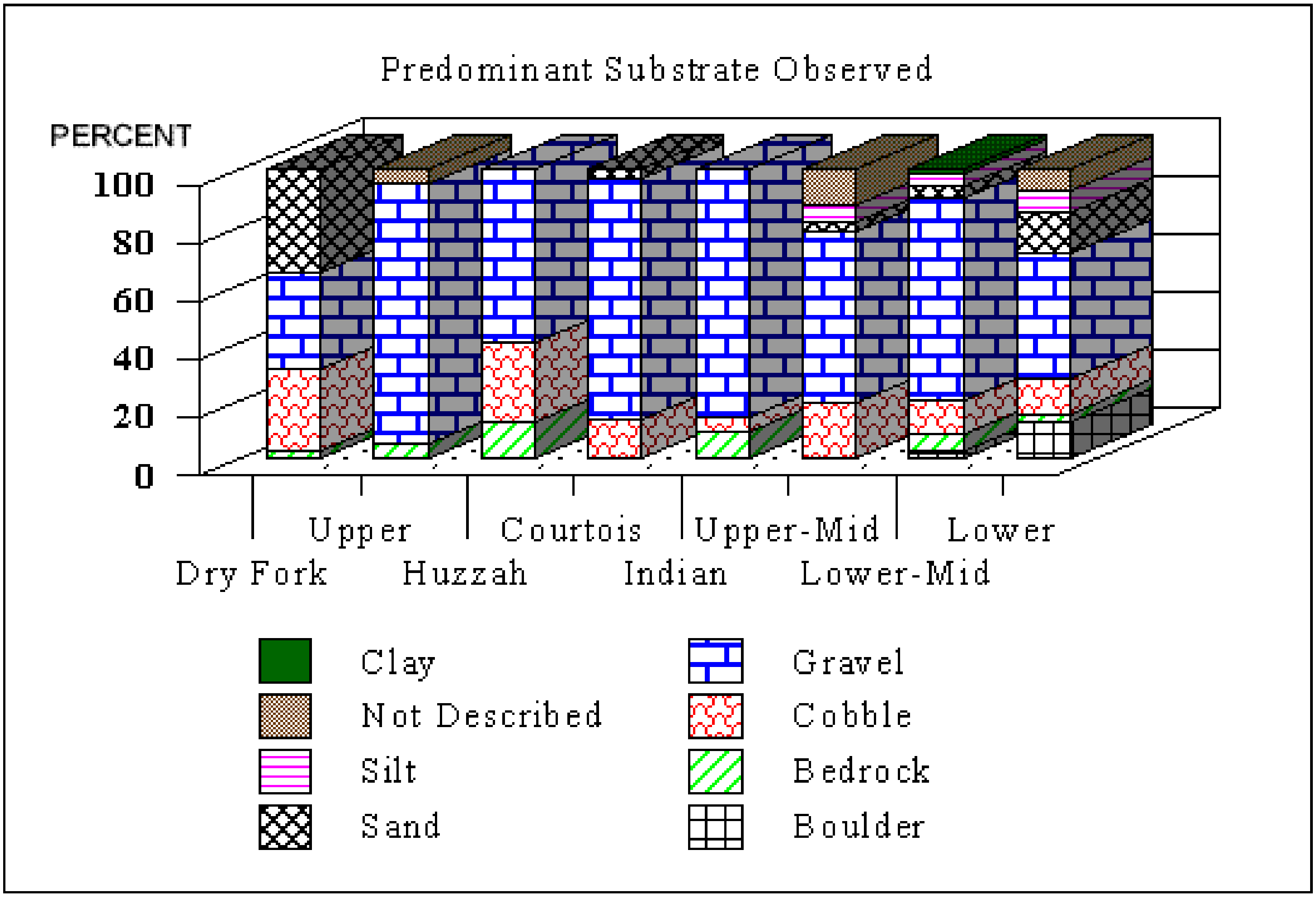


Figure 14. Streambed condition for the Meramec River watershed habitat assessment sites.

Table 15. Sensitive animal species known from the Meramec River basin (printout of Missouri Department of Conservation's Missouri Natural Heritage Database, 1995a).

Sensitive Animal Species	Federal Status[1]	State Status[2]	# of Locations
Amphibians			
Hemidactylium scutatum (Four-toed salamander)		R	2
Rana sylvatica (Wood frog)		R	2
Typhlotriton spelaeus (Grotto salamander)		WL	1
Fish			
Alosa Alabamae (Alabama shad)		R	2
Ameiurus nebulosus (Brown bullhead)		R	1
Crystallaria asprella (Crystal darter)	C2	E	4
Hiodon tergisus (Mooneye)		R	6
Notropis buccatus (Silverjaw minnow)		WL	7
Typhlichthys subterraneus (Southern cavefish)		WL	1
Crustaceans			
Allocrangonyx hubrichti (Central Mo. cave amphipod)	C2	R	2
Cambarus hubrichti (Salem cave crayfish)		WL	1
Styogromus onondagaensis (Onondaga cave amphipod)	3C	WL	4
Mollusks			
Arcidens confragosus (Rock pocketbook)		R	13
Cumberlandia monodonta (Spectacle case)	C2	WL	24
Elliptio crassidens crassidens (Elephant ear)		E	8
Epioblasma triquetra (Snuffbox)	C2	R	7
Fusconaia ebena (Ebony shell)		E	5
Hendersonia occulta (Cherrystone snail)		R	1
Lampsilis abruptus (Pink mucket)	E	E	16

Leptodea leptodon (Scale shell)	**C2**	**R**	**11**
Plethobasus cyphyus (Sheepnose)		**R**	**32**
Simpsonaias ambigua (Salamander mussel)	**C2**	**E**	**2**
Vertigo meramecensis (Bluff vertigo)	**C2**	**SU**	**2**
Insects			
Agapetus artesus (Artesien caddisfly)	**C2**	**WL**	**1**
Leucotrichia pictipes (A micro caddisfly)		**SU**	**1**
Ophiogomphus westfalli (Arkansas snaketail dragonfly)	**C2**	**R**	**1**
Sinella auita (A springtail)		**R**	**3**
Mammals			
Mustela frenata (Long-tailed weasel)		**R**	**1**
Myotis grisescens (Gray bat)	**E**	**E**	**10**
Myotis leibii (Eastern small-footed bat)	**C2**	**R**	**1**
Myotis sodalis (Indiana bat)	**E**	**E**	**9**
Birds			
Accipter cooperii (Cooper's hawk)		**R**	**12**
Accipiter striatus (Sharp-shinned hawk)		**C**	**2**
Ardea herodias (Great blue heron rookery)		**C**	**10**
Podilymbus podiceds (Pied-billed grebe)		**R**	**1**

1 Federal status: E=Endangered; T=Threatened; C#-Candidate for federal listing; 3C-Former candidate

2 State status: E=Endangered; R=Rare; SU=Status undetermined; WL=Watch listed.

(Recent changes made by the USFWS in Federal listing of candidate species has eliminated 3C and C2 categories.)

Table16. Occurrence of stream corridor lengths where fully timbered corridors are at least 100 feet wide within SHAD sample sites located in the Meramec River basin, Missouri from 1991-96. Calculated values were based on two corridors per sample site.

No. of Corridors	Percentage of Timbered Stream Corridor Length ≥ 100 ft. Wide				
	<25	25-49	50-74	75-99	100
LOWER MERAMEC WATERSHED					
90	44.4	6.7	12.2	8.9	27.8
DRY FORK WATERSHED					
38	39.5	5.3	2.6	13.2	39.5
UPPER MERAMEC WATERSHED					
42	50.0	7.1	4.7	14.3	23.8
HUZZAH CREEK WATERSHED					
44	41.0	11.5	6.8	6.8	34.1
COURTOIS CREEK WATERSHED					
30	26.7	3.3	6.7	16.7	46.7
UPPER MIDDLE MERAMEC WATERSHED					
32	50.0	9.0	4.0	6.0	31.0
INDIAN CREEK WATERSHED					
26	38.5		3.8	7.7	50.0
LOWER MIDDLE MERAMEC WATERSHED					
50	46.0	6.0	12.0	14.0	22.0

Table 17. Predominant instream cover of SHAD sample sites located in the Meramec River basin, Missouri 1991-96. Values represent percentage of predominant cover types for riffles and pools within each sample site. Some areas had no description for riffle or pool.

No. of Riffles and Pools Sampled	Instream Cover for Pools and Riffles									
	B[1]	CB[2]	CO[3]	M/V[4]	WS[5]	NC[6]	R[7]	RK[8]	G[9]	ND[10]
LOWER MERAMEC WATERSHED										
90	33%	1%	9%	3%/2%	17%	6%	3%	12%	3%	10%
DRY FORK WATERSHED										
38	13%	5%	16%	3%/0%	37%		24%	3%		
UPPER MERAMEC WATERSHED										
42	5%	5%		12%/14%	32%	14%	17%			2%
HUZZAH CREEK WATERSHED										
44	20%	10%		8%/15%	35%		5%	5%		3%
COURTOIS CREEK WATERSHED										
30	13%	3%	13%	37%/10%	7%		17%			
UPPER MIDDLE MERAMEC WATERSHED										
32	19%	3%		3%/9%	28%	13%	13%			12%
INDIAN CREEK WATERSHED										
26		8%		4%/15%	27%	31%	12%	4%		
LOWER MIDDLE MERAMEC WATERSHED										
50	10%	6%	8%	4%/4%	36%	12%	8%	10%		

1B = 'BOULDER'
2CB = 'UNDERCUT BANK'
3CO = 'COBBLE\GRAVEL'
4M/V = 'MACROPHYTES (WATER WILLOW, WATER MILFOIL) OVERHANGING VEGITATION
5WS = 'WOODY STRUCTURE (FALLEN)'
6NC = 'NO COVER'
7R = 'ROOTS'
8RK = 'ROCK, BEDROCK, ASPHALT, CONCRETE'
9G = 'GARBAGE - (REFRIGERATOR, CARS, WASHERS)'
10ND = 'NO DESCRIPTION'

BIOTIC COMMUNITIES

F.

The information contained within this section lists some fauna found in the Meramec River basin; however, it is not a complete list. Although the aquatic ecosystem is inextricably connected with the terrestrial ecosystem, the emphasis is the stream ecosystem. Other basin surveys, such as the Environmental Inventory of the Meramec River basin by Rychman, Edgerley, Tomlinson, and Associates, Incorporated, have detailed the entire Meramec River ecosystem with existing information (RETA 1973).

F.1. FISH COMMUNITY INFORMATION

F.1.1. Sampling Protocol

Fisheries biologists with the Missouri Department of Conservation (MDC) performed fish community collections on streams within Meramec River basin to evaluate changes in composition, distribution, and relative occurrence on fish species. In addition, stream fish communities that MDC did not survey in the past were sampled more completely. William Pflieger of MDC's Fish Research Section used mostly drag-seines or kick-seines for his collections. The size variation between the two seine types allowed sampling of different habitats and different fish species. Generally, drag-seining is selective for nektonic species (those fish found swimming above the substrate), and kick-seining is selective for benthic species (smaller bottom-dwelling forms). Electrofishing can be size and species selective and therefore, like seining, may not completely assess the fish community composition. The Research Section, typically, used the drag-seine for pool and run areas and the kick-seine for riffles that contained benthic species. East Central Region Fisheries Staff used electrofishing as the primary sampling method and supplemented some collections with seining.

The regional fisheries staff employed similar techniques to the SHAD site selection process for the fish community site selection. In fact, regional fisheries personnel sampled at least one fish collection site for every stream with habitat evaluations (SHAD). Larger streams required more effort; therefore, streams of larger size had multiple sites. Generally, collection effort depended on the stream size and stream order. The stream order and gradient were important determinants in site selection.

F.1.2. Fish Community Species List and Years Collected

Since 1930, MDC fish biologists have collected a diverse assemblage of 125 fish species from the Meramec River basin. The Fisheries Division Research and Management fish collections were combined into a comprehensive fish species list of the 124 species names and the corresponding occurrence year (Table 18). A cavefish species *Typhlichthys subterraneus* (Southern cavefish) found at Maramec Spring Park brings the total to 125 fish species (see Table 15, subsection E.2.2). The species list was divided into large, nektonic, and benthic species, a division created by William Pflieger that allowed sampling adequacy comparisons. Because of differences in the collection techniques between research and management, a species present within only one collection may be attributable to many factors, including sampling gear type. The large group consists of species that grow to six inches or more in total length as adults.

Several fish species were found in one collection but not the other collection . For example among the large species collected only by Fisheries Research were the northern pike, spotted gar, blue sucker, and pumpkinseed. Among the large species collected only by Fisheries Management were the white catfish, bowfin, brown trout, striped bass, spotted bass, and creek chubsucker. Most notable species among the benthic species collected only by Fisheries Research were the mud darter, stonecat, Ozark logperch, and suckermouth minnow, and those collected only by Fisheries Management were the mottled sculpin and the fanned tail darter. The nektonic species disparity between the two collections was somewhat greater and many are species collected solely by the Fisheries Research from 1950-60.

F.1.3. Seine data (Research Fish Collection)

Fish collections by various individuals at Missouri Department of Conservation's Fisheries Research Section are contained within a collective fish community database (otherwise known as William Pflieger's fish database). Fisheries Research Section compiled fish sample collections of 89 localities from 1930 and nearly every decade after 1930 for a comprehensive historical perspective of changes in species diversity and species composition. Research personnel of the Missouri Department of Conservation made the following collections:

- 5 collections in 1930's,
- 18 collections from 1941-46,
- 4 collections from 1947-54,
- 32 collections from 1958-65,
- 6 collections from 1967-69,
- 19 collections from 1974-77,
- 7 collections from 1982-84,
- 7 collections in 1992.

Fisheries biologists made 23 collections in 1963, making this the predominant collection year. The strength of this database lies in the long-term collections, but researchers had few collections to allow individual site comparisons on the temporal scale. Biologists made successive collections on the following individual sites:

- site #375 on the Dry Fork (RM 6.0) sampled in August 1941 and again in October 1992.
- site #389 on the Upper Meramec River (RM 217.0) sampled in October 1933, 1963, 1984, and October 1992.
- site #353 on the Upper Middle Meramec River (RM 114.0) sampled in August 1941, 1963, and March 1977.

F.1.3.1. Fish Species Diversity

Diversity is often equated with variety or complexity. From an ecological perspective, diversity depends on the number of individuals present and the evenness with which the individuals are distributed among these species. Simpson's Diversity Index is the probability that two individuals chosen at random from the population will belong to the same group. Consistent with Strahler (1952), within higher-order streams, diversity remained high. Also, some stream segments sampled within a watershed demonstrated increasing diversity with increasing order. The Meramec River (seventh order) had the highest diversity. Although sampled more intensively, fourth-order streams had the largest variation in diversity. Because of differences in number of sites sampled and stream orders sampled within watersheds, comparing diversity among watersheds was difficult.

F.1.3.2. Fish Species Relative Composition

Differences in fish species composition in streams across basins may be due to the physical habitat, energy resources (food abundances), water quality and watershed characteristics, flow regime, and biotic interactions. In addition, seining methods are selective for certain taxonomic groups. Species composition shows species numbers relative to the total number of specimens collected. The fish community summaries of each watershed within the Meramec River basin were the result of seine efforts and species enumeration. Within Pflieger's fish database, researchers categorized sample sites as adequate (all species collected were counted), marginal (a random sample was counted), or inadequate (not all specimens collected were counted).

For each USGS 11-digit watershed within the Meramec River basin, a percentage species composition was calculated for adequately sampled sites from 1930-1992. We found five species that generally had the highest percentage composition within each individual Meramec USGS 11-digit watershed. Relative composition was highest for longear sunfish, central stoneroller, northern hogsucker, black redhorse, and bluntnose minnow. Shiners, especially the bleeding and bigeye shiners, occasionally comprised the highest percentage composition within a watershed.

Relative dominance of fish community family components varied only slightly across watersheds. Percid, centrarchid, catostomid, and cyprinid families were the dominant families within all watersheds. The cyprinid component was always the most numerous and diverse, comprising up to 90% of the specimens collected. Number of cyprinid species varied from 16-36 from the headwaters (Dry Fork and Upper Meramec River) to the Lower Meramec River watershed. The number of catostomid and percid varied from 4-13 and 7-16 species, respectively, from the Upper to Lower Meramec River watersheds.

The observed differences in sucker and darter species (considered intolerant to pollutants) composition across watersheds were probably due to a combination of sampling bias, underlying geology, and fish habitat selection within the basin. In addition, the higher-order streams have greater habitat diversity than lower-order streams, which may contribute to the difference in species composition. Within the Dry Fork, percentage composition of suckers within the Dry Fork watershed, was relatively low (0.3%) compared with other watersheds that had between 7% (Lower Meramec River) and 45% (Courtois Creek). Compared with other watersheds, however, darters (as Percidae) were relatively high in composition (5.9% compared with 2%-5.5% for other watersheds).

Finally, the number of Centrarchidae species were relatively stable across watersheds. Smallmouth bass numbers exceeded largemouth bass in all watersheds except Dry Fork. Within the Dry Fork watershed, green sunfish (3.77%) and largemouth bass (1.74%) were the predominant Centrarchidae species. The adjacent watershed, Upper Meramec River, longear sunfish were predominant and rock bass and smallmouth bass, nearly as dominant. Fewer largemouth bass were collected in the Indian Creek watershed. Indian Creek had the lowest number of centrarchid species compared with other watersheds (East Central Region fisheries biologists believe the low percentage composition of centrarchids was due to sampling biases).

F.1.3.3. Fish Species Relative Occurence and Historical Occurrence

Percent occurrence was determined for all sites. Among all watersheds the central stoneroller and the longear sunfish occurred most often within sample sites, indicating a wider distribution compared with other species. The bleeding shiner and the wedgespot shiner also occurred frequently.

Two species of fish in the Meramec River are migratory, found only within systems that have not been affected by Mississippi River lock and dams. Listed as rare in Missouri, the Alabama shad (*Alosa alabamae*) is the only truly anadromous fish species of this region (Pflieger 1975). Adults migrate up the Mississippi River to spawn on the sand and gravel of the Meramec River. Historic and recent collections have found small numbers of juvenile Alabama shad in the Lower Meramec River watershed, including the Big and the Bourbeuse rivers. Similarly, another migratory species, the American eel, is the only catadromous fish species in this region. Adults live in fresh or brackish waters and return to the Sargasso Sea near Bermuda to spawn. In historic and recent collections, biologists have found eels in the main stem Meramec River.

F.1.4. Electrofish and Seine Data (Regional Fish Collections)

Fish sampling was completed by MDC Fisheries Management Biologists in the St. Louis and East Central regions from 1986-1996. From 1986-1996, 97 sites were sampled by regional fisheries personnel, and 104 species were collected. Biologists sampled the following number of sites within each basin:

- Dry Fork watershed, 11 sites in 1995;
- Upper Meramec River watershed, 11 sites in 1995-96;
- Huzzah Creek watershed, 10 sites in 1992, 1995;
- Courtois Creek watershed, 11 sites in 1995;
- Upper Middle Meramec watershed, 10 sites in 1986, 1994, 1995-96;
- Indian Creek watershed, 9 sites in 1992, 1994-95;
- Lower Middle Meramec watershed, 17 sites in 1986-87, 1991-92, 1994-96;
- Lower Meramec watershed, 26 sites from 1986-91.

F.1.4.1. Species Diversity

Simpson’s Diversity Index was used to evaluate species diversity in the Regional fish collections. Sampled segments of third-order streams sustained the highest diversity compared to other stream orders. Some third- and fourth-order streams are direct tributaries to the larger-order streams, and give fish a greater number of niches. Antire and William creeks had high species diversity and are fourth-order tributaries to the seventh-order Meramec River within the Lower Meramec River watershed. Their watersheds are relatively undeveloped compared to those of Grand Glaize and Fishpot creeks, which are also fourth-order tributaries but had lower species diversity. Within the Lower Middle Meramec River, main stem sample sites had poor diversity. Likely, adequate fish samples were difficult to obtain at these sites, so were sampled for target species only. Pierce Creek, a tributary to the Little Meramec River, had the highest diversity for sampled sites within this watershed. All Indian Creek sample sites were moderate in diversity. Sampled sections of the Huzzah Creek watershed exhibited higher species diversity than sites within the Courtois Creek watershed. A particularly poor diversity value was found in

Shoal Creek in the Huzzah Creek watershed. Of the eight USGS 11-digit watersheds, the Upper Meramec River and Dry Fork watersheds were more diverse than the other six watersheds.

F.1.4.2. Fish Species Relative Composition and Occurrence

The relative densities of species components were varied between watersheds, although some watersheds exhibited similarities. Basinwide, dominant minnow species collected by Fisheries Management personnel were the central stoneroller and bleeding shiner. Densities of these species were lower in the higher-order streams systems, especially in the Lower Meramec River watershed. These species were generally restricted to small, clear upland streams. Dry Fork, Indian Creek, and Lower Middle and Upper Middle Meramec River watersheds had more central stonerollers than Huzzah Creek, Upper Meramec River, Lower Meramec River, and Courtois Creek watersheds, which had more bleeding shiners. The Upper Middle Meramec River watershed had the highest number of minnow species, and the main-stem Meramec River watersheds possessed more minnow species than the Huzzah Creek, Courtois Creek, or Indian Creek watersheds.

The dominant darter species were the northern orangethroat darter, rainbow darter, barred fantail, and Missouri saddled darter. The main-stem Meramec River watersheds from headwaters to mouth had more darter species than either the Huzzah Creek, Courtois Creek, and Indian Creek watersheds. Darter species were not found frequently in the Lower Meramec River, but a state-listed endangered species, the crystal darter, was found in small numbers. The northern orangethroat was well distributed throughout the Meramec River basin and had fairly high densities relative to other darters. The cobble substrates found in the basin's watersheds made habitat ideal for darters. Gravel substrate found in riffle areas was too small for darters to use as cover. Other percids, sauger and walleye, were found only in the Lower Meramec River watershed in this collection.

The northern hog sucker was the dominant sucker species in the Dry Fork, Huzzah and Courtois creeks, and Upper Meramec River. The black redhorse and the golden redhorse were abundant in the Upper Middle Meramec River and the Lower Middle Meramec River, respectively. Within Indian Creek few sucker species were collected by Fisheries Management personnel. Anglers, however, have reported catching suckers. Also, within the Dry Fork only one site had sucker and darter species. Finally, the number of sucker species increased from three species to 14 species from upper to lower Meramec River basin.

Important as sportfish, dominant centrarchid species were the green sunfish, longear sunfish, and the bluegill sunfish. Black and white crappie were only found within the Lower Meramec watershed. In addition, the Lower Meramec watershed supports a modest but growing population of spotted bass. Fisheries biologists are concerned about the growing number of spotted bass in this area because of the high relative composition as compared to smallmouth and largemouth bass and because of the increasing hybridization with smallmouth. Distribution of smallmouth and largemouth bass ranged from the Dry Fork to the Lower Meramec River. Throughout their range, smallmouth bass dominated the sample except in the Dry Fork, Lower Meramec River, and the Lower Middle Meramec River watersheds, where largemouth bass dominated the sample. Rock bass occurred most frequently in the Courtois, Huzzah, Lower Middle Meramec watersheds, and least frequently in the Dry Fork and Lower Meramec watersheds.

The Meramec River fish assemblage has apparent differences in fish species from the upper to lower Meramec River basin that are of interest to anglers. Particularly noteworthy is the presence of the channel catfish, flathead catfish, freshwater drum, paddlefish, and the shortnose and longnose gars in the lower Meramec River basin, especially the Lower Meramec River watershed. The gar species have established themselves in the sand-and-gravel pit lakes that are found in the lower Meramec River basin. Other species include the temperate basses, the white bass and striped bass, collected primarily in the Lower Middle Meramec River and Lower Meramec River watersheds.

F.2. AQUATIC INVERTEBRATES

F.2.1. Mussels

Although many surveys of naiades have been conducted in the Meramec River basin, little information was collected on the distribution and relative abundance of mussel species. The Missouri Department of Conservation conducted a survey of naiad fauna from 198 sites during April 1977 to November 1978 (Table 19) under contract by the Army Corps of Engineers (Buchanan 1980). Historically, two individuals published mussels species lists for this watershed. Grier (1915) published the first mussel species list of the Meramec River. Utterback's list (1917) for the entire Meramec River basin (including the Bourbeuse River and the Big River) included 24 mussel species. Other studies, conducted in the 1960s and 1970s, revealed about 46 species of mussels within the entire watershed (Meramec, Bourbeuse, and Big rivers), showing that Utterback found about half the mussel species. Of the 42 species within the Meramec River portion, eight naiad species (*Amblema ligamentina., Amblema p. plicata, Lampsilis r. brittsi, Megalonaias nervosa, Quintardi pustulosa, Elliptio dilatata, Cumberlandia monodonta, and Potamilus alatus*) comprised 80.9% of the living naiades found (Table 19). Of those species *Amblema o. olicata* and *A. l. carinata* comprised about 48%. Within Dry Fork the dominant species was the *Lampsilis siliquoidea (*35%*). Lampsilis reeviana brittsi* was the dominant species for both the Huzzah Creek (96%) and Courtois Creek watersheds (76.9%). After creation of the Federal Endangered Species Act, the spectaclecase (*C. monodonta*) was listed as endangered in 1971 (Oesch 1995). After being listed as endangered in Missouri, several large populations were found in the Meramec and Gasconade rivers. Presently, Missouri has the largest population of spectaclecase mussels in the United States.

F.2.2. Crayfish

Surveys conducted by the Missouri Department of Conservation, have identified eight crayfish species in the Meramec River basin (Table 20 and Table 15, subsection E.2.2). A unique crayfish species found in the Maramec Spring system is the cave crayfish (*Cambarus hubrichti*), which inhabits the subterranean spring system. Of the eight known crayfish species, the saddlebacked crayfish (*Orconectes medius*) was dominant (57.9%); however, sampling was not evenly distributed throughout the basin (Table 20). Sampling showed that the saddlebacked crayfish was a dominant species within the upper reaches of the Meramec, especially the Courtois Creek watershed. High relative abundance of the saddlebacked crayfish indicated that habitat conditions were more appropriate in the Courtois Creek watershed. The devil crayfish, which lives in burrows in timbered and formerly timbered areas along the floodplain of streams, was the least abundant species with only one specimen found within the Upper Meramec watershed. A few woodland crayfish were collected in the Huzzah Creek watershed. Finally, one state watchlist species, the Big River crayfish (*Orconectes harrisoni*), was collected in the Lower Meramec River watershed. The Big River crayfish is a medium-small, tan-colored crayfish with distinctive olive-green and reddish-brown bands on the abdominal segments. It is indigenous to the Big River and its tributaries of the eastern Ozarks.

The upper Meramec River, from river mile 13-50, and Courtois Creek exhibited the most diverse assemblages of crayfish species (Table 21). Field sampling, however, indicated that the first 116 miles of the Meramec River was the richest area.

F.2.3. Benthic Insects and Other Invertebrates

Aquatic insects have been considered indicators of water quality. Several commonly found aquatic insects orders in the Meramec River basin were: Plecoptera (stoneflies), Ephemeroptera (mayflies), Odonata (dragonflies, damselflies), Trichoptera (caddisflies), Coleoptera (beetles), Diptera (flies, midges), Megaloptera (alderflies, dobsonflies, fishflies), Lepidoptera (butterflies, moths), and Hemiptera (true bugs). The species within the order's Plecoptera, Ephemeroptera, Trichoptera, including the water penny, riffle beetle, the gilled snail and dobsonfly are considered sensitive organisms (Merritt and Cummins 1978). These species are often found within clear, well-oxygenated, unpolluted streams such as the Meramec River (Table 22).

F.3. WETLAND SPECIES

Wetlands function as spawning, nurseries, adult feeding and refuge habitats of selected fish species. Many rare and endangered species use wetlands for all or part of their life cycle (MDC 1994). Approximately 43% of the threatened and endangered species within the U.S. use wetlands directly or indirectly for survival (EPA 1993); six percent of the species were listed as rare within the state of Missouri (Table 23). According to the Guidelines for Promoting Fishery Resource Benefits in Missouri Wetlands (MDC 1994), the Meramec River basin has 35 fish species that use wetlands for part of their life cycle. One crayfish species, the devil crayfish, utilizes and builds earth mounds in the floodplain of streams. Finally, the Asiatic clam, an exotic mussel species, and three other native mussel species known to inhabit wetlands, the giant floater, mucket, and lilliput were found within the Meramec River Basin.

Promoting the protection and proper hydrologic functioning of stream-recharge areas, cutoff ponds, and riverine wetlands could enhance water quality and thus, the fish community. Using the National Wetland Inventory database for the Meramec River basin, we will be able to better select areas or sub-watersheds for future landowner agreements. Lastly, the flood buy-out lands purchased through the Federal Emergency Management Agency and SEMA (State Emergency Management Agency) will aid in protection of riparian wetlands, possibly by allowing proper functioning of these zones.

F.4. RARE, THREATENED, AND ENDANGERED AQUATIC FAUNA

Differing fauna are thought to have contributed to the decline of some aquatic species within the Meramec River basin, but the factors generally point in the direction of habitat destruction or cumulative habitat degradation. For instance, the decline of the Meramec's mussel fauna is attributed to the loss of stable substrates due to bank and channel degradation (Roberts and Bruenderman 2000). A locational list of the sensitive species within the basin can be found within the Natural Heritage database (the database is updated periodically with recent locations and new species). Included in this list are seven different species of amphibians, six species of fish, three cave-dwelling crustacean species, 11species of mollusks, four species of aqutic insects, four species of mammals, and four avian species that occur within the Meramec River basin (Table 15, subsection E.2.2).

Mollusks, the most endangered group, include one federally endangered species, the pink mucket

(Lampsilis abrupta). At present, the known range of the pink mucket in Missouri's Meramec River basin extends from the Shaw Arboretum in Gray Summit, MO to the confluence with the Mississippi River (see F.7 *Other Management Efforts and Research Efforts*, regarding a recent survey).

Along with habitat destruction, another factor contributing to decline in mussel species, was the button manufacturing industry. This industry used mussel species from the later 1880s to World War II, whereupon plastics replaced their use. Once button manufacturing plants depleted mussel beds within one stretch of river, they would move in search of newer beds.

Today, no commercial harvesting of mussels is allowed within the Meramec River basin (MDC 2001). In 1995, the Missouri Department of Conservation seized several tons of illegally harvested mussels. A recent innovation in Japanese cultured pearl industry has created a resurgence in mussel collecting (Kohne 1995). A bead from the mussel shell is implanted within the oysters to start a cultured pearl.

In the Ozark Border region, several rare, threatened, and endangered fish species are found within the lower 93 miles of the Meramec River (Table 15; subsection E.2.2). According to the MDC Research fish collection, Dry Fork, Huzzah Creek, Courtois Creek, and Indian Creek have no endangered species. In the combined Natural Heritage database and the MDC Research historical fish collection, the State of Missouri lists two endangered, six watchlist, five rare, and one extirpated species in the basin. The flathead chub, found at the confluence of the Mississippi River, has recently been federally listed (MDC 1995a). The crystal darter and the blue sucker were once considered candidates for listing and now are considered species of concern. The blue sucker was once found within the lower 36 miles of the Meramec River. They have not, however, been collected since 1963.

Of the six aquatic invertebrates listed in the Natural Heritage database, two species are watchlist species--*Agapetus artesus* (Artesien caddisfly) and *Stygobromus onondagaensis* (Onondaga cave amphipod). *Leucotrichia pictipes* (a micro caddisfly) is found in Crooked Creek and has an undetermined status. The cave-dwelling springtail, *Sinella auita*--state listed as rare-- is found within three caves, Fisher, Fox, and Great Scott. Two other state-listed rare species are the *Allocrangonyz hubrichti* (Central Missouri cave amphipod) and the *Ophiogomphus westfalli* (Arkansas snaketail dragonfly). The Central Missouri cave amphipod is found at Maramec Spring and the Arkansas snaketail dragonfly at Meramec State Park (Linden Trail, personal communication). Other collections, performed by Fisheries Research biologists, contain three additional state-listed species. *Serratella frisoni*--found within the Huzzah and Courtois creeks--and *Baetisa abesa*--found within the Meramec River--have undetermined status. *Glyphopsyche missouri*, found at Maramec Spring, is endangered in Missouri.

F.5. ANGLER SURVEY

F.5.1. Historic Angler Surveys

Techniques to assess and manage stream fisheries resources have evolved within the last 50-60 years. In the 1930s, the Fish Commission performed direct surveys of Missouri's streams on a regular statewide basis. During the 1950s, they stocked an 80-mile section of the Big Piney River to assess the implications of stocking as fishing improvement. Based on this study and an additional study on the Current River, the Fish Commission concluded that stocking was not likely to improve bass fishing. Still, little information was available about potential fishing improvement techniques. Angler surveys have been a cost-effective means of gathering important biological information on fish, such as assessing rates of harvest, and determining the needs of anglers, among others.

From 1958-69, George Fleener conducted a quantitative creel survey on Huzzah and Courtois creeks during March 15-November 30 (ten consecutive-year seasons). The objectives were to estimate fishing pressure and catch on 5.37 miles of Huzzah Creek and 6.25 miles of Courtois Creek. Both Courtois and Huzzah creeks have higher fishing pressure than Big Piney Creek and the Current River. Concern for the large contribution of the smallmouth bass less than 12 inches in the creel and extremely high fishing pressure, led to experimental regulations on the Huzzah and Courtois creeks.

The Missouri Department of Conservation believed regulation would improve fishing quality. From January 1, 1969 to January 1, 1974, they imposed a "fish-for-fun" regulation on a 6.2 miles section of Courtois Creek (Table 24). Also, during 1969, they imposed a 12-inch minimum length limit on the Huzzah Creek. Several surveys listed in Table 24 assessed the merit of the regulation. These studies concluded that a 12-inch minimum length limit had beneficial effects on the fishery and met with public acceptance. Consequently, on January 1974, the Missouri Conservation Commission approved the black bass 12-inch length limit for statewide use on Missouri streams.

F.5.2. Recent Angler Surveys

A survey conducted from 1978-79 on a 74-mile segment of the upper Meramec River found that all types of fishing made up about 10% of all visits (Fleener 1988). In the 117-mile lower segment of the Meramec River, pole-and-line fishing was popular, making up 15% of all visits to the area (Fleener 1988).

A study on two segments (the lower segment--Bass River Resort Campground to Huzzah Creek and upper segment--Misty Valley Campground to Bass River Resort Campground) of Courtois Creek was initiated 11 years after Fleener's study to determine if a catch-and-release fishery would be biologically appropriate for the lower Courtois Creek (Smith 1991). One segment was the same sample segment as that used in the 1969-73 fish-for-fun evaluation. The central objective of the 1991 investigation was to determine the biological need to manage the smallmouth bass fishery with a more restrictive regulation than the existing 12-inch minimum protected length limit. Based on comparisons to historic population indices, growth data, and creel surveys, East Central Region Fisheries staff determined that a catch-and-release regulation would not meet the public's expectation of higher catch rates and larger fish (Smith 1991). In a 1977 survey conducted by Fajen (1981), mean catch rate was 0.94 fish/hour, while in the 1991 survey conducted by Smith, the catch rate was 1.69 fish/hour.

In addition, the Meramec River Special Trout Management Area (a coldwater sport fishery on the Meramec River from Highway 8 to Scott's Ford) was assessed for valuable angler use information in 1996 and 1997. Over 4,000 fishing trips per year were made to the area. It took anglers less than 2 hours to catch a trout and an average of 16 hours to catch a trout greater than 15 inches.

Within the last few years, the Department of Conservation conducted several additional creel surveys of portions of the Meramec River watershed. From April 1991-October 1996, East Central Region Fisheries personnel conducted yearly creel surveys to assess the effectiveness of the 15-inch smallmouth bass management regulation on the Smallmouth Bass Stream Management Area (SMB SMA) from Scott's Ford to the railroad crossing at Bird's Nest (15 miles). The creel survey on the SMB SMA had four stations: Indian Springs, Riverview Access, The Rafting Company (Highway 19), and Bird's Nest. Onondaga Cave State Park was used as a control. Before the effects of the regulation change could begin to be realized, it took bass anglers an average of 11.3 hours to catch a smallmouth bass greater than 12 inches in the SMBSMA and 11.7 hours in the control area. Even greater improvements in the smallmouth bass population have been documented in electrofishing surveys of the two areas. For example, in the 1995 comparison of the regulation area versus control via electrofishing samples, improvements in the 12- to 15-inch smallmouth bass size range, as well as a 27% greater PSD (Proportional Stock Density) over the control.

Finally, hatchery personnel conducted a creel survey on Maramec Spring Park as part of a survey of Missouri's four state trout parks. Personal interviews were conducted with 2,057 anglers by means of a walking roving survey during 96 sampling periods for March 1, 1996 to October 31, 1996. The survey yielded results pertaining to angler demographics and characteristics, opinions and attitudes, satisfaction, success, and catch rates (Stanovick 1998).

F.6. COMMERCIAL HARVEST

As specified in 3CSR10-10.726 of the Wildlife Code of Missouri (1996), no commercial harvest of fish or mussels is allowed in the Meramec River basin. Mussels may be taken from commercial waters in any number with certain size restrictions (Wildlife Code of Missouri, 1996).

F.7. OTHER MANAGEMENT EFFORTS AND RESEARCH EFFORTS

In addition to the commitment to enhance fishing quality and opportunities in the Meramec River basin, the Missouri Department of Conservation is a partner in protection of aquatic resources.

Part of aquatic resources protection involves researching species distribution. A mussel (naiades) study on the lower Meramec River (lower 55 miles, 1 mile upstream of Interstate 55 bridge, upstream to the mouth of the Bourbeuse River) was contracted in 1996 by the USFWS, Columbia, Missouri. The last comprehensive survey on the Meramec River was conducted by the Missouri Department of Conservation. In the survey conducted by Alan Buchanan in 1977 and 1978, mussels were sampled in 15 sites from the mouth of the Bourbeuse River to the mouth of the Meramec River. The intent of the study was to obtain population characteristics of federal, state-listed, and candidate freshwater mussel species. In the USFWS study an important work component was to focus on evaluating the pink mucket *(Lampsilis abrupta*) population viability status. This component was part of a statewide pink mucket survey and recovery plan. The species will be considered viable (a single disturbance-event does not eliminate the species) when at least five viable populations are found. Finally, a 1997 mussel survey of approximately 75 sites covering the Big, Bourbeuse, and Meramec rivers was performed by Sue Bruenderman of MDC Fisheries Research.

F.8. FISHING REGULATIONS

The Wildlife Code of Missouri contains specific information about the statewide fishing regulations (creel limits, size limits, seasons and gear) that apply to the Meramec River. All statewide stream fishing regulations apply to most streams within the basin. To assure the continued quality of fishing within the Meramec Basin, however, special management areas for particular species are in effect.

A Smallmouth Bass Stream Management Area is found on the Meramec River from Scott's Ford to the railroad crossing at Bird's Nest (15 miles). Black bass regulations within these areas are as follows: 1) Daily limit is six, in aggregate including smallmouth bass, largemouth bass, spotted bass, and all black bass hybrids, and 2) with a 12-inch minimum size limit; 3) Bass may not be taken from March 1 to the Friday before Memorial Day. Within the Smallmouth Bass Management Area, however, no more than one (1) of the six black bass taken can be a smallmouth bass with a 15-inch minimum size limit.

A trophy trout fishing area is established on the Meramec River (except Maramec Spring Branch) in Crawford and Phelps counties from Missouri Highway 8 Bridge to Scott's Ford. Regulations are as follows: 1) Daily and possession limit is three trout of any species. 2) Minimum length limit is 15-inch. 3) Only flies and artificial lures may be used--synthetic eggs and soft plastic lures are specifically prohibited.

Because of the cold spring found in the 3.7-mile long stretch of Blue Springs Creek in Crawford County, from Blue Spring to its junction with Meramec River, a wild rainbow trout fishery exits. Wild trout management area regulations are as follows: 1) Daily and possession limit is one trout. 2) Trout must be 18-inch or greater in size to possess. 3) Only flies and artificial lures may be used--synthetic eggs, live bait, and soft plastic lures are specifically prohibited.

No changes in fishing regulations or further establishment of management areas are planned at this time. In recent years, however, management of fisheries has moved from the maximum sustained yield criterion to an optimum sustained yield criterion that is aimed at increasing angler satisfaction. Therefore, we manage the fishery so that it sustains the aquatic resource and responds to the needs of the recreational fishing public. Our angler surveys and biological sampling provide the necessary information to successfully manage fisheries for sustained recreational use.

Table 18. Fish species collected within the Meramec River basin. Represented are both Fisheries Research Section (Pflieger) and Fisheries Management Section with corresponding collection year.

Species Name	Research Collection Year	Management Collection Year
Large (species that obtain six inches or more as adults)		
Alosa alabamae (Alabama shad)	1954,47 to 57	1987,88, 96
Alosa chrysochloris (Skipjack herring)	1954,47 to 57,61	1987
Ambloplites rupestris (Rock bass)	1941,42,54,47 to 57,61,63,67,77,84,92	1986,87,88,89,90,91,92,94,95,96
Ameiurus melas (Black bullhead)	1930,41,47 to 57,61,84	1986,91
Ameiurus catus (White catfish)		1989
Ameiurus natalis (Yellow bullhead)	1933,41,54,47 to 57,63,67,74,92	1986,87,91,94,95,96
Amia calva (Bowfin)		1989
Anguilla rostrata (American eel)	1954,47 to 57,61	1986,87,89,92
Aplodinotus grunniens (Freshwater drum)	1941,47 to 57,61,63	1986,87,88,89,90,91,92,94
Carpiodes carpio (River carpsucker)	1942,54,47 to 57,63	1986,87,88,89,90,91
Carpiodes cyprinus (Quillback)	1954,47 to 57,61	1987,88,89,91,92
Carpiodes sp.		1996
Carpiodes velifer (Highfin carpsucker)	1954,47 to 57,63	1989,90,91,94

***Catostomus commersonni* (White sucker)**	**1941,47 to 57,61,63,74,76,77**	**1991,95**
***Ctenopharyngodon idella* (Grass carp)**		**1992**
***Cycleptus elongatus* (Blue sucker)**	**1954,63**	
***Cyprinus carpio* (Common carp)**	**1941,54,47 to 57,61,63**	**1986,87,88,89,90,91,94,95**
***Dorosoma cepedianum* (Gizzard shad)**	**1941,42,54,47 to 57,61,63,92**	**1986,87,88,89,90,91,92,94,95,96**
***Esox americanus* (Grass pickerel)**	**1941,54,47 to 57,61,63,77,92**	**1986,87,95,96**
***Esox lucius* (Northern pike)**	**1947 to 57,63**	
***Erimyzon oblongus* (Creek chubsucker)**		**1992**
***Hiodon alosoides* (Goldeye)**	**1954,63**	**1987,89,91**
***Hiodon tergisus* (Mooneye)**	**1954,47 to 57,63**	**1987,88,89,90,91,92**
***Hypentelium nigricans* (Northern hog sucker)**	**1941,42,54,47 to 57,61,63,67,74,82,92**	**1986,87,88,89,90,91,92,94,95,96**
***Ichthyomyzon castaneus* (Chestnut lamprey)**	**1954,47 to 57,61,63**	**1986,89**
***Ictalurus punctatus* (Channel catfish)**	**1941,54,47 to 57,61,63**	**1986,87,88,89,90,91,95**
***Ictiobus bubalus* (Smallmouth buffalo)**	**1954,47 to 57,63**	**1986,87,88,89,90,91**

Ictiobus cyprinellus (Bigmouth buffalo)	1954,47 to 57	1986,87,89,91
Ictiobus niger (Black buffalo)	1954	1987,89,90
Lepisosteus oculatus (Spotted gar)	1954	
Lepisosteus osseus (Longnose gar)	1942,54,47 to 57,61,63	1986,87,89,90,91,92,94
Lepisosteus platostomus (Shortnose gar)	1954,47 to 57,63	1986,87,88,89,90,91,95
Lepomis cyanellus (Green sunfish)	1930,41,42,54,47 to 57,61,62,63,67,74,76,77,82,83,84,92	1986,87,89,91,92,94,95,96
Lepomis gibbosus (Pumpkinseed)	1963	
Lepomis gulosus (Warmouth)	1941,54,47 to 57,63	1987,91,92,96
Lepomis humilis (Orangespotted sunfish)	1941,42,54,47 to 57,63	1991
Lepomis macrochirus (Bluegill)	1941,42,54,47 to 57,61,63,67,74,76,77,84,92	1986,87,88,89,90,91,92,94,95,96
Lepomis macrochirus x Lepomis megalotis (Bluegill x longear sunfish)		1986,87,91,95
Lepomis megalotis (Longear sunfish)	1941,42,54,47 to 57,61,63,67,74,77,84,92	1986,87,88,89,90,91,92,94,95,96
Lepomis microlophus (Redear sunfish)	1961,92	1987,95,96
Lepomis punctatus (Spotted sunfish)	1947 to 57	

Micropterus dolomieu (Smallmouth bass)	1941,42,54,47 to 57,61,63,67,74,77,84,92	1986,87,88,89,90,91,92,94,95,96
Micropterus dolomieu x *Micropterus punctulatus* (Smallmouth bass x Spotted bass)		1988
Micropterus punctulatus (Spotted bass)		1986,87,88,89,90,91,92,94,96
Micropterus salmoides (Largemouth bass)	1941,54,47 to 57,61,63,67,74,82,92	1986,87,88,89,90,91,92,94,95,96
Minytrema melanops (Spotted sucker)	1941,47 to 57,61,92	1986,87,91,92,95,96
Morone chrysops (White bass)	1954,47 to 57	1987,89,91,94
Morone saxatilis (Striped bass)		1989
Moxostoma anisurum (Silver redhorse)	1954,47 to 57,61,63	1987,89
Moxostoma carinatum (River redhorse)	1954,47 to 57,61,63	1986,87,88,89,90,91,92,94,95
Moxostoma duquesnei (Black redhorse)	1941,42,54,47 to 57,61,63,92	1986,87,88,89,90,91,92,94,95,96
Moxostoma erythrurum (Golden redhorse)	1941,42,54,47 to 57,61,63,84,92	1986,87,88,89,90,91,92,94,95,96
Moxostoma macrolepidotum (Shorthead redhorse)	1941,54,47 to 57,61,63	1986,87,88,89,90,91,92,94,95
Oncorhynchus mykiss (Rainbow trout)	1947 to 57,61,63	1995
Pomoxis annularis (White crappie)	1941,54,47 to 57,61,63	1986,87,89,90,91,92

***Pomoxis annularis* x *Pomoxis nigromaculatus* (White crappie x Black crappie)**		**1988**
***Pomoxis nigromaculatus* (Black crappie)**	**1941,54,47 to 57,61,63**	**1986,87,89,91**
***Pylodictis olivaris* (Flathead catfish)**	**1954,47 to 57,61,63**	**1986,87,88,89,90,91,96**
***Salmo trutta* (Brown trout)**		**1995**
***Stizostedion canadense* (Sauger)**	**1954,63**	**1986,87,88,89,90,91**
***Stizostedion vitreum* (Walleye)**	**1954,47 to 57,61,63**	**1986,87,88,91**
Benthic (smaller, bottom-dwellers)		
***Ammocrypta clara* (Western sand darter)**	**1942**	
***Cottus bairdi* (Mottled sculpin)**		**1991,92,94,95,96**
***Cottus carolinae* (Banded sculpin)**	**1946,61,77,84,92**	**1986,91,92,95,96**
***Cottus hyoselurus* (Ozark sculpin)[1]**	**1933,41,46,54,47 to 57,61,62,63,67,74,76,77,82,84,92**	
***Crystallaria asprella* (Crystal darter)**	**1954,47 to 57**	**1991,96**
***Erimystax x-punctatus* (Gravel chub)**	**1941,42,46,54,47 to 57,61,63,92**	**1991,95,96**
***Etheostoma asprigene* (Mud darter)**	**1963**	

Etheostoma blennioides (Greenside darter)	1941,42,54,47 to 57,61,63,67,77,84,92	1986,91,92,95,96
Etheostoma caeruleum (Rainbow darter)	1933,41,42,46,54,47 to 57,61,62,63,67,74,76,77,82,84,92	1991,92,95,96
Etheostoma f flabellare (Barred fantail darter)		1992,94,95,96
Etheostoma f lineolatum (Striped fantail)	1933,41,47 to 57,61,62,63,67,76,77,82,84,92	1995
Etheostoma nigrum (Johnny darter)	1930,47 to 57,63,74,77,92	1991,95,96
Etheostoma s spectabile (Northern orangethroat darter)	1930,33,41,42,46,54,47 to 57,61,62,63,67,74,76,77,82,83,84,92	1991,92,94,95,96
Etheostoma tetrazonum (Missouri saddled darter)	1941,42,46,54,47 to 57,61,63,77,84,92	1992,95,96
Etheostoma zonale (Banded darter)	1941,46,54,47 to 57,61,77,84,92	1995,96
Ichthyomyzon (Larval lamprey)	1947 to 57,61,92	1995,96
Ichthyomyzon fossor (Northern brook lamprey)	1947 to 57,61,63,67	
Noturus exilis (Slender madtom)	1933,41,46,47 to 57,61,62,67,74,77,82,83,84,92	1991,92,94,95,96
Noturus flavus (Stonecat)	1946,54,47 to 57,61,77,92	
Noturus nocturnus (Freckled madtom)	1941,42,54,47 to 57	
Percina c caprodes (Ohio logperch)	1941,54,47 to 57,61,63	1986,91,95,96

***Percina c fulvitaenia* (Ozark logperch)**	**1992**	
***Percina evides* (Gilt darter)**	**1941,42,54,47 to 57,61,63,77,92**	**1996**
***Percina maculata* (Blackside darter)**	**1954**	
***Percina phoxocephala* (Slenderhead darter)**	**1941,42,54,47 to 57,63**	
***Percina shumardi* (River darter)**	**1954,63**	
***Phenacobius mirabilis* (Suckermouth minnow)**	**1942,54,63,74,77**	
Nektonic (mostly live above the substrate and inhabit pools and deeper water)		
***Campostoma anomalum* (Central stoneroller)**	**1930,33,41,47 to 57,54,61,62,63,67,74,76,77,82,83,84,92**	**1986,87,91,92,94,95**
***Campostoma oligolepis* (Largescale stoneroller)**	**1933,41,42,46,47 to 57,54,61,62,63,67,74,76,77,84,92**	**1991,95**
Campostoma sp.		**1996**
***Cyprinella lutrensis* (Red shiner)**	**1941,63**	
***Cyprinella whipplei* (Steelcolor shiner)**	**1941,42,46,47 to 57,54,61,63,76,77,76,92**	**1995,96**
***Cyprinella spiloptera* (Spotfin shiner)**	**1941,42,46,47 to 57,54,61,63,76,77,92**	**1987,96**
***Erimyzon oblongus* (Creek chubsucker)**	**1941,61,63,67,82,83**	**1995,96**

***Erimyzon sucetta* (Lake chubsucker)**	**1961,63**	
***Fundulus catenatus* (Northern studfish)**	**1930,33,41,42,46,47 to 57,54,61,62,63,67,74,76,77,82,84,92**	**1991,92,95,96**
***Fundulus notatus* (Blackstripe topminnow)**	**1930,41,54,47 to 57,61,62,63**	**1991,92,94,95,96**
***Fundulus olivaceous* (Blackspotted topminnow)**	**1954,61,62,63,67,74, 76,77,84,92**	**1991,92,95,96**
***Gambusia affinis* (Mosquitofish)**	**1963,74,76,84,92**	**1987,92,95,96**
***Hybognathus nuchalis* (Mississippi silvery minnow)**	**1942,47 to 57,54**	
***Labidesthes sicculus* (Brook silverside)**	**1941,42,47 to 57,54,61,63,74,77,82,84,92**	**1995,96**
***Luxilus chrysocephalus* (Striped shiner)**	**1933,41,42,47 to 57,54,61,62,63,67,74,76,77,83,84,92**	**1991,92,95,96**
***Luxilus cornutus* (Common shiner)**		**1991**
***Luxilus zonatus* (Bleeding shiner)**	**1933,41,42,46,47 to 57,54,61,62,63,67,77,82,84,92**	**1991,92,94,95,96**
***Lythrurus u cyanocephalus* (Eastern redfin shiner)**	**1930,41,46,47 to 57,54,61,63,74,77,92**	**1995,96**
***Hybopsis storeriana* (Silver chub)**	**1954**	
***Nocomis biguttatus* (Hornyhead chub)**	**1933,41,42,46,47 to 57,54,61,62,63,67,77,82,84,92**	**1986,91,92,95,96**
***Notemigonus crysoleucas* (Golden shiner)**	**1930,41,54,63,77,82, 84**	**1986,91,92**

***Notropis boops* (Bigeye shiner)**	**1930,41,42,47 to 57,54,63,61,74,77,84,92**	**1991,94,95,96**
***Notropis amblops* (Bigeye chub)**	**1930,33,41,42,47 to 57,54,61,63,77,84,92**	**1995,96**
***Notropis amnis* (Pallid shiner)**	**1954**	
***Notropis atherinoides* (Emerald shiner)**	**1942,47 to 57,54,63,77**	**1991,95,96**
***Notropis blennius* (River shiner)**	**1963**	
***Notropis buccatus* (Silverjaw minnow)**	**1941,63,74**	**1994,95,96**
***Notropis buchanani* (Ghost shiner)**	**1954,63,77**	
***Notropis dorsalis* (Bigmouth shiner)**	**1947 to 57,63**	**1992,94**
***Notropis greenei* (Wedgespot shiner)**	**1941,42,46,47 to 57,54,61,63,67,77,84,92**	**1996**
***Notropis nubilus* (Ozark minnow)**	**1933,41,47 to 57,54,61,62,63,67,74,77,84,92**	**1991,92,95,96**
***Notropis rubellus* (Rosyface shiner)**	**1941,42,46,47 to 57,54,61,63,77,84,92**	**1995,96**
***Notropis shumardi* (Silverband shiner)**	**1963**	
***Notropis stramineus* (Sand shiner)**	**1930,41,42,47 to 57,54,63,74,76,77**	**1991,95,96**
***Notropis volucellus* (Mimic shiner)**	**1941,42,47 to 57,54,61,63,77,92**	**1992,95**

Notropis wickliffi **(Channel shiner)**	**1963**	
Phoxinus erythrogaster **(Southern redbelly dace)**	**1941,61,62,63,67,74,76,77,82,83,84, 92**	**1991,92,95**
Pimephales notatus **(Bluntnose minnow)**	**1930,41,42,46,47 to 57,54,61,62,63,74,76,77,84,92**	**1991,92,95,96**
Pimephales promelas **(Fathead minnow)**	**1941,54,63,74**	**1989,91**
Pimephales vigilax **(Bullhead minnow)**	**1942,54,63,77**	
Platygobio gracilis **(Flathead chub)**	**1963**	
Semotilus atromaculatus **(Creek chub)**	**1941,47 to 57,61,62,63,67,74,76,77,82,83,92**	**1991,92,94,95**
[1]Recently, Ozark sculpin has been identified as the Mottled sculpin (Pflieger 1997).		

Table 19. Numbers and relative abundance of living naiades found in the Meramec River (USGS Code #07140102) and some of its major tributaries. (Buchanan 1980)

Species	Meramec River		Huzzah Ck.		Courtois Ck.		Dry Fork	
	No.	%	No.	%	No.	%	No.	%
Cumberlandia monodonta (Spectacle case)	456	4.8						
Anodonta imbecillis (Paper pond shell)	5	0					3	1.1
Anodonta g. grandis (Floater)	156	0					28	10.6
Anodonta grandis corpulenta (Stout floater)	35	0						
Anodontoides ferussacianus (Cylindrical paper-shell)	0	0						
Strophitus u. undulatus (Squaw foot)	88	0					8	3
Alasmidonta marginata (Elk-toe)	28	0			16	6.8		
Alasmidonta viridis (Slipper-shell)	21	0			9	3.8		
Arcidens confragosus (Rock pocketbook)	11	0						
Simpsonaias ambigua (Salamander mussel)	0	0						
Lasmigona complanata (White heel-splitter)	16	0					12	4.5
Lasmigona costata (Fluted shell)	40	0					2	0.8
Megalonaias nervosa (Washboard)	585	0						
Tritogonia verrucosa (Buckhorn)	9	0						
Quadrula quadrula (Maple-leaf)	80	0						
Quadrula metanevra (Monkey-face)	33	0						
Quadrula pustulosa (Pimple-back)	545	0						
Amblema p. plicata (Three-ridge)	2094	0					25	9.4
Fusconaia ebena (Ebony shell)	4	0						
Fusconaia flava (Pig toe)	216	0			3	1.3		
Cyconaias tuberculata (Purple warty-back)	78	0						
Plethobasus cyphyus (Bullhead)	39	0						
Pleurobema coccineum (Round pig-toe)	225	0						
Elliptio c. crassidens (Elephant's ear)	0	0						

Elliptio dilatata (Lady-finger)	**513**	**0**						
Obliquaria reflexa (Three-horned warty-back)	**33**	**0**						
Actinonaias ligamentina carinata (Mucket)	**2441**	**0**						
Venustaconcha e. ellipsiformis (Ellipse)	**92**	**0**	**1**	**1.3**	**26**	**11**	**5**	**1.9**
Plagiola lineolata **(Butterfly)**	**82**	**0**						
Truncilla truncata (Dear-toe)	**64**	**0**						
Truncilla donaciformis (Fawn's foot)	**9**	**0**						
Leptodea leptodon (Scale shell)	**9**	**0**						
Leptodea fragilis (Fragile paper-shell)	**37**	**0**					**6**	**2.3**
Potamilus alatus **(Pink heel-splitter)**	**304**	**0**					**7**	**2.6**
Potamilus ohiensis **(Fragile heel-splitter)**	**18**	**0**						
Toxolasma parvus (Lilliput mussel)	**0**	**0**					**4**	**1.5**
Ligumia recta **(Black sand-shell)**	**126**	**0**						
Ligumia subrostrata (Pond mussel)	**0**	**0**					**3**	**1.1**
Lampsilis t. teres **(Slough sand-shell)**	**60**	**0**						
Lampsilis teres anodontoides (Yellow sand-shell)	**2**	**0**						
Lampsilis radiata luteola (Fat mucket)	**1**	**0**					**92**	**34.7**
Lampsilis orbiculata **(Pink mucket pearly mussel)**	**19**	**0**						
Lampsilis ventricosa (Pocketbook)	**176**	**0**	**1**	**1.3**	**1**	**0.4**	**70**	**26.4**
Lampsilis reeviana brittsi **(Britt's shell)**	**720**	**0**	**73**	**96.1**	**182**	**76.9**		
Epioblasma triquetra **(Snuffbox)**	**0**							
Total	**9,470**		**75**		**237**		**265**	

Table 20. Location of crayfish species within the Meramec River basin and the percent composition upon the date of collection (Missouri Department of Conservation, Pflieger Collection).

Scientific Name	Basin	Stream	Twn	Rng	Sec	Mile Head	Date	Total #Individuals	% Comp.
Cambarus diogenes (trace)	2	Meramec River	37N	05W	6	50	10/24/85	1	3.1
Cambarus maculatus	2	Meramec River	37N	05W	6	50	10/24/85	5	15.6
Total: 41 species (3.4%)	2	Meramec River	37N	05W	6	50	5/5/86	5	13.2
	3	Huzzah Creek	37N	02W	6	38	10/23/86	5	17.2
	3	Huzzah Creek	38N	03W	11	45	3/4/77	1	33.3
	4	Hazel Creek	36N	01W	19	5	10/18/84	9	4.3
	4	Hazel Creek	36N	01W	19	5	3/25/85	7	5.3
	4	Hazel Creek	36N	01W	19	5	5/5/86	3	7.5
	4	Courtois Creek	35N	01W	33	31	2/22/88	3	5.8
	7	Meramec River	40N	02W	13	116	3/4/77	1	12.5
	8	Meramec River	44N	04E	32	194	10/1/87	2	2.4
Orconectes harrisoni (0.9%)*	8	Meramec River	44N	04E	32	194	10/1/87	12	14.6
Orconectes hylas (trace)	3	Huzzah Creek	36N	02W	29	20	3/27/84	1	0.8
Orconectes luteus	2	Meramec River	36N	05W	12	38	5/31/84	25	52.1
Total: 215 species (17.8%)	2	Meramec River	37N	05W	6	50	5/5/86	20	52.6
	2	Meramec River	37N	05W	6	50	10/24/85	10	31.3
	2	Unnamed Creek	36N	03W	33	1	10/10/83	1	2.7
	2	Meramec River	34N	04W	19	13	3/30/84	2	6.5
	3	Huzzah Creek	36N	02W	29	20	3/27/84	33	25.2
	3	Huzzah Creek	37N	02W	6	38	10/23/86	5	17.2
	3	Huzzah Creek	38N	03W	11	45	3/4/77	2	66.7
	4	Hazel Creek	36N	01W	19	5	10/18/84	18	8.7
	4	Hazel Creek	36N	01W	19	5	5/5/86	14	35.0
	4	Hazel Creek	36N	01W	19	5	3/25/85	17	12.8
	7	Meramec River	40N	02W	13	116	3/4/77	6	75.0
	8	Meramec River	44N	04E	32	194	10/1/87	62	75.6
Orconectes medius	2	Stone Hill Branch	34N	04W	35	4	9/20/85	32	80.0
Total: 697 species (57.9%)	2	Stone Hill Branch	34N	04W	35	4	6/8/82	140	95.9
	2	Meramec River	37N	05W	6	50	5/5/86	9	23.7
	2	Meramec River	37N	05W	6	50	10/24/85	10	31.3
	2	Meramec River	34N	04W	19	13	3/30/84	6	19.4
	2	Unnamed Creek	37N	05W	5	1	9/28/84	7	46.7
	3	West Fork Huzzah Creek	34N	03W	22	5	2/4/87	15	93.8
	3	Huzzah Creek	36N	02W	29	20	3/27/84	50	38.2
	3	Huzzah Creek	37N	02W	6	38	10/23/86	19	65.5
	4	Hazel Creek	36N	01W	19	5	10/18/84	175	84.1

	4	Courtois Creek	35N	01W	33	31	2/22/88	36	69.2
	4	Hazel Creek	36N	01W	19	5	3/25/85	100	75.2
	4	Hazel Creek	36N	01W	19	5	5/5/86	14	35.0
	5	Hamilton Creek	40N	01W	29	3	11/14/85	83	97.6
	7	Meramec River	40N	02W	13	116	3/4/77	1	12.5
Orconectes punctimanus	1	Dry Fork	34N	06W	7	17	10/24/85	8	100.0
Total: 237 specimens (19.7%)	2	Meramec River	34N	04W	19	13	3/30/84	23	74.2
	2	Meramec River	36N	05W	12	38	5/31/84	23	47.9
	2	Meramec River	37N	05W	6	50	5/5/86	4	10.5
	2	Meramec River	37N	05W	6	50	10/24/85	6	18.8
	2	Stone Hill Branch	34N	04W	35	4	9/20/85	8	20.0
	2	Stone Hill Branch	34N	04W	35	4	6/8/82	6	4.1
	2	Meramec River	34N	04W	33	9	6/8/82	9	100.0
	2	Unnamed	37N	05W	5	1	9/28/84	8	53.3
	2	Cutoff Pool	36N	05W	12		5/31/84	3	100.0
	3	West Fork Huzzah Creek	34N	03W	22	5	2/4/87	1	6.3
	3	Huzzah Creek	36N	02W	29	20	3/27/84	47	35.9
	3	Unnamed Creek	36N	03W	33	1	10/10/83	36	97.3
	4	Courtois Creek	35N	01W	33	31	2/22/88	13	25.0
	4	Hazel Creek	36N	01W	19	5	5/5/86	9	22.5
	4	Hazel Creek	36N	01W	19	5	3/25/85	9	6.8
	4	Hazel Creek	36N	01W	19	5	10/18/84	6	2.9
	5	Hamilton Creek	40N	01W	29	3	11/14/85	2	2.4
	7	Fox Creek	43N	03E	4	7	3/22/86	10	100.0
	8	Meramec River	44N	04E	32	194	10/1/87	6	7.3
* Watch Listed Species							Total:	1,203	

1: Dry Fork 3: Huzzah Creek 5: Mid-Meramec 7: Lower-Middle Meramec

2: Upper Meramec 4-Courtois Creek 6: Indian Creek 8: Lower Meramec

Table 21. Crayfish species diversity (Shannon) and richness (Margalef) within watersheds of the Meramec River basin (Missouri Department of Conservation Pflieger Collection).

Basin	Stream Name	Mile Head	No. of Species	Average Shannon Total (n)	Average Margalef Total (n)
Dry Fork	Dry Fork	17	1	0.000(1)	0.000(1)
Upper Meramec	Meramec River	13-50	5	1.008(3)	0.705(3)
	Stone Hill Branch	4	2	0.336(2)	0.236(2)
	Unnamed Creek	1	2	0.691(1)	0.369(1)
	Cutoff pool		1	0.000(1)	0.000(1)
	Meramec River	9	1	0.000(1)	0.000(1)
Huzzah Creek	Huzzah Creek	20-45	3	0.880(3)	0.706(3)
	Unnamed Creek	1	2	0.124(1)	0.277(1)
	West Fork Huzzah Creek	5	2	0.234(1)	0.361(1)
Courtois Creek	Hazel Creek	5	5	0.892(3)	0.663(3)
	Courtois Creek	31	3	0.766(1)	0.506(1)
Middle Meramec	Hamilton Creek	3	2	0.111(1)	0.225(1)
Lower Middle Meramec	Meramec River	116	3	0.736(1)	0.962(1)
	Fox Creek	10	1	0.000(1)	0.000(1)
Lower Meramec	Meramec River	194	4	0.775(1)	0.681(1)

(n)=number of collections

Mile Head= distance in miles to headwaters

Table 22. List of aquatic invertebrates within the Meramec River basin (MDC Fisheries Research printout 1995).

PLECOPTERA (Stoneflies)		
Acroneuria internata	Isoperla namata	Perlesta sp.
Acroneuria sp.	Isoperla mobri	Perlesta placida
Acroneuria evoluta	Isoperla sp.	Perlidae
Agnetina sp.	Isoperla richardsoni	Perlinella drymo
Allocapnia vivpara	Leuctra sp.	Perlinella sp.
Allocapnia sp.	Nemoura sp.	Perlodidae
Alloperla sp.	Neoperla clymene	Prostoia sp.
Amphinemura delosa	Neoperla sp.	Pteronarcyidae
Brachypterinae	Oemopteryx sp.	Pteronarcys sp.
Hydroperla crosbyi	Paracapnia sp.	Strophopteryx sp.
Hydroperla sp.	Paragnetina sp.	Taeniopteryx maura
		Taeniopteryx sp.
EPHERMEROPTERA (Mayflies)		
Acentrella sp.	Ephemera sp.	Hexagenia atrocaudata
Anthopotamus sp.	Ephemerella argo	Isonychia sp.
Baetinae	Ephemerella needhami	Leptophlebia sp.
Baetis sp.	Ephemerella invaria	Neoephemera bicolar
Baetisca obesa	Ephemerella sp.	Paraleptophebia moerens
Baetisca sp.	Ephemerella subvaria	Rhithrogena sp.
Caenis sp.	Ephoron album	Seriatella sp.
Callibaetis sp.	Eurylophella sp.	Stenacron sp.
Choroterpes sp.	Heptagenia sp.	Stenonema pulchellum
Cloeon sp.	Heterocloeon sp.	Stenonema sp.
Ephemera simulans	Hexagenia rigida	Traverella sp.
		Tricorythodes sp.

ODONATA Anisoptera (Dragonflies)		
Aeshna	Hagenius brevistylus	Ophiogomphus sp
Dromogomphus sp.	Libellulidae	Progomphus sp.
Gomphidae	Macromia sp.	
ODONATA Zygoptera (Damselflies)		
Agropmodae	Argia sp	Hetaerina sp.
Aeshna	Calopteryx	
TRICHOPTERA (Caddisflies)		
Agapetus sp.	Hydropsyche sp.	Ochrotrichia sp.
Agraylea sp.	Hydropsyche betteni	Oecetis avara
Brachycentrus sp.	Hydropsyche simulans	Oecetis inconspicua
Ceraclea sp.	Hydroptila sp.	Oecetis sp.
Cheumatopsyche sp.	Hydroptilidae	Oxyethira sp.
Chimarra obscura	Ironoquia sp.	Phryganea sp.
Chimarra socia	Leptoceridae	Polycentropus sp.
Chimarra aterrima	Limnephilidae	Polycentropus sp.
Chimarra sp.	Marilia sp.	Protoptila sp.
Chimarra feria	Nectopsyche sp.	Psychomia flavida
Glossosoma sp.	Neophylax sp.	Psychomyiidae
Glyphopsyche missouri	Neophylax fuscus	Ptilostomis sp.
Helicopsyche borealis	Neotrichia sp.	Pycnopsyche sp.
Hydrophysche frisoni	Neureclipsis crepuscularis	Rhyacophila sp.
Hydropsyche cuanis	Neureclipsis sp.	Setodes
Hydropsyche aerata	Nyctiophylax sp.	Triaenodes sp.
		Wormaldia sp.

COLEOPTERA (Beetles)		
Agabus sp.	Enochrus sp.	Macronychus glabratus
Anchodemus sp.	Gonielmis sp.	Microcylloepus sp.
Berosus sp.	Gyrinus sp.	Onychylis sp.
Chaetarthria sp.	Helichus sp.	Optioservus sandersoni
Dineutus sp.	Helophorus sp.	Paracymus sp.
Dryops sp.	Hydaticus sp.	Peltodytes sp.
Dubiraphia sp.	Hydrobius sp.	Psephenus herricki
Dytiscus sp.	Hydrophilidae	Sperchopsis sp.
Ectopria nervosa	Laccobius sp.	Stenelmis sp.
Elmidae	Lutrochus laticeps	
DIPTERA (Flys)		
Antocha saxicola	Endochironomus sp.	Ormosia sp.
Antocha sp.	Erioptera sp.	Pedicia sp.
Atherix lantha	Euparyphus sp.	Pseudolimnophila sp.
Atrichopogon sp.	Forcipomyia sp.	Psychoda sp.
Bezzia	Glyptotendipes sp.	Simuliidae
Ceratopogonidae	Hemerodromia sp.	Simulium sp.
Chrysops sp.	Hexatoma sp.	Stratiomyidae
Cricotopus sp.	Limnophila sp.	Tabanus sp.
Culicoides sp.	Limonia sp.	Tanytarsus sp.
Dicranota sp.	Microtendipes sp.	Tipula sp.
Empididae	Odontomyia sp.	Tipula abdominalis
OTHER INSECTS		
Chauliodes sp.	Lepidoptera	Nigronia sp.
Corydalus cornutus	Lethocerus sp.	Rhagovelia sp.
Elophila sp.	Microvelia sp.	Sialis sp.

Hymenoptera	Naeogeus sp.	Trepobates
CRUSTACEA (Freshwater Shrimps)		
Amphipoda (immature)	Cambarus hubbsi	Hyallela azteca
Asellus sp.	Gammarus sp.	Lirceus sp.
Asellus brevicandus	Gammarus fasciatus	Orconectes sp.
GASTROPODA (Snails)		
Amnicola sp.	Fossaria sp.	Planorbidae
Chauliodes sp.	Lymnaea sp.	Pleurocera sp.
Elimia sp.	Physella sp	Sialis sp.
Ferrissia sp.	Physidae	Viviparidae
MISCELLANEOUS GROUPS		
Acari	Gordiida	Oligochaeta
Bryozoa	Hirudinea	Tubellaria
Intolerant		
Caddisfly: Order Trichoptera		Riffle Beetle: Order Coleoptera
Dobsonfly (Hellgrammite): Order Megaloptera		Stonefly: Order Plecoptera
Gilled Snail: Phylum Mollusca		Water Penny: Order Coleoptera
Mayfly: Order Ephemeroptera		
Moderately Tolerant		
Alderfly larva: Order Megaloptera		Dragonfly: Order Odonata
Beetle Larva: Order Coleoptera		Fishfly larva: Order Megaloptera
Clam: Phylum Mollusca		Scud: Class Crustacea
Crane Fly: Order Diptera		Sowbug: Class Crustacea
Crayfish: Order Crustacea		Watersnipe Fly Larva: Order Diptera
Damselfly: Order Odonata		

Tolerant		
Aquatic Worm: Class Oligochaeta		Midge Fly Larva: Order Diptera
Blackfly Larva: Order Diptera		Pouch Snail: Phylum Mollusca
Leech: Class Hirudinea		Other snails

Table 23. Fish, crayfish, and mussels species collected in the Meramec River basin that inhabitat wetlands for part of their life cycle.

Scientific Name (Common Name)	
FISHES[1]	***Labidesthes sicculus* (Brook silverside)**
***Ameiurus natalis* (Yellow bullhead)**	***Lepisosteus osseus* (Longnose gar)**
***Ameiurus melas* (Black bullhead)**	***Lepisosteus oculatus* (Spotted gar)**
***Carpiodes carpio* (River carpsucker)**	***Lepisosteus platostomus* (Shortnose gar)**
***Cyprinus carpio* (Common carp)**	***Lepomis humilis* (Orangespotted sunfish)**
***Dorosoma cepedianum* (Gizzard shad)**	***Lepomis punctatus* (Spotted sunfish)**
***Erimyzon oblongus* (Creek chubsucker)**	***Lepomis gulosus* (Warmouth)**
Erimyzon sucetta* (Lake chubsucker)	***Lepomis microlophus* (Redear sunfish)**
***Esox americanus* (Grass pickerel)**	***Lepomis macrochirus* (Bluegill)**
Esox lucius* (Northern pike)	***Lepomis cyanellus* (Green sunfish)**
***Esox americanus* (Grass pickerel)**	***Lythrurus u cyanocephalus* (Eastern redfin shiner)**
***Etheostoma asprigene* (Mud darter)**	***Micropterus salmoides* (Largemouth bass)**
***Fundulus notatus* (Blackstripe topminnow)**	***Notemigonus crysoleucas* (Golden shiner)**
***Fundulus olivaceous* (Blackspotted topminnow)**	***Pimephales vigilax* (Bullhead minnow)**
***Gambusia affinis* (Mosquitofish)**	***Pimephales notatus* (Bluntnose minnow)**
***Hiodon alosoides* (Goldeye)**	***Pimephales promelas* (Fathead minnow)**
***Ictiobus cyprinellus* (Bigmouth buffalo)**	***Pomoxis annularis* (White crappie)**
***Ictiobus niger* (Black buffalo)**	***Pomoxis nigromaculatus* (Black crappie)**
CRAYFISH [1]	**MUSSELS [2]**
***Cambarus diogenes* (Devil crayfish)**	***Corbicula spp*. (Asiatic clam)**
	***Anodonta grandis grandis* (Floater mussel)**
	***Actinonaias ligametina carinata* (Mucket mussel)**
	***Toxolasma panvus* (Lilliput mussel)**

*** State listed as rare species.**

[1]Missouri Department of Conservation Pflieger Fish Collection

[2]Missouri Department of Conservation 1980

Table 24. Regulation experiment to improve fishing.

Survey	Investigator/Year	Years Surveyed	Purpose	Findings
Creel Census of Huzzah and Courtois creeks	Fleener 1971	1958-68	Estimate annual fishing pressure and catch	80% of catch under 12 in.
Harvest of fish from Huzzah Creek	Fleener 1974	1969-73	Effects of 12 in. length limit on Smallmouth Bass on fish harvest.	Fish harvest increased to 35.5 lbs/acre. 12 in. limit was effective.
Harvest of fish from Courtois Creek	Fleener 1974	1969-73	Evaluate the effect of catch-and-release on Smallmouth Bass.	Fish harvest increase to 40.5 lbs/acre. 12 in. limit was effective.

GIS ANALYSES

Project Overview

The Geographic Information System (GIS) demonstration project within the Meramec River Watershed Inventory and Assessment effort was funded by the Environmental Protection Agency (EPA). The initial goal of the project was to produce many different large scale GIS layers for the Meramec River basin, thus providing the raw material for high quality natural resource inventory and analysis. The final objective of the project was to use the products of the analyses to prioritize wetlands for protection through acquisition or stream incentive programs. Much of the analytic techniques learned from these analyses will be used statewide for other river basin inventories.

The analytic phase of the project is already generating many new questions, some of which will lead to further analysis and/or more field work and subsequent analysis. One goal of this project is to further define the relationships between basin topography, land use in the basin and around the stream channel, and the effects they have on aquatic biota. Understanding and quantifying these relationships will give a basis for developing better management practices and provide information vital in dealing with many important conservation and water quality issues.

Analyses Overview

The following seven analyses were completed to answer wetland protection objectives, as well as various other management and research objectives:

1. Stream Prioritization

2. Watershed Landcover Prioritization

3. Stream Landcover Prioritization

4. Fish Nursery Wetlands

5. Wetland Prioritization

6. Fish Community Prioritization

7. Spectaclecase Mussel/ Slender Madtom

The prioritization analyses, Stream Prioritization, Watershed Landcover, Stream Landcover, Fish Nursery Wetlands, Wetland Prioritization, and Fish Community Prioritization, are directly concerned with wetland prioritization and protection. Protection could be either through acquisition or through landowner stream incentive programs, such as the Natural Resources Conservation Service (NRCS) Stream Buffer Conservation Reserve Program, or the MDC Alternate Watering Sources for Planned Grazing systems (part of the Stream Stewardship Program). Two other analyses, Spectaclecase Mussel Distribution and Slender Madtom Distribution are used to answer research questions. They will guide sampling efforts so researchers can better understand the distribution of species and identify the effects of various human activities on the aquatic resource.

While many of the analyses can be utilized independently to plan for protection, management, or research activities, consulting other analyses is recommended. Each prioritization analysis can be used as a decision making tool for incentives in the stream stewardship program.

1. Stream Prioritization

The stream prioritization analysis was performed to find stream segments near public land and near sites known as providing habitat for endangered species, or within spawning restricted reaches. The resulting selected set of 528 priority stream segments form only 5.6% of the 9,364 major stream segments for the basin. A series of seven GIS layers identifying either attractive features on or around the streams, such as springs or observed natural heritage species; or degrading features, such as chemical spill sites or mines, have been made available to further assess specific lands identified by any of the protection analyses.

Recommendation: Use of the results of this analysis is as a decision making tool for the biologist or planner who is assessing property for potential public land acquisition, or for prioritizing stream segments for incentive programs.

2. Watershed Landcover Prioritization

Landcover characterization was carried out to prioritize areas for acquisition or the stream incentive programs. Two analyses were done to provide a distributional measure of landcover within the watersheds and near the streams by combining either the Meramec Watershed stream network or the subwatershed layer with the Level 1 Landcover Classification of the Missouri Resource Assessment Partnership (MORAP).

The first analysis, watershed landcover prioritization, involved merging the project subwatershed layer with the landcover classification, and then rating the subwatersheds based on the percentages of certain landcover types, such as the Forest or Urban classes. Rated subwatersheds in order of most negatively impacted to the least negatively impacted watersheds were: Mattese Creek, Lower Lower Meramec. Lower Meramec Mainstem 5, Grand Glaise Creek, Fishpot Creek, Fishwater Creek, Dry Branch, Lower Courtois Creek, Billy’s Branch, and Upper Indian Creek. Subwatersheds with greatest area of cropland from most to least were: LowMid Meramec main stem 6, Calvey Creek, LowMid Meramec main stem 3, Dry Fork main stem 1, and Lower Meramec main stem 6. Lastly, the subwatersheds with greatest area of grasslands were from most to least: Upper Dry Fork, Dry Fork main stem 1, Little Dry Fork, Spring Creek, and Norman Creek.

Recommendation: Rankings of the subwatersheds could be used by management to decide where to allocate monies from stream incentive programs. The cropland area totals indicate areas that could be targeted for corridor improvement funds, or in grassland areas, funds could be allocated toward cattle grazing management programs, such as the Alternative Watering Systems for Planned Grazing Systems program, this program gives a cost share for fencing off the stream and installing appropriate watering facilities for cattle managed in an intensive grazing system.

3. Stream Landcover Prioritization

The second analysis, stream landcover prioritization, involved merging the landcover classification with streams and a 90-meter buffer area around them to identify the landcover type percentages about the streams. The merged stream-landcover GIS layer enables biologist to identify with simple queries those places in the basin where extensive row crop agriculture is occurring in close proximity to the stream channel. The relationship between cropland and streams varies among the subwatersheds, and significant reaches of unprotected streambanks can occur in any subwatershed with cropland. This analysis produced a data set with 70.98 kilometers (44.12 miles) of streams that have a high potential for being sources of sediment and farm chemicals, because they are adjacent to cropland and may have little or no corridor.

Recommendation: Stream segments with 50% or greater contact with cropland should be used to identify landowners who have little or no stream corridor on their land. Programs such as the MDC Stream Restoration Program or NRCS Stream Buffer Conservation Reserve Program could be used to assist landowner in creating and maintaining an effective corridor.

4. Fish Nursery Wetlands Identification

In this analysis, a set of potential fish nursery wetlands areas were selected. The results were used to provide one of the criteria for the Wetland Prioritization Analysis. The analysis utilized the National Wetland Inventory system of classes and modifiers to select among the many types of Palustrine wetlands. These selected wetlands were then reduced to those that have a direct connection to perennial streams to ensure juvenile fish could have access to the stream resource when they are mature. Field reconnaissance further determined the accuracy of potentially nursery areas. Out of these natural wetlands, only 398, or 2.5% of the total are inundated for extended periods. Out of these 398, 31 wetlands, which comprise only 0.12% of the total number of wetlands, had connectivity to perennial streams and were selected as potential fish nursery wetlands. Natural wetlands that might provide habitat for extended periods of time and have direct connection to water filled segments of the stream network, prove to be rare in the Meramec River basin.

Recommendation: Additional research needs to be done to determine additional wetland classes that function as fish nursery areas, and field work done to verify the fish nursery function of those selected classes.

5. Wetland Prioritization

Wetlands were rated according to a series of criteria that are based not only on the rarity or importance of the wetland type, but also on the local land use, as well as the proximity of the wetland to either beneficial areas (public land) or potentially degrading ones (encroaching urban areas). Rated wetlands had to be natural and Palustrine. Natural polygonal wetlands comprised 11.8% on public land (already protected), 43.6% within a mile of public land, 8.4% within a city limit, and 16.7% within a mile of a town. Thirteen protection area polygons encompassed the areas with the densest clumps of highly rated wetlands. These areas were, from largest wetland clusters to smallest wetland clusters and with a polygonal wetland rating, respectively, from 1-13: Saline Creek, Pacific, Eureka, Telegraph Road, Steelville, St. Clair, Salem, Crooked Creek, Scotts Ford/Riverview, The Eagle, Courtois/Lost Creek, Huzzah CA, Short Bend.

Recommendation: Suggested wetland protection areas should be targeted for acquisition or landowner enrollment in stream incentive programs because they contain the greatest concentrations of the most important wetlands.

6. Fish Community Prioritization

The Fish Community prioritization analysis was done to prioritize areas for protection, based on differences in ecoregions, watersheds, fish sampling criteria, habitat considerations, and impact sources. A series of area "strata" were set up by dividing the basin using three sets of boundaries, Bailey's Ecoregion, NRCS 11-digit watershed units, and stream order of the subwatershed. Of the total of 28 strata created, only 22 were used. Criteria used for the analysis were 1) species richness, 2) habitat characteristics such as the presence of wetlands and springs, 3) public land, and 4) the presence of human impacts, such as mining sites or chemical dumping sites. The first analysis was a statistical analysis on the above data set. No correlation was found between the data sets. The second analysis used a ranking system (four to 18, the higher the value the more suitable the stratum) to determine which strata would be recommended for land acquisition. The highest score from the analysis was 16 for strata F. Thirteen strata received the scores of 12 or below, these areas were not considered for protection. The nine remaining strata above 12 were considered.

Recommendation: Three of these strata, Q, F, and J, were eliminated due to lack of fish sampling data, leaving six, U, S, G, B, H, and D, recommended for protection. More sampling should be carried out in stratum Q, F, and J to better determine protection potential.

7. Spectaclecase and Slender Madtom Distribution

Analyses were done to investigate the sampled range of aquatic habitat attribute values (stream order, gradient, miles to headwater) from collection sites making a "signature" for a species. These signatures were then used to select stream segments with the same attribute values in order to predict the potential range of the endangered spectaclecase mussel and the slender madtom. The spectaclecase sampled range was confined to the Meramec River from river mile 9.89 to 136.16, or a total of 126.27 stream miles. The predicted range using GIS was 167.86 stream miles, a potential range that was 32.9% greater than in length the sampled range. The predicted range of the slender madtom was extensive, 794.76 miles, or approximately 4.5 times the sampled range, which was 176.25 miles in extent.

Recommendation: Use the spectaclecase data to plan sampling work to fill in gaps in the data, especially between river mile 157.60 and 180.04, to see if populations are on higher reaches than the previously sampled populations. Use the slender madtom data to identify areas with few or no samples, and plan subsequent sampling excursions to identify the extent of the species range. The predicted range of the slender madtom included streams that need to be sampled within the Courtois Creek watershed: Courtois Creek between above Doss Branch (river mile 3.65) to below the confluence with Lost Creek (river mile 15.65), and the confluence of Indian Creek and upper Courtois Creek (river mile 30.77), the three major tributaries to Courtois, Lost Creek, Hazel Creek, and Cub Creek should be sampled higher in these creek's main stem. Also, the predicted range of the slender madtom included streams that need to be sampled within the Indian Creek watershed: Indian Creek from the confluence of Little Indian Creek (river mile 2.39) upstream to the confluence of Little Courtois Creek (river mile 11.40), between the confluences of Little Courtois Creek and the confluence of North Cut Branch on Indian Creek, and between the confluence of Simmsons Hollow and the confluence of Pinery Creek.

GIS DATA

General Data Descriptions

Streams

Watersheds

Springs

National Wetlands Inventory

General Data Descriptions

Streams

There are three different stream network files for the Meramec River wateshed. All three files feature a large set of attributes, including the USGS Hydrologic Unit hierarchy, three types of stream order classifications, county and topographic information, and Environmental Protection Agency (EPA) RF3 codes. Besides this common set of attributes, each file has a different purpose, and a different set of attributes beyond the common ones listed above.

The original full stream network file (mernetf) was digitized at 1:24,000 scale from Mylar separates provided by the Natural Resources Conservation Service (NRCS). It has all 1:24,000 streams and includes every stream/contour intersection, which allows gradient to be hard coded into the file.

Watersheds

The subwatershed file (mershed) was produced at 1:24,000 from topographic map separates. NRCS provided an early release of 14-Digit Hydrologic Unit files that corresponded roughly to counties. These files were edge matched (edited so their lines matched perfectly where two different files met), appended (put together), and subset to the study area (trimmed to the boundary of the study area). The intent of NRCS was to produce a series of evenly sized management areas based on drainages and applicable to their system of field offices, rather than a hydrologically strict set of true subwatersheds.

Lines were added increasing the number of subwatershed units from 42 to 103 while imposing stricter hydrological breaks. The breaks of the subwatersheds make them conform closely to the network of streams, and form a series of main stem subwatersheds which are broken at the confluences of any tributary having its own subwatershed.

Springs

The spring file (mersprf) has all 182 Meramec River watershed springs as points. Data from the stream file was joined to it, bringing along all of the attributes. Thus each spring carries the attributes of its spring branch. For example, if the branch is perennial, or has an RF3 code, that information is in the stream's record. The UTM X and Y coordinates of the spring point are also included. The distribution of the springs in the Meramec River basin is strongly related to the dolomitic rock formations of the Ozarks.

National Wetlands Inventory

The completed NWI files consist of two files that cover the entire 8-digit watershed. One file has point features (mrbnwip) and the other has polygon and line features (mrbnwic). The two files have been subset to the same extent as the 8-digit watershed boundary of the study area, matching the hydrologic organization of the rest of the files. The resulting polygon/line file is quite large (73 megabytes), so the coverages have been further subdivided into the 11-digit watershed boundaries. Any wetland that fell on the boundary of two watersheds (mostly upland farm ponds) was included in the watershed that had the majority of the pond's area already inside it.

The 1:24,000 National Wetlands Inventory data set is the most detailed data set available for water bodies. The existing 1:100,000 water body file, extracted from Digital Line Graph files (DLG) has a total of only 188 water bodies represented for the Meramec River basin with a minimum size of just over an acre. In contrast, the NWI data set has 19,120 polygonal wetlands with a minimum size of 1/10th of an acre, and 3,345 smaller wetlands designated by points. Though not all polygonal wetlands are water bodies, the wetlands that carry the classifications PUBGh and PUBFh, are farm ponds. According to NWI, there are 13,241 of these water bodies in the watershed. This is quite an improvement over the 188 water bodies from the DLG's.

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ACTION PLAN

There are opportunities to help outline approaches, partners, and programs to assist citizens and agency personnel in conserving the aquatic resources of the Meramec River watershed. In addition, discussion and recommendations pertaining to watershed conditions, can be found in the Geographic Information Systems (GIS) Analyses section of this report, and a list of potential partners is contained in the Related Information link.

GOAL I: MAINTAIN AND IMPROVE WATER QUALITY IN THE MERAMEC RIVER BASIN SO ALL STREAMS ARE CAPABLE OF SUPPORTING HEALTHY NATIVE AQUATIC COMMUNITIES.

Status: Overall, water quality within the Meramec River basin is quite good. In fact, the Missouri Department of Natural Resources Clean Water Commission designated segments of Courtois Creek, Huzzah Creek, Blue Springs Creek, and the Meramec River as Outstanding State Resource Waters. Despite the basin's overall good water quality, problems do exist. In the upper and middle basin, cattle grazing on creek bottom pastures is very common. When cattle have open access to streams, damage to riparian areas and excessive nutrient loading of the streams often results. In the upper basin, impoundments containing tailings from mining operations pose a potential threat to stream water quality. The lower watershed from Eureka to Fenton is an urbanized zone that poses other threats to water quality. Sediment and pollution laden runoff enter the lower Meramec system rapidly because of impervious surfaces from development and the channelization of tributaries.

Objective 1.1: Streams within the basin will meet state standards for water quality.

Strategy: Enforcement of existing water quality regulations and necessary revisions to these regulations will help reduce violations. Water quality problems must also be addressed through public awareness efforts and by encouraging good land use in riparian areas and throughout watersheds in the basin. The citizen activism present in the basin through STREAM TEAMs and a variety of related organizations should be encouraged. Working with related agencies to promote public awareness and incentive programs, cooperating with citizen groups involved with water quality issues in the basin, and helping to enforce water quality laws will be among the most efficient ways to achieve this objective.

Enhance people's awareness of 1) water quality problems affecting aquatic biota, 2) viable solutions to these problems, and 3) their role in implementing these solutions. Media contacts, personal contacts, special events, and literature development and distribution will be used to reach people throughout the basin.

Review Section 404, Non-point Discharge Elimination System (NPDES), and other permits and either recommend denial or appropriate mitigation for those which are harmful to aquatic resources. Related activities will include cooperating with other state and federal agencies to investigate pollution events and fish kills, assisting with the enforcement of existing water quality, mining, landfill, and dam safety laws, and recommending appropriate measures to protect and enhance aquatic communities.

Missouri Department of Conservation (MDC), the Missouri Department of Health, and the Missouri Department of Natural Resources (MDNR), should work together to reduce contaminant levels in fish by collecting fish for contaminant analysis, advising the fishing public on the impacts of contaminant levels, and identifying and eliminating sources of contamination.

MDC, MDNR, and the Missouri Department of Health should work together to monitor water quality, improve water quality, and ensure compliance with discharge permits.

Trained volunteer groups, such as STREAM TEAMs, can assist with water quality monitoring and improvement. Volunteers are presently monitoring water quality at over 30 locations in the Meramec River basin. Recruit volunteers to monitor Blue Springs Creek and Brazil Creek.

Related monitoring efforts such as a possible Fisheries Division biomonitoring program and/or participation in the Missouri Aquatic Resource Assessment Project should also be encouraged and directed to strategic locations such as the lower Meramec where mussel populations are declining, Dry Fork and Blue Springs Creek which appear to be becoming more enriched from nutrient input, and Courtois Creek below the mine at Viburnum.

Besides involvement in water quality monitoring and trash pick-up efforts such as the highly successful Operation Clean Stream, STREAM TEAMs have an advocacy role to play in regulatory and enforcement matters pertaining to water quality. Examples include the need for supporting funding initiatives related to municipal sewage treatment plant upgrades and supporting the drafting and passage of comprehensive state water law, including provisions related to in-stream sand and gravel mining.

GOAL II. IMPROVE RIPARIAN AND AQUATIC HABITAT CONDITIONS IN THE MERAMEC RIVER BASIN TO MEET THE NEEDS OF NATIVE AQUATIC SPECIES.

Status: Stream habitat quality is fair to good throughout most of the basin. Some areas, including portions of the Brazil Creek subwatershed, Courtois Creek, Huzzah Creek, and Indian Creek watersheds, suffer from a more severe lack of riparian vegetation. In these and other streams the lack of adequate riparian corridors, excessive nutrient loading, streambank erosion, excessive runoff and erosion, and the effects of extensive instream gravel mining are among the problems observed. Grazing practices along many streams contribute to streambank instability, nutrient loading, and poor riparian corridor conditions. Increased land clearing and higher runoff associated with urbanization also impact stream habitat quality.

Objective 2.1: Riparian landowners on third-order and larger streams will understand the importance of good stream stewardship and where to obtain technical assistance for sound stream habitat improvement and good watershed management.

Strategy: Advertising and promoting stream programs, installing and maintaining demonstration projects, and providing educational opportunities to landowners will make them more aware of the reasons and techniques for protecting streams. Emphasizing economic advantages of stream improvements will encourage more landowners to participate.

Work with MDC’s Outreach and Education Division to develop stream management related materials and present related courses for elementary and secondary school teachers so that the next generation of landowners will understand the importance of good stream stewardship.

Establish and maintain stream management demonstration sites. Initially, existing sites on the upper Meramec and Indian Creek will be used for demonstration purposes. Thereafter, additional sites will be developed as part of an anticipated Special Area Land Treatment (SALT) Project in the Dry Fork watershed. Other sites will be located to provide demonstration opportunities to landowners throughout the basin.

Promote good stream stewardship through landowner workshops and stream demonstration site tours.

Objective 2.2: Maintain, expand, and restore riparian corridors, enhance watershed management, improve instream habitat, and reduce streambank erosion throughout the basin.

Strategy: Along with good water quality, high quality aquatic habitat is the critical factor in maintaining and improving natural stream communities. Stream habitat conditions will be improved by cooperating with and providing technical assistance to private landowners, working with other local, state, and federal agencies to manage stream frontages on their properties, and installing stream improvement and habitat enhancement projects on public lands within the basin. Monitoring habitat conditions and using regulatory avenues to reduce impacts from development projects should also help to identify problems and minimize impacts on the stream resource.

Monitor habitat conditions in the basin periodically by using satellite imagery, aerial photography, and on-site inspections. Update as needed the GIS data sets that are part of this project report.

Ensure that all public areas are examples of good stream and watershed management by including appropriate recommendations and prescriptions in area plans, implementing these practices in a timely manner, and monitoring these practices throughout their life. These practices will include, but may not be limited to, riparian corridor re-establishment, riparian corridor management, and maintaining soil erosion levels at "T" (soil replacement level) or lower.

Provide technical recommendations to all landowners that request assistance and who are willing to reestablish and maintain an adequate riparian corridor.

Work with the Natural Resources Conservation Service (NRCS) and the Soil and Water Conservation District (SWCD) boards to help them address watershed management concerns with their programs.

Improve riparian corridor and watershed conditions by actively participating in SALT projects to incorporate fish and wildlife values and promote sound stream stewardship. Cooperate with NRCS and SWCD boards to establish a SALT Project in the Dry Fork subwatershed and in additional subwatersheds suggested in the GIS Analysis Section of this report.

Assist landowners with improving stewardship of streams by promoting cost share programs, including MDC’s Cost Share Program, that include streambank stabilization, alternative watering provisions, and establishment and maintenance of quality riparian corridors in target areas. Material presented in this report is useful in considering potential target areas.

Encourage agencies, municipalities, county governments, and citizen groups such as the Meramec River Recreation Association, Operation Clean Stream, and STREAM TEAMs to work together in establishing and maintaining riparian greenways. Creating a comprehensive Meramec River greenway plan to be shared by adjoining stakeholders would aid the process. Important wetlands identified in the GIS Analyses section of this report should be considered in future additions to existing greenways.

Assist with monitoring compliance with provisions of the Meramec Park Lake deauthorization (Public Law 97-128). Besides deauthorization of the reservoir, the state of Missouri was deeded a perpetual 600-ft. easement on privately-owned land bordering the Meramec River, Huzzah Creek, and Courtois Creek within the project area. This easement is intended to provide a natural corridor in which construction of new buildings, tree cutting, and trash deposition are prohibited.

Assist the US Army Corps of Engineers in their Section 404 regulatory activities, especially those pertaining to gravel mining and bridge replacements. Assistance shall be in the form of reporting unauthorized activity as well as participating in pre-application meetings and commenting as requested on 404 permit applications. Utilize contacts with landowners, contractors, developers, and municipal and county officials as opportunities to educate people about how to obtain gravel and control construction site erosion in ways that minimize damage to stream systems.

Objective 2.3: Protect and restore the limited wetland habitat within the Meramec River watershed, particularly Palustrine wetlands that function as fish nursery areas and areas containing significant clusters of Palustrine wetlands.

Strategy: Nearly all of the goals, objectives, and strategies in this Action Plan contribute to the conservation of Riverine wetlands. A more directed effort will be needed to address conserving important and scarce Palustrine wetlands.

Provide wetland location information contained within the GIS Analysis Section of this report to the entities involved in establishing greenways along the Meramec River and tributaries, so future greenway additions may possibly include these wetlands.

Provide wetland location information contained within the GIS Analysis Section of this report to entities responsible for the ownership and management of public lands to help ensure that special Palustrine wetlands already in public ownership are properly managed to protect and restore their unique characteristics. In addition, knowledge of special wetlands in an area may aid their acquisition if opportunities for purchase occur.

Where special Palustrian wetlands occur on private land, landowners should be made aware of the uniqueness of the resource in their possession. This could be accomplished by direct personal contact from agency personnel, agricultural agency field days, or other means such as mailing information.

Some landowners may have the desire to participate in private land incentive programs which help fund management techniques that benefit wetlands. There are a variety of programs available, and landowner services personnel with MDC, NRCS, and SWCD can assist in matching the right program with a particular landowner's resource and land management goals. Some examples of pertinent incentives include the Wetland Reserve Program, the Conservation Reserve Program, and cost shares for setting up planned grazing systems.

GOAL III: MAINTAIN DIVERSE AND ABUNDANT POPULATIONS OF NATIVE AQUATIC ORGANISMS WHILE ACCOMMODATING ANGLER DEMANDS FOR QUALITY FISHING.

Status: The basin has a very diverse fish assemblage of 125 fish species collected since 1930. The crystal darter, a state-listed species, is present in the lower Meramec Basin. Excellent sportfishing is available on the Meramec and its tributaries, and basin streams are widely acclaimed, particularly for smallmouth bass and rock bass. Sportfishing management emphasis species are smallmouth bass, largemouth bass, rock bass, brown trout, and rainbow trout. Crawford County contains the Meramec River Special Trout Management Area (from Scott's Ford Access to Bird's Nest Access), the Meramec River Smallmouth Bass Special Management Area (from Highway 8 to Scott's Ford Access), and the Blue Springs Creek Wild Trout Management Area. The heavily fished Maramec Spring Trout Park lies immediately adjacent to the Meramec in Phelps County. Floating and float-fishing are highly popular within the basin, particularly on the upper Meramec River, Huzzah, and Courtois Creeks. The taking of non-gamefish (mainly sucker species) by gigging is a strong tradition throughout the basin.

Meramec mussel populations have been surveyed periodically. Relative abundances are declining, and habitat disturbances are the suspected cause. Fortunately, the endangered pink mucket (federal listing) is still maintaining a presence in the lower Meramec.

The Meramec River basin contains eight species of crayfish and many aquatic insect groups, including pollution intolerant species that require clear, well-oxygenated, unpolluted streams. Unusual macroinvertebrates found in the Maramec Spring system include the cave crayfish (*Cambarus hubrichti*) and a caddisfly, *Glyphopsyche missouri* Ross. The cave crayfish inhabits the subterranean spring system while *Glyphopsyche missouri* is found in the spring branch. Maramec Spring is the only known location of *Glyphopsyche missouri* in the world.

Objective 3.1: Evaluate, maintain, and where feasible, improve sportfish populations, with primary emphasis on smallmouth bass, largemouth bass, brown trout, rainbow trout, and rock bass.

Strategy: Assess the quality of populations of sportfishing management emphasis species and take steps to maintain or improve their populations through public education, regulations, habitat improvement, stocking, and other methods.

Finish the evaluation of the regulations on the Meramec River Smallmouth Bass Special Management Area and conduct periodic sampling to monitor any changes in the smallmouth bass population over time.

Conduct black bass and rock bass population sampling on the Meramec River in Franklin County to help determine the feasibility of establishing special management area fishing regulations there.

Stay updated on the status of sportfish populations in the Meramec and its more heavily-fished tributaries through periodic sampling.

Complete and report on the assessment of the Meramec River Trout Special Management Area currently in progress. Adjust the brown trout stocking regime and regulations if appropriate. Work with the public to increase understanding and compliance with area regulations.

Proceed with experimental instream habitat improvement projects at Blue Springs Creek.

Objective 3.2: Maintain populations of native non-game fishes and aquatic invertebrates at or above present levels throughout the basin.

Strategy: Assess the status of fish and invertebrate communities through systematic, periodic sampling. Techniques to maintain or improve non-game fish or invertebrate communities will depend on the community in decline and the causes of the decline.

Develop standard sampling techniques for assessing fish and invertebrate communities, including the use of indicator species, and implement a monitoring program to track trends in species diversity and abundance.

Maintain aquatic biodiversity and protect or enhance fish and invertebrate species diversity and abundance using water quality improvement, habitat improvement, regulations, stocking, and related techniques.

Encourage the formation of a SALT Project for the Dry Fork watershed. The Dry Fork is the major recharge area for Maramec Spring. Maramec Spring is a vital water source for the Meramec River, and the spring branch itself contains very unique fauna.

GOAL IV. IMPROVE THE PUBLIC'S APPRECIATION FOR STREAM RESOURCES AND PROVIDE FOR RECREATIONAL USE OF STREAMS IN THE MERAMEC RIVER BASIN.

Status: Streams in the basin are used extensively for fishing, floating, motor boating, and other recreational activities. The upper Meramec, Huzzah, and Courtois creeks each receive considerable use by floaters. Seventeen MDC stream access sites are located in the basin. Access to stream frontage is also provided by a mix of MDC conservation areas, MDNR state parks, county parks, and United States Forest Service (USFS) lands.

The public's understanding of the biological, social, and economic importance of streams in the Meramec Basin may be above average as evidenced by the defeat of the Meramec Dam proposal by referendum in 1978. While landowner participation in Streams for the Future programs has been limited, participation in the STREAM TEAM program has been good. Efforts are underway by several groups in the basin, including STREAM TEAMs, to improve public awareness of the importance of high quality streams.

Objective 4.1: Access sites, bank fishing, and trails will be developed and maintained in sufficient numbers to accommodate public use.

Strategy: Fishing, floating, and other stream-based recreational activities are heavy within the Meramec Basin. Acquisition and development projects along basin streams should be geared to meet the heavy demand.

Acquire and develop public access and frontage sites (for boating and bank fishing) at Wesco in Crawford County, near Highway 30 in Franklin County, and at Route 66 State Park in St. Louis County.

Encourage agencies, municipalities, and county governments to establish and maintain riparian greenways, wetlands, provide stream access, and improve bank fishing and other aquatic wildlife-based recreational opportunities on public lands.

Objective 4.2: Increase the general public's awareness of stream recreational opportunities, local stream resources, and good watershed and stream management practices.

Strategy: The public will be made aware of stream related recreational opportunities and issues through media outlets, fair exhibits, and MDC publications. Increased appreciation of stream resources should follow enhanced public awareness and education. More concern about the quality of water and habitat within the basin's streams should follow, and greater citizen involvement and advocacy in related environmental issues should result. Newspaper articles, presentations, and special events highlighting streams should help foster this awareness.

Use streams for aquatic education programs with schools. Identify stream locations appropriate for educational field trips near participating schools. Water quality and proper land and riparian management should receive topical emphasis in rural areas, whereas water quality advocacy and stream user etiquette should be emphasized in suburban and urban locales.

Participate in special events such as the Water Festival funded by a MDNR grant to the Meramec Regional Planning Commission. The objective of the Water Festival is to teach school children the basics of water quality.

Maintain a stream emphasis in displays at public events, particularly the numerous community and county fairs.

Contribute to an annual fishing prospectus for selected streams and to future revisions of Missouri Ozark Waterways (Hawksley 1997) and other water-oriented publications.

There are over 80 listed STREAM TEAMs within the Meramec River basin. Despite very good coverage of the basin by TEAMs, a few gaps exist. Recruit TEAMs for Dry Fork and Brazil Creek. Promote the formation of STREAM TEAM associations.

Distribute information through organizations such as the Meramec River Recreation Association, STREAM TEAM, canoe outfitters, and angler clubs.

Assist private sector businesses, as appropriate, with developing Meramec River ecotours.

Create a condensed version of this report, and make it available on the Internet for general distribution.

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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 ($CaMg(CO_3)_2$).

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 agency, 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 1º Celcius 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.

Palustrine wetland Palustrine" comes from the Latin word "palus" or marsh. Wetlands within this category include inland marshes and swamps as well as bogs, fens, tundra and floodplains. Palustrine systems include any inland wetland which lacks flowing water and contains ocean derived salts in concentrations of less than .05%.

Perennial streams Streams fed continuously by a shallow water table.

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.

Return Period The average length of time between two floods of a given size or larger.

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.

RM River mile.

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 hierarchial 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 (USACE) Federal agency under control of the Army, responsible for certain regulation of water courses, some dams, wetlands, and flood control projects.

United States Forest Service The U.S. Department of Agriculture Forest Service is a Federal agency that manages public lands in national forests and grasslands.

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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List of Tables

Geology

Land Use

Hydro

Water quality

Habitat

List of Figures