Executive Summary of the

JAMES RIVER WATERSHED MANAGEMENT PLAN

by the SMCOG Southwest Missouri Council of Governments

Executive Summary

The James River Basin Partnership and Southwest Missouri Council of Governments, in cooperation with other governmental and non-governmental partners, have developed this watershed management plan for the James River Basin. The primary components of the plan are: 1) history, setting and water quality conditions of the James River Basin; 2) public participation in the planning process; 3) modeling of pollutant loads; 4) descriptions of water quality problems or "impairments;" 5) recommended management measures to address impairments; 6) action plans for each of the six sub-basins or watersheds in the James River Basin (See Figure 1); 7) financial and technical assistance; and 8) plan evaluation. Detailed discussions on each of these topics are found in the chapters of the plan.

The James River Basin lies in the Ozarks Bioregion in southwestern Missouri. A major tributary of the White River of the central U.S., the James River stretches for over one-hundred miles from its headwaters in Webster County to its mouth at the White River (now, Table Rock Lake) in Stone County. The 1,455 square miles of the basin cover all or parts of eight Missouri counties. Land-uses across the basin vary widely. Generally, agriculture predominates in the upper and lower ends of the basin, with urban and suburban uses in the central part of the basin in Greene and Christian Counties.

Water quality problems or "impairments" in the James River Basin have been identified, relating to both urban and agricultural land-uses. Streams and lakes identified as impaired are subject to a process mandated in the federal Clean Water Act. A Total Maximum Daily Load (TMDL), the process for which is outlined in the Introduction of the plan, was approved in 2001 and updated in 2004 to address nutrient impairments in the James River. This nutrient impairment is discussed in detail in Chapter 3, "Watershed Conditions." The James River is no longer considered impaired for nutrients, but implementation of this watershed plan will preserve and protect beneficial uses in the James River and other streams and groundwater in the James River Basin.

Table 1 shows the waterbodies in the James River Basin that are currently listed by the state of Missouri as "impaired" for beneficial uses. NPS refers to non-point source pollution, the primary cause of impairment in the James River Basin.

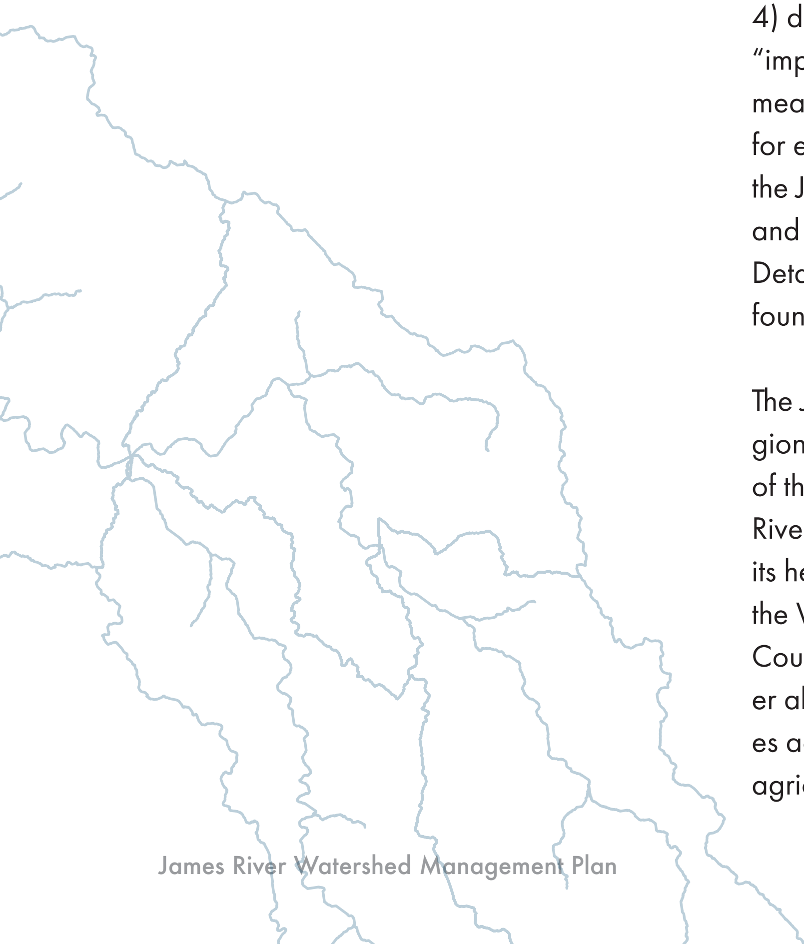


Table 1

Impairment	Water Body	Cause/Source
E. coli bacteria	Pearson Creek	NPS
	Wilsons Creek	NPS
	James River	Unknown
Aquatic Macroinvertebrate Bioassessments (loss of biotic diversity)	Crane Creek	Unknown
	Pearson Creek	Unknown
	Wilsons Creek	NPS/Unknown
Polycyclic Aromatic Hydrocarbons (PAH)	Jordan Creek	Urban NPS
Zinc	N. Br. Wilsons Creek	Urban NPS
Chlorophyll-a	Lake Springfield	NPS
Chloropl hyll-a, Total Nitrogen (TN), Eutrophication (nutrient enrichment, algal growth)	Table Rock Lake	Municipal PS/NPS

Figure 1 HUC-10 Watersheds in the James River Basin

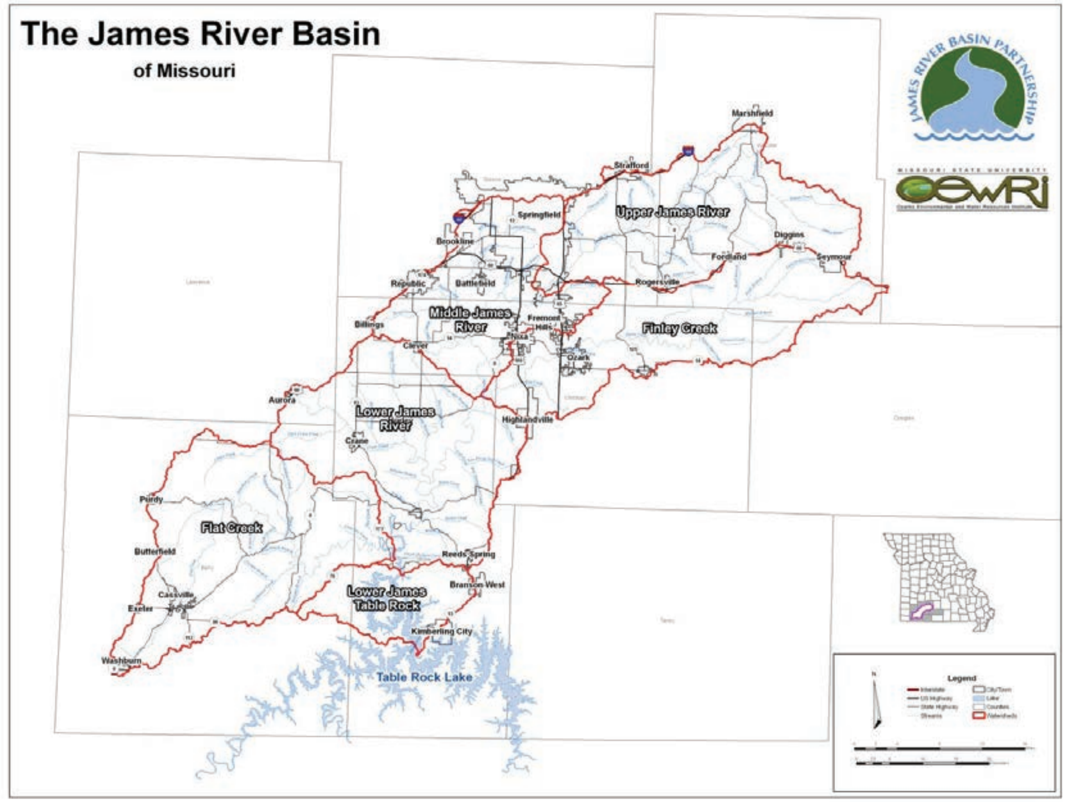


Table 2

Waterbody	Impairment	Sources	Extent in watershed
James River	Nutrients	Soil erosion, animal wastes Stormwater runoff	10% of basin urban or urbanizing 50% of basin in agricultural uses
James River	*E. coli*	Soil erosion, animal wastes, onsite wastewater systems Stormwater runoff	10$ of basin urban or urbanizing 50% of basin in agricultural uses Unknown number of onsite systems, but many thousands
Pearson Creek	*E. coli*	Soil erosion, animal waste Stormwater runoff Soil erosion, animal	About 30 square miles of urban or urbanizing areas One large dairy, about 10,000 acres in pasture 680 square miles of James River
Lake Springfield	Nutrients, algae (chlorophyll-a)	Domestic wastewater	20 publicly-owned wastewater treatment plants in basin; with appropriate effluent limits in permits, plants do not contribute to nutrient impairments
Table Rock Lake	nutrients		

Table 3

Practice	TN reduction	TP reduction	Sediment reduction
Vegetated stream buffers in agricultural (pasture) areas	34%	34%	20%
Vegetated stream buffers in urban areas	6%	9%	4%
Buffers in both agricultural and urban areas	40%	43%	24%
Total reductions	1,830,000 lbs./yr.	222,300 lbs./yr.	58,050 tons/yr.

Table 4

Total	Total	Total
Sediment	Nitrogen	Phosphorus
(T/yr)	(lb/yr)	(lb/yr)
136,147	4,576,493	516,701

Following the recommendation of the USEPA, this James River Basin management plan will follow nine key elements in order to address the impairments outlined above:

1. Element 1: Identification of the causes and sources of pollution that need to be controlled in order to achieve the desired load reductions of pollutants (Table 2).

2. Element 2: Pollutant load reductions expected from the application of management measures in critical areas (see Chapter 5). Estimates of load reductions were obtained using a Soil and Water Assessment Tool (SWAT) model, described in Appendix D, to estimate current loads of total nitrogen (TN), total phosphorus (TP) and sediment, and to estimate the anticipated load reductions from the applications of better practices in the basin. Table 3 shows the practices used in the model to compute load reductions, and the expected reductions:

3. Element 3: Description of the management measures that will need to be implemented in the basin to achieve the desired reduction in pollutants (Table 4). Other management

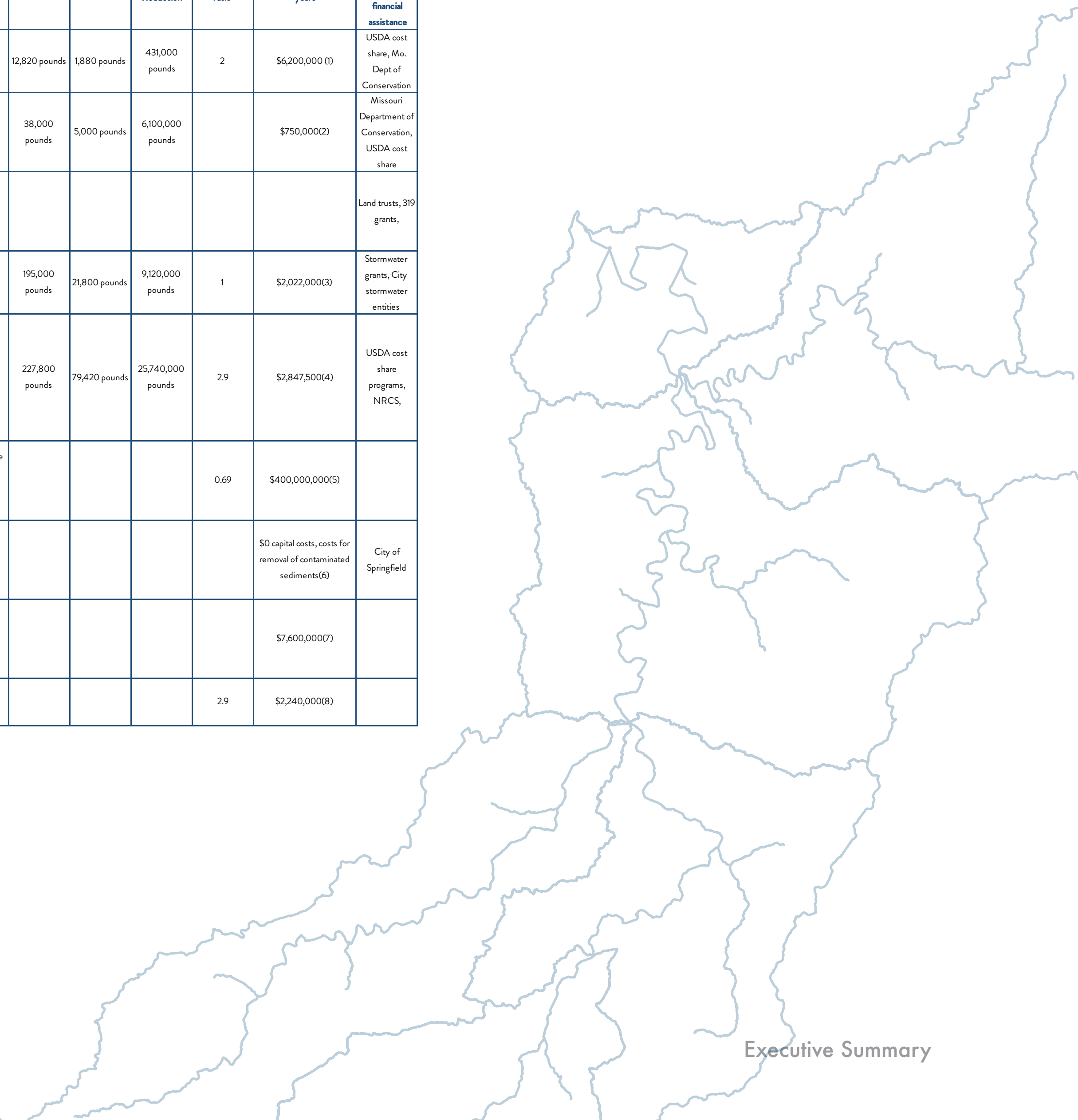
measure recommendations were developed through interviews with sixty-four individual watershed stakeholders and through four subsequent meetings with the technical committee (Appendices A and B contain name of those individuals). Concerns and ideas shared by stakeholders are presented in Chapter 2, and recommendations based on those interviews are found in Chapter 5. The reader is strongly encouraged to review the recommendations in Chapter 5.

4. Element 4: Technical and financial assistance that will be needed to implement practices over 20 years. Table 5 provides the estimated costs of practices, expected pollutant reductions, benefit-cost ratios and sources of technical and financial assistance

5. Element 5: Information and education programs that will lead to enhanced public understanding of water quality problems and solutions, and that will engage interest and participation in implementing BMPs. Table 6 is the Education Plan that has been developed by the James River Basin Partnership in conjunction with watershed partners.

Table 5

Practice	Acres, number or area installed	TN reduction	TP reduction	Sediment Reduction	Benefit/cost ratio*	Estimated cost over 20 years	Potential sources of technical and financial assistance
Stream buffer establishment, management	220 acres	12,820 pounds	1,880 pounds	431,000 pounds	2	$6,200,000 (1)	USDA cost share, Mo. Dept of Conservation
Streambank protection and/or restoration	5,000 feet	38,000 pounds	5,000 pounds	6,100,000 pounds		$750,000(2)	Missouri Department of Conservation, USDA cost share
Riparian buffers in long term protection plans	175 acres						Land trusts, 319 grants,
Detention basin retrofits	132 basins	195,000 pounds	21,800 pounds	9,120,000 pounds	1	$2,022,000(3)	Stormwater grants, City stormwater entities
Managed grazing systems, pasture improvements with alternative watering systems	56,950 acres	227,800 pounds	79,420 pounds	25,740,000 pounds	2.9	$2,847,500(4)	USDA cost share programs, NRCS,
Community stormwater management programs	Phase I and Phase II stormwater permitted communities				0.69	$400,000,000(5)	
Phase out of coal-tar based parking lot sealants						$0 capital costs, costs for removal of contaminated sediments(6)	City of Springfield
Onsite wastewater system management programs						$7,600,000(7)	
Public Education Programs					2.9	$2,240,000(8)	



6. Element 6: Schedule for implementation of the plan. Table 6 is a summary of the 20-year implementation goals for the six HUC-10 watersheds in the James River Basin.

Table 6

HUC-10 watershed	Goals	Pounds/yr. Sediment removed	Pounds/yr. TN removed	Pounds/yr. TP removed
James River Headwaters	2,500 feet of streambank stabilized; erosion protection	152,500	950	125
	50 acres of riparian buffers established in urban/urbanizing areas	4,700	130	22
	25 detention basins retrofitted	87,200	1,850	225
	18,750 acres of pasture in managed grazing systems	423,750	3,750	1,300
	50 acres of riparian buffer in conservation easements or other permanent protection	122,000	760	100
	200 septic system pump-outs			

Table 6 continued

HUC-10 watershed	Goals	Pounds/yr. Sediment removed	Pounds/yr. TN removed	Pounds/yr. TP removed
Finley Creek	2,000 feet of streambank stabilized; erosion protection	514,000	4,550	1,590
	22,750 acres of pasture in managed grazing systems	1,880	52	9
	25 acres of riparian buffers established in urban/urbanizing areas	2,285	88	10
	25 acres of riparian buffers established in agricultural areas	7,050	195	33
	Survey detention basins for retrofit candidates (5 years)			
	200 septic system pump-outs			

Table 6 continued from previous page

HUC-10 watershed	Goals	Pounds/yr. Sediment removed	Pounds/yr. TN removed	Pounds/yr. TP removed
Wilsons Creek-James River	75 acres of riparian buffers established in urban/urbanizing areas	81,360	720	252
	3,600 acres of pasture in managed grazing systems	373,216	7,918	863
	107 detention basin retrofits	30,500	190	25
	75 acres of riparian buffers in conservation easements or other permanent protection			
	Phase-out of coal-tar based parking lot sealants in the city of Springfield			
Flat Creek	500 feet of streambank stabilized; erosion protection	2,825	875	10
	25 acres of riparian buffer established in agricultural areas	149,000	1,320	46
	6,600 acres of pasture in managed grazing systems			

Table 6 continued

HUC-10 watershed	Goals	Pounds/yr. Sediment removed	Pounds/yr. TN removed	Pounds/yr. TP removed
Crane Creek-James River	25 acres of riparian buffers established in agricultural areas	2,825	88	10
	5,250 acres of pasture in managed grazing systems	118,650	1,050	367
	50 acres of riparian buffers along Crane Creek in conservation easements or other permanent protection			
	100 septic-tank pump-outs			
James River-Table Rock Lake	Onsite and small privately- owned wastewater treatment plant operation and maintenance oversight programs			
Total pollutant removal (20 years)		**41,474,800 pounds**	**489,700 pounds**	**99,740 pounds**

7. Element 7: Description of the interim milestones for completion of the goals and recommendations of the plan (Table 7)

Table 7

Interim Milestone	5 year goals	10 year goals	15 year goals	20 year goals
Managed grazing systems	14,238 acres	24,476	42,714	56,952
Riparian buffers established	55 acres	110 acres	165 acres	220 acres
Streambank stabilization	1,250 feet	2,500 feet	3,750 feet	5,000 feet
Detention basin retrofits	33 basins	66 basins	99 basins	132 basins
Phase-out of coal-tar based parking lot sealants (city of Springfield)	Coal-tar based parking lot sealant ban in effect			
Reduction of PAH concentrations in soil/sediment by 80%			PAH reduction 80% (to 2035 ug/kg)	
Septic system pump-outs	175	350	525	700
Understanding sources/pathways for E. coli in Pearson Creek	Major sources/pathways determined			
Riparian areas in permanent protection	44 acres	88 acres	132 acres	176 acres
Development of special outreach programs for agricultural community in headwaters	Program developed and implementation begins			

Table 7 continued

Interim Milestone	5 year goals	10 year goals	15 year goals	20 year goals
Point-of-sale inspection programs for onsite wastewater systems (counties)	2 counties	5 counties	5 counties	5 counties
Maintenance contract requirement for advanced onsite systems (counties)	2 counties	5 counties	5 counties	5 counties
Sediment reduction (all BMPs)	518,400	1,036,800	1,555,200	2,073,600
TN reduction (all BMPs)	6,100	12,200	18,300	24,400
TP reduction (all BMPs)	1,250	2,500	3,750	5,000

8. Element 8: Criteria for determining progress in meeting the goals of the plan. Descriptions of these criteria and the entities responsible for measuring progress toward goals is shown in Table 8.

Table 8

Criteria	Description	Responsible Monitoring Entity
Decrease in algal biomass (streams and reservoirs)	Decrease in chlorophyll-a indicates decrease in algal biomass; should lead to better water clarity	City Utilities of Springfield is responsible for managing surface drinking water sources.
Reduction in Total Nitrogen in streams	Phase I and Phase II routine monitoring in urban areas; data at gaging stations w/ water quality	Phase I and Phase II communities; USGS at gaging stations
Reduction in Total Phosphorus in streams	Phase I and Phase II community stormwater monitoring; USGS data at gaging stations	Phase I and Phase II community routine stormwater monitoring in urban areas; USGS data at gaging stations with Snapshot Monitoring.
Reduction in Sediment Loads in streams	City Utilities measures at intake to determine treatment adjustments	CU at intake of Blackman Water Treatment Plant on James River
Reduction in PAH levels in sediment and soil	PAH measurements in sediments of detention basins or soils beside parking lots	Cities and counties with MS4 permits.
Reduction in levels of E. coli bacteria	Consistently achieve less than 126/100 ml (body contact standard) in recreational waters	CU watershed sampling, Snapshot sampling
Reduction in Streambank erosion	Implement streambank stabilization projects and riparian corridor restoration	JRBP in conjunction with local governments and State and Federal agriculture agencies

9. Element 9: Clearly defined monitoring plan. Table 9 provides a brief description of the components of a monitoring plan and the entities responsible for carrying out the monitoring

Table 9

Component	Description	Responsible Entity	Timeline
Stormwater monitoring for compliance with NPDES permits	Required under DNR permits	Phase I and Phase II Stormwater Communities	As directed by EPA, storm event and base flow sampling as required
Source monitoring for James River intake, surface source	CU continually monitors water quality in drinking watersheds; and at drinking water intake on James River	City Utilities	Monthly, or more frequently in some cases
Watershed Monitoring	Snapshot monitoring every 3 years	JRBP	All samples collected on same day
USGS stream water quality monitoring	Continuous	USGS	To be determined in conjunction with USGS
Monitoring Group Assembled; Stormwater, Drinking Water, Wastewater monitoring group	Group to share data, work collectively, share resources	JRBP	Convene first meeting within 1 year of plan approval
Bacterial Source Tracking	Missouri State University (Ozarks Environmental and Water Resources Institute);	Stormwater Management Entities and Drinking Water Utilities	As mandated by MS4 permits and availability of funding
Spring Sampling	Part of snapshot;	Stormwater Management Entities and Drinking Water	As mandated by MS4 permits and availability of funding
Macroinvertebrate monitoring	Macroinvertebrate diversity and numbers as measures of stream health	Stream Teams; volunteer monitors; JRBP programs	Quarterly through year

JAMES RIVER WATERSHED

MANAGEMENT PLAN

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CONTENT

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Introduction

WHY MAKE A WATERSHED PLAN?

A watershed plan is kind of like a road map, telling us how to reach our destination of cleaner water in streams, lakes, and groundwater, with turn-by-turn directions of specific action steps in water quality protection and improvement. Developing a successful watershed plan means:

- Taking time to collect information from a variety of watershed stakeholders. Many people in the watershed, representing a variety of backgrounds and viewpoints, must be approached for their opinions, ideas and suggestions

- Obtaining "buy-in" from those residents—in other words, they must generally agree with the conclusions and recommendations and support the action steps that need to be taken in order to improve water quality

The purpose of this plan is to outline a strategy of goals, objectives and action steps for further restoring and protecting water quality in the James River Basin.

Restoration is needed for waters that do not meet Missouri's state water quality standards. These standards have been set up to protect the beneficial uses of Missouri waters, including drinking water, livestock watering, fishing, swimming, and aquatic life protection. Further protection is needed for waters that currently meet water quality standards but are threatened by existing and/or potential sources of pollution.

The plan will identify reasonable, appropriate and cost-effective best management practices (BMPs) to be used on farms, residences and development projects to reduce pollution. The plan will also attempt to set reasonable and realistic timelines for getting these BMPs into place. It will lay out ideas for evaluation and monitoring (e.g. water quality testing) programs that will help to determine in future years how successful the plan has been in protecting water quality in the James River and its tributaries

This plan is meant to be "user-friendly," in that there has been an attempt to avoid jargon and use non-technical wording wherever possible, or at least better explain the technical terms that must occasionally be used. The plan is also meant to be a "living" document, in that

Historic Post Card *(courtesy History Museum for Springfield and Greene County)*

changes will most likely be needed in the future as conditions change or as new information becomes available. Adjustments may be required to meet newly identified needs, to address new water quality problems that may arise, or to incorporate new information, techniques and practices that may become available.

Having a clear, reasonable and straightforward plan will help to ensure the success of future watershed projects and determine where future efforts need to be focused. The plan should also assist organizations, agencies and public entities (for example, cities and counties, soil and water conservation districts) in their water quality related efforts, including developing realistic budgets for future watershed projects and practices.

The watershed plan is first and foremost written to serve the people who live, work and play in the watershed. But there is another reason to develop a plan. Much of the pollution in the James River Watershed is called non-point source, meaning that it doesn't come from a pipe like you would see at a factory or sewage treatment plant. Non-point source pollution is more spread out and diffuse, like runoff from pastures, feedlots or subdivisions, urban runoff or seepage from septic tanks. If watershed residents want to obtain grant funding for watershed projects to address these kinds of sources, they must first have state and federally approved watershed plans.

WHAT DOES "IMPAIRMENT" MEAN?

The state has determined that water quality in the James River has been "impaired"—this means that water quality problems have been identified. The James River was put on a list of the state's "impaired" waters in 1998, because of excess nutrients and the over-growth of nuisance algae. Impairment may interfere with the listed *Beneficial Uses* of the James River and its tributaries, including swimming, wading, fishing, boating, livestock watering, drinking water and protection of aquatic life. All streams in the James River Basin are protected for most of these uses.

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James River Basin Partnership Membership Float

In *Missouri's Water Quality Standards*, there is a long list of pollutants that can be found in streams and lakes and that can cause impairments. Most pollutants on the list (such as bacteria, chemicals and pesticides) have *numeric criteria,* meaning that there are specific number limits on the amounts or concentrations of these pollutants that can be in the stream.

Currently, there are no numeric concentration limits for nutrients within the state's Water Quality Standards. But the standards also include *narrative criteria,* sometimes called "free-from statements," that say the stream or lake must be free from unwanted conditions such as unsightly bottom deposits or excessive growth of filamentous algae on the stream bottom or too much floating algae in a reservoir.

These kinds of impairments in the James River arm of Table Rock Lake in 1999 led to requirements for sewage treatment plants in the Table Rock Lake watershed to reduce the amount of nutrients in their treated wastewater discharges to prevent excessive growths of algae. Most of the wastewater treatment plants in the James River Basin have added nutrient removal to their treatment processes. However, nutrient levels in the river remain above the desired or "target" levels in several areas, as described below, and so there remain violations of the *narrative criteria* for nutrients in the James River. Also, some of the other streams in the James River Basin have also been identified as impaired, from a variety of causes. These will be discussed in detail in Chapter 3.

WHAT ARE THE PLAN'S MAJOR GOALS?

The overall goals of this watershed-based plan update are to:

1. Improve the quality of waters within the James River basin that are listed as *impaired.*

For waterbodies on the impaired list a plan must be developed to address problems, with the aim of getting the water removed from the list when the problems no longer exist. A broader goal is to improve the quality of water over the entire basin, whether or not it is considered impaired.

2. Guide the implementation of future programs and practices in ways that address impairments most efficiently and effectively.

Maintaining the strong economy in the basin is important, and we cannot afford to spend money on best management practices (BMPs) that don't turn out to be cost-effective. The plan should help to direct funding assistance where it is most needed and will do the most good.

3. Provide direction for multiple agencies, organizations and political entities as they apply measures to improve water quality.

For example, stormwater management typically occurs at the city or county level. Cities and counties need to know which BMPs will provide the most cost-effective treatment for removing pollutants from runoff.

Organizations on the agricultural side, such as county soil and water conservation districts, need to know which agricultural BMPs will be the most effective at protecting water quality while also providing benefits to the farmer or rancher.

These are broad goals, so the plan includes the development of more specific objectives in order to meet the three overarching goals stated above. These goals and the objectives of the watershed plan update are shown generally in Chapter 5 and more specifically in Chapters 6 through 11, along with milestones or timelines to be measured toward meeting the objectives.

None of these goals or objectives, in and of themselves, will ultimately provide for the long-term health and protection of all the waters within the James River Basin. However, if most of the goals and objectives are supported by watershed residents, and are aggressively pursued, the waters of the James River Basin should improve in quality as the twenty-year planning period advances.

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Watershed Setting

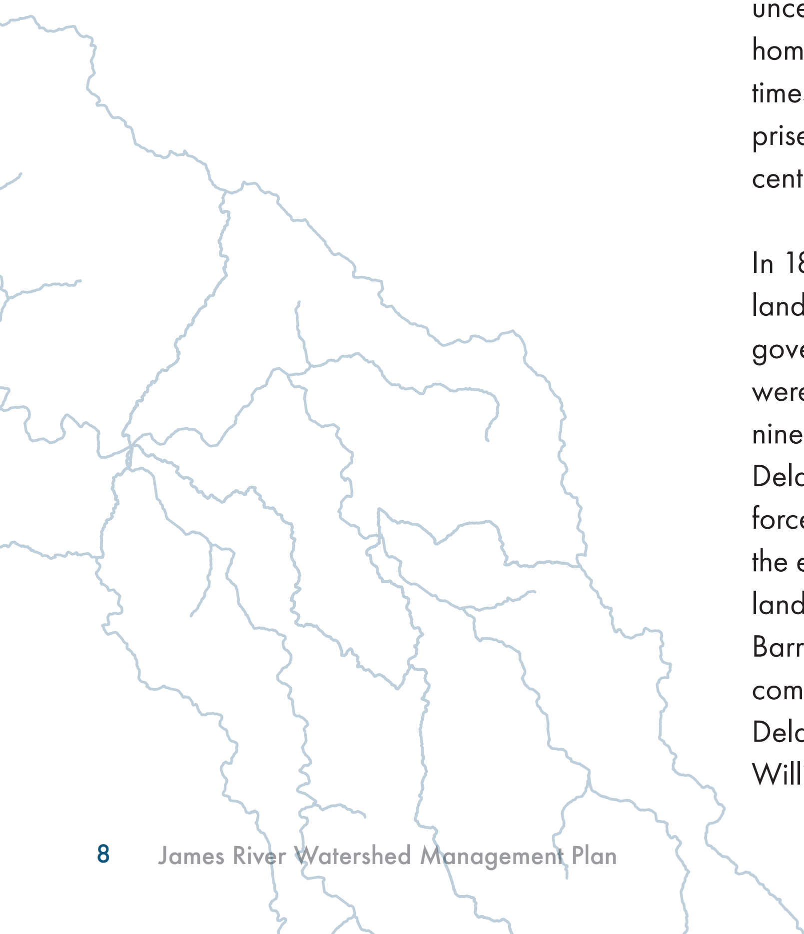
HISTORICAL SETTING OF THE BASIN

There is a long history of human occupation in the James River Basin. The Early and Middle Paleoindian prehistoric periods (13,000-3,000 years before present) are represented by relatively few sites in southwest Missouri, and the subsequent Mississippian Period (up to 1,000 years before present) is also poorly represented, but villages did exist in major valleys during those times, such as along the James River. It is uncertain which Native Americans made their homes in the James River valley in early historic times, but most of southwestern Missouri comprised Osage lands by the early nineteenth century.

In 1808, the Osage ceded almost all of their land in southwest Missouri to the federal government. Other Native American groups were forced to sign treaties in the early nineteenth century as well, including the Delaware Indians. In 1819, the U.S. government forced the Delawares, who originally lived on the eastern seaboard, to move to a large tract of land in what is now Christian, Stone, Taney and Barry counties. By 1820, the move had been completed, with the principal village located at Delaware Town, on the James River, where Chief William Anderson had his lodge.

The earliest white inhabitants in the James River Basin were primarily hunters and trappers, such as the Frenchman, Joseph Fillabere, who established a trading post among the Delaware Indians. Some of the first settlements in southwest Missouri were on the headwaters of the White River. By 1820 a thin chain of settlements extended up the White River into the James River Basin. The departure of Native American people from southwest Missouri mandated by federal treaties was followed by a large influx of American settlers after 1830. Part of the urge to move to the Ozarks derived from reports written by early explorers like Henry Rowe Schoolcraft, who ventured toward the James River from Potosi, Missouri in 1818-1819.

Schoolcraft and a companion set out on foot to locate and inspect the reported lead deposits near the James River. On the way, Schoolcraft recorded a variety of observations about the Ozarks, such as the "barren" nature of much of the land he traversed. But upon entering the valley of what he called the Findley's Fork (Finley Creek), a James River tributary, Schoolcraft and his companion passed over a "body of well-wooded, fertile river bottom." They stopped to admire the "stupendous cavern" (Smallin Cave)

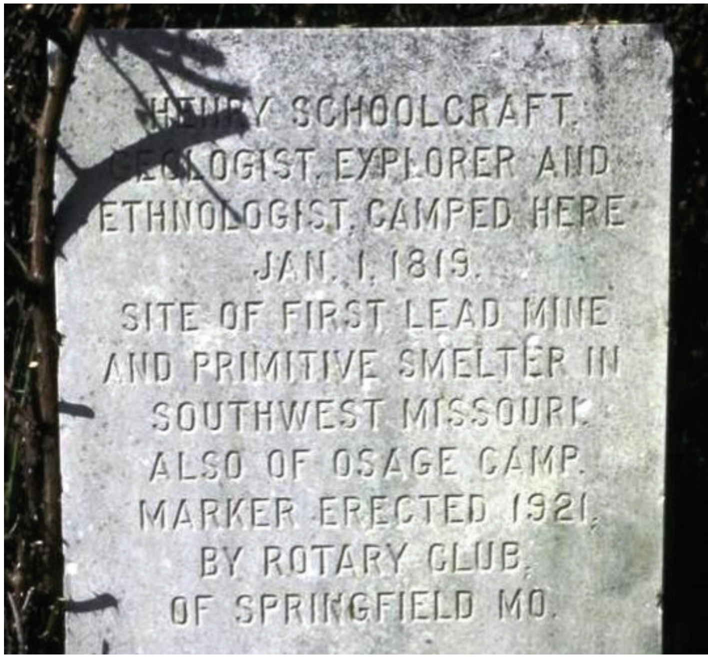


along Finley Creek and a few miles further found themselves "unexpectedly on the bank of James' River," a "large, clear, and beautiful stream." Along its banks they "found extensive bodies of the land, covered by a large growth of forest trees and cane, and interspersed with prairies."

On January 2nd, 1819, Schoolcraft located the small, crude lead smelter near Kerschner Spring at the confluence of Pearson Creek with the James River. This smelter was said to have been used by hunters and Indians for making bullets. Schoolcraft was headed back toward Potosi when he entered an extensive prairie on the James River uplands. He called it "the most extensive, rich, and beautiful, of any I have ever seen west of the Mississippi River." The coarse wild grass, he said, "attains so great a height that it completely hides a man on horseback." At the confluence of the James River with Finley Creek, he recorded a "high, rich, point of land," an "eligible spot for a town, and the erection of a new county out of this part of the unincorporated wilderness of Arkansas."

A city was never built at the confluence of the Finley and the James (although a subdivision is there now), but a village did form on the upper James River, along a tributary we now call Jordan Creek, at a site claimed by the Campbell brothers of middle Tennessee. To John Polk Campbell, the magnificent red oaks along Jordan Creek signaled fertile soils which, upon clearing, would yield healthy crops of corn. His decision to locate his cabin at one particular spot near the creek was based upon the presence of a peculiar geologic feature, a "natural well of wonderful depth." This natural well was what we would today call a "karst window," a vertical cave extending downward into the subterranean plumbing system of a spring.

Smallin Cave (Top)
Greene County Marker (Below)



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(top) Karst "Window"
(bottom) Kimberlin Mill

Springs served important functions for the settlers and citizens of the James River Basin. Springs and spring-fed streams served mills on upper Pearson Creek, at Jones Spring on Pearson Creek, and at Riverdale, Linden and Ozark on Finley Creek. Reynolds Mill was built on Spring Creek (near Hurley), Lewis Mill on Crane Creek, and Kimberlin Mill on Silver Lake Branch (on a small tributary of the James River). A major recreation center, later a city park, developed around Sequiota Spring in southeast Springfield. Visitors could take boat rides into the cave on the spring branch. This spring also supplied a state fish hatchery and formed the centerpiece of the state's smallest state park.

Clear Ozark streams like the James River, with its impressive bluffs, exciting shoals and good fishing, also contributed to the area's desirability as a vacation destination. By the 1920s, the Ozarks had become a recreational mecca, drawing large numbers of people from Kansas City, St. Louis, and even further. Guided float trips on the James River came into vogue. Before the days of Table Rock Dam, a five-day john-boat float could be taken from Galena to Branson—amazingly, given the geographic proximity of the two towns—a journey of nearly 65 miles by river.

Abundant springs, spring-fed streams and swiftly flowing, clear rivers thus guided and influenced patterns of settlement and development in the James River Basin. It is fair to say that water resources in abundance and good water quality have been prime considerations for the residents of the basin since the earliest times of settlement.

This historical context remains important today as resource professionals begin planning efforts designed to keep the James River flowing as Schoolcraft described it, a "large, clear and beautiful stream."

AGRICULTURE

The early settlers in the Ozarks, including those in the James River Basin, grew what crops they could on the best soils they could find. In the early days, corn was the most extensively farmed crop in the Ozarks because it provided food for both man and livestock, could be kept in fields as long as desired, grew well in newly cleared land, and was readily marketable as whiskey (Sauer, 1920). Upland areas often had thin, cherty soils that were not conducive to sustained yields of crops. Settlers found better soils in alluvial areas along streams, and to some extent on the adjacent benches above flooding zones. In general, wider valley bottoms were favored for row crops like corn, as well as grains and gardens. Clearing of bottomland forests for agriculture created one of the first significant disturbance and erosion patterns for many Ozark streams (Jacobson and Primm, 1994).

Greene County in the north-central portion of the

James River Basin has some of the best farming soils in the Ozarks, especially the deeper and richer Kickapoo Prairie soils near Springfield. Corn production in Greene County tripled between 1840 and 1850 (Sauer, 1920). By the 1870s, there were fifteen mills operating in Springfield. Wheat production became important in the county in the late nineteenth century, and for many years was the principal cash crop. In 1900, about one-third of the land in Greene County was used for either corn or wheat.

After the 1880s, the amount of farmed land increased markedly in the James River Basin. By 1910, 71% of the lands in Greene County were "improved" for agriculture. The percentages of lands being farmed in 1910 in each of the five counties comprising the bulk of the James River Basin were: Greene County (90-95%); Webster County (80-90%); Christian and Barry Counties (60-80%); and Stone County (40-60%) (Sauer, 1920). The average size of farms in Greene County in 1910 was less than 100 acres, while the average size of farms in Stone, Christian, Webster and Barry Counties was about 100 acres.

From the times of earliest settlement, cattle and hogs were the primary types of livestock kept on Ozark farms. By 1850, Greene County had more cattle and hogs than any other county in the Ozarks (Sauer, 1920). In warmer months, farmers typically fed cattle on bottomland grasses and on cleared upland areas. In winter, the cattle remained mostly in unfenced fields in the river bottoms, where they fed on cane and rushes. Livestock ate vegetation on gravel bars along the river and kept bottomland pastures cleared of woody understory vegetation.

Lands in the south part of the James River Basin, such as in the southern half of Stone County, were not as conducive to animal raising. In 1900, Stone county was largely unpopulated and undeveloped (Williams, 1904). Most of the residents in 1900 were farmers. Livestock production was one of the dominant agricultural activities, with cattle driven overland to markets to the north along the Missouri Pacific Railroad.

Cattle numbers in the basin rose substantially after about 1920 and took another sharp upturn after 1940. With the beginning of fencing and improvements to beef markets, the densities of cattle on pasture increased markedly. Dairies also increased in the early twentieth century. Of the five primary counties in the James River Basin, Greene County had the highest production of dairy products in 1909, with Webster County second and Stone and Barry Counties about tied for third (Sauer, 1920).

In the last decades of the nineteenth century and first two decades of the 20th, hogs were the dominant livestock on Ozark farms (Jacobson and Primm, 1994). The numbers of hogs peaked in most Ozark counties between 1880 and 1920. In 1909, the number of hogs per square mile ranged from 50-75 in Greene County to 40-50 in Christian County and 20-30 in Barry, Webster and Stone Counties (Sauer, 1920). To a large degree, these hog numbers corresponded with the production of corn in these counties. Hogs foraged for mast, primarily acorns, in upland areas, but also rooted and wallowed in springs, seeps and creeks, creating serious localized erosion of alluvial sediment.

Poultry raising is also a farming practice of long-standing in the Ozarks. In the early days, poultry raising was typically small scale. As noted by Sauer (1920), poultry raising was not dependent on soil fertility but was based on marketing facilities, and therefore mostly a "by-product of general farming." Large scale poultry raising was not profitable unless most of the feed could be raised on site. As a result, there were few exclusive poultry farms in the Ozarks in 1910. (Sauer, 1920). With improvements in feed availability, marketing, and integration of growers with producers, this situation has changed markedly. There are today scores of large-scale poultry operations in the James River Basin, particularly in Barry County in the Flat River watershed.

Specialty crops were introduced into the basin in the 1890s, with farmers producing peaches, apples, strawberries, and tomatoes (Soil Survey Greene County). In the early part of the twentieth century, tomato farming became a big business in southwest Missouri. This crop, referred to as "red gold," seemed to grow well (at least for the first few years) in poor, rocky Ozark soils, so was promoted by federal agricultural experts. Tomato canneries sprang up at many locations in the James River Basin. In the early 1900s, there were ten canneries in the Reeds Spring area alone. On the eastern outskirts of Reeds Spring stands the remains of an old cannery building, one of the last of its kind to close.

In the early twentieth century, the Ozarks were also known as the "land of the big red apple," with southwest Missouri ranking second in production only to the area of loess soils in the border counties of western Missouri (Sauer, 1920). Greene and Webster Counties, in the James River Basin, were among the five Ozark counties with the most numerous apple orchards. Strawberry growing also became common and profitable in the early twentieth century, but the center of the growing was in the vicinity of Neosho and Monett, west of the James River Basin.

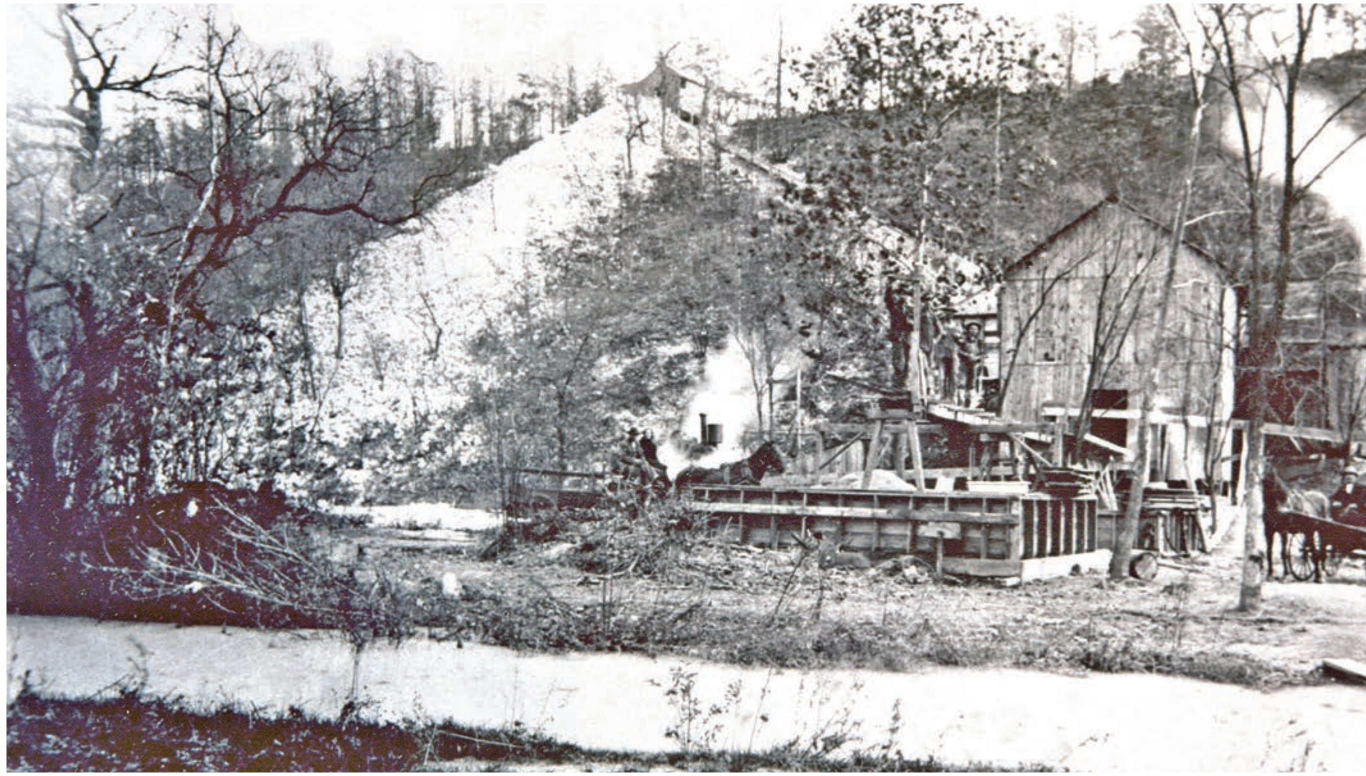
After WW II, many farmers in the Ozarks and the James River Basin shifted from specialty or row crops to livestock raising, especially beef cattle, in conjunction with part-time or off-the-farm employment. About 67% of the farmers in Greene County had off-the-farm employment for 100 days or more in 1969 (Greene County Soil Survey). Today, beef and dairy cattle are the prime agricultural enterprises in the majority of the James River Basin, with the poultry industry growing most strongly in the southwest part of the basin, especially in the vicinity of upper Flat Creek near Cassville.

MINING AND INDUSTRY

Mining, other than limestone quarrying, never became a big business in the James River Basin when compared to areas to the east and west. Not far to the west was the tri-state lead and zinc mining district, with Joplin and Granby serving as mining camps and production centers. However, Greene County did have a lead/zinc mining district along Pearson Creek, a James River tributary on the east side of Springfield, near the site of Schoolcraft's final stop on his Ozarks tour. Limited extraction and processing of lead ore occurred in the Pearson Creek area during the 1820s and 1830s (Thomson, 1986). More intense mining began in the area in 1875 when a shaft was sunk 77 feet. Larger scale mining in the area continued from the late 1880s until 1916.

Limestone quarries have operated in the James River Basin from the nineteenth century until the present. The Burlington-Keokuk limestone formation, at the surface over much of the James River Basin, has been extensively quarried for dimension stone and gravel. Limestones were used to construct the Drury Stone Chapel and St. John's Episcopal Church in Springfield. Today, limestone is the most important mineral commodity produced in Greene County and large limestone quarries are still active in other counties of the James River Basin. Timber production in the Ozarks occurred primarily in the eastern sections, particularly Reynolds, Shannon and Carter Counties. The boom of the late 1880s to 1920s was in the pine lands of the central Ozarks, where the huge mill at Grandin was notable. However, the railroad industry did create a market for white oak railroad ties in southwest Missouri, and there was some timber cutting and tie hacking in the James River Basin. Reeds Spring, for example, founded in 1904, was at first known as a "tie town," producing some of the millions of ties needed by the expanding railroads. Tie hacking provided subsistence farmers with seasonal employment and cash income.

Sunshine Mine, Pearson Creek



Heavy industry and manufacturing in the James River Basin had its beginnings in Springfield, a major railroad hub after the 1870s and the first railroad center in southern Missouri. Many people in the Springfield area were employed in the railroad car shops (Sauer, 1920). Manufacturing also began early in Springfield, including wagon factories, saddleries, and tanneries along with furniture and stove makers. An early gas plant in Springfield produced methane from the reduction of coal for streetlights on the city square. These early industries certainly produced their share of air and water pollution (see water quality history).

One unique "industry" in the James River Basin centered on the mineral water "craze" that swept America in the late nineteenth century. At Ponce de Leon, a small town in the James River Basin in Stone County, a Springfield business-man in 1882 had a "healing experience" at a spring issuing along Goff Creek, a tributary of the James River. Word soon spread and people flocked in, building houses or living in tents to be near the healing waters. By the beginning of the twentieth century, Ponce de Leon had become the largest town in Stone County. Although a bank was started in 1917 and a tomato cannery was built, "Poncie" is today home to only about fifty people (Bullard, 2004).

CLIMATE AND WEATHER

The James River Basin is located in the temperate zone of North America and has four pronounced seasons. The basin has a humid continental climate, with cool to cold winters and long, hot summers. Because of its location in the interior of the continent, with no nearby oceans to moderate climate, fairly severe temperature extremes are common. The average annual temperature is about 59 degrees F, but thirty-year average monthly temperatures measured at Springfield range from about 30 degrees F in January to near 80 degrees F in July. The record January high temperature at the Springfield Airport is 76 degrees F, and the February record high 84 degrees F. The record high in July is 113 degrees F, while the record low in July is 44 degrees F. Record lows are -19 degrees F in January and -29 degrees F in February.

Monthly average precipitation typically begins to rise in late winter and peaks in the spring, from May through June, with 4.5-5 inches of rainfall. However, in April 2017 Springfield received over 12 inches of rain, the second wettest April on record. On April 30, 2017 the USGS reported that its flow measuring crews had recorded over 20 preliminary record high flood measurements in Arkansas and the White River Basins. During this period, there were historic floods not only in Missouri, but also in Illinois, Ohio, Oklahoma and Arkansas. Rivers in the south-central Ozarks were especially hard hit. The North Fork River had a peak estimated flow on April 30, 2017 of 141,000 cubic feet per second (estimated because the gage was destroyed). To put this discharge in perspective, the peak flow recorded in the James River at Galena in 2008 was about 85,000 cubic feet pers second. In the James River Basin, the second highest rainfall totals for the year normally occur in the months of September and November. January and February receive the lowest average precipitation totals for the year with around 2 inches of rainfall per month.

As most residents of the James River Basin can attest, weather can change rapidly and is somewhat unpredictable. Strong thunderstorms can occur in about any month of the year, but are usually most frequent and severe in spring and summer. Tornados are also a fact of life in the basin, with the major, devastating tornado in Joplin a recent, and nearby, example. Cities in the basin including Springfield, Battlefield, Republic and Cassville have also been hit by tornados in the past. On April 18, 1880, two huge tornadoes converged on downtown Marshfield, in the northern part of the James River Basin. All but fifteen buildings in the town of 1,100 people were destroyed, with 101 people killed and 600 injured. This was one of the worst natural disasters to strike a small town anywhere in the country up until that time.

GEOLOGY

Two geologic provinces are represented in the James River Basin—the Springfield Plain and the Ozark Highlands of Arkansas and Missouri. Both regions are underlain primarily by limestone, dolomite, sandstone and shale. The bedrock units of the Ozarks Highlands are older, having formed in the Ordovician Period (450-490 million years ago), and are more dissected (cut through by river networks) than rocks in the Springfield Plain, which are Mississippian in age (320-360 million years ago). The James River Basin is underlain for the most part by Mississippian age limestone, with the deeper and older units comprised of dolomite and shale (Figure 1.

The basin is floored (the deepest exposed rock) with Jefferson City-Cotter dolomite. Higher up are units of Compton limestone, Northview Shale, Pierson Limestone, Elsey Limestone, Burlington-Keokuk limestone, and the uppermost Warsaw limestone. The Warsaw formation, at the surface in the very northernmost part of the basin, is a fine to coarsely crystalline limestone, with some fossil crinoids (ancient sea lilies—animals). Below the Warsaw, and at or near the surface over much of the James River Basin, is the Burlington-Keokuk limestone. It is gray and crystalline in structure, often with an abundance of crinoid fossils. This formation is extremely susceptible to solution by rainwater, and forms many of the distinct karst features (sinkholes, caves, springs) seen in the James River Basin.

Underlying the Burlington-Keokuk is the Elsey formation, a dense light gray limestone with 20-50 percent chert nodules. The chert occurs in long lenses or beds from six inches to a foot thick. Where limestone is in contact with these chert beds, the limestone dissolves very readily. Below the Elsey is the Pierson formation, a gray to brown, silty to cherty dolomitic limestone. It generally forms steep slopes between the overlying Elsey and the Northview shale. The Pierson ranges from about 30 to 40 feet thick.

The Northview Shale, just below, is a brown to bluish siltstone or greenish gray shale. It is easily eroded where exposed and tends to form deep gullies in road cuts. This siltstone often contains worm burrows or tubes and is sometimes called "worm rock." The Northview shale is considered an "aquiclude," in that its dense, flat layers and tight structure prevents the downward penetration of water.

Below the Northview is the Compton formation, a light to dark greenish gray, finely crystalline limestone. Next down is the Bachelor formation, a relatively thick, pale green quartz sandstone layer that weathers to a dark brown as a result of iron oxidizing. Underlying the Bachelor is the Cotter dolomite, a light gray to brown fine-grained dolomite 50 to 175 feet thick. Finally, the deepest exposed formation in the basin is the Jefferson City dolomite. It is very similar to the Cotter dolomite and is 190 to 220 feet thick, a medium to finely crystalline dolomite that often includes chert and sandstone units.

Rivers and streams in the James and Finley River headwater areas, and in the lower portions of the James River, have incised (or cut downward) into the older, underlying sandstone and dolomite units. Solutional weathering (dissolving) of carbonate rocks in the James River Basin leaves behind previously embedded chert fragments, which form the bulk of the bed of the area's streams (Jacobson and Primm, 1994). Most of the stream beds in the basin are comprised of chert cobbles and gravel, although some reaches are underlain by bedrock.

SOILS

The spatial distribution of soil types in the James River Basin largely reflects the underlying geology of the Springfield Plain and Ozark Highlands regions. There are eleven primary soil associations that make up the majority of soil types in the James River Basin (Figure 2).

On the Springfield Plain, prominent soil series associations are the Wilderness-Tonti group, the Tonti-Goss-Alsup group, the Keeno-Hoberg-Creldon group, the Pembroke-Keeno-Eldon-Creldon group, and the Nixa-Jay-Clarksville-Captina group. The following are brief descriptions of individual soils in these series:

- Alsup: Deep and moderately well drained soils, formed primarily on uplands and side slopes.

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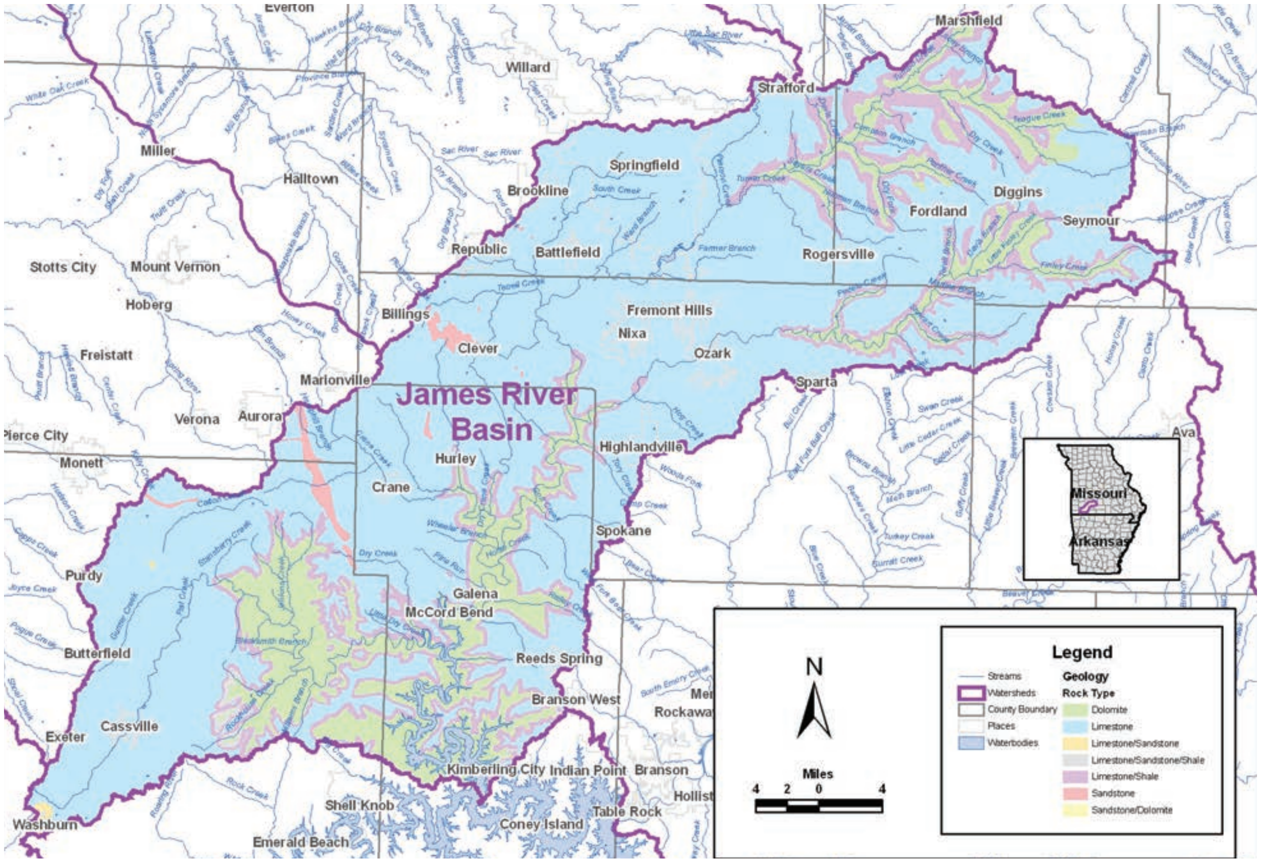
Figure 1 Generalized Geology of the James River Basin



- Goss: Very deep and well drained soils on uplands formed from the weathering of cherty limestone
- Tonti: Deep, moderately well drained soils on flat or gently sloping terrain formed from cherty limestone
- Wilderness: Deep and moderately well drained soils, often with a fragipan (dense layer) about 15 to 30 inches deep
- Keeno: Deep, moderately well drained soils on uplands with a fragipan from 18 to 36 inches deep
- Hoberg: Deep and moderately well drained soils, formed from cherty limestone and often with a fragipan
- Creldon: Deep and moderately well drained, gently sloping soils on uplands with fragipans at 18 to 35 inches deep
- Pembroke: Deep, well drained soils underlain by alluvium or limestone residuum (broken down bedrock) often found on nearly level uplands and karst areas
- Eldon: Very deep, well drained soils formed in residuum from cherty limestone interbedded with shale and sandstone
- Nixa: Very deep, slowly permeable soils on upland ridge tops and side slopes
- Jay: Deep, moderately well drained, slowly permeable soils formed in loamy material overlying siltstone or cherty limestone
- Clarksville: Deep, excessively drained soils formed on hillslope sediments and clay residuum

- Captina: Deep, moderately well drained soils on nearly level uplands and old stream terraces

Soils developed on the Ozark Highland Physiographic Unit include the Reuter-Moko-Clarksville association, the Ocie-Mano-Gatewood-Alred group, the Viraton-Ocie-Mano group, the Ocie-Mako-Gatewood group, and the Wilderness-Viraton group. The following are brief descriptions of individual soils in this series (unless described above):

- Reuter: Deep, excessively drained soils formed in colluvium or from residuum of cherty limestone. They are found on steep side slopes and narrow ridgetops
- Mako: Shallow, well drained soils formed from loamy colluvium or residuum from limestone or dolomite. They are very common on the uplands of northern Arkansas and southern Missouri
- Ocie: Deep, moderately well drained, slowly permeable soils formed and hillslope sediments and the residuum from cherty dolomite
- Mano: Deep, moderately well drained soils found on hills and formed from cherty limestone or the residuum from cherty dolomite

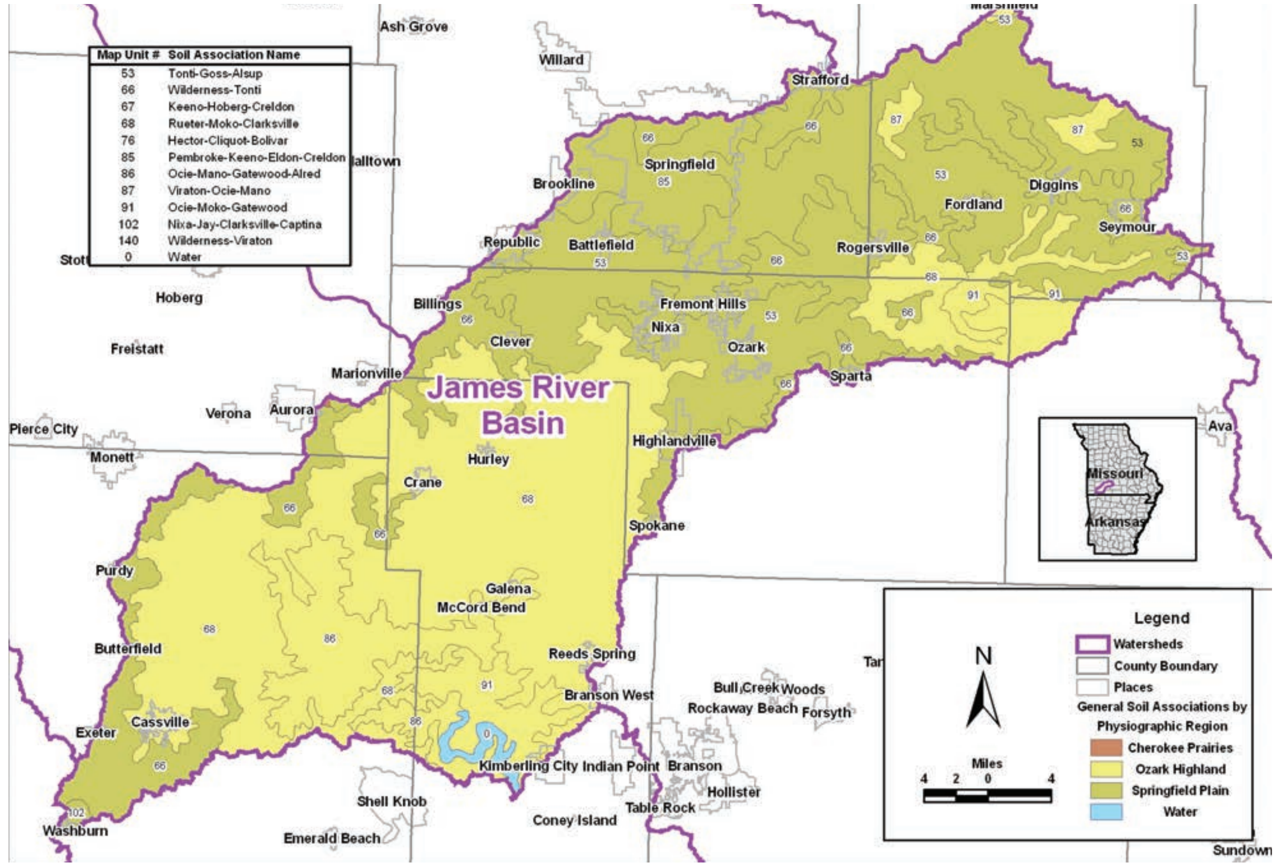


Figure 2: Soil Associations found in the James River Basin

- Alred: Deep, well drained soils found on cherty hillslopes
- Viraton: Deep, moderately well drained soils with a fragipan, formed in loess and the underlying cherty residuum of limestone.

As can be seen from these brief descriptions, soils in the James River Basin are highly variable depending on the underlying bedrock and the position of the soil unit in the landscape. Great differences in soils properties can occur within short distances. Some soils are wet seasonally or subject to flooding. Some are shallow over bedrock. Some have high chert contents. These properties affect runoff and infiltration characteristics and the ability to absorb rainwater and convey it into the ground as groundwater. Fragipans (dense layers of clay) prevent downward percolation of water and may prevent sewage in septic tank absorption trenches from receiving proper treatment in soil before being discharged to nearby springs or to hillslopes.

Seasonally wet or clayey soils are not suited to septic tank soil absorption fields. Cherty, excessively drained soils may allow effluent from onsite wastewater systems to access shallow groundwater systems without proper treatment. Some soils provide poor filtration for stormwater, and so are not conducive to inclusion in stormwater best management practices such as biofilters (vegetated soil filters). Soil types and conditions affect agriculture to a high degree. Some soils help to produce "prime" farmland, while others produce or retain only small quantities of nutrients for forage or croplands.

Soil health is critical to watershed health and good water quality. Soils with good texture and organic content readily infiltrate rainwater and provide good filtration. Some of the older methods of farming, such as deep plowing, actually decreased soil health by destroying soil structure and causing organic matter near the surface to be rapidly oxidized and degraded. Today, more and more farmers used methods such as no-till, or leave cover crops in place in the off season, to build up critical biologic life and the organic content of soils, thus increasing soil productivity.

In the James River Basin, many pastures have been overgrazed in the past, leading to impoverished soils and poor stands of forage grasses. Newer methods, such as rotational grazing, can prevent overgrazing. Since cattle are only in a paddock enclosure for a limited time, they eat only the tops, the most nutritious and tasty parts of the grass blades. Thus, animal health and weight gain are improved. These systems also help to disperse nutrients in manure across the entire pasture, and protect water quality by excluding cattle, all or part of the time, from streambanks and streams.

HYDROGRAPHY (STREAM NETWORK) OF THE BASIN

The James River is the largest tributary of the White River in Missouri. The James River Basin contains approximately 1,455 square miles and includes portions of eight counties: Stone, Christian, Barry, Lawrence, Greene, Webster, Wright and Douglas counties. However, the vast majority of the basin lies in the five counties of Webster, Greene, Christian, Barry and Stone, with only very small portions overlapping into Lawrence, Wright and Douglas counties.

The James River drains a portion of the Springfield Plateau, a 10,300 square mile subarea of the Ozark Physiographic Province (The Ozarks). Headwaters of the James River originate at just over 1740 feet above sea level in Webster County, Missouri. The river then flows generally southwesterly about 150 miles through Greene, Christian and Stone counties to its outlet in Table Rock Lake south of Galena, Missouri. The Table Rock Lake Dam was completed in 1959 and stores about 2.7 million acre-feet of water at multi-purpose pool, and another 3.5 million acre-feet at flood control pool.

From its headwaters in Webster County downstream, the James River receives major tributaries at Pearson Creek (23 sq. mi. watershed), Wilsons Creek (84 sq. mi. watershed), Finley Creek (277 sq. mi. watershed), Crane Creek (160 sq. mi. watershed), and Flat Creek (314 sq. mi. watershed). Flat Creek actually empties into the James River arm of Table Rock Lake, below the normal river outlet of the James River. The James River Basin contributes about 30% of the flow to Table Rock Lake (MEC, Gap Analysis).

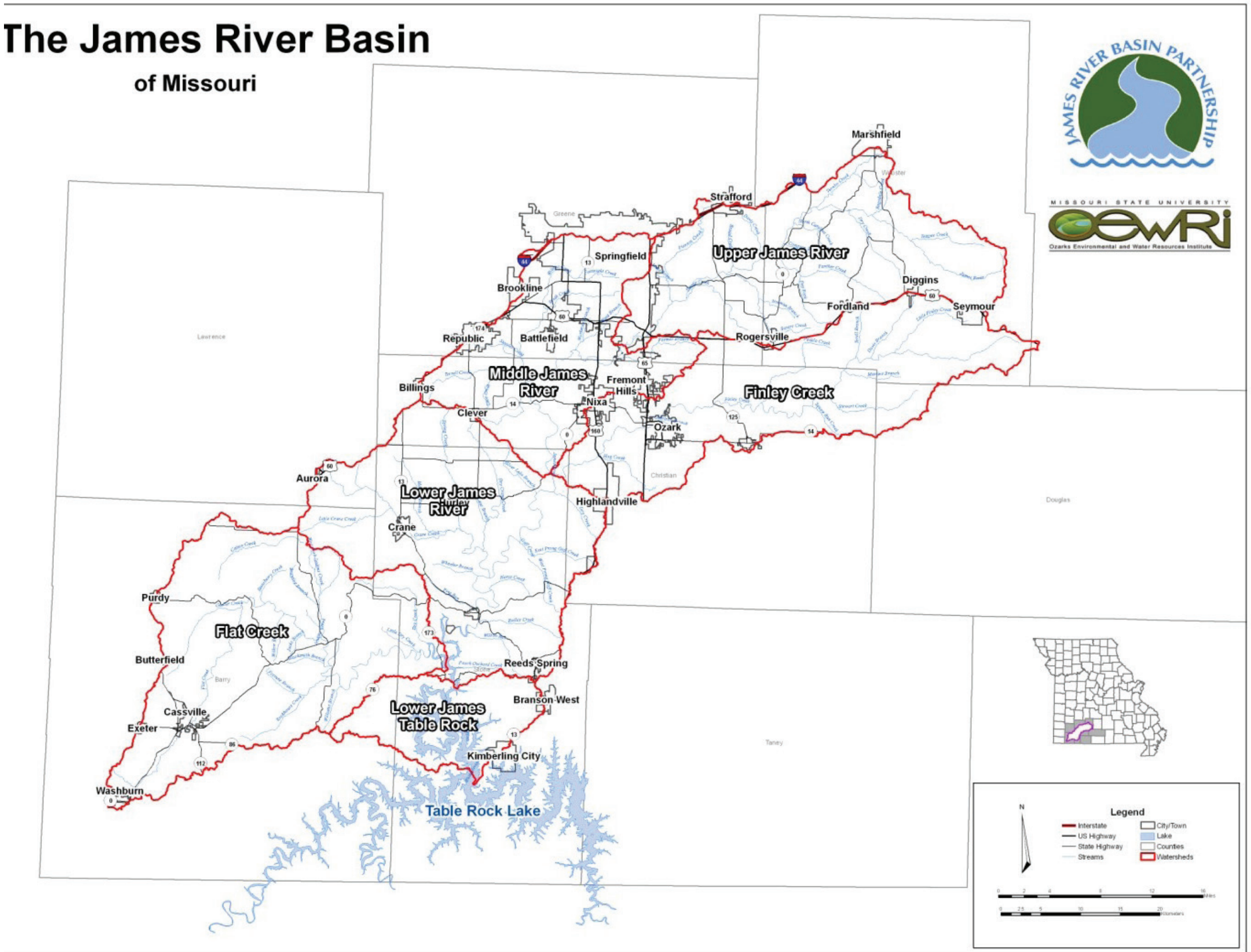
The James River Basin is classified in the United States Geologic Survey (USGS) watershed size classification system as a sub-basin and given an eight-digit hydrologic code (HUC-11010002). There are 66 sub-basins of roughly this size in Missouri, such as the nearby Sac River and Niangua River sub-basins. The James River sub-basin is further divided into six smaller HUC-10 watersheds, containing from 91.8 square miles to 326.1 square miles each.

From largest to smallest these HUC-10s are called: Flat Creek; Crane Creek-James River; Finley Creek; Headwaters James River; Wilsons Creek-James River, and Table Rock Lake-James River.

These six HUC-10 watersheds are further sub-divided into 43 sub-watersheds, a twelve-digit hydrologic unit (HUC-12) code. Table 1-6 provide information about the names, HUC numbers, and areal extents of each of the sub-watersheds

Lower James River at Y-Bridge

Figure 3: HUC-12 Sub-watersheds in the James River Basin



in the James River Sub-basin (for simplicity, referred to in this document as the James River Basin). In most cases, the HUC-12 sub-watersheds represent tributaries to the James River, Flat Creek, Finley Creek or Crane Creek.

There are three reservoirs of significant size in the James River Basin; one on the James River itself and two on one of its major tributaries, Finley Creek. Lake Springfield, just south of Springfield, is a 318-acre reservoir built in 1957 to provide cooling water for the City Utilities James River Power Plant. Another run-of-the river reservoir is located on upper Finley Creek at Linden. This reservoir was originally built to serve a grist mill, with the first mill constructed in about 1840. Downstream on Finley Creek is the concrete dam and reservoir at Riverdale. A low dam was built here to serve a mill constructed in the 1840s, but a larger concrete dam was built in 1906. Mills no longer exist at either site, but the reservoir at Linden is still used for recreation and fishing.

The USGS currently operates nine discharge (flow) gaging stations in the James River Basin (Figure 4). Three of the stations are located on the James River itself. The uppermost station is just southeast of Springfield near the Missouri

Department of Conservation Joe Crighton Access. The next station downstream is at Boaz, at the Frazier Bridge west of Nixa. The lowermost site on the James River is at Galena, about five to ten miles above the point where the flow of the James River normally enters Table Rock Lake. The distance the reservoir backs up into the river, greatly slowing its flow, depends on the water level in the reservoir. There are also three stream gaging stations on Wilsons Creek, and one each on South Creek, Finley Creek and Flat Creek.

The gages at Springfield and Galena contain over 60 years of recorded data, with the gage at Galena serving since 1921. Six of the remaining 9 stations have between 15 and 20 years of continuous records, with two gages having intermittent data of longer duration. Only one of the gages, at Flat Creek, has less than 15 years of continuous data collection (14 years). The discharge at Galena, the lowest gage on the James River, exceeds 430 cubic feet per second 50% of the time, and 118 cubic feet per second 90% of the time. The following are descriptions of the gage locations, periods of record, and maximum recorded flows at each of the nine stations.

Table 1

HUC-12 SUB-WATERSHEDS IN THE HEADWATERS JAMES RIVER HUC-10 WATERSHED

Total 172,506 acres (269.5 square miles)

HUC-12 Name	HUC-12 Number	Area (acres)	Area (sq.mi)
Headwaters James River	110100020101	26,884	42.0
Dry Creek-James River	110100020102	21,867	34.2
Panther Creek	110100021003	23,189	36.2
Turnbo Creek-James River	110100020104	26,993	42.2
Sawyer Creek-James River	110100020105	27,153	42.2
Pearson Creek	110100020106	14,624	22.9
Turner Creek-James River	110100020107	15,305	23.9
Lake Springfield-James River	110100020108	16,542	25.8

Table 2

HUC-12 SUB-WATERSHEDS IN THE FINLEY CREEK HUC-10 WATERSHED

Total 172,843 acres (270.1 square miles)

HUC-12 Name	HUC-12 Number	Area (acres)	Area (sq.mi)
Headwaters Finley Creek	110100020201	32,250	50.4
Stewart Creek	110100020202	12,703	19.8
Davis Branch-Finley Creek	110100020203	25,494	39.8
Pedelo Creek	110100020204	13,166	20.6
Squaw Run Creek-Finley Creek	110100020205	12,568	19.6
Parched Corn Hollow-Finley Creek	110100020206	30,126	47.1
Elk Valley	110100020207	12,197	19.1
Spout Spring Hollow-Finley Creek	110100020208	16,299	25.5
Finley Creek	110100020208	18,040	28.2

Table 3

HUC-12 SUB-WATERSHEDS IN THE WILSONS CREEK HUC-10 WATERSHED

Total 129,159 (201.8 square miles)

HUC-12 Name	HUC-12 Number	Area (acres)	Area (sq.mi)
Headwaters Wilsons Creek	110100020301	32,216	50.3
Terrell Creek	110100020302	16,917	26.4
Wilsons Creek	110100020303	16,314	25.5
Ward Branch-James River	110100020304	38,539	60.2
Green Valley Creek-James River	110100020305	25,173	39.3

Table 4

HUC-12 SUB-WATERSHEDS IN THE FLAT CREEK HUC-10 WATERSHED

Total 208,716 acres (326.1 square miles)

HUC-12 Name	HUC-12 Number	Area (acres)	Area (sq.mi)
Headwaters Flat Creek	110100020401	30,776	48.1
Corder Hollow-Flat Creek	110100020402	16,450	25.7
Little Flat Creek	110100020403	28,659	44.8
Gunter Creek-Flat Creek	110100020404	25,776	40.3
Jenkins Creek	110100020405	16,224	25.4
Rockhouse Creek	110100020406	21,401	33.4
Willow Branch-Flat Creek	110100020407	26,122	40.8
Dry Creek	110100020408	13,854	21.6
Flat Creek	110100020409	29,454	46.0

James River at Springfield

The uppermost gage on the James River is located at Kinser Bridge, a few miles southeast of Springfield, and about a mile below the confluence of Pearson Creek with the James River. This gage is now operated in conjunction with City Utilities of Springfield. The watershed area above this gage is 246 square miles. This gage has been in operation since 1955. The highest recorded discharge was on June 19, 2015 at 50,900 cubic feet per second; the second highest reading was on September 25, 1993, at 41,000 cubic feet per second. However, the flood of 1909 was said to have reached a crest of 22 feet, which the USGS has estimated would have been a discharge of about 62,000 cubic feet per second. This gaging site has had water quality sampling from November 1999 to the present.

James River at Boaz

This is the first gaging station downstream of the Springfield urban influence. It is located at Frazier Bridge, below the confluences of the James River with Wilsons Creek (which drains the Springfield urban area) and its western tributaries, Schuyler Creek (draining from the west side of the city of Republic), and Terrell

Creek (draining primarily low density residential and agricultural lands west of the James River). The watershed above this gage is 462 square miles. The gage was operated from 1972 to 1980, and then from 2001 to the present. The peak discharge was recorded on March 19, 2008 at 41,900 cubic feet per second; the second highest was on June 19, 2015 at 39,900 cubic feet per second. It may seem odd that this gage, located below Springfield, would have lower peak discharges than at the gage at Springfield, upstream, particularly for the same date. The USGS tables for the gage at Boaz note that peak readings are "affected to an unknown degree by regulation or diversion." A major dam, at Lake Springfield, exists between the two gages, and this may account for the "regulation." In June 2015, for example, the reservoir may have been at a low level and so held back a larger quantity of stormwater.

James River at Galena

This gage is the longest continuously operating gage on the James River, in place since October 1921. The watershed area above this gage is 987 square miles. It is located below the major tributaries of Crane Creek and Spring Creek, which enter the James River downstream of the

Table 5

HUC-12 SUB-WATERSHEDS IN THE CRANE CREEK HUC-10 WATERSHED

Total 190,277 acres (297.3 square miles)

HUC-12 Name	HUC-12 Number	Area (acres)	Area (sq.mi)
Goff Creek	110100020501	15,270	23.9
Upper Crane Creek	110100020502	24,804	38.7
Spring Creek	110100020503	27,764	43.4
Middle Crane Creek	110100020504	28,329	44.3
Lower Crane Creek	110100020505	18,232	28.5
Tory Creek-James River	110100020506	29,472	46.1
Railey Creek	110100020507	15,481	24.2
Pine Run-James River	110100020508	16,570	25.9
Wilson Run-James River	110100020509	14,355	22.4

Table 6

HUC-12 SUB-WATERSHEDS IN THE TABLE ROCK LAKE HUC-10 WATERSHED

Total 58,727 acres (91.8 square miles)

HUC-12 Name	HUC-12 Number	Area (acres)	Area (sq.mi)
Piney Creek	110100020601	11,193	17.5
Aunts Creek	110100020602	15,998	25.0
Table Rock Lake-James River	110100020603	31,536	49.3

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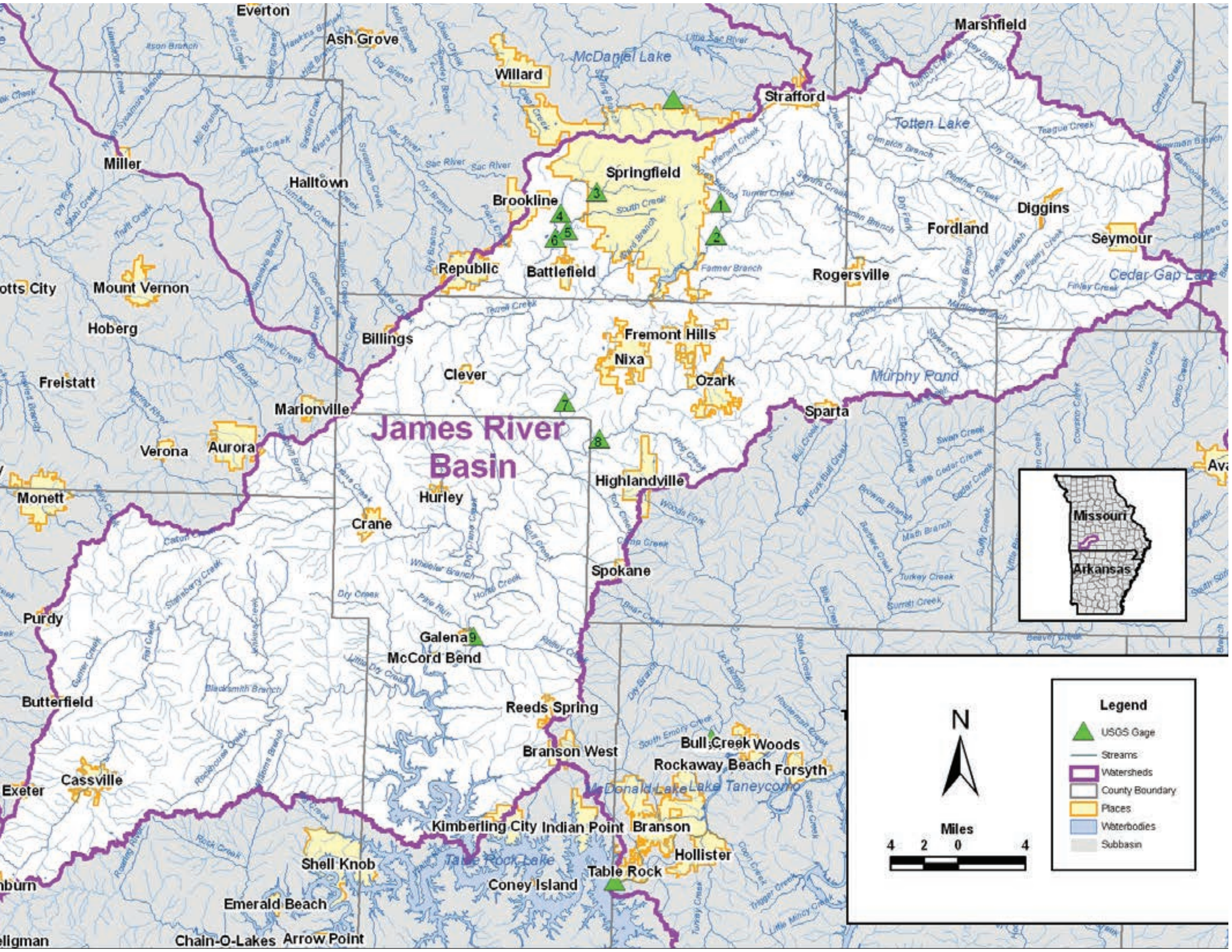

Figure 4: USGS Gaging Stations in the James River Basin

Boaz gage. A near historic crest occurred on the James River during the flood of April 29-30, 2017. On Sunday, April 30 the river peaked at 35.8 feet on the gage, or about 84,100 cubic feet per second. The highest recorded peak is 36 feet, which occurred on March 19, 2008 at a discharge of 85,100 cubic feet per second. It is interesting to note that four of the highest five peak flows recorded since 1921 were in the last nine years. The third highest flow was on December 28, 2015 at 78,100 cubic feet per second (34.1 feet on the gage), and the fifth highest flow was on April 26, 2011 at 64,000 cubic feet per second (31 feet). The fourth highest reading (73,200 cubic feet per second) occurred in the high water period during the fall of 1993. The water year with the lowest average flow and the lowest recorded flow was 1954, during a 40-month drought in southwest Missouri. The average discharge in 1954 was 119 cubic feet per second, and the lowest recorded flow was 10 cubic feet per second on September 20, 1954. Water quality records have been kept at the Galena gage since November 1999.

Wilsons Creek at Springfield

It's confusing, but the gage at Springfield is different than the gage near Springfield, described below. The Wilsons Creek gage AT Springfield is located at the Scenic Avenue Bridge. This is the highest gage on Wilsons Creek, with 17.8 square miles of drainage above this point. This gage was operated from 1932 to 1939, then from 1973 to 1977, then from 1998 to the present. The peak discharge was recorded on July 12, 2000 at 6,750 cubic feet per second. The second highest peak was on June 13, 2008 at 5,760 cubic feet per second, and the third highest was on December 25, 2016 at 4,240 cubic feet per second.

Wilsons Creek near Springfield

This gage is located on the center pier of the road bridge on Greene County Farm Road 156, about one mile upstream of the Springfield Southwest Wastewater Treatment Plant (SWTP) and about two and one-half stream miles below the gage at Scenic, described above. The gage is operated cooperatively with the city of Springfield Public Works Department. The drainage area above this point is 31.4 square miles. This gage was operated from 1972 to 1982, and then from 1998 to the present. The peak discharge was recorded on December 26, 2015 at 6,710 cubic feet per second, and the second highest peak was on June 13, 2008 at 6,410 cubic feet per second. It is interesting to note that the peak discharge recorded here was in 2015, not in 2000, as at the gage a few miles upstream. Both gages, however, had their second highest peaks in 2008, with 650 cubic feet per second more flow at the lower gage. Of course, these differences could reflect problems or malfunctions with gage readings at one or both sites. There is also a significant losing section in Wilsons Creek (a zone where water flows out

USGS Gage at Wilsons Creek, Farm Road 156 of the stream into fissures in the bedrock below) between these gages, and during low flow periods there is normally no flow at the gage at Farm Road 156.

Wilsons Creek at Brookline

This gage is located on the bridge at Farm Road 168, on the north side of Wilsons Creek Battlefield Park, about three miles downstream of the Southwest Wastewater Treatment Plant (SWTP) The drainage area above this gage is 51.0 square miles. This gage has been operated from July 2001 to the present. The peak discharge was recorded on June 13, 2008 (the same day as the second-highest readings at the gages above) at 9,530 cubic feet per second, and the second highest was on December 26, 2015 at 9,200 cubic feet per second.

South Creek at Springfield

This gage is located about fifty feet downstream of the highway FF Bridge in southwest Springfield and is operated cooperatively with the city of Springfield Public Works Department. The gage has been in operation since 1998. The drainage area above this gage is 10.5 square miles. The highest recorded flow was on July 12, 2000 at 2,870 cubic feet per second. However, the maximum flows for the flood on December 27, 2015 are "unknown," and the flood discharge for August 17, 2002 is also "unknown." The 2002 flood discharge was estimated at 2,400 cubic feet per second.

Finley River below Riverdale

This gage is on the bridge just downstream of the dam at Riverdale, on Aspen Bridge Road, just east of U.S. 160 south of Nixa and about 6.3 river miles above the confluence of Finely Creek with the James River. There is 261 square miles of drainage in the watershed above this point. The gage was operated from 2001 to 2005, and then from later in 2005 to the present. The peak flow recorded at this gage was on March 18, 2008 at 37,000 cubic feet per second, and the second highest reading was on June 10, 2015 at 36,500 cubic feet per second. Water quality sampling has occurred at this site from 2001 to the present.

Flat Creek below Jenkins

This gage is located at the lower Flat Creek Access on highway EE. There is 274 square miles of drainage in the watershed above this point. Flat Creek has its confluence with the James River in the James River arm of Table Rock Lake. This gage has been operated from 2003 to the present. The peak flow recorded at this gage was on December 28, 2015 (two days after the peak recorded discharge at the Wilsons Creek gage near Springfield) at 33,400 cubic feet per second, and the second highest peak was recorded on October 9, 2009 at 26,300.

The James River station at Boaz, the station on South Creek, and two of the three Wilsons Creek stations recorded peak discharges during the extremely wet July of 2008. The record flood at the James River station near Springfield occurred during July 2015, with a discharge of over 50,000 cubic feet per second. Prior to the 2008 and 2015 storm events, the highest floods on record for the two longest continually recording stations along the James River were during the floods of 1993. The flow peak during the 1993 floods was about 41,000 cubic feet per second near Springfield and about 73,000 cubic feet per second at Galena. While three established stations with non-continuous periods of record were established in the basin, they were not recording in 1993. Until the floods of 2008, 2015 and 2017, the highest floods on record for the non-continuously recording or more recently established stations resulted from locally intense storm events in July 2000 and May 2002.

KARST CONDITIONS

In many parts of the James River Basin, low-flow to moderate-flow hydrology is controlled largely by karst features such as sinkholes, springs and losing or gaining sections of streams. These karst features provide higher sustained flows to surface watersheds between rainy periods than would normally be found in similarly sized, non-karst watersheds. An important exception in the James River Basin is Wilsons Creek, which is heavily influenced by flows from the Springfield Southwest Wastewater Treatment Plant (SWTP). This plant discharges on average about 35 million gallons per day of treated wastewater into Wilsons Creek. During low flow periods, this wastewater discharge contributes a high proportion of the flow to the James River below Springfield. This is demonstrated by the fact that the 90% exceedance flow (flows that are exceeded ninety percent of the time) for Wilson Creek increases from 0 cubic feet per second above the SWTP to 34 cubic feet per second below. The 34 cubic feet per second flow at the Brookline gage is over half of the flow recorded at the James River gage at Boaz (67 cubic feet per second) for the 90% exceedance discharge.

Karst conditions are prevalent over a portion of the James River Basin. Prominent karst features include caves, losing streams, swallow holes, karst windows, sinkholes and springs. About 3,200 sinkholes have been identified in the basin. These may be very large, steep-sided and deep (e.g. Avin Sink near Nixa), or small, shallow, bowl-shaped depressions. Major sinkhole plains, or areas of intense sinkhole development, exist in the areas northwest of Nixa and eastern and northwestern Springfield. Over 150 losing stream segments, where significant flow is lost to the shallow groundwater system, have also been identified in the basin.

Over 560 springs have been identified in the James River Basin, but this is much lower than the actual number when "wet weather" springs, those that flow for short periods after rain events, are included. These springs provide cool, consistent base flow to streams that would otherwise be totally dry during long periods of dry weather. Springs are therefore of great ecological benefit to aquatic and riparian (land along the stream) life. Spring flow also exerts a strong influence on water quality of streams. For example, nitrogen compounds are very water soluble and show up in significant concentrations in spring flow. Phosphorus, on the other hand, tends to adhere to sediment, which is usually found in lower concentrations in springs than in streams. Springs therefore typically have very low phosphorus concentrations at base flow.

The recharge areas (areas of surface land contributing flow to a given spring) for most of the springs in the James River Basin have not been studied or delineated. Most of the dye tracing to date has been done in the Springfield-Nixa area, where springs are in proximity to urbanized areas and major transportation networks. Often, the recharge areas of these springs include industrial sites, railroads and highways, so there is a need to know where pollution released at or near the surface might go, and what springs might be affected. In the James River Basin, dye traces have been conducted from sinkholes and losing streams to Camp Cora, Jones, Winoka, Rader and Ward Springs near Springfield, and to Blue Spring near Nixa.

Dye tracing information has been collected by many agencies and individuals over the years, most of it since the late 1960s. Greene County first began a dye-tracing registration in the early 1990s, and the state of Missouri began a registration process a short time later. This information is now recorded and archived by the Missouri Department of Natural Resources. Since many of the dye traces in the basin are several decades' old, newer techniques and methodologies would no doubt improve the understanding of the very complex karst groundwater systems found over much of the James River Basin.

The following are the more prominent springs in the James River Basin. Flow data was taken from *Springs of Missouri* (Vineyard and Feder, 1974). This document also contains limited water quality information from 1925 (one spring) to 1964 (most springs) on selected springs including calcium, magnesium, sodium, iron, potassium, carbonate, bicarbonate, nitrate, phosphate and specific conductance. It is noted on the descriptions which springs have this data recorded in the *Springs of Missouri* book. It is also noted which springs were sampled during the 2013, 2016, and 2019 "Snapshot" Surveys, described later in this plan.

- Bell Spring: Located on the upper James River, south of Marshfield on the Bell Ford Road in Webster County. Provides significant flow to the upper James River; sampled during the 2013 and 2016 snapshots.

- Blue Spring: Flows directly into the James River near Farm Road 94 south of Battlefield in Christian County; measured five times between 1928 and 1964, with flows ranging from 1 to 2 million gallons per day; water quality data available in Springs of Missouri; sampled during the 2013, 2016, and 2019 snapshots. This spring drains a large area of sinkholes northwest of Nixa (see map in Springs of Missouri). This karst area contains several sinking streams, which flow on the surface for a short distance before plunging into large sinkholes. One sinking stream, the Saunders Valley, disappears into a large sinkhole about one-half mile southeast of Blue Spring. Between this sinkhole and the spring is a "karst window," where the spring can be seen flowing across the bottom. This flow has been dye traced to Blue Spring. Water entering Avin Sink, the largest sinkhole in the James River Basin, also probably goes to Blue Spring, two miles away.

- Bonebrake Spring: Flows from a small cave near the headwaters of Jones Branch just east of Springfield in Greene County. This spring is an overflow outlet for Jones Spring, described below, and flows through an old spring house. An underground dam or diversion was built in a cave to divert water from Jones Spring into Bonebrake Spring.

- Brown Spring: Issues from the bed of Spring Creek, a tributary of the James River, near highway M at the town of Brown Spring in Stone County; measured three times between 1931 and 1964, at 3 to 7 million gallons per day; water quality data available in Springs of Missouri; sampled during the 2013, 2016, and 2019 snapshots. Brown Spring once served as a resort town, with a small lake built near the spring used for rearing trout. A dam built in 1900 at Hurley, four miles downstream, captured the flow of the spring and was used to operate a mill.

- Camp Cora Spring: Flows directly into the James River from a low bluff on the south side of the river southwest of the James River Power Plant in Greene County; measured three times between 1955 and 1964 at from 0.5 to 1 million gallons per day; sampled during the 2013, 2016, and 2019 snapshots. There have been several dye traces to this spring, many of them conducted by an MSU student as part of a Masters project. The recharge area lies mostly to the east, along U.S. 60 in the Highlands Springs area.

- Cave Spring: Flows into Wheeler Branch, a tributary of the James River, on Cave Spring Road off AA Highway in Stone County; sampled during the 2013, 2016, and 2019 snapshots. This spring flows from a cave on private property and once served a fish hatchery, the remains of which can still be seen near the cave.

- Crystal Spring: Flows into the headwaters of Flat Creek a few miles downstream of the city of Cassville, in Barry County; measured two times, in 1942 and 1964, at 1 and 7 million gallons per day. The spring once served a fish hatchery.

- Danforth Spring(s): Located on the headwaters of Pearson Creek in eastern Greene County. There are four springs in close proximity that are collectively called the Danforth Springs. Flows were measured in 1964 at from 0.2 to 0.5 million gallons per day, and there is water quality data in *Springs of Missouri*.

- Hayes Spring: Flows from a large cave into Dry Crane Creek in northern Stone County. The cave was surveyed and mapped in 1967. The cave and spring are now part of the 104-acre Missouri Department of Conservation Hayes Spring Conservation Area; spring flow measured by the Conservation Department at 260,000 gallons per day; sampled during the 2013, 2016, and 2019 snapshots.

- Indian Spring: Flows into a small tributary of the James River about one-fourth mile north of the Greene-Christian County line, opposite Blue Spring; flow measured in 1964 at 129,000 gallons per minute.

- Jones Spring: Issues from a small cave near the head of Jones Branch just east of Springfield in Greene County; measured three times in 1965 at 0.7 to 7.7 million gallons per day; water quality information in Springs of Missouri; sampled during the 2013, 2016, and 2019 snapshots, but much other water quality and flow information has been collected over the years since this spring drains a major portion of the sinkhole plain in eastern Springfield; several dye traces have been used to connect sinkholes to Jones and Bonebrake Spring, including at least five from sinkholes in the eastern Springfield Cherry Street karst plain; spring has been the source of contamination leading to fish kills in the past (major one in 1964). A large filled sinkhole between the lanes of U.S. 65 has a conduit leading into the cave systems feeding Jones Spring (diagrams and descriptions in *Springs of Missouri*). A limestone wall once standing near the spring was built by slaves in 1823 to anchor the flume for a grist mill.

- McMurtry Spring: Flows from a spring house just off U.S. Highway 37 into the uppermost headwaters of Flat Creek a few miles southwest or upstream of the city of Cassville in Barry County; flows measured in 1964 at 284,000 gallons per minute; water quality information in *Springs of Missouri.*

- Mineral Spring: Small spring flowing in a steep-sided ravine into Rockhouse Creek, a tributary of Flat Creek, about five miles east of Cassville in Barry County. This was the site of Panacea, later renamed Mineral Springs, a mineral spring "spa town" that boomed suddenly in the early 1880s with bathhouses, hotels, boardinghouses and residences. By the 1890, the boom had taken a downturn. Several houses remain in Mineral Spring, but the last store closed in the 1960s (Bullard, 2004).

- Monroe Spring: Flows into the headwaters of Jones Branch just east of Springfield in Greene County; flow measured in 1964 at 0.5 million gallons per day.

- Montague Spring: Flows into Tory Creek, a James River tributary, on Highway O about four miles west of U.S. 160 in Christian County; measured two times in 1941 and 1964 at 1.7 and 1.8 million gallons per day; sampled during the 2013, 2016, and 2019 snapshots; spring serves the Mountain Springs Trout Park, a pay-to-fish facility.

- Mountaindale Spring: Flows from a low limestone bluff into the headwaters of Finley River in Webster County; measured three times in 1966 at 0.5 to 3.5 million gallons per day; water quality information in Springs of Missouri. At 1,520 feet above sea level, one of the highest springs in Missouri to have substantial perennial flow (Vineyard and Feder, 1974).

- Ollie Lasley Spring: Flows down a beautiful cascading branch into Pedelo Creek, a Finely Creek tributary, in Christian County; measured in 1966 at 1 million gallons per day; sampled during the 2013 and 2016 snapshots.

- Patterson Spring: Flows into Finley Creek a few miles northeast of the city of Sparta in Christian County; sampled during the 2013 and 2016 snapshots; one of the earliest settlement sites in southwest Missouri.

- Rader Spring: Flows into Wilsons Creek one-half mile south of M Highway in Greene County; a very large spring, largest in Greene County, ranking third among springs on the Springfield Plateau and second among those in the White River Basin (Vineyard and Feder, 1974); flow enhanced significantly by the discharge from the Springfield Southwest Wastewater Treatment Plant, which releases treated wastewater into Wilsons Creek upstream of the spring; measured in 1964 and 1965 at 1 to 23 million gallons per day; water quality information in Springs of Missouri and sampled during the 2013,2016, and 2019 snapshots. Rader Spring is the master resurgence for a large area drained by sinkholes north of the spring. Dye traces in 1968 showed that prior to construction of the tertiary treatment lagoon at the wastewater facility, most of the flow from the plant was lost through the bottom of Wilsons Creek and re-appeared at Rader Spring. With the construction of the lagoon, more of the discharge entered below the losing section, thus by-passing Rader Spring and reducing its flow. Dye traces in 1969 showed that Rader Spring also received flow from a losing section of South Creek, from Pfaff Cave (near U.S. 60 Highway), and from a subdivision east of U.S. 160 Highway south of Springfield (Vineyard and Feder, 1974). This karst complex is described in a 1970 issue of *Ozark Caver*, along with maps showing dye traces to Rader Spring.

- Reeds Spring: Flows in a sunken, walled basin in the downtown section of Reeds

Spring in Stone County; measured five times between 1943 and 1966 at 65,000 to 300,000 gallons per day. This spring has a very uniform flow compared to many other springs (Vineyard and Feder, 1974); water quality information in *Springs of Missouri.* The spring was originally a source of water for the settlement but was later used by farmers and stockmen during dry periods (Vineyard and Feder, 1974).

- Roundtree Spring: Flows into a pond and then into a small tributary of Wilsons Creek west of Highway FF in Greene County; measured two times in 1964 at 60,000 and 84,000 gallons per minute.

- Rumfelt Spring: Flows into the headwaters of the James River in Webster County; measured in 1966 at 1 million gallons per day; water quality information in *Springs of Missouri.*

- Sequiota Spring: Flows from a large cave in Sequiota Park in southeast Springfield in Greene County; measured five times from 1936 to 1954 at 0.6 to 11 million gallons per day; water quality information in Springs of Missouri and sampled during the 2013, 2016, and 2019 snapshots. This spring has a long and colorful history. In 1883, the attractive area around the spring was turned into a "pleasure ground," served by the Chadwick branch railroad line from Springfield. A four-foot dam was built about 200 feet below the cave opening to back up water and allow 25-cent boat rides into the cave. This was the site of one of the earliest state fish hatcheries in Missouri, established in 1924, which was later moved to Table Rock Lake. Part of the reason for the move was inadequate summer flows from the spring, but water quality may have also been a factor. In the 1960s and 1970s, the spring became contaminated by large numbers of septic tanks at houses in the village of Galloway to the north and east. In 1973, a dye trace was conducted to the spring by flushing dye down the urinal at Sequiota School, about one-half mile away. Since that time, municipal sewers have been constructed in most of the recharge area and the spring is much cleaner.

- Sherrod Spring: Flows into a small lake at the Horton Smith Golf Course on South Creek in south Springfield, Greene County; measured four times between 1956 and 1964 at 150,000 to 300,000 gallons per day.

- Spout Spring: Flows into Spout Spring Hollow, a small tributary of the Finley River, about one mile east of Nixa on Highway 14 in Christian County; measured in 1964 at 180,000 gallons per day. This spring once served as a wagon watering stop on the Nixa to Ozark Road.

- Tallman Spring: Flows from a limestone bluff near the former lodge site at Jude Ranch into Pedelo Creek, a tributary of Finley Creek in Christian County; sampled during the 2013, 2016, and 2019 snapshots.

- Todd Spring: Flows from the side of a steep roadside ravine into Martins Branch, a tributary of Finley Creek, in the very northeastern corner of Christian County; measured in 1966 at 2 million gallons per day; sampled during the 2013, 2016, and 2019 snapshot events; water quality information in *Springs of Missouri.*

- Ward Spring: Flows from a small cave into

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Ward Branch, a tributary of the James River south of Springfield near U.S. 160 in Greene County; measured two times in 1964 at 0.7 and 1.1 million gallons per day; water quality information in Springs of Missouri; sampled during the 2013, 2016, and 2019 snapshots. Dye tracing has been conducted to Ward Spring from the large Park Crest sinkhole about one mile north of the spring.

- Wasson Spring: Flows into a small tributary of Finley Creek about two miles south of Nixa in Christian County; measured in 1963 and 1964 at 52,000 gallons per day and 1.1 million gallons per day.

- Welch Spring: Flows into Workman Branch, and then Ward Branch, tributaries of the James River in south Springfield in Greene County; measured in 1964 at 116,000 gallons per day.

- Winoka Springs: A series of springs flowing from limestone ledges about 40 feet above the James River in southeast Springfield in Greene County; flow measured five times between 1932 and 1964 at 150,000 gallons per day to 3.9 million gallons per day; water quality information in *Springs of Missouri*. Dye traces to Winoka Spring have been made from at least five sinkholes to the east of the spring, near the Greene-Christian County line. The Winoka Club, which started as a hunting club, was founded around the springs in about 1890. The springs were once used to fill a swimming pool and fountains on the beautifully landscaped grounds. Fire destroyed the old Winoka Lodge in 1977, but the remains of the pool and stone structures are still in the underbrush.

- Young Spring: Flows from a cave and spring house into a small tributary of the James River about four miles southwest of Nixa in Christian County; measured in 1963 and 1964 at 71,000 and 240,000 gallons per day; sampled during the 2103 and 2016 snapshots.

Other prominent karst features and related events:

- Riverbluff Cave: On September 11, 2001 (known in familiar parlance as 9-11), workmen blasting for road construction in southern Greene County near the James River accidentally penetrated a cavern. Crews stopped working immediately (such works was soon stopped nationwide because of the 9-11 tragedy) and a local geologist was consulted. The explorers subsequently discovered a cave about 2,000 feet long, the natural entrance of which had been sealed shut for thousands of years. Inside were many amazing archeological artifacts dating from the Pleistocene (Ice-age) Era, 11,000 to 1.8 million years ago, including peccary (pig-like animals) tracks, claw marks of short-faced bears and large cats, bear beds, and fossilized turtle shells. An air-tight opening was constructed to seal the blasted area and a locked gate was added to restrict access. The cave is used only for scientific research and is closed to the public, but a new Missouri Institute of Natural Science facility has been constructed nearby. Prior to the finding of the cave, there was a small farm house located near the cave site. In the early 1980s the former landowner, Comer Owen, notified a health department worker who was collecting a water well sample that he had occasionally drawn up "white fish" from his shallow well.

- Devil's Den: This is a deep, sheer walled sinkhole located near the Dry Fork of Panther Creek, a tributary of the upper James River, west of Fordland off Highway PP in Webster County. The sinkhole is about 100 feet deep with a lake in the bottom. Reportedly, cars have been pushed into the sinkhole, but this has never been verified. A statement was also once made that cedar trees were found floating in the sinkhole, which, since no cedars were found growing in the immediate vicinity, led people to believe that the water came from some distance. However, the Fordland band did once play on a wooden dance platform built over the sinkhole, providing a unique experience for attendees.

- Avin Sink: This is the largest sinkhole in the James River Basin. It is located about three miles northwest of Nixa, but drainage to the sinkhole extends southward at least two miles to a point due west of Nixa. The sink is about 140 feet deep as measured from a nearby ridgetop, and it drains an area of several square miles containing sinkholes and ephemeral losing streams.

- Nixa Sinkhole Collapse: In August 2006, the owner of a home in Nixa heard a loud crashing noise and thought his house had been hit by a truck. Instead, his garage and car had fallen into a newly formed sinkhole. The sinkhole was at first almost 90 feet deep, but slumping of the steep earthen sides soon reduced it to about 75 feet of depth. About 12 hours after the initial collapse, more of the house gave way, cracking in half and leaving the kitchen dangling precariously over the 60-foot wide hole. The house and six neighboring homes were evacuated. After consulting with a geologist, the city supervised the filling of the sinkhole, but some settling and slumping still occur. This sinkhole is most likely connected to the Avin Sink karst

Devil's Den, ca. 1910 (hand tinted glass slide)

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(Top) Nixa Sinkhole Collapse
(Middle) Barry County Sinkhole Collapse
(Bottom) Sequiota Spring with Red Water

zone described above, with subterranean flow going to Blue Spring on the James River.

- Barry County Sinkhole: This sinkhole formed suddenly in March 2005 in a farmer's field, eventually becoming about 300 feet long by 85 feet wide, and about 150 feet deep. The sinkhole is west of Exeter near Highway M in Barry County and is located just outside the James River Basin, in the headwater area of Big Sugar Creek.

- Natural Well: This karst feature was at the founding site of the city of Springfield, close to present-day Founders Park. Early settler John Polk Campbell built his cabin here in 1830, having discovered the site a year earlier. He probably used the natural well for his water supply. The "well" (what we would today call a "karst window," a vertical cave extending down into a spring's plumbing system) was about eight feet long and a foot wide. Later, the well was considered for Springfield's first public water supply. A newspaper description of a pump test conducted in 1874 to evaluate the well's output stated that "fish, and even eels," had once been drawn up from below. The well was not used for the city supply and sometime in the 1890s the site was mostly destroyed by a quarry and street railway construction. However, a downtown business owner claims that the original natural well can still be accessed through a building basement.

- Swallow hole on Wilsons Creek: On April 18, 2017, during a clean-up and riparian area assessment on Wilsons Creek, participants discovered a "new" swallow hole, a vigorously swirling whirlpool going down into a dark opening in the stream bottom. A video clip of the whirlpool interested a reporter for the Springfield News-Leader and the subsequent story elicited considerable response from the public. This swallow hole is in a prominent losing section of Wilsons Creek below the outfall of the Springfield Southwest Wastewater Treatment Plant. Several estavelles (reversible sinkholes) and other karst features are located in the immediate vicinity. Dye traces have shown that the stream zone near the swallow hole, along with Pfaff Cave, a losing section of South Creek, and the Park Crest Sinkhole east of U.S. 160, all connect to Rader Spring, the master resurgence of the lower Wilsons Creek karst complex.

- Sequiota Spring "Muddy" Water Episode: In December 2006 the water flowing from Sequiota Spring suddenly turned very murky and reddish. It had rained about three inches the previous week, but that was too early to explain the sudden appearance of the muddy water. Instead, it was presumed that a sinkhole collapse had occurred in the spring's recharge area. This turned out to be the case. A sinkhole over a mile east of the spring, in an undeveloped area, had collapsed. Running through the sinkhole was a small diameter (4-inch) water main, which had sagged and broken during the collapse. It was not determined whether the sinkhole had collapsed first, breaking the water line, or whether the line had been leaking for some time, inducing the collapse. In any case, water gushing from the broken main had probably scoured mud from the sinkhole bottom and solution channels in the limestone below, creating the sudden appearance of mud at the spring mouth.

BASIN BIOLOGY

Every watershed contains a unique balance of animal and plant life resulting from its geology, hydrology, climate, soils and other biotic and abiotic factors. The James River Basin enjoys a diverse mix of species, both aquatic and terrestrial. The White River region is the most diverse in Missouri as far as the number of fish species found there. Seventy-one species of fish have been collected in the James River and its tributaries and springs (MDC website). Common sport fish include smallmouth bass, largemouth bass, spotted bass and channel catfish. The James River also contains several fish species that are restricted to the White River region, including the Ozark bass, Arkansas saddled darter, yoke darter and duskystripe shiner. Table 7 on the next page, shows the fish species that have historically been collected from the James River Basin, their population status (likely present or unknown), and their status as a species of concern (state or federal threatened or endangered)

In addition to the fish species listed on the next pages, the James River Basin Inventory and Management Plan, published in 1997, identified 16 species of crayfish and 32 species of mussels that have been found in the basin. Buchanon (1982) reported that mussels in the twenty miles of the James River downstream of the Springfield wastewater plant had been severely impacted, and many species were absent. Twenty fish species were identified in the 1997 inventory that were historically collected in the basin but had been absent from more recent collections. The report also listed 8 species of amphibians and reptiles which have localized distributions in the James River Basin.

In addition to aquatic habitats, the *James River Basin* also includes a number of unique terrestrial habitats, including dolomite glades, limestone glades, dry chert forests,mesic limestone and bottomland forests, and one wetland community (Pond Shrub Swamp). These unique community types have been identified by the Missouri Department of Conservation, which stresses the importance of protecting these habitat types from degradation, as well as the animals and plants that have become specially adapted to live in them. With the karst topography found in the James River Basin, caves and underground streams are common, providing habitat for rare and in some cases threatened cave species like grotto salamanders, bristly cave crayfish and Ozark cavefish. Springs also provide important habitat for surface species, including game fish.

Table 7

FISH SPECIES OF THE JAMES RIVER BASIN

Fish Species	Population status	Species of Concern
Arkansas saddled darter (White River form)	Unknown (last seen 1952)	X
Autumn darter	Likely present	
Banded darter	Likely present	
Banded sculpin	Likely present	
Bigeye chub	Likely present	
Bigeye shiner	Likely present	
Black bullhead	Likely present	
Black crappie	Likely present	
Black redhorse	Likely present	
Blackspotted topminnow	Likely present	
Bluegill	Likely present	
Bluntnose minnow	Likely present	
Brook silverside	Likely present	
Carmine shiner	Likely present	
Central stoneroller	Likely present	
Channel catfish	Likely present	
Checkered madtom	Unknown	X
Common carp	Non-native (introduced)	
Creek chub	Likely present	
Creek chubsucker	Likely present	
Duskystripe shiner	Likely present	
Fantail darter	Likely present	
Fathead minnow	Likely present	
Flathead catfish	Likely present	

Many species of animals and plants in the basin are adapted to live in springs or spring-fed streams. Studies have shown that smallmouth bass, the premier game fish of the James River Basin, have higher rates of growth in spring-fed streams than in streams without this spring influence (Whitledge et al., 2006).

Many streams in the James River Basin have been negatively impacted by loss of riparian vegetation, excessive nutrients coming into the stream in runoff, streambank and channel erosion, overgrazing by livestock, and clearing of land for urban development (MDC website). All of these disturbances affect life found in and along streams. Streams in the Wilsons Creek watershed in particular have been heavily impacted by urban development, with greater rates of runoff, destabilized stream channels, and increased erosion and sedimentation. Smaller streams tributary to the James River in the central part of the basin, such as Ward Branch and Farmers Branch, have also been impacted by urbanization, as have sections of Finley Creek near Ozark and Nixa. Livestock raising, dairying and other types of agriculture have also led to localized water quality problems and negative effects on wildlife.

RIPARIAN ZONES

Healthy riparian zones (ribbons of land along and near streams) are critical to the proper functioning of aquatic ecosystems. These vegetated areas along rivers and streams have been called the "safety nets" that protect streams from the negative effects of adjacent land uses, included polluted runoff. Streamside vegetation slows floodwaters, filters and absorbs sediment and nutrients, and provides shade, food, and habitat for a very wide variety of organisms. The importance of these functions cannot be overstated. Many headwater streams in the James River Basin have little or no riparian vegetation. This leads to a loss of fallen leaves that normally form the basis of food chain; lack of shading and increased sunlight penetration, stimulating abundant algae growth on stream bottoms; and changes in ecosystem structure and species due to the increased growth of algae and the organisms that use algae for food. De-vegetated riparian areas are also much more likely to have rapid and severe erosion during times of heavy stream flow. Healthy riparian vegetation protects streambank and floodplains

Table 7 Continued

FISH SPECIES OF THE JAMES RIVER BASIN

Fish Species	Population status	Species of Concern
Freshwater drum	Likely present	
Gilt darter	Likely present	
Gizzard shad	Likely present	
Golden redhorse	Likely present	
Golden shiner	Likely present	
Goldfish	Likely present	
Grass pickerel	Likely present	
Green sunfish	Likely present	
Green sunfish cross with bluegill	Likely present	
Greenside darter	Likely present	
Highland darter	Likely present	
Hornyhead chub	Likely present	
Knobfin sculpin	Likely present	
Largemouth bass	Likely present	
Largescale stoneroller	Likely present	
Logperch	Likely present	
Longear sunfish	Likely present	
Longnose darter	Likely extirpated	
Longnose gar	Likely present	
Northern hog sucker	Likely present	
Northern studfish	Likely present	
Orangethroat darter	Likely present	
Ozark bass	Likely present	
Ozark cavefish	Likely present	X

Table 7 Continued

FISH SPECIES OF THE JAMES RIVER BASIN

Fish Species	Population status	Species of Concern
Ozark chub	Unknown	
Ozark madtom	Likely present	
Ozark minnow	Likely present	
Ozark sculpin	Likely present	
Ozark shiner	Unknown	X
Plains topminnow	Unknown	X
Rainbow darter	Likely present	
Rainbow trout	Non-native (introduced)	
River redhorse	Unknown	
Silver chub	Unknown	
Slender madtom	Likely present	
Smallmouth bass	Likely present	
Southern redbelly dace	Likely present	
Spotted bass	Likely present	
Stippled darter	Likely present	
Striped shiner	Likely present	
Telescope shiner	Likely present	
Western creek chubsucker	Likely present	
Western mosquitofish	Likely present	
White crappie	Likely present	
White sucker	Likely present	
Whitetail shiner	Likely present	
Yellow bullhead	Likely present	
Yoke darter	Likely present	

from the negative effects of flooding.

Healthy riparian zones along Ozark streams feature a diverse mixture of trees, bushes, shrubs and grassy plants. Along streams in the James River Basin, riparian areas are mostly dominated by hardwood trees. Trees commonly seen along streams in the basin include sycamore, black gum, bur oak, red maple, river birch, willow, shagbark hickory, red maple, redbud and dogwood. Because of their deep root systems, trees are very desirable for holding bottomland and floodplain soils in place during floods and reducing the speed of flood currents, lessening downstream flood damages. Trees are also very important for habitat and food. Many mammals and birds utilize tree holes and hollow trees. Oaks and hickories produce acorns and nuts providing food for deer, squirrel and turkey, especially during the winter. Dogwoods and persimmons provide food for wide variety of birds and mammals.

Shrubs form an important understory of plants in the riparian zones of streams in the James River Basin. Commonly seen along streams are witch hazel, ninebark, buttonbush, spicebush and elderberry bushes. Below and around them grow smaller plants such as sunflowers, cardinal flowers, coneflowers, mints, phloxes, smartweeds, asters, milkweeds, and a variety of grasses, sedges and rushes. In many places along the James River are thick stands of horsetails, also called scouring rushes, which were used by pioneers for scouring pots and pans. These and other rooted plants not only hold and stabilize soil, but provide food and cover for wildlife, attract pollinators when in bloom, and serve as hosts for many beneficial insects. Native plant species have formed many unique relationships with animals found along the stream. For example, spicebush is host to the spicebush swallowtail, a beautiful butterfly often seen along streams in the Ozarks (Beaver Watershed Alliance, undated).

The absence of trees in riparian zones depletes one of the most important food sources for Ozark headwater streams—fallen leaves. These leaves serve as food and growing surfaces for a wide variety of fungi, bacteria and other organisms, which, in turn, provide food for larger species such as macroinvertebrates (especially insect larvae). Macroinvertebrates are critical food items for larger species such as turtles, snakes and fish.

Small headwater streams also serve important functions as shelter and habitat for the young of many species, including game fish. For these reasons, riparian zones in poor condition, whether in headwater or large streams, or whether in urban or agricultural areas, contribute to lessened biological diversity (fewer numbers of animal and plant species) as well as, potentially, water quality degradation.

Erosion from destabilized streambanks and land clearing increases the amount of sediment in streams. This sediment can have harmful effects on stream life by clogging the gills of fish and filling nesting sites with sediment. Some fish, such as darters, are especially sensitive to stream bottom disturbances and the clouding of streams with sediment. Sediment clogging gravel on the stream bottom reduces the flow of oxygen and takes away living spaces for macroinvertebrates, the small animals like snails and insect larvae that form the basis of food chains in Ozark streams. And sediment in water can increase its temperature, negatively affecting animals adapted to live in the cool waters normally found in the basin.

Many riparian zones in the James River Basin are negatively affected by prolific growths of non-native, invasive species such as Japanese honeysuckle and purple winter creeper. Although these plants may help to hold soil and streambanks in place, they are undesirable because they are poor food sources or habitat for native animals, which are adapted to live with the native Ozark plants. Unfortunately, invasive species often grow very quickly, and can completely take over a barren or even forested area within a few years.

In the 1997 James River Inventory and Management Plan, the Missouri Department of Conservation suggested that stream habitat quality was "fair to good" throughout the basin. The department concluded that some areas, notably along Crane Creek (a unique fishery), suffered from a severe lack of riparian vegetation. The report further noted that grazing practices along many streams in the basin contributed to streambank instability, nutrient loading in runoff, and poor riparian conditions. Clearing of vegetation and greater runoff were noted as significant problems in urban and urbanizing areas leading to poor habitat conditions.

In urban areas, riparian zones along small headwater streams are typically in very poor condition, with thick stands of invasive plant species. Urban areas also have large amounts of impervious areas (such as roads and parking lots, where water can't soak into the ground), which funnel runoff and its pollutants directly to the stream with little or no filtration through vegetation. These affects can extend far downstream. For example Wilsons Creek, which drains the majority of the Springfield urban area, exerts negative effects downstream for many miles in the James River. Urban contaminants have been found in stream bottom sediment as far down as the USGS gaging station at Boaz. The negative effects of urban runoff on biota can be severe. Studies by City Utilities of Springfield in Pearson Creek, on the eastern urban fringe of Springfield, showed that the effects of urban runoff resulted in decreased diversity of stream life (mainly macroinvertebrates), between the 1960s and the 1990s. Because they are important food sources, the loss of macroinvertebrates can have significant impact on game fish and larger aquatic species.

Streams also have little or no riparian cover in many agricultural areas of the James River basin. The lack of shading and increased sunlight leads to prolific growth of algae on the stream bottom. This, in turn, leads to changes in the species structure of the streams, favoring fish such as stonerollers that are adapted to feed on algae. Stonerollers and suckers are therefore much more common in unshaded streams in agricultural areas, while sunfish and darters are more common in streams with riparian cover containing mature trees and other shading vegetation. In a study of Ozark streams with healthy riparian zones, stonerollers comprised about 10 to 20% of the minnows sampled, but in more open agricultural watersheds, the abundance went up to 20 to 50% (Petersen, 1996 Water Resources Investigations Report 98-4155).

Livestock in riparian zones can exert several negative effects on streams and stream life. Cattle tend to concentrate and linger in stream zones during hot, dry weather, particularly if they find shade there. Because animals tend to spend most of their time here, most of their bodily wastes are deposited near the stream, where nutrients and bacteria can immediately reach the stream with the first runoff after a rain. Further, concentrated livestock cause erosion of banks by constant travel. Livestock also compact soil on streambanks with their hooves, causing these streamside soils to store less water between rains. These compacted banks will therefore hold less water to release back to the stream during dry periods. Healthy, non-compacted and aerated streambank soils, in contrast, will hold water longer and release it more slowly to the stream, sustaining flows during dry weather.

MACROINVERTEBRATES AND WATER QUALITY

Aquatic invertebrates, the small animals living in the stream bottom, are good indicators of the overall quality of water or "health" of a stream. The 1997 Inventory reported that macroinvertebrate diversity (number of species) had been reduced by pollution or other impacts in several portions of the James River Basin. The aquatic ecosystem was said to be worse in the lower stretches of Pearson Creek, where the stream was impacted by urban runoff from Springfield, than in the higher sections. Also, macroinvertebrate types collected indicated that the ecosystem had been negatively impacted in Flat Creek just below Cassville but recovered downstream. In Finley Creek, the macroinvertebrate indices showed negative impacts in a seven mile reach below Ozark and Nixa, and Wilsons Creek was severely impacted for about five miles below the Southwest Wastewater Treatment Plant (SWTP), and for 14 miles in the James River below its confluence with Wilsons Creek (Missouri Department of Conservation, 1997).

SPECIES OF CONCERN

Several organisms in the James River Basin are threatened or endangered or "species of concern." This status can be due to a variety of causes, but habitat loss is often a key element. Water typically plays a vital role in habitat. Aquatic biology may also be adversely affected by water quality and hydrologic changes, such as dams or changes in streamflow caused by development in the watershed. The status of endangered and threatened species living in a watershed is important information for a watershed plan, as these species often serve as sensitive indicators of the overall effectiveness of water quality measures and implemented practices and improvements. The Missouri Department of Conservation's Natural Heritage Database (MDC, 2008a) and the Missouri Fish and Wildlife Information System (MDC, 2008b) were used to identify species that are threatened or endangered at the state and/or federal level in the James River Basin. Table 11 on the next page shows the species that have been listed and their approximate location by county:

Gray bats and Indiana bats are both listed as endangered by the state of Missouri and threatened by the U.S. Fish and Wildlife Service. Gray bats like limestone caves, so are found in the Ozarks of southern Missouri. Missouri contains about 20% of the entire population of gray bats. Indiana bats are found mostly in northern Missouri. 85% of Missouri's total population of Indiana bats hibernate in only eight specific locations, with three of these being in the Ozark counties of Shannon, Washington and Iron. The James River Basin is not shown as part of the current range of Indiana bats.

Bachman's sparrow was historically found in the glades and pine woods of Missouri, but its population declined sharply in the early 1900s with the heavy logging of pines. Missouri is in the extreme northwest portion of its range. The bald eagle, in contrast, has recovered dramatically from its very low numbers in the 1960s and 1970s. Habitat loss and hunting in the late 1800s decimated their populations. Missouri's eagles were already gone by the mid-1900s, when DDT was reducing egg hatching success in other parts of the country. Now, Missouri is one of the leading bald eagle states, with over 2,000 overwintering here. In southwest Missouri, Taney and Ozark counties have the most nesting sites. Bald eagles are now commonly seen along the James River, along with ospreys.

The barn owl is found throughout the world, but in Missouri is considered a very rare resident and "species of conservation concern." The prairie chicken is listed as endangered in Missouri, with fewer than 500 birds now found in the state. It lives primarily on native prairies and in southwest Missouri is found mainly to the west of the James River Basin in Dade and Barton counties. The least tern is also endangered in Missouri and is considered a rare summer resident. It feeds on fish by diving into the water. Today, it is found almost entirely in Missouri along the Mississippi River from Cape Girardeau south.

The northern harrier, also called a marsh hawk, is a hawk of wetlands and grasslands, usually seen near prairies or hay fields. It occurs across North America and Europe but is listed as endangered in Missouri and is only found in the south part of the state. The peregrine falcon is another (partial) success story. In Missouri, it historically nested along bluffs on the Missouri, Mississippi and Gasconade Rivers. By the late 1800s, there were only a few pairs remaining in the state. But re-introduction has been partially

Table 8

SPECIES OF CONCERN IN THE JAMES RIVER BASIN

Group	Common Name	Scientific Name	Location (by county)*
Mammals	Black-tailed jackrabbit	Lepus californicus	Br,Ch,Dg,Gr,Lw,St,Wb,Wr
	Gray Bat	Myotis grisescens	Br,Ch,Gr,Lw,St,Wb,Wr
	Indiana Bat	Myotis sodalist	Br,Ch,St,Wr
Birds	Bachman's Sparrow	Aimophila aestivalis	Br,Dg,Gr
	Bald Eagle	Haliaeetus leucocephalus	Br,Ch,Dg,Gr,St,Wr
	Barn Owl	Tyto alba	Br,Lw,Gr
	Greater Prairie Chicken	Tympanuchus cupido	Lw
	Interior Least Tern	Sterna antillarum	Gr
	Northern Harrier	Circus cyaneus	Gr,Lw
	Peregrine Falcon	Falco peregrinus	Ch,Gr,Lw
Reptiles	Yellow Mud Turtle	Kinosternon flavescens	Br
Amphibians	Ozark Hellbender	Cryptobranchus alleganiensis	Dg
Fishes	Longnose Darter	Percina nasuta	St
	Niangua Darter	Etheostoma nianguae	Gr,Wb
	Ozark Cavefish	Amblyopsis rosae	Br,Gr,Lw,St
Mussels	Scaleshell	Leptodea leptodon	Wr
Plants	Geocarpon	Geocarpon minimum	Gr,Lw
	Missouri Bladderpod	Lesquerella filiformis	Ch,Gr,Lw

*County Abbreviations: Br-Barry, Ch-Christian, Dg-Douglas, Gr-Greene, Lw-Lawrence, St-Stone, Wb-Webster, Wr-Wright

successful, using tall buildings as substitutes for its cliff nesting sites. This "hacking" in the 1990s in St. Louis, Kansas City and Springfield, along with captive rearing, has resulted in some birds returning to the skies over Missouri's largest cities.

The yellow mud turtle is olive to dark colored and semi-aquatic, preferring sandy habitats around sloughs and oxbow lakes. It is listed as endangered in Missouri and is found in marshes in northeast Missouri, and in southwestern Missouri, primarily Barry County. According to the Missouri Department of Conservation, this turtle is in great danger of being extirpated (wiped out) from the state. The Ozark hellbender is a large aquatic salamander growing to about 20 inches long, which lives under flat rocks in large, permanently flowing streams. Its numbers have declined drastically since the 1970s and declined a further 85% since the 1980s. The Conservation Department predicts that it may become extinct in Missouri within the next 20 years. The hellbender occurs in Missouri only in the White River System of southern Missouri but is probably not found in the James River Basin.

Three fish species found, or formerly found, in the James River Basin, are now listed as

(Top) Niangua Darter
(Bottom) Ozark Cavefish

endangered. The longnose darter formerly inhabited large Ozark streams in Missouri, Arkansas and Oklahoma. There are no records of the fish from the James River, but there are pre-impoundment records of it in the White River. It is now extremely rare in Missouri, with most of its historic stream range now covered by Table Rock Lake. It is known only from historic records in Stone and Taney Counties and areas near the St. Francis mountains in the eastern Ozarks. The Niangua darter is endangered in Missouri and on the threatened list posted by the U.S. Fish and Wildlife Service. This small fish, of the perch family, grows to about 4 inches long. During the mating season, the males have brilliant breeding colors. It is now found only in a few tributaries of the Osage River, particularly the Niangua and Little Niangua Rivers, and probably does not occur in the James River Basin.

The Ozark Cavefish is on the Missouri endangered and federally threatened lists. It is blind, colorless and only grows to about 2 ¼ inches. It lives only in cave streams and springs on the Springfield Plateau and nowhere else in the world. It has been found in caves in Greene, Stone and Barry Counties in the James River Basin. Currently, populations of Ozark cavefish are being monitored at three sites in the basin. The latest sightings of cavefish at these sites were in 2009, 2011 and 2014. Very little is known about the life cycle of Ozark Cavefish. They are known to have very low reproductive rates, and relatively long lifespans for fish, over ten years.

Mussels of many species were once common in the James River Basin and in most of Missouri's streams, as they can live in a variety of river habitats from mud to sand to gravel. But mussels are in peril nationwide. There are 65 species in Missouri, with nearly half of these listed as species of concern. Ten of these are listed as endangered at the state or federal level. Millions of mussels were formerly harvested from Missouri's streams in the early 1900s, mostly for their shells for the button-making industry. Now, buttons are made from plastic, but mussels continue to decline, probably from water quality and habitat changes. Mussels are filter-feeders and so are very good indicators of water quality and stream health. Their absence means there is some kind of problem in the stream. The Missouri Department of Conservation and U.S. Fish and Wildlife Service are currently working with Missouri State University on programs to study mussel decline and propagate them for potential return to the wild.

Two species of plants found in the James River Basin are listed as endangered by the Missouri Department of Conservation. Geocarpon is a very small plant that grows on sandstone glades. It is found in Greene County in the James River Basin, but mostly in the northwestern part of the county, outside the basin. Missouri bladderpod grows to about 8 inches high and is found on limestone glades. There is a protected population of this endangered plant at Wilsons Creek Battlefield Park. In the James River Basin, it is found only in Greene and Christian counties.

HUMAN POPULATION AND POPULATION TRENDS

As of 2015, approximately 342,000 people lived in the James River Basin. This represents a 3.3% increase over 2010, when the estimated population of the basin was 331,000. The largest portion of the population lives in the urbanized sections of the basin in Greene and Christian Counties. The three largest cities in the basin—Springfield, Nixa and Ozark—are located in this area. Springfield, the largest city in the basin, had an estimated population of 168,122 in July 2019, up about 5.3 percent from the 2010 population of 159,600. Springfield also has the highest population density, with an average of 1,950 people square mile in 2010. However, this is reduced from the 2000 estimate of 2,072 people per square mile, representing the continuing population shift from city center to single-family residential subdivisions further out. More recently, however, there has been an influx of people into downtown housing such as apartments and loft apartments, so the downtown density is increasing. In contrast to some smaller communities in the basin, the growth rate in Springfield has continued on a gentle incline since 2000, not at a steep rate.

Figure 5 shows the James River Basin population density in people per square mile in 2018. High and low-density urban land-uses predominate in the areas around Springfield, Republic, Nixa and Ozark. Headwater areas of Wilsons Creek are highly urbanized. The highest population densities are in the downtown areas of Springfield and Republic, with densities decreasing gradually outward from these urban centers. Population changes between 2010 and 2015 show that the greatest proportional increases have been in southeast Springfield, near Highlandville in

Christian County, near Galena and Crane in Stone County, and in eastern Barry County (Figure 6). These high growth areas indicate sections of the basin where land disturbance and development activities are currently concentrated and continuing at a rapid pace.

The Springfield Metropolitan Statistical Area (MSA), which includes parts of three counties in the James River Basin (Greene, Christian and Webster) and two counties outside the basin (Polk and Dallas), has an estimated 2016 population of about 460,000. The growth rate of the Springfield MSA from 2000 to 2016 was steep, 24.1 percent. The rate of growth slowed somewhat between 2010 and 2016, standing at 5.1 percent. This represents one of the fastest growing population centers in the state, and most of the MSA growth (>75 percent) has occurred within the James River Basin. The 2020 projected population for the Springfield MSA is 469,000. Projections of growth from 2000 to 2030 range from 37.2% in Greene County to 141.4% in Christian County (Missouri Office of Administration, 2013).

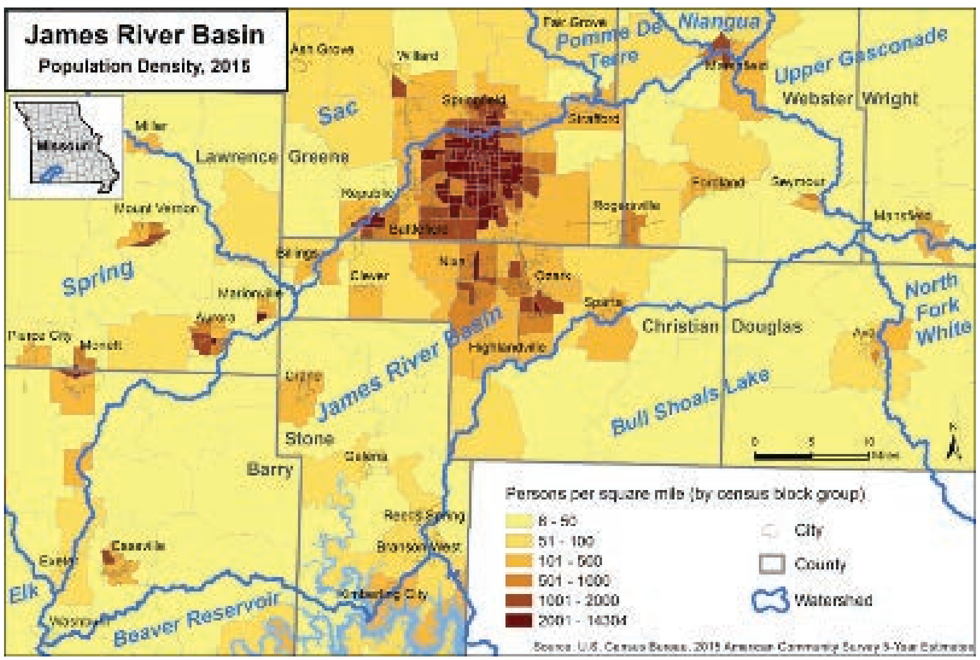
Christian County, the northwestern half of which is located within the James River Basin, has also experienced rapid population growth. The estimated population of the county on July 1, 2019 was 88,595, up 14.4% from the 2010 population of 77,400. The county population in 2005 was 66,400, in 2000 was 55,000, and in 1970 was 15,352. Between 2000 and 2010, Christian County was the fastest growing county in Missouri, and one of the fastest growing counties in the nation. One of its fastest growing cities has been Nixa, which is now the largest city in Christian County with a 2018 estimated population of 21,868, up 14.8% from 2010. The county currently has a population density of 138 people per square mile, but is becoming more and more suburban, with much of the growth outside city limits. The growth rate flattened somewhat between 2000 and 2016, especially after the market slump of 2008, but continued its upward trend.

The James River Basin includes all or parts of eight counties in Missouri. However, only a very small area of Wright County is in the basin, and there are no towns in this section. A slightly larger piece of Douglas County is in the basin, the Stewart Creek sub-watershed of the Finley Creek watershed in the extreme northwest part of the county, but there are no towns in this section. In Lawrence County, most of the Hemphill Branch sub-watershed of the Crane Creek watershed in the southeastern portion of the county is in the basin but is located to the southeast of the city of Aurora and has only a small suburban population. Over 98% of the population of the basin is in the five remaining counties of Barry, Christian, Greene, Stone and Webster.

Barry County contains primarily the Flat Creek watershed, but also western portions of the Crane Creek watershed. About half of Barry County is in the James River Basin, including Cassville, the county seat. The 2019 estimated population of Barry County is 35,789, up a mere 0.5 percent from the 2010 population of 35,600. The 2000 population was 34,050, and the 1970 population was 19,700. There are five cities located in the basin in Barry County, with all but one of them, Cassville, located on the western basin divide, with portions of these smaller cities extending into the adjacent Spring River Basin. There are no cities located in the eastern half of the county in the basin. There is some suburban growth near Cassville and close to Table Rock Lake, but most of the county is in agricultural uses. Table 9 provides the populations of the basin cities in Barry County and their

Sunset on the James River Basin

Figure 5: James River Population Density, 2015



recent growth rates. Butterfield Township is not included because no 2014 population data was available, and no 2010 data was available for Washburn. From this table, it can be seen that the Barry county cities in the basin have had small rates of growth over the last five years.

There are eight cities in Christian County located wholly or partially within the James River Basin. The city of Ozark, the county seat, is within the Finley Creek watershed. The eastern one-quarter of the city of Billings is within the Basin. The remaining five cities are almost entirely within the basin. Table 10 shows the populations of Christian County cities within the basin and their growth rates. The 2014 population for Spokane was not available. As can be seen, most cities had growth rates of 2 percent or more over the last five years, with Nixa and Ozark at 10 percent, and Clever almost 14%.

Greene County is the fourth most populous county in Missouri, with a population density of 356 people per square mile. The July 1, 2019 population was estimated at 293,086, up 6.5 percent from the 2010 population of 275,174. However, the 2019 estimated population of 293,000 is 21.9 percent higher than the 2000 population of 240,391, representing an actual growth of over 50,000 people in those nineteen years, and almost 135,000 people since 1970. This represents the single largest portion of the population growth in the James River Basin, although the rate of growth has slowed over the last five years. Although Christian County has had higher rates of growth, the actual numbers of people added are much smaller. About 90% of the city of Springfield, the southeast one-half of Republic and the southern one-half of Strafford are in the James River Basin. Table 11 provides the populations of the six cities in Greene County that are wholly or partially in the James River Basin and their growth rates. There is no data for Brookline as this community is no longer incorporated. This former village had a population of 326 in 2000. Part of the city of Rogersville is in Webster County. All of the cities had significant rates of growth over the last five years, between 3.7 and 8.5 percent, except for the city of Strafford.

Stone County is the least populated of the five counties comprising the bulk of the James River Basin. Further, the population is dwindling some-what. The 2019 estimated population of Stone County was 31,952, 0.8 percent less than the

Table 9

THE POPULATIONS OF THE BASIN CITIES IN BARRY COUNTY AND THEIR RECENT GROWTH RATES

City	2010 Population	2014 Population	Rate of Growth (%)
Cassville	3,266	3,287	0.6
Exeter	772	770	-0.3
Purdy	1,098	1,099	0.0
Washburn	?	433	?

Figure 6: James River Basin Population Change, 2010 to 2015.

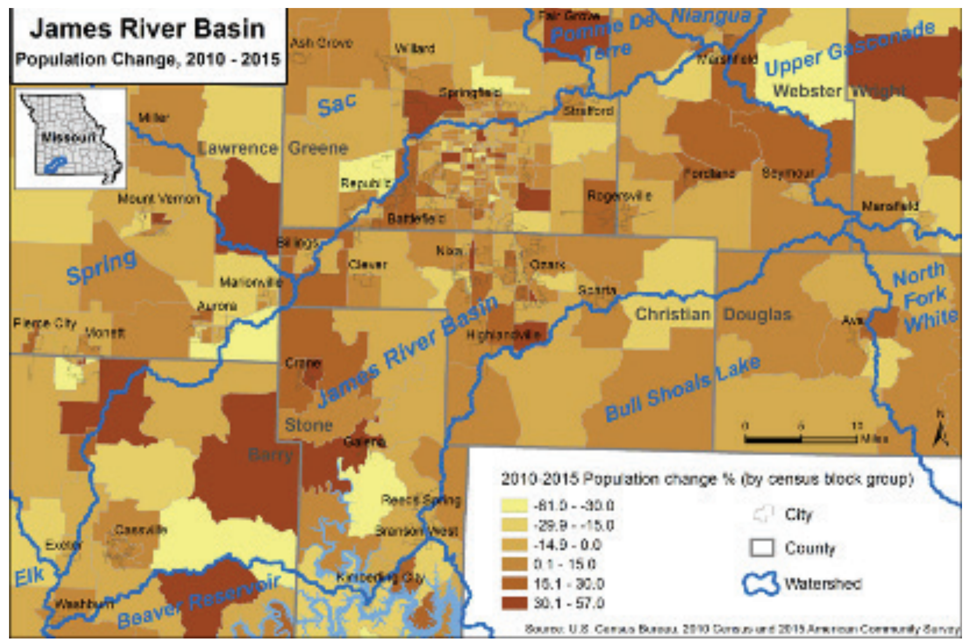


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Table 10

POPULATION GROWTH OF THE BASIN CITIES IN CHRISTIAN COUNTY

City	2010 Population	2014 Population	Rate of Growth (%)
Billings	1,035	1,073	3.7
Clever	2,139	2,434	13.8
Fremont Hills	826	856	3.6
Highlandville	911	934	2.5
Nixa	19,022	20,570	8.1
Ozark	17,820	19,120	7.3
Sparta	1,756	1,787	1.8
Spokane	177	?	?

Table 11

POPULATION GROWTH OF THE BASIN CITIES IN GREENE COUNTY

City	2010 Population	2014 Population	Rate of Growth (%)
Battlefield	5,590	5,925	6.0
Brookline	?	?	?
Republic	14,751	16,005	8.5
Rogersville	3,073	3,308	7.6
Springfield	159,498	165,378	3.7
Strafford	2,358	2,366	0.3

2010 population of 32,200. The population is also largely rural. The density in Stone County is about 62 people per square mile, about the same as Webster County. There are six cities or towns in Stone County located wholly or partially within the James River Basin. About the western one-fourth of Branson West and the northwest one-third of Kimberling City are in the basin. Table 15 provides the populations of towns in Stone County within the James River Basin and their growth rates. As can be seen, all of the cities in Stone County in the basin lost population between 2010 and 2014.

Webster County, in the upper James River and Finley Creek watersheds, is also largely rural. The population density is 61 people per square mile. But the population is growing. The estimated 2019 population was 35,592, 5.2 percent higher than the 2010 population. The county's population in 2000 was 31,260, and 15,696 in 1970. There are four cities in Webster County located wholly or partially within the James River Basin, with only about the southern 1/3 of Marshfield in the basin. Table 16 provides the populations of the four cities in the basin and their growth rates. As can be seen, only Marshfield had significant growth over the last five years, the majority of these people have not located in the James River Basin.

Four cities in the basin have populations in excess of 15,000: Springfield, Ozark, Nixa and Republic. Only about half of the city of Republic is in the James River Basin. This means that about 215,000 people in these four cities live in the basin, or 63% of the basin's estimated population. There are no cities in the basin with populations between 10,000 and 15,000, but there are twelve cities with populations between 1,000 and 10,000: Purdy, Billings, Sparta, Strafford, Marshfield, Seymour, Kimberling City, Crane, Battlefield, Rogersville, Clever and Cassville. However only about one-half of Purdy is in the basin, one-fourth of Billings, one-half of Strafford, one-third of Marshfield, and one-third of Kimberling City. This means that the population in these cities living in the basin is about 25,000. Thus, about 240,000 people, or 70% of the basin's population, live in these sixteen largest cities.

Significantly, rapid growth is also occurring outside of cities. The trend for people to move into large lot residential properties has not abated over the last few decades. Although not as large

Table 12

POPULATION GROWTH OF THE BASIN CITIES IN STONE COUNTY

City	2010 Population	2014 Population	Rate of Growth (%)
Branson West	478	452	-5.8
Crane	1,462	1,390	-5.2
Galena	440	414	-6.3
Hurley	178	171	-4.0
Kimberling City	2,410	2,340	-2.6
Reeds Spring	913	879	-3.9

Table 13

POPULATION GROWTH OF THE BASIN CITIES IN WEBSTER COUNTY

City	2010 Population	2014 Population	Rate of Growth (%)
Diggins	299	304	1.7
Fordland	800	803	0.4
Marshfield	6,633	7,138	7.6
Seymour	1,921	1,943	1.1

as the total numbers of people moving into Springfield and other large cities in the basin, this suburban influence is growing with the increasing number of people living on and managing small acreages. Population increases will likely continue, further changing land-use characteristics and hydrologic and pollutant loading dynamics. Growth of the counties and communities has greatly increased demands on the river for drinking water and wastewater assimilation, including both publicly owned treatment works as well as onsite wastewater systems.

JAMES RIVER BASIN LAND USES

The James River Basin covers approximately 1,455 square miles (931,000 acres), including portions of eight counties in southwest Missouri (Stone, Christian, Barry, Lawrence, Greene, Webster, Wright and Douglas). However, only a very small portion of the basin extends into Lawrence, Wright or Douglas counties. Land-use in the basin changes significantly from the easternmost end in Webster County to the most southwestern end in Barry County (Figure 7). Agricultural uses, primarily cattle on pastures interspersed with small patches of timber, predominate in the upper basin, in the headwater areas of the James River and Finley Creek. In the middle section of the basin, near the cities of Springfield, Ozark, Nixa, Battlefield and Republic, urban and suburban uses dominate. Further south, agricultural uses predominate again. At the most southern end of the basin, where the James River empties into Table Rock Lake, there is little agriculture on the steep, forested slopes found there.

Nearly 50% of the land in the James River Basin is in agricultural uses, with cattle raising the most prevalent type of farming use (Figure 8). Greene and Webster counties, in the upper part of the watershed, are top beef cattle producing counties in the state. Most of the livestock are on grasses, and grasslands make up about 47% of the land-use in the basin. Pastures make up much of the land cover on the flatter land in the upper and middle James River sections. About half of northern Stone County in the middle section of the James River Basin is in grasslands. Pasture lands also predominate in the flatter sections of the upper Flat River watershed, especially south of Cassville in the Flat River headwaters. Pasture lands also predominate the western panhandle of Christian County west of Nixa.

Cultivated croplands comprise less than 1% of the James River Basin. Almost all of the cropland is in either alfalfa, soybeans, corn or winter wheat. Corn, soybeans and winter wheat are farmed in relatively isolated areas in the southeast corner of the basin including areas south, west and northwest of Cassville, northwest of McDowell, west of Jenkins, and near Scholten, all in Barry County, and in Lawrence County east of Aurora. In Christian County, most of the cropland is in the western panhandle, in areas southwest of Clever and south of Republic, and in the eastern part of the county south of Rogersville. In Greene County winter wheat, corn, soybeans and alfalfa are grown north of Cody and southeast of Brookline. In Webster County, corn and soybeans are grown north of Rogersville, Diggins and Seymour in the James River valley.

Forests make up about 38% of the land-cover in the basin. The largest areas of contiguous forest are in Stone County near Table Rock Lake and in the Piney Creek and Rockhouse Creek watersheds in Barry County. Considerable forest cover (over 50%) is also found in the Gunter Creek and Little Flat Creek watersheds in Barry County. In Stone County, forest cover predominates in the Tory Creek watershed near the James River. In Christian County there are significant patches of forest near the James River and Finley Creek east of Ozark. In Greene County, extensive forest cover is found along Sawyer Creek and Davis Creek in eastern Greene County. Good forest cover is also found on upper Finley Creek in the Pedelo Creek, Squaw Creek and Stewart Creek watersheds.

Urban and suburban development now make up about 11% of the James River Basin land-use. The basin's three largest cities, Springfield, Nixa and Ozark, have a combined area of about 100 square miles, or 6.9 percent of the basin's total land area. However, much of the growth is in the metropolitan area outside of these city limits. It is estimated that there is about 9.7 square miles of urban high-density development in the basin, and about 155 square miles of medium and low density urban development (including urban open space, e.g. parks), for a developed area of about 165 square miles, or 11.3 percent of the total land area in the basin.

Figure 7: Land Use/Land Cover in the James River Basin

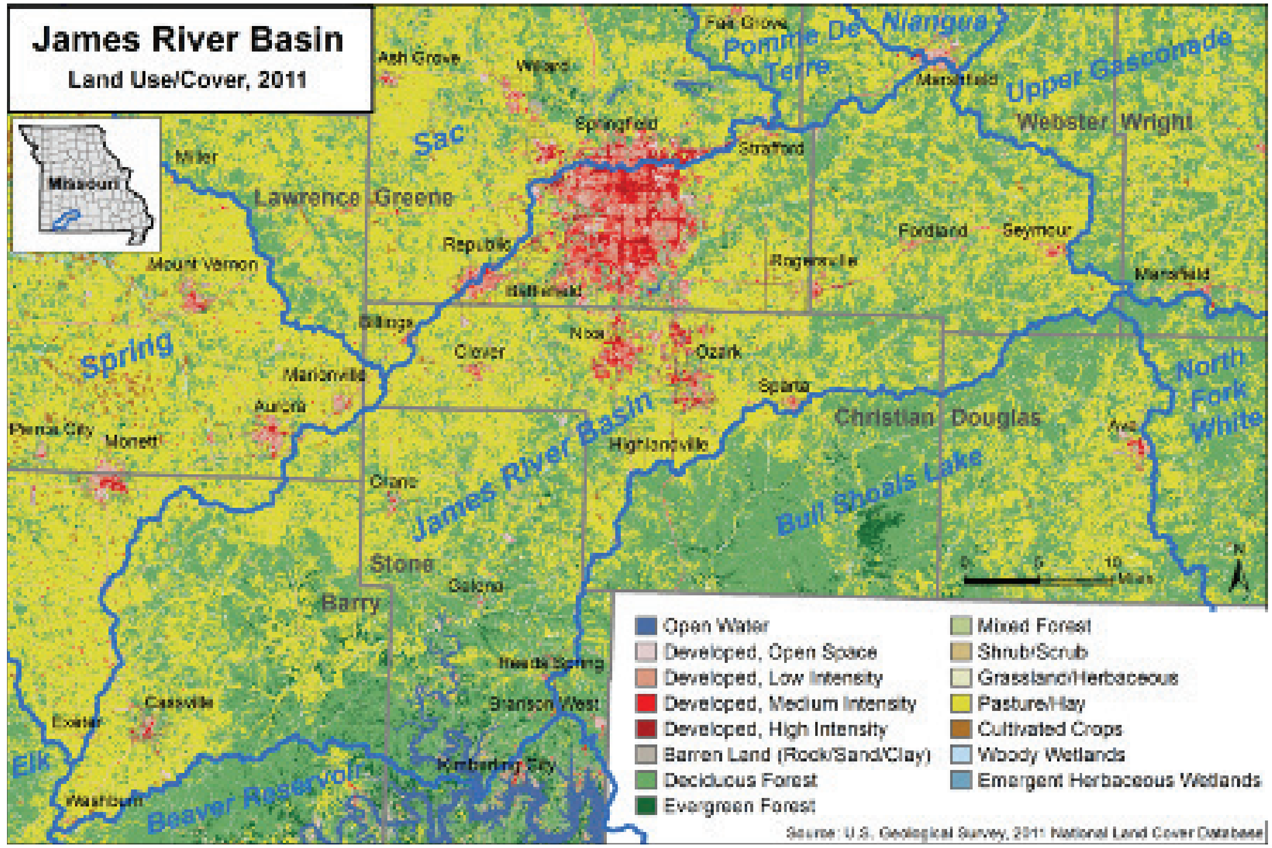

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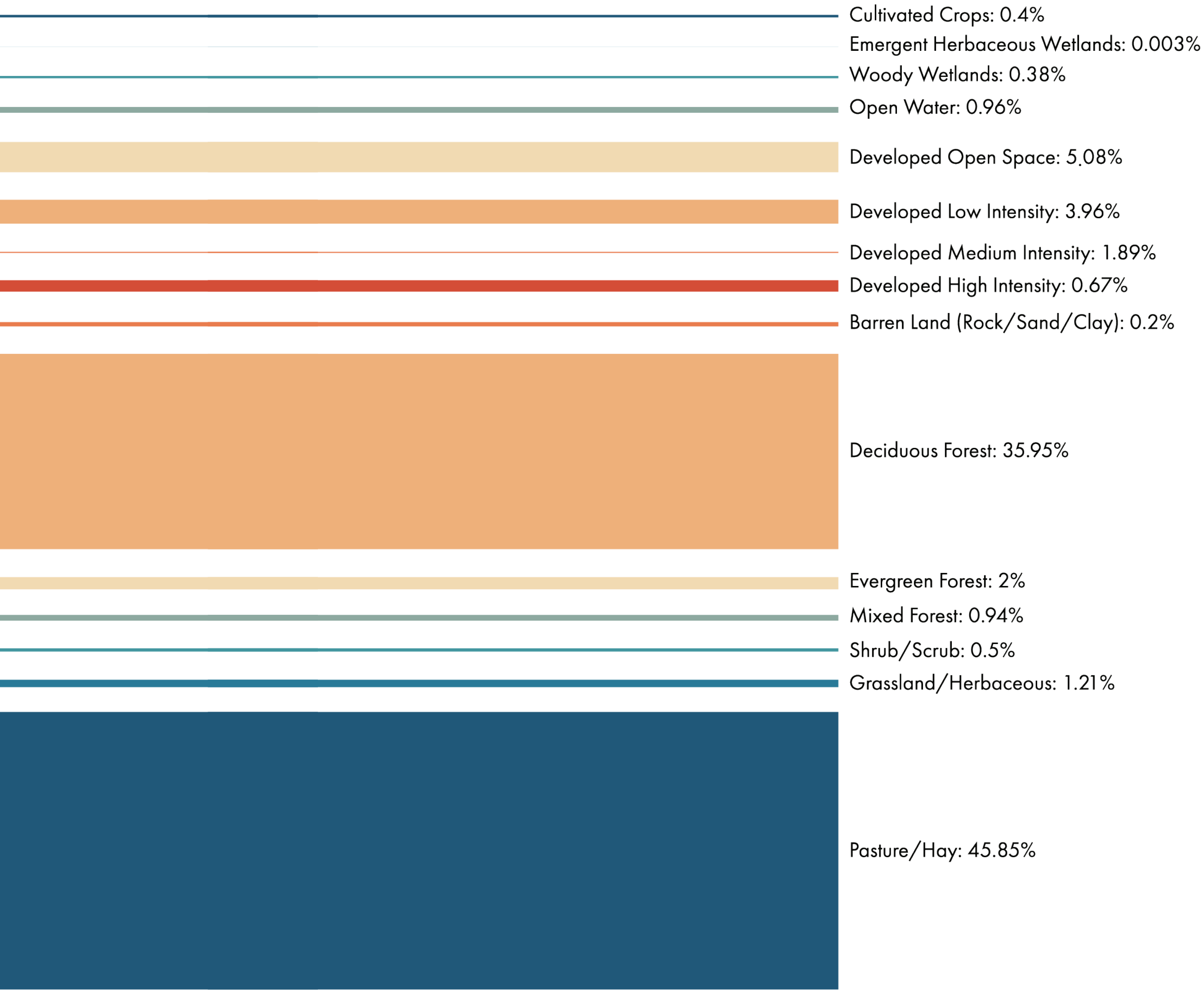
Figure 8

2011 LAND USE/LAND COVER OF THE JAMES RIVER BASIN



CHAPTER 02 »
PUBLIC PARTICIPATION

02

Public Participation

Public participation is at the heart of watershed planning. The idea is to “bring everyone to the table;” to involve the watershed “stakeholders” (anyone who lives or works in the watershed) or at least “stakeholder groups” in the planning process. For effective planning, there must be a spirit of cooperation; and a willingness to admit that we all contribute to the problems.

In spite of efforts to reach a large cross section of watershed residents, watershed planning efforts typically involve only a small segment of the watershed population—people who have some particular interest in what the plan will say or do. Most watershed planning exercises are driven by relatively small groups of people representing different “stakeholder groups” in the watershed: agriculture, businesses, tourism, local governments, etc.

The goals of different stakeholders and stakeholder groups are not always compatible. Stakeholders may be concerned with different water quality problems than those identified as most serious by the scientists.

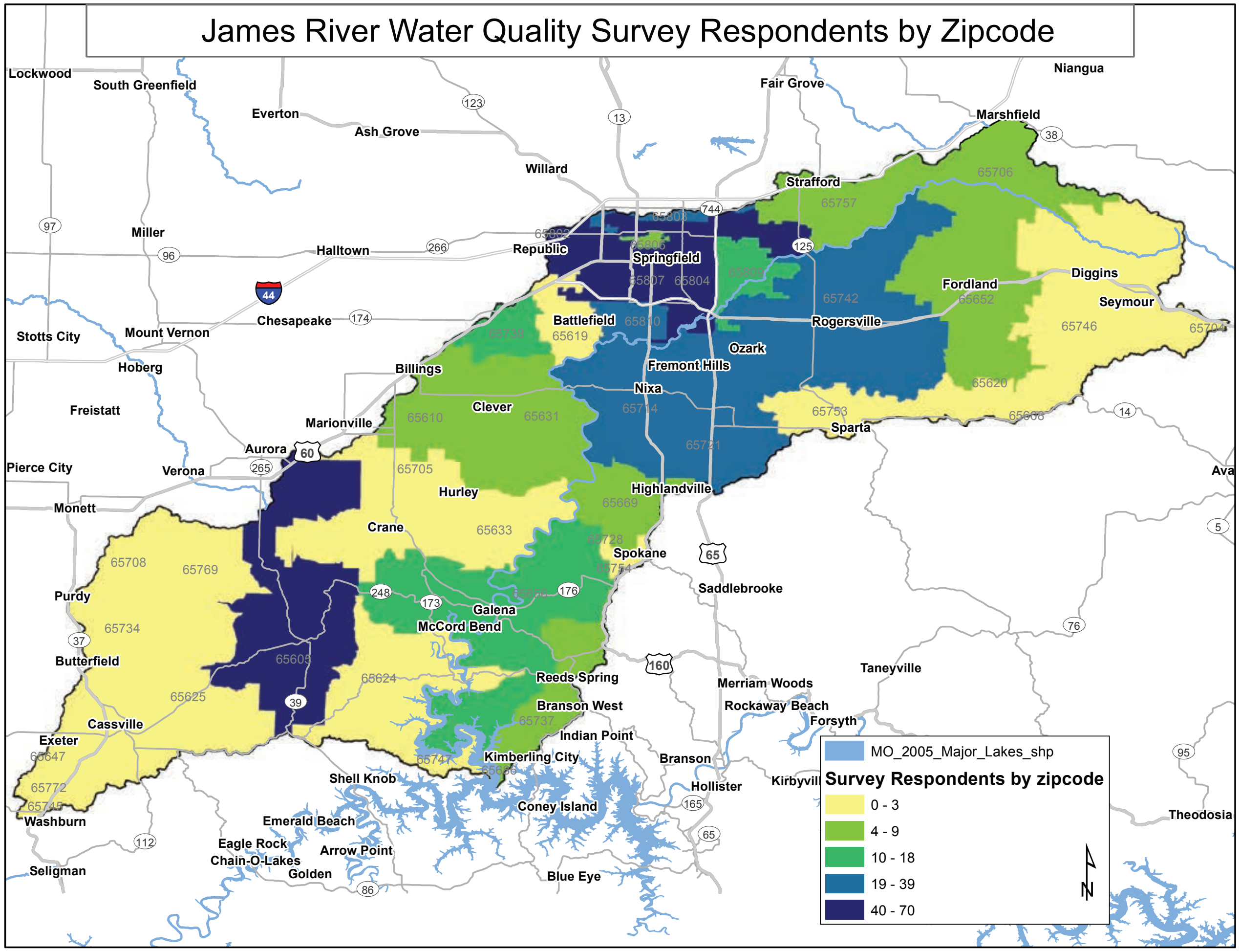
In most cases, solutions recommended in the watershed plan are voluntary. Therefore, to be successfully put into action, the plan must address a variety of concerns identified by stakeholders.

Agencies specify a very prescriptive process for developing watershed plans, including the “nine elements” that must be included in every plan. This process is very science-driven in terms of identifying and quantifying pollutants that affect water quality. The plan must describe how water quality problems will be addressed, including what types of BMPs should be used, where these practices will be placed, how much they will cost, and how long it will take to reduce pollutants to a certain level. However, the plan is also required to have public involvement. Therefore, the public must generally understand the scientific information about specific problems and solutions.

A good watershed plan has been compared to a “road map” or “blueprint” for action. But unlike a roadmap, the watershed plan is developed within a landscape that is not only part of the physical environment, but contains social, economic and emotional elements as well. While there is no perfect way to involve the public

02

Figure 9: James River Survey Respondents by Zipcode



in planning, an online survey and stakeholder interviews were used in this planning process to provide a reasonably high level and quality of stakeholder feedback.

ONLINE SURVEY

Five-hundred twenty-six people in the James River Basin completed a fifteen-question online survey. The survey was promoted and advertised via news releases, email newsletters and social media posts for two months, from late August to November 2017. Figure 9 shows how the 526 respondents were distributed by zip code in the James River Basin:

Key points derived from the survey indicate that respondents:

1. Value their local rivers and streams,
2. Think water quality in the basin is generally good, but not excellent,
3. Consider trash in the water to be a major threat to its quality, and,
4. Identified at least one BMP, with many listing multiple BMPs, which they have used to protect water quality.

Over 50% of survey respondents use or visit their local rivers, lakes and streams more than ten times a year. Also, 90% of the respondents considered access to clean rivers lakes and streams to be highly important to their enjoyment and quality of life. Four hundred forty (83%) respondents listed their personal experience as a major factor shaping their opinion of water quality. Opinions were also often affected by hearing about water quality problems and trends from friends and neighbors and from local media coverage. Fifty percent of respondents considered water quality in the James River to be good for recreation and for wildlife habitat, but only 26% considered water quality in the river to be of good enough quality for drinking purposes.

Survey participants were asked to rank from 1 (least) to 10 (most) the relative impact of water quality threats from a list provided. That list included: urban stormwater runoff, leaking septic tanks, wastewater treatment plant discharge, rural farm runoff, streambank erosion, and dumping of trash into creek, streams and sinkholes. Respondents ranked dumping of trash into creeks, streams and sinkholes as having the highest impact. However, most of the listed water quality threats were ranked between 8 and 10, indicating that respondents considered all of these threats to be significant.

The main agricultural activity in the James River watershed is raising beef cattle on pastures and tending cow/calf herds. Of the twenty-five survey participants who listed cattle ranching as one of their land uses, fifteen said rotational grazing was a BMPs that they have used. Also, eleven of the twenty-five respondents who owned cattle farms listed vegetative buffers, and ten listed fencing cattle out of streams, as BMPs that they have used. A list of all the survey questions and noted response information is included in Appendix E.

PERSONAL INTERVIEWS

Sixty-four people were interviewed during the preparation of this plan. The list of interviewees is included in the appendix. This interview group included thirteen landowners, along with agricultural and urban resource management professionals, educators, businesspeople and representatives of non-profit organizations.
In each interview, people were asked about problems and concerns related to their area of interest or knowledge. This information has been summarized on the following pages.

CITIZENS OF THE BASIN

KEVIN AND JEANNIE SKIBISKI

Kevin and Jeannie Skibiski operate the Heron's Nest Farm on Crane Creek in Stone County. This 175-acre farm, with the recently completed Walnut Bend Lodge, was formed as an LLC in 2009 by 5th generation Stone County Residents. The spring-fed waters of Crane Creek traverse the property and provide excellent habitat for naturally reproducing, wild McCloud rainbow trout. Key goals for the Skibiskis at Heron's Nest Farm are to **"maintain Crane Creek as a unique and pristine trout stream, and to improve recreational opportunities through riparian buffers and other conservation methods, while also maintaining ongoing agricultural operations."**

02

Agriculture:

Interviews were conducted with farmers, ranchers, a veterinarian and several agricultural agency representatives (AARs). Common problems/concerns identified included:

- AARs no longer have time to build personal relationships with landowners
- Landowner re-imbursement prices for practices are often not realistic
- Local AARs should have more authority and flexibility in working with landowners; every situation is different
- Land near cities is over-valued for agriculture. "Hobby" farms near urban areas compete with "real" farms for cost-share programs
- Many farms are not well run as a business; better businesses should dictate better practices, even without cost-share
- Landowners often want a problem fixed, but AARs have to make sure taxpayers get what they pay for
- Cost-share rules are complicated; paperwork is significant, can be scary for landowners
- Up-front costs for BMPs difficult for many landowners, especially farmers who may be living check to check
- Small farms are at a competitive disadvantage for cost-share dollars; larger farms are often doing more practices so get a higher ranking
- Special Area Land Treatment (SALT) projects were specifically aimed at water quality improvements; but DNR no longer has money for SALT
- There are no "bad actor" provisions for correcting or addressing farming practices that may be harming water quality.
- Some farmers (e.g., Amish) are not interested in cost-share, and don't typically ask for technical assistance from Ag agencies
- The USDA website is confusing and not user-friendly; difficult to find out what's available and get details about how the programs work
- Ag newsletters go only to landowners who the agency has worked with in the past; not to the majority of people they should really be reaching
- Agricultural "demonstration" farms have worked very well in the past for "field days" and others educational events, but these facilities are no longer in service
- Concerns were raised about feeding antibiotics to animals, and antibiotic resistant organisms in the environment
- Many poultry growers have sold off houses with small portions of their land; new owners have no room to spread litter
- Most of the poultry litter in the JRB is now exported out of the basin; growers must sell for much less than the actual fertilizer value of the litter
- Grazing cattle have direct access to streams; poultry operations are spreading much less litter than in the past; in some areas cattle may now present a bigger water quality problem than poultry
- People who rent pasture often charge per acre, while the person grazing cattle on that land is likely to overgraze in order to get the most from each acre

- More people apply for grazing system cost-share projects than there are dollars available
- Continuous hay cutting hurts grasslands; grazing improves infiltrative capacity of soils and returns nutrients to it
- Timber stand improvement is not being addressed by many landowners
- A "sensitive" area for landowners is streambank livestock exclusion

Wastewater (Wastewater Treatment Plants and Onsite Wastewater Systems):

Interviews were conducted with rural homeowners, non-profit organizations dealing with wastewater, and resource agency personnel (local health departments and Missouri Department of Natural Resources). Common problems/concerns identified included:

Onsite Wastewater Systems (Septic Tanks):

- Citizens generally very concerned about septic tanks, but little scientific evidence to back up this level of concern
- Difficult to build an onsite wastewater system in karst areas that will function properly
- Advanced systems may cost $15,000 to $30,000; difficult for many homeowners to afford
- There is no funding available to assist homeowners with replacement of failing onsite systems; state revolving funds were mentioned as a potential source of funding
- Most available state and federal funding goes to large wastewater systems; more funding need to be directed to onsite wastewater systems
- Inspections of onsite wastewater systems for home sales are not required in most counties
- Maintenance contracts for advanced systems are not required in most counties
- Many homeowners give little if any thought to maintenance of their systems
- If land was platted years ago, septic tanks may still be allowed on small, city-sized lots

CITIZENS OF THE BASIN

JASON AND ANGELA FRANTZ

"I believe that we're tied to our rivers, They're part of us. They flow through our lives like the blood in our veins. They're the lifeblood of the land."

Jason, an Ozark native, has also lived in California, Texas and Virginia, which he says has given him an even greater appreciation for Missouri and the Ozarks. He spent much of his youth in the rivers and forests of Webster County, and his parents took him on a canoe trip when he was only two months old! Jason and Angela live in eastern Greene County where they operate Wood Shop Artisans, a studio specializing in custom furniture and cabinetry. They love to get out on our beautiful Ozark streams.

Small, Privately Owned Wastewater Plants:

- Many small plants not well operated or maintained; developers don't want to spend the money to keep the plant upgraded and operating properly
- DNR still issuing permits to build and operate small treatment plants, even though many of them have problems
- DNR does not require proof of financial capacity to operate small plants, as they do for public wastewater plants
- Operators of private wastewater plants are "left on their own;" have no organized body to join for information and support
- Phosphorus removal expensive for small systems
- Small, privately-owned wastewater plants not required to have certified operators
- Unscrupulous operators of small plants have submitted false reports about plant performance

Municipal Wastewater Systems:

- Several cities have had more problems with old collection systems (especially infiltration and inflow into sewers) than with the treatment plants themselves
- Cities may apply for grant or low-interest loan funds to upgrade their systems, but if sewer rates are too low they can't qualify.
- State revolving funds can be used, but cities usually have to pass bonds to pay these loans back
- Leaders of small communities sometimes pride themselves on not having raised sewer or water rates for many years

Urban Areas, Stormwater Runoff:

Interviews were conducted with city and county managers and planners, stormwater engineers and landowners. Common problems/concerns identified:

- Stormwater rules are "unfunded mandates;" cities struggle for funding and staffing needed to comply
- Lack of trained personnel and access to training for existing personnel in stormwater management
- Communities and counties in the James River Basin vary with respect to their ability to enforce new stormwater provisions
- Many people with small acreages in suburban areas apply chemicals to their lawns, even though their "fescue" doesn't really need these chemicals
- Lack of sediment and erosion control at construction sites, or improper installation of practices, remains a problem in some areas
- City of Springfield and Greene County personnel stressed the importance of the Integrated Plan for the Environment currently under development. They suggested this plan needed to be referenced in the Watershed Plan and the goals of both plans should be mutually supportive
- Better communication and cooperation among urban and urbanizing entities, such as for stormwater and other types of water quality monitoring
- Springfield, as the largest urban area in the basin, might do more to serve as a "mentor" to other developing communities

Drinking Water:
Representatives of City Utilities of Springfield and Public Works and Planning Departments were interviewed. Common problems/concerns identified:

- Potentially high levels of Cryptosporidium (protozoan parasite) at CU's Blackman intake on the James River.
- James River and Pearson Creek are often above the whole-body contact standard for enterococci, although this standard is set up more for beach closings.
- Need for a comprehensive monitoring plan where agencies share information and develop cooperative arrangements, rather than each entity worrying only about their own monitoring needs.
- There is a need to find sustainable sources of drinking water for southwest Missouri communities, which are growing rapidly.
- Institutional investments in source water protection through preserving riparian systems, the single best "safety net" for protecting drinking water supplies

Riparian Zones/Streambank Erosion:
Representatives of the Missouri Department of Conservation (MDC), agricultural agencies and rural landowners were interviewed. Common Problems/Concerns Identified:

- Farmers want assistance for riparian restoration projects after big floods, but this is primarily the domain of the Corps of Engineers, not the USDA.
- Agencies have spent a lot of money on big projects on the lower James River, but these projects are at high risk of being blown out with recurring major floods.
- Agencies should "layer" funding opportunities, several programs added together to maximize non-landowner cost-share. Some rules work against this; for example, can't match federal dollars with federal dollars.
- MDC has had most success with landowners who are already conservation minded; but after big floods, lots of people come looking for help.
- Erosion problems along streams are complicated; some degree of erosion is natural, and resource managers have to

CITIZENS OF THE BASIN

TIM CLARKSON

"When we take care of the soil properly, we are in turn taking care of our waterways. We see less runoff into streams and rivers and have less erosion issues."

Tim Clarkson moved from north Missouri to the Ozarks when he was five, and now works with the Atkinson family, multi-generational farmers in Webster County, to run a 1,400-acre certified Organic Dairy Farm. Cattle on the farm have been fenced from ponds and streams to prevent damage to dams and banks. Tim has been working to improve animal health using natural substances, such as organic kelp, since organic farms can't use chemical pesticides. He has also taken a big interest in natural fertilizers.

CITIZENS OF THE BASIN

DIANE AND LONNIE ASHER

"It's important to keep our watershed clean to keep the ecosystem in working order. We do use the creek to water cattle, but they only have a small watering hole to get to the water."

Lonnie and Diane Asher own a farm in Barry County where they run around 100 cow/calf pairs along with about 100 goats. Lonnie's grandfather, John Asher, settled in the area, and let immigrants help on his farm during the Depression. The Asher's use rotational grazing, fertilize their land from soil test recommendations, use springs for watering systems and exclude their cattle from nearby Flat Creek either with fencing or by bluffs. One of their biggest problems has been pasture flooding and gravel deposition. They have utilized cost-share for gravel removal and for replacement fencing.

determine if erosion at a particular site is excessive.

- Erosion is often significant for individual landowners, but not that significant in the watershed as a whole.
- There are no BMP cost-share programs for urban and suburban residential landowners or developers.
- Hard to convince a landowner to do something when a problem is found by others, rather than when the landowner comes in asking for help.
- Can identify riparian areas most in need of work but can only address the issue if a landowner in that area asks for help.
- New MDC Strategic Plan suggests the agency be more proactive in priority watersheds but will probably mean the agency needs "watershed planners."
- Need to prioritize important riparian areas for easements and/or acquisition and the application of better management practices.

Education:

Several formal and non-formal educators representing organizations and agencies were interviewed, along with landowners and Chamber of Commerce representatives. Common problems/concerns identified:

- Both agricultural and urban stakeholders must understand the importance of water quality to their livelihoods and be supportive of water quality goals.
- People who have businesses around the lake should be supportive of programs to assist agricultural landowners in the basin
- Some landowners are still in more of a "dominion" mode than a "stewardship" mode. We need novel new programs for information flow to landowners.
- Make sure all kids go through hands-on watershed education programs at some point in their educations.
- Table Rock Lake is a potential water supply source for the whole region. This should strengthen support for adopting specific water quality standards for it.

- There needs to be greater collaboration among watershed groups; the need to speak with one voice.
- There needs to be more opportunities for personal involvement in watershed programs and projects.
- Several landowners suggested water quality in the basin is not as good as it was ten years ago.
- Watershed plan needs to be accessible and understandable to people in all kinds of businesses, and of interest to people from different backgrounds.
- Need to educate the "typical" summer canoeist, who may only go to the river for relaxation or to party.
- Education of the "non-experts" is often a missing piece in environmental education; from "what is a watershed?" to "why does a watershed matter?"
- Need a watershed "call to arms" campaign, in which a solitary, key concept is identified and promoted at every possible opportunity.
- Watershed plan should have a short executive summary, a "readers digest" version, for those who don't want to read the whole document.

RECOMMENDATIONS FROM PUBLIC INVOLVEMENT

Concerns raised by watershed stakeholders through online surveys and during personal interviews, and potential solutions to problems, were discussed with a technical working committee that met four times in 2017 (list of Committee members in Appendix B). From these working meetings, the committee developed a set of recommendations for inclusion in the watershed plan. These are included in Chapter5, Recommended Management Measures.

03

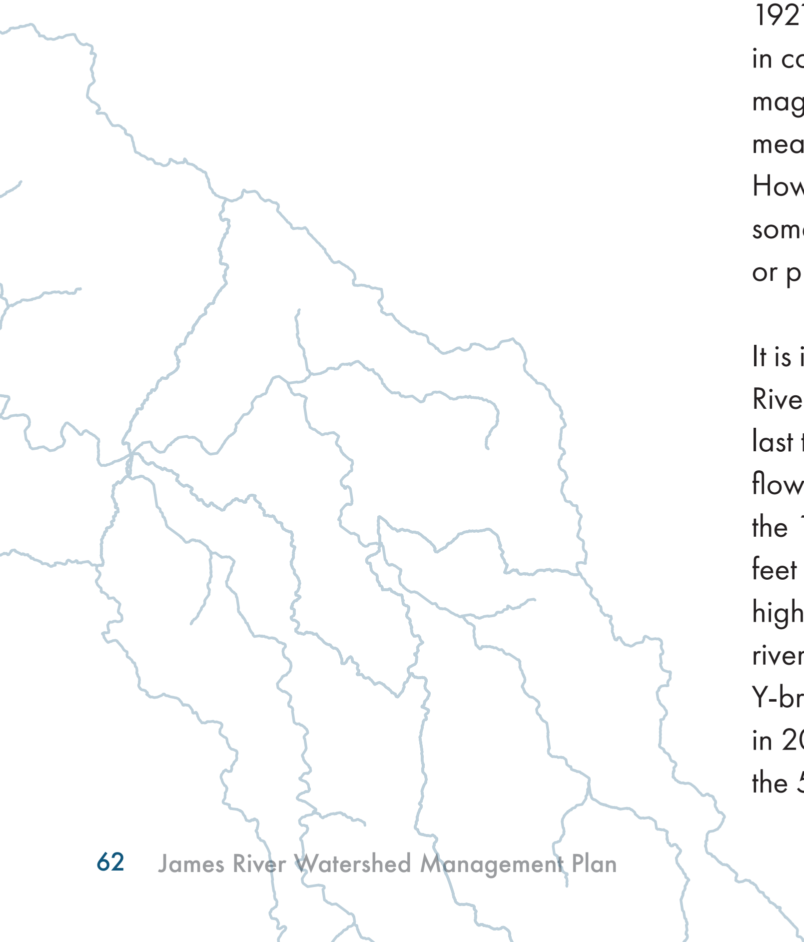
Watershed Conditions

This chapter will provide an overview of the water quality history and recent river and stream conditions found in the James River Basin. Water monitoring has been conducted in the basin at many sites and for many years. Most of the monitoring in the past involved gaging the flows of major streams. The oldest water discharge (flow) gage in the basin, at Galena on the lower James River, has been in place since 1921. Historical records of old floods are found in county and local documents, but the actual magnitudes (sizes) of floods were not accurately measured before gages were in operation. However, approximate flooding levels can sometimes be determined from old descriptions or photographs.

It is interesting to note that although the James River gage at Galena, there have been within the last ten years to 1921, four out of the five highest flows ever recorded have been since 2008. On the 1st of May 2017, a flow of 84,100 cubic feet per second (cfs) was recorded, the second highest flood on record. The water surface in the river was just a few feet below the deck on the Y-bridge. The record flow, 85,100 cfs, occurred in 2008, the 3rd highest flood was in 2015, and the 5th highest in 2011. The 4th highest flow was during the fall flood of 1993. These recent high water events may reflect the effects of climate change, which could be producing stronger storms with higher rainfall amounts.

Water quality in the basin is generally fair to good, but there have been serious problems in the past, some of which continue to the present day. The basin has seen intensive agriculture in the past, and more recently, urban and suburban development. The James River and other Ozark streams have been significantly affected by land-use practices since the times of European settlement, if not before. Some pre-European practices, such as forest burning for game propagation, may have had significant water quality effects (Jacobson and Primm, 1994). After the first major wave of settlers had become established, Ozark streams were directly affected by logging, mining and agriculture.

There is little information about water quality before the 1950s and 1960s. Most of the oldest water quality information is anecdotal and relates largely to problems with sewage or chemical contamination of streams. For example, there are historical accounts of the pollution of Jordan Creek with the city of Springfield's sewage in



the early 1900s. Jordan Creek was said to have been "reeking in poisons" and "devoid of life" below the gas plant, indicating that it may have had chemical contamination as well. Scientific methods for detecting and measuring pollution in water were not well developed until the mid to late nineteenth century.

Because of the nature of the forests in the James River Basin, logging was never done on a large scale as it was in the eastern Ozarks. However, some logging has occurred and continues to occur on public and private lands in the basin. Water quality impacts from logging have probably been fairly isolated and not particularly severe compared to effects of the widespread logging in watersheds of the eastern Ozarks. A study in northern Arkansas, where the terrain is similar to the southern parts of the James River Basin, have indicated that erosion and sedimentation from logging roads may be a significant water quality factor in local streams. Most gravel or dirt roads in the James River Basin are not primarily logging roads today, but serve farms and residential developments.

Mining no doubt impacted some streams or groundwater in the late 1800s and early 1900s, but mining was never widespread in the basin and its negative water quality effects were most likely fairly localized. However, significant lead and zinc mining did occur in the Pearson Creek watershed, southeast of Springfield, and residual contaminants remain. The mining in the basin from the early 1900s on has been quarrying for building stone, primarily limestone. This may have affected local groundwater levels or quality because of blasting and/or mine dewatering, but major impacts on the quality of surface water or springs have not been documented.

Two land-uses are primarily responsible for the water quality impacts in the James River Basin: agriculture and urban growth. The possible water quality effects of agriculture were not well documented in the late 1800s or early 1900s, but some of the related effects, such as soil erosion rates and depths of siltation in floodplains, can be measured today. The early effects of urban development were mainly sewage pollution of streams and springs, but actual water quality monitoring records that could be tied to this are very scarce before the 1960s. More recently, widespread urban and suburban development have become areas of heightened water quality concern in the basin. In areas of concentrated urbanization, development has created both water quality and water quantity problems. However, monitoring for the water quality effects of urban runoff did not begin in earnest until the 1990s.

Two major shifts in land-uses in the basin over the years seem to have had significant effects on water quality. The first was a major change in agricultural practices in the early to mid-1900s, away from extensive row-crops such as corn, oats and wheat toward pasture and livestock raising. Since plowing opens soil and exposes it to wind and water erosion, this change away from row-cropping probably benefited water quality, at least in terms of reducing the amount of sediment being eroded from farmland and finding its way to streams.

The second major change is still occurring, and that is the conversion of previously forested and farmed lands to high and medium-density residential and commercial development. The 1990s and 2000s, in particular, saw phenomenal population growth in the basin, particularly in the middle sections near Springfield and around

Table 15

IMPAIRED WATERBODIES OF THE JAMES RIVER BASIN

Waterbody	Year	Pollutant/Problem	Miles/Acres	County
Crane Creek	2012	Macroinvert. bioassessment	13.2 mi.	Stone
James River	2020	E. coli	39 mi.	Greene
Jordan Creek	2014	PAH (polycyclic aromatic hydrocarbons)	3.8 mi.	Greene
Lake Springfield	2020	Chlorophyll-A	293 acres	Greene
N. Br. Wilsons Cr.	2014	Zinc	3.8 mi.	Greene
Pearson Creek	2008	Macroinvert. bioassessment	8 mi.	Greene
Pearson Creek	2006	E. coli	8 mi.	Greene
Table Rock Lake	2002	Chlorophyll-A, nutreint enrichment	41,747 acres	Stone
Wilsons Creek	1998	Macroinvert. bioassessment	14 mi.	Greene
Wilsons Creek	2006	E. coli	14 mi.	Greene

Nixa and Ozark in northern Christian County. Christian County during these decades had the highest rate of growth of any county in Missouri. This urban and suburban development has had major impacts, especially on headwater streams in the basin such as upper Wilsons Creek in the Springfield metropolitan area.

Table 15 provides a list of waterbodies in the James River Basin which the Missouri Department of Natural Resources has classified as "impaired." This is the list currently (April 2020) under consideration by the Missouri Clean Water Commission. All of the impaired waterbodies are located within or primarily within two counties, Greene and Stone. Jordan Creek, Lake Springfield, Pearson Creek and Wilsons Creek are in the Springfield metropolitan area.

WATER QUALITY HISTORY

Agriculture

Agricultural practices, along with mining, probably have the longest history of water quality impairment of any land-use types in the Ozarks. Jacobson and Primm (1994) suggested that the peak of Ozark stream channel destabilization occurred in the period after 1920, with one of the most destructive practices being open range livestock grazing. Clearing trees for pasture in riparian areas, where shade and water were readily available, followed by continuous grazing, destroyed much of the vegetation in channels and on banks. While on open range, the numbers of livestock along streams increased markedly. In fact, densities of cattle near streams was probably larger then than it is with today's grazing practices and pasture layouts. Cattle spending much of their time in riparian zones browsed heavily on immature vegetation, leading to decreased vegetative cover and increased disturbance and erosion of the alluvial (stream deposited) soils during high water events. Hogs foraged for mast, primarily acorns, in upland areas, but also rooted and wallowed in springs, seeps and creeks, creating serious localized erosion of alluvial sediment.

Soils in upland areas of the Ozarks were generally not conducive to sustained yields of crops. Without consistent fertilization (with manure in the early days), these soils soon became depleted of nutrients and crop production dwindled. Also, there was a tendency to run crop rows up and down hillsides, rather than on the contours, which greatly accelerated soil erosion. Respondents to Primm's survey recalled that plowing up and down hills was an accepted practice in the 1930s (Jacobson and Primm, 1994). Also, most respondents recalled substantial erosion occurred during the 1920s through 1950s, and often recalled seeing large gullies in fields.

In a study sponsored by Missouri State University, Owen et al. (2011) concluded that about one-half to one meter (20 to 40 inches) of overbank sedimentation occurred on the James River floodplain after settlement, with the largest rate of deposition corresponding to the peak of corn production in the county in the late 1800s to early 1900s. Upland erosion, stream gravel movement, downstream sedimentation and channel instability all resulted from intensive and/or poor agricultural land-use practices from those times (Jacobson and Primm, 1994)

The peak time of agricultural land development in southwest Missouri, including the James River Basin, was the period from 1890 to 1900 (Rafferty and Holmes, 1982). Greene County was the second highest corn producing county in the Ozarks by 1909, with over 2,000,000 bushels harvested (Sauer, 1920). Not long after this period, there was a rather rapid transition from row crop agriculture to pasturing. As mechanized agriculture advanced statewide, Ozark counties, with their relatively poor soils, lower crop yields, smaller areas of contiguous cultivable land and poorly developed transportation networks could not compete successfully with more fertile regions elsewhere (Sauer, 1920). The largest proportion of agricultural production in the Ozarks today is animal raising, with cattle on pastures the most common type.

In addition to sediment and nutrients, elevated levels of bacteria in Ozark streams have been linked to agriculture. In the early 1980s, water quality in Sayers Creek (formerly, Sawyer Creek) in Greene County was surveyed by the Springfield-Greene County Health Department. High levels of fecal coliform (bacteria living in the gut of warm-blooded animals), above the standards for whole-body contact, were found in stream and springs in this mostly agricultural watershed (Watershed Committee of the Ozarks, 1997). In the USGS National Water Quality Assessment of stream water quality on the Springfield Plateau (where the James River is located), fecal coliform densities had a strong positive correlation with the percent of agricultural land in the watershed (Davis and Bell, 1998).

Agricultural trends in the James River Basin have, to some extent, followed national trends. A 1997 nationwide study of animal agriculture indicated a strong trend for small to medium-sized livestock operations to be replaced at a steady rate by larger operations (JRBP, 2004). The number of livestock in the U.S. being raised in confinement increased significantly in the 1980s and 1990s, including dairy cattle, poultry and swine. In the James River Basin, this trend was followed with respect to poultry, but not for swine and dairy cattle. Poultry operations began to increase significantly in the James River during this period, particularly in the southern portion, due to the proximity of poultry processing facilities and nearby crops for animal food production. In contrast, the number of dairy operations in the James River Basin declined after the mid-1990s.

Wastewater Treatment Facilities

A few of the larger cities in the James River Basin had installed wastewater treatment plants before 1950. But most of the treatment plants of smaller cities were not built until the second half of the century. Many of the basin's smallest cities did not have treatment plants until the 1980s, and before that time used onsite wastewater systems (septic tanks) or lagoons. Federal funds were often used for construction of municipal treatment

(Top) Remains of one of the City of Springfield's Two "Imhoff" Sewage Treatment Plants
(Bottom) Wilson's Creek 1977

plants after the 1980s. In 1956, the U. S. government, through the Federal Water Pollution Control Act, began making grants to cities for the construction of wastewater plants and in 1957, the Missouri Water Pollution Board enacted a state water pollution law. Most of the attention was at first directed at providing primary treatment (settling and sludge removal) for Missouri's largest sewage systems.

Springfield was the first city in the James River Basin to have a large urban population and was thus the first city to be served by sewers. The city began installing sewers along Jordan Creek in the early 1890s, but at first there was no treatment plant. Raw, untreated sewage was simply discharged into Wilsons Creek downstream of the city center. The city constructed its first sewage treatment plant in 1912, a German-designed "Imhoff Cone" treatment plant, commonly referred to by local citizens as a "septic tank" (Watershed Committee of the Ozark, 2008). This treatment plant discharged into the upper end of Wilsons Creek.

With the advent of regulations on wastewater discharges in the second half of the twentieth century, Wilsons Creek was designated by the state as the receiving stream for the city of Springfield's sewage, meaning that the creek was intended to dilute the city's treated wastewater. Protection of water quality in the James River downstream of its confluence with Wilsons Creek was the primary consideration at that time (Harvey and Skelton, 1969).

Springfield's first "modern" plant was built further downstream on Wilsons Creek (current site) in 1959. Springfield upgraded and expanded its wastewater treatment capacity several times over the years, but overloaded facilities, inadequate funding for timely expansions and stormwater by-passes (too much water seeping into sewers for the treatment plant to handle, so some of the diluted sewage by-passed the treatment plant and went directly into the creek) were continuing problems (Harvey and Skelton, 1968). Major fish kills in Wilsons Creek and the James River were reported in 1954, 1960, and 1966, all at times of low flows (less than 25 cubic feet per second) in the James River.

In October 1977, a larger and more advanced treatment plant was placed into operation at the southwest location on Wilsons Creek. Biological oxygen demand (BOD-a measure of how much oxygen organisms use up in breaking down wastes) exceedances in Wilsons Creek were for the most part corrected with this upgrading. Dissolved oxygen levels in the James River downstream of its confluence with Wilsons Creek increased significantly after the plant upgrade, but so did levels of total nitrogen and total phosphorus (Berkas, 1982).

In spite of the upgrade, some problems persisted. State water quality reports from 1975 to 1994 noted impairments in the James River in 1975, 1978, 1980 and 1984 due to low dissolved oxygen. Problems in Wilsons Creek were noted in 1982, 1986, 1988 and 1994 due to low dissolved oxygen or high BOD (Water Resources of Greene County, 1997). In 1991, Pulley et al. (1998) detected toxicity in Wilsons Creek downstream of the Springfield Southwest Wastewater Treatment Plant (SWTP), but this could have resulted from the effects of both treated wastewater and urban runoff. In 1992, a health advisory for high bacteria levels in Wilsons Creek and the James River was issued after a treatment plant malfunction at the SWTP. In August 2000, a break in the trunk sewer near the SWTP released an estimated 5 million gallons of raw sewage into Wilsons Creek.

By the 1960s, a few of the other cities in the basin had installed wastewater treatment plants. The city of Ozark constructed a trickling filter plant with an Imhoff Tank in about 1951. This plant was replaced by an activated sludge plant in 1983, but only about one-fourth of the town was initially served, with most of the homes still on septic tanks. Seymour had an Imhoff-type plant built in 1952, but upgraded to an oxidation ditch in 1972. Nixa built its first modern plant in 1969, an oxidation ditch.

Most of the smaller communities in the James River Basin did not construct secondary sewage treatment plants until the 1980s or even later (Perkins, 2013). Galena built its first modern plant in 1987, but the plant has been flooded by the nearby James River several times. Fremont Hills had a small plant built in 1988, which was expanded in 1992. Sparta's first plant was built in 1988, Fordland's in 1984, and Branson West's in 1998. Personnel at the regional office of Missouri DNR state that several of the plants in the James River Basin have had treatment malfunctions over the years, often due to operator error (Hess, 2017). All of the plants in the James River basin have been upgraded over the last three decades, and all of them now have nutrient removal capabilities.

In addition to municipal or publicly-owned treatment works (POTWs), there are many non-public wastewater facilities in the James River Basin, especially in the lower basin near Table Rock Lake. For the most part, these serve small developments such as subdivisions, trailer parks or commercial facilities. Around the lake, there are many small "package" treatment plants, and more are being installed. These small plants are often owned by developers or homeowners associations, who may be reluctant to spend the money necessary for routine maintenance or timely upgrades. In contrast to publicly-owned treatment plants, no state or federal funding assistance is available for these privately owned plants. In spite of the problems often created by small plants, the Missouri DNR continues to issue operating permits for them, even though financial assurance for proper upkeep is not required.

In the Springfield-Greene County area, there has been a concerted effort to phase out small plants because of their long history of treatment problems and the inability or unwillingness of owners to repair or replace failing systems. Several of these smaller systems have been removed, with the sewage sent to nearby, publicly-owned plants. In 1980, there were 23 privately owned wastewater facilities in Greene County alone. Many of them used aerobic lagoons or small aeration plants for treatment, and many of them periodically failed to meet effluent limitations. Although small, these plants were thought to have collectively caused significant degradation of the area's surface water and groundwater, including Pearson Creek and Galloway Creek. (Wastewater Facilities Report, Greene County, 1984).

In the 1990s, excessive nutrients, primarily from treated wastewater, became the focus of concern in the James River and its receiving waterbody, Table Rock Lake. The National Water Quality Assessment (NAWQA) program summarized results from over 600 samples taken at two sites on the James River downstream of Springfield. From 1964 to 1987, both sites showed strong upward trends in both total phosphorus (TP) and total nitrogen (TN). Borchelt (2007), surveying sites in the upper White River Basin, including several in the James River Basin, found a strong correlation between nutrient concentrations and wastewater discharges.

Onsite Wastewater Systems (Septic Tanks)

Resource professionals have long known that onsite wastewater systems perform poorly in the thin, rocky, often steeply sloped soils commonly found in the Ozarks. These poor soils can allow partially treated effluent from septic systems to flow practically untreated into the shallow groundwater system feeding springs and shallow wells. This point was brought home vividly in 1973 when fluorescein dye was introduced into urinals at Sequiota School in southeast Springfield. The dye showed up within a few days in Sequiota Spring, in the valley below and about 2,400 feet from the school.

Since that time, several studies and research projects have attempted to quantify the pollutant threat posed by onsite wastewater systems. A study by Aley and Thomson (1984) of 75 springs in Greene County found that almost half of the springs contained measurable amounts of optical brighteners (fabric dyes in detergents that enter septic tanks with washing machine water), while 18% were moderately or strongly positive for the dyes. From this and from estimations of each spring's recharge area size (the recharge area is the area of land where the spring gets its water), the authors concluded that 60% of the septic systems in Greene County contribute measurable amounts of pollution to groundwater. Further, the authors suggested that the Elsey formation, at the surface in much of northeastern Greene County, was more permeable because of its abundance of chert rock fragments and thus more prone to have onsite systems leaking poorly treated effluent into groundwater.

The Missouri Department of Health adopted a rule in 1996 establishing minimum standards for the installation of onsite wastewater systems. These standards cover new systems and major changes to existing systems. When the permitting authority is based on local ordinances, as it is in the counties of the James River Basin, local health departments or building departments issue the construction permits for onsite systems. These local regulations can be and often are more restrictive than the state standard. No longer is a simple "perc test" used for evaluating the suitability of soils for an onsite system. Rather, a more extensive soil pit analysis is required. However, there are large numbers of onsite systems that were installed prior to the adoption of these standards, and many of these are most likely failing, leaching poorly treated sewage into the groundwater system.

Stormwater Runoff

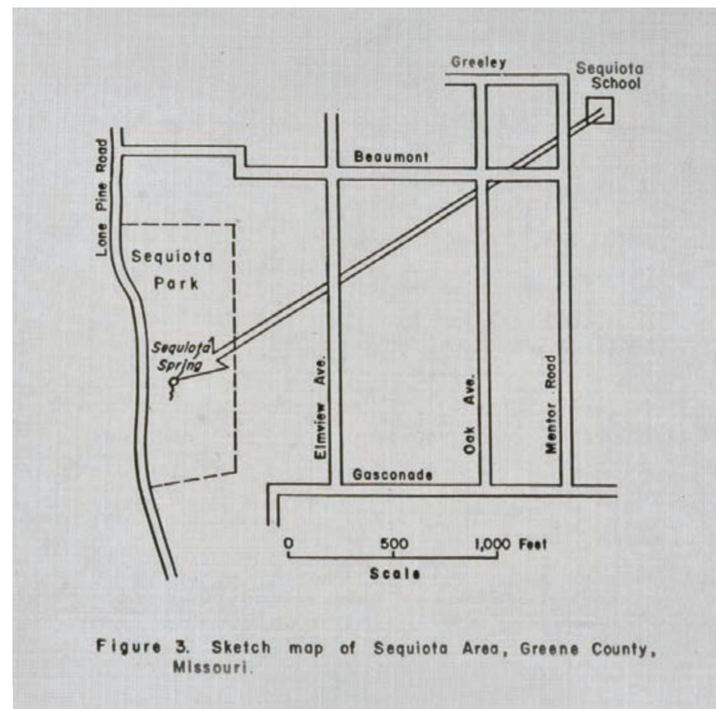
Problems created by polluted runoff have been recognized for a long time, but efforts to address this type of pollution in a systematic way are fairly recent. Springfield, the first city in the basin, was also one of the first to suffer large financial losses from locating buildings and businesses too near a creek. Disastrous floods causing extensive property damage were recorded in Springfield from the 1840s through 1880s. Efforts to control the flooding usually involved widening bridge openings and straightening and armoring channels in an attempt to convey the storm water out of town as soon as possible.

But the quality of the runoff, not just its quantity, eventually became an issue. In 1883, Springfield's engineer called Jordan Creek a nuisance and a "death-breeding cesspool." He suggested enclosing the entire creek in a box so that it could serve as an "authentic sewer." By 1904, because of Jordan Creek's degraded condition, an ordinance had been passed making it unlawful to dump "dirt, trash, debris, refuse or offal" into the creek. In 1914, a fish kill was reported in twelve miles of the creek below the Springfield Gas and Electric Plant from "carbolic acid, coal tar and other waste."

By the late 1930s, much of Jordan Creek in downtown Springfield had been encased in concrete "tunnels", with its water quality impairments and deplorable condition at least partially "out of sight and out of mind." Some local citizens attempted to clean up creek-side dumps and blighted areas as part of city beautification programs, and some laws were passed to alleviate nuisance conditions, but until the late twentieth century there was no systematic, organized effort to improve the quality of stormwater runoff.

In the 1970s, when effluent from Springfield's poorly performing Southwest Wastewater Treatment Plant polluted Wilsons Creek, urban runoff was noted as a significant factor (Berkas, 1982). Runoff was observed to lower dissolved oxygen levels in Wilsons Creek and the James River, but unlike that of the wastewater treatment facility, this effect was of relatively short duration (Berkas, 1980). In 1973, a study was made of heavy metals, possibly from urban runoff, in streams below Springfield (Watershed Committee of the Ozarks, 1997). In 1990 the city of Springfield funded a stormwater study on Fassnight Creek, identifying potential problems with nutrients, BOD and heavy metals.

(Top) Example of Trickling Filter Bed
(Bottom) Dye Trace from School Restroom to Sequiota Spring



Of course, these kinds of problems were not unique to Springfield or the James River Basin. By the 1980s, urban runoff had become recognized as a major water quality problem for almost all large urban areas. In 1972, the U.S. Congress passed the Clean Water Act, which established the National Pollutant Discharge Elimination Program (NPDES). At first, this program dealt primarily with point sources, such as municipal wastewater treatment plants and industries with direct discharges to rivers and streams. But research sponsored by the USEPA between 1979 and 1983 as part of the National Urban Runoff Program (NURP) showed that urban stormwater was also adding large volumes of pollution to the nation's waterways. In Missouri, a NURP study in Kansas City showed that the Blue River received tons of lead every year from urban runoff.

The results of the NURP study were used to justify amendments to the Clean Water Act in 1987 that required urban areas to obtain NPDES discharge permits for urban runoff. By 1990, a rule was published in Missouri that required large cities to obtain stormwater permits and develop detailed stormwater management programs. Phase I communities, with populations exceeding 100,000, were the first to be regulated. Springfield, the only Phase I community in the James River Basin, was the first city in the state to get a stormwater permit, which it received in July 2002.

Phase II communities have populations between 1,000 and 100,000 and were required to get a general permit, which has fewer and less specific provisions. There are seven Phase II communities located all or partially within the James River Basin. Most of the urbanized portions of Greene and Christian County, two Phase II "communities," lie within the basin. Nixa, Ozark and Battlefield are mostly within the basin, and Republic and Strafford are partially within the basin. All of these Phase II communities were required to begin the permitting process in 2003 and have stormwater management programs in place by 2008.

SPILLS, LEAKS, INDUSTRIAL CONTAMINATION

The first report of industrial contamination in the James River Basin may have been in the 1870s, when downstream landowners complained about colored dyes from the Springfield woolen mill tainting the water of Jordan Creek. By 1883, Springfield's city engineer reported that mills and factories were seriously polluting the creek. After passing by the gas factory, Jordan Creek's current flowed away "reeking in poisons." (Jordan Creek, WCO). A 1909 newspaper article lamented the fact that beyond the city limits, the "poisoned waters" of Jordan Creek were nearly "devoid of life."

Building a sewage system in Springfield helped to clean up Jordan Creek and Wilsons Creek, but pollution from factories and industries would not be controlled adequately until Clean Water Act provisions called for waste treatment and disposal for industrial sources. In spite of more stringent regulations, spills and leaks of hazardous or toxic materials occurred at regular intervals in the James River Basin over the years.

In the twenty years between 1973 and 1993, 19 spill incidents or pollution complaints were worked on Jordan Creek alone. Seven separate spills into Jordan Creek between 1984 and 1997 caused fish kills. Most of the kills on Jordan Creek occurred near Grant Street, where a large stormwater outfall received drainage from about 30 industrial facilities. A fish kill in the James River in 1984 was blamed on an overflow from the City Utilities Southwest Power Plant ash pond. Jones Spring branch, on the east side of

Springfield, suffered a fish kill in 1980, thought to be related to a spill at an industrial facility along U.S. 65 in eastern Springfield.

In 1989, a pond in the Burlington-Northern Railroad yard overflowed, spilling oil into upper Wilsons Creek. Runoff from stockyards on Kansas Street also polluted upper Wilsons Creek. Turner Creek, a James River tributary east of Springfield, was contaminated when a dairy lagoon overflowed. Sewer lift stations in Springfield overflowed and polluted Galloway Creek, and in 1991 an overflowing lift station in Republic caused a fish kill in Schuyler Creek. A pipeline carrying fertilizer ruptured into Davis Creek, east of Springfield. Railroad oil spills contaminated the James River and Turner Creek, and another railroad accident spilled creosote into Jones Branch. A spring on Pearson Creek and at least two wells were contaminated when solids were allowed to pool in a sinkhole area from an agricultural land application site (Watershed Committee of the Ozarks, 1997).

CURRENT WATER QUALITY CONDITIONS

Because water quality monitoring has been conducted in the James River Basin and Wilsons Creek at many sites and for many years (at some sites as long as fifty years), an abundance of data exists to shed light on where water quality problems have occurred in the past, or may still be occurring. A data gap analysis for the James River Basin completed in 2007 summarized this data and its relevance to the impairments suggested by Missouri DNR and other entities. Although the gap analysis was completed in 2007, it remains the most recent attempt to collect and summarize data from several sources related to nutrients and bacteria in the James River Basin. 42 sites with data considered of suitable quality were used in the data gap analysis, including 12 sites on the James River, 7 sites on Finley Creek, 8 sites on Wilsons Creek, 5 sites on Flat Creek, one site on Crane Creek, 6 sites on smaller tributaries and 2 springs. The gap analysis observed that there was a concentration of data collection at USGS gaging sites, and that areas of the watershed outside of these established, long term monitoring sites were largely not monitored, so water quality conditions there are not as well known.

AGRICULTURE

The major shift from row cropping to pasturing in the early 1900s, and especially after the 1940s, probably resulted in improvements to water quality in the James River, especially with respect to sediment. However, many types of farming are practiced in the basin, and the impacts can vary widely. In several parts of the basin, localized impacts occur from livestock and their wastes placed in close proximity to streams and springs.

One change in agricultural production over the last few decades has been the gradual disappearance of many dairies in the basin (Hess, 2017). In the 1990s, there were many more dairies operating in the basin than there are today. Webster and Greene County had scores of dairies, while Christian County had somewhat fewer. Some have been phased out for economic reasons, due to the increasing expense of operations and/or the cost of compliance with regulations. Other dairies have closed due to changes in lifestyles and career paths for younger family members. Dairying is hard work, and children of dairy farmers often did not want to continue the business.

The price of land also affects the number of dairies. Land values have gone up, especially in Greene and Christian Counties, so dairy owners could sell their land at a profit for development or other uses. As a result, there are now only a handful of dairies in operation in the upper basin. And several of the dairies remaining have converted to smaller operations to serve niche markets, such as selling whole milk for farmers' markets.

In the early 1990s, most of the animal waste complaints received by the regional DNR office related to dairy operations. Many of these involved holding pens or animals concentrated near creeks, with rain washing animal waste into waterways. When pollutants were found to be getting into water, DNR required that a waste management plan be developed. Some dairies fixed their problems (for example using EQIP money from USDA), but others chose to get out of the business. The closing of some dairies probably had beneficial effects on the quality of nearby streams. However, there is no monitoring data to back this up. Seldom if ever were streams sampled below these operations before, during or after investigations and/or intervention by DNR (Hess, 2017).

By the late 1990s, most of the animal waste complaints received by the regional DNR office were related to poultry operations, especially in the Flat Creek part of the basin. A 2004 report on poultry production in southwest Missouri focused on the number of birds (chickens and turkeys) in southwest Missouri watersheds, including the James River Basin, and the amount of poultry litter and waste being produced (JRBP, 2004). In southwest Missouri, as in much of the U.S., the numbers of birds being raised in confinement increased significantly in the 1990s, creating localized problems with the disposal of wastes or their utilization as fertilizer. In some areas of southwest Missouri, there were more nutrients being produced in wastes than the local land and soil had the capacity to assimilate.

In 1997, the James River basin was estimated to have 935,000 turkeys and 39,370,000 chickens, producing a total of 48,000 tons of manure per year (JRBP, 2004). The average-sized facility contained 20,000 birds, with approximately 100-120 tons of litter created per 100,000 chickens. While the numbers of birds in the southwest section of the James River Basin (particularly the Flat Creek and Lower James River HUC-10 watersheds) was relatively high, it was not as high as the numbers in the Spring River and Elk River Basins to the west and southwest.

The 2004 report also focused on the percentage of land in each of the HUC-12 sub-watersheds that was suitable for the application of animal wastes. Areas considered suitable for land application were relatively flat (low slope), non-forested, and were parcels greater than 3 acres. Using these criteria, the percentages of land in each of the six HUC-10 watershed in the James River Basin considered suitable for the land application of poultry wastes were calculated (Table 17). There is a wide variation in the amount of land suitable for land application of wastes in the HUC-10 watersheds of the basin. Because of the high slopes and high degree of forest cover, the area near Table Rock Lake has very little suitable land. Similarly, several of the HUC-12 sub-watersheds in the lower James River have high slopes and forest cover. The rest of the HUC-10 watersheds in the basin have an average of 25-30% of the land that would be considered suitable for land application of poultry wastes were determined.

The situation with respect to the application of poultry litter in southwest Missouri has changed since the late 1990s. Prior to this time, growers had no outlet for the litter, so most of it was spread on area fields for its fertilizer value. However, there was more litter than could be accommodated on local fields, so growers were in large measure simply trying to "get rid of it." As the price of chemical fertilizers rose with rising oil prices, however, the nutrient value of litter became more widely recognized. Today, many buyers outside the James River Basin buy this litter from growers and haul it considerable distances for fertilizer. Much of the littler from Barry County growers goes to farm fields in western Missouri where it is used as fertilizer for corn or soybeans. Further, field-level research has shown that the littler contains other attributes for improving soil health, such as microbial content, which are mostly absent from chemical fertilizers. Thus, there is now a net export of litter out of the James River Basin and the material is providing benefits to growers in other counties and land application of poultry wastes.

There is a significant Amish population in the headwaters portion of the James River Basin. Most of these farms are in Webster County, in the headwaters of the Finley River or James River. Amish tend to run small animal feeding operations, below the size required to be permitted by DNR. There is also a tendency to concentrate animals in small, overgrazed enclosures, and often near springs and spring

Table 16

ESTIMATED NUMBER OF CATTLE IN THE JAMES RIVER BASIN IN 2016

County	Beef Cattle	Dairy Cattle
Greene	61,000	1,900
Christian	37,500	800
Webster	81,000	5,400
Stone	27,500	1,100
Barry	84,000	2,400

Table 17

SUITABILITY OF WATERSHEDS FOR LAND APPLICATION OF POULTRY WASTE

HUC-10 watersheds in James River Basin	Range of suitability in HUC-12 sub-watersheds (%)	Average suitability of all HUC-12 sub-watersheds
Finley River	24-36	31
Flat Creek	12-48	28
Lower James River	2-49	29
Upper James River	24-28	30
Middle James River	12-41	24
James River/Table Rock Lake	0	0

branches where there is reliable water and shade (Hess, 2017). Springs and spring branches are perennially wet and muddy, and bacteria and nutrients from animal wastes deposited in these areas are quickly mobilized by even small rain events, with a rapid flushing of wastes directly into streams.

The Amish usually do not participate in traditional USDA cost-share programs and have not often adopted new practices. Although most of the animal waste problem areas are small and localized, the Amish own many farms in a contiguous area of the watershed (and are gradually increasing holdings), so the cumulative effects of many small polluting sites could be significant. There has been little focused monitoring done to determine if this is in fact the case. Alternative watering systems, for example pumping from a spring or creek to a stock tank located outside the riparian area, might alleviate some of these problems (Hess, 2017).

Over most of the basin, better agricultural practices are more widespread than they were twenty years ago, particularly for cow-calf operations, and this is probably having a positive effect on water quality (Hess, 2017). There is not as much evidence of overgrazing as in years past, and there are more managed grazing systems in use. However, many of these grazing systems use whole rather than sub-divided pastures, with cattle rotating between different large pastures rather than dividing a large pasture into many smaller paddocks, as with more intensive grazing methods.

To some extent, the increasing number of better practices reflect a new generation of farmers who are often better educated than their parents or grandparents, and who often see the benefits (both economic and environmental) of using these better practices. However, some resource professionals have stressed the need to monitor the performance of better practices over longer time frames (Hess, 2017). If cost-share funding is involved, the farmer typically signs a contract to keep the practices in operation and maintained over a fairly long period (e.g., 10 to 20 years). Many practices have been put in place during special projects, such as SALT Projects (Special Area Land Treatment), but long-term monitoring of the practices or their positive effects may not be taking place.

Water quality problems related to agriculture in the James River Basin include: 1) the concentration of animals in stream zones, resulting in localized erosion and access of wastes to water; 2) loss of riparian vegetation along streams in agricultural areas, increasing erosion and polluted runoff; and 3) land-application of wastes from concentrated animal operations, particularly dairies and poultry houses, where this material is not properly applied. Managed grazing systems with cattle exclusion from stream zones could prevent much of the first problem. Maintaining healthy riparian zones along agricultural streams could significantly reduce streambank erosion and polluted runoff. Careful applications of animal wastes and litter to prevent polluted runoff would protect streams draining these agricultural areas.

MUNICIPAL WASTEWATER TREATMENT FACILITIES

At this time, there are 20 permitted Publicly Owned Treatment Works (POTWs), or wastewater treatment plants, in the James River Basin (see Table 18). None of the plants in the James River Basin discharge directly into the James River. Springfield discharges into Wilsons Creek. Rogersville, Fremont Hills, Galena and

Reeds Spring discharge into tributaries of the James River. Clever, Hurley and Crane discharge into Crane Creek or its tributaries. Five municipal wastewater plants discharge into the Finley River. Nixa and Ozark discharge directly into the Finely River, while Seymour, Fordland and Sparta discharge into Finley River tributaries. Cassville, Purdy, Washburn and Exeter discharge into Flat Creek or its tributaries.

The largest wastewater discharger in the James River Basin is the city of Springfield's Southwest Wastewater Treatment Plant (SWTP), which has an average flow of about 35 million gallons per day (MGD), but can consistently treat up to 42.5 MGD. This plant accounts for approximately 50% of the point-source discharge for the entire James River Basin (MEC, 2006). The SWTP is a regional facility, accepting wastewater from the nearby communities of Willard (in the Sac River Basin), and Battlefield and Strafford (all or partially within the James River Basin). Nixa and Ozark, discharging into the Finley River, have the second and third largest discharges in the basin, with design flows of 4 MGD (Nixa), and 3.1 MGD (Ozark, two plants) MGD, but actual flows total about 2 MGD.

The plant at Cassville, the fourth largest discharger in the basin, has a design flow of 1.1 MGD, but an actual flow of about 0.7 MGD. Seymour, the fifth largest discharger, has a design flow of 378,000 gallons per day and an actual flow of 250,000 gallons per day. Sparta, the sixth largest plant, has a design flow of 200,000 gallons per day, but an actual flow of about 90,000 gallons per day.
All of the other plants in the James River Basin have design and actual flows of less than 200,000 gallons per day.

Almost all of the permitted municipal wastewater plants have actual discharges that are less than their design flows. The exceptions are Diggins and Fordland, which, according to recently posted state operating permits, have actual flows exceeding design flows. Most of the wastewater facilities in the basin land apply their sludge (after treatment called biosolids, the solids left over after the pollutants have been removed in the treatment plant).

Nutrients in wastewater discharges in the basin became an issue in the 1990s, especially after a large algae bloom in the James River arm of Table Rock Lake in 1999. Missouri's Water

Springfield Southwest Wastewater Treatment Plant

Quality Standards after 2000 required that all wastewater discharges in the Table Rock watershed, including facilities in the James River Basin, achieve a discharge limit of less than 0.5 mg/l total phosphorus (TP). Nixa and Springfield, both discharging on average over one million gallons per day, had to comply by November 2003, while smaller facilities in the basin had until November 2007.
The data gap analysis completed by Ozark Environmental and Water Resources Institute (OEWRI) and Midwest Environmental Consultants (MEC) in 2007 found that TP mean values in the James River at sites downstream of Springfield and Wilsons Creek trended from a high of 1.5 mg/l in 1969, before phosphorus removal at the SWTP, to 0.1 mg/l TP in 2004, after P removal was added.

All the wastewater treatment plants in the basin now have phosphorus removal capabilities, with most of the smaller plants using chemical treatment and precipitation (Perkins, 2013). Most of the plants utilize tertiary water filtration and ultraviolet light (UV) for disinfection. The exceptions are Fordland, Reeds Spring and Hurley, which do not have tertiary filtration; Springfield, which disinfects with ozone; and Fordland and Seymour, which disinfect with chlorine (Seymour will soon be switching to UV). Sparta, Clever, Fordland, Fremont Hills, Springfield, Seymour, Purdy, Exeter, Diggins and Rogersville all discharge to losing streams, which means that treatment requirements are more restrictive.

There have been no major problems recently with any of these treatment plants requiring attention from DNR, the permitting agency (Hess, 2017). Most problems have been in smaller communities, and mostly with collection systems (sewers), rather than with the treatment plants themselves. Many of the old sewers in these towns need to be replaced, but cities often lack the money. In some cases, small-town mayors have expressed pride that sewer rates have not been raised for many years. Now, the cities do not have the funds to replace leaking sewer lines and manholes.

Some of these problems are being address by DNR through the Sanitary Sewer Overflow (SSO) inspection process. SSOs happen when rainwater gets into sewers (infiltration) or manholes (inflow), diluting the sewage but causing too much flow for the treatment plant to handle, resulting in a plant by-pass or reduced treatment capacity. These cities need financial help to correct these problems, possibly through the SRF (State Revolving Fund) program.

ONSITE WASTEWATER SYSTEMS

Residents in the James River Basin have long expressed concerns about failing septic systems. The problem has been brought to their attention largely by health departments and local watershed groups. Numerous educational events, such as septic tank pump-out demonstrations and pump-out rebates, have been sponsored by watershed organizations over the years. With population growth continuing in the James River Basin and large numbers of homes being built in rural and suburban areas, higher treatment standards for onsite wastewater systems are necessary, and are increasingly being required by counties and cities.

It is difficult to estimate the actual numbers of onsite wastewater systems operating in the James River Basin. Many of the older systems were put in before controls on design, siting and installation were in place, and many localities lack precise information on where systems are located. More recently, the adoption of GIS programs has helped to track the locations of newer systems. Microbial contamination of ground and surface water by poorly functioning onsite systems is probably the largest water threat to groundwater quality or drinking water.

Actions at the state and local levels have led to significant improvements in the siting, design, installation and maintenance of new onsite wastewater systems. However, there have been few concerted efforts to better define the scope and scale of existing onsite wastewater problems in the basin. Focused monitoring for optical brighteners and/or bacterial source tracking methods might help to more clearly define onsite wastewater contributions to groundwater and surface water contamination.

The effective functioning of onsite treatment systems depends on the ability of soil to absorb and filter pollutants in the effluent from the septic

Table 18

WASTEWATER TREATMENT FACILITIES IN THE JAMES RIVER BASIN

Community	Treatment Plant Discharges To:	Losing Stream?	Design flow*	Actual Flow*	Sludge Produced (dry tons/ yr.)
Battlefield	City of Springfield's POTW				
Branson West	Aunts Creek, Table Rock Lake, James River Arm	Unk.	740,000 gpd.		111
Brookline	Part of city goes to Republic POTW, rest on septic tanks				
Cassville	Flat Creek	No	1.1 MGD	0.68 MGD	115
Clever	Tributary of Spring Creek		210,000 gpd.		72
Crane	Crane Creek	No	0.3 MGD	0.064 MGD	63
Diggins	Tributary of James River	Yes	45,000 gpd.	136,000 gpd.	10
Exeter	Tributary of Flat Creek	Yes	0.09 MGD	0.04 MGD	11.2
Fordland	Tributary of Terrell Branch	Yes	100,000 gpd.	137,000 gpd.	23
Fremont Hills	Tributary of James River	Yes	176,000 gpd.	77,000 gpd.	35
Galena	Pine Run Creek, James River Trib.	No	99,000 gpd.	50,000 gpd.	26
Hurley	Spring Creek	No	52,000 gpd.	7,300 gpd.	14
Nixa	Finley Creek	No	4 MGD	2 MGD	1.317
Ozark	Finley Creek	No	3.1 MGD	1.37 MGD	827
	(Two plants; Elk Valley and N. 22nd Street)		*(total two plants)*	*(total two plants)*	(total two plants)
Purdy	Little Flat Creek	Yes	120,000 gpd.		10.5
	(in process of clos-ing WWTP and hooking to Monett)				
Reeds Spring	Railey Creek, James River Trib.	No	0.27 MGD	0.09 MGD	69
Rogersville	Sayers Creek, James River Trib.	Yes	960,000 gpd	550,000 gpd.	290
Seymour	Tributary of Finley Creek	Yes	378,000 gpd.	250,000 gpd.	78
Sparta	Carter Hollow, Tributary of Finley Creek	Yes	200,000 gpd.	99,000 gpd.	36
Springfield Southwest Plant	Wilsons Creek	Yes	64 MGD	33.4 MGD	9,000
Strafford	City of Spring-field's POTW				
Washburn	Tributary of Flat Creek	No	39,150 gpd.	25,000 gpd.	9.7

*MGD = Million Gallons per Day; gpd. = gallons per day tanks or primary/secondary treatment tanks. Problems stem from the lack of suitable soil in many parts of the basin, including shallow, rocky soils over fractured bedrock or tight clay soils with very low infiltration rates. Septic systems in shallow, humus depleted soils with poor absorption rates can release significant amounts of bacterial or nutrient pollution into watersheds. Nitrogen compounds from septic systems are largely soluble and so move readily with water, often leaching into groundwater and contaminating wells and springs.

With the passage of state rules governing county onsite system oversight a few decades ago, all of the counties in the James River Basin now have programs in place to help ensure that new onsite wastewater systems are properly sited, designed and installed. However, there remains a need for better onsite management programs and ways to find and replace failing systems. One way to accomplish this is to require inspections at the point of sale of the home, as is now required in Stone County. This provides an opportunity to identify and replace systems that are failing to groundwater, have tanks that leak, or have absorption fields that are plugged or leaking to groundwater. In Stone County, many homeowners with known problems repair or replace their systems before the required inspection (Casaletto, 2017).

Another option is for a public or private non-profit entity to own and maintain individual onsite wastewater systems. This puts routine maintenance into the hands of professionals who understand its importance for proper long-term functioning of the system. This kind of management program could help to improve water quality and reduce groundwater contamination. However, limited experience with this management model in southwest Missouri has shown that individual homeowners are very reluctant to give up ownership of their onsite systems (Casaletto, 2017).

Septic system pump-out programs and educating homeowners about proper onsite system maintenance are also important ways to encourage better management. The James River Basin Partnership, for example, has had a septic tank pump-out program since 2006. This service has now been expanded to the counties near Table Rock Lake. Public response to these kinds of programs has been vigorous. However, only a limited number of residents are reached with these kinds of programs.

In the past, much if not most of the solids pumped from septic tanks was land applied. Now, much of this waste is taken directly to the headworks (where sewage arrives) of wastewater treatment plants. The city of Springfield worked with haulers to make this option affordable so they wouldn't have to go to the trouble of getting a land application permit from DNR. As a result of this and other plants accepting septic tank solids, the number of applications for permits to land apply solids has dropped significantly in the basin over the last ten years (Hess, 2017). As of July 2017, there were 17 land application permits open in the basin. Three of the permittees were located in Greene County, three in Barry County, two in Stone County, five in Webster County and four in Christian County.

Many of the haulers bring their septic tank solids to the Springfield Plant, especially those in Greene and Christian County. Other wastewater treatment plants in the basin may or may not accept these solids. Galena accepts it, for example, but Fordland does not. It is difficult to determine whether haulers in the more "remote" parts of the basin (Webster, Stone, Barry Counties) go to wastewater treatment plants, get land applications permits, or, in some (hopefully rare) cases, dump illegally.

Complaints related to septic tank pumpers and haulers have decreased in the basin, perhaps 50% over the last 10 years (Hess, 2017). Most complaints in the past were related to odors from land application. Some of the credit for this change may be due to the increased education from watershed groups, which have raised awareness about the need to properly handle septic tank wastes and maintain onsite systems. In addition, the bad publicity surrounding one hauler, who in the late 1990s dumped waste into a sinkhole and contaminated Clear Creek Spring, focused greater attention on the problem, especially in karst terrain, and may have discouraged other haulers from dumping illegally.

STORMWATER RUNOFF

All the major urban and urbanizing areas in the basin are now required to have National Pollutant Discharge Elimination System (NPDES) stormwater permits, as required by the 1987 amendments to the federal Clean Water Act. The larger (over 100,000 population) Phase I communities, such as Springfield, have specific requirements for monitoring stormwater quality; developing requirements and standards for stormwater practices such as detention basins, grassed drainageways and biofilters (vegetated areas for infiltrating stormwater into soil); and for detecting and eliminating illicit (non-stormwater) connections to storm drains. Permits are required to be renewed every five years. Springfield received its first permit in 2002.

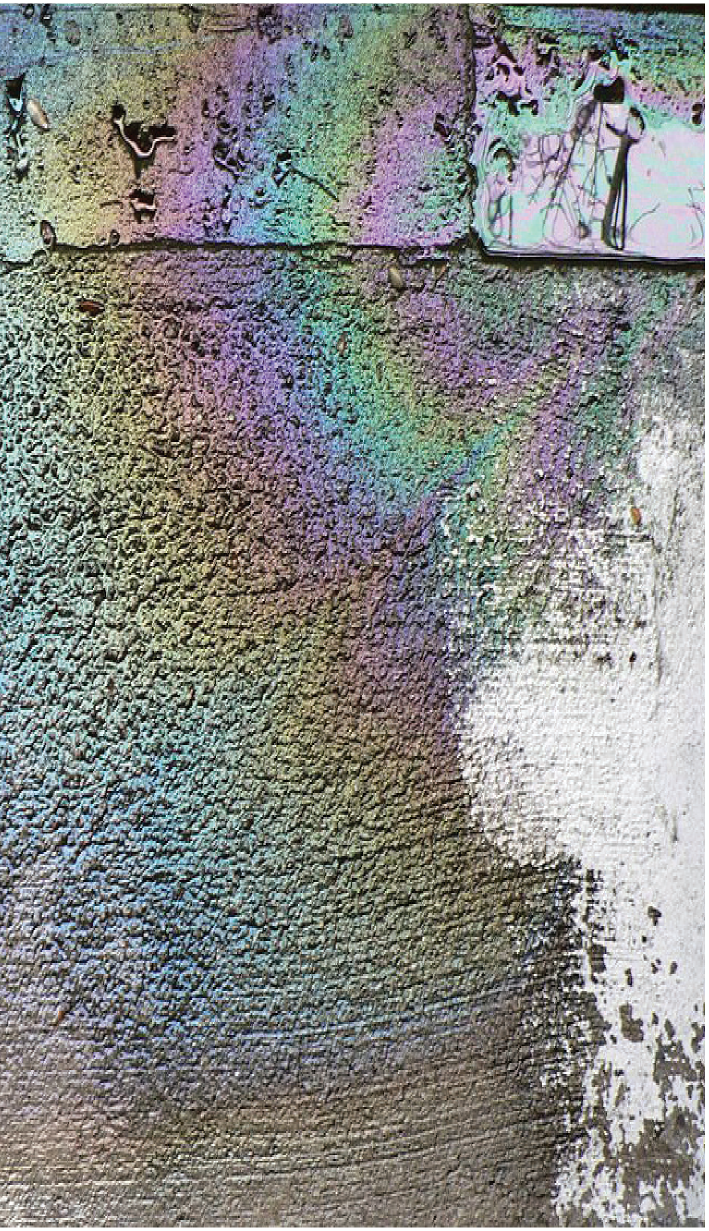
Smaller communities (Phase II) received permits in 2007, so had to re-apply in 2013. All the Phase II community permits in the basin have now been renewed based on a 2016 permit. Phase II communities have general “control measures” that must be in place, such as public education; illicit connection detection and elimination; good housekeeping practices (such as preventing polluted runoff from city service areas like salt storage facilities); construction site runoff control; and control of runoff from sites that have been developed, such as a residential subdivision or industrial park.

Stormwater monitoring became commonplace with the issuance of stormwater permits for the Phase I and Phase II urbanizing entities in the basin. The city of Springfield now routinely monitors stormwater quality at sites in the James River Basin, four times per year for “first flush” sampling (catching the first slug of runoff), and once per year at six sites during base flow (non-storm flow). In addition, the city annually conducts biomonitoring on two urban streams, in the fall and spring.

In addition to the city of Springfield’s 12-15 stormwater monitoring sites, nine sites in the basin are routinely monitored by other responsible management entities, such as the Phase II communities of Nixa and Republic and Greene and Christian Counties. Three sites on James River tributaries are monitored near the city of Battlefield. The city of Republic monitors two sites on Schuyler Creek southeast of the city; Nixa monitors two sites on unnamed tributaries of the James River; and Christian County monitors two sites, one on Terrell Creek and the other on an unnamed tributary of the James River north of Nixa and Ozark.

Springfield, which has been monitoring stormwater quality since 2009, has the longest record of water quality monitoring of any urban area in the basin. Based on these records, Jordan Creek

Urban Runoff with Oil



(downtown, the founding site of the city) has been shown to be a high priority for focusing management programs because it has consistently had the highest concentrations of nutrients and suspended solids during first flush conditions. However, the geometric means (related to the "average levels") for concentrations of nutrients and sediment have shown slight downward trends over the last few years.

Stormwater studies in Springfield have also indicated that levels of polycyclic aromatic hydrocarbons (PAHs) may be of concern. PAHs are organic compounds created by the burning of materials, and are found in cigarette smoke, barbequed food, parking lot sealants and incinerator residues. In 2012, the Ozarks Environmental and Water Resources Institute (OEWRI), an arm of Missouri State University, conducted a baseline study of PAH sources and concentrations in stream and pond sediments in the Wilsons Creek Watershed (City of Springfield, 2017). Seventy-two samples were collected at sites in both urban and rural settings, including stream channels, stormwater basins, wet ponds and parking lots. PAHs were detected at all 49 sites within the city of Springfield or in streams draining urban areas.

Large commercial and residential parking lots were found to be a major source of PAHs to streams and ponds in Springfield. A more detailed watershed-scale analyses showed that PAH concentrations in one watershed were strongly related to the percent of upstream area covered in sealed parking lots. Coal-tar based parking lot sealants have been shown to contain high levels of PAHs.

Although not all the PAH samples in Springfield were collected from locations where sediment-dwelling organisms live (e.g., parking lot sediments), the results were compared to sediment quality guidelines for aquatic life protection. This comparison showed that 36% of the samples were within the threshold effect concentration range (levels below which there should not be harmful effects on organisms) for sediment dwelling organisms and 51% were in the toxic range, exceeding the probable effects concentration (PEC) of 22,800 micrograms per kilogram (ug/kg). Twelve (25%) sites had PAH concentrations exceeding five times the PEC. Monitoring has uncovered problems with toxic constituents in several urbanized portions of the basin. Toxicity and loss of biodiversity, for example, have been suggested by DNR as impairments in Wilsons Creek and its very urbanized tributary, Jordan Creek. This toxicity could be related to individual chemical constituents, such as PAHs or other organic chemicals, or could be more related to changes in hydrology (e.g. high flow fluctuations) and sedimentation associated with urban runoff. More recent toxicity testing (EPA) indicated no toxic effects in these streams, and there have been suggestions of removing them from the 2016 proposed 303 (d) list of "impaired waters."

Springs in urban areas are particularly prone to chemical contamination. One spring in downtown Springfield uncovered during re-development and thought to be the "long lost" Fulbright Spring has been found to contain hydrocarbons, probably breakdown products from gasoline. The source of contamination in this spring has not been discovered.

NUTRIENTS

The available data clearly shows that before the addition of nutrient removal capabilities at wastewater plants in the James River Basin, levels of nutrients in the river rose with increasing amounts of sewage (wastewater) being discharged into the basin. Monitoring of nutrients completed by OEWRI and DNR further suggested that nutrient levels in parts of the basin downstream of urban and wastewater influences were above the "eutrophic threshold," the levels above which algae growth would become excessive. However, nutrients from agriculture in the basin were also mentioned as adding to excessive algae production and eutrophication.

The James River was placed on the Missouri 303(d) list of impaired waters in 1998 due to excessive nutrients, particularly phosphorus. Nutrient levels in wastewater discharges have long been of concern, especially after a large algae bloom in the James River arm of Table Rock Lake in 1999. Nutrient "non-point source pollution" comes from agricultural runoff, septic systems, or land development, and nutrient "point source pollution" comes from wastewater treatment facilities or heavily urbanized zones (which are permitted as "point sources"). Wastewater discharges, whether from treatment facilities or onsite systems, are rich in nutrients from human fecal matter, a byproduct of digestion. Nutrients are also found in high concentrations in animal wastes.

The James River nutrient Total Maximum Daily Load (TMDL) approved in 2001 had a stated goal of reducing benthic (bottom growing) algae in the James River and James River Arm of Table Rock Lake to less than 100 mg of algal mass per square meter of stream bottom (DNR, 2001). In-stream target limits for TN and TP were set at 1.5 mg/l and 0.075 mg/l, respectively, to be determined during base flow conditions. It was projected that meeting these targets levels would reduce phosphorus (TP) loading in the James River at Galena (just upstream of its confluence with Table Rock Lake) from an estimated 850,000 pounds per year in 2001 to 155,000 pounds per year, and total nitrogen (TN) from 5.4 million pounds per year in 2001 to 3.1 million pounds per year.

Missouri's Effluent Regulations require that all wastewater facilities with design flows over 22,500 gallons per day into the Table Rock Lake watershed, including facilities in the James River Basin, achieve a discharge limit of less than 0.5 mg/l of phosphorus (DNR, 2001). Nixa and Springfield, both discharging on average over 1 million gallons per day (MGD), had to comply by November 2003, while smaller facilities in the basin had until November 2007. A DNR report from 2004 noted a marked improvement in water clarity and less algae production after implementation in the James River below the Springfield SWTP.

As with phosphorus, the 2007 Data Gap Analyses showed that the highest, levels of TN in the James River Basin were found in the vicinity of Springfield, Nixa and Ozark. But TN concentrations in areas of the basin outside of urban influences were also largely above the eutrophic threshold. The lowest TN concentrations were found on Panther Creek, Flat Creek, Finley River above Ozark, and upper sections of the James River. The largest TN concentrations in the basin were found in Wilson Creek (Table 20).

TN means in Wilson Creek ranged from 1.97 mg/l above the SWTP to 12.93 mg/l at the Brookline station, below the SWTP. The elevated TN levels at the Brookline station suggests that wastewater effluent significantly influences nitrogen levels in Wilson Creek and the James River. From the 2007 data gap analysis, TN levels along the James River ranged from 0.35 mg/l at thes most upstream station to 4.1 mg/l at Shelvin Rock MDC access, well below the confluence with Wilsons Creek.

Stormwater has also been identified as a significant contributor of nutrients to urban streams. According to the city of Springfield's stormwater permit report (2015-2016), the five sites in the James River Basin (Jones Branch, Jordan Creek, Wilsons Creek, Galloway Creek, Ward Branch) monitored since 2009 had base flow TP geomean levels that met the James River TP target value of 0.075 mg/l. However, the base flow TN levels for these sites exceed the James River TN target value of 1.5 mg/l. The first flush sample results for TP and TN since 2009 for these sites did not show strong trends over time.

Since 2008, Ozarks Water Watch (OWW) has been completing "Status of the Watershed" reports for the entire upper White River Basin in Arkansas and Missouri, including the James River and Table Rock Lake. The survey included measurements of dissolved oxygen, clarity in lakes, total phosphorus, total nitrogen, E. coli and macroinvertebrates (the small animals living in the stream bottom, which are good indicators of water quality).

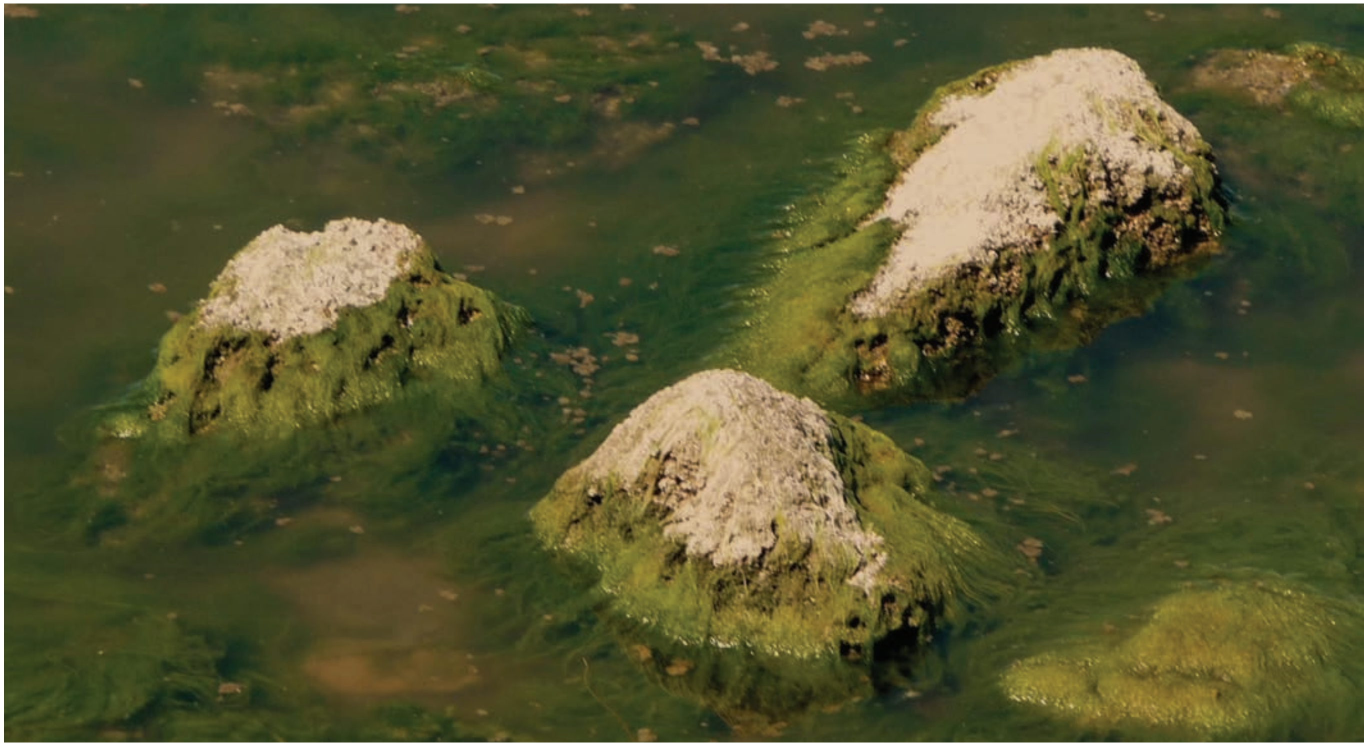
In 2014, the OWW report included water quality measurements at 59 sites in the James River basin. The report followed a color-coded format indicating good, fair or poor water quality at each of the sites. For nutrients, the criteria for total phosphorus (TP) was "good" (green) for less than 0.02 mg/l, "medium" (yellow) for 0.021 to 0.035 mg/l, and "poor" (red) for over 0.035 mg/l. For total nitrogen (TN), good was less than 0.5 mg/l, medium 0.51 to 0.9 mg/l, and poor over 0.9 mg/l Using these criteria, 30% of the stream sites on the James River had a rating of "good" with respect to TP, 25% "medium, and 21% "poor." For nitrogen, 15% of the sites were rated "good", 4% "medium," and 58% "poor."

In 2015, 31 sites on the James River were included in the OWW report. Using a combination of water quality criteria, the OWW report suggested that water quality was "high" at 26% of the sites, "medium" at 55%, and "low" at 19%. According to that year's report, the James River had the lowest scores of all the watersheds in the upper White River Basin, primarily because of high nutrient levels. The 2016 OWW report was further simplified. For all the sites on the James River, the total nitrogen was indicated as red or "high," and total phosphorus was yellow, or "medium." The OWW report in 2016 featured an interactive map where the user could click on any of the sites monitored to see the data source as well as the specific water quality parameters measured during the survey.

In 2013, a "snapshot survey" of 70 sites in the James River Basin upstream of Galena (excluding the Flat Creek watershed) was undertaken as a thesis project at Missouri State University (Bullard, 2014). The study included 21 sites on the James River, 14 on Finley Creek, 4 on Crane Creek, 2 on Pearson Creek, 5 on Wilsons Creek, 17 springs and 7 small tributaries. Samples were taken by volunteers but laboratory tests were run by trained professionals. All sites were sampled within a four-hour period on July 13, 2013.

For total nitrogen (TN), the two uppermost sites on the James River exceeded the target level for TN of 1.5 mg/l (the readings were 1.96 mg/l and 2.35 mg/l), and all sites on the James River below the confluence with Wilsons Creek exceeded the target level (2.21 mg/l to 4.98 mg/l). All four sites sampled on Wilsons Creek exceeded the target level for TN, from 1.71 mg/l at the uppermost site (Scenic Avenue) to 20.33 mg/l at the site immediately downstream of the SWTP. The lowermost site on Wilsons Creek, about a mile above its confluence with the James River, had at TN level of 7.28 mg/l, almost five times the target level.

Algae Growth on Rocks



With respect to total phosphorus, all sites on the upper James River were below the target level (0.075 mg/l). Three sites on the James River below its confluence with Wilsons Creek were slightly over the target level (0.092 mg/l to 0.125 mg/l), but all sites downstream were below the target level (0.039 to 0.066 mg/l). The highest TP value recorded in the entire snapshot was in Wilsons Creek (0.553 mg/l). Of the four sites sampled in Wilsons Creek, three exceeded the target level for TP (0.173 mg/l, 0.226 mg/l and 0.553 mg/l). The highest value was found at the site immediately downstream of the outfall of the SWTP. This is not surprising, given that this wastewater treatment facility has a discharge limit of 0.5 mg/l. Even the lowest TP value in Wilsons Creek (0.050), found at the uppermost site (Scenic Avenue), was higher than

Table 19

TP/TN CONCENTRATIONS PRE AND POST UPGRADE AT THE SCWP

(Note: Count refers to the number of samples pre- and post-upgrade)

		TN:TP (Average)		Count		Period of Record	
Site #	Station Name	Pre-Upgrade	Post-Upgrade	Pre-Upgrade	Post-Upgrade	Pre-Upgrade	Pre-Upgrade
052152	Wilson Cr. nr. Brookline, MO	4.8	37.0	105	84	9/2/1992-1/23/2001	3/7/2001-7/22/2004
7052160	Wilson Cr. nr. Battlefield, MO	6.6	30.7	54	49	9/21/1993-1/23/2001	3/29/2001-6/17/2004
2375/2.4	Wilson Cr.4.3 mi.bl. WWTP	7.9	26.3	48	17	9/21/1993-1/23/2001	3/29/2001-1/2/2004
2375/1.0	Wilson Cr. at Wilson Rd.	9.3	44.1	61	53	9/2/1992-1/23/2001	3/29/2001-1/2/2004
2362/8.1	James R. West of Nixa	8.0	34.6	70	42	9/2/1992-2/20/2001	3/9/2001-1/2/2004
7052250	James R. nr. Boaz, MO	6.4	43.1	95	23	7/10/1973-11/8/2000	3/9/2001-1/2/2004
2362/2.6	James R. at Shelvin Rock	5.0	35.7	5	36	6/4/1993-11/2/1993	8/22/2001-8/27/2003
2347/27.4	James R. at Hootentown Acc	9.0	31.4	47	18	9/2/1992-1/23/2001	3/29/2001-1/2/2004
7052500	James R. at Galena, MO	9.6	32.6	62	116	6/4/1993-2/6/2001	3/6/2001-9/16/2005

Table 20

TN AND TP MEANS AT WILSONS CREEK AND JAMES RIVER MONITORING STATIONS

Station #	Station Name	n	Sample Years	Mean TN (mg/L)	Mean TP (mg/L)	TN:TP Ratio
07050700	James River near Springfield, MO	29	2008-2009	1.41	0.029	49.3
07052000	Wilson Creek at Springfield, MO	8	1999-2006	1.97	0.123	16.0
		27	2004-2005			
		30	2008-2009			
07052120	South Creek near Springfield, MO*	30	2012-2014	1.11	0.199	5.6
07052152	Wilson Creek near Brookline, MO**	154	2002-2015	12.93	0.351	36.8
07052250	James River near Boaz, MO	30	2008-2009	3.78	0.093	40.8
		86	2002-2015			

* No base flow in stream,** below Springfield's Clean Water Plant, 1. Hutchison, 20102. USGS (downloaded from www.usgs.gov) 3. Miller, 20064. Owen et. al, 2015

most of the other stream TP values in the snapshot survey. At the lowermost site on Wilsons Creek, TP levels had decreased to 0.173 mg/l, still well above the target level.

In 2016 and 2019, the James River Basin Partnership sponsored a second and third snapshot in the James River Basin, utilizing the same sites and methods as in the 2013 survey. Sweeping conclusions cannot be made based on the three sampling events, as flow and temperature conditions varied somewhat between them, but some generalizations can be made and precursory trend analyses. For example, all three sites on Wilsons Creek below the Springfield urban area and the Southwest Wastewater Treatment Plant far exceeded the target value total nitrogen (TN) values of 1.5 mg/l. Most of the sites in the basin, including springs and streams, were above the target value for TN. Sites on Wilsons Creek and three sites on the James River below the confluence with Wilsons Creek were elevated above the target value of total phosphorus (TP) of. 0.075 mg/l for all three snapshot events. All sites on the upper James River above Springfield were below the target values for TP. Crane Creek, which is heavily influenced by springs, had elevated levels of TN compared to other James River tributaries.

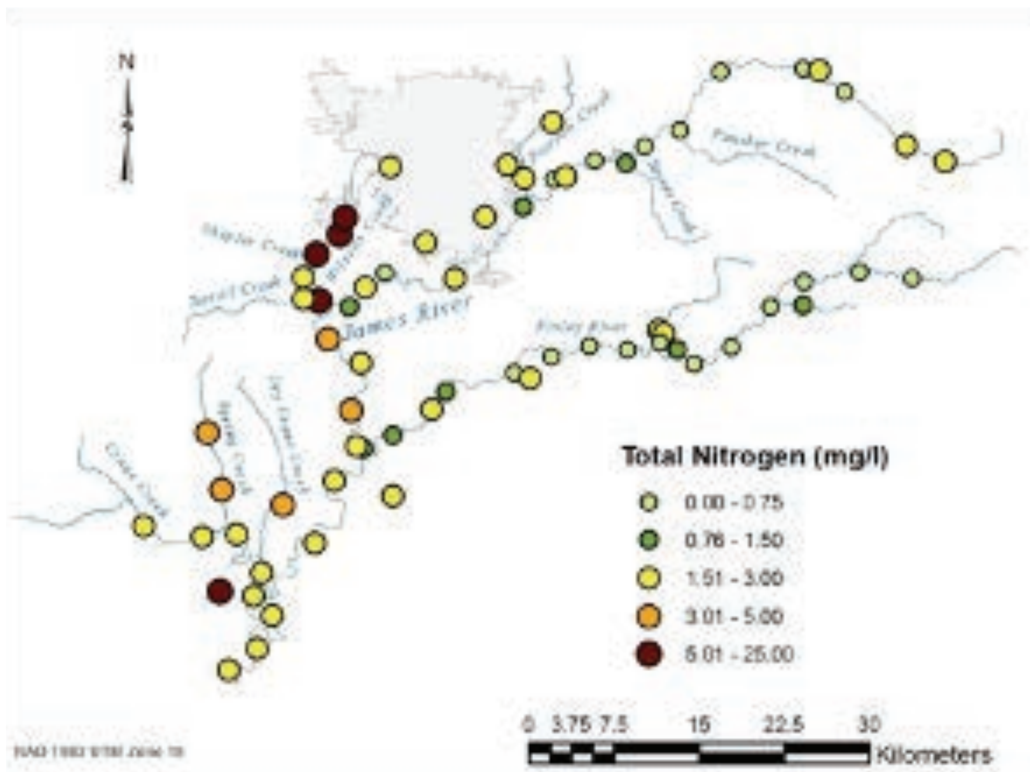
BACTERIA

E. coli bacteria are used as indicators of water quality. Although *E coli* are not necessarily harmful themselves, their presence in water could indicate that the water has become contaminated with fecal material from warm-blooded animals. Bacterial levels vary widely, with the highest numbers normally occurring in the first flush of stormwater or in rising water in a stream or spring after a rain event. The state of Missouri has established a standard of 126 colonies of *E. coli* per 100 milliliters of water (expressed as a geometric mean during the recreational season, April 1 through October 31) as the limit for water that will be used for human contact, as in swimming and wading. *E. coli* data was collected at 24 of the 42 sites included in the 2007 data gap analysis. These bacteria were primarily sampled in the water bodies with the highest likelihood of recreational use: James River, Wilsons Creek, Flat Creek, and Finley Creek.

Pearson Creek, a spring-fed stream in the upper James River Basin, has been consistently found to contain high levels of *E. coli* bacteria during sampling projects over the last eight years. In the 2007 data gap analysis, Pearson Creek had the only site in the survey that was above the *E. coli* geomean value of 126 colonies/100 ml, at 290. *E coli* values were highest in Wilsons Creek downstream of Springfield (138 to 462), but these did not exceed the Missouri Water Quality Standards "Category B" Criteria for Wilsons Creek (type A waters are those designated for public swimming access). The analysis did not detect any trends in bacterial data at the Boaz station on the James River from sampling in 1997 through 2006.

E. coli samples were used during the "Status of the Watershed" projects of Ozarks Water Watch, mentioned earlier. The OWW survey used the level of less than 70 *E. coli* as green or "safe," between 71 and 126 as yellow or "caution," and above 126 as red or "unsafe." Using this criteria in the 2014 survey, 55% of the sites sampled in the James River were "safe," 11% were "caution," and 13% were "unsafe." As mentioned earlier, the surveys in 2015 and 2016 used a combination of parameters to provide a general rating for the James River. In 2016, the average *E. coli* ranking of all James River sites was given as

Figure 10: Snapshot Total Nitrogen, 2013



"green," or safe.

E. coli were also sampled during the 2013, 2016 and 2019 snapshot surveys, which included river, stream and spring sites. A total of twelve of the 70 sites sampled had *E. coli* levels above the standard of 126/100 ml. Both sites on Pearson Creek had levels exceeding the standards for all three snapshot sampling events. These sites were the highest in any of the survey. One site on the uppermost James River exceeded the standard in 2016 (2,419), the highest reading obtained on the James River during all three surveys. Two other creeks had values exceeding the standards during at least one snapshot sampling event: Crane Creek and Spring Creek.

The other sites with high bacterial reading during the snapshots were springs. Three urban springs had high readings during all three snapshot events: Rader Spring, in the Wilsons Creek watershed, had the highest *E. coli* reading of any spring in all three surveys at 579. This spring was also high in the 2007 data gap analysis, with an *E coli* geomean of 413. Sequiota Spring (196) and Ward Spring (153) also exceeded the standard in at least one of the surveys. It is important to remember that snapshot events took place during base flow conditions, when bacterial levels in springs and creeks would be expected to be at their lowest.

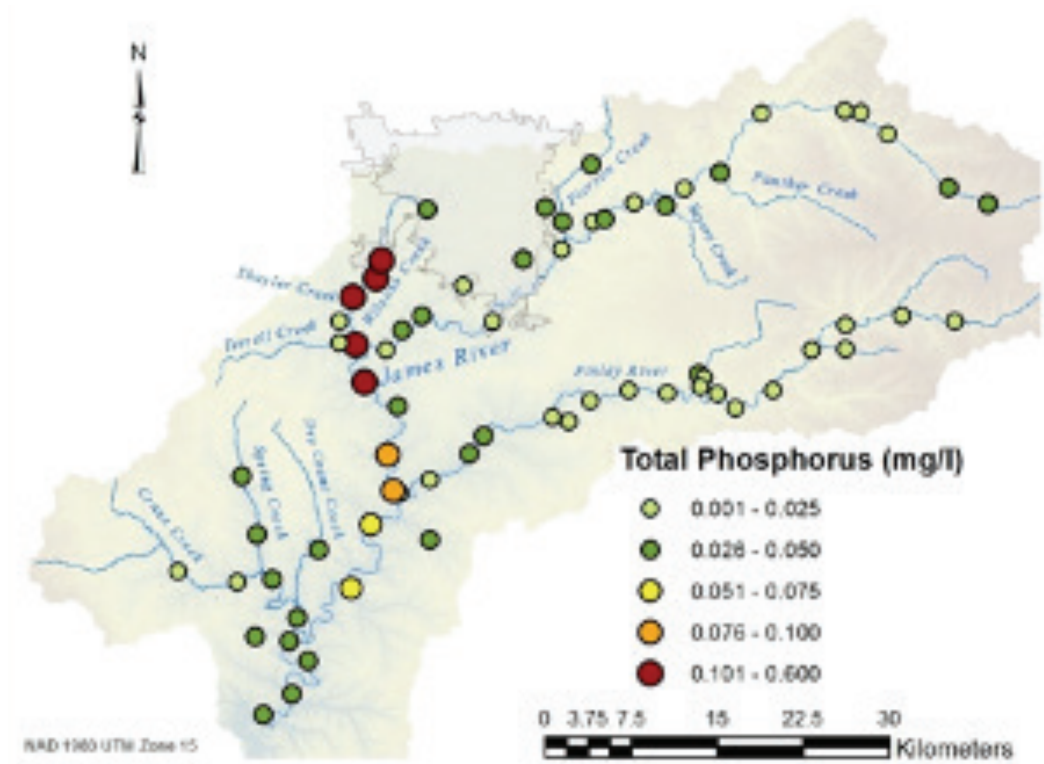
Bacterial source tracking is now being used to differentiate sources of bacteria, for example those from humans, dogs, cattle, swine, geese, deer or other warm-blooded animals. This technology should become more widespread as source-tracking methods get more efficient and become less costly. These methods could eventually help to differentiate between sources of bacterial contamination such as septic tanks, pet wastes, livestock wastes or waterfowl.

GROUNDWATER AND DRINKING WATER

The James River Basin contains a prodigious amount of groundwater. Most of the basin is within the Springfield Plateau Groundwater Province, which stretches over 27 counties in southwest Missouri. Only the upper headwaters of the James River, in Webster County, and the lower reaches in southern Stone and Barry Counties, are outside the province. Over much of the basin there are two distinct aquifers. Aquifers are geologic formations that will produce usable amounts of groundwater through wells.

Near the surface is the Springfield Plateau Aquifer, made up mostly of limestones and up to 400 feet thick. Wells here produce small amounts of water, typically less than 15 gallons per minute. This shallow groundwater is also easily contaminated because of the karst topography that has developed near the ground surface. The resulting sinkholes, losing streams and caves allow polluted surface water to easily reach the underlying groundwater. There have been numerous instances of contamination of the shallow aquifer, especially in southern Greene and northern Christian Counties, where karst development (e.g., large numbers of sinkholes) is

Figure 11: Snapshot Total Phosphorus, 2013



intense, along with intensive urban development and concentrated transportation networks. Missouri well drilling regulations now requires that new wells "case out" the shallow Springfield Plateau Aquifer (casing depths are set below this aquifer and the casing is sealed so that shallow water cannot reach deeper water in the well)

The lower aquifer is the Ozark Aquifer, which is made up mostly of limestone, dolomite and sandstone. The Ozark Aquifer can be up to 2,000 feet thick within the basin, and contains huge amounts of groundwater. It has been estimated that the Ozark Aquifer contains 112.6 trillion gallons (364 million acre-feet) of usable water (Groundwater Resources of Missouri, 1997). One of the most productive formations in the Ozark Aquifer is the Potosi Dolomite. Wells in the vicinity of Springfield penetrating the Potosi formation at about 1,500 feet of depth can produce up to 2,000 gallons per minute, although more commonly produce about 1,000 gallons per minute. However, drilling a well to this depth is very expensive, so most residential wells are usually much shallower.

Most of the municipal, industrial and large agricultural wells in the basin are drilled into the Ozark Aquifer. In most cases, this water is very clean, meeting all of the state drinking water standards without treatment of any kind. However, the water has a considerable hardness. Because of the tremendous amount of groundwater pumping in the areas of Springfield-Nixa-Ozark and Branson, large cones of depression, or lowering of the local water table, have occurred in those areas. In Springfield, the deep groundwater level has been lowered by as much as 500 feet. This lowering of the local groundwater level can affect water levels in nearby wells.

All of the community public water supplies in the James River Basin use groundwater for their drinking water supplies. With the exception of Springfield, all of the communities, as well as smaller water supplies serving developments like trailer parks and restaurants, rely totally on groundwater. Major incidences of contamination of these public water supplies have been relatively rare, since in most cases well construction (deep, well-sealed casings) has kept shallow, potentially polluted groundwater from accessing deep wells.

However, contamination can occur, as in the city of Republic many years ago when a chemicals stored in the basement of a downtown building that burned (the building also contained a shallow well) seeped into the city's deep groundwater supply. Such incidents reinforce the need for aggressive wellhead protection programs.

The city of Springfield uses deep wells for its public water supply, but also a large spring, three large reservoirs and the James River. The James River, which supplies on average about 40% of the city's drinking water, has been a source of concern because its quality can change so dramatically with changing flows. At high flows, the river becomes very turbid (muddy), and can contain large numbers of bacteria and other pollutants. The treatment system has to be adjusted to account for these changes in quality.

One immediate concern is the quality of water in Pearson Creek, which flows into the James River less than a mile above the City Utilities Blackman Intake Structure. As stated earlier, Pearson Creek has had high levels of E. coli recorded over the last several years. Further, sampling by City Utilities for Cryptosporidium (a microbial parasite) in Pearson Creek has indicated relatively high levels of cysts in the creek during high flows (Aderhold, 2017).

Coagulation and filtration processes at the treatment plant will typically remove these organisms, but with higher numbers in the raw water the risk is higher that some might make it through the treatment process. For this reason, City Utilities does not use the James River when turbidity is high, but instead uses water from the city's reservoirs. A raw water pipeline between Fellows Lake (north of Springfield) and the Blackman Water Treatment Plant (near the James River in southeast Springfield) allows the utility to switch rapidly from river water to lake water. But if the pipeline didn't happen to be usable at the time when the river was high and muddy, river water would have to be used, regardless of its quality. For this reason, City Utilities officials expressed the need for a redundant pipeline to remedy this potential situation (Brewer, 2017).

Figure 12: Snapshot *E. coli*, 2013

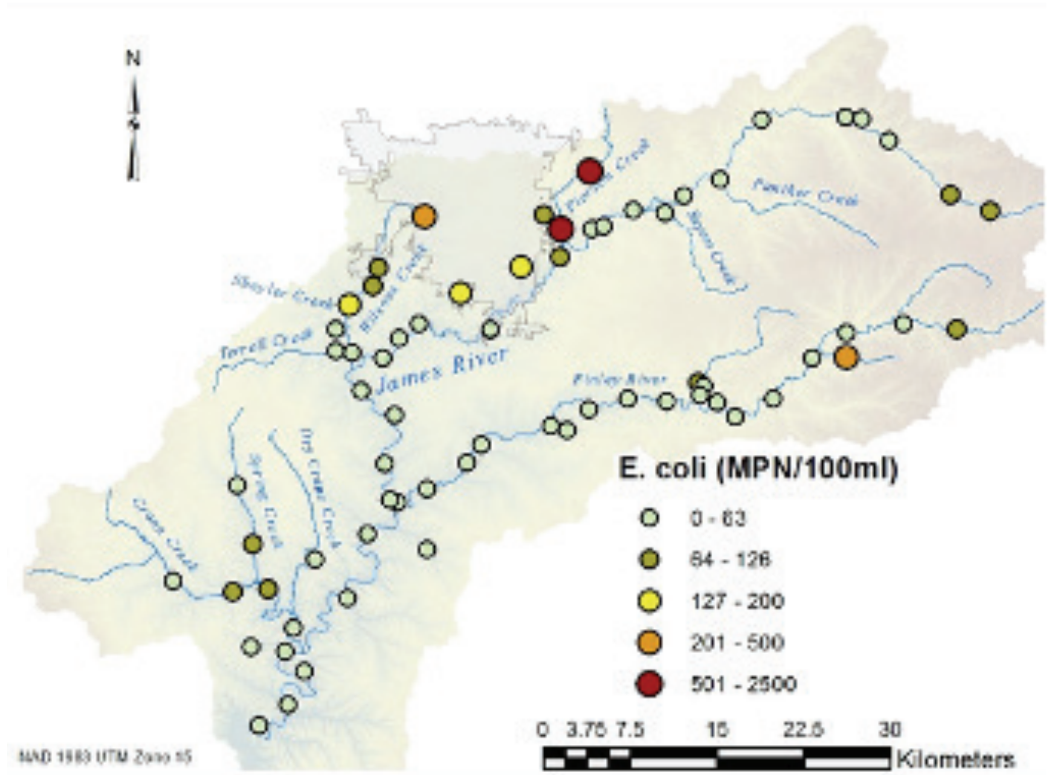
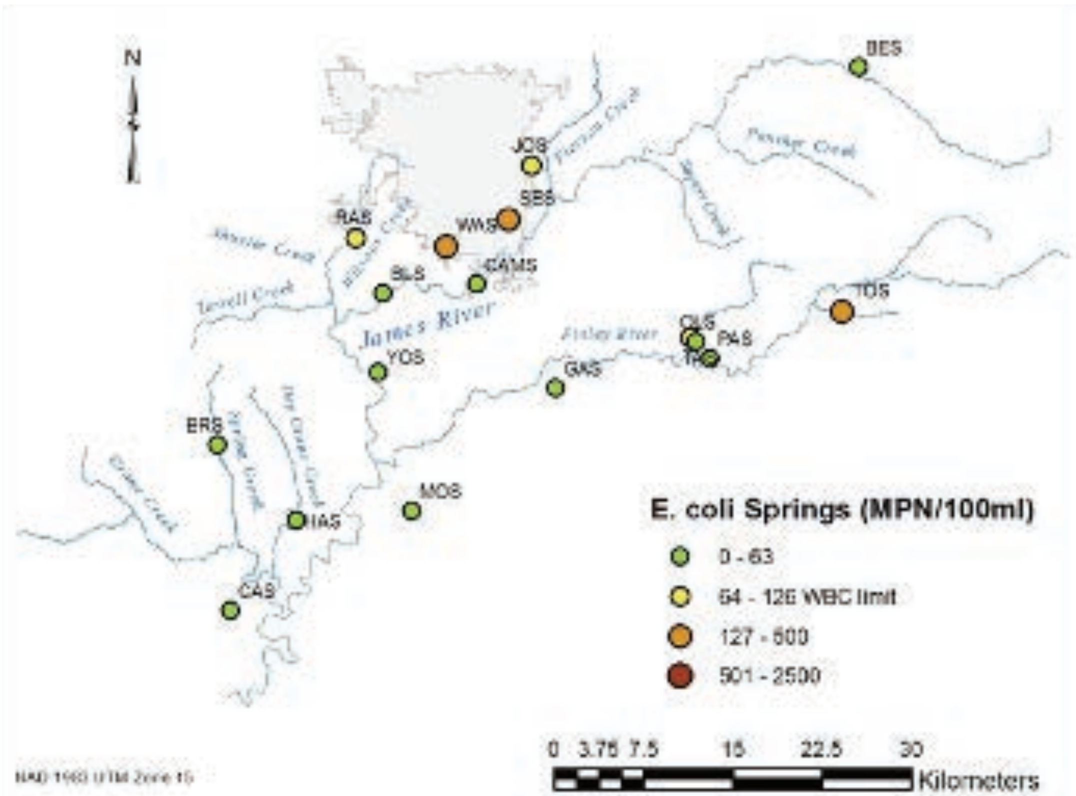


Figure 13; Snapshot E. coli in Springs, 2013



James River Sunset, taken by Semipaw, 2014

04

Modeling and Critical Areas Identification

One of the most important parts of the planning process is to identify areas in the James River Basin that may need to have more or better management measures applied in order to protect water quality. As a way to identify these areas, a Soil and Water Assessment Tool (SWAT) model was used. This model was developed for the United States Department of Agriculture. With this model, the effects of different management strategies and practices can be simulated before actually investing the time, labor and money into developing these practices.

The particular derivation of the SWAT model used in this plan was developed by professional modelers at the Ozark Environmental and Water Resources Institute at Missouri State University (OEWRI). Those interested in the technical aspects of this model are encouraged to read the technical paper included in the appendix.

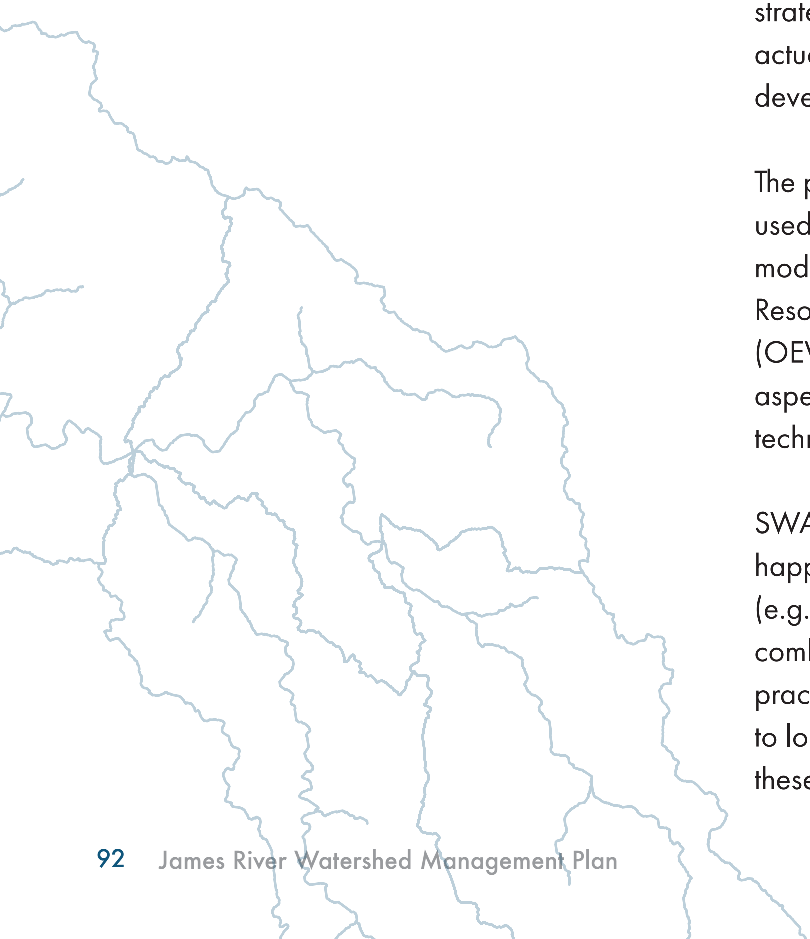
SWAT modeling is helpful in predicting what will happen to water quality when natural conditions (e.g., rainfall amounts, soil types, vegetation) combine with human impacts (farming types and practices, urban development) to affect the runoff to local waters. The model is able to take all of these factors into consideration in determining how changes in any or all of these inputs will ultimately affect the watershed and water quality.

In SWAT modeling, a large drainage basin is typically subdivided into many smaller units, called hydrologic response units, which have unique combinations of soils, vegetative cover, slopes and management practices. The model has three phases:

1. Land phase: The model simulates what happens when rain falls on the small unit and either soaks into the ground or produces runoff that is collected and flows to the main channel, or outlet.

2. Routing phase: The model determines how water, sediment and pollutants move from the individual units through the channel network to the basin to the outlet.

3. Total loading calculation: The results of the above two steps are used to calculate the loading, usually given in pounds per year, of sediment or pollutants reaching the lower end of the basin.



Before the model is used, it must be calibrated to determine if the model results match up well with what is already known. For the nutrients, nitrogen and phosphorus, the annual loading amount at the lower end of the basin has already been estimated using water samples at various places in the basin and flow data from the gage at Galena.

If we already have an estimate of the loading of pollutants at Galena, then why is it necessary to do the modeling? The model tells us how much of the loading is likely to come from each of the smaller units, or sub-watersheds, in the basin. This saves us the time, expense and effort of actually sampling for water quality over long periods of time and through many changes in flow conditions in every small stream.

After calibration, the model will then be able to apportion the pollutants between the individual units based on their unique characteristics—slopes, soil types, vegetation and management practices. If many units within a sub-watershed have higher than average predicted amounts of pollutants in their runoff, these sub-watersheds could be identified as critical areas, where better practices should first be targeted.

Table 21

POLLUTED WATERBODIES IN THE JAMES RIVER BASIN

Waterbody	Year Listed	Pollutant/Problem	Miles/Acres	County
Crane Creek	2012	Macroinvert. bioassessment	13.2 mi.	Stone
James River	2020	*E. coli*	39 mi.	Greene
Jordan Creek	2014	PAH *(polycyclic aromatic hydrocarbons)*	3.8 mi.	Greene
Lake Springfield	2020	Chlorophyll-A	293 acres	Greene
N. Br. Wilsons Cr.	2014	Zinc	3.8 mi.	Greene
Pearson Creek	2008	Macroinvert. bioassessment	8 mi.	Greene
Pearson Creek	2006	*E. coli*	8 mi.	Greene
Table Rock Lake	2002	Chlorophyll-A, nutrient enrichment	41,747 acres	Stone
Wilsons Creek	1998	Macroinvert. bioassessment	14 mi.	Greene
Wilsons Creek	2006	*E. coli*	14 mi.	Greene

For the purposes of this plan, critical areas are defined using the following criteria:

1. Critical areas were identified through SWAT modeling. Those areas are depicted and discussed in Chapters 6-11, which focus on each of the individual HUC-10 watersheds in the James River Basin
2. Critical areas are also defined as watersheds or sub-watersheds containing waterbodies with known water pollution problems. These waterbodies show up on the Missouri Department of Natural Resources 303 (d) list of "impaired" waters. Table 21 shows the 303 (d) waterbodies in the James River Basin, the listed pollutants, and miles or acres affected.

This table is based on the 2020 303 (d) list currently (April 2020) under consideration by the Missouri Clean Water Commission

3. The third type of critical areas in this plan are the class of waterbodies serving as source waters for public drinking water supplies. These include groundwater, which provides municipal drinking water for most of the public water supplies in the basin, and the upper James River, which supplies drinking water for the city of Springfield. Springfield is the only city in the basin using surface water as part of its public supply. The intake for the water supply on the James River is in southeast Springfield, just below the confluence of Pearson Creek with the James River. All of these critical areas will be discussed further in Chapters 6-11, which focus on each of the six individual HUC-10 watersheds in the James River Basin.

MODELING THE APPLICATIONS OF BMP

A series of meetings with SWAT modelers and resource management personnel indicated that it would be very difficult and complicated to try to model the performance of a variety of BMPs, all with different pollutant removal rates, for the entire basin. Instead, the modelers suggested using a few "surrogate" BMPs with known ranges of removal efficiencies suited to the soil, geologic and land-use conditions in the James River Basin. Two surrogate BMP types were selected for insertion into the model: filter strips (vegetated buffer strips along streams); and pasture and forage grass improvements, leading to increased soil health and infiltrative capacities. Four BMP scenarios were then selected to the used in the SWAT model to estimate sediment and nutrient loadings in the James River Basin:

- Scenario 1: Practices for conservation of soil health in pasture areas. In this scenario, the influence of soil conservation practices, such as vegetative (forage) stand improvement, was simulated for modeling purposes by reducing the Soil Conservation Service Curve Number (SCS-CN0 by a value of three (3) in all hay and pasture related hydrologic response units (HRUs). The SCS-CN is utilized in runoff modeling to simulate the amount of runoff generated within the HRU based on soil types and other conditions.

- Scenario 2: Vegetative buffer strips in pasture areas. For this scenario, it was assumed that a vegetative filter strip (VFS) approximately 50-feet (15 meters) in width would be established in all hay and pasture-related HRUs.

- Scenario 3: Vegetative stream buffers in urban areas. For this scenario, it was assumed that a VFS approximately 30-feet (10 meters) in width would be established in urban HRUs. This width is smaller than in the pasture simulations because in urban areas, development has typically already encroached more closely to the stream.

- Scenario 4: A combination of all three of the scenarios described above.

For the BMP simulation model, baseline data shown in Table 23were used to estimate current annual loadings of sediment, TN and TP. This data was derived by flow-weighted water quality sampling over many years at Galena, near the lower end of the James River Basin. The data was analyzed and summarized by personnel at the Ozark Environmental and Water Quality Institute. The technical report on this data is included as an appendix in this plan. Using the baseline water quality loading data and applying the four BMP modeling scenarios outlined above, the following basin-wide percent reductions in sediment, TN and TP were determined as shown in table 24. The load reduction charts give the tons per year and percent reductions in each of the three pollutant categories based on acres treated by the first three BMP scenarios.

The foregoing charts provide a generalized representation of the possible reduction in pollutant loads across the entire watershed as predicted by the SWAT model. The SWAT model provides the scientific basis for the recommendations made in the following chapters (6-11). However, it must be understood that the SWAT model provides only generalized results for application of the surrogate BMP types that were utilized for modeling purposes.

Actual installation of BMPs will be made on a site-specific basis. BMPs for each individual site must be designed, installed and maintained in accordance with established standards and procedures to ensure that adjacent or upstream acres receive effective "treatment." The NRCS has published design, construction and maintenance guidelines for the agricultural BMPs referred to in Scenarios 1 and 2. Design guidance for urban stream buffers is available

Table 22

BMP SCENARIOS

Scenario	Brief description	Area applied
1	BMP to conserve soil health in pasture areas	Pasture
2	A 15 m vegetative buffer in pasture areas	Pasture
3	A 10 m vegetative buffer in urban areas	Urban
4	All BMPs included	Pasture and Urban

Table 23

BASELINE ANNUAL LOADS FOR THE JAMES RIVER

Sediment (T/yr)	Total Nitrogen (lb/yr)	Total Phosphorus (lb/yr)
136,147	4,576,493	516,701

Table 24

PERCENT REDUCTIONS IN POLLUTANT LOADINGS EXPECTED UNDER FOUR BMP SCENARIOS

BMP Scenario	Sediment	Total Nitrogen	Total Phosphorus
1	4%	2%	6%
2	20%	34%	34%
3	4%	6%	9%
4	29%	39%	45%

04

Figure 14

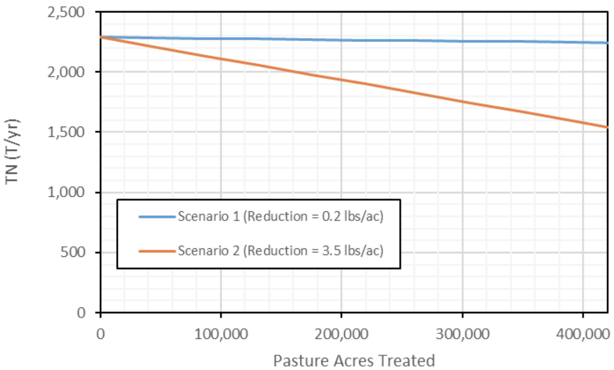


Figure 15

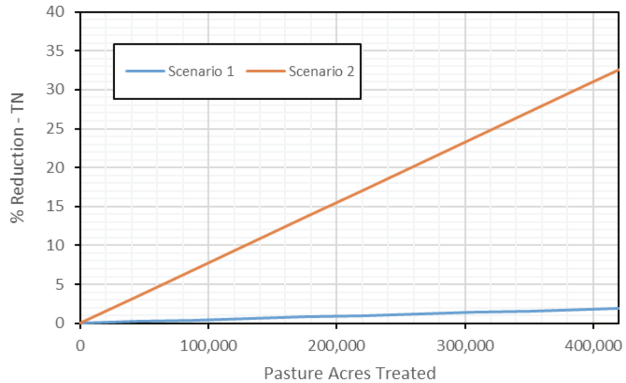


Figure 16

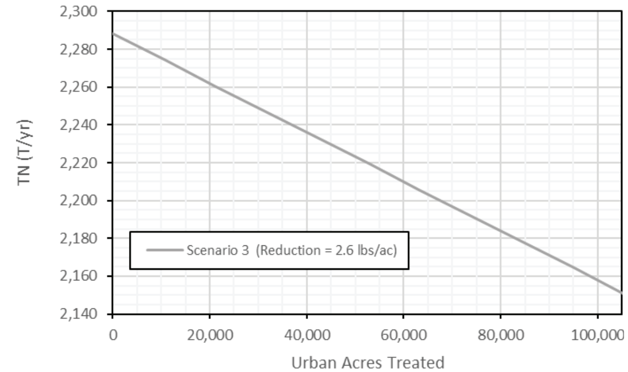
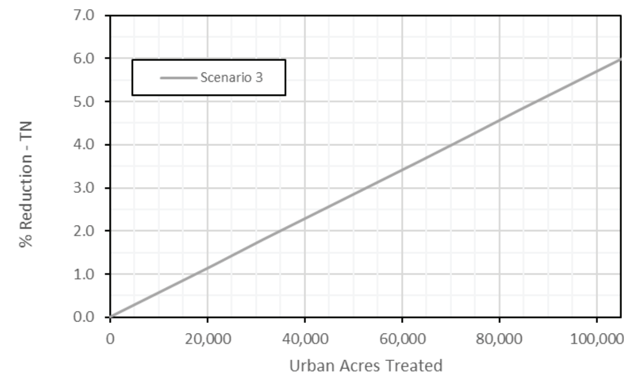


Figure 17



through organizations such as the Center for Watershed Protection and the American Society of Civil Engineers (ASCE). Larger cities, including Springfield, have adopted specific requirements and standards for stream buffers. It must be understood that the location and size of areas to be considered "treated" must be appropriate to the location, design and size of the buffers provided.

Load reductions estimated in the SWAT model for each of the BMP scenarios were used to develop goals for each of the HUC-10 watersheds, or in some cases for HUC-12 sub-watersheds with water quality impairments. These goals for each of the HUC-10 watersheds, as well as recommended BMPs for each watershed, are provided in Chapters 6-11.

Figure 18

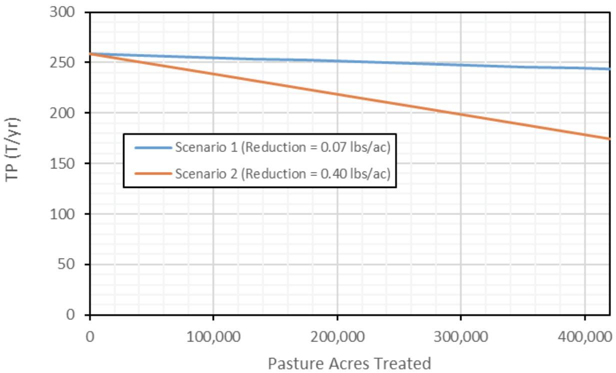


Figure 19

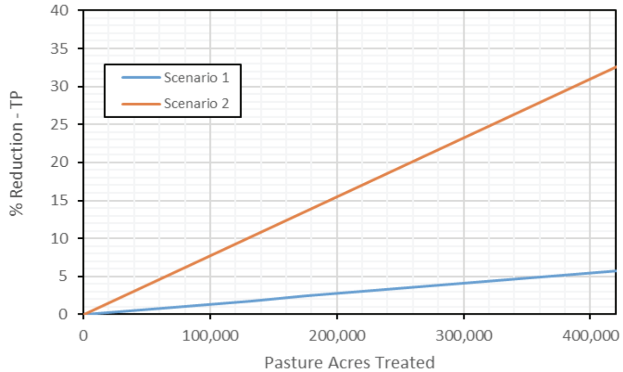


Figure 20

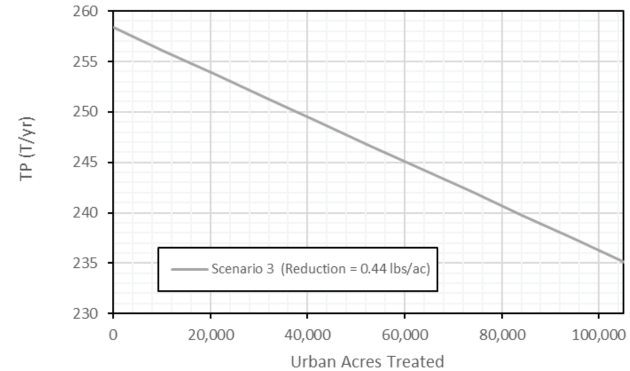


Figure 21

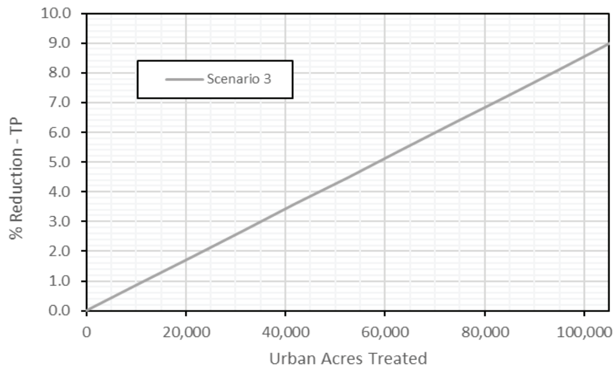


Figure 22

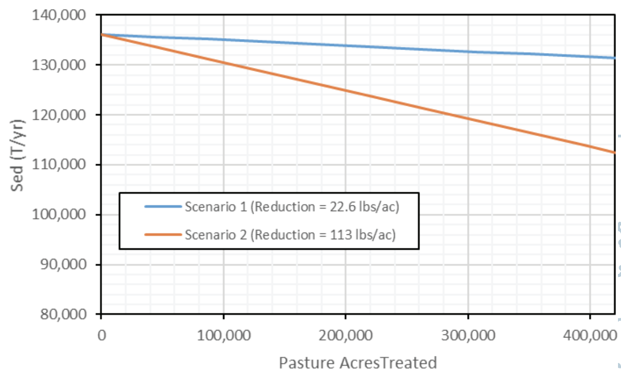
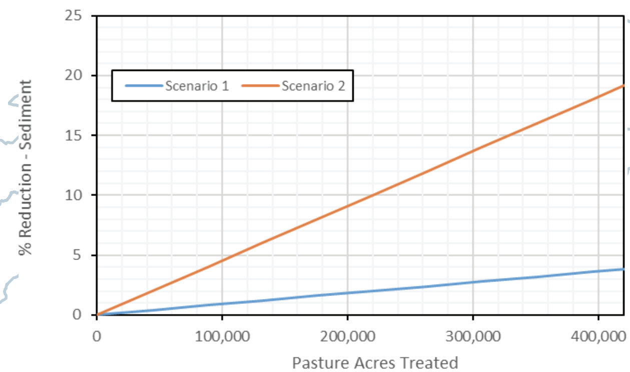


Figure 23



05

Recommended Management Measures

A Best Management Practice (BMP) describes any behavior, action or practice implemented in a watershed to help protect, preserve or improve water quality. BMPs can be structural, such as a filter strip along a farm field, or non-structural, such as educating homeowners about proper maintenance of onsite wastewater systems.

Different kinds of BMPs are stressed in different areas, depending on the topography and land-uses. In areas of karst topography (sinkholes, caves, springs), for example, more attention should be paid to the siting, design and installation of onsite wastewater systems. In agricultural areas where there may be a high potential for nutrients in runoff, vegetative filter strips may be indicated.

A watershed management plan typically focuses much of its attention on BMPs that can be adopted voluntarily, since municipal wastewater treatment plants, large animal feeding operations, and manufacturing facilities are already regulated, with BMPs required. A BMP can also be a policy or regulation that requires certain water quality protection practices be incorporated into development, business or agricultural operations.

The following section describes commonly used BMPs, most of which have already been used in at least some places in the James River Basin. These are the BMPs that have been shown to be effective in the Basin, and are therefore specifically recommended for further use. Prioritization of what kinds of BMPs to use, and where they should be used, is based on the results of modeling along with known water quality problems.

The number of landowners willing to adopt better practices is largely determined by the conservation-mindedness of the individual and the cost of the BMP. Government cost-share can help to offset landowner costs, but the individual is usually on the hook for at least part of the costs. BMPs that are easy for landowners to understand, and that they see benefits from, are obviously easier to "sell." The most cost-effective BMPs, and the ones most likely to be adopted by landowners, are the ones that should be promoted most vigorously in the plan.

AGRICULTURAL BMPS

Most of the agricultural uses in the James River Basin are either animals on pastures or poultry in confined feeding operations. There are few dairy operations in the basin, and a small, but expanding number of row crop areas. Types of agricultural BMPs most effective for animal agriculture include vegetative buffers along streams, managed or rotational grazing, fencing livestock out of streams, and alternative watering systems. For poultry operations, appropriate BMPs include the management of litter spread on fields to prevent nutrients and/or bacteria from reaching streams or groundwater; and the export of litter from the basin to areas of crop production where the litter will have beneficial nutrient value. For crop agriculture, common BMPs include vegetative buffers along farm fields, crop rotations, cover crops and no-till.

Vegetative buffers are areas excluded from crop production or grazing activities and allowed to remain in permanent vegetation. Buffers are most effective along edges of waterways and should be larger and wider proportional to the size and extent of the field or pasture area that is being treated. These buffers have the added benefit of providing habitat for wildlife such as deer and quail. Many farm owners also enjoy hunting, fishing and outdoor recreation, and natural buffers have the added benefit of helping to maintain and improve these uses.

Prescribed grazing systems involve moving animals frequently from one small, separate pasture to the next through a planned rotation. Prescribed or managed grazing systems have unlimited potential to improve water quality in the James River Basin. Improving grassland management, in turn, improves soil health, provides valuable ecological services, and improves the health of grazing animals. Improved soil health and vegetative cover increases infiltration of rainwater and contributes to nutrient cycling and plant health.

Managed grazing prevents overgrazing, which could lead to increased soil erosion and loss of productive soil during rain events or floods. By moving animals between smaller grazing areas, the animal waste is also spread more evenly. This allows the waste to be assimilated by soils, providing fertilizer value. With this system, animals eat only the uppermost, most nutritious and highly palatable parts of the grass blades, helping them to gain weight faster. With traditional grazing, animals with access to a stream and it's shade will tend to spend most of their time in the stream and riparian area in summer, only walking far enough away to get enough grass to eat. With managed grazing, animals spend less time in stream zones, meaning less waste is deposited near the stream. Streambank erosion and soil loss are reduced because the animals do not trample streamside vegetation and denude streambanks.

With managed grazing systems, there is often a need to provide water to livestock in some manner other than direct access to streams. Many grazing systems also use an alternative water source such as a stock tank fed by a well, pond, or stream. For sites without access to electric power for pumps, solar-powered pumps have been used effectively. Solar-power can also be used to charge high-tensile electric fencing, which is cheaper to install than traditional barbed wire fences. Further, electric fencing is easier to repair or replace after streamside pastures have been flooded.

Often a pond or well with a stock tank located away from the stream will discourage livestock from entering the stream, even with no fencing or restricted access. A practice that has been used on sloping land is the creation of a water retention basin, formed by constructing a small earthen dam in the down-slope area of a pasture. This creates a pond that can trap sediment and nutrients from part of the field and provide a source of water for livestock.

Crop rotation is alternating or rotating between two or more different types of crops in the same soil in a planned rotation. Crop rotation reduces pesticide use because pests cannot build up populations when crops change from year to year. Crop rotation also helps reduce fertilizer use when crops like soybeans and other legumes are included in the rotation to restore nitrogen and other nutrients to the soil. Also, high residue crops such as corn can be alternated with low residue crops like wheat and soybeans to help prevent the erosion that would otherwise occur when low residue crops are grown continuously.

In addition to crop rotation, cover cropping and no-till planting practices contribute significantly to soil health and water quality. Cover cropping provides an additional income source for producers while keeping the soil covered. No-till planting allows farmers to plant crops with minimal soil disturbance, saving money on fuel and labor. Both practices reduce erosion, increase infiltration, retain and restore nutrients, and improve water retention by increasing organic matter and minimizing water loss due to evaporation.

URBAN AND SUBURBAN BMPS:

Many BMPs are used in urban and urbanizing areas, including practices used at individual homes, residential subdivisions, shopping centers, commercial or industrial sites, parks, or other developed areas. These types of BMPs include stormwater detention basins, extended detention basins, retention basins, vegetated buffers, green spaces, rain gardens, green roofs, and biofilters. All of these BMPs are designed to reduce soil erosion and downstream sedimentation, and to reduce polluted runoff. The primary functions of these BMPs include slowing down runoff, allowing water to infiltrate into soil, and filtering runoff through vegetation to remove sediment and other pollutants.

A detention basin is designed primarily to hold back stormwater runoff long enough to reduce downstream flooding. Traditionally designed dry detention basins are not considered water quality improvement structures because runoff water is not in the basin long enough to allow sediment and pollutants to settle out. An extended detention basin, on the other hand, is designed to allow water to stand in the basin for a longer period of time (usually over 24 hours), which does provide enough time for some sediment and pollutants to settle out.

Some extended detention basins have outlet structures that contain a filter made by placing filter fabric over outlet pipe holes. Gravel is typically used to hold the filter structures in place. Data from a study on the Finley River watershed in Christian County (part of the James River Watershed) suggests that installing a filter on existing, traditionally designed detention basins has the potential to reduce nutrient and sediment loads in stormwater runoff from residential developments by 30-60% (Owen and Pavlowsky, 2011). However, detention basins with "enhanced" removal by filters have been shown to greatly increase maintenance time and costs.

The city of Springfield in its "Integrated Plan for the Environment" studied the benefit-cost ratios of retrofitting traditional detention basins into extended detention basins by altering outlet structures in order to provide increased settling times. About 3,600 acres of the city's 134,000 urban acres drain to extended detention basins. The study found for water moving through these extended detention basins, there was an approximate removal rate for TP of 0.56%, of TN of 0.60%, and of sediment of 1.27%. While relatively low, these removal rates are achieved at very low costs since retrofitting of outlet structures is comparatively inexpensive.

Tree planting in urban areas, especially in riparian zones, is one of the most cost-effective BMPs for future watershed health. A healthy tree canopy protects soil from erosion, produces oxygen, combats the "heat island" effect in urban areas, and helps with energy conservation through shading and cooling. Maintaining natural vegetative buffers along streams and drainage ways helps to reduce downstream flooding, prevent streambank erosion, and reduce the amount of polluted runoff reaching the stream. To be effective, vegetation in buffers should include trees, shrubs and grasses. Typical lawn grasses have shallow root systems that will not hold soil in place as well as native grasses, with their much longer root systems. Trees standing alone on streambanks, with no grasses or shrubs below them to hold soil, will often be toppled as rising stormwater undercuts their roots.

In highly urbanized areas, restoring streams will often include major "re-engineering" of the stream channel, with re-shaped and anchored banks, drop structures to reduce velocity, and vegetative plantings to hold the newly shaped channel in place. These BMPs are typically very expensive to design and build.

Rain Gardens are small, generally flat-bottomed basins planted with vegetation. They are designed to catch and filter small amounts of runoff from rooftops, driveways, sidewalks and parking lots, usually from one to a few individual lots. Rain gardens help mimic natural forest, meadow, or prairie conditions by using a variety of plants and shrubs that are tolerant to being very wet temporarily and dry at other times. The plants act as a filter for nutrients and sediments. Rain gardens are generally used as water quality BMPs on smaller developments and for individual residences.

A bioswale or vegetated swale is a broad, shallow channel densely planted with a variety of long-rooted trees, shrubs and grasses that are tolerant of periodic flooding by stormwater. Vegetated swales can be used to convey stormwater as an alternative to a concrete channel or pipe. A well-designed vegetated swale can effectively control erosion and reduce pollutants in stormwater while enhancing the landscape. If soils permit, swales can be designed with check dams or other features to provide for increased infiltration of stormwater.

Porous pavement on streets and parking lots reduces the volume of stormwater runoff that leaves paved areas. This helps reduce erosion in downstream drainage areas and stream channels. By infiltrating stormwater into soil below paved areas, these BMPs reduce pollutants that would otherwise wash off of paved areas into streams. Porous pavements can be made of interlocking bricks, porous concrete, porous asphalt or various types of gridwork infilled with gravel. Porous pavement must be installed with a stable but porous underlying infiltration bed, such as clean, angular stone, which allows water to infiltrate into the underlying soil.

Maintaining and improving soil health in urban areas, as in suburban and agricultural areas, is a key to improving water management functions. In urban areas, the "strive for five" program encourages homeowners and landscapers to maintain at least five percent organic matter in the soil. Maintaining a high level of organic matter in the soil increases infiltration and retention and makes nutrients naturally available for plants. A related BMP is soil testing, which determines organic matter content and also the available soil nutrients. Practices designed to improve soil health include aeration, leaving grass clippings on lawns rather than removing them and top-dressing soils where needed with compost or other soil amendments to maintain soil health, nutrient value and infiltration capacity.

CONSTRUCTION SITE BMPS

With the degree of urban development in the central part of the James River Basin, there are typically many construction projects in progress at any given time. There was some slowdown of construction during the economic slowdown of 2008, but new construction is now back close to the level of 2007. Exposed soil at construction sites, especially on steep slopes, is vulnerable to erosion. Soil eroding from construction sites can create problems in streams, such as murky water or siltation, higher temperatures and loss of aquatic life. Silt fences, silt socks, gravel construction entrances, sediment basins, and seeding or hydro-seeding and mulching exposed soils are some of the commonly used construction site BMPs. When properly installed and maintained, these BMPs can reduce erosion and nutrient pollution.

Construction site sequencing is a very effective BMP. With more careful construction planning and sequencing of construction phases and activities, the amount of area exposed to potential erosion at any given time can be vastly reduced. Sequencing can also help to avoid seasonal problems when sites must be left open because they can't be worked due to wet weather.

A silt fence consists of a length of filter fabric stretched between supporting posts spaced at regular intervals. The main function of a silt fence is to provide a filter down-slope of exposed soil areas and trap any soil that is washed away in a rain event. Silt fences must be installed correctly by placing the lower 6 to 8 inches of the fence below soil level to prevent water from flowing under the fence, thus bypassing the BMP.

A silt sock is a long, cylindrical tube that is essentially a mesh or fabric skin filled with a filter material such as straw, wood chips or compost. This BMP is designed to slow and trap sediment-laden runoff and allow trapped soil and nutrients to settle out before the water makes it to the nearest stream or drainage way.

Gravel construction entrances (or tire track-out prevention devices) are placed at entrances of construction sites to remove soil and mud from tires of vehicles as they exit the site. These devices can be a constructed as a section of coarse gravel, a steel grate, or as a tire washing area.

Seeding and hydro-seeding (spraying a mixture of seed and biodegradable fiber to help grass seeds adhere to slopes) are effective BMPs for holding soil in place after grading is complete. Timing and method of seeding is critical to its success, since seeding will not protect the soil immediately. Depending on the grass species, soil and climate conditions, seeds may take a month to three months to germinate and then grow to the point that plants will protect the soil from erosion.

Sediment basins are small, often temporary ponds created down-slope of disturbed soils at construction sites. These banked structures hold runoff and allow soil and sediment to settle out. Basins must be periodically cleaned to maintain their effectiveness and are most useful in areas with gentle slopes that don't receive large volumes of runoff. With excessive runoff, the functions of the basin can be overwhelmed. Once construction is complete, the berm or bank of the basin is removed, the soil is regraded to match the surrounding landscape, and the area is reseeded.

STREAMBANK BMPS

BMPs that reduce streambank erosion include vegetative and structural methods to protect streambanks during high-flow events, particularly on the outside of stream curves. In more severe cases, the bank may need to be reshaped and re-stabilized. Armoring of banks can be accomplished using rock, fiber material, or vegetation. Rock vanes and weirs or wood log structures can be used to direct flow away from the eroding bank. Willow staking and revetments have also been used with some success to stabilize banks. Stabilizing the streambank prevents soil erosion and nutrient and sediment deposition in the stream, while also preventing soil loss and property damage from properties adjacent to the stream.

Stabilization and repair of eroding streambanks is tricky, and projects typically do best when there has been an on-site assessment of problems by professionals, and the repair work is overseen by people with knowledge of how streams behave. Restoration work of the wrong kind, or in the wrong place, can cause increased damage to sites downstream. Because this work is so difficult to perform correctly, streambank BMPs are relatively expensive compared to other onsite BMPs.

ONSITE WASTEWATER (SEPTIC SYSTEM) BMPS

Failing or leaking septic systems can pollute ground water or surface water with bacteria, nitrogen, phosphorus and other pollutants. Best management practices for septic systems includes regular maintenance of the system and replacement or repair of all or part of a failing or leaking system.

The proper maintenance of septic systems depends upon the type of system. For conventional septic systems that contain a tank to capture solids and a gravity-fed leach field for dispersal of tank liquids, the tank should be pumped out every 3 to 5 years by a licensed professional. For more advanced systems, which may include aeration tanks with electric control panels and/or pressurized distribution pipes buried in a leach field, a professional maintenance service should be hired to periodically monitor the system and perform needed maintenance, usually on a six month to two year interval, depending on the type of equipment.

Whether a failing or leaking septic system needs to be replaced or repaired depends partially upon the condition of the various components of the system. Often a septic system will fail when tree roots or solids from the tank clog the drainage pipes in the leach field. In these cases, the leach field may need to be replaced and the system repaired. At sites with thin and/or rocky soils, steep slopes or high clay content, an advanced treatment system with a drip irrigation lateral field may be required.

MODELLING BMPS:

A series of meetings with SWAT modelers and resource management personnel indicated that it would be very difficult and complicated to try to model the performance of a variety of BMPs, all with different pollutant removal rates and ranges of removal rates, for the entire basin. Instead, the modelers suggested using a few "surrogate" BMPs with known ranges of removal efficiencies suited to the soils, geologic and land-use conditions in the James River Basin. Two surrogate

05

RECOMMENDED BEST MANAGEMENT PRACTICES FOR THE JAMES RIVER WATERSHED

Vegetative Buffer **(rural-agricultural)**	Cost to maintain: $60 to $1,000 per acre per year (dependent on land use production). 40% to 100% reduction in sediment and phosphorus from treated site.
Vegetative Buffer **(urban)**	Cost to impliment: $65 to $2,000 per acre (dependent on site, restoration design, land value). 50% to 90% reduction in sediment load from treated site.
Stormwater detention basin **(urban)**	Cost to impliment: $1.50 to $12 per cubic foot. 40% to 85% of sediment. 10% to 50% Total Phosphorus reduction, up to 80% Total Suspended Solids (with outlet filter) from treated site. Note: Modify to Bioretention Basin for better nitrogen and metals removal.
Rotational Grazing **(agricultural)**	Cost to impliment: $1,500 to $5,000 for additional fencing 25% to 75% percent phosphorus reduction from pasture areas.
Fencing cattle out of streams alternate water source **(rural)**	Cost to impliment: $1,500 to $5,000 up, depending on cost of fencing 95% to 100% percent phosphorus reduction from affected stream area.
Stream bank restoration eroding cut-banks	(re-shaping, armoring, erosion control, re-planting) $200 to $500 per linear foot initial cost. Maintenance varies and is reduced as restoration planting matures. 24% to 80% annual sediment load. 20% to 60% annual Total Phosphorus reduction from affected stream bank.

BMP types were selected for insertion into the model: filter strips (buffer strips along streams) and pasture and forage grass improvements, leading to increased soil health and infiltrative capacities. Four BMP scenarios were then selected to be used in the SWAT model to estimate sediment and nutrient loadings in the James River Basin:

Scenario 1: Practices for conservation of soil health in pasture areas. In this scenario, the influence of soil conservation practices, such as vegetative (forage) stand improvement, was simulated for modeling purposes by reducing the Soil Conservation Service Curve Number (SCS-CN) by a value of three (3) in all hay and pasture related hydrologic response units (HRUs). The SCS-CN is utilized in runoff modeling to simulate the amount of runoff generated within the HRU based on soil conditions.

Scenario 2: Vegetative buffer strips in pasture areas. For this scenario, it was assumed that a vegetative filter strip (VFS) approximately 50-feet (15 meters) in width would be established in all hay and pasture-related HRUs.

Scenario 3: Vegetative stream buffers in urban areas. For this scenario, it was assumed that a VFS approximately 30-feet (10 meters) in width would be established in urban HRUs. This width is smaller than in the pasture simulations because in urban areas development has typically already encroached more closely to the stream.

Scenario 4: A combination of all three of the scenarios described above.

Table 25 provides a brief description of the four scenarios.

For the BMP simulation model, the following baseline data were used to estimate current annual loadings of sediment, TN and TP. (Table 26) This data was derived by flow-weighted water quality sampling over many years at Galena, near the lower end of the James River Basin. The data was analyzed and summarized by personnel at the Ozark Environmental and Water Quality Institute (OEWRI). The technical report on this data is included as an appendix in this plan.

Table 25

BMP SCENARIOS

Scenario	Brief description	Area applied
1	BMP to conserve soil health in pasture areas	Pasture
2	A 15 m vegetative buffer in pasture areas	Pasture
3	A 10 m vegetative buffer in urban areas	Urban
4	All BMPs included	Pasture and Urban

Table 26

BASELINE ANNUAL LOADS FOR THE JAMES RIVER

Sediment (T/yr)	Total Nitrogen (lb/yr)	Total Phosphorus (lb/yr)
136,147	4,576,493	516,701

Table 27

PERCENT REDUCTIONS IN POLLUTANT LOADINGS EXPECTED UNDER FOUR BMP SCENARIOS

BMP Scenario	Sediment	Total Nitrogen	Total Phosphorus
1	4%	2%	6%
2	20%	34%	34%
3	4%	6%	9%
4	29%	39%	45%

Using the baseline water quality loading data and applying the four BMP modeling scenarios outlined above, the following basin-wide percent reductions in sediment, TN and TP were determined. (Table 27) Modeling of BMPs and their estimated loading reductions then provided information in terms of setting goals for each of the HUC-10 watersheds in the James River Basin. Those goals are found in chapter 6-11, which describe the water quality conditions and problems unique to each of those HUC-10 watersheds.

Water quality problems and potential management measures were discussed with resource personnel (technical committee list in the Appendix) in the James River basin during the development of this plan. The technical committee consisted of representatives from DNR, USDA, MDC, Missouri State University, Drury University, and city and county officials. Four face-to-face meetings were conducted during the development of this plan, along with numerous follow-up phone calls and interviews. Members of the technical committee reviewed the comments and suggestions from over 60 watershed stakeholders interviewed early in the planning process (Chapter 2). From these meetings and the information gathered, the following recommendations for management measures were developed in each of eight service areas: agriculture, wastewater, drinking water, urban stormwater, riparian areas, water monitoring, watershed programs, and education.

AGRICULTURE

- The USDA should increase the amount of cost-share dollars available for managed grazing systems, since there are more applicants in the basin than there is money available to pay for projects. Watershed-based, targeted EQIP funding would help increase the numbers of funding grazing systems in the sub-watersheds that need them the most. By keeping cattle out of streams (at least part of the time) and spreading animal wastes evenly around pastures, grazing systems are one of the most cost-effective water-quality enhancing practices available to agricultural landowners.

- Local resource personnel and watershed organizations should partner with the University of Missouri Extension and NRCS to promote additional regional grazing schools. The values of these intensive, three-day, hands-on educational events are widely recognized. NRCS and Extension could provide the expertise and teachers while other organizations could provide logistical support.

- Agricultural agencies should create SWAT model maps overlaid with the USDA geographic information (using the same scale and same sub-watershed units) depicting where BMPs have already been deployed in the watershed. In this way, managers can see what and how many BMPs already exist in areas that are shown by models to need BMPs. Maps would not be distributed to the public but would be used by resource agencies for program management.

- Rainwater harvesting should be in the docket of USDA-approved cost-share practices. Many barns have large roofs that could be used to collect huge volumes of rainwater. This has the added benefit of diverting roof runoff away from areas near the barn, which often contain high concentrations of animal waste.

- The Resource Conservation Partnership Program (RCPP) has been suggested as a good way for the USDA to extend technical and financial resources to landowners. Non-profit groups could fill some of the gaps created by reduced numbers of NRCS employees. However, the RCPP currently provides no salary support for partnering non-profits, making it difficult to get effective programs on the ground. The RCPP should allocate federal dollars for partner staff support.

- Allocations of funding for single practice (e.g., riparian fencing) contracts should be encouraged, since these are simpler to apply for and manage. This makes a good "first effort" at a cost-share practice that allows the producer to have an easy, gratifying experience with their first USDA cost-sharing project, and lets them get to know their local Soil and Water District and NRCS personnel.

- The Special Area Land Treatment (SALT) program (no longer funded) was helpful because it had a watershed-water quality focus. Resource personnel and watershed groups should encourage watershed targeting and addressing local resource concerns by providing consistent input to the NRCS state technical committee and local working groups.

- To help with assistance and outreach to Amish/Mennonite farmers in the basin, Ag agencies should bring in representatives who have had success working with these communities. Amish/Mennonite farmers should receive training on the benefits of USDA programs and practices that would improve their farming and profitability, including high tunnel systems, cover crops and rainwater harvesting systems.

- Ag agencies should provide opportunities for user feedback on website design and functions to make sure that there are no online impediments to getting programs on the ground.

- Ag agencies should educate landowners about the downsides of continuous hay cutting of grasslands, including impoverished soils, decreased infiltration and increased runoff. Programs to encourage grazing on these grasslands at least intermittently should be initiated.

- Ag agencies and NGOs should encourage large working farms as well as "hobby farms" to use better management practices, even in the absence of cost-share programs, as a way to protect soil and water quality, thus making their operations more sustainable, productive and profitable in the long term.

- Farmers should be encouraged and assisted in raising confined animals without the use of antibiotics. University of Missouri Ag-Extension is sponsoring studies on the effects of antibiotic use and is moving the industry towards reductions in use. These initiatives should be supported and encouraged.

- There should be more emphasis on timber stand improvement, agro-forestry, and silvo-pasture techniques in whole-farm planning. There is funding for these programs through EQIP. Timber could be a significant economic adjunct to farming, particularly since farms in the basin are often near urban areas. This would provide more incentive to keep trees growing on suitable sites and reduce pressure to clear timber for pastures on steeper or rockier sites that would be unproductive for forage, thus making "unproductive" portions of the farm more productive.

- Agricultural demonstration farms, like the one below Fellows Lake Dam, should be developed in the James River Basin. These provide excellent opportunities for educating landowners about better practices, both before and after practices are adopted.

ONSITE WASTEWATER

- More studies like the one conducted in Greene County in the 1980s, which attempted to quantify the problem of poorly treated effluent from onsite systems reaching surface water and groundwater, should be undertaken. The highest priority for study should be areas of concentrated onsite systems near the James River and Table Rock Lake.

- Additional bacterial source tracking should be done to determine the relative contributions of onsite wastewater systems to water quality degradation of surface and groundwater.

- Additional State Revolving Funds (SRF) should be made available for dealing with locating and replacing failing onsite wastewater systems.

- Counties in the James River Basin should be encouraged to initiate point of sale inspections of onsite wastewater systems. This has worked effectively in Stone County.

- Counties in the James River Basin should be encouraged to require maintenance contracts for advanced onsite wastewater systems.

- Funding should be provided to help offset the cost of replacing failing onsite wastewater systems. In many cases, homeowners do not have the money needed to install more advanced systems.

- Additional training for realtors on home water systems and onsite wastewater systems should be provided. Realtors have reported that training sessions held in the past were very useful and helpful.

DE-CENTRALIZED WASTEWATER SYSTEMS

(small sewage treatment plants, typically serving 10-100 homes)

- DNR should require some level of financial and technical capacity assurances for small wastewater treatment facilities in order to make sure these plants are well maintained and functioning properly for the long-term. New plants should not be permitted without this type of capacity assurance in place and signed off on before permits are issued.

- Owners of private wastewater facilities should have some organization or entity to turn to for technical support and information regarding rules and regulations.

COMMUNITY WASTEWATER SYSTEMS AND POTWS

(Publicly owned treatment works)

- Small communities should focus on sustainable solutions for wastewater facilities. In many small communities, people are leaving, and relative income levels are declining. Expensive, complex facilities should not be installed that have no realistic chance of being well maintained and operated for the long-term.

- Technologies and programs to remove pharmaceuticals and personal care products from wastewater and biosolids need to be developed, along with community drug take-back events and information disseminated on proper disposal of unused drugs.

DRINKING WATER

- Source water protection plans for water providers in the James River Basin should be integrated with the watershed plan to make sure the goals of the plans align.
- Communities should seek funding sources for acquisition or easements on buffer lands near or upstream from drinking water intakes, especially if these lands contain pollution sources that threaten the quality of drinking water.
- Communities should be encouraged to develop well-head protection programs. Missouri DNR will provide technical assistance to help communities develop effective programs.
- Communities, water providers and NGOs should encourage programs designed to reduce the use of drinking water for non-drinking purposes.

URBAN STORMWATER PROGRAMS

- The MS-4 communities in the basin, including Greene and Christian counties and the cities of Springfield, Ozark, Nixa and Republic, should continue partnering with watershed groups and non-profits to improve and expand stormwater education opportunities and special projects such as soil testing, rain barrels, and rain gardens.
- Funding sources for sustainable stormwater management programs should be sought by communities in the James River Basin. The "stormwater utility" concept should guide this discussion, since the stormwater system is in fact a utility akin to water and sewer systems. Community stormwater programs need a consistent, stable source of funding in order to do watershed planning as well as day-to-day activities such as plan reviews, routine maintenance and inspections.
- The city of Springfield, because its stormwater programs are advanced and tested, should take a lead in mentoring other urbanizing communities in the basin. Other communities look to Springfield for technical guidance and educational resources. This should include planning and implementing educational events such as workshops and conferences related to watershed planning and stormwater management.
- Tools and support are needed for urban tree canopy enhancement as a stormwater management strategy, including tree preservation and planting ordinances and adequate funding for community forestry efforts.
- Communities should seek funding for MDC Community Conservation Grants that combine stormwater management strategies with projects to protect and enhance riparian areas, aquatic habitat, and forests and vegetated riparian areas, including erosion protection and invasive species management.
- Local jurisdictions should review their regulations and remove or modify those that are barriers to a developer or resident's ability to implement conservation practices.
- Local jurisdictions should update in-house management guidelines and procedures so

that best practices for water quality are used on public lands, including water conservation and native landscaping techniques.

- Agency support and funding sources should be sought for cost-share programs for property owners and developers who are interested in applying low impact development techniques above and beyond minimum permit requirements

- Developers and property owners should have access to technical assistance for incorporating conservation and water quality improvement practices that will maintain and improve water quality, wildlife and stormwater management.

STREAMS AND RIPARIAN PROGRAMS

- Resource agencies should offer additional cost-share opportunities to landowners for protecting and restoring riparian areas, alternative watering for livestock, etc. To the extent possible, program dollars should be leveraged with those from multiple agencies to provide strong incentives for landowners to participate.

- Communities should be encouraged to adopt stream buffer requirements. Springfield's stream buffer requirements provide one model for consideration.

- Agency support and funding sources should be sought for stream restoration projects, including stream daylighting, restoration of channelized streams, and riparian corridor improvements on urban streams, including small tributary stream channels.

- State, county and local road and bridge departments should consult with the Missouri Department of Conservation as road crossings are replaced in order to reduce aquatic organism passage barriers. Barrier-free passages not only help aquatic life, but also allow for natural stream processes such as sediment transport.

WATER MONITORING PROGRAMS

- A "monitoring group" should be set up that meets on a regular basis to discuss topics connected to water quality and quantity monitoring, to work together on special projects, to share information and results, and to cooperate on the development and implementation of monitoring plans. This group should include people monitoring for stormwater, wastewater and drinking water programs. This does not have to be an "official" organization or new group, but rather should be an informal group that meets occasionally or as needed. The JRBP could play a role in logistical support or planning for this group.

WATERSHED PROGRAMS

- The goals and strategies in the watershed plan, to the extent possible, should support and align with the goals and strategies of the Springfield/Greene County Integrated Plan for the Environment.

- The Missouri Department of Conservation (MDC) should consider funding "watershed planner" positions that would work closely with other agencies and organizations to provide proactive programs for riparian and watershed protection.

EDUCATION AND OUTREACH

- Non-governmental organizations (NGOs) such as watershed groups need to help with regular communication between the different stake-holder groups in the basin, such as farmers, ranchers, the development community, public officials, businesses, etc. These groups must communicate often and effectively if the goals of the watershed plan are to be met.

- The JRBP should focus efforts on enrolling landowners along the James River and its tributaries as members of the organization. This would provide a very effective means of direct outreach to landowners whose activities can directly affect waterbodies and water quality. The goal of the JRBP should be to extend memberships to as many riverside landowners as possible.

- NGOs should work with cities, counties and resource agencies to design and implement targeted events and workshops, such as media workshops (for the media), field trips for local officials, and workshops and field trips related to agricultural best management practices, green infrastructure and low-impact development

- NGOs should provide services in support of communities with MS-4 stormwater permits, including public education and cooperative projects, so that communities don't have to create their own education programs to satisfy permit requirements.

- NGOs should help to promote and disseminate agricultural newsletters to the whole community. These organizations should provide ideas and articles for newsletters and should encourage readers to pass this information along to friends and family who may be connected to agriculture.

- Communities and NGOs should encourage best management practices for urban yard management and make information readily available on soil health, nutrient management, native landscaping, the reduction or elimination of chemical use, mulching, composting and pet waste management.

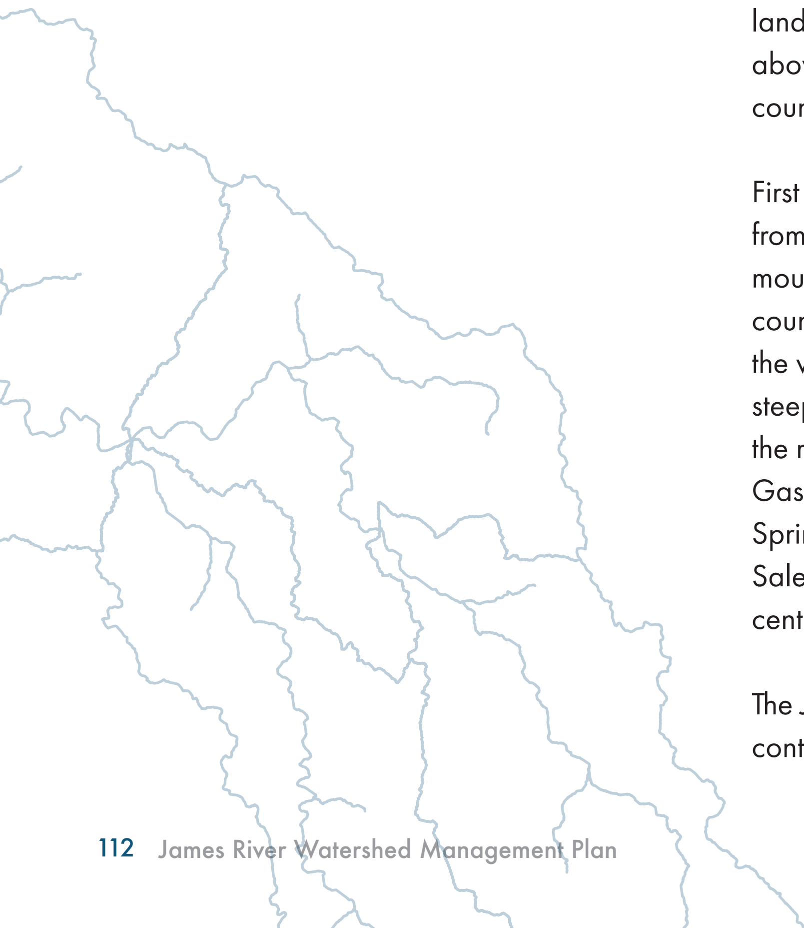
- Communities, Ag agencies, resource agencies and NGOs should encourage water conservation and conservation techniques such as low-flow fixtures, cover crops, rainwater harvesting and gray water reuse.

- Communities should examine policies that deal with the use of gray water and rainwater and where possible, remove barriers to wider implementation of these conservation measures.

- Communities, businesses and NGOs should actively work to remove single-use plastics from the environment.

06

Action Plan for James River Headwaters HUC-10 Watershed



WATERSHED SETTING

The headwaters of the James River lie in Webster County about forty miles east of Springfield. Flow in the James River begins at about 1740 feet of elevation. This is only about thirty feet lower than the highest elevation in Missouri. The broad, gently sloping lands north and south of U.S. 60, along the upper James and Finley Rivers, represent some of the highest contiguous lands in the state. Webster County has more land above 1,600 feet of elevation than any other county in the state.

First flow of the James River headwaters occurs from a small pond five miles northeast of Seymour. Traveling a mile east of this pond on a county road affords an outstanding view from the watershed divide, looking east over the steeply sloping Eureka Springs Escarpment into the rugged headwaters of the Woods Fork of the Gasconade River. This escarpment separates the Springfield Plateau to the west from the larger Salem Plateau, to the east, which makes up the central portion of the Ozarks Highlands.

The James River Headwaters HUC-10 Watershed contains 172,506 acres, or 269.5 square miles, and lies in two counties—the central portion of Webster County and the eastern portion of Greene County. The watershed is about evenly split between pasturelands and forests. Forests are found primarily on the steeper slopes near rivers, creeks and minor drainages. The land is generally flat on watershed divides, especially on the divide between the upper James River and Finley Creek to the south. U.S. Highway 60 generally follows this watershed divide (as does the railroad), passing through the communities of Seymour, Diggins, Fordland and Rogersville.

Historically, the land in this area has been used primarily for farming. In 1910, over 80% of the land in Webster County and over 90% of the land in Greene County was being farmed. Cattle raising has been a major agricultural enterprise in both counties, a use that continues today. In 1990, Webster County was second in the state for beef cattle production. The area north of Seymour, and to a lesser extent south of the city, is an Amish farming community. Amish farms tend to be clustered into contiguous areas in Greene and Christian Counties, both north and south of U.S. 60 Highway.

Around 1870, farmers near Seymour began cultivating fruit trees. Apples were the chief cash crop by 1900. From 1900 to 1910, Webster County was a leader in fruit production, with grapes, peaches and pears grown. By the 1920s, both Greene and Webster counties had become centers for orchard fruit growing, with apples especially prominent. In 1925, the county was one of the largest strawberry producers in the state. Tomato growing was also common in the watershed. Between 1900 and 1940, there were over 300 tomato canneries in Webster County alone.

Mining activities were once more prevalent. Lead mining occurred historically in the southeast part of Webster County, with almost 2,000 tons of lead produced in 1876. Sandstone near the community of Marshfield has been used in the production of glass. In the Pearson Creek area, there were several lead and zinc mines operating from the 1830s to about 1916.

The James River normally has perennial flow below the large Mountaindale Spring in Webster County. Other springs add to the flow, with Rumfelt Spring and Bell Spring two of the larger ones. Danforth Springs and Okino Dairy Spring provide a large portion of the flow to Pearson Creek, and more is added by Jones and Bonebrake Springs in the lower portion of the Pearson Creek sub-watershed. There is one USGS gaging stations in the watershed, located at Kinser Bridge southeast of Springfield. This gage has been in operation since 1955. The highest recorded flow was on June 19, 2015 at 50,900 cubic feet per second.

The USGS has delineated eight HUC-12 sub-watersheds within the Headwaters James River HUC-10 watershed (shown as numbers 1, 2, 3, 4, 5, 6, 7, and 9 on Figure 24 on the following page).Those sub-watersheds are listed below along with some of their general characteristics:

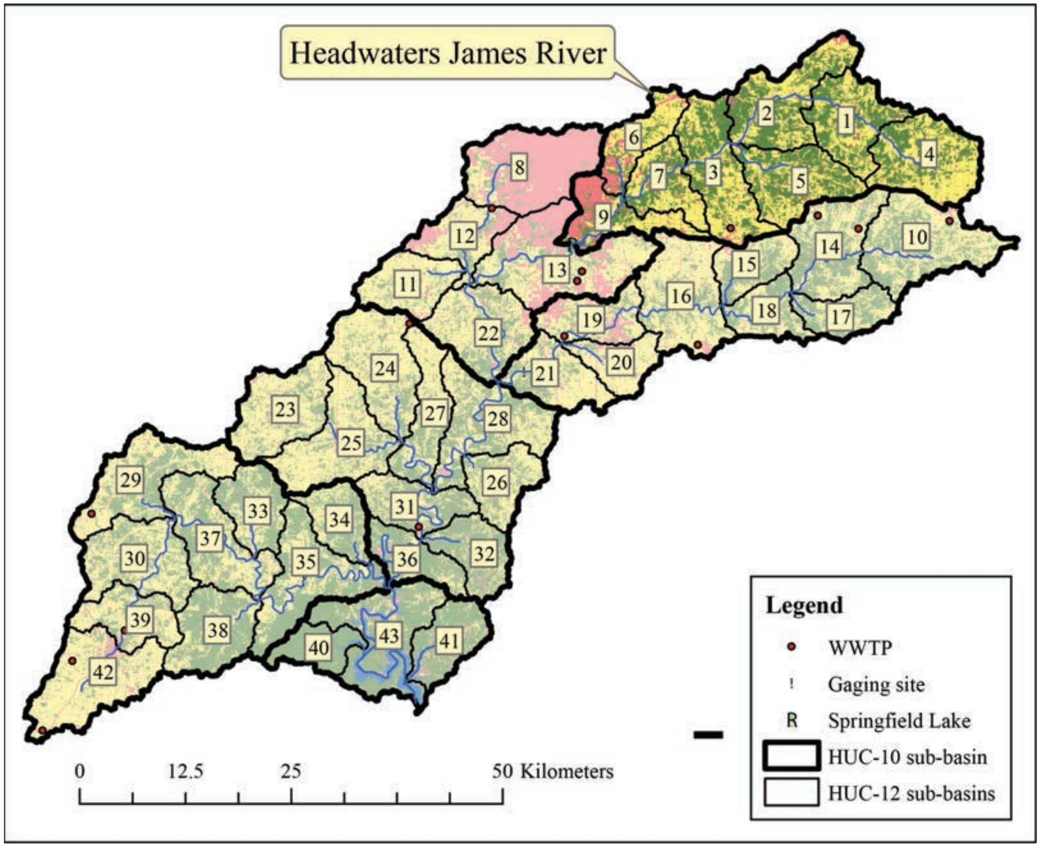
Map ID 1: Dry Creek-James River (21,867 acres): About 50% pastures on flat to gently sloping land and in stream bottoms; about 45% forested, mainly on steeper slopes near streams and in woodlots; about 2% cultivated corps in center of sub-watershed; less than 1% urban; no community wastewater discharges, and no permitted animal feeding operations; more rugged topography along the valley slopes of the James River and Clubhouse Creek in the northern part of the sub-watershed.

Map ID 2: Turnbo Creek-James River (26,993 acres): About 50% pasture lands, on flat to gently sloping land and in larger stream bottoms, mainly southwest of Marshfield; about 45% in forests, mostly on sloping terrain near drainages and in large woodlots; about 3% urbanized, mainly south side of Marshfield; a few isolated areas of crop cultivation (less than 1%); southern one-third of the city of Marshfield, including a major industrial area, drains to Turnbo Creek; city of Marshfield grew almost 8% between 2010 and 2016, including significant residential development to the south of the city in the Turnbo Creek sub-watershed; city of Marshfield's treated wastewater is discharged to the north, into the Niangua River Basin; Turnbo Creek south of Marshfield is rather scenic, with several small bluffs along the creek.

Map ID 3: Sayers Creek-James River (27,153 acres): About 55% forested, with large areas of contiguous forest on slopes along James River and in large woodlots; Broad Creek and Davis Creek, James River tributaries, have steep topography and are mostly forested; Davis Creek, in particular, has one of the largest areas of contiguous forest of any creek in the upper James River watershed; about 40% pasture on flat to

06

Figure 24: James River Basin with Headwaters James River Watershed



Map No.	Sub-watershed Name	Map No.	Sub-watershed Name	Map No.	Sub-watershed Name
1	Dry Creek-James River	16	Parched Corn Hollow-Finley Cr.	31	Pine Run-James R.
2	Turnbo Creek-James R.	17	Stewart Creek	32	Railey Creek
3	Sayers Creek-James R.	18	Squaw Run Creek-Finley Cr.	33	Jenkins Creek
4	Headwaters-James R.	19	Spout Spring Hollow-Finley Cr.	34	Dry Creek-James R.
5	Panther Creek	20	Elk Valley	35	Flat Creek
6	Pearson Creek	21	Finley Creek	36	Wilsons Run-James R.
7	Turner Creek-James R.	22	Green Valley Creek-James R.	37	Willow Branch-Flat Cr.
8	Headwaters Wilsons Cr.	23	Upper Crane Creek	38	Rockhouse Creek
9	Lake Springfield-James R.	24	Spring Creek	39	Corder Hollow-Flat Cr.
10	Headwaters Finley Cr.	25	Middle Crane Creek	40	Piney Creek
11	Terrell Creek	26	Goff Creek	41	Aunts Creek
12	Wilsons Creek	27	Lower Crane Creek	42	Headwaters Flat Cr.
13	Ward Branch-James R.	28	Tory Creek-James R.	43	Table Rock Lake-James R.
14	Davis Branch-Finley Cr.	29	Little Flat Creek		
15	Pedelo Creek	30	Gunter Creek-Flat Cr.		

gently sloping land and in large stream bottoms, especially along the James River; at least one large dairy in the sub-watershed; 2% urban, including south side of Strafford and north side of Rogersville; Rogersville, on the Webster, Greene County line (population 3,300) has seen tremendous growth in the last decade (7.6% from 2010 to 2014) and, like Marshfield, is one of the fasting growing communities in the James River Basin; Rogersville wastewater treatment facility (550,000 gallons per day) discharges into Sayers Creek; increasing residential development north of Rogersville and large-lot residential development near the mouth of Sayers Creek; no permitted animal feeding operations.

Map ID 4: Headwaters James River (26,884 acres): About 50% in pasture on flat to gently sloping land and along stream bottoms; about 45% forested, mostly on steeper slopes and in large woodlots; isolated areas of cultivated crops in center of sub-watershed (1%); about 2% urban development, including north side of Seymour and small community of Diggins, both along Highway 60; Diggins wastewater treatment plant, serving a population of about 300 (136,000 gallons per day), discharges to a small tributary of the James River; Diggins is one of the few towns in the James River Basin which has a wastewater discharge well in excess of the "design flow;" the city of Seymour (population 1,950) discharges its treated wastewater to the south, into a tributary of Finley Creek; no permitted animal feeding operations. An area of Amish farms is concentrated near Seymour and Diggins; on many farms, animals are concentrated in small lots where grass has often been overgrazed; many poultry or hog houses, but unlike the very large poultry operations in the Flat Creek watershed, these are small to medium sized; one large dairy operation at the confluence of West Wildcat Creek with the James River, with an area around this dairy denuded of vegetation; during windshield surveys, small groups of cattle (10-20) were seen standing at several places in the James River.

Map ID 5: Panther Creek (23,189 acres): Relatively rugged topography and about 65% forested, mostly on steep slopes near drainages and in woodlots; about 30% pasture on gently sloping land, flat drainage divides (e.g., between Panther Creek and Dry Creek) and in larger stream bottoms, especially the wide valley bottom of Panther Creek; about 1% developed area at Fordland and along 60 highway on south edge of sub-watershed; Fordland (population 800) is the only town of significant size in the sub-watershed; surface drainage from Fordland goes to Panther Creek, but the city's treated wastewater (137,000 gallons per day) is discharged into Turkey Creek, a tributary of Terrell Creek, which flows into Finley Creek; there are no permitted animal feeding operations; Devil's Den is a deep, steep-sided sinkhole located a few miles west of Fordland.

Map ID 6: Pearson Creek (14,624 acres): About 70% pasture lands on flat or gently sloping lands; one large dairy operation in north part, with some areas of denuded vegetation; about 20% urbanized, especially on the west side of the sub-watershed along U.S. 65 Highway near Springfield; much of the urbanized land is in large-lot residential subdivisions; Little forest left (about 10%) except on steep slopes near Pearson Creek; Jones and Bonebrake Springs drain large sinkhole areas on the east side of Springfield, including extensive zones of commercial and industrial development; no community wastewater discharges into Pearson Creek, as this stream has been designated a "Metropolitan No-Discharge Stream" in the state water quality standards; however, a large trunk sewer runs

Table 28

TOTAL PHOSPHORUS VALUES

Site	Years Sampled	TP (ug/l) mean	TP (ug/l) max.
James River at Highway B	2001-2002	20	57
James River at Kinser Bridge	2001-2003	38	151
Panther Creek at Highway B	2001-2002	40	106
Pearson Creek	2001-2005	48	430

Table 29

TOTAL NITROGEN VALUES

Site	Years Sampled	TP (ug/l) mean	TP (ug/l) max.
James River at Highway B	2001-2002	346	10,750
James River at Kinser Bridge	2001-2003	1,234	23,120
Panther Creek at Highway B	2001-2002	693	20,280
Pearson Creek	2001-2005	2,694	20,240

down the valley of Pearson Creek, connecting the large pumping station in Strafford with the Springfield Southwest Wastewater Treatment Plant; in the past, lead and zinc mining occurred near the mouth of Pearson Creek; no permitted animal feeding operations.

Map ID 7: Turner Creek-James River (15,305 acres): About 60% pasture, mainly on gently sloping lands or flat drainage divides; compared to other sub-watersheds, fairly large (about 3-4%) percentage of land in cultivated crops, mostly along Highway 125, including alfalfa, corn and soybeans. About 25% forested, mostly on steeper slopes along the James River and in large woodlots; about 5% urban, including large subdivisions east of Springfield and near the James River; regional pipeline crosses north part of sub-watershed; no permitted animal feeding operations.

Map ID 9: Lake Springfield-James River (16,542 acres): About 60% pasture and grasslands on flat to gently sloping lands and in stream bottoms, mainly in eastern half of sub-watershed; about 30% urbanized, containing a large portion of southeast Springfield and residential development north and south of Lake Springfield; land near Galloway Creek, flowing into Lake Springfield, is heavily urbanized; about 10% forested, mainly on steep slopes near the James River; sub-watershed includes Lake Springfield, a 300-acre impoundment used as cooling water for the City Utilities James River Power Plant; no wastewater discharges in sub-watershed but Sequiota Spring, which provides most of flow in Galloway Creek, has in the past been contaminated by onsite wastewater systems (septic tanks) in the village of Galloway; most of the spring's recharge area is now served by municipal sewers and water quality has improved; a large quarry is located on the west side of Galloway Creek; no permitted animal feeding operations.

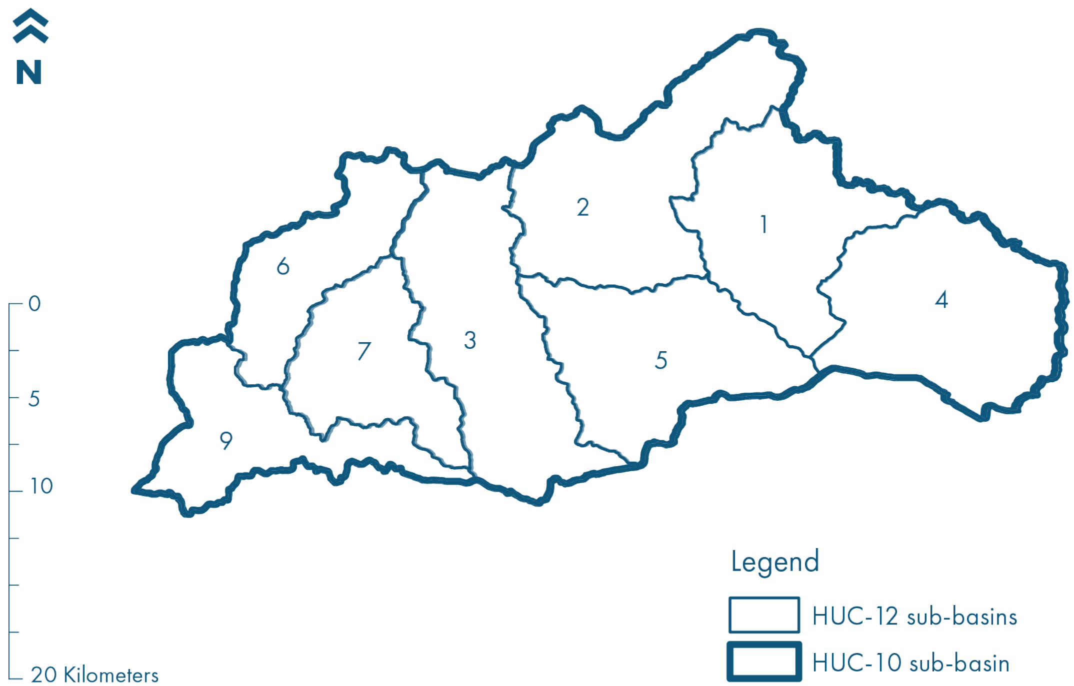
MODELING AND CRITICAL AREA IDENTIFICATION

Critical areas as identified in this plan include: 1) watersheds or sub-watersheds identified in the model as likely to contribute excessive loadings of total nitrogen (TN), total phosphorus (TP) or sediment to waterbodies; 2) watersheds or sub-watersheds of waterbodies which have been placed on the 303-d list and identified as impaired, and 3) watersheds or sub-watersheds contributing source water to public drinking water supplies.

By these definitions, sub-watershed 9 (Lake Springfield-James River) in the Headwaters James River HUC-10 watershed has been shown in the SWAT model as likely to contribute excessive loads of sediment, total TN and TP, much higher than the remaining seven HUC-12 sub-watersheds in the Headwaters James River HUC-10 watershed (see figure 25). Sub-watershed 6 (Pearson Creek) ranks second of the HUC-12 sub-watersheds in likely loading contributions of TN and TP. These sub-watersheds are also the closest to the Springfield urban area and the most urbanized of the Headwaters James River sub-watersheds, with about 20% of the Pearson sub-watershed and 30% of the Lake Springfield-James River sub-watershed urbanized.

The second category of Critical Areas as defined in this plan include those sub-watersheds con-

Figure 25: Land Uses in James River Basin HUC-10, HUC-12 Sub-watersheds.



Rank	Sediment (Mg/km^2)	Sub-basin	TN (kg/ha)	Sub-basin	TP (kg/ha)	Sub-basin
1	516	9	41.4	9	2.6	9
2	372	5	36.3	6	1.7	6
3	318	4	23.9	4	1.2	1
4	313	1	23.1	3	1.2	7
5	263	2	22.9	7	1.1	5
6	248	3	15.1	2	0.9	4
7	224	7	14.8	5	0.8	2
8	189	6	13.3	1	0.7	3

tributing flow to waterbodies which have been placed on the 303-d list of impaired waters. In this category are the James River, 39 miles of which is on the 2020 proposed 303-d list for E. coli, Pearson Creek, 8 miles of which is on the 2006 list for E. coli, and the 2008 list for aquatic macroinvertebrate bioassessment (reduced diversity of macroinvertebrates, unknown causes), and Lake Springfield, 293 acres on the 2020 proposed 303-d list for chlorophyll a (excessive algae). During E. coli monitoring sponsored by the city of Springfield, Pearson Creek has been shown to have consistently high levels of these bacteria. As part of volunteer-based water quality "snapshot" sampling in the summers of 2013, 2016 and 2019, the two sites on Pearson Creek had the highest E. coli levels of any of the other 68 sites in the James River Basin. Therefore, Pearson Creek will also be a targeted priority area for the identification of sources of bacteria into the creek and shallow groundwater system.

Lake Springfield is on the 303-d list of impaired waters for excessive chlorophyll-a, a measure of increased algal production. There is about 270 square miles of watershed above Lake Springfield contributing flow, as well as sediment and nutrients, to the lake. Sub-watershed 9 (Lake Springfield-James River), however, has been shown by the SWAT model to have by far the highest loading potential for sediment, TN and TP of any of the eight sub-watersheds in the Headwaters James River HUC-10. Therefore, sub-watershed 9 will also be considered a Critical Area among the 303-d listed sub-watersheds.

The third category of critical areas are those sub-watersheds contributing flow to source waters for public drinking water supplies. All the sub-watersheds in the Headwaters James River HUC-10, exclusive of number 9 (Lake Springfield-James River) contribute significant flow to the city of Springfield's public drinking water supply. However, Pearson Creek empties into the James River less than one mile above the city of Springfield's Blackman James River drinking water intake. Laboratory personnel at the City Utilities Blackman Water Treatment Plant have expressed concerns about levels of Cryptosporidium spores in Pearson Creek above the intake. For this reason, Pearson Creek will be targeted for the identification of sources and pathways for microbes and for the development of management practices both to protect the public water supply as well as to help to remove it from the list of "impaired" waters.

The Table 31 provides the three sub-watersheds in the Headwaters James River HUC-10 watershed identified as Critical Areas and the pollutants targeted in each sub-watershed.

RECOMMENDED MANAGEMENT MEASURES

Except for areas near Springfield in the Pearson Creek and Lake Springfield-James River sub-watersheds, most of the lands in this HUC-10 watershed are in agricultural uses. The most common agricultural use is grazing of beef cattle on pastures. There are no large confined animal feeding operations in the watershed, but there are several smaller operations, including small turkey and hog-raising facilities.

Small growing houses have become more common in recent years, especially among the Amish communities in the uppermost headwater sub-watershed north of Seymour. Through windshield surveys, several farming operations in these areas have been found to have significant numbers of cattle or hogs on small lots, which are often overgrazed or rooted and trampled, therefore having poor vegetative covers. Further, many of these animals have direct access to small springs or spring-fed creeks for watering purposes. Many if not most of these farms use manure for fertilizer. Riparian covers are typically poor to entirely absent along small streams and spring branches.

Promoting and implementing better practices in these rural communities will require a special approach, as historically these farmers do not utilize government technical assistance or cost-share. Recently, several farmers have shown interest in vegetable raising. The NRCS has promoted the use of high tunnels for this type of farming, and several of these have been installed. Local NRCS and USDA agency personnel should seek assistance from counterparts in other parts of the state or elsewhere who have had success with outreach and assistance efforts directed toward Amish and Mennonite farmers.

Recommended agricultural management measures for agriculture in this HUC-10 include the installation of managed grazing systems, the provision of alternative watering systems, protection and enhancement of riparian zones and pasture stand improvements. Targeted funding can be provided through the USDA EQIP program for these practices. Sub-watershed 4, the Headwaters James River sub-watershed, should be targeted for agricultural BMPs that will prevent overgrazing and protect or establish vegetated riparian zones along small creeks and spring branches. The provision of alternative watering sources for cattle should be a priority in farms where animals now have direct access to long runs of creeks or spring branches.

Table 31

Critical Area (Sub-watershed)	Targeted Pollutant/Problem
Lake Springfield-James River	Sediment, TN, TP
Pearson Creek	Bacteria *(E. coli)*, loss of macro. diversity
Headwaters James River	Sediment, TN, TP

The other major source category in this HUC-10 watershed is urban stormwater runoff, primarily in the lower (southwestern) part of the watershed. Most of the urban growth in the last ten years has been in the Pearson Creek Sub-watershed east and southeast of the city of Springfield. Practices recommended for these areas include stormwater detention basins, extended detention basins, vegetated buffers along streams and drainageways, rain gardens, green roofs, and bioswales and biofilters. The city of Springfield is currently looking to retrofit standard stormwater basins into extended storage basins by modifying outlet structures. In a sustainable return on investment (SROI) study as part of the city's Integrated Plan for the Environment, these practices haves been shown to have a positive benefit to cost ratio. Because Pearson Creek is a part of the city's public drinking watersheds, and because it is currently on the 303-d, urban stormwater practices will be targeted in this basin.

Urban stormwater practices for new construction sites include sequencing of construction operations, silt fences and silt socks, gravel construction entrances, sediment basins, and seeding or hydro-seeding and mulching exposed soils. Springfield, the only Phase I permitted city in the basin, has rigorous stormwater management and sediment and erosion control programs. All the Phase II stormwater communities in the basin also have sediment and erosion control programs for new development. These communities are doing the best they can to deal with high levels of urban and suburban development, but often suggest that funding is needed for more aggressive oversight and enforcement.

06

Only two sub-watersheds in the Headwaters James River HUC-10 watershed are more than 5% urbanized: 1) Lake Springfield-James River, at 30%, includes most of southeast Springfield, the area, and development north and south of Lake Springfield; 2) Pearson Creek, about 20% urbanized, with most of the development in the southern and southeastern portions of the sub-watershed near and in Springfield. These sub-watersheds both fall within the purview of either a Phase I stormwater permitted community (Springfield), or Phase II communities (Greene and Christian Counties). Both Phase I and Phase II communities are requiring stormwater management BMPs. As the first Phase I permitted entity in Missouri, the city of Springfield was required to develop practices and procedures that in many ways serve as a guide for Phase II communities. Springfield has been a leader in providing education and training opportunities for stormwater professionals. Many engineering consultants and contractors work in both Springfield and the outlying communities. Thus, practices developed for the city of Springfield permit requirements are frequently applied when developing projects in other communities, even where these practices are not expressly required.

Several areas of severe streambank erosion occur in this watershed. There are some very large cut banks along the James River upstream of Springfield. It is estimated that about 15% of the linear stream miles of the James River need bank protection and stabilization measures. Large bank erosion problems may need hard armoring, rip-rap or bendway weirs. Grading of flaring of banks, vegetative reinforcement mats and stone toes or gabion baskets may also be required in areas of severe erosion.

Recommended measures for onsite wastewater systems include better siting and design of facilities, and periodic inspection and maintenance of systems. Better siting and design are already occurring in Greene and Christian Counties, as both counties have required soil pit evaluations for onsite system design for many years. When site conditions indicate, advanced systems must be used, above and beyond the traditional "septic system" design. However, neither county requires maintenance contracts for advanced systems or "point of sale" inspections. "Point of sale" inspections have been used by Stone County to successfully promote system maintenance. Greene and Christian counties should consider adopting such a program. Watershed organizations such as the Watershed Committee of the Ozarks and the James River Basin Partnership have for years sought to educate homeowners about the need for periodic maintenance of onsite systems. Rebate programs for septic tank "pump outs" have been used very successfully in the basin, with heavy public participation.

The problems of high E. coli and worrisome levels of Cryptosporidium spores in Pearson Creek are not well understood. This is especially problematic since Pearson Creek discharges into the James River a short distance upstream of the Blackman James River public water supply intake. The city of Springfield conducted a seepage analysis of the Pearson Creek trunk sewer to determine if this was the likely source of high bacterial counts in the stream. There were a few elevated sites below certain sewer line crossings but results of the study were inconclusive. Further, there have been high bacterial readings at springs above the urban and sewer influences. Both bacterial and protozoan parasite concentrations are higher when Pearson Creek is at high flows and therefore turbid. For this reason, the community drinking water provider, City Utilities of Springfield, tries not to use the James River during times of high turbidity. CU would like to build a second, "redundant" pipeline from Fellows Lake to the Blackman Treatment Plant in southeast Springfield. The second pipeline would be available if problems occur with the existing pipeline during times when the James River can't be used.

The management measures needed to address these concerns in Pearson Creek include: 1) A better understanding of the sources and pathways for E. coli and Cryptosporidium in Pearson Creek. This could include source tracking of organisms in the creek or in the major springs feeding into Pearson Creek, focused microbial monitoring over time in the creek and springs, optical brightener studies on springs, or all of these. 2) Once sources have been identified, the application of practices which are designed to reduce the discharge of bacteria and protozoan parasites into surface waters or shallow groundwater. These will most likely include better design and construction of onsite systems (already occurring with new systems, but many old systems are still out there), getting more homes with onsite systems hooked onto city sewer, maintenance programs for existing systems, setbacks of cattle raising areas (especially pens for calves) from streams and sinkholes, and good vegetated buffers around sinkholes and along streams in both urban and agricultural areas.

GENERAL GOALS FOR THE HUC-10 WATERSHED

There are about 75,000 acres of pasture/hay land in this watershed above the drinking water intake for the city of Springfield. A goal would be to have at least 25% of pasture lands in managed grazing systems within 20 years, or 18,750 acres.

Most of the land in this Watershed outside the Springfield Urban Service Areas is served by onsite wastewater systems. A goal is to have Greene and Webster Counties develop point-of-sale inspections for onsite systems and require management contracts for advanced onsite system within 10 years. Septic tank pump-outs improve the performance of onsite wastewater systems and provide a vehicle to educate homeowners on system performance and maintenance. A goal is to perform 200 pump-outs in this watershed within 20 years.

PEARSON CREEK HUC-12 SUB-WATERSHED

Pearson Creek has shown consistently high levels of E. coli for several years. City Utilities of Springfield, the municipal water provider, has also expressed concerns about the potential for Cryptosporidium cysts in the James River raw water supply. For these reasons, a primary goal in the Pearson Creek sub-watershed is to better understand the sources and pathways of these organisms in the sub-watershed within five years. This includes looking at leaking municipal sewers, onsite wastewater systems, livestock operations and a large dairy operation in the Pearson sub-watershed as potential sources of organisms. Bacterial source tracking and optical brightener sampling of springs are two potential ways to help determine the likely sources of organisms.

About 15,000 acres in the Pearson Creek sub-watershed are urban or urbanizing. Over the last ten years, about 30% of the urban growth of Springfield has been in this sub-watershed. During its Integrated Plan process, the city determined that retrofitting traditional detention basins into extended detention basins by modifying outlet structures had a relatively high benefit to cost ratio. Retrofitting does not require any additional land disturbance and is simple and relatively inexpensive to accomplish. Eight standard detention basins in the Pearson Creek sub-watershed have been identified as suitable for retrofits. These basins would collectively receive drainage from 14,567 acres. The goal of this plan is to have all eight basins retrofitted within 20 years. Estimated load reductions for these basin retrofits were calculated using data from the city of Springfield basin retrofit study (City of Springfield, 2017).

Healthy riparian zones are some of the best water quality management BMPs available. Because of the proximity of Pearson Creek to the city of Springfield drinking water intake on the James River, vegetated riparian zones along this creek are especially important. The lower section of Pearson Creek has relatively healthy riparian zones, but the width and quality of riparian zones diminishes in the upstream reaches. A goal of this plan is to have 25 acres of additional healthy riparian zones along Pearson Creek within 20 years. Estimated load reductions from these added riparian zones were calculated using the OEWRI modeling results, which showed average reductions per acre per year. Adding stream buffers in urbanized areas is difficult, but the city of Springfield now has a stream buffer ordinance that will help protect intact riparian zones during new development.

Ideally, once protected, riparian zones should be placed into some type of long-term protective status such as a conservation easement. The James River Basin Partnership is currently using 319 grant funding to help secure easements along Wilsons Creek. This is a trend that will hopefully continue in urban areas, although it is difficult. The goal in the Pearson Creek sub-watershed is to have at least 50 acres of healthy riparian zones placed into protective easements within 20 years.

LAKE SPRINGFIELD-JAMES RIVER HUC-12 SUB-WATERSHED

About 8,100 acres in this sub-watershed are urban or urbanizing. There are 17 detention basins in this sub-watershed considered adequate for outlet retrofits. These 17 basins collectively receive drainage from 6,820 acres. The goal of this plan is to have all 17 of these basins retrofitted within 20 years.

The lower sections of Galloway Creek, including areas that run through Sequiota Park, lack healthy riparian zones, as do the middle and upper sections of Farmers Branch. The goal of this plan is to provide and additional 25 acres of healthy riparian zones within 20 years.

HEADWATERS JAMES RIVER SUB-WATERSHED.

This sub-watershed contains the bulk of the Amish farms in the James River Basin. These producers have not been amenable to the standard cost-share programs and recommended management measures available from the USDA. A goal for this sub-watershed is the development of an effective outreach and technical assistance program for non-traditional agricultural producers, especially the Amish community. Programs should be designed for acceptance and buy-in for the need to be good stewards of the land and water in ways that fit the farmer's lifestyles and belief systems. The goal is to have such programs developed and in use within five years.

GOALS FOR THE HEADWATERS JAMES RIVER HUC-10 WATERSHED

05 Years

- Effective outreach and technical assistance for Amish communities
- Understanding sources and pathways for bacterial contamination in Pearson Creek

10 Years

- County point-of-sale inspections of onsite wastewater systems
- County requirement of maintenance contract for advanced onsite wastewater systems

20 Years

- 50% of drainage area of Pearson Creek draining through riparian buffers
- 18,750 additional pasture acres in managed grazing systems. 423,50 lbs of sediment, 3,750 lbs of TN, and1,300 lbs of TP reduced per year.
- 200 septic system pump-outs
- 2,500 linear feet of bank erosion protection/stabilization measures. 152,500 lbs of sediment, 950 lbs of TN, and 125 ilbs of TP reduced per year.
- 8 detention basin retrofits for Pearson Creek resulting in 27,904 lbs of sediment, 592 lbs of TN, and 72 lbs of TP reduced per year.
- 50 acres of riparian zones in protective easements for Pearson Creek.
- 17 detention basin retrofits for Lake Springfield resulting in 59,296 lbs of sediment, 1,258 lbs of TN, and 153 lbs of TP reduced per year.
- 25 acres (16,500 linear feet of 66-foot buffer) of healthy riparian buffers for Lake Springfield resulting in 2,350 lbs of sediment, 65 lbs of TN, and 11 lbs of TP reduced per year.

07

Action Plan for Finley Creek HUC-10 Watershed

Finley Creek, with a watershed of over 172,000 acres (260 square miles), contains about 18% of the drainage area of the James River Basin and extends over portions of six Missouri counties; Stone, Christian, Greene, Webster, Douglas, and Wright. The headwaters of Finley Creek lie in the extreme southwest corner of Wright County. The stream then flows west and southwest to its confluence with the James River in the northeast corner of Stone County. Finley Creek is a perennial stream fed by numerous springs.

The watershed is generally more forested in eastern sections; contains more grassland and pastures in the middle section; urban development near the city of Ozark; and low-density residential areas in the lower section. Agriculture remains the dominant land use in the Finley Creek Watershed. In the early twentieth century, corn was the major row crop grown, supplemented with swine, sheep, beef and dairy cattle livestock production.

Agricultural activities today are primarily livestock and hay production with some interspersed dairy operations, particularly in the northeast part of the watershed. Horse farms are becoming more common, especially near populated areas.

There are no permitted animal feeding operations in the watershed and row crop production is minimal. Forestry and mining activities were once more prevalent. Mining for zinc, lead, and copper occurred in the late nineteenth and early twentieth centuries. Sawmills and railroad tie production centers were once common industries.

The Finley Creek watershed is close to Springfield, the largest urban area in the James River Basin. Urban areas within the Finley Creek watershed include Christian County's largest urban centers at Nixa and Ozark, as well as all or portions of the towns of Highlandville, Rogersville, Fordland, Diggins, Seymour, and Sparta. There were large influxes of people into Christian County in the 1980s through 2000s, but growth rates flattened somewhat after 2010.

Most of the urban areas within the watershed have seen large population increases over the last few decades, and urban boundaries have extended into areas which were formerly agricultural, resulting in larger service areas for municipal water and sewer systems. Several wastewater treatment facilities discharge in the watershed, including Seymour, Fordland, Sparta, Nixa and Ozark.

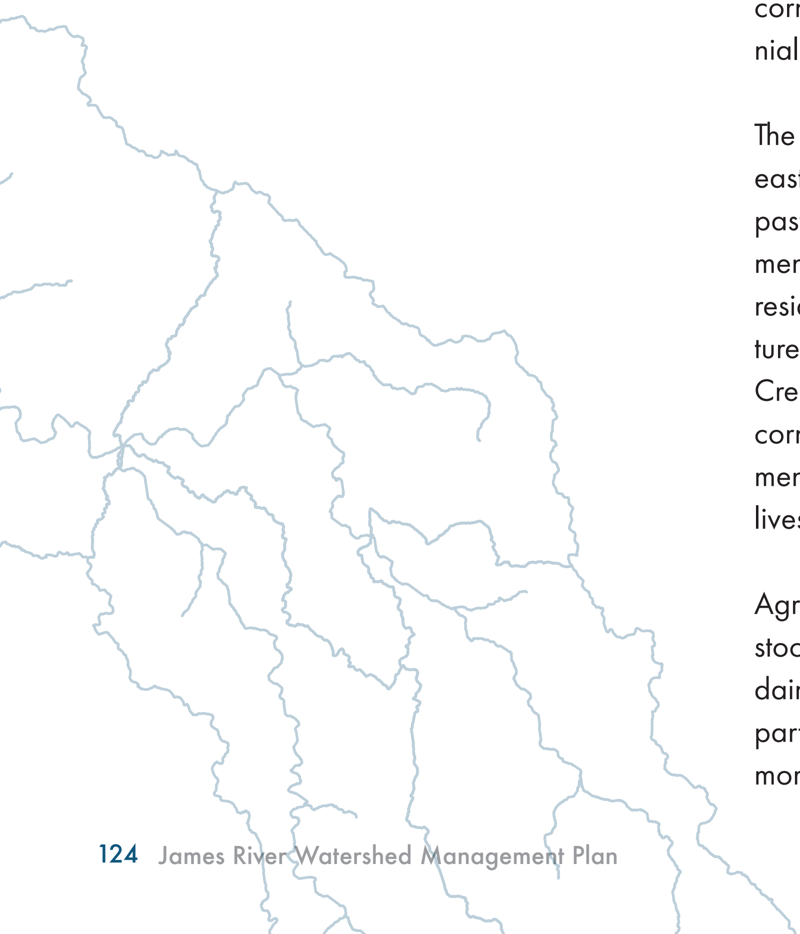
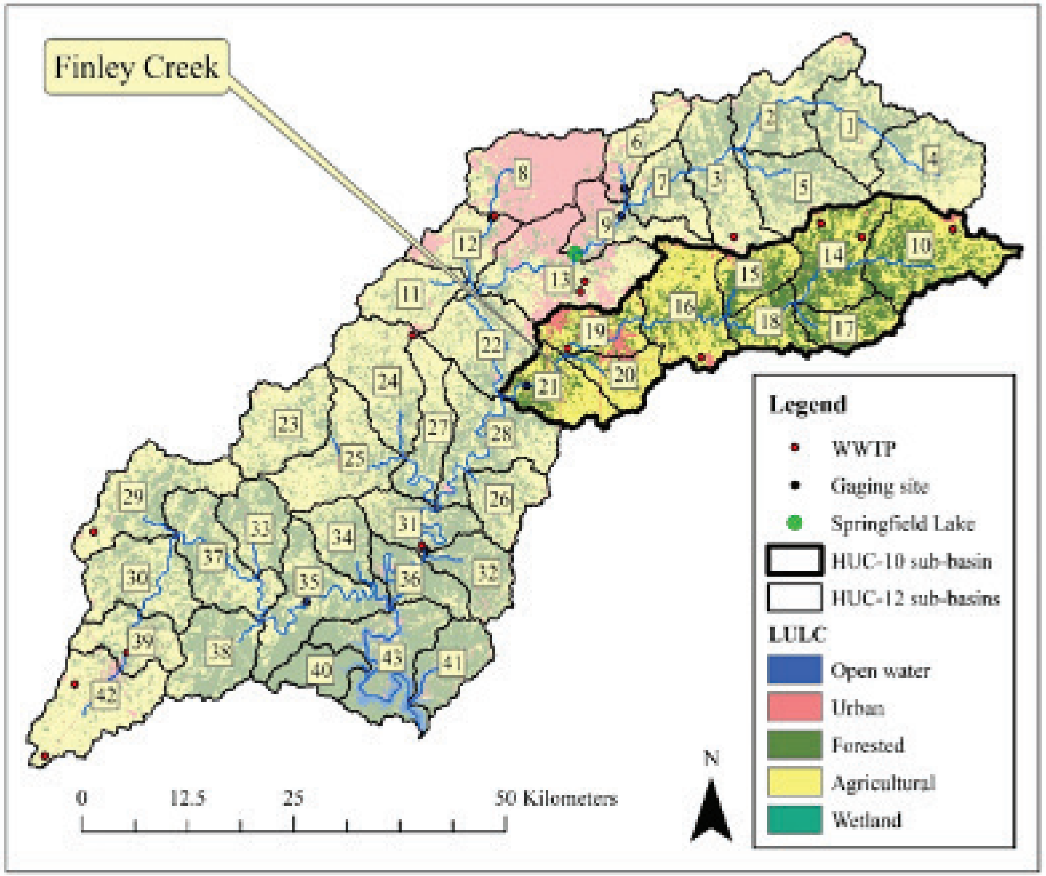


Figure 26: James River Basin with Finely Creek



Map No.	Sub-watershed Name	Map No.	Sub-watershed Name	Map No.	Sub-watershed Name
1	Dry Creek-James River	16	Parched Corn Hollow-Finley Cr.	31	Pine Run-James R.
2	Turnbo Creek-James R.	17	Stewart Creek	32	Railey Creek
3	Sayers Creek-James R.	18	Squaw Run Creek-Finley Cr.	33	Jenkins Creek
4	Headwaters-James R.	19	Spout Spring Hollow-Finley Cr.	34	Dry Creek-James R.
5	Panther Creek	20	Elk Valley	35	Flat Creek
6	Pearson Creek	21	Finley Creek	36	Wilsons Run-James R.
7	Turner Creek-James R.	22	Green Valley Creek-James R.	37	Willow Branch-Flat Cr.
8	Headwaters Wilsons Cr.	23	Upper Crane Creek	38	Rockhouse Creek
9	Lake Springfield-James R.	24	Spring Creek	39	Corder Hollow-Flat Cr.
10	Headwaters Finley Cr.	25	Middle Crane Creek	40	Piney Creek
11	Terrell Creek	26	Goff Creek	41	Aunts Creek
12	Wilsons Creek	27	Lower Crane Creek	42	Headwaters Flat Cr.
13	Ward Branch-James R.	28	Tory Creek-James R.	43	Table Rock Lake-James R.
14	Davis Branch-Finley Cr.	29	Little Flat Creek		
15	Pedelo Creek	30	Gunter Creek-Flat Cr.		

The United States Geological Survey has delineated nine HUC-12 sub-watersheds within the Finley Creek HUC-10 Watershed. They are listed below along with their general characteristics:

Map ID 10: Headwaters Finley Creek (32,250 acres): Uppermost headwaters of Finley Creek, south of Seymour, extending into extreme western Wright County and the extreme northwestern corner of Douglas County; about 50% pasture and grasslands on flat or gently sloping land and along major stream bottoms; forest about 45%, on steeper slopes near creeks and in woodlots; a few isolated areas of cultivated lands (less than 1%); developed areas about 3%, mostly around Seymour (population 1,950); Seymour discharges about 250,000 gallons per day of treated wastewater into a Finley Creek tributary; many Amish farms south and southwest of Seymour; these farms often contain confined animal operations (pigs and chickens), but these are usually too small to require state permits; no permitted animal feeding operations, but at least ten fairly large grow houses can be seen on aerial photographs.

Map ID 14: Davis Branch-Finley Creek (25,494 acres): About 50% pasture and grasslands, primarily on flat and gently sloping land and in larger stream bottoms; about 50% forested, mainly on steeper slopes near Finley Creek; about 1% urbanized, including the south parts of Fordland and Diggins along U.S. 60; Fordland (population 800) discharges about 137,000 gallons of treated wastewater per day into Terrell Branch, a Finley Creek tributary; no permitted animal feeding operations.

Map ID 15: Pedelo Creek (13,166 acres): Enters Finley Creek from the north upstream of Lindenlure; About 50% forested, primarily on steeper slopes and in woodlots, with large areas of contiguous forest along the lower portions of Pedelo Creek near Finley Creek; large springs along lower Pedelo Creek include Ollie Lasley and Tallman springs; about 45% pastures, primarily on flat and gently sloping lands and in wider stream bottoms; about 3% urbanized, including the south part of city of Rogersville and areas along U.S. 60 east of Rogersville; a drag strip is located in the north part of the sub-watershed; no community wastewater treatment plant discharges; no permitted animal feeding operations.

Map ID 16: Parched Corn Hollow-Finley Creek (30,126 acres): About 75% pastures and grasslands, mainly on flat to gently sloping lands and along larger stream bottoms; about 20% forested, primarily on steeper slopes near Finley Creek; About 5% urbanized, including portions of Rogersville and most of city of Sparta on the south edge of the sub-watershed; Sparta (population 1,800) discharges about 100,000 gallons per day of treated wastewater into Carter Hollow, a tributary of Finley Creek; several isolated areas of cultivated crops (about 1%) in the north half of the sub-watershed; no permitted animal feeding operations.

Map ID 17: Stewart Creek (12,703 acres): Northern part of Finley Creek watershed in Douglas and Christian Counties; about 60% forested, primarily on steep slopes near streams and in large woodlots; 40% in pasture and grasslands on flat lands at ridge divides and in stream bottoms; no significant development in sub-watershed (less than 1% urbanized), no community wastewater treatment discharges; no permitted animal feeding operations.

Map ID 18: Squaw Run Creek-Finley Creek (12,568 acres): About 50% pasture and grasslands on flat to gently sloping lands and in larger stream bottoms; about 50% forested, primarily on steeper slopes along drainages and in woodlots; no significant areas of development (less than 1%); no community wastewater discharges; no permitted animal feeding operations.

Map ID 19: Spout Spring Hollow-Finley Creek (16,299 acres): About 40% urban, including southeast one-half of the city of Nixa and 75% of the city of Ozark; the third most urbanized sub-watershed in the James River Basin; also several large areas of residential development between Ozark and Nixa; the city of Ozark's (population 19,100) 2nd Street Plant and Elk Valley Plant discharge a combined total of about 1.4 million gallons per day (MGD) of treated wastewater downstream of the city of Ozark; the Elk Valley Plant discharges only a few hundred yards downstream of the city of Nixa's wastewater treatment plant; city of Nixa (population 20,600) discharges about 2 MGD of treated wastewater into Finley Creek; about 45% pasture and grasslands, on flat and gently sloping lands and in larger stream bottoms; about 20% forested, mostly on steep slopes near creeks and isolated woodlots; one small area of cultivated crops west of Ozark (less than 1%); no permitted animal feeding operations.

Map ID 20: Elk Valley (12,197 acres): About 80% pasture and grasslands on gently sloping lands, flat drainage divides, and along larger stream bottoms; about 10% forested, mostly in woodlots and on steep slopes near streams; about 10% urban, including south part of the city of Ozark; The city of Ozark's Elk Valley wastewater plant discharges at the west end of the sub-watershed, but the discharge point is actually in the Spout Spring Hollow-Finley Creek sub-watershed just upstream; no permitted animal feeding operations.

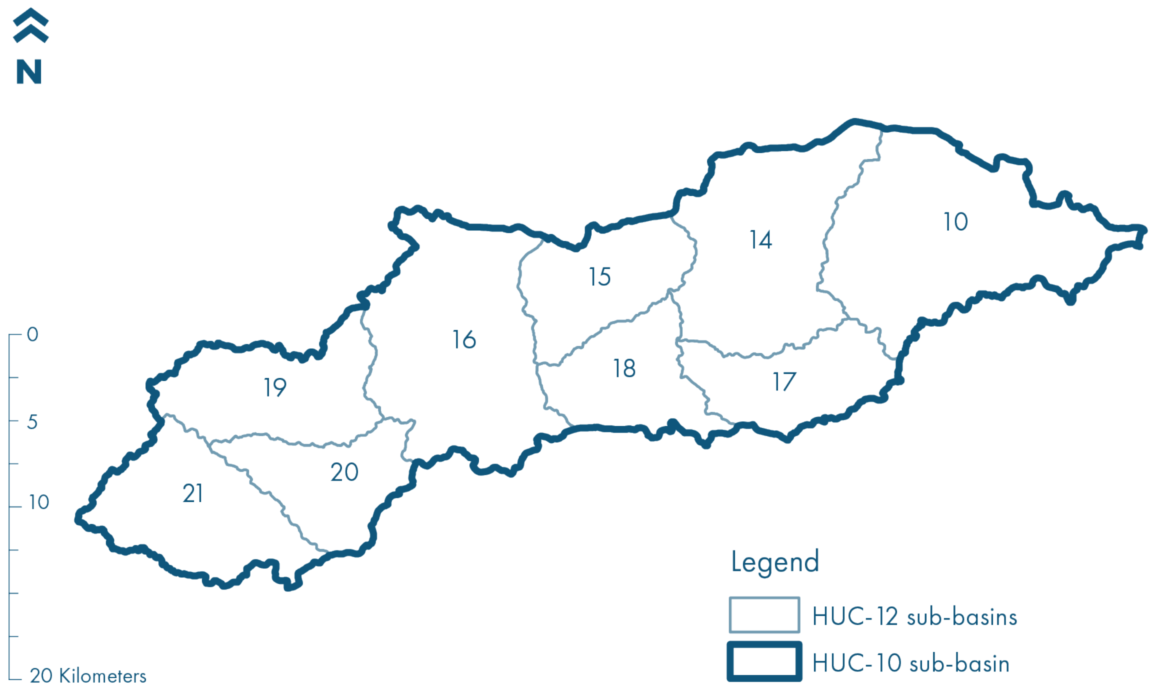
Map ID 21: Finley Creek (18,040 acres): The lowest portion of the Finley Creek watershed, near the James River; about 60% in pasture and grasslands, mainly on flat or gently sloping land and along larger stream bottoms; about 30% forested, primarily on steep slopes near drainages and in woodlots; about 10% urbanized, with many large residential subdivisions in the south-central part of the sub-watershed; developed areas along Highway 160 in the central part of the sub-watershed, and south part of the city of Nixa; small areas of cultivated crops (less than 1%) in eastern part of sub-watershed.; no permitted animal feeding operations.

MODELING AND CRITICAL AREA IDENTIFICATION

Based on the SWAT modeling results, Sub-watershed 19 (Spout Spring Hollow-Finley Creek), in the lower half of the watershed below the city of Ozark, has the highest loading potentials for sediment, TN and TP. This sub-watershed is about 40% urbanized, the third most urbanized sub-watershed in the James River Basin (43 total sub-watersheds). About one-half of the city of Nixa and 75% of the city of Ozark are in this sub-watershed. According to the SWAT model, this sub-watershed ranks highest of the Finley Creek sub-watersheds in sediment, TN and TP. These modeling results suggest that sub-watershed 19 should be considered a critical area for the applications of BMPs.

There are no 303-d listed segments in the Finley Creek HUC-10 watershed, and no surface sources for public drinking water. However, both the city of Ozark and Nixa rely on deep wells for public drinking water. Given the predominance of karst terrain in the lower part of the Finley Creek watershed, with large sinkhole plains lying in and to the north and west of the city of Nixa, protection of the shallow groundwater system is a

Figure 27: Land Uses in James River Basin HUC-10, HUC-12 Sub-watersheds.



Rank	Sediment (Mg/km²)	Sub-basin	TN (kg/ha)	Sub-basin	TP (kg/ha)	Sub-basin
1	520	19	41.7	19	2.7	19
2	445	21	41	16	2.4	20
3	444	20	37.5	20	1.9	16
4	399	16	34.2	21	1.9	21
5	263	10	24.3	14	1.4	10
6	190	14	19.9	10	0.9	15
7	159	18	19.4	18	0.7	14
8	140	15	18.1	17	0.6	18
9	76	17	17.1	15	0.4	17

heightened concern. Most of the small tributaries of Finley Creek are dependent on spring flow, so water quality of springs can have significant impacts on the quality of water in the streams.

RECOMMENDED MANAGEMENT MEASURES

For sub-watershed 19, which is highly urbanized (40%), the emphasis should be on urban stormwater management and associated BMPs. The south half of the city of Nixa and ¾ of the city of Ozark lie in this sub-watershed. The cities of Nixa and Ozark, and Christian County, are Phase II NPDES stormwater permitted entities. All currently have up-to-date permits and are delivering stormwater management programs as prescribed by Missouri DNR and EPA.

All three of these Phase II communities look to Springfield, which has the longest standing stormwater permit of any Phase I community in the state, for guidance and technical assistance. Springfield should continue to offer training and technical assistance to the surrounding communities. Non-profits such as the James River Basin Partnership should continue to play a key role in providing stormwater education for these communities, as well as logistical and organizational support for training and workshops for stormwater management professionals.

Given the degree of development in sub-watershed 19, the application of construction site BMPs should be aggressively pursued, including an emphasis on construction sequencing and pre- and post-construction BMPs such as sediment and erosion control, extended detention (through basin retrofits) and healthy riparian buffers.

There are about 91,000 acres of pasture/hay land in the Finley Creek Watershed. Management measures here should include managed grazing systems, alternative watering system with stream exclusion for livestock, and the protection and enhancement of riparian zones along Finley Creek and its major tributaries.

Streambank stabilization and erosion protection are needed on many streams, both urban and rural, in this watershed. It is estimated that about 15% of the streambank miles in rural/agricultural areas need stabilization work, and about 25% of the streambank miles in urban settings. Streambank stabilization measures include bank armoring using vegetation and in severe cases, erosion blankets; willow staking, grading and re-vegetation of banks.

Upper Finley Creek above Finley Falls

Most of the homes in this watershed outside the service areas of Nixa and Ozark are served by onsite wastewater systems. Recommended management measures include point-of-sale inspections, advanced system maintenance contract requirements, and onsite system pump-outs.

07

GOALS FOR FINLEY CREEK

– 05 Years

- Survey detention basins for appropriate candidate retrofits for Spout Spring Hollow-Finley Creek HUC- 12 Sub-watershed

–10 Years

- Point-of-Sale Inspection system for onsite wastewater systems in Christian County
- Advanced onsite wastewater system management (contract required)

–20 Years

- 25% (22,750 acres) of pasture lands in managed grazing systems resulting in 514,000 lbs of sendiment, 4,550 lbs of TN, and 1,590 lbs of TP removed per year.
- 200 Septic System Pump-outs
- 25 acres of healthy riparian zones (100-foot wide, 10,890 feet long) established in rural areas resulting in 2,285 lbs of sediment, 88lbs of TN, and 10lbs of TP.
- 200 Septic System Pump-outs
- 2,000 feet of streambank erosion protection/stabilization measures, resulting in 122,000 lbs of sediment, 760 lbs of TN and 100 lbs of TP reduced per year.
- 20 acres of riparian zones (66 –feet wide, 13,200 feet long) in urbanizing zones, resulting in 1,880 lbs of sediment, 52lbs TN, and 9 lbs of TP reduced per year.

CHAPTER 08 »
ACTION PLAN FOR WILSONS CREEK-JAMES RIVER HUC-10 WATERSHED

08

Action Plan for Wilsons Creek-James River HUC-10 Watershed

WATERSHED SETTING

The Wilsons Creek-James River HUC-10 Watershed encompasses an area of 129,159 acres (201.8 square miles) in the central portion of the James River Basin. This watershed contains the most urbanized section of the James River Basin, including almost 90% of the metropolitan area of Springfield. The second and third largest cities in the basin, Nixa and Ozark, also partially lie within the watershed. Springfield, the largest urban center in the James River Basin, has a population of about 160,000 (2016 estimate). Significantly, rapid growth is also occurring outside of the major cities. The two counties containing the Wilsons Creek Watershed, Greene and Christian, are among the fastest growing in the state. Projections of growth from 2000 to 2030 range from 37.2% in Greene County to 141.4% in Christian County (Missouri Office of Administration, 2013).

High and low-density urban land-uses dominate the areas around Springfield, Republic, Nixa and Ozark. Headwater areas of Wilsons Creek, in particular, are highly urbanized. The highest population densities are in the downtown areas of Springfield and Republic, with densities decreasing gradually outward from these urban centers. Population changes between the 2000 and 2010 censuses, however, show that the greatest proportional increases in population in the sub-basin have occurred to the west and southwest of Springfield, west of Nixa in Christian County, and north of Ozark in Christian County. These high growth areas indicate sections of the watershed where land disturbance and development activities are currently concentrated and continuing at a rapid pace.

Agricultural land in the watershed is rapidly being converted to urban uses. For many years, this has led to concerns related to the detrimental effects of stormwater runoff. Runoff can create hydrologic changes leading to increased bank erosion, channel destabilization and downstream sedimentation. Runoff can also become polluted with a variety of materials deposited in the urban environment. National Pollutant Discharge Elimination System (NPDES) stormwater permits for Springfield, Ozark, Nixa, and Greene and Christian counties are now directed toward protecting rivers and streams from the effects of urban runoff. Outside of urban areas, in the southern and western portions of the watershed, grass and pasture lands still predominate,

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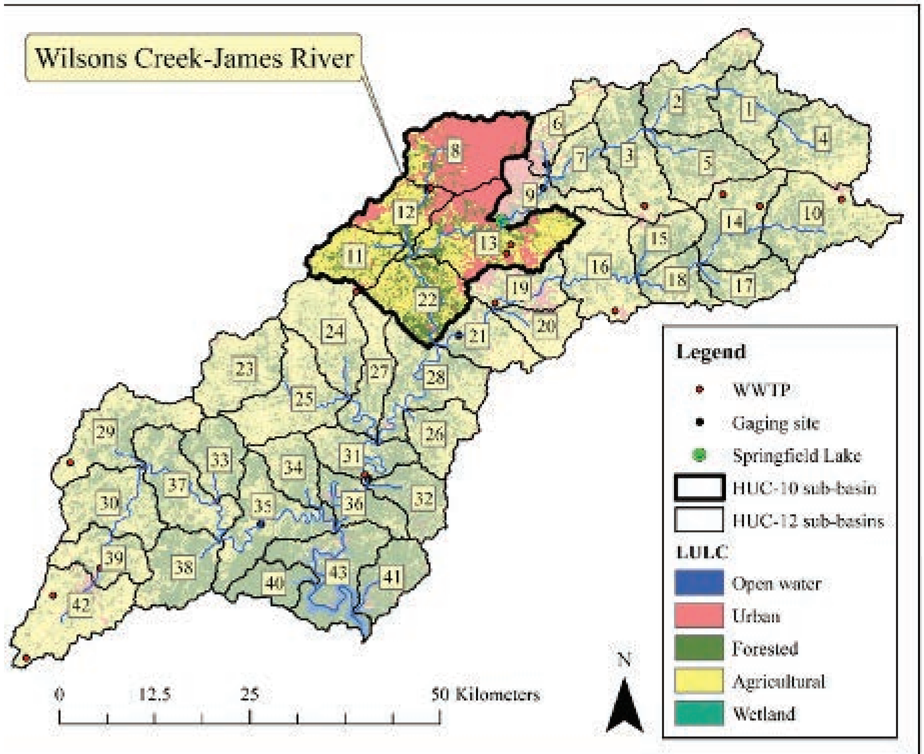
Figure 28: James River Basin with Wilsons Creek



1 Dry Creek-James River	16 Parched Corn Hollow-Finley Creek	31 Pine Run-James River
2 Turnbo Creek-James River	17 Stewart Creek	32 Railey Creek
3 Sayers Creek-James River	18 Squaw Run Creek-Finley Creek	33 Jenkins Creek
4 Headwaters-James River	19 Spout Spring Hollow-Finley Creek	34 Dry Creek-James River
5 Panther Creek	20 Elk Valley	35 Flat Creek
6 Pearson Creek	21 Finley Creek	36 Wilsons Run-James River
7 Turner Creek-James River	22 Green Valley Creek-James River	37 Willow Branch-Flat Creek
8 Headwaters Wilsons Creek	23 Upper Crane Creek	38 Rockhouse Creek
9 Lake Springfield-James River	24 Spring Creek	39 Corder Hollow-Flat Creek
10 Headwaters Finley Creek	25 Middle Crane Creek	40 Piney Creek
11 Terrell Creek	26 Goff Creek	41 Aunts Creek
12 Wilsons Creek	27 Lower Crane Creek	42 Headwaters Flat Creek
13 Ward Branch-James River	28 Tory Creek-James River	43 Table Rock Lake-James River
14 Davis Branch-Finley Creek	29 Little Flat Creek	
15 Pedelo Creek	30 Gunter Creek-Flat Creek	

interspersed with small areas of cropland. High density forest cover is found primarily on steeper slopes along major streams, mainly in the southernmost portion of the watershed.

The U.S. Geological Survey has divided the Wilsons Creek-James River HUC-10 Watershed into five smaller HUC-12 sub-watersheds, ranging in size from 16,314 acres to 38,539 acres. These sub-watersheds are listed below along with some of their general charactistics:

Map ID 8: Headwaters Wilsons Creek (32,216 acres): About 90% urbanized; the most urbanized HUC-12 sub-watershed in the James River Basin; most of the sub-watershed is within the city of Springfield; Wilsons Creek receives most of the stormwater generated in the city of Springfield, which flows into Jordan Creek and South Creek; nearly the entire sub-watershed is served by municipal sewers, but there are no municipal wastewater discharges within this sub-watershed itself. That is because the USGS has established the downstream boundary of this sub-watershed at the point where South Creek meets Wilsons Creek, just upstream of the Springfield Southwest Wastewater Treatment Plant discharge; about 5% pasture and grasslands, mainly on flat to gently sloping land at the west end of the sub-watershed; about 5% forested, primarily on steep slopes and in small woodlots; no permitted animal feeding operations; many permitted stormwater discharges regulated by the Missouri Deparment of Natural Resources and the city of Springfield.

Map ID 11: Terrell Creek (16,917 acres): A largely rural, agricultural sub-wateshed, with about 85% pasture and grasslands on flat to gently sloping land and along stream bottoms; about 5% urbanized, mainly the north side of the city of Clever, the east side of Billings, and large subdivisions south of the city of Republic; about 5% forested, mainly on steeper slopes near Terrell Creek; less than 1% cultivated crops; no municipal wastewater discharges; no permitted animal feeding operations.

Map ID 12: Wilsons Creek (16,314 acres): About 35% urbanized, including the southwest portion of the city of Springfield, the eastern half of the city of Republic, the west side of Battlefield, and developed areas along U.S. 60 west of Springfield; about 50% in pastures and grasslands, on flat to gently sloping lands and in stream bottoms; about 10% forested, primarily on steep slopes near streams in south-central part of sub-watershed, especially in Wilsons Creek Battlefield Park, and in isolated woodlots; some areas of cultivated crops in the cental part of the sub-watershed (less than 1%); municipal wastewater from the city of Republic is discharged into Pickerel Creek, to the west of this sub-watershed, but there have been sewer lift stations overflows on the east side of Republic which discharged into Shuyler Creek, a tributary of Wilsons Creek; wastewater from the city of Battlefield goes to the Springfield Southwest Plant, which discharges at the upper end of this sub-watershed about 33.5 million gallons per day (MGD) of treated wastewater into Wilsons Creek; no permitted animal feeding operations; large number of permitted stormwater discharges regulated by the Missouri Department of Natural Resources and the cities of Springfield and Republic.

Map ID 13: Ward Branch-James River (38,539 acres): About 50% urbanized, the second most urbanized HUC-12 sub-watershed in the Wilsons Creek-James River Watershed; contains about half of the city of the Nixa, the south-central portion of Springfield, and the community of Fremont Hills; Fremont Hills (population 900) discharges 77,000 gallons per day of treated wastewater into a small tributary of the James River; about 40% in pasture, mostly on flat to gently rolling land; about 7% forested, mostly on steeper slopes near drainages and in isolated woodlots; Two large springs, Ward and Welch, discharge in this sub-watershed, and it contains the River-bluff or "Ice-Age" Cave; no permitted animal feeding operations; large number of permitted stormwater discharges regulated by the Missouri Department of Natural Resources and the cities of Springfield and Nixa.

Map ID 22: Green Valley Creek-James River (25,173 acres): About 50% pastures and grasslands, mainly on flat to gently sloping land and in the larger stream bottoms, especially along the James River; about 45% forested on steeper slopes near drainages and in woodlots; about 5% urbanized, primarily the southwest part of the city of Nixa and a small developed area east of Clever; a few areas of isolated cultivated crops (less than 1%), with large fields along the James River; no permitted animal feeding operations; contains the Delaware Town Access on the James River on Highway 14 west of Nixa.

SPRINGFIELD/GREENE COUNTY INTEGRATED PLAN FOR THE ENVIRONMENT

In 2014, the city of Springfield, Greene County and City Utilities of Springfield began working on an integrated plan to address environmental problems and priorities in stormwater, wastewater, drinking water, solid waste and air quality. In 2012, the USEPA released its "Integrated Municipal Stormwater and Wastewater Planning Approach Framework," which emphasized its commitment to work with states and communities to improve environmental conditions. The three entities used this opportunity to develop an integrated planning approach led by local citizens. The plan subsequently received approval from both the Missouri Department of Natural Resources and USEPA Region 7 in Kansas City.

This is not meant to be a static plan, but is intended to be "adaptive," or ever changing in the face of new information, ideas or technologies. The local planning effort was guided by six principals:

- Affordability for the community
- Effectiveness, or getting the "biggest bang for the buck" or best benefit to cost ratio
- Fairness, in that all citizens treated fairly
- Attainability, or can be accomplished within the "community affordability" limit
- Measurability, the ability to track progress over time
- Adaptability, to adjust as needed when new information comes in.

The citizen task force developed the local environmental priorities, and a technical team gathered and analyzed data to determine current conditions and problem areas. The technical team used this information to create reports for the group to help making decisions about which environmental problems to tackle first, and where the best benefit to cost ratios could be found.

In February 2015, the citizen task force released the final report on environmental priorities. Included was information of a community survey completed by 694 local citizens. The highest priority identified was "clean drinking water." Secondary priorities were water contact recreation, aquatic life impacts, fish consumption advisories and waterway aesthetics. Potential threats to drinking water sources included pathogens, nutrients and sediment, along with industrial sources. The upper James River supplies a portion of the city's municipal drinking water supply. Wilsons Creek and the Middle James River were listed as secondary priorities because of their use for contact recreation, fishing, and protection of aquatic life.

A "Multiple Criteria Decision Analysis" for prioritizing sources of water pollution was completed in December 2017. An expert panel was used to assign weights to a group of water quality indicators and determine their relative impacts on the community priorities. Indicator weights were assigned based on how many of the community's watersheds are affected, the severity of the impacts, the likelihood of impacts, frequency of impacts and the ability to control the pollution source. Using this method, the highest priority sources for water pollution were ranked as follows: (1) agricultural runoff, (2) urban runoff, and (3) sanitary sewer exfiltration (sewage leaking OUT of sewers). Medium priority sources were ranked as (1) stream bank erosion, (2) industrial runoff, and (3) permitted wastewater discharges. Lowest priority sources were (1) failing onsite wastewater systems, (2) land disturbance runoff, and (3) sanitary sewer overflows.

The technical group produced a "Sustainable Return on Investment" report based on a pilot study of opportunities to enhance stormwater and wastewater treatment in the community. Standard economic benefit-cost analyses methods were used to address goals and outcomes from a triple bottom-line perspective; the full range of environmental, social and economic impacts. The pilot analysis was performed on the following four opportunities:

1. Stormwater Detention Basin Retrofits

2. Polycyclic Aromatic Hydrocarbon (PAH) Reduction Measures

3. Enhanced Nutrient Removal at the Southwest Wastewater Treatment Plant (SWTP)

4. Sanitary Sewer Overflow (SSO) Controls.

The anticipated change in water quality was estimated for each opportunity in each of the following receiving waters:

- Springfield Urban Streams
- Wilson's Creek Below the SWTP
- James River below Wilsons Creek
- Lake Springfield
- Table Rock Lake

Using this method, benefit to cost ratios for each of the four opportunities listed above were computed. A benefit to cost ratio of over one indicates that there should be a higher value for the benefits than what will be spent on the improvements. The ranking of the four opportunities, from highest to lowest benefit to cost ratios, is as follows:

!. Stormwater detention basin retrofits, benefit to cost ratio 1.28, or $1.28 of benefit for every dollar spent. This opportunity involved the changing of regular detention basins into extended detention basins. In other words, stormwater was let out of the structure much more slowly, allowing them to drain in 24 hours or more. Most of the basins in Springfield are designed only for flooding control. By changing the outlet structure, the basin can be made to drain much more slowly, providing opportunity for sediment and other pollutants to settle out.

There are about 1,500 detention basins in the city of Springfield, with the vast majority privately owned. The 178 basins constructed between 1995 and 2005, during the building boom, had large storage volumes compared to earlier basins. For a relatively low cost, the outlet structures on these basins could be modified to allow them to hold water for 24 to 48 hours. Of these 178 basins, 110 were found to be candidates for the retrofit. The amount that pollutants would be reduced by retrofitting all 110 basins was calculated to provide the benefit to cost ratio.

The technical team also calculated benefit to cost ratios for "enhanced" detention, or providing amended soils and vegetation in the basin to improve water quality treatment. However, the benefit to cost ratio for this was only 0.26, largely because of the much larger costs for amended soil, plant materials and lifetime maintenance. The water quality improvements for these basins was only marginally more than those produced by simply changing the outlet structures.

2.Polycyclic Aromatic Hydrocarbon (PAH) Reduction Measures, benefit to cost ratio 1.13. This opportunity was low cost, in that it involved developing a city polity to no longer allow coat-tar based parking lot sealants to be used.

These have been shown to be a major source of PAHs in Springfield's urban streams and basins. A second alternative was also evaluated—excavating PAHs in sediments from existing basins—but the benefit to cost ratio for this alternative was lower, 0.81.

3.Sanitary Sewer Overflow Controls, benefit to cost ratio 0.91, near the break-even point. This opportunity involved the removal of infiltration and inflow of stormwater into sewer lines (which can result in overflows at manholes and, potentially, by-passes at the treatment plant).

4. Enhanced Nutrient Removal at the Southwest Wastewater Treatment Plant, benefit to cost ratio 0.81. The plant currently has both biological and chemical nutrient removal processes and a land application program for residuals removed by the treatment plant. The SWTP is now meeting its 0.5 mg/l total phosphorus limit. Nitrogen removal results in an effluent with about 20 mg/l of total nitrogen. Upgrades to further enhance nutrient removal could include larger biological reactors and supplemental chemical additions. Incorporation of these processes could produce effluent total nitrogen as low as 3 mg/l and total phosphorus as low as 0.3 mg/l. Although the benefit to cost ratio has been estimated at less than 1, it is close, and the technical team indicated that cost reductions might be found, bringing the ratio closer to the break-even point.

MODELING AND CRITICAL AREA IDENTIFICATION

This HUC-10 watershed was modeled again as part of the SWAT model constructed for the entire James River Basin by OEWRI. OEWRI had run an earlier model, which, since it covered a smaller total area, also had smaller Hydrologic Response Units (HRUs). The results of both modeling efforts were similar.

Critical areas as identified in this plan include: 1) watersheds or sub-watersheds identified in the model as likely to contribute excessive loadings of total nitrogen (TN), total phosphorus (TP) or sediment to waterbodies; 2) watersheds or sub-watersheds of waterbodies which have been placed on the 303-d list and identified as impaired, and 3) watersheds or sub-watersheds contributing source water to public drinking water supplies.

By these definitions, four of the five sub-watersheds in the Wilsons Creek-James River HUC-10 watershed have been determined to be critical areas (see Figure 29). Sub-watershed 8 (Headwaters Wilson Creek) was shown by the second SWAT model to contribute the highest load of TP of any sub-watershed in the watershed. This sub-watershed is about 90% urbanized, the most urbanized sub-watershed in the entire James River Basin. Sub-watershed 11 (Terrell Creek), is mostly agricultural, with about 85% of the land in pastures and only 5% urban. According to the SWAT model, this sub-watershed would have the highest loads of sediment and TN of any of the four critical areas. Sub-watershed 12 (Wilsons Creek) had the second highest TN and third highest TN of the four critical areas. Sub-watershed 13 (Ward Branch-James River) had the second highest sediment, and third highest TN.

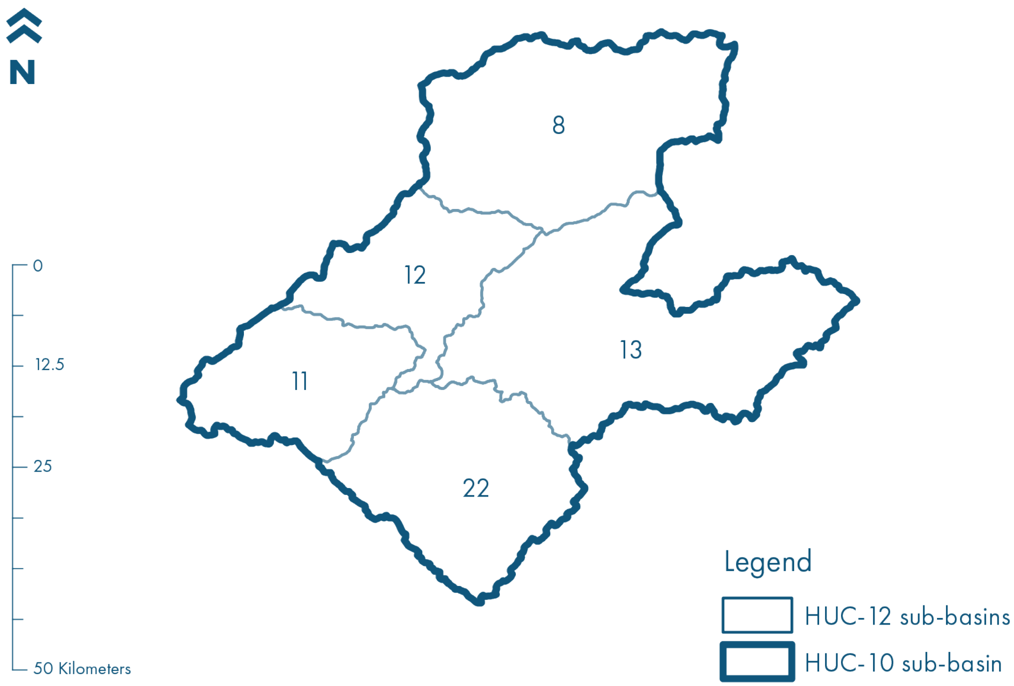
Four waterbodies within or partially within this HUC-10 watershed are on the 303-d list of impaired waters: 1) The James River, 39 miles for E. coli on the 2020 proposed list; 2) Jordan Creek, a Wilsons Creek tributary, 3.8 miles for polycyclic aromatic hydrocarbons (PAH) on the 2014 list; 3) North Branch Wilsons Creek, 3.8 miles for zinc on the 2014 list; and 4) Wilsons Creek, 14 miles on the 1998 list for aquatic macroinvertebrate bioassessment (loss of diversity), and on the 2006 list for E. coli.

Jordan Creek and North Branch Wilsons Creek are both in sub-watershed 8 (Headwaters Wilsons Creek), which was identified in the SWAT model as potentially contributing high loads of TP as well. The Wilsons Creek watershed contains sub-watersheds 8, 11, 12 and 13, which were identified by the SWAT model as potentially contributing excessive loads of sediment, TN and TP, but also sub-watershed 22 (Green Valley Creek), which the SWAT model ranked the lowest in the HUC-10 for sediment and TP. The Green Valley Creek sub-watershed is also the least urbanized of the five sub-watersheds in the HUC-10, only about 5%, so it will not be included as a critical area for addressing Wilsons Creek impairments.

There are no public drinking water systems in the HUC-10 that use surface sources. However, there are many small community systems in the HUC-10 that rely on groundwater, and with the predominance of karst topography in this HUC-10, shallow groundwater quality is a concern.

RECOMMENDED

Figure 29: Land Uses in James River Basin HUC-10, HUC-12 Sub-watersheds.



Rank	Sediment (Mg/km²)	Sub-basin	TN (kg/ha)	Sub-basin	TP (kg/ha)	Sub-basin
1	537	11	65.8	11	3.6	8
2	470	13	36.3	13	3.4	13
3	240	12	35.6	12	1.8	12
4	178	8	33.5	8	1.6	11
5	38	22	27	22	0.7	22

MANAGEMENT MEASURES

This is by far the most heavily urbanized HUC-10 watershed in the James River Basin. Sub-watersheds 8, 13 and 12, in the northern part of the HUC-10, are most urbanized. Sub-watershed 8 (Headwaters Wilsons Creek), containing most of the city of Springfield, is 90% urbanized; sub-watershed 13 (Ward Branch-James River), containing the rapidly growing south side of Springfield and about half of the city of Nixa, is about 50% urbanized; sub-watershed 12 (Wilsons Creek), containing the western part of Springfield, west side of Battlefield and eastern half of Republic, is about 35% urbanized.

The focus for BMP applications in these three sub-watersheds should be on pre- and post-construction sediment and erosion control, and the applications of measures designed to reduce TN, TP, PAHs and bacteria in runoff. As part of its Integrated Plan, the city of Springfield conducted Sustainable Return on Investment (SROI) studies, which showed that the benefit to cost ratios of modifying outlet structures on standard detention basins, making them into extended detention basins, were favorable. The city should proceed with the outfitting of basins in critical areas.

Modeling has also shown that riparian zone establishment and protection has a high benefit to cost ration in terms of reducing sediment, TP and TN. The city of Springfield has a stream buffer ordinance in place to protect and enhance riparian zones along streams. Both the city of Springfield and Greene County have ordinances in place to limit construction in and near sinkholes and springs, and to improve the quality of runoff going into sinkholes. The James River Basin Partnership is currently implementing a 319 project in the Wilsons Creek corridor to establish conservation easements designed to protect water quality in the stream. This tool should be used to protect as much of the corridor of Wilsons Creek and its major tributaries as possible, as these protections are permanent.

Sub-watershed 11 (Terrell Creek) was ranked by the SWAT model as highest of the four critical sub-watershed in sediment and TN. It is about 85% pasture lands and about 5% urbanized, draining the east side of the city of Republic. Terrell Creek flows into Wilsons Creek on the south side of Wilsons Creek Battlefield Park. Recommended BMPs in this sub-watershed include managed grazing systems, alternative watering systems, restricted stream access for cattle and protected and enhanced riparian areas along the upper part of Terrell Creek.

GOALS FOR THE WILSONS CREEK-JAMES RIVER HUC-10 WATERSHED

Three of the critical sub-watersheds in the Wilsons Creek-James River HUC-10 watershed have the highest amount of urban and urbanizing acres of any sub-watersheds in the James River Basin, with Headwaters Wilsons Creek at 90% urbanized (28,800 acres), Ward Branch-James River at 50% urbanized (19,250 acres) and Wilsons Creek at 35% urbanized (5,600 acres), for a total urbanized area in the three critical sub-watersheds of 53,650 acres.

Extended detention basins are required for new developments in Springfield and Greene County. During its Integrated Planning for the Environment process, the city determined that retrofitting existing detention basins into extended detention basins by modifying outlet structures had a relatively high benefit to cost ratio. Retrofitting does not require any additional land disturbance and is simple and relatively inexpensive to accomplish. A goal for the three sub-watersheds is to have the 107 detention basins identified by the city as candidates for extended detention facilities retrofitted within 20 years. The city should also look to build, operate and maintain quasi-regional basins. This would require additional, sustainable sources of funding for stormwater programs, however, which is discussed in Chapter 12, Financial and Technical Assistance.

BMP scenario 3 in the SWAT model shows the expected reduction in sediment, TN and TP achieved by treating urban acres with filter strips and healthy stream buffers (riparian zones) of 10 meters (about 33 feet) in width. Adding additional buffers in already urbanized areas is difficult, but the city of Springfield now has a stream buffer ordinance that will help protect intact riparian zones during new development. Other cities and counties do not yet have stream buffer ordinances. The goal of this plan is to increase healthy riparian buffers by 25 acres in each of the three critical urban HUC-12 Sub-watersheds.

Ideally, once protected and enhanced, riparian zones should be placed into some type of long-term protective status such as a conservation easement. The James River Basin Partnership is currently using 319 grant funding to help secure easements along Wilsons Creek. This is a trend that will hopefully continue in urban areas, although it is difficult. The goal in the three critical sub-watershed is to have at least 75 acres of healthy riparian zones placed into protective easements within 10 years.

Jordan Creek, a sub-basin within the Headwaters Wilsons Creek HUC-10 sub-watershed, is on the 2014 303-d list for PAH contamination. Based on a study by the Ozarks Environmental and Water Resources Institute (OEWRI), the most likely source of PAH contamination in this critical sub-area is coal-tar based parking lot sealant. These pollutants would normally be found in drainage from any highly urbanized sub-watershed where parking lot sealants are used. For this reason, a goal of the plan is to phase out the use of coal-tar sealants within 15 years in all urban areas of the three critical sub-watersheds. The anticipated loading reduction of PAHs, however, had to be calculated from the Galloway Creek sub-sub-watershed, where the surface area of sealant treated parking lots was determined. It should be noted that the reductions in the Jordan Creek sub-sub-watershed should be higher, since residual PAH levels found in the sediments there were much higher than in Galloway Creek.

Terrell Creek, about 85% pasture and hay lands (14,450 acres), has been identified through SWAT modeling as a critical area because of high sediment and TN inputs. At its lower end, Terrell Creek drains through Wilsons Creek Battlefield Park. Recommended management measures are managed grazing systems, alternative watering, restricted livestock access to streams and vegetated riparian zone. The goal of this sub-watershed is to have at least 25% of the grazing lands in managed grazing systems within 20 years.

GOALS FOR WILSONS CREEK

15 Years

- Phase out of coal-tar based parking lot sealants for Jordan Creek sub-watershed, resulting in 2,035 Ug of PAHs removed in 15 years

20 Years

- 75 acres of riparian zones permanently protected
- 44 Detention basins retrofitted for the Headwaters Wilsons Creek HUC-12 Sub-watershed resulting in the reduction of153,472 lbs of sediment, 3,256 lbs of TN, 396 lbs of TP.
- 25 acres (16,500 linear feet of 66-foot wide) riparian buffers 2,350 lbs of sediment, 65 lbs of TN and 11lbs TP.
- 47 detention basins retrofitted for Ward Branch-James River HUC-12 Sub-watershed resulting in163,936 lbs of sediment, 3,478 lbs of TN and 423 lbs of TP removed per year.
- 25 acres (16,500 feet of 66-foot wide) riparian buffers for Ward Branch-James River HUC-12 Sub-watershed resulting in 2,350 lbs of sediment, 65lbs of TN, and11 lbs of TP removed per year.
- 16 detention basins retrofitted in Wilsons Creek HUC-12 Sub-watershed resulting in 55,808 lbs of sediment, 1,184 lbs of TN, and 144 lbs of TP removed per year.
- 25 acres (16,500 linear feet of 66-foot wide) riparian zones, resulting in the removal of 2,350 lbs of sediment, 65lbs of TN, 11lbs of TP per years.
- 25% (3,600 acres) of pasture in managed grazing systems for Terrell Creek HUC-12 Sub-watershed resulting in the removal of 81,360 lbs of sediment, 720 lbs of TN, and 252 lbs of TP.

CHAPTER 09 »
ACTION PLAN FOR FLAT CREEK HUC-10 WATERSHED

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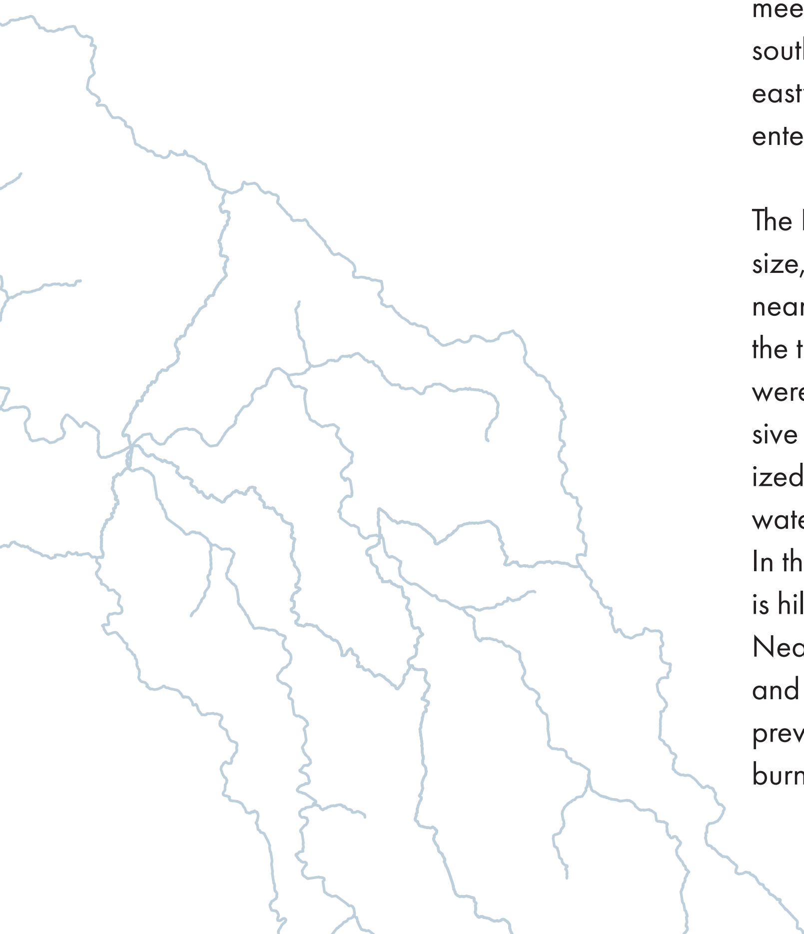
Action Plan for Flat Creek HUC-10 Watershed



Flat Creek is the largest tributary of the James River, flowing from headwaters in the southwest corner of the James River Basin to its meeting with the James River in Table Rock Lake near Cape Fair. Unlike other large James River tributaries and the James River itself, Flat Creek flows generally north and east. Its headwaters begin south of Cassville. The creek then flows through the center of Cassville northward to McDowell, where it meets Little Flat Creek. From here, it turns to the southeast. Below Jenkins it turns again, heading eastward in a series of broad meanders before entering the Flat Creek arm of Table Rock Lake.

The Flat Creek watershed is 208,716 acres in size, or 326 square miles. In its western sections, near the headwaters and the city of Cassville, the terrain is generally flat to gently rolling. These were formerly prairie lands, including the extensive Washburn prairie. Apart from the urbanized area around Cassville, this portion of the watershed is today predominantly pasture lands. In the eastern part of the watershed, the terrain is hilly with steep slopes dominated by forests. Near Table Rock Lake the terrain is very hilly and rocky. Historically, forestry and mining were prevalent land uses in the watershed. Lime was burned in kilns near Cassville and good building stone, called “Barry Gray,” was quarried nearby.

Agriculture has long been a mainstay in the watershed. Near Exeter, apple orchards and vineyards were once common. Along the western, flat watershed divide near Purdy and Butterfield, there are today scores of large poultry houses. There is a total of 13 DNR-permitted animal feeding operations in the Flat Creek Watershed, most of them raising broiler or fryer chickens. This is the highest number of permitted animal facilities of any of the six HUC-10 watersheds in the James River Basin. There is a very large poultry processing facility near the town of Butterfield. Elsewhere in the watershed, land-use is predominantly livestock pastures, with very few dairies and little cropland.

The Flat Creek watershed is the least populated of the six HUC-10 watersheds in the James River Basin. Except for a small area in and around Cassville where the population density is over 100 people per square mile, the watershed contains fewer than 40 people per square mile. Cassville is the largest city in the watershed, with a population of about 3,300. It has a modern sewage treatment facility with an average

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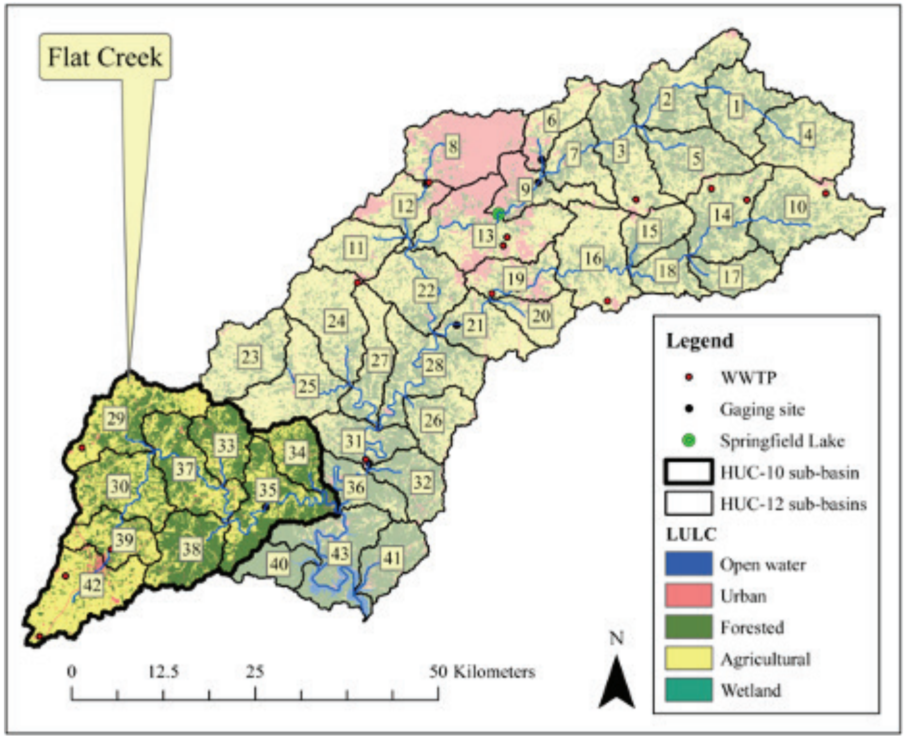
Figure 30: James River Basin with Flat Creek



1 Dry Creek-James River	18 Squaw Run Creek-Finley Creek	34 Dry Creek-James River
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12 Wilsons Creek	28 Tory Creek-James River	
13 Ward Branch-James River	29 Little Flat Creek	
14 Davis Branch-Finley Creek	31 Pine Run-James River	
16 Parched Corn Hollow-Finley Creek	32 Railey Creek	
17 Stewart Creek	33 Jenkins Creek	

discharge of about 1.1 million gallons per day. Purdy is the next largest town in the watershed, with a population of about 1,100 and a waste-water discharge of about 120,000 gallons per day. Exeter and Washburn are small towns, with populations of 800 and 450 respectively, served by a lagoon (Washburn) and small oxidation ditch treatment plant (Exeter).

Most of the Flat Creek watershed lies in Barry County. The 2016 estimated population of Barry County is 35,700, up only 0.4 % from 2010. This is a slower rate of growth than in the remainder of the counties in the James River Basin, with the exception of Stone County, immediately to the east of Barry County.

There is one USGS gaging station on Flat Creek, located below the village of Jenkins at the lower Flat Creek Access off Highway EE. This gage has been working since 2003. The highest recorded flow was on December 28, 2015, at 33,400 cubic feet per second.

There are nine HUC-12 sub-watersheds desig-nated by the United States Geological Survey within the Flat Creek HUC-10 watershed, rang-ing in size from 14,000 acres to 31,000 acres. They are listed on the following pages, along with some of their general characteristics:

Map ID 29: Little Flat Creek (28,659 acres): About 50% pasture and grasslands, on flat to gently rolling land and in the larger stream bottoms, particularly in the western part of the sub-watershed; about 50% forested, primarily on steeper slopes near drainages and in woodlots; about 1% urbanized, including the city of Purdy and development along U.S. 37 at the western edge of the sub-watershed; Purdy is located on the western sub-watershed divide. The waste-water lagoon serving this town has been taken out of service, and sewage is now pumped to Monett for treatment; there are two DNR-permitted animal feeding operations in the sub-watershed—a class 1C broiler operation southeast of Purdy with 1178 animal units (about 35,000 birds), and a class II chicken egg operation northeast of Purdy (permit expired); at least 48 houses at non-permitted facilities can be identified from aerial photos, including a cluster east of Purdy (7 houses), northeast of Purdy (23 houses), south of Pleasant Ridge (4 houses), southwest of Pleasant Ridge (7 houses), and southeast of Monett (7 houses), however, it is difficult to tell from aerial photos how many of these are in use; there is a quarry along Flat Creek in the middle section of the sub-watershed; the small village of McDowell, once the site of a grist mill, is located on Little Flat Creek just above its confluence with Flat Creek.

Map ID 30: Gunter Creek-Flat Creek (25,776 acres): About 50% in pasture or grasslands, on flat to gently sloping land, especially in wide stream bottoms; 50% forested, mainly on steeper slopes near drainages and in woodlots; there are four DNR-permitted animal feeding operations in the sub-watershed—three 1C broiler operations on Road 2110 west of Highway C with 640, 400 and 400 animals units (12,000 to 19,000 birds each), and another 1C broiler operation south of Z highway with 1848 animal units (about 55,000 birds); two clusters of apparently non-permitted animal raising houses can be identified on aerial photos—a cluster southeast of Butterfield with 4 houses, and one north of Butterfield with 14 houses, although it is difficult to tell from aerial photos if these are still in operation; George's Poultry Processing Plant is located just west of the sub-watershed divide; town of Butterfield is located on the west end of the sub-watershed, at the James River Basin divide; less than 1% urbanized.

Map ID 33: Jenkins Creek (16,224 acres): About 65% in pasture and grasslands on flat to gently sloping land and in stream bottoms, especially in the southern half of the sub-watershed; about 45% forested, mainly on steeper slopes near drainages, with large areas of contiguous forest in the north half of the sub-watershed; no permitted animal feeding operations; no major cities or municipal wastewater discharges; the village of Jenkins is located at the mouth of Jenkins Creek, where an iron bridge spans Flat Creek.

Map ID 34: Dry Creek ((13,854 acres): The smallest of the nine HUC-12 sub-watersheds in the Flat Creek Watershed, with steep topography and little flat land except in the valley bottoms of Dry Creek and Flat Creek; about 70% forested, the fourth most forested sub-watershed in the James River Basin; about 30% pasture, primarily in stream bottoms; one permitted animal feeding operation—a class 1C broiler operation southwest of Crane (the permit information shows 0 animal units); no major towns (less than 1% urbanized), but many homes on large lots near Table Rock Lake.

Map ID 35: Flat Creek (13,854): Located at the lower end of the Flat Creek Watershed, near its mouth at Table Rock Lake; about 50% pasture or grasslands, especially in the wide stream bottoms at the lower end of Flat Creek; some large farms are located in the big valley of Flat Creek near Table Rock Lake; about 50% forested, mainly on steep slopes near drainages and mostly in the north and south ends of the sub-watershed; Table Rock Lake backs water into Flat Creek at the lower end of this sub-watershed; there are no large cities or towns, no municipal wastewater discharges; no permitted animal feeding operations.

Map ID 37: Willow Branch-Flat Creek (26,122 acres): About 50% pasture and grasslands, on flat to gently sloping land and in the larger stream bottoms, with more grasslands in the southern half of the sub-watershed; about 50% forested, on steeper slopes and near drainages, with several large areas of contiguous forest land; two permitted animal feeding operations—a class 1C broiler operation north of Highway 248 with 1,440 animal units (about 43,000 birds), and a 1C broiler operation south of Highway 248 with 1,200 animal units (36,000 birds); large quarry in the southern portion of the sub-watershed near Highway 248; Stubblefield MDC Access is located on Flat Creek near its confluence with Willow Branch; no municipal wastewater discharges.

Map ID 38: Rockhouse Creek (21,401 acres): This sub-watershed is dominated by steep terrain, and is the most heavily forested sub-watershed in the Flat Creek Watershed (85), and the second most forested sub-watershed in the entire James River Basin; about 15% in pastures and grasslands, mainly on flat ridge tops and in larger floodplains; there is one DNR-permitted animal feeding operation: a 1C broiler operation near Highway 76 at the western edge of the sub-watershed with 2520 animal units (about 76,000 birds); The small village of Mineral Springs, once a spa-town, is the only town in the sub-watershed; no permitted wastewater discharges; less than 1% urbanized.

Map ID 39: Corder Hollow-Flat Creek (16,450 acres): About 50% pastures and grasslands, on flat to gently rolling land, especially along the wide valley bottoms at the lower end of Flat Creek; about 45% forested, mainly on steep slopes near drainages and in woodlots, especially in the northern and southern parts of the sub-watershed; about 2% urbanized, including the northeast part of the city of Cassville and isolated areas of residential subdivisions in the center of the sub-watershed; the city of Cassville (population 3,300) discharges about 1.1 million gallons per day of treated wastewater into Flat Creek in this sub-watershed; there is one DNR-permitted animal feeding operation, a class 1C broiler chicken operation northeast of Cassville with 1056 animal units (about 32,000 birds); at least 35 animal raising houses, apparently non-permitted facilities, can be identified on aerial photographs (a cluster northeast of Cassville with 20 houses, a cluster northwest of Cassville with 10 houses near the watershed divide with Shoal Creek, and a cluster east of Cassville with 5 houses on the watershed border with Rockhouse Creek), however, it is difficult to tell from aerial photographs how many of these remain in use; about 2% is in urban uses, including the northeast part of the city of Cassville; there are isolated areas of residential development in the central part of the sub-watershed; forests comprise about 35% of the land area, primarily on steeper terrain near creeks and smaller drainages, with the steep slopes generally forested; other than Cassville, no major cities or towns.

Map ID 42: Headwaters Flat Creek (30,776 acres): About 85% pastures and grasslands, mainly on flat to gently sloping land and along larger stream bottoms; in the past, several large orchards were located near the town of Exeter, but most of these are gone; there are a few isolated areas of cultivated crops in the southern portion of the sub-watershed (less than 1%); about 5% urbanized, with the southern two-thirds of the city of Cassville in the sub-watershed; Cassville (population 3,300) discharges about 1.1 million gallons per day (MGD) of treated wastewater into Flat Creek to the north, or downstream, of the city; Exeter (population 800) has a small oxidation ditch treatment plant that discharges about 40,000 gallons per day of treated wastewater into a small tributary of Flat Creek; Washburn (population 450), at the most southwestern tip of the James River Basin, uses a lagoon for sewage treatment and discharges about 25,000 gallons per day into a tributary of Flat Creek; two DNR-permitted animal feeding operations—one class 1C poultry operation southeast of Cassville with 960 animal units (about 29,000 birds), and one Class II turkey operation east of Washburn; from aerial photographs, it appears that are at least 36 non-permitted growing houses (a cluster near the watershed divide with Roaring River with 14 houses, a cluster west of Highway 112 with five houses, a cluster northeast of Washburn with 11 houses, and one southeast of Cassville with 6 houses), although it is difficult to tell from aerial photos how many of these remain in use.

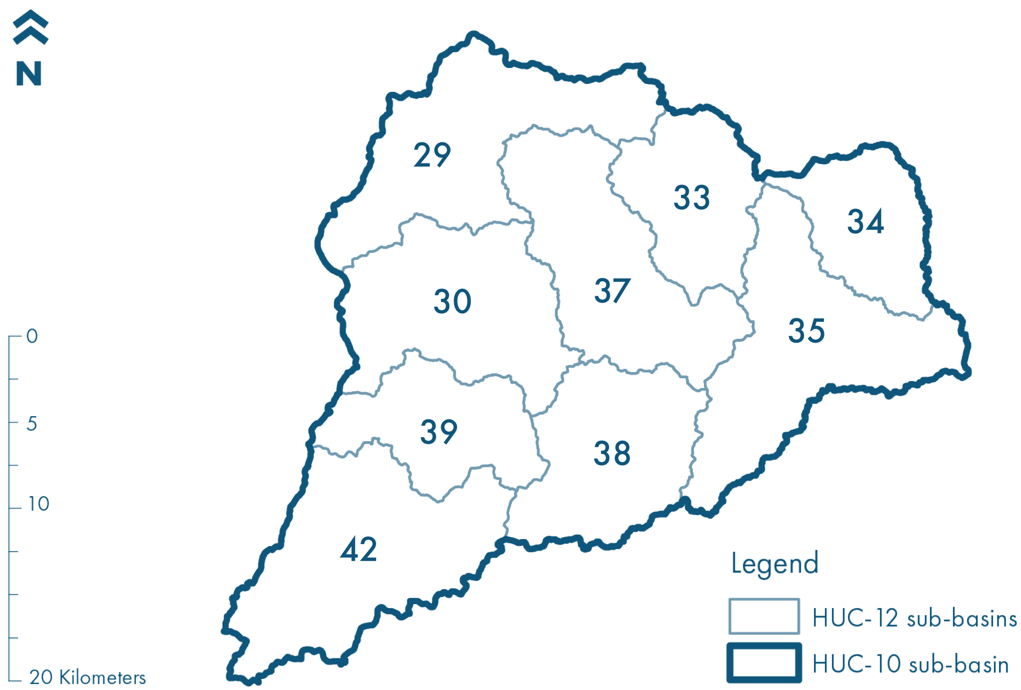
One of the most severe problems in this sub-watershed is the flooding along Flat Creek in the city of Cassville. Some storms have done millions of dollars in damage to downtown businesses. The city opted out of the federal flood insurance program many years ago. Now, with more frequent and severe floods, some large industries have threatened to move out of the community unless the city takes steps to alleviate the flooding problems. The city is currently engaged with FEMA, SEMA, the USGS and other federal and state agencies to determine a course of action.

MODELING AND CRITICAL AREA IDENTIFICATION

Critical areas as identified in this plan include: 1) watersheds or sub-watersheds identified in the model as likely to contribute excessive loadings of total nitrogen (TN), total phosphorus (TP) or sediment to waterbodies; 2) watersheds or sub-watersheds of waterbodies which have been placed on the 303-d list and identified as impaired, and 3) watersheds or sub-watersheds contributing source water to public drinking water supplies.

From SWAT modeling, sub-watershed 42 (Headwaters Flat Creek) was determined to have by far the highest potential loadings of sediment, TN and TP of any of the nine sub-watersheds in the Flat Creek HUC-10 watershed (Figure 19). This sub-watershed is about 85% in pasture and about 5% urbanized at its lower end, with the city of Cassville. There are two DNR permitted concentrated animal feeding operations (CAFOs) in the watershed, with many smaller, non-permitted facilities. Most if not all of these are poultry operations. There are two small municipal wastewater facilities in the upper part of the sub-watershed, at Exeter (oxidation ditch) and Washburn (lagoon). The city of Cassville has a large wastewater facility discharging into Flat Creek at the lower (northern) end of the sub-watershed. A major problem identified in this sub-watershed is recurrent flooding along Flat Creek and its tributaries in the city of Cassville. This is due to both encroachment of urban development in the floodplain and increasing frequency of flooding events on Flat Creek and its tributaries. The Flat Creek HUC-10 watershed does not contain any 303-d listed stream segments or surface water public water supply watersheds.

Figure 19: Land Uses in Flat Creek HUC-10, HUC-12 Sub-watersheds.



Rank	Sediment (Mg/km²)	Sub-basin	TN (kg/ha)	Sub-basin	TP (kg/ha)	Sub-basin
1	767	42	37	42	3.7	42
2	408	39	25.1	39	2.1	39
3	136	33	21.5	34	1.2	30
4	122	37	20.4	29	0.9	29
5	106	35	16.3	35	0.7	37
6	77	29	15.9	30	0.5	33
7	66	38	15.1	33	0.5	34
8	52	34	14.3	37	0.5	35
9	42	30	12.5	38	0.3	38

RECOMMENDED MANAGEMENT MEASURES

The application of litter from poultry operations in Flat Creek sub-watersheds has been of concern to resource professionals in the past. However, recent conversations with USDA representatives in Barry and Greene County suggest that water quality concerns from land applications of litter have been reduced because 1): much if not most of the litter is now being exported from the Flat Creek sub-watershed to row crop production areas elsewhere, especially in western Missouri north of Barry County. The fertilizer value of litter is now widely recognized, and its cost, even with transportation, is lower than chemical fertilizers. 2) many growers in these sub-watersheds now have covered litter storage facilities and composting facilities for dead birds.

The recommended management measure is that there be specific monitoring programs and documentation of improved water quality related to better management of poultry growing operations and the wastes produced by them.

Resource professionals mention that cattle operations are now of larger concern, with large numbers of animals grazing with direct access to stream zones. For this reason, a management measure recommended in this plan is managed grazing systems, with alternative watering and restricted or controlled animal access to stream zones. Also, improved forage conditions and soil health in grazing areas would improve soil infiltrative capacities. This, along with healthy riparian zones along perennial streams, would reduce runoff to surface streams that contribute to downstream flooding problems in the city of Cassville.

Surveys in the upper Flat Creek watershed have also revealed that there are many de-stabilized and denuded banks along upper Flat Creek. Bank erosion is apparent along several stretches of the creek just upstream of Cassville. Bank stabilization and protection are needed to improve water quality, reduce sediment inputs, and provide increasing flood

GOALS FOR FLAT CREEK

10 Years

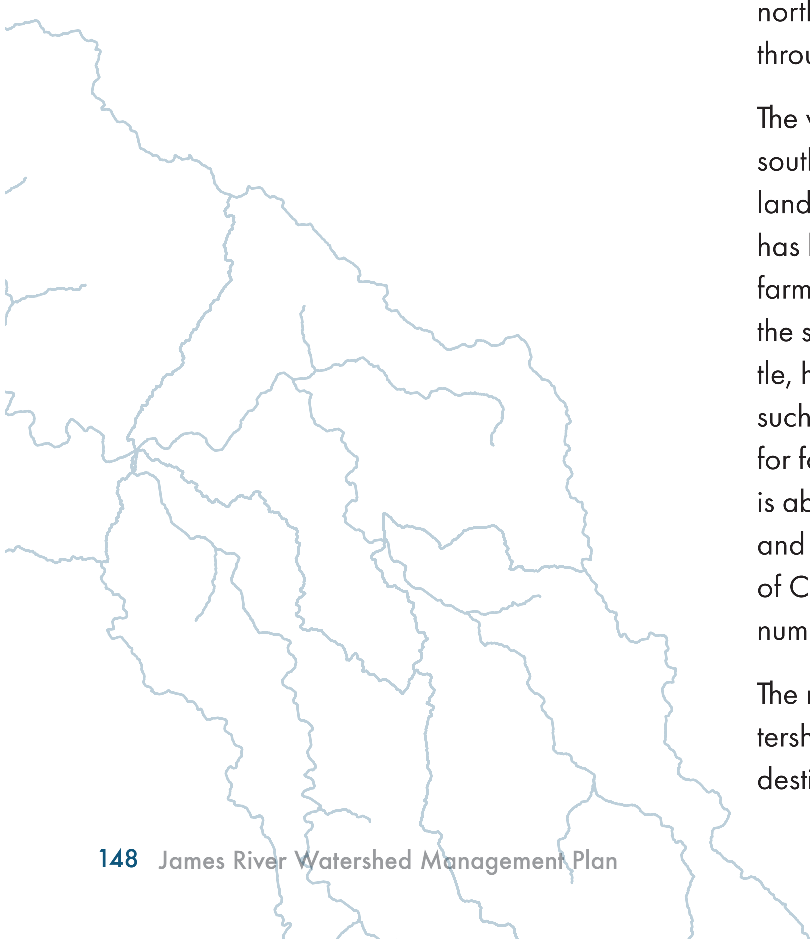
- County Point-of-sale inspections of onsite wastewater systems
- County requirement of maintenance contracts on advanced wastewater systems

20 Years

- 200 Septic system pump-outs
- Managed grazing system on 25% (6,600 acres) of pasture lands for Headwaters Flat Creek HUC-12 Sub-watershed, resulting in the removal of 149,000 lbs of sediment, 1,320 lbs of TN, and 462 lbs of TP per year.
- Riparian zone protection on 25 acres (100-foot buffers) for Headwaters Flat Creek HUC-12 Sub-watershed resulting in the removal of 2,825 lbs of sediment, 88 lbs of TN, and 10 lbs of TP per year.
- Streambank erosion protection/stabilization on 500 linear feet of stream for Headwaters Flat Creek HUC-12 Sub-watershed resulting in the removal of 30,500 lbs of sediment, 190 lbs of TN and 25 lbs of TP per year.

10

Action Plan for Crane Creek-James River HUC-10 Watershed



The Crane-Creek-James River HUC-10 Watershed, located in the lower James River Basin, contains 190,277 acres, or 297.3 square miles in Stone, Barry, Christian and Lawrence Counties, with most of the watershed in Stone County. Crane Creek is a large spring-fed stream that has headwaters near the Spring River Basin to the west. The stream flows generally east to southeast toward its confluence with the James River, north of the town of Galena. Crane Creek flows through the city of Crane at the City Park.

The watershed is predominantly forested in its southern portion, with more pasture and grasslands to the north and west. Historically, land use has been primarily agriculture, with small family farms in cleared areas and forests and glades on the steeper slopes and hilltops. Farmers raise cattle, hogs, and poultry, grow fruit and vegetables such as peaches and tomatoes, and grow grass for forage and hay production. The watershed is about 60% in agricultural uses, 37% forested and less than 2% urbanized (small communities of Crane and Galena). There is an increasing number of homes scattered in rural areas.

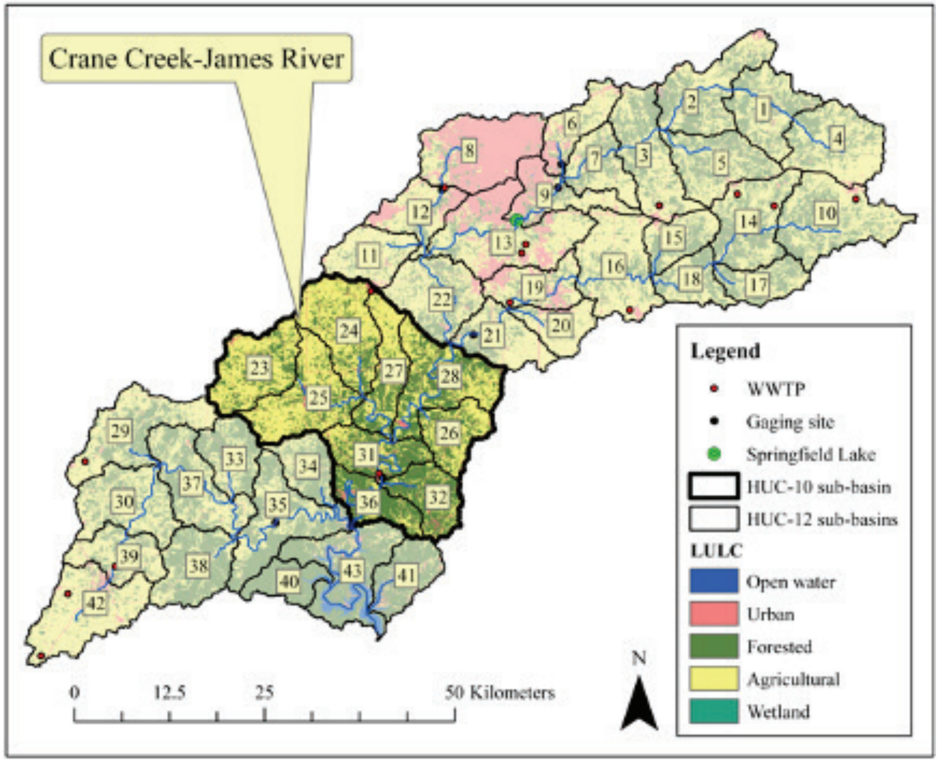
The rural nature and scenic values of this sub-watershed make it one of the most popular tourist destinations in the James River Basin. Large numbers of people canoe on the James River and many fly fishermen try their luck in Crane Creek, which has a self-sustaining population of red-band trout from the McCloud River of California.

The Crane-Creek James River HUC-10 Watershed has been divided by the USGS into nine smaller HUC-12 sub-watersheds, ranging in size from 14,355 acres to 29,472 acres. These sub-watersheds are listed below, along with some of their general characteristics:

Map ID 23: Upper Crane Creek (24,804 acres): About 70% pastures and grasslands on flat to gently sloping land and in larger stream bottoms; about 30% forested, mostly on steeper slopes near drainages and in woodlots; Less than 1% urbanized, primarily the east side of Aurora near U.S. 60 Highway; small area of cultivated crops (less than 1%) in the north part of the sub-watershed; no municipal wastewater discharges; no permitted animal feeding operations.

Map ID 24: Spring Creek (27,764 acres): About 80% pasture on flat to gently sloping land and along stream bottoms; about 20% forested, mainly on steeper slopes near drainages and in woodlots, especially along Spring Creek in the southern part of the sub-watershed; about 1% urban, including the west side of Clever and

Figure 31: James River Basin with Crane Creek



1 Dry Creek-James River	18 Squaw Run Creek-Finley Creek	34 Dry Creek-James River
2 Turnbo Creek-James River	19 Spout Spring Hollow-Finley Creek	35 Flat Creek
3 Sayers Creek-James River	20 Elk Valley	36 Wilsons Run-James River
4 Headwaters-James River	21 Finley Creek	37 Willow Branch-Flat Creek
5 Panther Creek	22 Green Valley Creek-James River	38 Rockhouse Creek
6 Pearson Creek	23 Upper Crane Creek	39 Corder Hollow-Flat Creek
7 Turner Creek-James River	24 Spring Creek	40 Piney Creek
9 Lake Springfield-James River	25 Middle Crane Creek	41 Aunts Creek
10 Headwaters Finley Creek	26 Goff Creek	42 Headwaters Flat Creek
11 Terrell Creek	27 Lower Crane Creek	43 Table Rock Lake-James River
12 Wilsons Creek	28 Tory Creek-James River	
13 Ward Branch-James River	29 Little Flat Creek	
14 Davis Branch-Finley Creek	31 Pine Run-James River	
16 Parched Corn Hollow-Finley Creek	32 Railey Creek	
17 Stewart Creek	33 Jenkins Creek	

the small village of Hurley; Hurley (population 200) discharges about 7,300 gallons per day of treated wastewater into Spring Creek; no permitted animal feeding operations.

Map ID 25: Middle Crane Creek (28,329 acres): About 75% in pasture and grasslands, on flat to gently sloping land and along stream bottoms; about 20% forested on steeper slopes, especially near Crane Creek; about 3% urban development in the center of the sub-watershed at the city of Crane; Crane (population 1,400) discharges about 64,000 gallons per day of treated wastewater into Crane Creek; no permitted animal feeding operations.

Map ID 26: Goff Creek (15,270 acres): About 60% pasture on flat to gently sloping land and in stream bottoms; about 35% forested on steeper slopes near drainages and in woodlots; about 2% urbanized, at Spokane along U.S. 160 highway and at the small town of Ponce de Leon, once a mineral water spa town; one permitted Class 1C animal feeding operation, a turkey and turkey egg production facility with 1018 animal units; no municipal wastewater discharges.

Map ID 27: Lower Crane Creek (18,232 acres): About 50% pasture and grasslands on flat to gently sloping land; northern half of sub-watershed south of Clever is almost all pasture land; about 50% forests, on steeper slopes and in woodlots, with most forests in the southern half of the sub-watershed; less than 1% urbanized, including a small developed area south of Clever; a few areas of cultivated crops (less than 1%) just south of Clever; no municipal wastewater discharges; no permitted animal feeding operations.

Map ID 28: Tory Creek-James River (29,472 acres): About 60% pasture on flat to gently sloping land and in stream bottoms, mostly in the eastern part of the sub-watershed near Highlandville; about 35% forested on steeper slopes, especially near James River; about 2% urbanized, along U.S. 160 Highway near Highlandville; a few isolated areas of cultivated crops (less than 1%) in the eastern part of the sub-watershed; no municipal wastewater discharges; no permitted animal feeding operations.

Map ID 31: Pine Run-James River (16,570 acres): About 75% pasture and grasslands on flat to gently sloping lands and along stream bottoms, especially at the east end of the sub-watershed, with some very large pastures along the James River; about 20% forested, mostly on steeper slopes near drainages and in large woodlots; about 2% urbanized, including the city of Galena and developed areas along the James River north of Galena; city of Galena (population 400) discharges about 50,000 gallons per day of treated wastewater into Pine Run Creek, which flows immediately into the James River; three permitted animal feeding operations—two class 1C turkey and turkey egg facilities north of Galena, with 200 and 400 animal units each, and one 1C broiler/fryer facility southeast of Crane with 1,152 animal units.

Map ID 32: Railey Creek (15,481 acres): About 50% pasture on flat to gently sloping land and along stream bottoms; about 45% forested, mainly on steeper slopes near drainages and in stream bottoms; about 3% urban, with developed areas near Reeds Spring and along U.S. 160 Highway on the eastern divide of the sub-watershed; Reeds Spring (population 900) discharges about 90,000 gallons per day of treated wastewater into Railey Creek, which flows to the west and northwest toward the James River; no permitted animal feeding operations.

Map ID 36: Wilson Run-James River (14,355 acres): Located at the lowermost James River where it enters the James River arm of Table Rock Lake; contains a significant amount of water surface in the James River arm of Table Rock Lake; about 75% forested, with steep topography over most of the sub-watershed; about 20% in pastures, mainly along the flatter drainage divides; about 1% urbanized, including the south side of Galena, a large residential subdivision near Table Rock Lake at McCord Bend (onsite wastewater systems), and another large developed area on Table Rock Lake; no municipal wastewater discharges; no permitted animal feeding operations.

MODELING AND CRITICAL AREA IDENTIFICATION

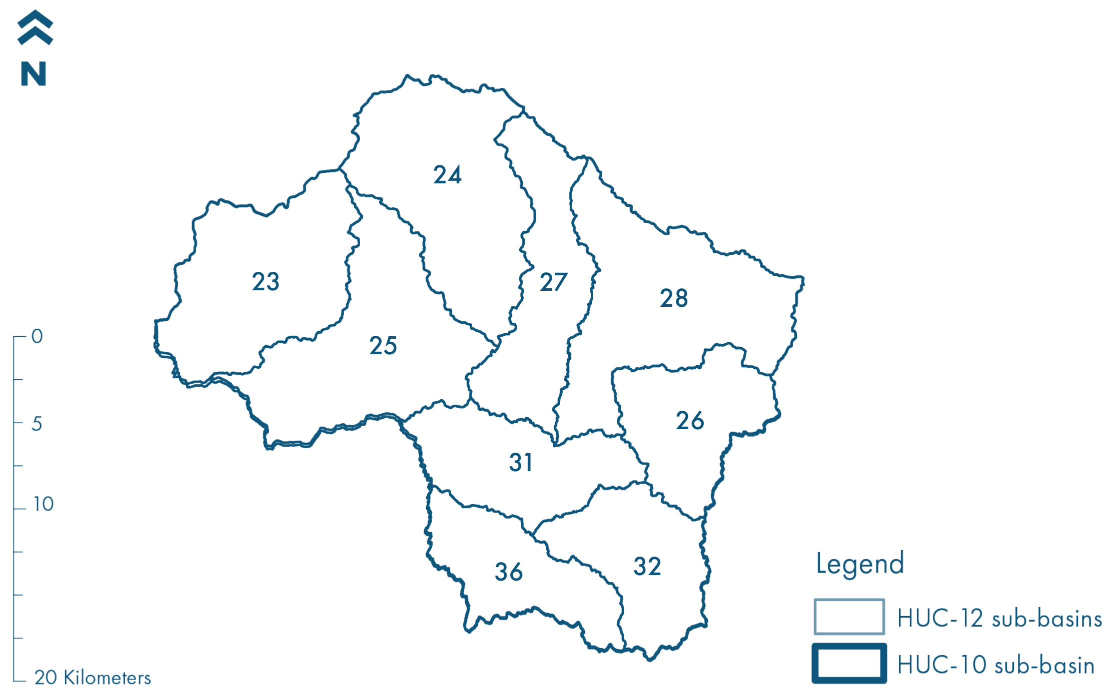
Critical areas as identified in this plan include: 1) watersheds or sub-watersheds identified in the model as likely to contribute excessive loadings of total nitrogen (TN), total phosphorus (TP) or sediment to waterbodies; 2) watersheds or sub-watersheds of waterbodies which have been placed on the 303-d list and identified as impaired, and 3) watersheds or sub-watersheds contributing source water to public drinking water supplies.

By these definitions, sub-watershed 25 (Middle Crane Creek) has been identified as a critical area in this plan. This sub-watershed has been shown in the SWAT model as likely to contribute excessive loads of sediment, TN and TP, much higher than the remaining six HUC-12 sub-watersheds in the Crane Creek-James River HUC-10. Sub-watershed is 75% pasture lands. 13.2 miles of Crane Creek is on the 2012 303-d list for aquatic macroinvertebrate bioassessment (loss of biotic diversity). This section of Crane Creek runs primarily through the upper and middle sub-watersheds. Further, Crane Creek has been shown during Snapshot monitoring in 2013, 2016 and 2019 (for description of Snapshot Monitoring Program, see Appendix) to have higher TN levels than other tributaries of the James River. Because Crane Creek supports a unique trout fishery, these higher levels of nitrogen have been of concern to fisheries biologists.

RECOMMENDED MANAGEMENT MEASURES

Most of the land in the western and northern portions of the Crane Creek-James River HUC-10 are in agricultural uses. In the southern and eastern portions of the watershed, topography is hilly and steeper areas are mostly forested. The most common agricultural use is grazing of beef cattle on pastures, although there are a few poultry operations. Recommended management measures for agriculture in this HUC-10 include the installation of managed grazing systems, the provision of alternative watering systems, protection and enhancement of riparian zones and pasture stand improvements.

Figure 21: Land Uses in Crane HUC-10, HUC-12 Sub-watersheds.



Rank	Sediment (Mg/km^2)	Sub-basin	TN (kg/ha)	Sub-basin	TP (kg/ha)	Sub-basin
1	386	25	47.8	25	1.6	25
2	318	23	37.3	23	1.1	26
3	198	24	35.7	24	1	23
4	65	26	23.7	26	0.9	24
5	61	36	19.9	28	0.7	31
6	50	32	17.1	27	0.5	27
7	41	31	14.2	31	0.5	28
8	36	27	9.3	36	0.4	32
9	25	28	9.2	32	0.3	36

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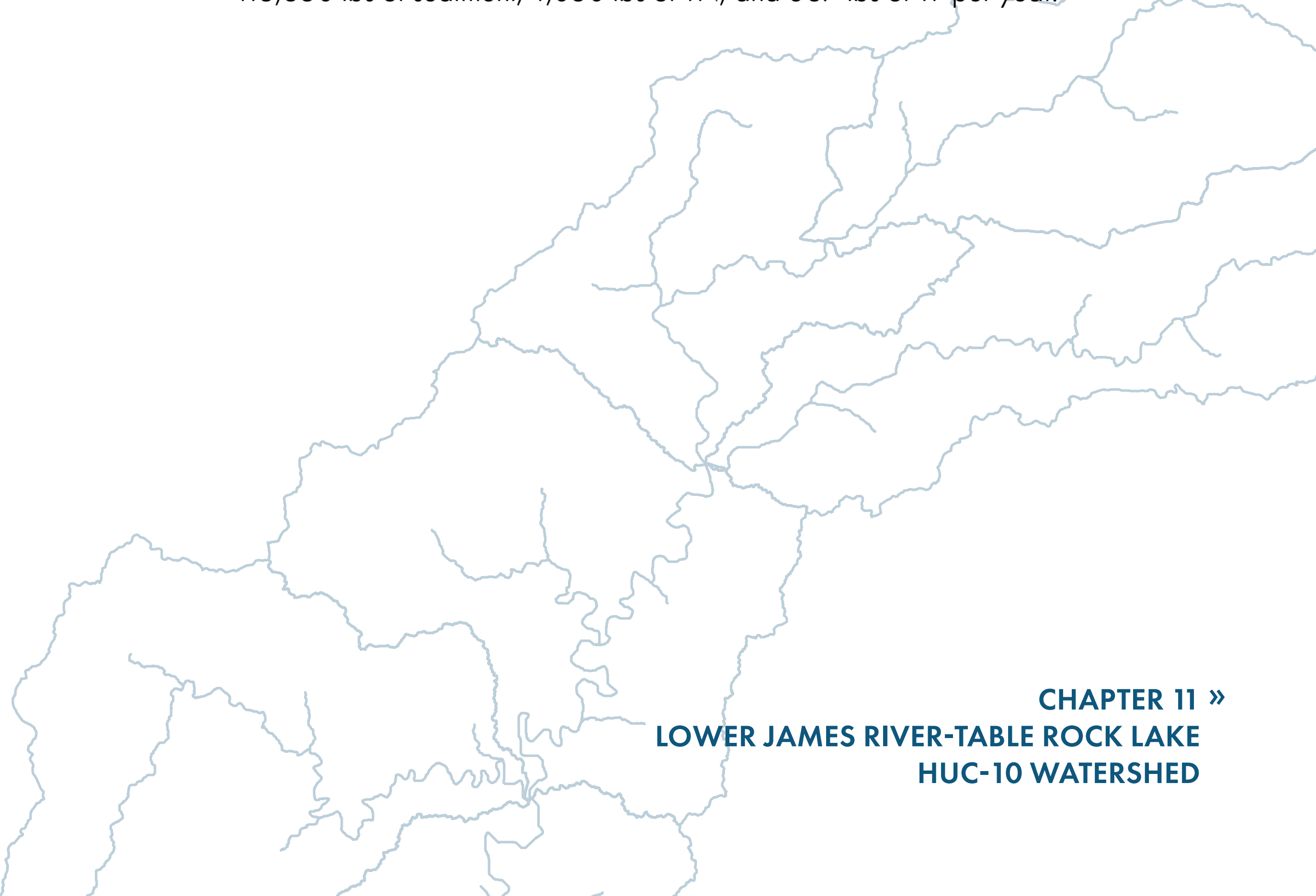
Because the James River is a popular float and fishing stream where it passes through this HUC-10 watershed, riparian areas along the river are very important. Some conservation easements have been established along the James River in this watershed, placing healthy riparian areas in permanent protection. There are also public lands along Crane Creek where riparian areas are protected, although the Missouri Department of Conservation's James River Basin Inventory and Management Plan (1997) identified the need for more and larger riparian zones along other sections of Crane Creek to support a viable trout fishery. For these reasons, riparian zone protection and enhancements are management measures that should be strongly supported in this watershed.

GOALS FOR CRANE CREEK

20 Years

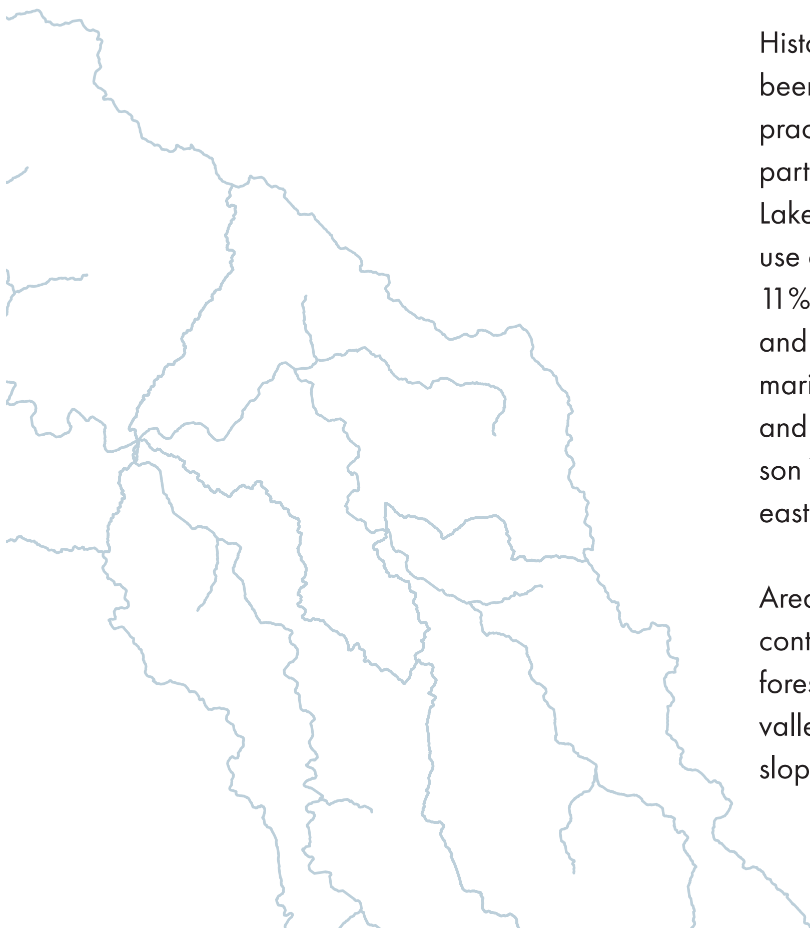
- 25 acres of riparian zone (100-foot buffer width) protected along Crane Creek resulting in the removal of 2,825 lbs of sediment, 88 lbs of TN, and 10 lbs of TP per year.
- 50 acres of riparian zones in conservation easements or otherwise permanently protected along Crane Creek
- 100 Septic Tank pump-outs
- 25% (5,250 acres) of pasture lands in managed grazing systems for the Middle Crane Creek HUC-12 Sub-watershed resulting in the removal of 118,650 lbs of sediment, 1,050 lbs of TN, and 367 lbs of TP per year.



CHAPTER 11 »
LOWER JAMES RIVER-TABLE ROCK LAKE
HUC-10 WATERSHED

11

Lower James River-Table Rock Lake HUC-10 Watershed



The James River flows into Table Rock Lake at the southern end of the James River Basin. This lower section of river, once wide and shallow in places and interspersed with deep holes along high bluffs, is now submerged by the reservoir. The Lower James River-Table Rock Lake watershed encompasses an area of 58,727 acres in Stone and Barry Counties, with the majority of the watershed lying in Stone County.

Historically, land cover in this watershed has been primarily forest with livestock agriculture practiced in wide bottom lands along the river, particularly prior to the formation of Table Rock Lake in the 1950s. According to a recent land use classification, this watershed is now about 11% in agricultural uses, with 72% forest cover and 2% urban area. Agricultural areas are primarily cleared pasture and grasslands for forage and hay production. Urban areas include Branson West and Kimberling City, which lie on the eastern divide of the watershed.

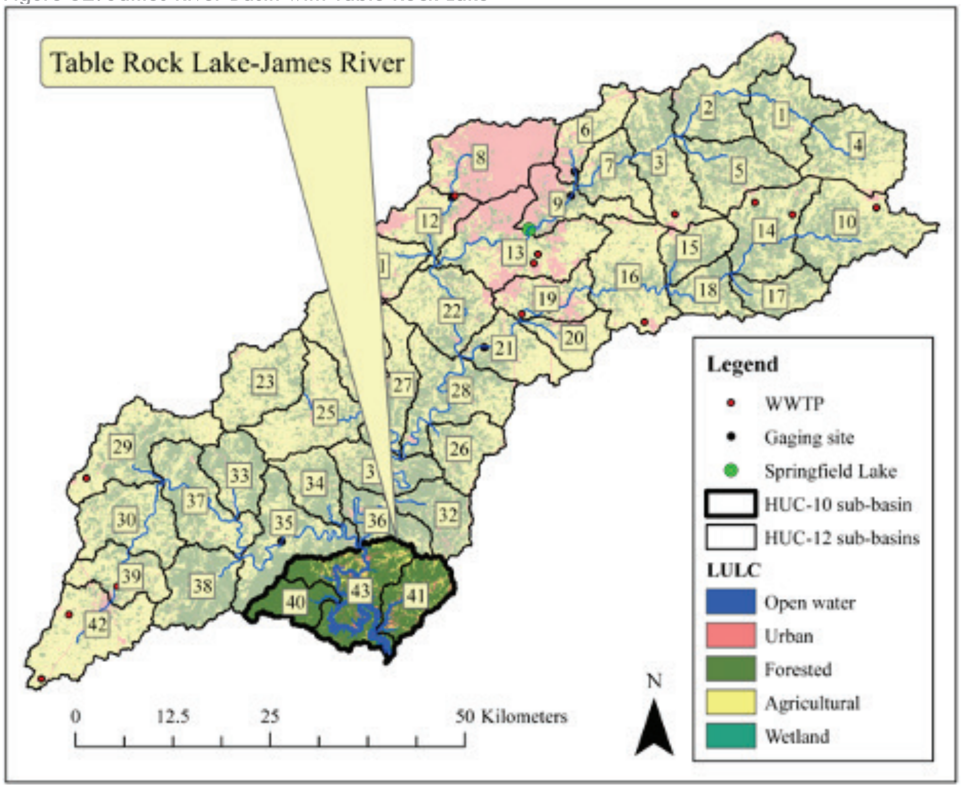
Areas of the watershed near Table Rock Lake contain high slopes and are mostly covered in forests. Soils on the ridge tops and large river valley bottoms are relatively deep. Soils on slopes are thin and poor, supporting mainly post-oaks and cedar. Creek bottoms soils are gravelly in the upper reaches of the watershed but become deeper silty loams in the lower reaches of streams. Most of the streams are clear and shallow with chert gravel and in some stretches, smooth limestone bottoms.

Scenic landscapes, clear, spring-fed streams and Table Rock Lake have made this watershed a very popular family vacation, lake home, resort and retirement destination. Rapid population increase is largely taking place in rural, lake-front communities. These increases are projected to continue as people move to the area for lower taxes, relatively low cost of living, and lake-oriented recreational opportunities.

There are no USGS gaging stations in this watershed. It is located downstream of the lowermost reference gage in the James River Basin at Galena.

There are three HUC-12 sub-watersheds designated by the United States Geological Survey within the Lower James River—Table Rock Lake HUC-10 watershed, ranging in size from 11,193 acres to 31,536 acres. They are listed below, along with some of their general characteristics:

Figure 32: James River Basin with Table Rock Lake



1 Dry Creek-James River	18 Squaw Run Creek-Finley Creek	34 Dry Creek-James River
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5 Panther Creek	22 Green Valley Creek-James River	38 Rockhouse Creek
6 Pearson Creek	23 Upper Crane Creek	39 Corder Hollow-Flat Creek
7 Turner Creek-James River	24 Spring Creek	40 Piney Creek
9 Lake Springfield-James River	25 Middle Crane Creek	41 Aunts Creek
10 Headwaters Finley Creek	26 Goff Creek	42 Headwaters Flat Creek
11 Terrell Creek	27 Lower Crane Creek	43 Table Rock Lake-James River
12 Wilsons Creek	28 Tory Creek-James River	
13 Ward Branch-James River	29 Little Flat Creek	
14 Davis Branch-Finley Creek	31 Pine Run-James River	
16 Parched Corn Hollow-Finley Creek	32 Railey Creek	
17 Stewart Creek	33 Jenkins Creek	

Map ID 40: Piney Creek ((11,193 acres): About 98% forested; most highly forested sub-watershed in the James River Basin; contains the large Piney Creek Wilderness Area, administered by the U.S. Forest Service; small pastures and grass lands along some tributary creeks (2%); less than 1% urbanized; no permitted animal feeding operations; no municipal wastewater discharges.

Map ID 41: Aunts Creek (15,998 acres): Second most forested sub-watershed in the James River Basin at about 85%; contains Aunts Creek arm of Table Rock Lake; about 10% in pastures, mainly in stream bottoms; about 3% developed areas, along the lakefront and on the sub-watershed divide north of Kimberling City and at Branson West; treated wastewater from Branson West (about 740,000 gallons per day) discharged into Aunts Creek; no permitted animal feeding operations.

Map ID 43: Table Rock Lake-James River (31,536 acres): About 30% in open water, primarily the large James River arm of Table Rock Lake; about 55% forested, especially south part of sub-watershed; about 5% urbanized, mostly in developed areas near the lake, but also at the town of Cape Fair; about 10% pasture lands, especially in valley bottoms, mostly in the northern part of sub-watershed; no permitted animal feeding operations; no municipal wastewater discharges.

WATER QUALITY CONDITIONS

The James River Arm of Table Rock Lake is currently listed as an impaired water body or 303(d) list due to excessive nutrients, particularly phosphorus. Excessive nutrient loading in streams occurs in association with areas of urban development and agricultural uses. The James River Arm is affected by population increases as towns expand and subdivisions spring up around the lake to accommodate people who value lakefront living. Pollutants generated by residential and commercial development include lawn fertilizers, construction erosion, pet wastes and impervious area runoff.

Another potential source of pollution commonly found in lakeside areas is onsite wastewater systems, mostly septic tank systems. Large numbers of septic systems in the shallow, rocky and often sloping soils in this sub-watershed may be releasing significant nutrient pollution into the reservoir. A study by Table Rock Lake Water Quality Inc. found that average septic tank effluent contains 5 milligrams per liter (mg/l) of total phosphorus (TRLWQ, 2007). Based upon this and an estimated 60 gallons of water usage per day per person, the average phosphorus output would be 2,270 milligrams of total phosphorus per year for a 2-person household.

Many homes in the James River Arm of Table Rock Lake watershed are utilizing 500 gallon metal (many now heavily rusted) drums as septic tanks. With approximately 35,000 residents in Stone County and an estimated 50% septic system failure rate, water quality degradation is probably significant, although this is difficult to monitor. This sub-watershed is therefore considered a priority area for onsite wastewater treatment BMPs, including advanced and clustered treatment systems.

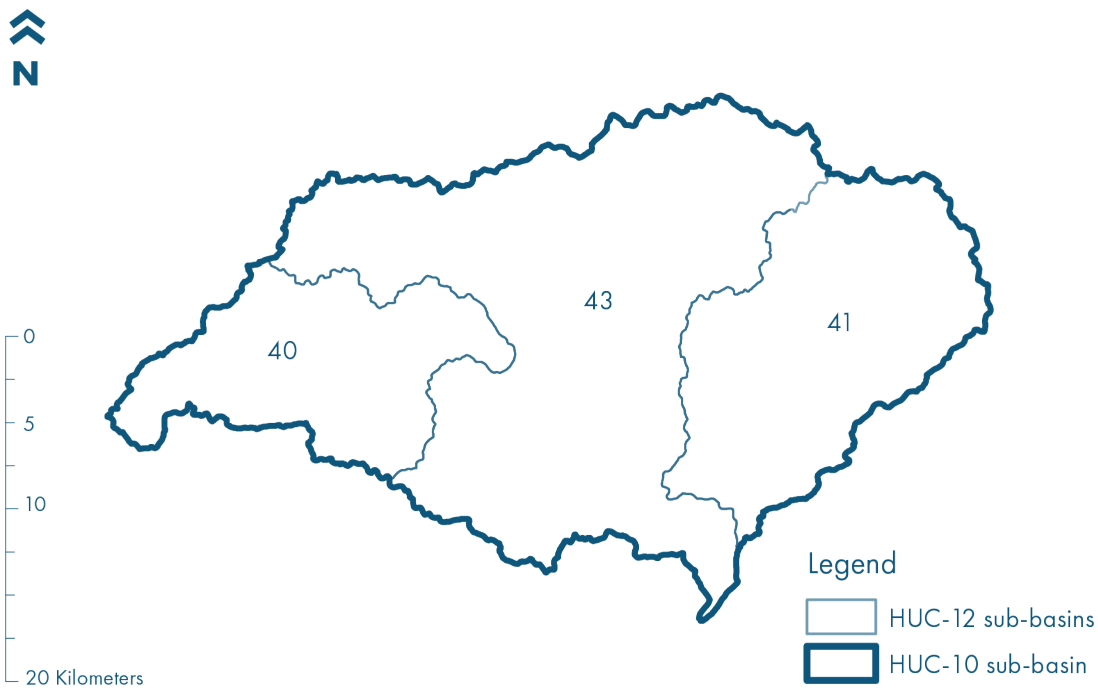
Failing and inadequate septic systems have been listed by area residents as a major concern. A septic tank pump-out incentive program for James River Basin residents has been well received in the Table Rock Lake area. Table Rock Lake Water Quality Inc. (TRLWQ) has implemented a project to demonstrate and monitor the performance of alternative wastewater treatment technologies. Stone County Health Department (SCHD) has also launched a program focusing on septic regulations and enforcement as well as revising ordinances to reflect needed changes in the installation and operation of onsite wastewater treatment systems. These actions and programs have been in response to the potentially negative water quality implications of an increasing population as well as concerns raised by local citizens.

The James River Arm also contains many construction sites at any given time. These can add significant loads of sediment and associated nutrients to streams or directly to the lake. Erosion is accelerated when trees and vegetation are removed to create better views of the lake, especially on steep slopes. Heavy rains cause streams and Table Rock Lake to become very muddy, especially in isolated coves where a significant amounts of land clearing and construction are occurring. The actual effects and benefits of detention basins, silt fences and other BMPs to help prevent erosion on construction sites are difficult to measure.

MODELING AND CRITICAL AREA IDENTIFICATION

According to the SWAT model, the three sub-watersheds in this HUC-10 are very low in inputs of TN and TP compared to the majority of sub-watersheds in the James River Basin. This is because the sub-watersheds are steep topography and heavily forested. Piney Creek,

Figure 23: Land Uses in Table Rock Lake HUC-10, HUC-12 Sub-watersheds.



Rank	Sediment (Mg/km²)	Sub-basin	TN (kg/ha)	Sub-basin	TP (kg/ha)	Sub-basin
1	95	43	10	43	0.4	43
2	72	41	8.9	40	0.3	41
3	48	40	8.6	41	0.2	40

at 98% forested, is by far the most heavily forested HUC-12 sub-watersheds of the 43 sub-watersheds in the James River. A majority of this sub-watershed is in National Forest, containing the Piney Creek Wilderness Area. It produces very little TP or TN in runoff. The Aunts Creek sub-watershed, at 85% forested, is the second most forested sub-watershed in the James River Basin. The Table Rock Lake-James River sub-watershed, the middle sub-watershed of the three along both sides of the James River and James River arm of Table Rock Lake, is 55% forested, but about 30% of the HUC-12 sub-watershed is the open water of Table Rock Lake.

Table Rock Lake itself, however, is on the 2002 303-d list for chlorophyll-a and nutrient enrichment. This was largely the result of a large algae bloom in the James River arm of Table Rock Lake in 1999. Most of the nutrients at that time originated from treated wastewater discharges and agricultural runoff from cities and farmland in the James River above Table Rock Lake, and most likely not from land very near the lake. For this reason, the three sub-watersheds are not being considered critical areas for sediment or nutrients in runoff. However, a study conducted by Ozark Water Watch indicated the likelihood that onsite wastewater systems and small package treatment plant near coves were contributing effluent to the lake.

RECOMMENDED MANAGEMENT MEASURES

Onsite wastewater systems in steep, often rocky terrain around Table Rock Lake are most likely contributing nutrients and bacteria to coves of the lake where these systems are concentrated. Stone County, where the Aunts Creek and Table Rock Lake-James River sub-watersheds are located, already has point of sale inspections and required maintenance contracts for advanced systems. These programs have been successful, in that most homeowners needing systems repaired do so before placing the house on the market. It is especially important that advanced systems have maintenance contracts.

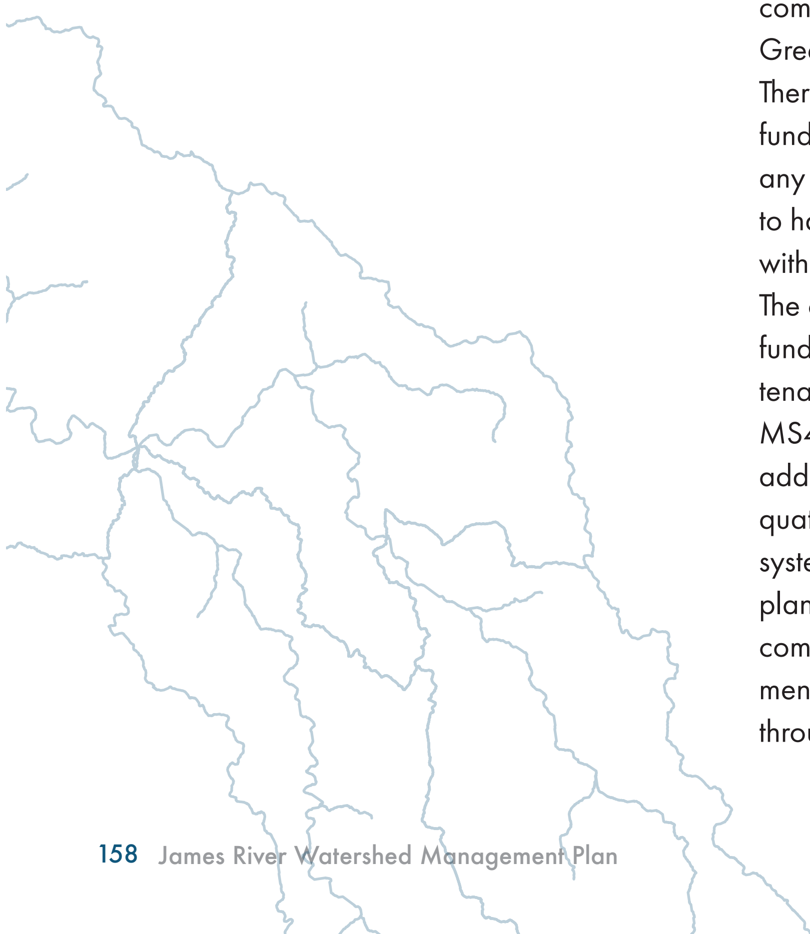
However, there are no doubt many older systems in these sub-watersheds that are failing to groundwater. Low interest loan or grant programs for septic system remediation or replacement are needed for homeowners who cannot afford to upgrade their systems.

Small wastewater treatment plants are also common in developed areas near the lake. These plants are now required to have phosphorus removal, which increases operating expenses because of the cost of chemicals needed to remove phosphorus. Several older small plants have not been properly operated or maintained in the past, and have created localized water quality problems. Small plants are still being permitted by Mo DNR, although there is no financial or technical capacity assurance programs in place to ensure that plants will be properly operated and maintained into the future. This lack of capacity assurance will probably mean more failing systems in the future.

Models that are being evaluated around the lake include non-profit sewer companies and utility companies which have begun to own and/or operate onsite systems. In these programs, homeowners can pay a sewer bill to have a company inspect, maintain or repair their systems. An example is the Ozarks Clean Water Company, which is a good example of contractual operation and maintenance. These companies remove the homeowner or homeowners' association from the responsibility of providing the expertise needed to properly maintain and operate wastewater facilities Thus, these are models that should be encouraged and supported.

12

Financial and Technical Assistance



The following is a list of financial and technical resources potentially available for water quality BMPs in the James River Basin:

URBAN STORMWATER MANAGEMENT:

Phase I and II Communities: There is one Phase I NPDES MS4 (Municipal Separate Storm Sewer System) permitted community in the James River Basin (city of Springfield), and four Phase II communities within the basin (Christian County, Greene County, city of Nixa, city of Ozark). There are no dedicated, sustainable sources of funding for stormwater management programs in any of these communities. Funding for personnel to handle stormwater permitting activities falls within the purview of city or county governments. The city of Springfield has a level of dedicated funding for construction, operation and maintenance, as well as activities required by their MS4 permit, such as public education. However, additional resources are necessary to adequately operate and maintain the storm drainage system, as well as to do long-range watershed planning and performance monitoring. Phase II communities typically have construction management programs for sediment and erosion control through departments of Public Works.

Sustainable Funding for Stormwater Programs: Cities and counties need dedicated, sustained funding sources for stormwater programs. One possibility is the "stormwater utility," concept, whereby stormwater funding comes through utility rate structures like public sewer or drinking water systems. State statutes provide other potential means to raise funds via sales taxes, or formation of special property taxing districts. However, these are generally limited in application to certain classes of counties and cities. Missouri's Hancock Amendment requires that any new tax be approved by the voters within the area to be taxed.

Integrated Plan for the Environment: With their Integrated Plan for the Environment, the city of Springfield, Greene County and City Utilities of Springfield have worked in cooperation to develop an effective template to address environmental issues, including water quality issues, in a more comprehensive manner. As part of the Integrated Plan, the partners have developed the Sustainable Return on Investment (SROI) methods to allow for prioritization of pollution issues. The SROI is utilized to determine the relative benefits versus costs of various programs and activities in order to best focus available funds where needed. This is an extremely valuable tool, since the costs of managing water quality are potentially very large, and recognizes the fact that there will likely always be a shortage of funding considered "adequate."

319 Program: 319 grants are made available to units of government, public institutions and 501-c-3 non-profits for projects designed for prevention, control or abatement of non-point source pollution. Project lengths are typically up to three years, but some have been extended. Awards are made through an RFP process.

319 grant funds have been used in conjunction with city or county stormwater programs, usually to enhance the water quality programs by establishing or protection riparian zones, adding water quality enhancing features to basic stormwater practices (e.g, rain gardens, vegetated detention structures, etc.), or in the case of Wilsons Creek, establishing conservation easements along riparian zones.

604-b Water Quality Management Planning Grants: These funds have been used to assist state and regional comprehensive planning organizations to carry out water quality planning. Funds can be used to determine non-point sources of pollution and the development of management plans, with an emphasis on a watershed approach. These funds are typically used in larger watersheds for both urban and rural planning.

AGRICULTURE

Soil and Water Conservation Cost Share Programs: These funds, available through the Soil and Water Program of Missouri DNR, are for voluntarily implementing practices that prevent soil erosion and/or protect water quality. Cost-share programs fund up to 75% of the state average cost for construction or implementation of soil and water conservation practices. Funding for the program comes through the state's one-tenth of one percent state sales tax for parks, soil and water, which is renewed every 10 years.

EQIP: (Environmental Quality Incentive Programs), provides financial and technical assistance to agricultural producers in order to address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, reduced soil erosion and sedimentation, or improved or created wildlife habitat. Interested landowners apply through their local USDA service centers. EQIP funds have been used extensively in the James River Basin for managed grazing systems, alternative water for livestock, protected and enhanced riparian zones, and improved forage and soil health.

Conservation Stewardship Program: This program helps agricultural producers maintain and improve existing conservation systems and adopt additional conservation activities to address priority resource concerns.

Conservation Innovation Grants: These grants drive public and private sector innovation in resource conservation. CIG projects inspire creative problem solving that boosts production on farms, ranches and private forests, and improves water quality, soil health and wildlife habitat. Local USDA officials believe this program has merit in promoting new ideas in multiple use conservation areas, such as growing nuts and/or berries in buffer zones, silvo-culture, etc.

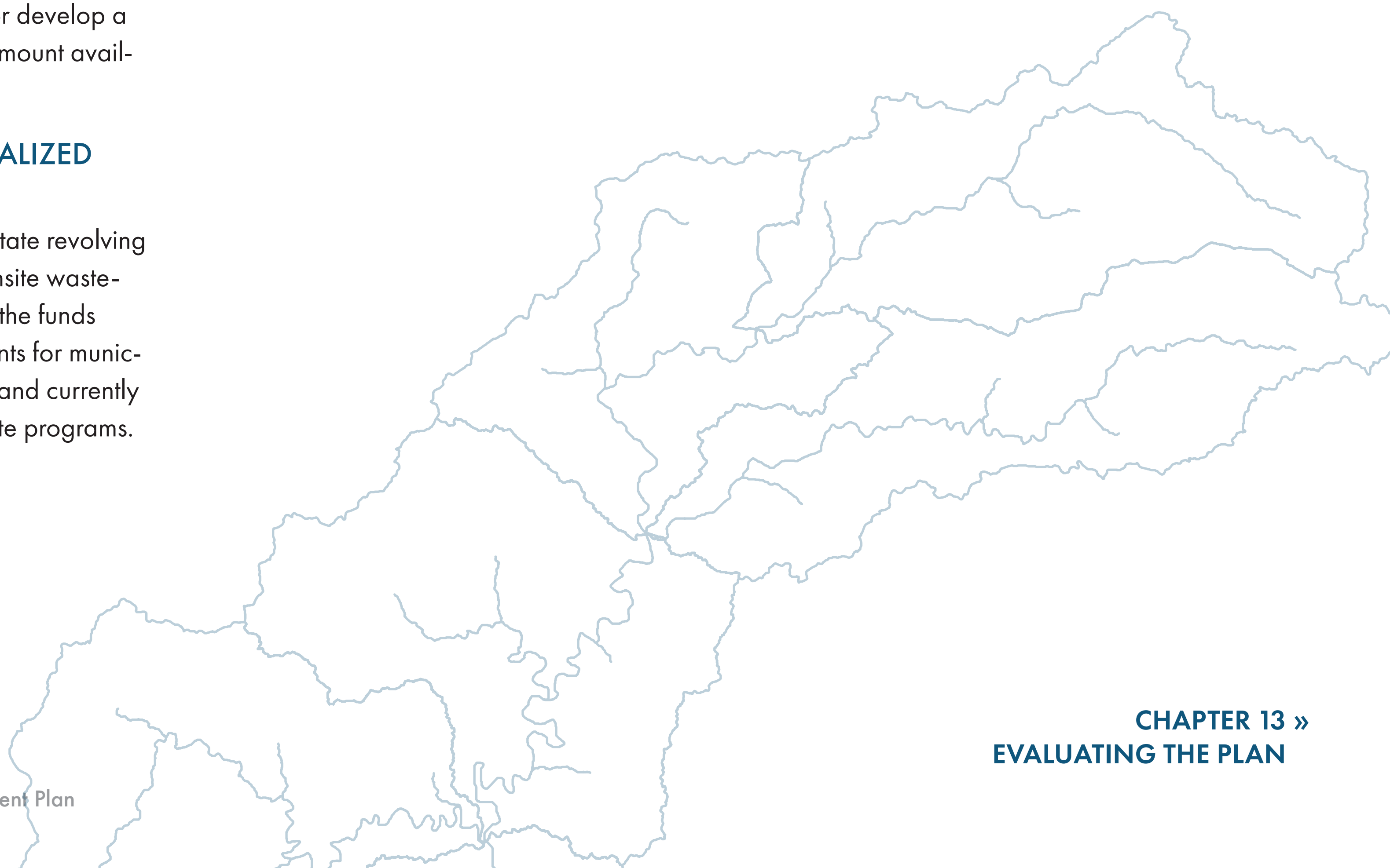
Regional Conservation Partnership Program (RCPP): These funds promote the coordination of NRCS conservation activities with partners that offer value-added contributions to expand our collective ability to address on-farm, watershed and regional natural resource concerns. Through RCPP, the NRCS seeks to co-invest with partners to implement projects that demonstrate solutions to conservation challenges and provide measurable improvements and outcomes tied to the resource concerns they seek to address

DRINKING WATER

Drinking Water Source Protection Grants: This grant program is administered through the Missouri Department of Natural Resources and is provided to community systems to implement source water protection strategies or develop a source water protection plan. The amount available varies by year.

ON-SITE AND/OR DE-CENTRALIZED WASTEWATER

State Revolving Funds: In the past, state revolving funds have been used to support onsite wastewater programs. However, most of the funds have gone toward construction grants for municipal wastewater treatment systems, and currently no SRF funding is available for onsite programs.



13

Evaluating the Plan

Progress toward goals will be evaluated at least every five years by the James River Basin Partnership through contacts with resource agencies, especially the Missouri Department of Natural Resources (water quality monitoring, information), Missouri Department of Conservation (fish and wildlife information), and the Natural Resources Conservation Service (agricultural program information). The following pages are a summation of the 20-year goals developed in this plan for each of the six HUC-10 watersheds in the James River Basin.

JAMES RIVER HEADWATERS

- 2,500 feet of streambank stabilized; erosion protection, resulting in 152,500 lbs of sediment, 950 lbs of TN, and 125 lbs of TP removed per year.
- 50 acres of riparian buffers established in urban/urbanizing areas, resulting in 4,700 lbs of sediment,130 lbs of TN, and 22 lbs of TP removed per year.
- 25 detention basins retrofitted resulting in 87,200 lbs of sediment, 1,850 lbs of TN and 225 lbs of TP removed per year.
- 18,750 acres of pasture in managed grazing systems resulting in 423,750 lbs of sediment, 3,750 lbs of TN, and 1,300 lbs of TP removed per year.
- 50 acres of riparian buffer in conservation easements or other permanent protection.
- 200 septic system pump-outs.

FINLEY CREEK

- 2,000 feet of streambank stabilized; erosion protection, resulting in 122,000 lbs of sediment, 760 lbs of TN, and 100 lbs of TP removed per year.
- 22,750 acres of pasture in managed grazing systems resulting in 514,000 lbs of sediment, 4,550 lbs of TN, and 1,590 lbs of TP removed per year.
- 25 acres of riparian buffers established in urban/urbanizing areas resulting in 1,880 lbs of sediment, 52 lbs of TN, and 9 lbs of TP removed per year.
- Survey detention basins for retrofit candidates. (5 years)
- 200 septic system pump-outs.

WILSONS CREEK-JAMES RIVER

- 75 acres of riparian buffers established in urban/urbanizing areas, resulting in 7,050 lbs of sediment, 195 lbs of TN, and 33 lbs of TP removed per year.
- 3,600 acres of pasture in managed grazing systems, resulting in 81,360 lbs of sediment, 720 lbs of TN, and 252 lbs of TP removed per year.
- 107 detention basin retrofits, resulting in 373,216 lbs of sediment, 7,918 lbs of TN, and 863 lbs of TP removed per year.
- 75 acres of riparian buffers in conservation easements or other permanent protection.
- Phase-out of coal-tar based parking lot sealants in the city of Springfield.

FLAT CREEK

- 500 feet of streambank stabilized; erosion protection resulting in 30,500 lbs of sediment, 190 lbs of TN, and 25 lbs of TP removed per year.
- 25 acres of riparian buffer established in agricultural areas resulting in 2,825 lbs of sediment, 875 lbs of TN, and 10 lbs of TP removed per year.
- 6,600 acres of pasture in managed grazing systems resulting in 149,000 lbs of sediment, 1,320 lbs of TN, and 46 lbs of TP removed per year.

FLAT CREEK

- 25 acres of riparian buffers established in agricultural areas resulting in 2,825 lbs of sediment, 88 lbs of TN, and 10 lbs of TP removed per year.
- 5,250 acres of pasture in managed grazing systems resulting in 118,650 lbs of sediment, 1,050 lbs of TN, and 367 lbs of TP removed per year.
- 50 acres of riparian buffers along Crane Creek in conservation easements or other permanent protection
- 100 septic-tank pump-outs

JAMES RIVER-TABLE ROCK LAKE

- Onsite and small privately owned wastewater treatment plant operation and maintenance oversight programs

Total pollutant removal (20 years): 41,474,800 pounds of sediment, 489,700 pounds of TN, and 99,740 pounds of TP.

Table 32

Interim Milestone	5 years	10 years	15 years	20 years
Managed grazing systems	14,238 acres	24,476	42,714	56,952
Riparian buffers established	55 acres	110 acres	165 acres	220 acres
Streambank stabilization	1,250 feet	2,500 feet	3,750 feet	5,000 feet
Detention basin retrofits	33 basins	66 basins	99 basins	132 basins
Phase-out of coal-tar based parking lot sealants (city of Springfield)	Coal-tar based parking lot sealant ban in effect			
Reduction of PAH concentrations in soil/sediment by 80%			PAH reduction 80% (to 2035 ug/kg)	
Septic system pump-outs	175	350	525	700

Table 33

	Criteria for measuring success	Responsible parties of program	Monitoring frequency
Nutrient (TP and TN) Reduction	Measurement of chlorophyll-a levels in Lake Springfield and James River arm of Table Rock Lake	Lakes of Missouri Volunteer Program	Annually
	TP and TN levels in urban stormwater	Phase I and Phase II community stormwater sampling programs	Per NPDES permit
	TP and TN levels in streams and springs	JRBP Snapshot Monitoring Program/volunteers	Every 3 years (2022 next event)
Sediment reduction	TSS measurements in James River at drinking water intake, and in drinking watersheds	City Utilities of Springfield	Daily at intake, monthly in watershed
	TSS measurements in urban stormwater runoff	Phase I and Phase II community stormwater sampling programs	Per NPDES permit
	Specific conductivity measurements in springs and stream (indirect measure)	JRBP Snapshot Monitoring Program/volunteers	Every 3 years (2022 next event)

Table 32 hows the interim milestones and cumulative totals for the completion of the plan goals.

Table 33 shows the criteria for measuring the success of the plan toward meeting pollutant reduction goals, the responsible monitoring entities, and the frequency of monitoring.

Table 33 continued from previous page

PAH reduction	Measurement of PAH levels in soils and sediments (urban areas)	Ozarks Environmental and Water Resources Institute (OEWRI)	Within 5 years
E. coli and microbe reduction	Measurement of E. coli levels in raw drinking water	City Utilities of Springfield	Daily
	Measurement of Cryptosporidium cysts in raw drinking water and in Pearson Creek	City Utilities of Springfield	Per Surface Water Treatment Rule
	Measurement of E. coli levels in Pearson Creek	OEWRI (through contract with Greene County)	Bi-weekly, at present (October 2020)
	Measurement of E. coli levels in streams and springs	JRBP Snapshot Monitoring Program/volunteers	Every 3 years (2022 next event)
	Bacterial source tracking at streams and springs	OEWRI/Missouri State University	Program under development
Establishment of monitoring group	Participation by governments and agencies involved in water, wastewater, stormwater, drinking water monitoring programs	City and county governments, Department of Natural Resources	Goal of this plan is to form group within 2 years

Table 34 is the education plan developed by JRBP staff in conjunction with watershed partners. The success of the educational activities described in this plan can be represented numerically. From a high level, we can look at the number of participants or implementations, such as the number of rebates issued, the number of trees planted, or the number of individuals that participate in outreach events. We can further define success by utilizing modeling, mapping, and software programs including i-Tree, ArcMap, and SROI (Sustainable Return on Investment) models, such as the model developed as part of the City of Springfield's Integrated Plan. Utilizing website and social media analytics, we can monitor trends and gauge public interest and knowledge of local water quality. Integrating pre and post-program surveys into our outreach events is an effective way to gauge the success of our programs and activities. Finally, regular communication between local partners will allow us to track trends, share tools and resources, identify priorities, and increase our overall effectiveness.

Table 34

Youth Education & Outreach Opportunities	Creating in-classroom and extra-curricular opportunities for kindergarten through college students throughout the basin. Explore partnership opportunities with --local libraries, churches, scout groups, community centers, etc. Activities can be formatted for distance learning when needed. Potential topics could include point source vs. non-point source pollution, solutions to pollution, the water cycle, what is a watershed, macroinvertebrates, understanding streams, water chemistry, and careers in water.	Watershed Committee of the Ozarks Local Governments City Utilities of Springfield Springfield-Greene County Parks-Outdoor Initiatives MO Dept. of Conservation James River Basin Partnership	Annually; Ongoing; In conjunction with grants and special events
Community Presentations & Tabling Events	Providing water quality presentations to community groups, including professional societies, volunteer groups, clubs, HOA's, and special interest groups. Attend local fairs and community events such as the Springfield Lawn & Garden Show, native plant sales, farmers markets, etc. Provide information on topics such as septic tank maintenance, rainwater harvesting, non-point source pollution, pet waste, soil health, resources for streamside landowners, etc.	Watershed Committee of the Ozarks Ozarks Water Watch City Utilities of Springfield MO Dept. of Conservation	Annually; On Invitation; In conjunction with special events
Rebates & Incentives	Provide rebates and incentives to promote practices that reduce non-point source pollution and increase citizen knowledge of local water quality issues. Programs could include septic pump-out and replacement rebates, rainwater harvesting rebates, soil testing programs, yard certification programs, and "clean pavement" programs.	Local Governments City Utilities of Springfield James River Basin Partnership Ozarks Water Watch Watershed Committee of the Ozarks	Ongoing
Membership & Community Support	Increase individual and corporate memberships to build a constituency of educated and engaged water quality advocates.	James River Basin Partnership Watershed Committee of the Ozarks	Ongoing

Table 34

Educational Signage & Brochures	Topics could include non-point source pollution, best management practices, animal waste, septic tank maintenance, PAH's, nutrient management, etc.	James River Basin Partnership Watershed Committee of the Ozarks Ozarks Water Watch Local Governments	Ongoing; In conjunction with grants and special events
For-Profit Partnerships	Develop partnerships with local businesses to increase awareness of water quality issues. These partnerships could include presentations, signage/messaging, and eco-tourism programs.	Missouri Stream Teams (MDC/DNR)	Ongoing; In conjunction with special events
Volunteer Water Quality Monitoring	Citizen water quality monitoring following the Missouri Stream Teams standards. Including chemical and biological monitoring, as well as events such as the James River Snapshot Sampling event.	Missouri Stream Teams MO Dept. of Conservation	Ongoing
Stream Clean-Ups & Other Volunteer Opportunities	Organize hands-on events and opportunities for citizens and community groups. This could include litter cleanups, tree planting events and invasive species removal.	James River Basin Partnership Watershed Committee of the Ozarks Missouri Stream Teams MO Dept. of Conservation Ozarks Water Watch Local Governments	Ongoing; In conjunction with grants and special events
Media Workshops	Host events for local media contacts to meet with local water quality experts, discuss water quality issues and promote programs and events.	James River Basin Partnership	In conjunction with community contracts and future 319 grants
Social Media	Engage with citizens and organizations throughout the James River watershed. Share topics related to programs, rebates, events, and local water quality.	James River Basin Partnership Watershed Committee of the Ozarks Local Governments City Utilities Ozarks Water Watch Missouri Stream Teams	Ongoing
Eco-Tourism	Develop opportunities to connect citizens of the James River watershed to our local water resources through recreation. Potential programs could include paddling trips, walking/bicycling tours, scavenger hunts, geocaching, fishing, camping, etc.	James River Basin Partnership Springfield-Greene County Parks Local Businesses	Ongoing; In conjunction with community contracts and special events

Table 34 continued from previous page

Agricultural Demonstrations	Partner with USDA/NRCS to showcase best management practices and cost-share programs designed to improve soil health and plant and animal production, protect wildlife habitat and improve water quality. Potential programs could include co-hosting grazing schools, sponsoring pasture walks, and organizing farm tours for producers and government officials.	James River Basin Partnership NRCS/USDA Missouri State University Local Soil and Water Conservation Districts	In conjunction with community contracts and future 319 grants

CHAPTER 14 »
REFERENCES

14

References

A. Davis, 2003, Univ. of Maryland. Engineered Bioretention for the Treatment of Storm Water Runoff.

Aderhold, C., 2017, personal communications March 2017.

Aley, T. and Thomson K., 1984. Septic Fields and the Protection of Ground-water Quality in Greene County, Missouri. *Unpublished report by the Ozark Underground Laboratory to the City of Springfield, Mo., Fantastic Caverns Inc., Springfield City Utilities, Protem, Missouri.*

Berkas, W. R., 1982. Streamflow and Water-Quality Conditions, Wilsons Creek and James River, Springfield Area, Missouri. *U. S. Geological Survey Water-Resources Investigation Report.*

Borchelt, G. G., 2007. *Nutrient Concentrations at Baseflow Conditions in the Upper White River Basin, Southwest Missouri and Northwest Arkansas.* M. S. Thesis, Missouri State University.

Brewer, T., 2017, personal communication 8/10/17.

Buchanon, 1982, A Report on Freshwater Mussels, Workshop held at St. Louis, Oct. 26-27, 1982.

Bullard, Loring, 2004. *Healing Waters: Missouri's Historic Mineral Springs and Spas,* University of Missouri Press

Casaletto, 2017, personal communication 8/10/17.

City of Springfield, 2019. *Integrated Planning Opportunities Analysis—Detention Basin Retrofits.*

City of Springfield, 2019. *Integrated Planning Opportunities Analysis—Polycyclic Aromatic Hydrocarbon Reduction Measures.*

City of Springfield, 2020. *Integrated Planning Opportunities Analysis—Riparian Restoration.*

City of Springfield, 2020. *Integrated Planning Opportunities Analysis—Public Education and Outreach*

Davis, J. V. and Bell, R. W., 1998. *Water Quality Assessment of the Ozark Plateaus Study Unit, Arkansas, Kansas, Missouri and Oklahoma: Nutrients, Bacteria, Organic Carbon and Suspended Sediment in Surface Water, 1993-95*. U. S. Department of the Interior, U. S. Geological Survey

G. Borchelt, 2011. Onsite System Identification and Remediation Project, Final Report.

Greene County, 2019. I*ntegrated Planning Opportunities Analysis—Alternative Watering and Managed Grazing Systems.*

Harvey, E. J., and Skelton, J., 1968. Hydrologic Study of a Waste-Disposal Problem in a Karst Area at Springfield, Missouri. *Geological Survey Research* C217-C220.

Helmers, M. J. et. al 2006. Buffers and Vegetative Filter Strips (https://www.epa.gov/sites/production/files/2015-7/documents/2006_8_24_msbasin

Hess, K., 2017. Missouri Department of Natural Resources, personal communications 6/15/17 and 11/14/17.

Jacobson, R. B., and Primm, A. T., 1994. Historical Land-use Changes and Potential Effects on Stream Disturbance in the Ozark Plateaus, Missouri. U.S. Geological Survey Open-File Report 94-333, Rolla.

Kiner, L. and Vitello, C., 1997. *James River Watershed Inventory and Assessment.* Missouri Department of Conservation

M. Owen and R. Pavlowsky, 2008. Ward Branch Stream Restoration Project, Post-Construction Assessment and Final Report.

M. Owen and R. Pavlowsky, 2011. Water Quality Monitoring and Load Reduction Evaluation from Residential Developments in Christian County, Missouri - Final Technical Report.

Marney, A., 2004, Poultry Production in Southwest Missouri, James River Basin Partnership

MEC Water Resources Inc. and Ozarks Environmental Water Resources Institute, 2007. *Southwest Missouri Water Quality Improvement Project James River Basin Water Quality Gap Analysis*

Miller, Con. E. and Vandike, James E. 1997. *Missouri State Water Plan Series II, Groundwater Resources of Missouri,* Missouri DNR Division of Geology and Land Survey.

Missouri Department of Natural Resources, 2004, *Update for the James River TMDL, Webster, Greene, Christian and Stone Counties, Missouri.*

Owen, M. R., Pavlowsky, R. T., and Womble, P. J., 2011. Historical Disturbance and Contemporary Floodplain Development along an Ozark River, Southwest Missouri. *Physical Geography* 32.5: 423-444.

Perkins, G., 2013. Missouri Department of Natural Resources, personal communication, Dec. 20, 2013.

Petersen, J. C., Friewald, D. A. and Davis, J. V., 1995. *Environmental and Hydrologic Setting of the Ozark Plateaus Study Unit, Arkansas, Kansas, Missouri and Oklahoma*. Vol. 94, No. 4022. National Water-Quality Assessment Program

Pully, T. S., Nimmo, D. W. R. and Tessari, J. D., 1998. Characterization of Toxic Conditions above Wilsons Creek National Battlefield Park, Missouri. *Journal of the American Water Resources Association* 34.5: 1087-1098.

Rafferty, M. D., and Holmes, W. M., 1982. *Historical Atlas of Missouri*. University of Oklahoma Press.

Sauer, C. O., 1920, The *Geography of the Ozark Highland of Missouri*, University of Chicago Press

Soil Survey of Greene and Lawrence Counties, Missouri, 1982. U.S. Department of Agriculture, Soil Conservation Service

The Value of Green Infrastructure (Center for Neighborhood Technology and American Rivers, americanrivers.org, 2010).

Thomson, K. C., 1986. *Geology of Greene County, Missouri*. Watershed Management Coordinating Committee.

U.S. EPA and Missouri DNR, F*inley River Watershed Management Plan*, MoDNR Subgrant #G06-NPS-23.

U.S. EPA and Missouri DNR, *James River Basin Watershed Management Plan: Finley River and Middle James River;* MoDNR Subgrants: Finley River #G-6-NPS-23, Middle James #G)6-NPS-15.

Vineyard, J. D. and Thomson, K. C., 1993. *Springs of Missouri*. Missouri Geological Survey and Water Resources, Rolla.

Watershed Committee of the Ozarks, 1997. *Water Resources of Greene County*

Watershed Committee of the Ozarks, undated. *Jordan Creek: Story of an Urban Stream.*

Williams, Walter, 1904, *The State of Missouri: An Autobiography*, E. W. Stephens Press, Columbia, Mo.

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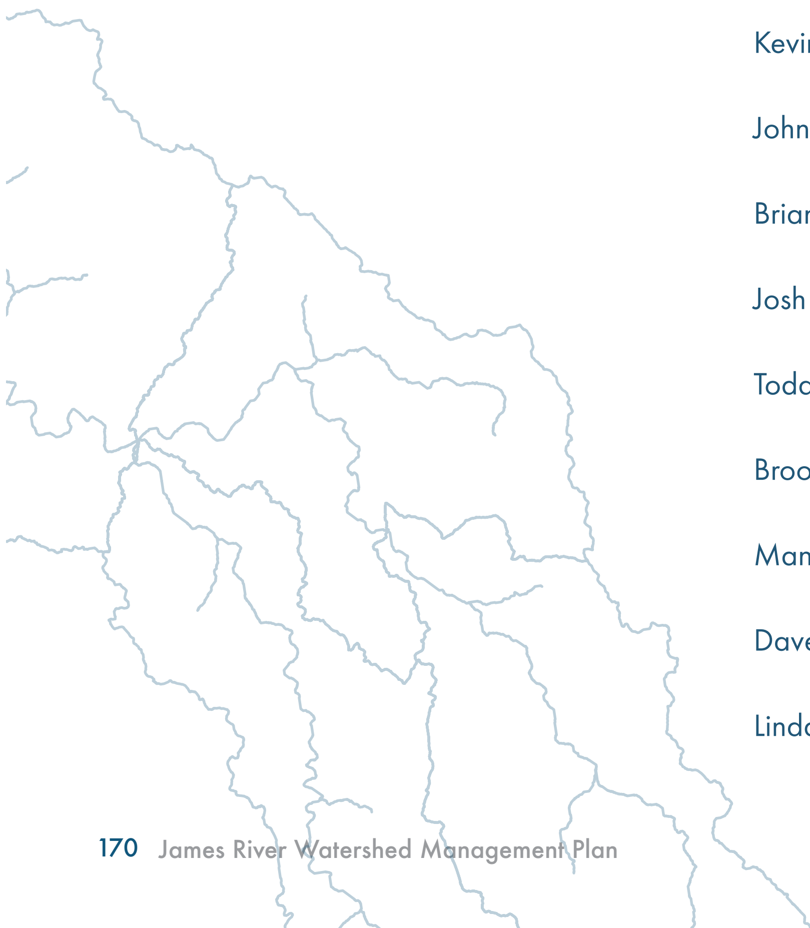
Appendix A

INTERVIEW LIST

Michael Abbott	Department of Natural Resources
Chuck Aderhold	City Utilities of Springfield
Diane Asher	Landowner, Barry County
Andy Austin	Department of Conservation
Kevin Barnes	Greene County
John Benson	City of Marshfield
Brian Bingle	City of Nixa
Josh Bird	Christian County
Todd Brewer	City Utilities of Springfield
Brooke Widman	Missouri Stream Teams
Mandy Carr	Landowner, Stone County
Dave Casaletto	Ozarks Water Watch
Linda Chorice	Missouri Department of Conservation
Tim Clarkson	Landowner, Webster County
Travis Cossey	City of Nixa
Erica Cox	Project WET
Cindy Davies	Department of Natural Resources
Tim Davis	Greene County
Gary Dierking	Landowner, Webster County
Eric Dove	HDR Engineers
Laurie Duncan	City of Springfield
Chris Dunnaway	City of Springfield
Mark Emerson	Natural Resources Conservation Service
Todd Fickbohm	Stone County
Jason Frantz	Landowner, Greene County



Jerry Fry	Landowner, Webster County
Tammy Grantham	Missouri Small Flows Organization
John Havel	Missouri State University
Champ Herren	Landowner, Webster County
Kevin Hess	Department of Natural Resources
Ted Hillmer	Wilsons Creek Battlefield Park
Aaron Hoefer	Natural Resources Conservation Service
Drew Holt	Nature Conservancy
Adam Houseman	Finley River Farms, Christian County
Wes Johnson	Springfield News-Leader
Kara Tvedt	Missouri Department of Conservation
Errin Kemer	City of Springfield
Mike Kromrey	Watershed Committee of the Ozarks
Carrie Lamb	City of Springfield
Bob Lovett	Landowner, Christian County
Bruce Martin	Landowner, Christian County
Rudy Martinez	Missouri Department of Conservation
Gail Melgren	Southwest Missouri Water
Michael and Terri Leigh Baird	Landowners, Greene County
Holly Neill	Nature Conservancy
Danny Newell	City of Nixa
Jeremy Parsons	City of Ozark
Samantha Payne	City of Ozark
Dan Philbrick	Natural Resources Conservation Service
Randy and Burliss Dye	Landowners, Webster County
Jason Salchow	Landowner, Christian County
Diana Sheridan	Natural Resources Conservation Service
Kevin and Jeanie Skibiski	Landowners, Stone County
Tim Smith	City of Springfield
Sheila Thomas	Lakes Area Chamber of Commerce
Todd Wiesehan	Christian County
DeDe Vest	Natural Resources Conservation Service
Steve Walensky	City of Cassville
Randall Whitman	City of Springfield
Dave Woods	Department of Conservation

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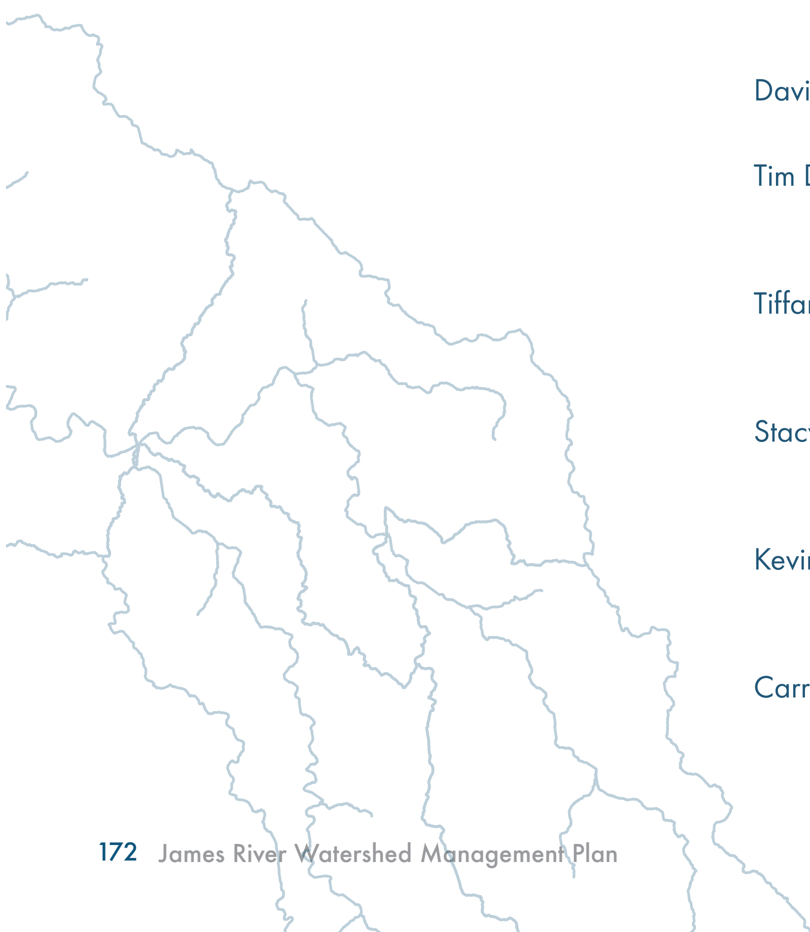
Appendix B

WATERSHED PLAN TECHNICAL COMMITTEE

Dennis Wright	Landowner, Stone County
Stacey Armstrong	Watershed Committee of the Ozarks
Loring Bullard	James River Basin Partnership
Ronda Burnett	Missouri Department of Conservation
David Casaletto	Ozarks Water Watch
Tim Davis	Greene County Resource Management
Tiffany Frey	James River Basin Partnership
Stacy Hamilton	University of Missouri Extension
Kevin Hess	Missouri Department of Natural Resources
Carrie Lamb	Environmental Services, City of Springfield
Roddy Rogers	City Utilities of Springfield
Diana Sheridan	Natural Resources Conservation Service
Kara Tvedt	Missouri Department of Conservation
DeDe Vest	Natural Resources Conservation Service
Steve Walensky	City of Cassville
Randall Whitman	City of Springfield
Dave Woods	Department of Conservation



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Appendix C

SNAPSHOT REPORT

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Appendix D

SOIL AND WATER ASSESSMENT TOOL (SWAT) SIMULATED SEDIMENT AND NUTRIENT YIELDS IN JAMES RIVER BASIN

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Appendix E

SURVEY QUESTIONS AND RESULTS