6-1-2010

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June 2010

AWRC

FINAL REPORT TO ILLINOIS RIVER WATERSHED PARTNERSHIP: RECOMMENDED WATERSHED BASED STRATEGY FOR THE UPPER ILLINOIS RIVER WATERSHED, NORTHWEST ARKANSAS

MSC Publication 355| Arkansas Water Resources Center

ARKANSAS WATER RESOURCES CENTER – UNIVERSITY OF ARKANSAS
TECHNICAL PUBLICATION NUMBER MSC 355 – YEAR 2010

Final Report to the Illinois River Watershed Partnership: Recommended Watershed Based Strategy for the Upper Illinois River Watershed, Northwest Arkansas

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This publication serves as the final report to the Illinois River Watershed Partnership (IRWP) regarding the project entitled "Development of the Watershed Management Plan for the Upper Illinois River". This document was intended to provide this stakeholder based organization guidance in the development of a watershed management plan for the Illinois River drainage area (i.e., the Upper Illinois River Watershed, UIRW) in Arkansas. This document represents the final report from the Arkansas Water Resources Center (AWRC) and affiliated project investigators, and the IRWP may alter this document before the final submission of its watershed management plan to the Arkansas Natural Resources Commission (ANRC) and the U.S. Environmental Protection Agency.

Acknowledgements: This document was completed with the assistance of many individuals, including (1) Christina Laurin, Ray Weida and Kent Thornton of FTN Associates, Ltd., reviewed and revised documents used to develop this final report, provided the framework establishing the document outline, and assessed where the nine elements regarding U.S. Environmental Protection Agency criteria for watershed management plans are within this document; (2) the Watershed Advisory Group and other stakeholders within the IRWP provided specific feedback to the AWRC on this final report and its supplemental documents during multiple meetings through this project period; and (3) ANRC provided feedback during the development of this document through the IRWP.

Executive Summary

The Upper Illinois River Watershed lies in Benton, Washington and a small portion of Crawford Counties in northwest, Arkansas. The Illinois River originates in the headwaters near Hogeye, Arkansas, approximately 15 miles southwest of Fayetteville. The river flows westerly crossing the Ozarks of northwest Arkansas and into Oklahoma five miles south of Siloam Springs, Arkansas, near Watts, Oklahoma. Land use in the UIRW is diverse with about 46% as pasture, 41% forest and woody herbaceous vegetation, and 13% urban. The watershed is characterized by rapidly growing urban centers from south Fayetteville to Bentonville and Rogers, Arkansas, in the headwaters to more rural areas along the Oklahoma border. The Illinois River and its major tributaries in Arkansas (Osage Creek, Clear Creek, Baron Fork and the Muddy Fork) exhibit a range of conditions from areas with dense riparian forest buffers illustrating exceptional beauty and ecological value to areas without the streamside buffers showing exposed and eroding banks.

The Illinois River and its tributaries have many uses that have been designated by Arkansas Department of Environmental Quality including fisheries, aquatic life usage, primary contact waters, secondary contact waters, drinking water supply and agricultural and industrial water supply. However, portions of the Illinois River and its tributaries have been cited as not meeting these designated uses due to impairment from sediment and or nutrients, as well as bacteria (see Arkansas's 2008 303(d) list). The goal of this watershed management plan is to improve water quality in the Illinois River and its tributaries so that all waters meet their designated uses both now and in the future.

The watershed management strategy described within this document considers watershed land use, current water quality conditions, and existing and potential pollutant sources among others. The management strategies for the Upper Illinois River Watershed were developed based on water quality conditions at the sub-watershed level. Based on the identified priorities, recommended best management practices specific to each sub-watershed should be implemented to improve water and watershed quality. Since no single management option can "fix" the watershed, the recommended practices address pasture management, forest management, unpaved road management, urban management and also Lake Frances. Since watershed processes and systems are dynamic, adaptive management is the best means of achieving sustainable watershed management. Stakeholders should expect the implementation of this management plan to be a cooperative, evolving, on-going process.

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Glossary of Terms and Acronyms

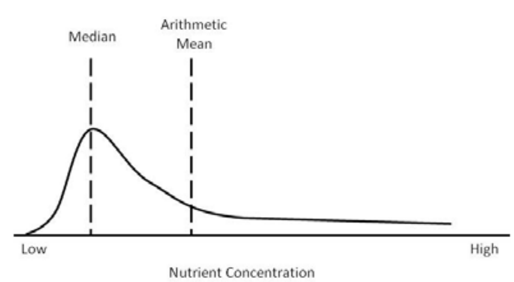
303(d)	Identification of impaired waters or waters not meeting designated uses
319	Non-Point Source Pollution Program
ADEQ	Arkansas Department of Environmental Quality
ADH	Arkansas Department of Health
AFC	Arkansas Forestry Commission
AHTD	Arkansas Highway and Transportation Department
ALPC	Arkansas Livestock and Poultry Commission
ANRC	Arkansas Natural Resources Commission
AWAG	Arkansas Watershed Advisory Group
AWRC	Arkansas Water Resources Center
BMP	Best Management Practice
CAFO	Confined Animal Feeding Operation
CAST	Center for Advanced Spatial Technology
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
DEQ	Department of Environmental Quality
EPA	Environmental Protection Agency
ERW	Extraordinary Resource Waters
FEMA	Federal Emergency Management Agency
GIS	Geographic Information Systems
HUC	Hydrologic Unit Code; code used to identify watersheds in the United States
HUC 8	Hydrologic Unit Code Level 8; a larger watershed identified by 8 digits, e.g. the Illinois River Watershed
HUC 12	Hydrologic Unit Code Level 12; a smaller watershed identified by 12 digits, e.g. the subwatersheds of the Upper Illinois River Watershed
IRWP	Illinois River Watershed Partnership
KGA	Knowledge Gap Assessment
LULC	Land use and land cover
MGD	million gallons per day; a measure of water flow or discharge
mg L^{-1}	milligrams per liter; a measure of concentration
MS4S	Multiple Separate Storm Sewer Systems
NACA	Northwest Arkansas Conservation Authority
NALMS	North American Lake Management Society
NAWQA	National Water Quality Assessment Data Warehouse
NPEDS	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
NSW	Natural and Scenic Waterway
NTU	Nephelometric Turbidity Unit; a measure of turbidity or the cloudiness of water

ROW	Right-of-Way
SRF	State Revolving Fund
SSURGO	Soil Survey Geographic Database
STEP	Septic Tank Effluent Pump
SWAT	Soil and Water Assessment Tool
TN	Total Nitrogen; the amount of dissolved inorganic and organic nitrogen and particulate organic and inorganic nitrogen in water
TNC	The Nature Conservancy
TP	Total Phosphorus; the amount of dissolved and particulate phosphorus in water
UA	University of Arkansas
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USGS	United States Geological Survey
UIRW	Upper Illinois River Watershed
WWTP	Wastewater Treatment Plant

Glossary of Math and Statistics Terms

This watershed management plan was written so that any concerned stakeholder could be a part of the watershed management strategy. That being said, this plan was also based on the science of the watershed and the priorities outlined in this strategy were determined using statistics so that any bias would be eliminated. If you are interested in the math and science that were applied in the development of this plan check out Chapter 4, and you may find the following definitions and explanations helpful to understanding the process that was used:

Arithmetic mean	A type of mean or average where a set of data is summed and divided by the number of data points in the data set. For example, the arithmetic mean of 2 and 8 is: $\left(\frac{2+8}{2}\right) = 5$.
Geomean	Geometric mean; a type of mean or average which is calculated by multiplying the numbers in a set of data together and taking the *n*th root of the resulting product where n is the number of data points in the data set. For example, the geomean of 2 and 8 is: $\sqrt[2]{(2 \times 8)} = 4$. Geomean is a good indicator of the central tendency or typical value of a set of numbers; geomean is similar to the arithmetic mean but is not as influenced by high and low values.
Linear Regression	A model that explains the relationship between two variables by fitting a linear equation (straight line) that best describes the data; as one variable increases, so does the other.
Logarithmic Distribution	Water quality data is bound by zero, because concentrations are zero or greater for the parameters. So, water quality data has an arithmetic mean which is usually greater than its central value or median. This type of data spread is known as a logarithmic distribution.
Statistically Significant	In normal English, significant just means important or meaningful, but in statistics significant means probably true or unlikely to have occurred by chance based on some level of confidence.



Plan Guidance 1

1.1 A Vision for the Upper Illinois River Watershed

The Upper Illinois River Watershed (UIRW) is a special place where the threads of private, public and non-profit partnerships are woven into the regional fabric of economic vitality, environmental stability, and social responsibility. Through its cultural heritage, the legacy of land stewardship, integrated with respect for personal property rights, continues. Natural resources are restored and sustained within a healthy mosaic of fields, forests, farms, woodlands, wetland prairies, pastures, cities, and naturally flowing streams. It is an incubator for green energy, entrepreneurial, educational and environmental initiatives.

1.2 Watershed Management Plan Funding Sources and Management

The Illinois River Watershed Partnership was awarded a grant to oversee the development of a Watershed Management Plan for the UIRW (i.e., Arkansas portion). This grant was funded with U.S. EPA 319 funds through the Arkansas Natural Resources Commission (ANRC) 319 program and The Walton Family Foundation provided equal match.

The mission of the IRWP is to improve the integrity of the Illinois River through public education and community outreach, water quality monitoring, and the implementation of conservation and restoration practices throughout the Illinois River Watershed.

The Illinois River Watershed Partnership (IRWP) is a not-for-profit membership based organization working to protect and restore the Illinois River and its tributaries throughout Arkansas and Oklahoma. Current information about this group and its members is available at www.irwp.org.

1.3 Development Team

The IRWP hired technical experts to develop a watershed management plan for the UIRW, Arkansas. Phase 1, the development of a scoping document for the IRWP, was completed by Tetra Tech, Pasadena, CA. Phases 2 and 3 were developed by the University of Arkansas Division of Agriculture Arkansas Water Resources Center (AWRC), FTN Associates, LTD., Foth Infrastructure & Environment, LLC, and University of Arkansas Division of Agriculture Cooperative Extension Service.

1.4 Nine Element Watershed Management Plan

Watershed-based plans developed using Clean Water Act 319 funding must address nine essential planning elements to manage and protect against nonpoint source pollution. Therefore, this watershed management plan provides a roadmap containing the following elements aimed at improving water quality through watershed-based environmental protection programs and practices focused on reducing non-point source pollution.

Table 1.1. The required nine essential planning elements to manage and protect against non-point source pollution, and the location of the elements within this plan.

Required Watershed Plan Elements	Location in this Plan
(a) The identification of sources of pollutions that could be contributing to water quality degradation	Section 4.4; Chapter 6
(b) Expected changes in water quality once management actions are implemented	Section 5.3 (targets); Section 6.6 (efficiencies)
(c) A description of non-point source pollution management actions that stakeholders can participate in and help to implement, especially in critical areas	Chapter 6
(d) An estimate of the amounts of technical and financial assistance needed, associate costs, and/or the sources and authorities that should be relied upon	Chapter 8
(e) An education and outreach strategy to encourage stakeholders to learn more about selecting, designing and implementing management actions	Chapter 7
(f) A schedule for implementing identified management measures	Chapter 9
(g) A description of goals and measureable milestones along the way to a fully implemented vision	Chapter 9
(h) A set of criteria that can be used to determine if water quality is improving towards attaining water quality standards	Chapter 10; Chapter 12
(i) A method to determine if implemented management actions are really improving water quality	Chapter 11

1.5 The Implementation Process

This watershed management plan recommends voluntary, non-regulatory practices that can be implemented to improve the quality of the water and the landscape throughout the UIRW. The existing IRWP has established partnerships with those organizations which have resources for managing the condition of the watershed. Therefore, the IRWP is already suited to oversee the administration and implementation of the actions recommended in this plan and will continue to invite and encourage public participation in restoration and service activities. In addition, multiple organizations including the IRWP, UA Division of Agriculture, The Nature Conservancy, Audubon Arkansas, Watershed Conservation Resource Center, Northwest Arkansas Conservation Authority, municipalities and others are suited to seek funding to implement parts of this watershed management.

1.6 Adaptive Watershed Management

This Watershed Management Plan for the IRWP was developed under the adaptive management concept. Adaptive management is an iterative process of optimal decision making by evaluating results and adjusting actions based on what has been learned. As watershed processes and systems are dynamic, adaptive management is the best means of achieving sustainable watershed management.

Utilizing an adaptive management approach means that periodic assessments must be made to determine if water quality in the UIRW is headed in the right direction. Watershed conditions should be re-evaluated in July 2015 and the plan modified, as needed. The IRWP should take the lead to make sure a current, relevant plan is available for the watershed at all times. The Partnership should also coordinate with technical experts to complete the following steps:

1. Evaluate five-year trends in water quality conditions;
2. Re-evaluate land-use conditions in each of the HUC 12s and in riparian areas;
3. Determine geomean constituent concentrations for each HUC 12 on a five year or less basis to establish new, current priorities;
4. Redefine high priority HUC 12s based upon new, current information; and
5. Redefine high priority projects based on funding opportunities and watershed changes (improvement or decline) for each HUC 12.

Watershed Description 2

A Summary of the Upper Illinois River Watershed

Area:	758 square miles (484,947 acres)
Location:	Benton County (40%), Washington County (60%) and Crawford County (<0.5%) in northwest Arkansas
Population:	Approximately 194,000 (2000 Census)
Land Use:	13% Urban, 41% Forest and woody herbaceous vegetation, 46% Pasture, and <1% Water
Agriculture:	♦ Arkansas is the 2nd largest producer of broiler chickens in the United States; Benton and Washington Counties are the largest producers in the state ♦ The main form of agricultural lands are pastures and forage fields; there are minimal row crops in the watershed
Industry:	♦ Northwest Arkansas is home of Wal-Mart Headquarters, the largest public corporation, and Tyson Foods, the largest meat producer in the world ♦ 25 federally-regulated food processing facilities (identified in EPA data systems) ♦ The most common industries include poultry processing, and prepared feeds and feed ingredients for animals and poultry
Municipalities:	♦ Northwest Arkansas is one of the fastest growing metropolitan areas in the state and the United States ♦ The Fayetteville-Springdale-Rogers Metropolitan area grew over 13 times faster than the state of Arkansas from 1990 to 2000 ♦ Multiple federally-regulated wastewater treatment facilities with four holding "major" NPDES designations

2.1 Geography

The Illinois River originates in the headwaters near Hogeye, Arkansas, approximately 15 miles southwest of Fayetteville. The river flows westerly crossing the Ozarks of northwest Arkansas and into Oklahoma five miles south of Siloam Springs, Arkansas, near Watts, Oklahoma. The river continues southwesterly in Oklahoma to Lake Tenkiller and eventually flows into the Arkansas River near Gore, Oklahoma. The Illinois River is about 145 miles long draining approximately 1,645 square miles in Arkansas and Oklahoma.

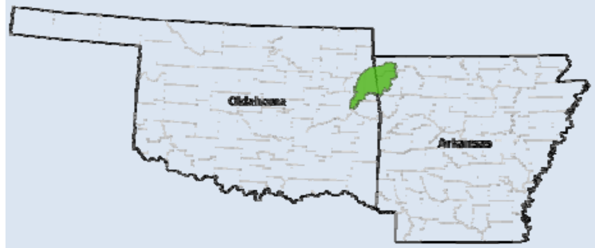


Figure 2.1. Location of the Illinois River Watershed in northwest Arkansas and northeast Oklahoma.

The UIRW is identified as HUC 11110103. HUC is an acronym for hydrologic unit code which is simply a way of identifying drainage basins in the U.S. based the basin's geographic area and size. The more digits in the HUC, the smaller the drainage area. The Upper Illinois River drainage area which lies in Benton and Washington Counties in northwest Arkansas totals about 758 square miles, or 484,947 acres, and is contained within the Ozark Plateaus Province in northwest Arkansas. The watershed lies mostly in the Springfield Plateau with a small part of the southeast corner in the Boston Mountains. In the UIRW, land use is diverse with about 46% pasture, 41% forest, and 13% urban.

2.2 Geology

The Springfield Plateau is underlain by limestone and cherty limestone, while the Boston Mountains are underlain by sandstone, shale, and limestone. The Springfield Plateau is gently rolling for the most part, with land surface relief rarely exceeding 200 to 300 feet. The Boston Mountains area is more rugged, with greater topographic relief and steep-sided valleys. Both the Springfield Plateau and the Boston Mountains are marked by Karst topography—the landscape created when groundwater dissolves limestone creating pathways for water to quickly move under the soil surface. This creates sinkholes and caves which groundwater seeps into and through, resulting in a scenic landscape that has hidden vulnerabilities to the transport of pollutants (e.g., nitrates, fertilizers, manures, etc.). Figures 2.2 and 2.3 depict the areas within Benton and Washington Counties, Arkansas, that are sensitive to groundwater pollution.

2.3 Climate

The regional climate is humid temperate, showing distinct hydrological patterns in precipitation, surface runoff and groundwater flow. Average annual precipitation in the watershed is about 43

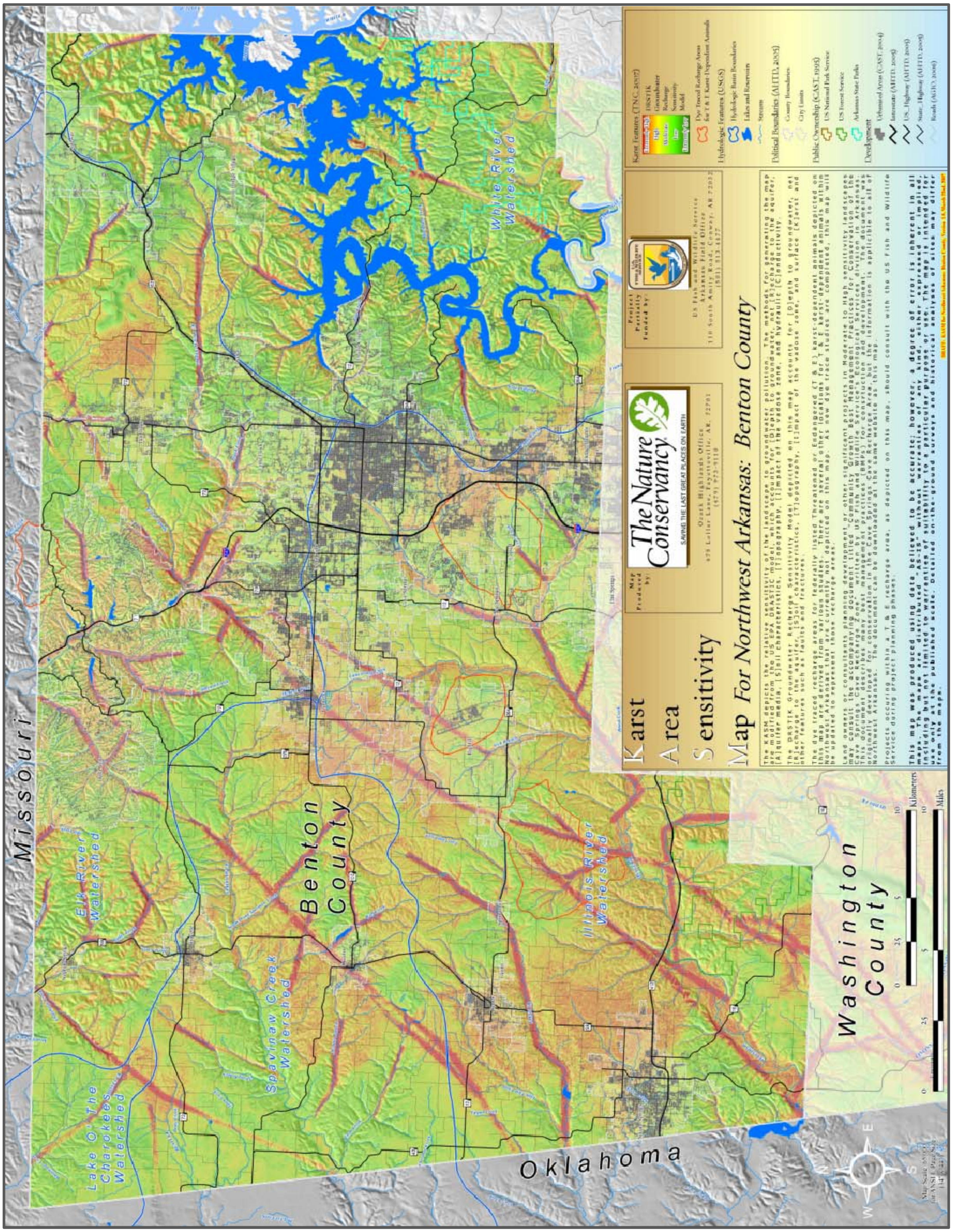


Figure 2.2 Karst area sensitivity map for Benton County, Arkansas.
Produced by The Nature Conservancy.
View this map online at www.nwarpc.org/pdf/GIS-Imagery/KASM_BENTON_CO.pdf

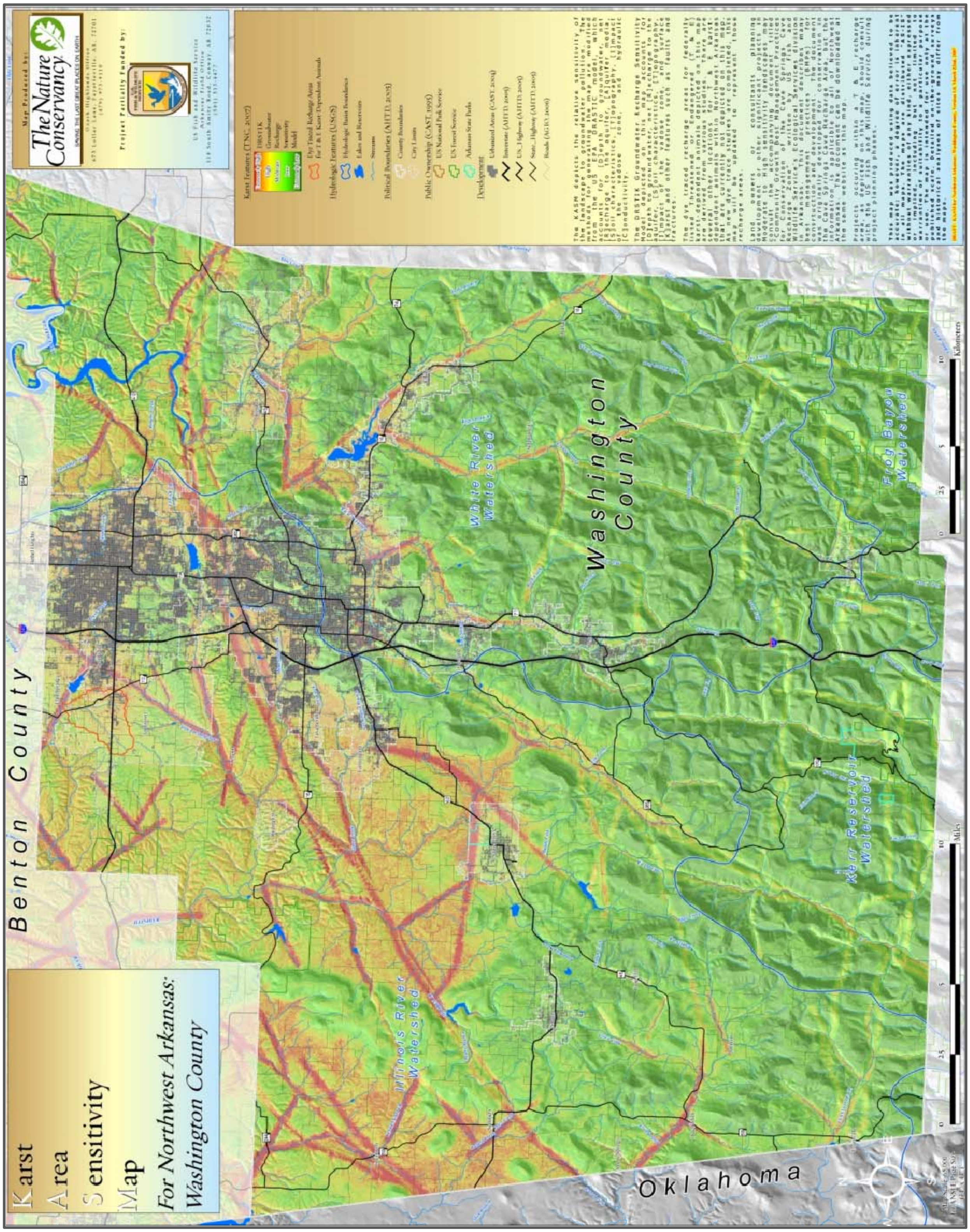


Figure 2.3. Karst area sensitivity map for Washington County, Arkansas. Produced by The Nature Conservancy.

View this map online at www.nwarpc.org/pdf/GIS-Imagery/KASM_WASHINGTON_CO.pdf

inches per year, while average annual evapotranspiration (loss of water to evaporation and transpiration by plants) is about 25 inches per year. Streamflow within the watershed varies with precipitation, and the majority of the surface runoff occurs from November through June. In early spring, the watershed receives moisture-laden air from the Gulf of Mexico, which often results in severe weather including intense thunderstorms that produce surface runoff and potential flooding. The amount of precipitation is much less from July through October, although occasional storm events during summer may produce large amounts of surface runoff.

2.4 Soils

The layer of soil covering the UIRW, except where land development has either removed it or covered it with an impervious layer, is a critical mantle buffering the actions of air and water on the environment. These actions influence:

- Plant growth (i.e., as pastures, crops, forest and native shrub lands)
- Hydrologic response (i.e., where rainwater goes when it hits the land as either surface runoff or subsurface flow); and
- Nutrient and sediment movement to stream and rivers within the UIRW

Properties of the surface soil layers, usually the top 6 to 12 inches, influence not only the chemistry but the amounts of rainfall leaving the land as surface runoff or stormwater flow. For instance, fine textured soils or clays, tend to have low infiltration capacities and thus, a greater proportion of rainfall ends up as runoff. On the other hand, gravelly or coarse textured soils tend to absorb more rainwater and produce less runoff, for a given amount and intensity of rain. One very important factor about soils and how they influence water quality in the UIRW, is slope; the steeper the slope the greater the potential for surface runoff during heavy rainfall to occur and possibly transport nutrients and sediments to streams and rivers. The corollary to this is that for soils with less surface runoff, rainwater becomes subsurface flow that can move to shallow aquifers and ground water in the UIRW. In this case, subsoil properties (and geology) influence the rate at which water moves though the soil to aquifers and ground water and the amounts and forms of chemicals transported.

The common soil types (i.e., Clarksville, Enders and Linker series) within the UIRW are Ultisols, which are found primarily in humid, temperate areas across the southeastern U.S. The word "Ultisol" is derived from "*ultimate*," because Ultisols are seen as the ultimate product of continuous weathering of minerals in a humid temperate climate. Because of this weathering, Ultisols are inherently of poor fertility, requiring the application of lime and fertilizer to be agriculturally productive. In fact, the high quality manure byproduct from poultry production has greatly increased agricultural productivity in the region over the past several decades.

The Clarksville series covers the majority (~74%) of the watershed, with Enders (~19%) and Linker (~7%) covering the rest, based on the State Soil Geographic Database (STATSGO). However, the Soil Survey Geographic (SSURGO) database would show that many different soil series are present within this watershed – but these soils may be grouped by similar characteristics and represented as Clarksville, Enders, and Linker.

The United States Department of Agriculture (USDA) Natural Resources Conservation Commission (NRCS) provides detailed reports on different soil series, which may be summarized as:

- Clarksville soils are gravelly silt loams; these soils are generally considered very deep (greater than 80 inches to bedrock), and somewhat excessively drained soils that are moderately permeable with medium to high runoff, with slopes ranging from 1 to 65%.
- Enders soils are typically gravelly fine sandy loams; these soils are generally deep (40-60 inches to bedrock), well drained, and slowly permeable with medium to very rapid runoff. Ender soils are level to moderately steep upland mountain tops and ridges to very steep mountain sides and bases with a slope that can range from 1 to 65%.
- Linker soils are generally fine sandy loams; these soils are moderately deep (20-40 inches to bedrock), well drained, and moderately permeable with slow to rapid runoff, dependent upon slope. Linker soils are on broad plateaus, benches, and mountain and hilltops with much of the slope ranging from 2 to 8% and with the full range from 1 to 15% (with a few isolated locations up to 30%).

These descriptions represent the general characteristics of these soils as observed across their larger geographic area, but these soils may have some characteristics specific to the UIRW and northwest Arkansas. Many of these local soils within the watershed have a shallow depth to bedrock, where the local geology may have Karst features allowing the movement of water from the soil to the groundwater without much natural filtering of nutrients by being bound to soil components, such as clays and iron or aluminum minerals.

A soil erosion hazard index can be extracted from the SSURGO database for the UIRW and broken into five categories: Not Rated, Slight, Moderate, Severe, and Very Severe (Figure 2.4). Baron Fork Creek and Headwaters-Upper Illinois River have the highest percentages in the "moderate" and "severe" erosion hazard index classes. Also, Clear Creek, portions of Muddy Fork, and the Upper Illinois River (particularly Cincinnati Creek) are identified as areas that may be subject to higher rates of soil loss if the soils were exposed to wind and water erosion (Figure 2.4). This type of soil survey analysis suggests that caution should be needed in conducting land disturbing activities and designing new development, particularly in soils falling in the moderate to very severe erosion hazard classifications. Most of the agricultural and pasture area (90%) is considered "slightly" hazardous to erosion by the index, which makes intuitive sense in that agricultural land is often located on the lower sloped areas of a watershed (Figure 2.4). Over 21,485 acres of established cool and warm season grasses in the watershed are classified as moderate to severe erosion hazard, and these are the areas where pasture management practices should be focused. In addition, riparian management will likely be the most cost-effective means to reduce sediment transport from the edge of fields to streams.

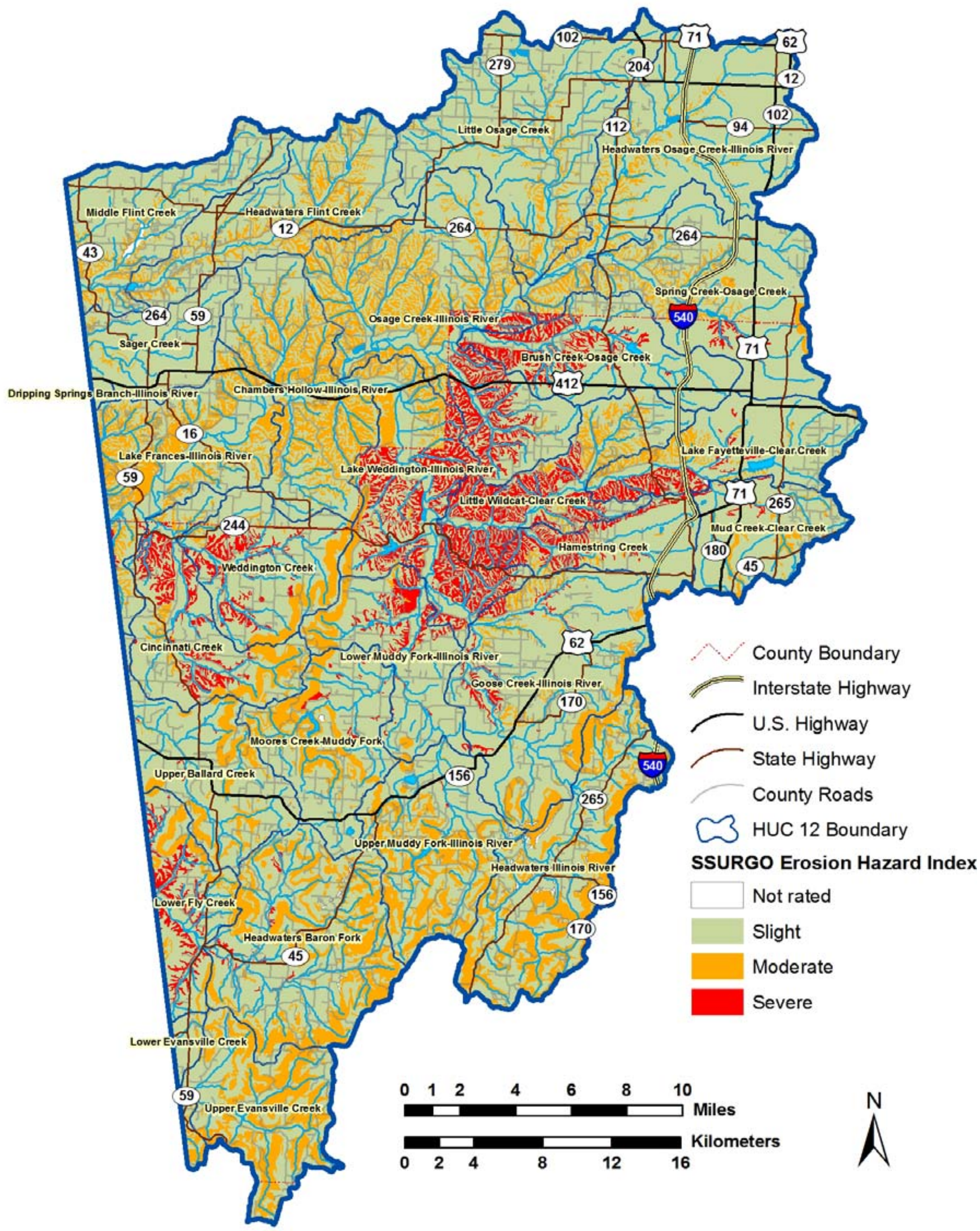


Figure 2.4. Soil Erosion Hazard Index classes for the Upper Illinois River Watershed, northwest Arkansas.

Soils are often used to provide drain-fields for on-site wastewater treatment and effluent discharge, (e.g. conventional septic tanks). The appropriate soil conditions must be available for effective on-site wastewater treatment to insure adequate removals of nutrients, bacteria and other pollutants. Standard septic systems using soils require that percolation rates (i.e., water infiltration) must fall within an acceptable range, that sufficient depth to the water table (i.e., ground water) is available or that an impermeable layer (e.g., clay layer) exists, and that slopes are amenable to effluent dispersal within the soil. The presence of underlying Karst features can also be problematic.

In terms of agricultural production (i.e., mainly pastures), soils present in the UIRW are naturally acidic and generally have low native fertility with nitrogen, phosphorus, potassium and calcium typically low in these soils. Soils often require or have required the application of lime or a liming agent to improve soil conditions and the input of nutrients (e.g., nitrogen, phosphorus, potassium or poultry litter) for forage and crop production. These soils have the ability to store some nutrients (e.g., phosphorus) when applied in excess of forage and crop needs, and these nutrients have the potential to be transported from the landscape during runoff events.

2.5 Hydrology

The main tributary streams in to the Illinois River include Osage Creek, Flint Creek, Clear Creek, and Baron Fork. Natural stream channels in the watershed generally consist of a series of well defined riffles and pools, along with channel beds predominantly consisting of coarse gravel, rubble, boulders, and bedrock. However, natural drainage areas in some areas of the watershed have been hydrologically altered by the installation of ditches and other drainage structures. Stream gradients are relatively high, generally exceeding 3 feet per mile even in larger streams. A small run-of-the-river impoundment (locally referred to as Lake Frances) exists on this river near the state line, which is of environmental concern because of sedimentation within this impoundment and its flood plain.

2.6 Land Use/Land Cover

Originally, the UIRW was primarily covered with hardwood forest and mounded upland prairies. However, much of this forest was cleared and prairies leveled around the start of the 20th century for use as pasture, which resulted in a cycle of geomorphic adjustments in local streams. As the population of northwest Arkansas has increased, especially over the past decade, land use and land cover in the UIRW has shifted away from pasture and towards urban development and forested areas. See Figure 2.5.

The Illinois River and its major tributaries in Arkansas (Osage Creek, Clear Creek and the Muddy Fork) exhibit a range of conditions from areas with dense riparian forest buffers illustrating exceptional beauty and ecological value to areas without the streamside buffers showing exposed banks.

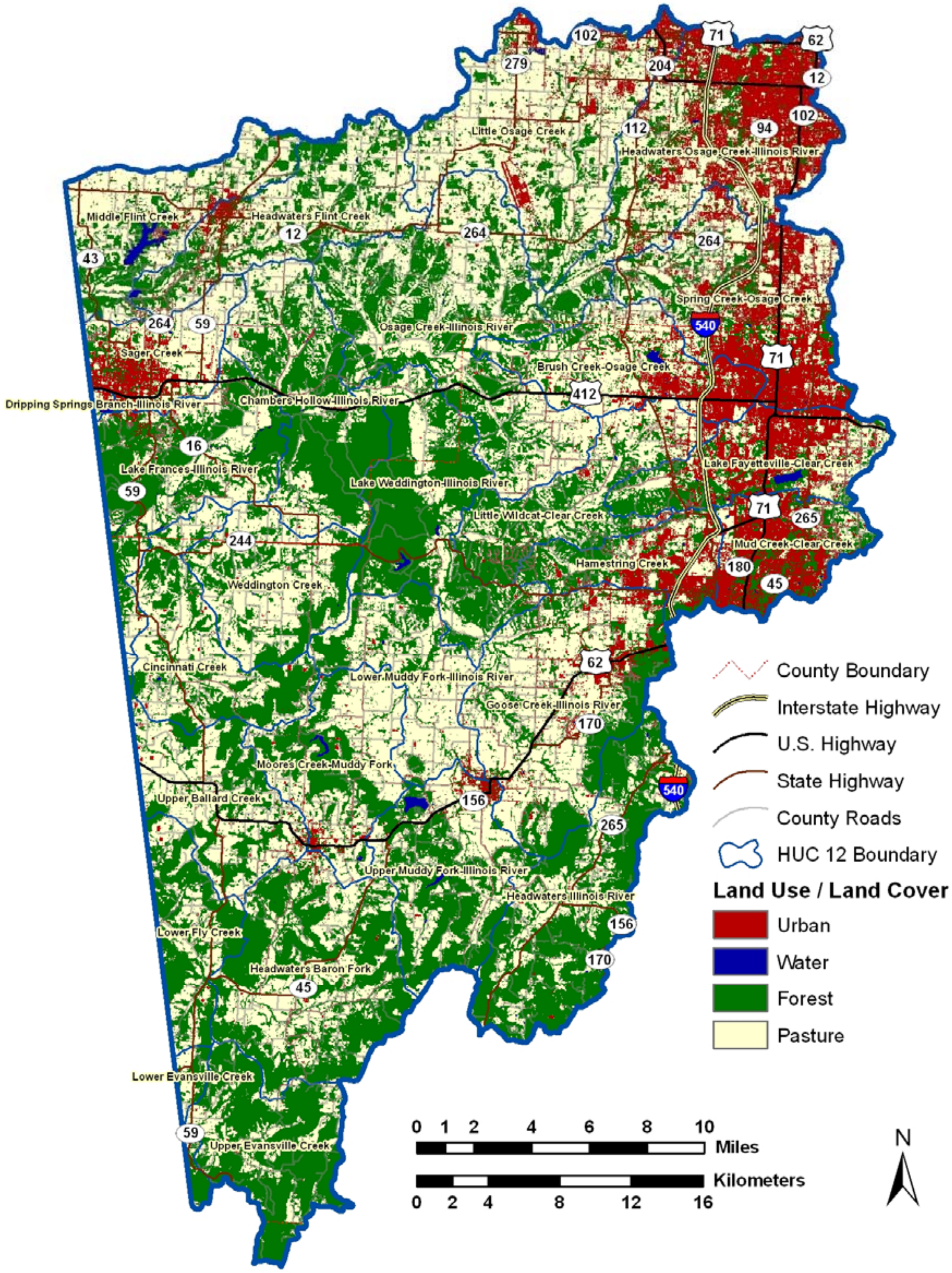


Figure 2.5. Land use distribution across the Upper Illinois River Watershed, northwest Arkansas. Based on 2006 land use/land cover data.

2.6.1 FORESTED AREAS

Forested areas compose about 37% of the watershed area within the UIRW, and these areas can be generally described as mixed upland hardwoods, or oak-hickory forests. Our local forested areas are deciduous hardwoods, but there exist a few smaller areas of coniferous, or evergreen, trees dispersed throughout the watershed. The large majority of the forested areas are owned by private land owners, although the U.S. Forest Service (USFS) owns and manages a few tracts of land within the UIRW. The Lake Wedington portion of the Ozark National Forest is entirely within the watershed area of the Illinois River, and this area is about 24 square miles. The Ozark National Forest also exists along the southern watershed boundary, but this portion of federally managed forest is less than two square miles. Forests generally conserve nutrients, such that most nitrogen and phosphorus input in precipitation is taken up by forest vegetation. In managed forests, erosion and turbidity may be the major concerns related to streams; these are also concerns in forested areas with high all-terrain vehicle (ATV) traffic from recreational activities. Wildlife within undisturbed forests near streams are potential sources of microbial organisms, such as bacteria, to streams.

The primary pollutant associated with forests addressed within this strategy is sediment.

2.6.2 PASTURE LANDS AND FORAGE PRODUCTION

The majority of the land use and land cover within the UIRW is pasture and grasslands, where these areas represent the dominant form of agriculture within the region (e.g., integrated poultry production and cattle management). Approximately 46% of the watershed area within the UIRW is in pasture and forage production. The amount of land within the UIRW representing typical row crops is minimal—less than 0.1% across the watershed. The main water quality concerns associated with agricultural land in pasture and forage production is the loss of nitrogen, phosphorus, and sediment in surface runoff and primarily nitrate in groundwater flows.Because the dominant soils in the UIRW do not naturally contain sufficient nutrients to maintain pasture and forage production, these nutrients are added in the form of commercial fertilizer and poultry litter. In fact, poultry litter has provided a much cheaper source of essential nitrogen, phosphorus, and potassium than mineral fertilizer. Historically, poultry litter was recommended to be applied to meet plant nitrogen requirements, which meant that about three to four times more phosphorus was added than plants needed each year. Over time, phosphorus tended to build up in soils, with the result that there was a greater potential for phosphorus loss to streams when surface runoff occurred. The corollary is that poultry litter application has greatly improved pasture production and soil cover in the UIRW, minimizing pasture erodibility and sediment loss to the Illinois River and its tributaries.

The primary pollutants associated with pastures addressed within this strategy are nitrogen, phosphorus, and sediment.

2.6.3 URBAN DEVELOPMENT AND IMPERVIOUS SURFACES

The percent of urban land use has more than doubled over the last two decades, where 13% of the watershed area is now classified as either low or high density urban development. The main concern with urban development is the increase in impervious areas, which increases the amount of surface runoff following rainfall events and ultimately impacts the tributaries draining urban areas. Urban streamflow increases rapidly following rainfall events, which reduces bank and channel stability, biodiversity, and water quality. The large amounts of runoff from urban development also carry nitrogen, phosphorus, sediment, and other contaminants, representing a nonpoint source within the UIRW. There are four major municipal wastewater treatment plants in the cities of Fayetteville, Springdale, Rogers and Siloam Springs, Arkansas, which discharge effluent into the headwater tributaries of the Illinois River. The influent into these facilities comes from residential, medical, industrial, and food processing centers. The main agricultural or food processing facilities in our region are poultry processing and feed production plants. The majority of the residential properties within the UIRW are served by these municipal facilities. Most of the urban development within non-municipal areas, and a few areas within those boundaries, are served by individual onsite and community wastewater treatment systems that discharge to soil. Clustered soil discharging systems are also becoming more popular, such as the septic tank effluent pump (STEP) systems that collect wastewater from multiple septic tanks and route it to a centralized treatment facility prior to drip irrigation soil dispersal. All of these wastewater treatment systems represent potential sources of nitrogen, phosphorus, and other emerging contaminants to streams within the UIRW.

The primary pollutants associated with urban areas addressed within this strategy are nitrogen, phosphorus, and sediment.

2.6.4 LAND USE CHANGES OVER THE LAST DECADE

In the land use categories represented in the watershed map, pasture includes areas with bare soil as seedbeds and row crops, forest includes herbaceous vegetation, and urban includes low and high density development as well as barren land (e.g, construction sites and rock quarries). Over the last decade, pasture lands have reduced in area from 64% to 46% where these areas were converted into urban development or restored to forested lands. The amount of urbanized areas within the IRWP has more than doubled with the majority of the growth in the last seven years, and the forested areas have increased from 29% to 37%. Forest area in the watershed has increased over the past decade because of an increase in both designated forests and herbaceous vegetation (e.g., shrubs and other woody plants) in the watershed. These changes over time (e.g., from 1992 to 2006) show the dynamic nature of watershed land use, as the landscape is changing with each survey of land use and land cover conducted. Watershed management strategies must be adaptive to landscape dynamics, because changes in land use and land cover may alter the selection of appropriate management strategies to address water quality concerns within the UIRW.

2.7 Socioeconomics

The watershed is characterized by rapidly growing urban centers from south Fayetteville to Bentonville and Rogers, Arkansas, in the headwaters to more rural areas along the Oklahoma border. It is also home to commercial poultry broiler and non-commercial beef grazing production systems, which are essential to the economic well-being of the region. Arkansas is the second largest producer of broilers in the U.S., of which Benton and Washington counties are the largest contributors of poultry as well as beef in the state. In addition, northwest Arkansas is home to Wal-Mart headquarters, the world's largest public corporation, and Tyson Foods, the largest meat producer in the world, as well as hundreds of small businesses supporting these industries.

In 2000, there were approximately 194,000 residents living in the UIRW representing a 30% increase in population over the last decade (e.g., from 1990 to 2000). Population growth has been forecasted in northwest Arkansas, particularly to understand the future demands or needs from a drinking water perspective, and this growth was forecasted in select watersheds. For instance, Carollo Engineers (2005) predicted the number of people living in the UIRW to almost double in the coming decades (i.e., from approximately 250,000 in 2010 to almost 500,000 in 2055). The majority of this population growth will occur in the major cities along the eastern watershed boundary (e.g., Fayetteville, Springdale, and Rogers), as well as Siloam Springs near the Arkansas – Oklahoma border. Future increases in population will prompt changes in land use and land cover, which without proper watershed management will likely impact water quantity and quality in the UIRW.

2.7.1 POLITICAL BOUNDARIES AND JURISDICTIONS

The UIRW includes parts of Benton and Washington Counties and a very small portion of Crawford County within the State of Arkansas. Approximately 40% of the watershed lies in Benton County while 60% is in Washington County and less than 1% is within Crawford County. There are 21 incorporated municipalities within this watershed, with the largest municipalities defined as the Fayetteville-Springdale-Rogers metropolitan area. This area grew over 13 times faster than the rest of the state from 1990 to 2000. In fact, northwest Arkansas is one of the fastest growing metropolitan areas in the state and the U.S. Currently, the incorporated municipalities combined cover approximately 22% of the watershed area, while urban land use only accounts for 13%. The towns and cities in the watershed have designated planning areas, defining the potential extent of future annexation and municipal service extensions in the coming decades. The full extent of the municipal planning areas would constitute almost 58% of the total watershed area, approximately tripling the current incorporated area within the UIRW.

Municipalities and counties are local jurisdictions and political boundaries, which can be used to influence local policies or regulations that might influence water quality conditions within the UIRW. Specific regulations at the municipal, state and federal levels are further described in Section 2.11, Regulatory Drivers.

2.8 Water Quantity

The volume of water discharged each year to Oklahoma from the UIRW varies depending on the annual precipitation. Over the past decade, annual discharge has ranged from 257,000,000 m^3 during a dry year (2006) to 1,010,000,000 m^3 during a wet year (2008). The percentage of discharge attributed to base flow and storm flow conditions also varies with annual precipitation; during a wet year as much as 63% of the total flow is attributable to storm events while during dry years storm flow can be as little as 42% of the total flow. In addition, the three major wastewater treatment plants (WWTP) in Fayetteville, Springdale, and Rogers contribute, on average, 10% to 20% of the annual base flow volume.

2.9 Water Quality Monitoring

Waterbodies in the UIRW are monitored by a variety of entities including Arkansas Department of Environmental Quality (ADEQ) and U.S. Geological Survey (USGS), AWRC, dischargers, and volunteers. Collected data is used to characterize waters, identify trends in water quality over time, identify emerging problems, predict future problems, and determine if pollution control programs are working.

ADEQ has been monitoring select reaches of the Illinois River and its tributaries since the early 1990s. ADEQ's surface water quality monitoring stations data files are available on the web at http://www.adeq.state.ar.us/techsvs/water_quality/monitors.asp. The USGS has been monitoring several of the same sites that ADEQ monitors, as well as additional sites in the watershed. Data is available online at the USGS National Water Quality Assessment Data Warehouse (NAWQA); at http://infotrek.er.usgs.gov/traverse/f?p=NAWQA:HOME:. The AWRC has been monitoring water quality at the Illinois River since 1995 and at Ballard Creek, a tributary to the Illinois River since 2002. The available data is viewable online at http://www.uark.edu/depts/awrc/pubs-MSC.htm.

Water quality studies in the UIRW primarily began in the early 1980s and have become more frequent and in-depth as the watershed has changed from its natural characteristics to an urban and agricultural dominated watershed. A list of citations of water quality studies that have been completed in the UIRW is available in Appendix A.

2.10 Wildlife Resources—Endangered & Threatened Species and Fisheries

The Karst terrain of northwest Arkansas supports numerous springs and spring-fed tributaries which harbor threatened, endangered or endemic species including the Ozark cavefish (*Amblyopsis rosae*l), Least darter (*Etheostoma microperca*), Oklahoma salamander (*Eurycea tynerensis*), and Neosho Mucket mussel (*Lampsilis rafinesqueana*). The presence of these endangered species and or other aquatic species of concerns have placed several areas within the UIRW as extraordinary resource waters or ecologically sensitive waters (ESWs) as defined by ADEQ. In addition, all lakes and reservoirs and most streams are designated as fisheries.

2.11 Regulatory Drivers

Regulations that apply in the UIRW both drive the need for restoration and protection in the watershed, and constrain the restoration and protection activities that can be implemented. Waters in the UIRW are under the jurisdiction of both Federal and State regulations.

2.11.1 US ENVIRONMENTAL PROTECTION AGENCY (EPA)

The EPA has primary responsibility for implementation of the Clean Water Act and the Safe Drinking Water Act.

The **Clean Water Act** pertains to protection of surface and ground waters of the U.S. The specific objective of the act is to protect the physical, chemical and biological integrity of the nation's waters. Pertinent sections are:

- Section 301 establishing effluent limitations,
- Section 302 establishing water quality related effluent limitations,
- Section 303 requiring States to develop ambient water quality standards,
- Section 305 requiring States to conduct biennial water quality inventories,
- Section 307 requiring toxic and pretreatment effluent standards,
- Section 314, the clean lakes program,
- Section 319, nonpoint source pollution management,
- Section 402, the National Pollution Discharge Elimination System Program, and
- Section 404 (enforced by COE), Permits for dredged or fill material.

The **Safe Drinking Water Act** is the primary federal law pertaining to provision of potable water for the public. Regulations promulgated by the EPA under the Safe Drinking Water Act that are pertinent to the source water protection program are:

- National Primary and Secondary Drinking Water Regulations (40 CFR sections 141, 142, 143),
- National Primary Drinking Water Regulations; Long Term 2 Enhanced Surface Water Treatment Rule,
- Stage 2 Disinfectants and Disinfection Byproducts Rule,
- Underground Injection Control Program (40 CFS section 144 - 147)

2.11.2 US DEPARTMENT OF AGRICULTURE (USDA)

Beginning in 1985 with the passage of the Food Security Act, or Farm Bill, all farm operators in the U.S. were required by law to meet specific soil erosion control standards. Compliance with these standards (including the sodbuster and swampbuster provisions) is now prerequisite for participation in most federal farm programs.

Subsequent Farm Bills in 1990 and 1996 enhanced the water quality benefits of the program by retiring highly erodible lands from production and adding new incentive programs, such as the Wetlands Reserve Program, encouraging farmers to restore farmed wetlands to their natural condition.

2.11.3 FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

The National Flood Insurance Program (NFIP) is a federal non-regulatory program that can provide some water quality protection by restricting development in the floodplain. The NFIP, which is administered by FEMA, makes federally-backed flood insurance available in communities that agree to adopt and enforce floodplain management ordinances to reduce future flood damage. The program generally includes identifying flood prone areas, elevating buildings above the base flood, and relocating structures out of the floodplain. Local governments may go beyond the minimum FEMA requirements to provide added protection.

2.11.4 ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY (ADEQ)

According to their website, www.adeq.state.ar.us, the ADEQ strives to protect Arkansas' priceless natural resources - its air, water and land - from the threat of pollution. They do this through a combination of regulatory programs, proactive programs and educational activities. ADEQ is the designated agency in the State for implementation of the State’s water quality management plan and the National Pollution Discharge Elimination System (NPDES) program. ADEQ enforces regulations established by the Arkansas Pollution Control and Ecology Commission. Regulations of the Commission relevant to management of the UIRW are:

- Regulation No. 2, Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas as revised, effective November 25, 2007,
- Regulation No. 4, Regulation to Require a Disposal Permit for Real Estate Subdivisions in Proximity to Lakes and Streams, effective July 7, 1973,
- Regulation No. 5, Liquid Animal Waste Management Systems as revised, effective April 26, 2008,
- Regulation No. 6, Regulations For State Administration Of The National Pollutant Discharge Elimination System (NPDES), effective January 17, 2008,
- Regulation No. 8, Administrative Procedures as revised, effective June 12, 2000,
- Regulation No. 9, Permit Fee Regulations as revised, effective March 15, 2008.
- Regulation No. 12 (PDF File) - Storage Tank Regulations as revised, effective October 15, 2007,
- Regulation No. 17 (PDF File) - Arkansas Underground Injection Control Code, effective February 14, 2005,
- Regulation No. 22 (PDF File) - Solid Waste Management Rules, effective April 26, 2008,

- Regulation No. 23 (PDF File 3.5mb) - Hazardous Waste Management as revised, effective May 26, 2008,
- Regulation No. 29 (PDF File) - Brownfields Redevelopment as revised, effective March 3, 2006, and
- Regulation No. 30 (PDF File) - Arkansas Remedial Action Trust Fund Hazardous Substances Site Priority List, effective December 16, 2005.

2.11.5 ARKANSAS DEPARTMENT OF HEALTH (ADH)

- Rules and Regulations Pertaining to Public Water Systems, Effective January 11, 2007 (http://www.healthyarkansas.com/eng/pdf/pwsregsfinal.pdf)
- Rules and Regulations Pertaining to Onsite Wastewater Systems, Designated Representatives and Installers, Effective December 16, 2006 (http://www.sosweb.state.ar.us/elections/elections_pdfs/register/novdec_06/016.24.06-009.pdf)
- Rules and Regulations Pertaining to Mobile Home and Recreational Vehicle Parks, Effective April 1, 2008 (http://www.healthyarkansas.com/rules_regs/mobile_home_parks.pdf)
- Rules and Regulations Pertaining to General Sanitation, Effective November 1, 2000 (http://www.healthyarkansas.com/rules_regs/general_sanitation.pdf).

2.11.6 ARKANSAS HIGHWAY AND TRANSPORTATION DEPARTMENT (AHTD)

The AHTD maintains standards for State Highway construction including erosion and sediment control, spill prevention and site stabilization practices.

2.11.7 ARKANSAS LIVESTOCK AND POULTRY COMMISSION (ALPC)

The mission of the ALPC is, "to safeguard human and animal health, assure food safety and quality, and promote Arkansas livestock and poultry industries for the benefit of our citizens". ALPC is not a primary environmental agency. However, they regulate disposal of on-farm mortality which may become a water quality issue if not properly managed.

2.11.8 ARKANSAS NATURAL RESOURCES COMMISSION (ANRC)

The mission of the ANRC is "To manage and protect our water and land resources for the health, safety and economic benefit of the State of Arkansas". In fulfillment of this mission, the ANRC has a number of regulations relevant to the source water protection program including:

- Title III, Rules for utilization of surface water,
- Title V, Administrative rules and regulations for financial assistance,
- Title VI, Rules for water development project compliance with the Arkansas Water Plan,
- Title VIII, Rules governing water rights investigations,
- Title IX, Rules and procedures for claiming tax credit,
- Title X, Rules governing the Arkansas water resource cost-share program,

- Title XI, Rules governing the surplus poultry litter removal incentives cost share program,
- Title XII, Rules governing the Arkansas wetlands mitigation bank program,
- Title XIII, Rules governing the tax credit program for the creation and restoration of private wetland and riparian zones,
- Title XIV, Rules implementing the water resource conservation and development incentives act,
- Title XV, Rules governing loans from the safe drinking water fund,
- Title XVI, Rules governing the Arkansas clean water revolving loan fund program,
- Title XVII, Rules governing water authorities,
- Title XXII, Nutrient and poultry litter application and management program, and
- Title XXIII, Rules governing water and wastewater project funding through the Arkansas community and economic development program.

The UIRW has been designated as a **Nutrient Surplus Area** under Arkansas Acts 1059 and 1061, as implemented by Title XXII of the Arkansas Natural Resources Commission *Rules Governing the Arkansas Soil Nutrient and Poultry Litter Application and Management Program*, effective January 2006. The purpose of these rules is to maintain the benefits derived from the wise use of poultry litter and other soil nutrients while avoiding undesirable effects from excess nutrient applications on the waters of the State. Among other provisions, these rules state that persons applying nutrients from poultry litter to soils or associated crops on land areas greater than 2.5 acres within a Nutrient Surplus Area must apply in compliance with a nutrient management plan (NMP) or poultry litter management plan. Requirements for soil testing, record keeping, placement and timing of litter application and other elements of NMPs are specified in the rules (see next section). The rules require the maintenance of records for 5 years and require their availability for inspection by Commission or Conservation District employees. In addition, the Commission and Conservation District employees inspect 5% of nutrient management plans, and if there is a complaint, an inspection is conducted.

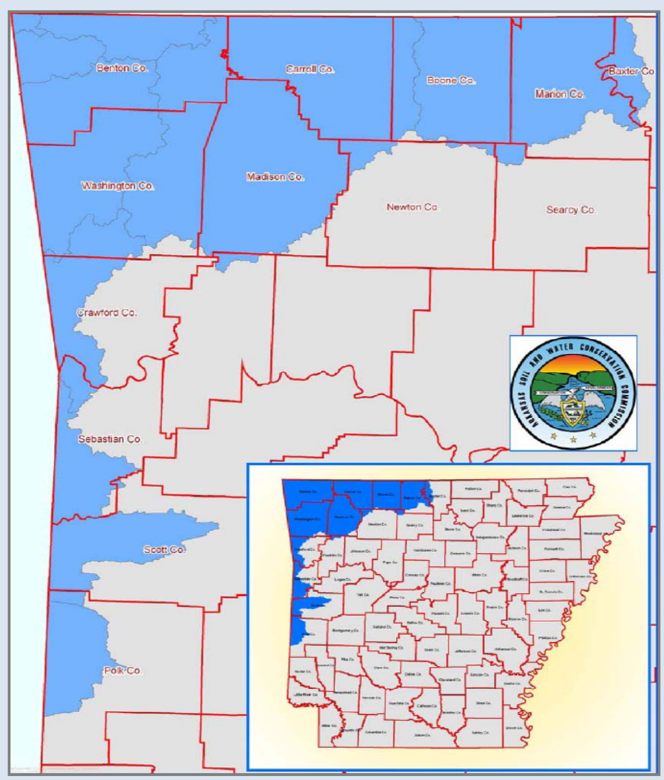


Figure 2.6. Nutrient surplus areas in Arkansas

Act 1061: An Act to Require Proper Application of Nutrients and

Utilization of Poultry Litter in Nutrient Surplus Areas requires that:

- All nutrient applications on land exceeding 2.5 acres in a Nutrient Surplus Area must be done according to a Nutrient Management Plan;
- Applications within a Nutrient Surplus Area on residential lands of 2.5 acres or less shall be applied at a rate not to exceed a protective rate (as defined in Title XXII);
- Nutrients may be applied only by a certified nutrient applicator within Nutrient Surplus Areas;
- The landowner is responsible for maintaining documentation of the nutrient application in accordance with their plan;
- Poultry feeding operations within a Nutrient Surplus Area shall develop and implement a poultry litter management plan acceptable to the Arkansas Natural Resources Commission (ANRC);
- The poultry litter management planner shall have obtained certification from ANRC in planning.

Additional legislation supports Act 1061, including:

- **Act 1059**: Arkansas Soil Nutrient Management Planner and Applicator Certification Act, requiring the certification of persons to properly develop NMPs or to properly supply soil nutrients and requiring ANRC to develop and implement a nutrient management education, training, and certification program.
- **Act 1060**: An Act to Register Poultry Feeding Operations, establishing annual registration with ANRC of poultry feeding operations where more than 2,500 poultry are housed or maintained.

2.12 Regulated Activities

2.12.1 WASTEWATER EFFLUENT DISCHARGES

The effluent limitations guidelines (40 CFR 400 through 699) specify discharge limitations for industries discharging to collection systems for municipal wastewater treatment facilities. In addition, local pretreatment ordinances may impose additional and or more stringent limitations. The following cities within the Illinois River Watershed have pretreatment programs.

- Fayetteville (Title V, Chapter 51, Article III);
- Siloam Springs (Municipal Code, Chapter 98, Articles IV and V);
- Springdale (Code of Ordinances, Chapter 118); and
- Rogers (Code of Ordinances, Article V).

These cities have established pretreatment programs which require industries to pre-treat their wastewater before releasing it to the municipal wastewater treatment system. These cities issue permits to regulate discharges into their collection system.

2.12.2 MULTIPLE SEPARATE STORM SEWER SYSTEMS (MS4S)

Stormwater discharges for large- and medium-sized communities are controlled by the federal NPDES regulations, but administered and enforced by ADEQ. This program regulates all major discharges of stormwater to surface waters. The purpose of the NPDES permits is to reduce pollutants in stormwater runoff from certain municipal separate storm sewer systems (MS4s) and industrial activities by requiring the development and implementation of stormwater management measures.

Table 2.1. Summary of surface water discharging wastewater treatment plants in the Upper Illinois River Watershed, northwest Arkansas.

Treatment Plant	Average Effluent Discharge (MGD)	Receiving Water Body	Effluent P Permit Limit (mg/L)	Pretreatment Program?	Sludge Disposal Method
Fayetteville	10	Goose Creek	1.0	Yes	Landfilled
Springdale	12	Spring Creek	1.0	Yes	Landfilled
Rogers	7	Osage Creek	1.0	Yes	Landfilled
Siloam Springs	3	Sager Creek	1.0	Yes	Landfilled
NACA Regional	4	Osage Creek	0.1		
Gentry	<1	SWEPCO Lake	None	No	
Prairie Grove	<1	Muddy Fork	None	No	Land Applied/ Landfilled
Lincoln	<1	Bush Creek	None	No	Land Applied

Arkansas Department of Environmental Quality has designated certain communities as MS4 communities and issued a general permit (No. ARR040000) with stormwater management conditions that all MS4 communities must meet by 2008, including:

- Public education
- Public involvement / participation
- Illicit discharge detection and elimination
- Construction site runoff control plan
- Post-construction stormwater management program
- Pollution prevention / good housekeeping

In the UIRW, MS4 communities include Benton County, Washington County, Fayetteville, Greenland, Lowell, Rogers, Springdale, Bentonville, Bethel Heights, Elm Springs, Farmington, Johnson, Little Flock, and the University of Arkansas. These MS4 communities have contracted with the University of Arkansas Cooperative Extension Service to develop and administer a Northwest Arkansas Regional Stormwater Education Program covering Benton and Washington counties or the "Fayetteville – Springdale" urbanized area. This program is designated to address the public education and involvement requirements of the MS4 permits through development of educational

Table 2.2 Cluster systems in the Upper Illinois River Watershed permitted by the Arkansas Department of Health and Department of Environmental Quality.

City	Project Name	Permitted	Description
Bethel Heights	Lexington Addition Water & Sewer Bethel Heights	3/11/2003	Part of Bethel Heights municipal system
Bethel Heights	Courtyard 3 Springdale Water & Bethel Heights Step Sewer	12/2/2004	Part of Bethel Heights municipal system
Bethel Heights	Logan Heights	7/5/2005	28 Lots, STEP System, Connection to Bethel Heights
Bethel Heights	Great Meadows Subdivision Water & Sewer Bethel Heights	2/22/2005	Part of Bethel Heights municipal system
Bethel Heights	Chantel Subdivision Water & Sewer	6/9/2004	Part of Bethel Heights municipal system
Cave Springs	Legacy Subdivision Water & Sewer Improvements	5/19/2004	205 lots, Cave Springs water, Cave Springs sewer, 260 GPD Lot^{-1} design flow plus 4,500 GDP commercial, Advantex AX100 treatment units loaded at 38.5 GPD ft^{-2} preceding drip irrigation, 0.38 GPD ft^{-2} loading rate
Cave Springs	Mandalea Subdivision Water & Sewer	4/8/2005	134 lots at 260 GPD design flow. Lotus treatment units design flow 35,250 GPD. Drip irrigation with 0.4 GPD ft^{-2} loading rate
Lowell	The Meadowlands		44 lots, STEP collection Advantex AX100 treatment units drip disposal at a loading rate of 0.11 GPD ft2. City of Lowell operation. Proposed design flow of 60 GPCD at 2.6 pop lot^{-1}.
Centerton	Cowger Property		64 lots, STEP system, 16,000 GPD design flow, Bioclere treatment, chlorination, dechlorination. Drip disposal loading rate of 0.160 GPD ft^{-2}. Operation by Tom Bartlett/Greenfield Development.
Springdale	Southeast Elementary	4/21/2005	Non-subdivision
Springdale	Steel Creek Subdivsion Water & Sewer	10/14/2004	36 lots with STEP collection. Bioclere with design flow of 8,250 GPD. Drip irrigation with a loading rate of 0.22 GPD ft^{-2}.
Fayetteville	Sloan Estates	5/5/2005	61 lots at design flow of 260 GPD. STEP collection system, Bioclere treatment plant preceding drip irrigation with a loading rate of 0.39 GPD ft^{-2}. Private sewer system operation.
Fayetteville	Cherry Hills Subdivision		198 lots, gravity collection, 50,000 GPD flow, lotus treatment, drip disposal at a loading rate of 2.52 GPD ft^{-2}. Operated by Fayetteville water.

materials for the general public and schools (fact sheets, brochures, and posters), conducting public outreach and youth education, and hosting workshops and training events.

Based on the latest annual reports from the MS4s, several of the MS4s have met the 2008 deadline for adopting a construction site runoff control ordinance or plan and an ordinance or plan for controlling post-construction runoff. However, a number of communities have not begun or have just begun to work on developing the programs and ordinances that are due this year. It appears that the largest gap in meeting the 2008 requirements is development of the Illicit Discharge Detection and Elimination Plan and the Pollution Prevention Plan. Local governments were not provided additional resources to develop and implement these new stormwater program requirements, and find it challenging to meet the deadlines. The table below summarizes the status of the MS4 requirements for the different jurisdictions.

Table 2.3. Regulated MS4 communities and status of permit requirements

Area	Public Education	Public Involvement	Illicit Discharge Plan	Construction Site Control	Post-Construction Control	Pollution Prevention Plan
Bentonville	●	●	◗	Ordinance ●	○	○
Fayetteville	●	●	◗	Ordinance ●	Ordinance ●	◗
Farmington	●	●	○	Plan ◗	○	○
Johnson	●	●	○	Ordinance ●	○	○
Little Flock	●	●	○	○	○	○
Greenland	●	●	○	○	○	○
Lowell	●	●	○	Plan ●	○	○
Elm Springs	●	●	○	○	○	○
Rogers	●	●	◗	Ordinance ●	Ordinance ●	○
Springdale	●	●	◗	Ordinance ●	○	○
Bethel Heights	●	●	tbd	tbd	tbd	tbd
Benton Co.	●	●	◗	Plan ◗	○	○
Washington Co.	●	●	○	Plan ●	Program ●	○

Note: ○ 0 to 20% complete
◗ 40% to 60% complete
● 100% complete or fully meeting requirements

2.12.3 CONFINED ANIMAL FEEDING OPERATIONS

Livestock operations consist of either confinement or pasture systems. Permitting is based on number of animals units (AU) in confinement where an AU is defined as one mature cow of approximately 1000 lbs and a calf up to weaning, usually 6 months of age or their equivalent. Equivalents are provided in Table 2.4. If a confined operation is greater than 1,000 AUs or is determined to threaten water quality, the operation is required to obtain a federal Concentrated

Animal Feeding Operation (CAFO) permit under the Clean Water Act's NPDES. CAFOs are required to develop a nutrient management plan (NMP) as a part of the CAFO permitting process. The CAFO NMP consists of manure management strategies that minimize the release of excessive nutrients into the surface and groundwater. The CAFO NMPs are based on Natural Resource Conservation Service (NRCS) defined standards and technical expertise. Each NMP varies according to the type of operation and site-specific conditions. According to ADEQ, there are no permitted CAFOs in Arkansas; however, this may change with EPAs final revisions to the CAFO requirements made in October 2008.

Table 2.4. Definition of animal units as defined by the U.S. Department of Agriculture.

Animal	Number of Animals per Animal Unit (AU)
Fattened Cows	1.14
Milk Cows	0.74
Breeding Hogs	2.67
Hogs for Slaughter	9.09
Chicken Layers	250
Chicken Broilers	455
Pullets	250
Turkeys for Breeding	50
Turkeys for Slaughter	67

Waterbody Uses 3

3.1 Water Quality Standards

Regulation No. 2 establishes general and specific water quality standards for surface waters of the state of Arkansas. The standards were established based upon present, future and potential water uses. Specific standards applicable to the UIRW include:

Table 3.1. Established water quality standards for waters of the Upper Illinois River Watershed

Parameter	Criteria
Temperature	29˚C, should not exceed due to manmade influences
Turbidity	10 NTU during base flow; 17 NTU during all flow
pH	Between 6.0 and 9.0
Dissolved Oxygen	< 10 mi^2 watershed: 6 mg L^{-1} (primary*); 2 mg L^{-1} (critical*) 10 to 100 mi^2 watershed: 6 mg L^{-1} (primary*); 5 mg L^{-1} (critical*) > 100 mi^2 watershed: 6 mg L^{-1} (primary*); 6 mg L^{-1} (critical*)
Bacteria	Primary Contact Waters: geomean of 126 col per 100 mL Secondary Contact Waters: geomean of 630 col per 100 mL Criteria shall not be exceeded in more than 25% of the samples in no less than 8 samples taken during the primary or secondary contact season
Chloride	20 mg L^{-1}, monthly average concentration

* The primary season is the period of the year when water temperatures are 22 ^{o}C or below. This includes the major part of the year from fall through spring, including the spawning season of most fishes; it normally occurs from about mid-September to mid-May. The critical season is the period of the year when water temperatures exceed 22 ^{o}C. This is normally the hot, dry season and after the majority of the fish spawning activities have ceased; this season normally exists from about mid-May to mid-September.

3.2 Stream Classifications and Use Support

The State of Arkansas has established designated uses for all waters including streams and publicly-owned lakes in the UIRW. The definitions of these designated uses are based on Regulation 2.

- **Extraordinary Resource Waters (ERWs):** These waters are designated for their scenic beauty, aesthetics, scientific values, broad recreation potential and intangible social values based on a combination of chemical, physical, and biological characteristics. **Any and all areas in the IRWP that support the Arkansas darter, least darter, Oklahoma salamander, and cave fish, snails and crawfish would be considered ERWs.**

- **Natural and Scenic Waterways (NSWs):** These waters have been legislatively adopted into a state or federal system of natural and scenic waterways. **No streams in the UIRW are designated with this use by the State of Arkansas.**
- **Ecologically Sensitive Waterbodies (ESWs):** These waters are known to provide habitat within the existing range of threatened, endangered or endemic species of aquatic or semi-aquatic organisms. **In the UIRW, the following portions are considered ESWs:**
    1. **Illinois River (From the Arkansas - Oklahoma state line upstream to its confluence with Muddy Fork), and any other portion where the Neosho mussel is known to inhabit**
    2. **Little Osage (From its confluence with Osage Creek ~2.5 miles upstream)**
    3. **Numerous springs and spring-fed tributaries, which support threatened, endangered or endemic species (11 locations within the UIRW)**
- **Primary Contact Recreation:** These waters are designated for primary contact recreation, or full body contact, use. **All streams with drainage areas greater than 10 square miles and all lakes and reservoirs are designated with this use within the UIRW; this designated use typically applies from May 1st through September 30th.**
- **Secondary Contact Recreation:** These waters are designated for secondary recreational activities including boating, fishing, or wading. **All waters are designated with this use in the UIRW.**
- **Domestic, Industrial Agricultural Water Supply:** These waters are designated for use as domestic, industrial or agricultural water supply. **All waters are designated with this use in the UIRW.**
- **Fisheries:** These waters are designated for the protection and propagation of fish, shellfish and other forms of aquatic life. **In the UIRW, the following waterbodies are designated with this use or subsets of the use:**
    1. **All lakes and reservoirs**
    2. **Perennial fisheries—all streams with drainage area equal to or greater than 10 square miles**
    3. **Seasonal fisheries—all streams with drainage area less than10 square miles during the primary season (generally mid-September to mid-May); these streams may be designated as perennial fisheries with further evaluation of water sources or aquatic communities.**

Interests & Issues 4

4.1 Impaired Stream Reaches in the Illinois River

Arkansas Department of Environmental Quality (ADEQ) submits a list of waterbodies to EPA that do not meet current water quality standards, assessment criteria, and designated beneficial uses called the 303(d) list. ADEQ submitted the most recent list to EPA in 2008 based on evaluation of data collected between July 1, 2002 and June 30, 2007. ADEQ indicated that four segments within the UIRW were impaired (category 5d or 5e); however, EPA added additional segments (category 5g) to this list for a total of 14 stream reaches or reservoirs in the UIRW. These segments and impairments are illustrated in Figure 4.1 and further discussed in section 4.4. These listings represent obvious priority areas for the Illinois River Watershed Partnership, and the map of the UIRW depicts the location of the impaired waterbodies in the UIRW.

Fourteen stream segments in the IRWP are listed as “impaired” on the Arkansas 303(d) list (2008). Eight of the stream segments were listed by EPA for bacteria related impairments with a low priority for TMDLs or other remedial actions. Four segments were listed by EPA for impairments resulting from elevated total phosphorus concentrations with a low priority for TMDLs or other remedial actions. Two segments were listed by ADEQ as impaired due to siltation, but stated that additional data is needed to verify the impairment.

4.2 History of Phosphorus Issues in the Illinois River

The UIRW is a transboundary watershed located in northwest Arkansas and northeast Oklahoma. This watershed management plan is intended to protect the designated uses as defined in the State of Arkansas. Designated uses in Oklahoma may or may not change downstream.

The primary focus has been on phosphorus within this basin, because the State of Oklahoma has long been concerned with the impact of phosphorus loading on Tenkiller Ferry Lake (Lake Tenkiller), an impoundment of the Illinois River, and has listed 6,450 acres of Lake Tenkiller as impaired water due to low dissolved oxygen and elevated total phosphorus loadings. When the City of Fayetteville, Arkansas, diverted a portion of its wastewater discharge from the White River into the Illinois River Watershed, Oklahoma became concerned about the increased phosphorus loading to Lake Tenkiller and, in 1986, sued to stop Fayetteville’s discharge. The dispute reached the U.S. Supreme Court in 1992, which ruled that the downstream state’s (i.e., Oklahoma’s) water quality regulations must be met. After this court ruling, nutrient removal was established in the Fayetteville discharge. The City of Springdale’s phosphorus load remained high, but in 2003 the cities of Fayetteville, Springdale, Rogers, Bentonville, and Siloam Springs entered into an agreement with the State of Oklahoma to limit the municipalities’ wastewater effluent phosphorus concentrations to 1 mg L^{-1} (Soerens, 2003).

The new effluent limit spurred a round of wastewater treatment plant upgrades in northwest Arkansas that continued to the present time.

Oklahoma has contended that the point source agreement alone was not sufficient to ensure attainment of water quality standards in Lake Tenkiller, and that nonpoint loads must also be addressed through the development of a TMDL. In 1997, Arkansas/Oklahoma Arkansas River Compact Commission agreed to a goal of a 40% reduction of the 1980 through 1993 average annual total phosphorus loads to Lake Tenkiller (Soerens, 2003). In 2001, Oklahoma and EPA Region 6 developed a draft TMDL for Tenkiller Ferry Lake and the Illinois River Watershed, which proposed reductions up to 35% in phosphorus loads present in 1990 through 1995. The TMDL analysis identified application of poultry litter to pastures as a major source of phosphorus loading, and the allocations in the draft TMDL called for reductions in phosphorus loading up to 55% from this source. However, this TMDL has not been finalized.

The Illinois River was designated by the State of Oklahoma as a Scenic River in 1969. In 2002, the State of Oklahoma adopted a numerical water quality criterion for phosphorus in its Scenic Rivers. The regulation stipulates, "The thirty day geometric mean total phosphorus concentration in waters designated "Scenic River" shall not exceed 0.037 mg L^{-1}" (Soerens, 2003). Also, in 2002 Arkansas and Oklahoma came to an agreement on a "statement of joint principals and actions" regarding point and nonpoint activities in the watershed.

4.3 Summary of Current Water Quality Monitoring

To establish current water quality conditions in the UIRW, AWRC conducted a water quality monitoring program to collect data representing measured nitrogen, phosphorus, and sediment concentrations across the UIRW. The designed program selected 29 sites across the watershed, particularly focused on outlets of individual HUC 12s, multiple access points along the Illinois River, and at sites upstream and downstream of the major WWTP effluent discharges. Water samples were collected during base flow conditions (e.g., low flow) by AWRC field services personnel; twelve samples were collected during low flow, and six samples were collected during high flow. The collected water samples were delivered to the AWRC Water Quality Lab (WQL) and analyzed for multiple parameters that were considered to be important to water quality conditions of the HUC 12s across the UIRW, including chloride, nitrogen, phosphorus, total suspended solids, turbidity, and bacteria (total coliform and *E. coli*). The quality assurance plan under which these samples were collected is provided in Appendix B as well as tables describing concentrations of the water quality parameters measured during this comprehensive monitoring program.

In 2008, a volunteer monitoring program was established to measure water chemistry at 37 sites within the UIRW and to evaluate changes in water chemistry over the past 15 years. This project was funded by ANRC, and IRWP contracted with AWRC to manage the volunteer monitoring program, to train volunteers to collect samples following EPA approved methods, and to analyze the collected samples at the AWRC Water Quality Lab. The AWRC trained 27 volunteers to collect water samples at these sites, and water samples were collected during base flow conditions during September and December 2008, and February and May 2009. Each water sample was analyzed for nitrogen, phosphorus, sulfate, chloride, fluoride, total suspended solids and turbidity. The results from this volunteer monitoring program are available in PDF on the AWRC website at www.uark.edu/depts/awrc/pdf_files/MSC_354.pdf. These data were used to help establish HUC 12 priorities within this watershed strategy for UIRW, showing the utility of volunteer collected data.

In 2009, ANRC also funded an additional monitoring program that had the goal of estimating constituent loads at select sites within the UIRW. The grant was funded by ANRC, and the IRWP contracted with AWRC to collect and analyze water samples from eight sites, including a Mud Creek tributary, Ballard Creek, Baron Fork, two sites on Flint Creek, Osage Creek and two sites on the Illinois River. The collected water samples were analyzed for nitrogen, phosphorus, sulfate, chloride total suspended solids, and turbidity. Daily constituent loads were determined using the relation between constituent concentrations, discharge, and seasonal factors, which are then summed to produce monthly, seasonal and annual load estimates. The selected sites are all at established discharge monitoring stations maintained by either the AWRC or the US Geological Survey. The results of this study should be available in July 2010.

4.4 Causes/Sources

4.4.1 SECTION 303(d) LISTINGS

Table 4.1 identifies the pollutants identified as causing the impairments on the 2008 303(d) List. A plan must be developed to address the impairing pollutant(s) within 13 years of the parameter being listed on the 303(d) list, provided the water body is not removed from the list for the cause of insufficient data, standard change or other. The waterbody must remain on the list sequentially for the 13 year period.

4.4.2 WATERSHED ASSESSMENT MODEL

The IRWP contracted with Dr. Mike White to develop a watershed assessment model to provide load allocations within the UIRW. The model chosen was the Soil & Water Assessment Tool (SWAT) which is a watershed–scale distributed hydrologic model. This model is a commonly used watershed-scale (i.e., HUC 8 Level) model that applies science-based descriptions of actual soil and water processes occurring in a watershed that determine nutrient and sediment fate, transport, and loads in a watershed. Because of this, SWAT has been adopted as the model of choice by USDA, EPA and others, in several resource assessments and water quality response to remedial strategies.

POINT SOURCES. The constituent loads in the Illinois River may be partitioned into effluent discharges (e.g., end of pipes), and the landscape (e.g., various land uses). Dr. White's SWAT model estimated that on average 37% of the average annual phosphorus load (~465,000 lbs year^{-1}) from 1995 through 2007 was from effluent discharges, and the remaining fraction was from upland sources.These numbers for phosphorus loadings are fairly consistent with other studies based on

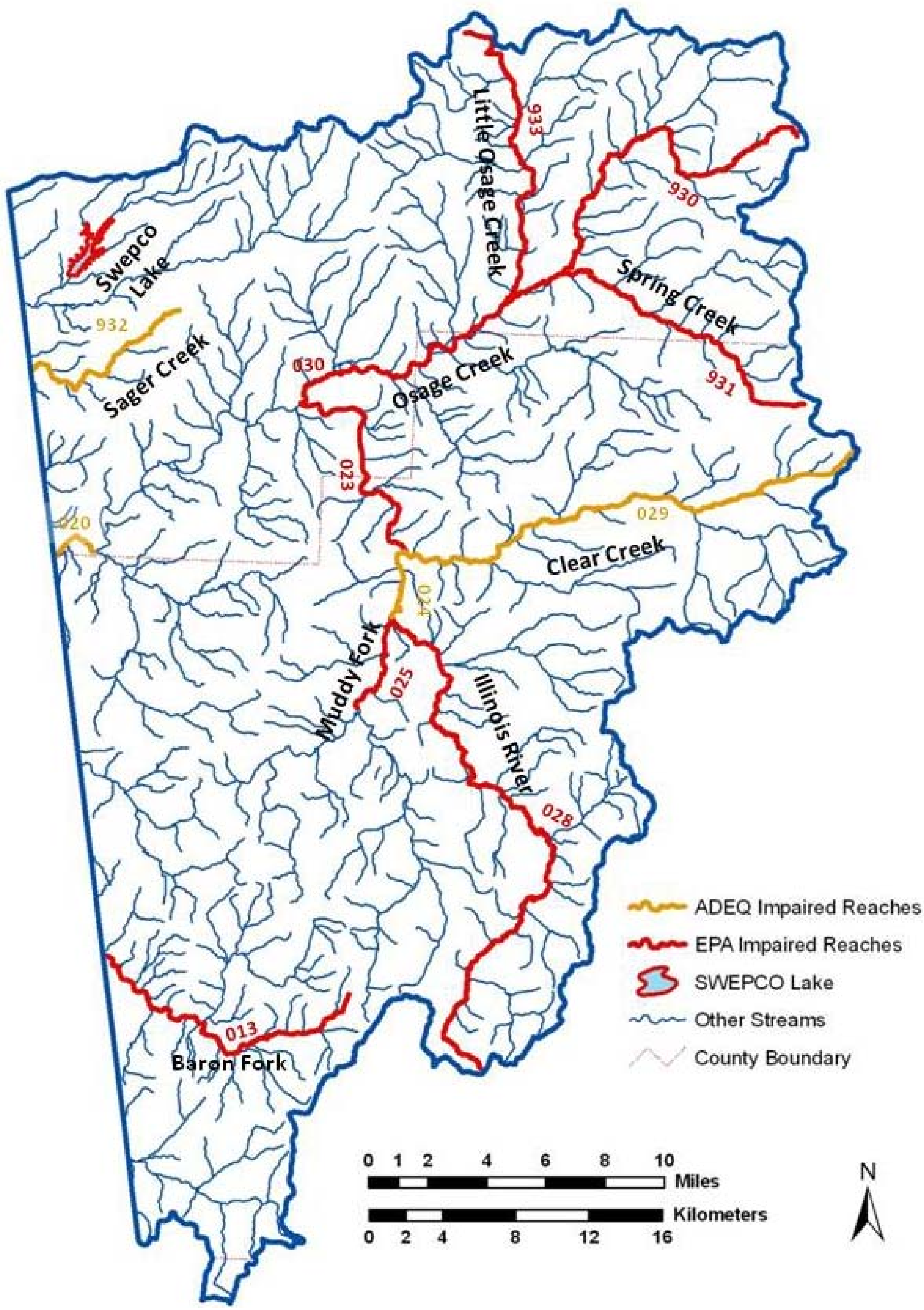


Figure 4.1. Stream segments listed as impaired on the 303(d) list by ADEQ and EPA.

Table 4.1. 303(d) listed stream segments within the Upper Illinois River Watershed, 2008, as reviewed by Arkansas Department of Environmental Quality.

Stream Name	Reach	Length (miles)	Impaired Uses	Pollutant	Source	Category	Priority
Reaches Listed by ADEQ							
Illinois River	020	1.6	Aquatic Life	Siltation	Surface Erosion	5d [1]	Low
Illinois River	024	2.5	Aquatic Life	Siltation	Surface Erosion	5d [1]	Low
Clear Creek	029	13.5	Primary Contact	Pathogen	Urban Runoff	5d [1]	Low
Sager Creek	932	8.0	Drinking Water	Nitrate	Municipal Point Source	5e [2]	Low
Additional Reaches Listed by EPA Region 6							
Baron Fork	013	10.0	Primary Contact	Pathogen	Unknown	5g [3]	Low
Illinois River	023	8.1	Primary Contact	Pathogen	Unknown	5g [3]	Low
Illinois River	024	2.5*	Primary Contact	Pathogen	Unknown	5g [3]	Low
Muddy Fork	025	3.2	Aquatic Life Primary Contact	Pathogen	Unknown	5g [3]	Low
Muddy Fork	025	3.2	Aquatic Life Primary Contact	Total Phosphorus	Unknown	5g [3]	Low
Illinois River	028	19.9	Aquatic Life Primary Contact	Pathogen	Unknown	5g [3]	Low
Osage Creek	030	15.0	Aquatic Life Primary Contact	Total Phosphorus	Unknown	5g [3]	Low
Osage Creek	030	15.0	Aquatic Life Primary Contact	Pathogen	Unknown	5g [3]	Low
Osage Creek	930	10.2	Aquatic Life Primary Contact	Total Phosphorus	Unknown	5g [3]	Low
Little Osage Creek	933	10.2	Aquatic Life Primary Contact	Pathogen	Unknown	5g [3]	Low
Spring Creek	931	8.4	Aquatic Life Primary Contact	Total Phosphorus	Unknown	5g [3]	Low
Swepco Lake	Lake	NA	Aquatic Life	Unknown	Unknown	5g [3]	Low

[1]Additional data is needed to determine the extent of impairment
[3]Future permit restrictions are expected
[3]Reach listed by USEPA

monitoring data from relatively short periods of time (e.g., 1997 through 2001, see Haggard and others, 2003; Nelson and others, 2006). It is important to understand that annual phosphorus loads from effluent discharges have decreased dramatically with improvement in phosphorus management at WWTPs over the last decade. The annual phosphorus load from effluent discharges have decreased more than 60% from prior to 2003 to present day, and these reductions have translated into reduced phosphorus transport in the Illinois River from Arkansas to Oklahoma.

Often, the question gets asks – how much further can phosphorus loads be reduced in the UIRW with lower effluent phosphorus concentrations? Dr. White's SWAT model does provide a means to evaluate the effects of reduced effluent phosphorus concentrations as that is an input parameter. Table 4.2 illustrates the effect of different effluent phosphorus concentrations on phosphorus loads within the drainage area used in Dr. White's SWAT. The historic concentration represents the average prior to 2003 across the WWTPs and the other effluent concentrations are applied across all WWTPs contained within Dr. White's SWAT model. It is evident that if the WWTPs did not make the changes in WWTP phosphorus management, the simulated, average loads for this time period (1995-2007) would have increased approximately 12% (Table 4.2). The average phosphorus load reductions resulting from decreased effluent phosphorus discharge concentrations are also illustrated. Currently, average concentrations across the major effluent discharges are likely less than 0.5 mg L^{-1} because these facilities currently operate with an effluent limit of 1 mg L^{-1}. Additional reductions in effluent concentrations result in only small decreases in the average annual load as simulated from 1995 to 2007. Any further reductions in effluent concentrations from current levels would require that the WWTPs invest millions of dollars to retrofit the facilities, and based upon Dr. White's SWAT model, the investment would result in only small changes in the average annual load. On the other hand, only 27% of the average nitrogen load (~3,940,000 lbs $year^{-1}$) was from effluent discharges, with the remaining fraction from upland sources or from within the stream channel. There has not been much emphasis placed on nitrogen outputs from the major municipal effluent discharges within the UIRW, likely because the focus has been on phosphorus for so many years. It is important to remember that Dr. White's SWAT model simulated hydrology and water quality from 1995 through 2007, and some major changes in the effluent discharges occurred during this time.

Table 4.2. Total phosphorus loads from the Upper Illinois River Drainage Area affected by different effluent phosphorus concentrations and compared to the average annual load (~465,000 lbs $year^{-1}$) from 1995 to 2007.

Effluent Phosphorus Concentrations (mg L^{-1})	Total Phosphorus Loads (lbs per $year^{-1}$)	Average Reductions (% increase↑ or decrease↓)
Average annual load (1995 to 2007)	465,000	
Historic (Average 1995 to 2003)	520,000	12%↑
1.00	353,000	24%↓
0.50	313,000	33%↓
0.25	293,000	37%↓
0.10	282,000	39%↓
0.05	278,000	40%↓

The effects of phosphorus management changes in the major WWTPs was evident, but the effects of the new WWTP effluent discharge at Goose Creek and the elimination of the outfall into Mud Creek were not simulated during this time period.

NONPOINT SOURCES. The remaining 63% of average P load and 73% of the average nitrogen load is loss from the upland sources. The largest source on a percent basis was undoubtedly pasture, because it comprised the largest part of the watershed area (~487 square miles) within the Illinois River drainage area. However, it is important to note that there is very little difference in the yields

What are the average loads from major land uses?

- On average, pasture contributed 242,000 lb of phosphorus, 2,002,000 lb of nitrogen and 50,000,000 lb of sediment to the Illinois River and its tributaries each year from 2000 to 2007;
- On average, urban areas contributed 40,900 lb of phosphorus, 375,000 lb of nitrogen and 11,500,000 lb of sediment to the Illinois River and its tributaries each year from 2000 to 2007; and
- On average, forested areas contributed 1,700 lb of phosphorus, 251,000 lb of nitrogen and 5,000,000 lb of sediment to the Illinois River and its tributaries each year from 2000 to 2007.

River drainage area. However, it is important to note that there is very little difference in the yields of nitrogen, phosphorus and sediments on a unit area basis (e.g., based on lbs acre^{-1}) between urban and pasture land use. So, land conversion from pasture to urban development results in relatively similar nutrient and sediment losses— but land conversion from forest to pasture or to urban development would greatly increase the loss of nutrients and sediments.

Table 4.3 below shows the model simulated yields (i.e., lb acre^{-1}) and annual loads (lbs year^{-1}) from Dr. White's SWAT model for the three major land use categories (e.g., forest, pasture and urban) within the Illinois River drainage area used in the SWAT model. The model simulation provides yields and numbers that are in agreement the range in nitrogen, phosphorus and sediment loss often associated with these land uses across the Ozark Highlands and the U.S.

These simulated yields and loads can be used to estimate some of the effects of urbanization within the UIRW. However, a series of assumptions have to be made regarding urbanization and two important questions are 1) what land use is being converted into urban development? and 2) where is the urban development occurring? It can be assumed that most urban development will occur in the HUC 12s with large percentages of this land use, and that the conversion from pasture or forest to urban development would be proportional to the percentages of these land uses in the watershed. Based on these assumptions, Dr. White's SWAT model estimates a 50% increase in urban development within the Illinois River drainage area would increase nitrogen and phosphorus loads less than 5%. Why so small? Well, the primary conversion would be pasture to low density urban---the yields from these two land uses are similar on a unit area basis (i.e., lbs acre^{-1}). The slight increase in nutrient loads would reflect the conversion of other land cover types to urban development, although these other land covers make up a smaller fraction of what was changed to simulate urbanization.

Table 4.3. Dr. White's SWAT model simulated loss of phosphorus (P), sediment and nitrogen (N) from upland sources within the Illinois River drainage area.

	Pasture		Urban		Forest	
	Yields (lb $acre^{-1}$)	Loads (lb $year^{-1}$)	Yields (lb $acre^{-1}$)	Loads (lb $year^{-1}$)	Yields (lb $acre^{-1}$)	Loads (lb $year^{-1}$)
Total P	0.78	242,000	0.63	40,900	0.01	1,700
Soluble P	0.34	106,000	0.26	16,700	<0.01	840
Sediment	0.20	50,000,000	0.18	11,500,000	0.03	5,000,000
Total N	6.42	2,002,000	5.80	375,000	1.30	251,000
Nitrate-N	5.80	1,808,000	5.35	346,000	1.25	235,000

4.5 Prioritization

Watershed models are historically applied to larger watersheds such as the HUC 8 level (the size of the entire UIRW). While Dr. White's SWAT model provided valuable loading information about the larger watershed, there was limited confidence in the ability of the model to simulate nitrogen, phosphorus and sediment transport from the smaller watershed such as the HUC 12s. So, for the development of this WMP, the prioritization process focused on the best available, current water quality data. The cornerstone of this prioritization process was to clearly define a methodology that would be used to classify the HUC 12s into high, medium and low priorities and to identify solid scientific, statistical and practical reasons for the classification that could be used to defend the defined priorities as needed. In addition, the IRWP decided to base priorities solely on three parameters--total phosphorus, total nitrogen and sediment (i.e., non-forested riparian area) as these are the parameters that the state (i.e., ANRC Nonpoint Source Management Program) uses to set priorities.

Regarding sediment, Ozark streams contain minimal suspended solids ranging less than 10 mg L^{-1} during base flow to 25 mg L^{-1} during storm events, and turbidity is generally less than 10 NTU making a range in prioritization difficult. Most of the sediment load in streams is a result of erosion from the stream channel or flood plain. Therefore, the HUC 12s were prioritized for sediment based on the percentage of stream riparian zone that is not forested based on satellite imagery from 2006.

For nutrients, there are no numeric water quality standards designed to protect designated beneficial uses for the Illinois River and its tributaries, such as aquatic life. A process was selected that utilizes readily available information that reflects watershed alterations (i.e., land use changes) that have occurred to date. It is not reasonable to expect these streams to return to pre-development conditions because the watershed has changed. However, those HUC 12s where the nutrient concentrations are higher than expected could be identified.

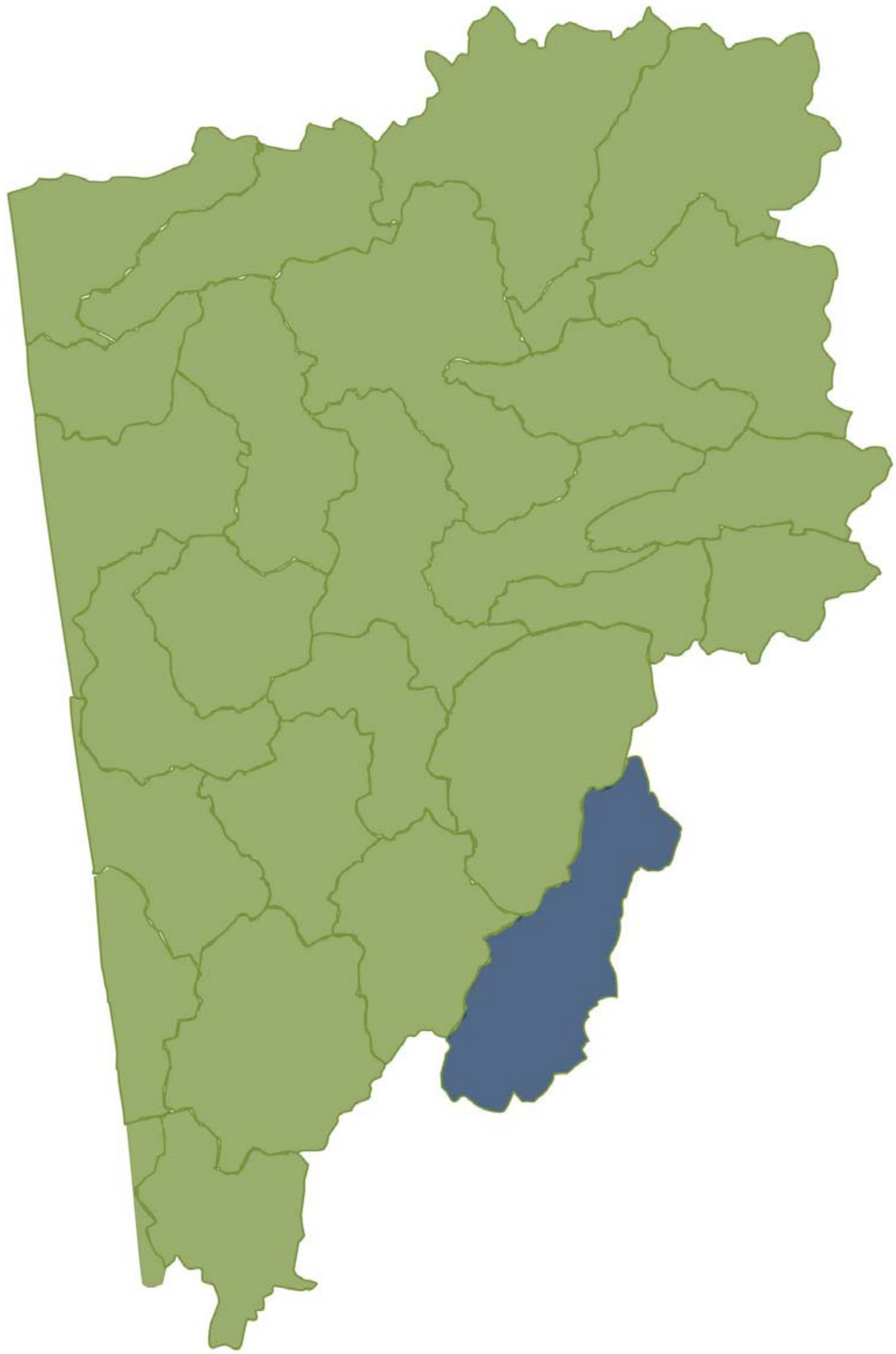


Figure 4.2. The Upper Illinois River Watershed (UIRW) is a HUC 8 level watershed. The UIRW can be subdivided into 27 smaller sub-watersheds or HUC 12s. The Headwaters of the Illinois River HUC 12 is highlighted, and the characteristics of this headwaters HUC 12 vary from the overall characteristics of the larger watershed.

Several studies conducted in northwest Arkansas (e.g., see Giovannetti, 2007; Haggard and others, 2003, 2007) have shown that stream nutrient concentrations are positively related to the percent of pasture and urban development within its watershed; simply, stream nutrient concentrations increase with increasing percent pasture and urban areas upstream. These studies show that the increase in nutrient concentrations along a land-use gradient (e.g., low to high pasture and urban development) may be represented by a straight line (or, simple linear regression in statistical terms). As stream constituent concentrations are a function of land use this relationship could be used to define priorities. Figure 4.2 illustrates hypothetical constituent concentrations in streams along a land use gradient to demonstrate the technique used to define the HUC 12 prioritization.

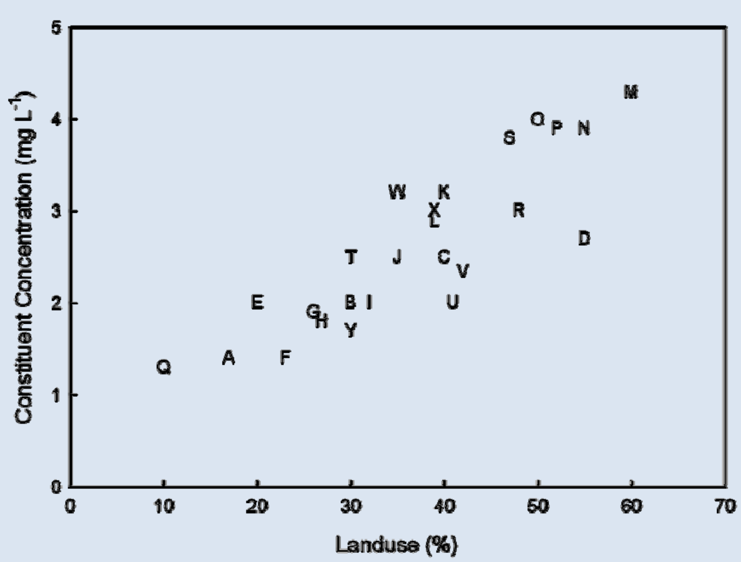


Figure 4.2. Hypothetical relationship between constituent concentration and land use percentage. In this example, constituent concentration increases as a function of increased land use percentage.

For nutrient concentrations, the situation was complicated but the prioritization approach as outlined was successfully used. The data used to calculate the regressions between stream nutrient concentrations and the percent pasture plus urban land use included the data available from the HUC 12 monitoring program during 2009 and the data from the Illinois River Watershed Partnership (IRWP) Volunteer Monitoring Program (VMP). Merging these two databases to establish the linear relationship between concentration and land use provided a large number of sites, and it was determined that each HUC 12 should be represented by a single value in the regression. The geomean of the concentration data was selected, because this value is not strongly influenced by low or high values like the arithmetic mean, or average. The geomean is also a good estimate of the central tendency or middle of concentration data, because concentrations are bounded by zero on the low end and therefore likely display a skewed set of numbers often represented statistically by a logarithmic distribution.

For total phosphorus (TP) concentrations, the regression between geomean concentrations and land use was statistically significant showing that concentrations generally increased with pasture and urban development in HUC 12. Figure 4.4 illustrates the data points and the linear relationship, where the numbers on the graph correspond to the site numbers in the HUC 12 monitoring program. This relationship was used to prioritize the HUC 12s into high, medium and low categories. Nine HUC 12s were identified as high priorities for total phosphorus using this approach.

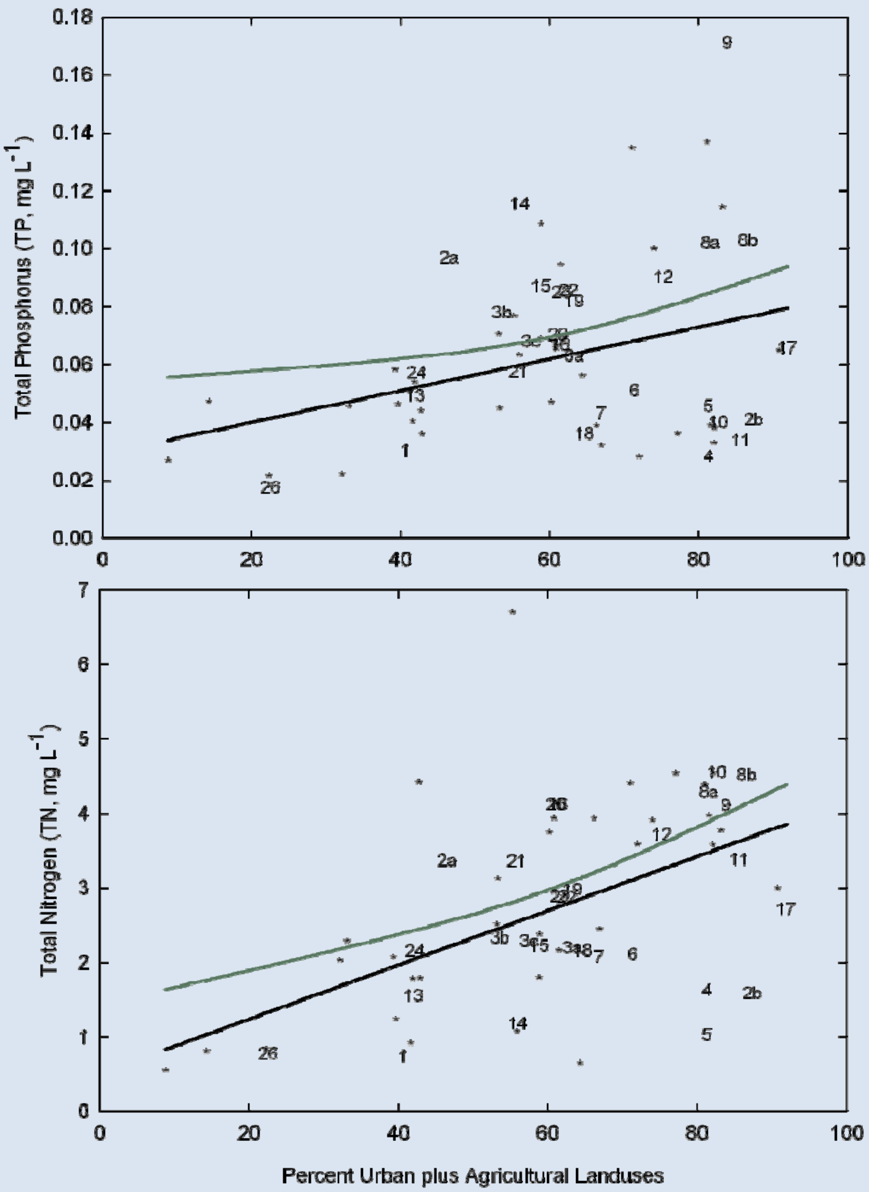


Figure 4.3. Total phosphorus (TP) concentration (i.e., site geomeans) as a function of pasture and urban land use. This was the method used to identify high, medium and low priorities for total phosphorus (TP_ throughout the UIRW. Asterisks represent data collected from sites established through a volunteer monitoring program (i.e., Illinois River Volunteer Monitoring, July 2008-June 2009, awarded to Illinois River Watershed Partnership by Arkansas Natural Resources Commission.

The relationship between stream nitrogen concentrations and percent pasture plus urban development within the watershed was stronger than that observed with phosphorus concentrations. This difference would be anticipated because nitrate is generally a large part of the total nitrogen in streams, and this anion is highly mobile through various flow paths (e.g., ground-water inflows and surface runoff). The aforementioned regional studies have also observed that the relation between nitrogen in streams and its watershed land use is stronger than that observed for phosphorus.

For total nitrogen (TN) concentrations, the regression between geomean concentrations and land use was statistically significant showing that concentrations increase with an increase in the percent of agricultural and urban development within the watershed (Figure 4.3). This regression was used to prioritize the HUC 12s into high, medium and low categories.

Overall, this prioritization approach worked well for all constituents and highlights those sites with elevated nutrient concentrations relative to what the typical geomean concentration would be for sites with a given amount of pasture plus urban land use. This technique used to prioritize the HUC 12s within the UIRW is unique and innovative but technically sound (scientifically defensible), and based on real-world monitoring in addition to model simulations estimates.

Water Quality Improvement & Protection Goals 5

5.1 Objectives

The objective of this watershed management plan is to provide a strategy to address nonpoint source pollution within the UIRW thereby improving water quality throughout the basin so that all waterbodies meet their designated uses as well as the water quality standards of the State of Arkansas as designated in Regulation No. 2.

5.2 Specific Goals

The goals for the UIRW are to improve water quality through measured reductions in these three standards: 1) to remove all streams from the 303(d) list; 2) to prevent streams from being listed on the 303(d) list in the future; and 3) to reduce total phosphorus concentrations at the watershed outlet (i.e., Arkansas-Oklahoma state border) with a target reduction of 40% during base flow conditions. These goals are achievable through the implementation of best management practices (BMPs) and restoration activities throughout the watershed.

5.3 Reductions to Achieve Goals

A critical component of any watershed management plan is the spatial scale at which the watershed should be managed. Watershed management is more complex at large spatial scales, such as the 8 digit HUC (11110103) representing the UIRW. Thus, because of the UIRW's size, heterogeneity of land uses and diversity of contributing sources, the creation of management strategies for the UIRW in its entirety might be more challenging. Furthermore, the ability to detect subtle improvements in water quality over short periods of time that result from the implementation of management strategies at the HUC 8 scale are limited—the effects of changing weather, episodic rainfall and upstream sources of pollution may mask water quality improvement at large scales. The UIRW can be sub-divided into smaller 12 digit hydrologic units often called HUC 12s as illustrated in Figure 5.1, and it is at this spatial scale that implementation is targeted with specific strategies within a smaller geographic unit and where the ability to monitor water quality change is greatest.

To achieve the specific goals outlined in Section 5.2, water quality parameters and riparian zones should be addressed to meet the water quality and riparian density targets in each HUC. Achieving the reductions listed will restore the HUC to the average condition of the HUC given its land use and allow all stream reaches to meet designated uses and primary contact standards. The priority level (i.e., high, medium or low) for restoration needs based on current water quality conditions are depicted in Figure 5.1. As a separate project, ANRC prioritized the HUC 12s based on a SWAT model; these priorities are provided in figure 5.2. The targeted parameter reductions are provided for each HUC 12 in Table 5.1.

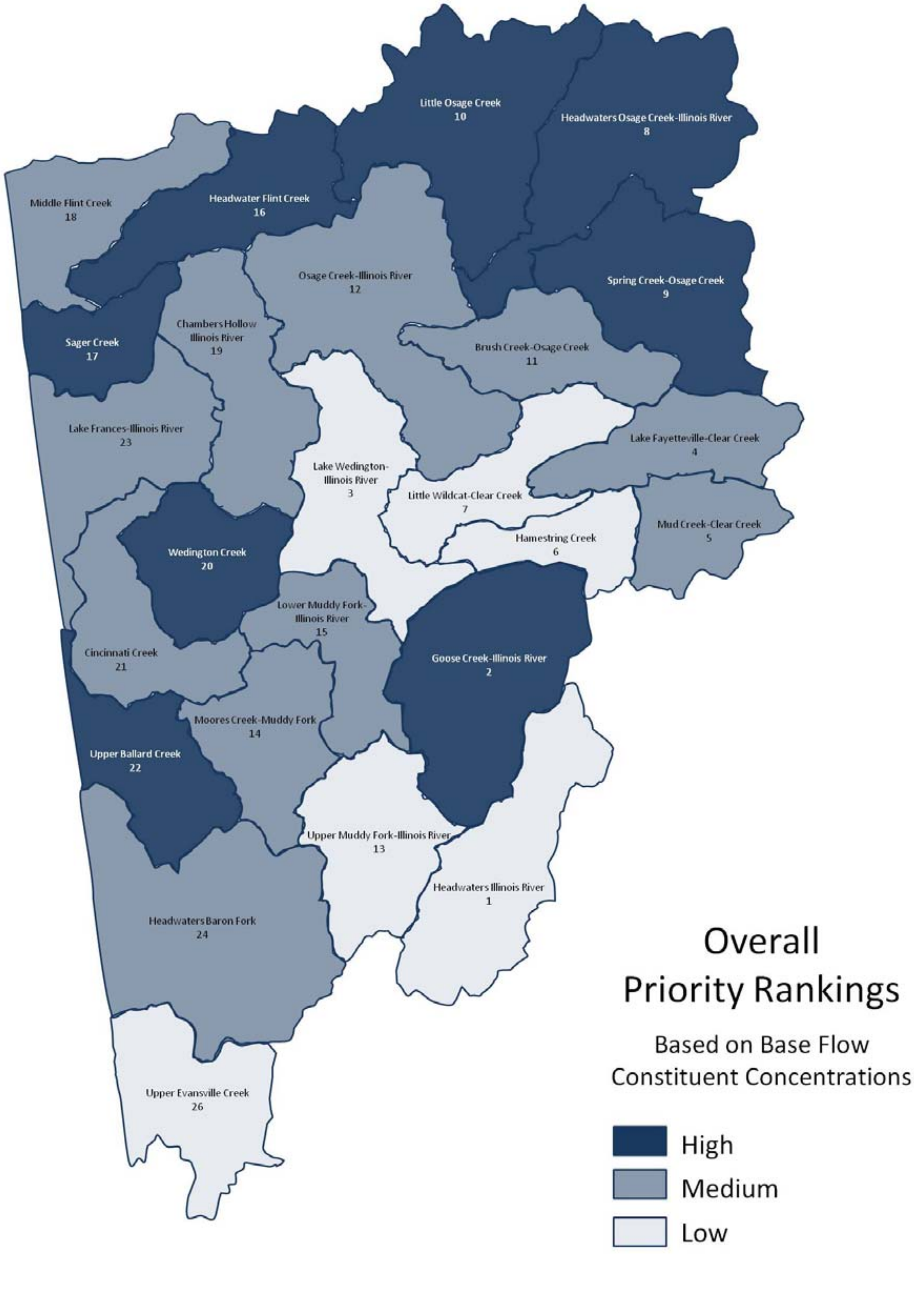


Figure 5.1. Map of the overall HUC 12 priority rankings for the Upper Illinois River Watershed, northwest Arkansas. The overall priorities were established by summing the priorities for total nitrogen, total phosphorus, and sediment (i.e., non-forested riparian areas).

At the request of ANRC, a map of the high priority areas within the Illinois River drainage area was included in this watershed management plan (Figure 5.2). These priority areas were defined using a different SWAT model than that discussed earlier from Dr. White. This was a separate project funded by ANRC, and similar projects should be completed in the other HUC 8 priority watersheds within the state. The following is the reference for this report:

> Saraswat, D., M. Daniels, P. Tacker, and N. Pai. 2009. A comprehensive watershed response modeling for 12-digit hydrologic unit code "HUC" in selected priority watersheds in Arkansas, REPORT: Illinois River Watershed (IRW), Arkansas Natural Resources Commission Grant No. C999610316-30, Project No. 08-300, 75 pp.

The IRWP recommends focusing efforts to implement BMPs in the HUC 12s where there is overlap between ANRC's SWAT model output and the best available data from the watershed. However, ANRC's priorities based upon SWAT modeling should be considered dynamic and will likely change as model revisions, updates and all available input data are included. This model has already been revised and another final report will be distributed to ANRC, and the priorities likely have changed and will need to be updated.

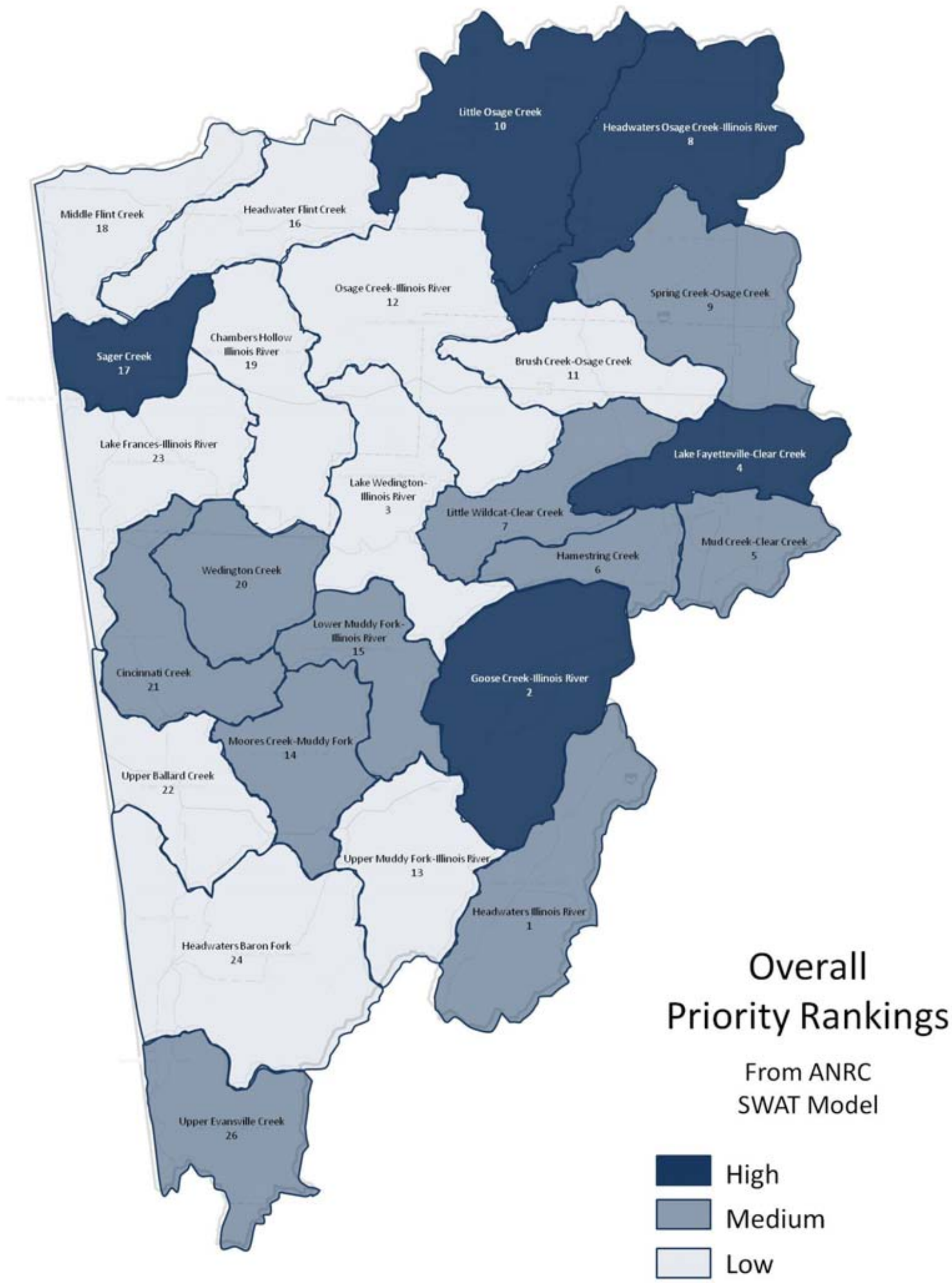


Figure 5.2. Map of the priority areas within the Illinois River drainage area from Arkansas Natural Resources Commission.

Table 5.1. Summary of overall, sediment, phosphorus, and nitrogen priorities for each HUC 12 in the UIRW.

HUC No.	HUC Name	Overall Priority	Sediment Priority	Phosphorus Priority	Nitrogen Priority
2	Goose Creek- Illinois River	High	High	High	High
8	Headwaters Osage Creek- Illinois River	High	High	High	High
9	Spring Creek- Osage Creek	High	High	High	High
10	Little Osage Creek	High	High	Low	High
16	Headwaters Flint Creek	High	Medium	Medium	High
17	Sager Creek	High[1]	High	Low[1]	Low[1]
20	Wedington Creek	High	Medium	Medium	High
22	Upper Ballard Creek	High	Medium	High	Medium
4	Lake Fayetteville- Clear Creek	Medium	High	Low	Low
5	Mud Creek- Clear Creek	Medium	High	Low	Low
11	Brush Creek- Osage Creek	Medium	High	Low	Low
12	Osage Creek- Illinois River	Medium[2]	Medium	High[2]	High[2]
14	Moores Creek- Muddy Fork	Medium	Medium	High	Low
15	Lower Muddy Fork-Illinois River	Medium	Medium	High	Low
18	Middle Flint Creek	Medium	High	Low	Low
19	Chambers Hollow- Illinois River	Medium	Low	High	Medium
21	Cincinnati Creek	Medium	Low	Low	High
23	Lake Frances- Illinois River	Medium	Low	High	Medium
24	Headwaters Baron Fork	Medium	Low	Medium	Medium
1	Headwaters Illinois River	Low	Low	Low	Low
3	Lake Wedington- Illinois River	Low	Low	Low	Low
6	Hamestring Creek	Low	Medium	Low	Low
7	Little Wildcat-Clear Creek	Low	Low	Low	Low
13	Upper Muddy Fork-Illinois River	Low	Medium	Low	Low
26	Upper Evansville Creek	Low	Low	Low	Low

[1]The site sampled in this HUC was upstream of the influence of the WWTP.
[2]The elevated nutrients in this HUC should be address by improvements in upstream HUCs.

Table 5.2. Baseline condition, target percent reduction and current (i.e., 2006) land use in each HUC 12 in the Upper Illinois River Watershed. Land use legend—green: forest; yellow: pasture; pink: low density urban; red: high density urban; blue: water. Baseline condition for total P and total N is average baseflow concentration.

HEADWATERS ILLINOIS RIVER | HUC NO. 1 (111101030101) | LOW PRIORITY

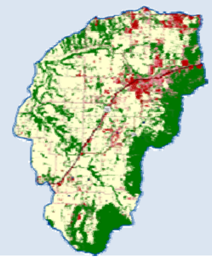
Headwater Illinois River HUC is not influenced by any other HUC in the UIRW.

Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.030	--
Total Nitrogen (mg L^{-1})	0.74	--
Non-Forested Riparian Area (%)	34%	9%

GOOSE CREEK-ILLINOIS RIVER |HUC NO. 2 (111101030102) | HIGH PRIORITY

Goose Creek HUC lies downstream of the headwaters of the Illinois River HUC.

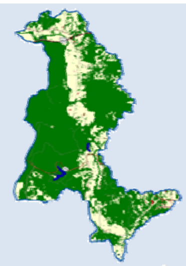
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.097	46%
Total Nitrogen (mg L^{-1})	3.37	34%
Non-Forested Riparian Area (%)	60%	35%



LAKE WEDINGTON-ILLINOIS RIVER | HUC NO. 3 (111101030103) | LOW PRIORITY

Lake Wedington-Illinois River HUC lies downstream of and is influenced by 10 other HUCs in the UIRW.

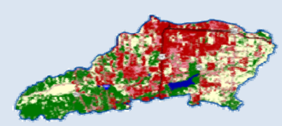
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.063	4%
Total Nitrogen (mg L^{-1})	2.20	--
Non-Forested Riparian Area (%)	27%	2%



LAKE FAYETTEVILLE-CLEAR CREEK | HUC NO. 4 (111101030201) | MEDIUM PRIORITY

Lake Fayetteville-Clear Creek HUC lies downstream of and is influenced by Mud Creek-Clear Creek HUC.

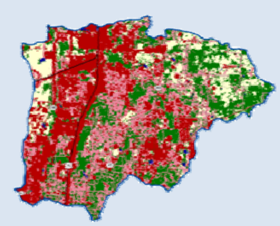
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.028	--
Total Nitrogen (mg L^{-1})	1.63	--
Non-Forested Riparian Area (%)	66%	41%



MUD CREEK-CLEAR CREEK | HUC NO. 5 (111101030202) | MEDIUM PRIORITY

Mud Creek-Clear Creek HUC is a headwaters HUC and is not influenced by any other HUCS in the UIRW.

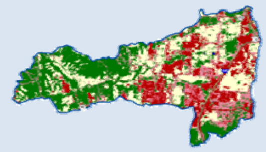
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.046	--
Total Nitrogen (mg L^{-1})	1.03	--
Non-Forested Riparian Area (%)	66%	41%



HAMESTRING CREEK | HUC NO. 6 (111101030203) | LOW PRIORITY

Hamestring Creek HUC is a headwaters HUC and is not influenced by any other HUC in theUIRW.

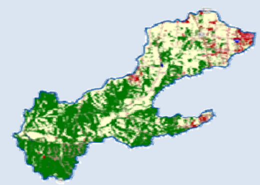
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.051	--
Total Nitrogen (mg L^{-1})	2.11	--
Non-Forested Riparian Area (%)	57%	32%



LITTLE WILDCAT-CLEAR CREEK | HUC NO. 7 (111101030204) | LOW PRIORITY

Little Wild Cat-Clear Creek lies down stream of and is influenced by three other HUCs in theUIRW.

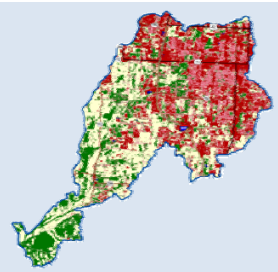
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.043	--
Total Nitrogen (mg L^{-1})	2.07	--
Non-Forested Riparian Area (%)	42%	17%



HEADWATERS OSAGE CREEK-ILLINOIS RIVER | HUC NO. 8 (111101030301) | HIGH PRIORITY

Headwaters Osage Creek is not influenced by other HUCs in the UIRW.

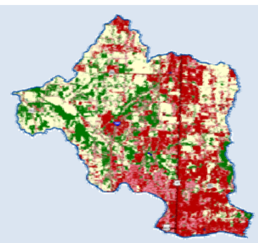
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.102	31%
Total Nitrogen (mg L^{-1})	4.29	18%
Non-Forested Riparian Area (%)	75%	50%



SPRING CREEK-OSAGE CREEK | HUC NO. 9 (111101030302) | HIGH PRIORITY

Spring Creek is a headwaters HUC and is not influenced by other HUCs in the UIRW.

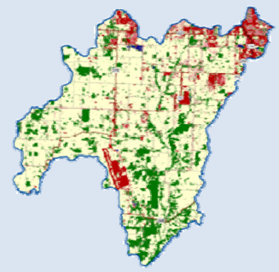
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.171	58%
Total Nitrogen (mg L^{-1})	4.11	13%
Non-Forested Riparian Area (%)	73%	48%



LITTLE OSAGE CREEK-ILLINOIS RIVER | HUC NO. 10 (111101030303) | HIGH PRIORITY

Little Osage Creek is a headwaters HUC and is not influenced by other HUCs in the UIRW.

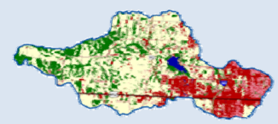
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.040	--
Total Nitrogen (mg L^{-1})	4.56	22%
Non-Forested Riparian Area (%)	73%	48%



BRUSH CREEK-OSAGE CREEK | HUC NO. 11 (111101030304) | MEDIUM PRIORITY

Brush Creek-Osage Creek HUC is a headwaters HUC and is not influenced by other HUCs in the UIRW.

Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.034	--
Total Nitrogen (mg L^{-1})	3.38	--
Non-Forested Riparian Area (%)	72%	47%



OSAGE CREEK-ILLINOIS RIVER | HUC NO. 12 (111101030305) | MEDIUM PRIORITY

Osage Creek-Illinois River HUC lies downstream of and is influenced by five other HUCs in the UIRW.

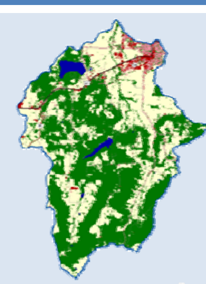
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.090	26%*
Total Nitrogen (mg L^{-1})	3.73	12%*
Non-Forested Riparian Area (%)	50%	25%*

*These target reductions should be met by reductions in upstream HUCs

UPPER MUDDY FORK-ILLINOIS RIVER | HUC NO. 13 (111101030401) | LOW PRIORITY

Upper Muddy Fork-Illinois River HUC is a headwaters HUC and is not influenced by other HUCs in the UIRW.

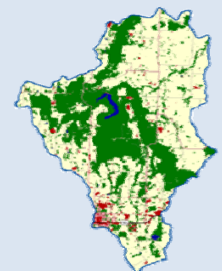
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.049	--
Total Nitrogen (mg L^{-1})	1.55	--
Non-Forested Riparian Area (%)	47%	22%



MOORES CREEK-MUDDY FORK | HUC NO. 14 (111101030402) | MEDIUM PRIORITY

Moores Creek-Muddy Fork HUC lies downstream of and is influenced by Goose Creek-Illinois River HUC.

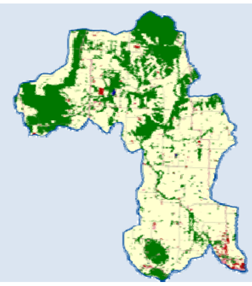
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.115	51%
Total Nitrogen (mg L^{-1})	1.18	--
Non-Forested Riparian Area (%)	55%	30%



LOWER MUDDY FORK-ILLINOIS RIVER | HUC NO. 15 (111101030403) | MEDIUM PRIORITY

Lower Muddy Fork-Illinois River HUC lies downstream of and is influenced by Upper Muddy Fork and Moores Creek HUCs.

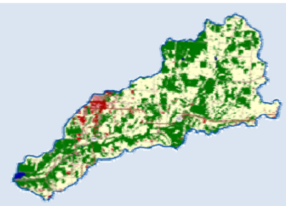
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.087	33%
Total Nitrogen (mg L^{-1})	2.22	--
Non-Forested Riparian Area (%)	59%	34%



HEADWATERS FLINT CREEK | HUC NO. 16 (111101030501) | HIGH PRIORITY

Headwaters of Flint Creek HUC is not influenced by other HUCs in the UIRW.

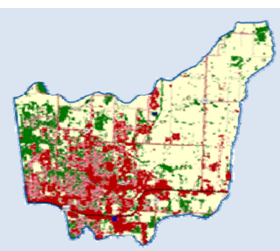
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.068	12%
Total Nitrogen (mg L^{-1})	4.13	33%
Non-Forested Riparian Area (%)	54%	29%



SAGER CREEK | HUC NO. 17 (111101030502) | HIGH PRIORITY

Sager Creek HUC is a headwaters HUC and is not influenced by other HUCs in the UIRW.

Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.066	Unknown*
Total Nitrogen (mg L^{-1})	2.72	Unknown*
Non-Forested Riparian Area (%)	75%	50%

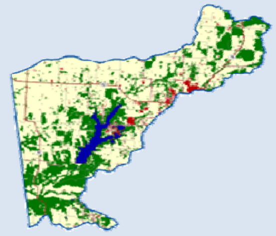


* % reductions need to be defined after the WWTP upgrades.

MIDDLE FLINT CREEK | HUC NO. 18 (111101030503)| MEDIUM PRIORITY

Middle Flint Creek HUC lies downstream of and is influenced by Headwater of Flint Creek HUC.

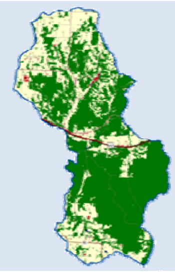
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.036	--
Total Nitrogen (mg L^{-1})	2.17	--
Non-Forested Riparian Area (%)	62%	37%



CHAMBERS HOLLOW-ILLINOIS RIVER | HUC NO. 19 (111101030601) | MEDIUM PRIORITY

Chambers Hollow-Illinois River HUC lies downstream of and is influenced by 16 other HUCs in the UIRW.

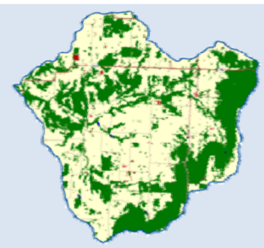
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.082	27%
Total Nitrogen (mg L^{-1})	2.97	4%
Non-Forested Riparian Area (%)	30%	5%



WEDINGTON CREEK | HUC NO. 20 (111101030602)| HIGH PRIORITY

Osage Creek-Illinois River HUC lies downstream of and is influenced by five other HUCs in the UIRW.

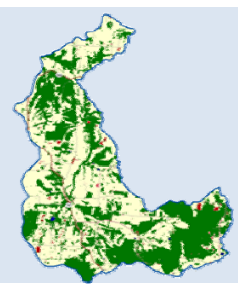
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.070	19%
Total Nitrogen (mg L^{-1})	4.12	33%
Non-Forested Riparian Area (%)	51%	26%



CINCINNATI CREEK | HUC NO. 21 (111101030603) | MEDIUM PRIORITY

Cincinnati Creek HUC is a headwaters HUC and is not influenced by other HUCs in the UIRW.

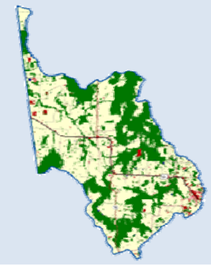
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.057	--
Total Nitrogen (mg L^{-1})	3.36	24%
Non-Forested Riparian Area (%)	44%	19%



UPPER BALLARD CREEK | HUC NO. 22 (111101030604) | HIGH PRIORITY

Upper Ballard Creek is a headwaters HUC and is not influenced by other HUCs in the UIRW.

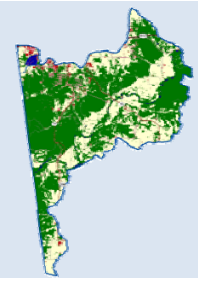
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.086	30%
Total Nitrogen (mg L^{-1})	2.88	2%
Non-Forested Riparian Area (%)	49%	24%



LAKE FRANCES-ILLINOIS RIVER | HUC NO. 23 (111101030606) | MEDIUM PRIORITY

Lake Frances-Illinois River HUC is the outlet of the UIRW and lies downstream of 19 other HUCS.

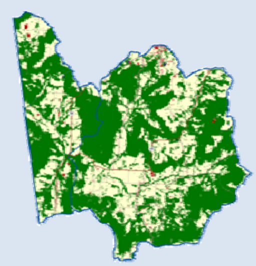
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.085	41%
Total Nitrogen (mg L^{-1})	2.89	4%
Non-Forested Riparian Area (%)	28%	3%



HEADWATERS BARON FORK | HUC NO. 24 (111101030701)| MEDIUM PRIORITY

Headwaters Baron Fork HUC is not influenced by other HUCs in the UIRW.

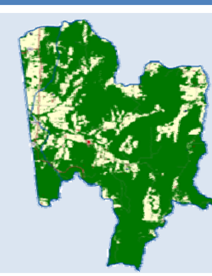
Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.057	29%
Total Nitrogen (mg L^{-1})	2.15	4%
Non-Forested Riparian Area (%)	39%	14%



UPPER EVANSVILLE CREEK | HUC NO. 26 (111101030703)| LOW PRIORITY

Upper Evansville Creek is a headwaters HUC and is not influenced by any other HUC in the UIRW.

Constituent	Baseline Condition	Target % Reduction
Total Phosphorus (mg L^{-1})	0.018	--
Total Nitrogen (mg L^{-1})	0.77	--
Non-Forested Riparian Area (%)	20%	--



Management Activities 6

Watershed management actions targeted for the UIRW fall within five general areas:

1. Development of watershed interest groups,
2. Pasture Management,
3. Forest Management,
4. Unpaved Road Management
5. Lake Frances Management, and
6. Urban Management.

Development of watershed interest groups should be discussed in the Education and Outreach section. The remaining management actions are discussed briefly below. Extensive descriptions the recommended actions, as well as additional best management practices, are provided in the *Handbook of Best Management Practices for the Upper Illinois River Watershed and Other Regional Watersheds.*

6.1 Pasture Management

Pasture is the most prevalent land use in the watershed, and was identified by both the monitoring data and the Dr. White's SWAT model as a significant source of nutrients and sediment. Target BMPs for pastures include but are not limited to:

- Vegetative filter strips (NRCS Code 393)
- Riparian buffers (NRCS Code 390 & 391)
- Stream bank fencing (NRCS Code 382)
- Alternate water source (NRCS Code 614)
- Farm ponds (NRCS Code 378)
- Use of legumes (NRCS Code 512)
- Waste transfer and utilization (NRCS Code 634 &633)

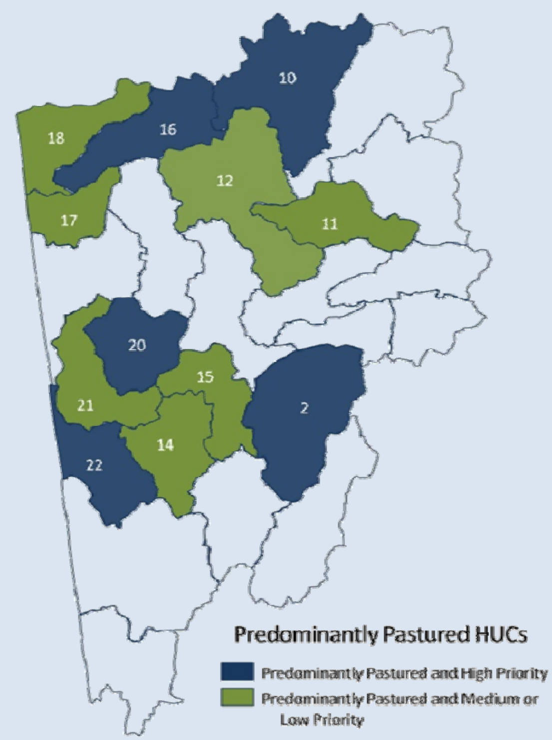


Figure 6.1. Subwatersheds in the Upper Illinois River Watershed where pasture is the predominant land use.

Table 6.1 identifies the 12-digit HUCs where pasture management activities are a priority, and the acres or miles over which a practice needs to be installed. These activities are described in greater detail below.

Table 6.1. Recommended pasture best management practices and the estimated area of which the practices should be established in each HUC 12 of the Upper Illinois River Watershed.

HUC No.	HUC 12 Name	Overall Priority	Filter Strips (acres)	Riparian Buffers (acres)	Alternative Water Source (mi^2)	Farm Ponds (mi^2)	Legumes (mi^2)	Waste Transfer (mi^2)
2	Goose Creek – Illinois River	High	66	663	11	11	23	23
8	Headwaters Osage Creek – Illinois River	High	45	450	6	6	12	12
9	Spring Creek – Osage Creek	High	111	1,108	15	15	30	30
10	Little Osage Creek – Illinois River	High	43	429	6	6	11	11
16	Headwaters Flint Creek	High	51	512	7	7	14	14
17	Sager Creek	High	16	162	4	4	8	8
20	Wedington Creek	High	44	439	7	7	13	13
22	Upper Ballard Creek	High	30	301	7	7	13	13
4	Lake Fayetteville—Clear Creek	Medium	5	52	1	1	2	2
5	Mud Creek—Clear Creek	Medium	16	158	2	2	4	4
11	Brush Creek – Osage Creek	Medium	115	1,150	13	13	26	26
12	Osage Creek – Illinois River	Medium	30	300	5	5	11	11
14	Moores Creek – Muddy Fork	Medium	41	414	7	7	13	13
15	Lower Muddy Fork – Illinois River	Medium	43	425	7	7	13	13
18	Middle Flint Creek	Medium	39	392	7	7	15	15
19	Chambers Hollow – Illinois River	Medium	34	335	5	5	10	10
21	Cincinnati Creek	Medium	40	402	6	6	13	13
23	Lake Frances – Illinois River	Medium	34	341	5	5	10	10
24	Headwaters Baron Fork	Medium	71	709	11	11	21	21
1	Headwaters Illinois River	Low	37	368	5	5	10	10
3	Lake Wedington – Illinois River	Low	39	386	4	4	8	8
6	Hamestring Creek	Low	38	377	5	5	9	9
7	Little Wildcat – Clear Creek	Low	64	644	7	7	15	15
13	Upper Muddy Fork—Illinois River	Low	24	238	3	3	6	6
26	Upper Evansville Creek	Low	21	210	3	3	6	6

6.1.1 VEGETATIVE FILTER STRIPS

A vegetated filter strip is a strip or area of herbaceous vegetation that removes contaminants from overland flow. They are planted perpendicular to overland flow to intercept it. The NRCS specifies that filter strips have minimum flow lengths (i.e. width) of 20 ft to 30 ft. Filter strips reduce sediment, nutrients, and bacteria in runoff when they are placed between pastureland and environmentally sensitive areas.

6.1.2 RIPARIAN BUFFERS

Riparian buffers are areas of permanent vegetation (predominantly trees and/or shrubs) adjacent to and up-gradient from water bodies. The NRCS specifies that riparian buffers should extend a minimum of 35 ft from the waterbody, but 100 ft is recommended. Riparian buffers reduce pollutants in runoff such as nutrients, sediment, and bacteria; provide stream bank protection and stabilization from erosion; increase wildlife and aquatic wildlife habitat; and lower stream temperatures.

6.1.3 STREAM BANK FENCING AND ALTERNATE WATER SOURCES

The condition of stream banks in the IRWP is of utmost importance for maintaining or improving water quality standards in the future. Numerous studies have shown that grazing livestock can damage stream banks in the process of grazing and seeking access to water and shade. Besides the trampling of stream-bank vegetation resulting in sediment loss and stream-bank erosion, water quality is impaired and farm nutrients can be lost through the deposition of manure and nutrients directly in streams instead of pastures.

To eliminate these ill effects, streams associated with pastures can be fenced off to prevent access by cattle. Excluding cattle from pasture streams can reduce nutrient, bacteria, and sediment loads to streams. When producers have relied on cattle access to streams or ponds to provide water to livestock, alternate water sources for the cattle will need to be provided. Establishment of alternative water sources requires some financial investments, but improved cattle health, farm sustainability, farm profits, and reduced environmental impacts can often justify those costs.

6.1.4 FARM PONDS

Farm ponds can be created by building a dam or excavating a pit. Farm ponds provide erosion control, nutrient containment, and a drinking water source that can complement a controlled livestock grazing system. Installation of farm ponds can reduce nutrient, sediment, and bacteria loads.

6.1.5 USE OF LEGUMES

Legumes incorporated in pastures can provide nitrogen that is fixed from the atmosphere. Seeding clover or other legumes into pastures provides ground cover, reduces the need for nitrogen fertilization in pastures and increases forage quality. This can result in reduced nutrient, sediment, and bacteria loads.

6.1.6 WASTE TRANSFER

Waste transfer or litter export is the process of transporting manure and poultry litter out of the nutrient surplus areas in the UIRW to be used as a soil amendment in nutrient limited watersheds (e.g., watersheds in Oklahoma). This practice can result in reduced nutrient and bacteria loads in the UIRW. The P-index should be used to determine how much waste should be exported.

6.2 Forest Management

Properly managed forests are a cornerstone of clean water and many other ecosystem services within a watershed. It is important to maintain and manage existing forests on private and public lands, especially in riparian areas, which serve as a filter to reduce nutrient and sediment delivery to the Illinois River and its tributaries. While commercial timber production is minimal in the UIRW, landowners that manage and market natural hardwood timberstands should follow forest BMPs developed by the Arkansas Forestry Commission (AFC). Target forest management practices in the UIRW include, but are not limited to:

1. Conservation of Existing Forests
2. Streamside Management Zones
3. Harvest BMPs

These management practices can control or reduce sediment loads to forest streams. Table 6.2 identifies the 12-digit HUCs where forest management activities are a priority and the miles or acres over which the practice should be implemented. The management activities are described in greater detail below.

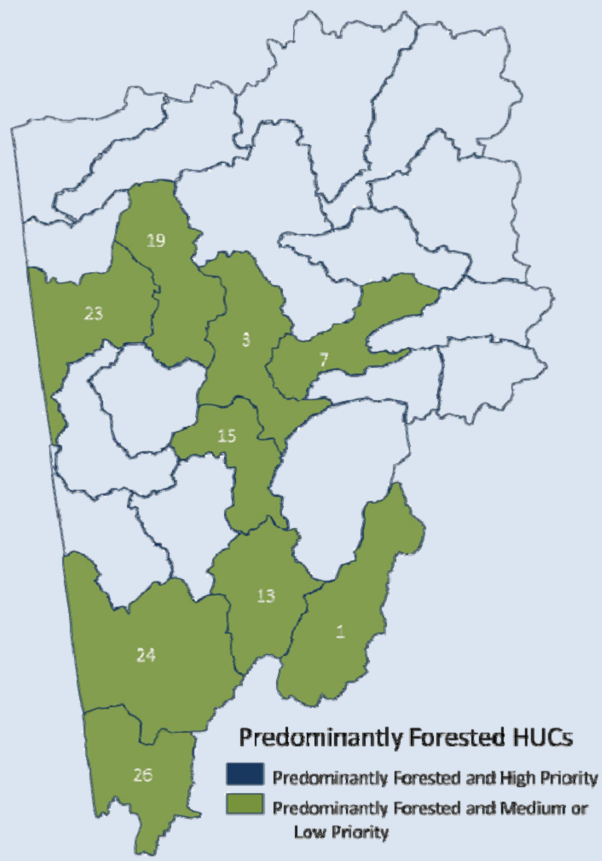


Figure 6.2. Subwatersheds in the Upper Illinois River Watershed where forest is the predominant land use.

Table 6.2. Recommended best management practices for forested areas in the Upper Illinois River Watershed and the estimated area over which the practices should be established; this is not specific to managed forests.

HUC No.	HUC 12 Name	Overall Priority	Forest Conservation (mi^2)	Streamside Management Zones (acres)	Harvest BMPs
2	Goose Creek – Illinois River	High	13	713	Minimal
8	Headwaters Osage Creek – Illinois River	High	6	440	Minimal
9	Spring Creek – Osage Creek	High	8	635	Minimal
10	Little Osage Creek – Illinois River	High	4	319	Minimal
16	Headwaters Flint Creek	High	11	654	Minimal
17	Sager Creek	High	2	121	Minimal
20	Wedington Creek	High	9	578	Minimal
22	Upper Ballard Creek	High	9	447	Minimal
4	Lake Fayetteville—Clear Creek	Medium	3	233	Minimal
5	Mud Creek—Clear Creek	Medium	5	292	Minimal
11	Brush Creek – Osage Creek	Medium	23	1,584	Minimal
12	Osage Creek – Illinois River	Medium	14	524	Minimal
14	Moores Creek – Muddy Fork	Medium	9	479	Minimal
15	Lower Muddy Fork – Illinois River	Medium	6	416	Minimal
18	Middle Flint Creek	Medium	7	361	Minimal
19	Chambers Hollow – Illinois River	Medium	19	1,162	Minimal
21	Cincinnati Creek	Medium	11	729	Minimal
23	Lake Frances – Illinois River	Medium	17	1,400	Minimal
24	Headwaters Baron Fork	Medium	33	1,694	Minimal
1	Headwaters Illinois River	Low	25	1,075	Minimal
3	Lake Wedington – Illinois River	Low	22	1,500	Minimal
6	Hamestring Creek	Low	10	803	Minimal
7	Little Wildcat – Clear Creek	Low	8	538	Minimal
13	Upper Muddy Fork—Illinois River	Low	6	313	Minimal
26	Upper Evansville Creek	Low	21	933	Minimal

6.2.2 EXISTING FOREST CONSERVATION PROGRAM

Research shows that forests are linked to water yield and water quality in the following ways:

- Riparian forest buffers can filter nutrients and sediment in runoff from upslope land uses.
- Forest canopies shade streams and intercept rainfall, protecting the soil from erosion and reducing runoff volumes and velocities
- Forest root systems increase water infiltration into the soil, groundwater recharge, and soil stabilization.

Existing forests should be maintained and conserved to protect water quality in the watershed as well as provide industrial, ecological and recreational services including timber production, wildlife, recreation, and aesthetic value.

6.2.1 STREAMSIDE MANAGEMENT ZONES.

Streamside vegetation and soils act as buffer zones and have a strong influence on the health of adjacent aquatic systems. Streamside management zones protect water quality by providing bank stability and acting as a filter.

- **Ephemeral Streams:** Ephemeral streams have a defined channel but no banks. Water only flows during or immediately after rain. Streamside management zones are not required for these streams.
- **Non-Ephemeral Streams:** Non-ephemeral streams have a defined channel and often have banks. Water flows all or most of the year, though some may stop flowing during hot, dry seasons. Stream side management zones are recommended for these streams. AFC guidelines can be found at http://www.forestry.state.ar.us/bmp/smz.html and discuss:

  - **Management zone widths:** Variable by bank slope (35-80 feet on each side of stream)
  - **Tree management:** Planting and removal tips
  - **Discouraged Activities:** Some management practices (i.e., harvesting trees growing directly on the bank or overhanging a water body) can be harmful to water quality when implemented on land directly adjacent to a waterbody (i.e., the streamside management zone).

6.2.3 REGENERATION HARVEST METHODS AND BEST MANGEMENT PRACTICES

Timber harvesting methods should be conducted to achieve specific goals that maintain sustainability and minimize the effects on soil and water resources. They should always be designed to successfully regenerate a new stand. Several regeneration harvest methods may be implemented for hardwood forests within the UIRW, which fall into two categories:

Even-Aged Management means that the majority of trees in a forest stand are within a few years of being the same age. Even-aged management is typically the method of choice for desirable tree species (i.e., pine, oak, and ash), because they are usually intolerant of shade. There are several types of harvests that produce an even-aged stand including clearcutting and shelterwood harvesting.

Uneven-Aged Management involves maintaining a wide range of tree ages within a stand. This type of management is desirable when protecting water quality. However, due to a shading effect created by a significant presence of overstory trees, uneven-aged management can be difficult when attempting to regeneration tree species that are intolerant of shade. Two methods of uneven-aged management include single tree selection and group selection.

In addition to considering what and where trees should be harvested, harvesting BMPs include layout and construction of access roads, skid trails for transporting logs, and strategic planning of landing locations.

The AFC provides BMP guidelines that should be conducted to minimize the effects on soil and water at www.forestry.state.ar.us/bmp/harvesting.html, and the guidelines discuss:

- **Design of Harvest Sites**: Overall design of the harvest site including harvest size, skid trails and landing location.
- **Log Landings:** Areas of concentrated equipment use and site traffic during harvesting.
- **Felling and Bucking**: Cutting trees down and cutting them into useable lengths.
- **Skidding:** Removing trees, logs, and other materials from the felling location.
- **Weather Conditions:** Logging should be avoided in excessively wet areas or during excessively wet weather.
- **Harvest Site Closeout:** On-site examination of harvest area to ensure proper implementation of BMPs.

6.3 Unpaved Road Management

The UIRW contains about 2,997 miles of roads and highways, of which approximately 1,295 miles (43%) are unpaved. About 80% of these unpaved roads (1,036 miles) occur in the rural portion of the watershed (i.e., outside city limits; analysis completed using AHTD All Roads 2006, AHTD City Boundaries 2005, and EPA HUC 08). These unpaved roads play an important role in the UIRW by supporting economic activities including farming and ranching, poultry production, timber, recreation, and commuting. However, unpaved roads can also contribute to water quality degradation in the watershed. Concerns about water quality, connectivity of roads to streams, sensitive species and wildlife, land use, and watershed and ecosystem health may influence the way that unpaved roads are viewed and managed. A variety of structural and non-structural BMPs can be implemented to improve and maintain existing unpaved roads and construct new unpaved roads:

- Identify and deal with off-right-of-way issues
- Road bank management
- Road-side ditch management
- Ditch outlets
- Road surfacing and drainage
- Road-stream interface management
- Pipe Usage

The need for these management practices should be further identified through site visitation and survey in each HUC12.

6.3.1 OFF RIGHT-OF WAY ISSUES:

It is important to first consider features off the managed road right-of-way (ROW) that potentially deliver water and runoff onto the road system. None-ROW sources include driveways, logging and farm access, pipeline and utility ROW, ATV trails, agricultural fields, wet weather channels, springs and others. Excess water from none-ROW sources can cause a saturated road base, potholes, increased ditch erosion, and increased sedimentation. Addressing none-ROW runoff before it reaches the road system may be easier than managing the water on the road system.

6.3.2 ROAD BANKS:

On hills and mountains, roads are often built by excavating the roadway from native hillside soil and using the excavated material to extend the roadway to the downhill side as fill for road base. Road banks are often also created by the down cutting of the road profile over time from erosion and grading. The exposed cut banks become a significant potential site of erosion within the road system.

6.3.3 ROADSIDE DITCHES

Roadside ditches are a typical feature of many unpaved roads. Ditches generally occur on the inslope side of the road, though some roads have ditches on both sides of the road. Ditches are especially susceptible to scouring and erosion because they are generally narrow features that capture, concentrate, convey runoff from larger areas such as the road surface, road banks, and none-ROW areas. Best management practices for ditches include eliminating ditches when feasible, providing stable outlets to reducing the volume of runoff and subsurface water entering the ditch, reducing the volume of ditch water, and stabilizing ditch materials.

6.3.4 DITCH OUTLETS:

It is important to provide ditch relief outlets often enough to minimize the erosive power of flowing water in the ditch. Important aspects of ditch relief include the spacing and location of the outlets, proper installation and maintenance of outlet structures, and the stability of the outlet location. Common outlet structure types include crossdrain (sometimes called a crosspipe) and wing ditch (sometimes called lead-off ditch or turn-out).

6.3.5 ROAD SURFACING AND DRAINAGE:

A critical aspect to maintaining an unpaved road surface is to preserve and maintain a proper shape or crown so that rainfall runoff on the road surface will drain away from the road. Dips and grade breaks can also be used to force a road to shed surface runoff.

6.3.6 ROAD-STREAM INTERFACE:

The road stream interface is one of the most critical places for reducing the impacts of unpaved roads on streams. This interface is generally a local low point in the landscape, so runoff on the road surface or in a roadside ditch can lead directly into the stream. Often, stream crossings modify the hydrology of the stream by constricting the channel width, leading to destabilization of the stream channel, its banks, and the stream crossing structure.

It is important to stabilize disturbed or unstable streambanks immediately upstream or downstream of a crossing. Bioengineering techniques can be implemented to stabilize streambanks using live vegetation, and many technical resources exist for streambank stabilization projects.

6.3.7 PIPES:

Culvert stream crossings are a common type of crossing. Improved crossing design, pipe selection and installation can reduce the impacts of the crossing by reducing erosion potential as well as reducing the potential for the crossing acting as a migration barrier for aquatic animals.

6.4 Lake Frances Management

There are many small reservoirs within the UIRW, and these reservoirs (i.e., Lake Fayetteville, Lake Wedington, Lake Elmdale, Lake Bobb Kidd, and Lake SWEPCO) are currently meeting their designated uses except for Lake SWEPCO. However, Lake Frances is a small impoundment located at a particularly important location – the Arkansas and Oklahoma border. Lake Frances likely plays a major role in the transport and transformation of nutrients through the Illinois River. Thus, this small impoundment has the potential to influence how each state (i.e., Arkansas and Oklahoma) perceives how water quality is changing within the UIRW, because Arkansas monitors water quality upstream from Lake Frances, and Oklahoma monitors water quality downstream.

Historical studies have shown that algae growing in the water column consume dissolved, bioavailable nutrients (like ammonia, nitrate, and phosphate) and transform these nutrients into organic matter (particulate nutrients), which can be transported through the small impoundment or accumulated in bottom sediments. Small impoundments like this also have the potential to accumulate sediment and sediment associated constituents (like phosphorus) during high flow events, because the water may slow down as it moves through this lake system. Now that the wastewater treatment plants have reduced effluent phosphorus loads in the UIRW, it is likely that Lake Frances will release the phosphorus it has accumulated over time.

The overlying concern revolving around Lake Frances is its ability to serve as an internal source of nutrients to the Illinois River which might mask improvements in water quality at sites downstream of the impoundment.

There are many methods that exist to decrease the release of nutrients, particularly phosphate, and other contaminants from sediment to the overlying waters. The two methods that appear the most applicable for Lake Frances are:

- **Dredging:** The physical removal of contaminated, nutrient enriched or excess sediments in impoundments; the accumulated contaminants and nutrients are removed with the sediments and either land applied or land filled.

- **Chemical Treatment:** The addition of select metal salts such as aluminum sulfate (more commonly known as alum), iron sulfate, and or calcium sulfate to the overlying water column; these metal salts bind with the nutrients released from the sediments and reduce the amount in the water column.

In order to understand which treatment options are best suited for Lake Frances, it is recommended that these alternatives be evaluated in a feasibility study that would need to focus on logistics, economics, and achieved reductions to meet specific goals for the UIRW. However, the fact that Lake Frances still serves as the water supply reservoir to the city of Siloam Springs, Arkansas means that all options evaluated must consider both short– and long–term impacts on water quality and availability to this municipality.

6.5 Urban Management

As the population in the UIRW increases so does the need for new developments, stormwater infrastructure, and waste-water infrastructure. However, these developments need to occur with minimal hydrological alterations. Best management practices to prevent and restore the effects of urbanization include:

- Riparian vegetation restoration
- Urban stormwater management,
- Municipal wastewater treatment,
- Septic system repair/maintenance.

Table 6.3 identifies the 12-digit HUCs where urban management activities are a priority. The management activities are described in greater detail below.

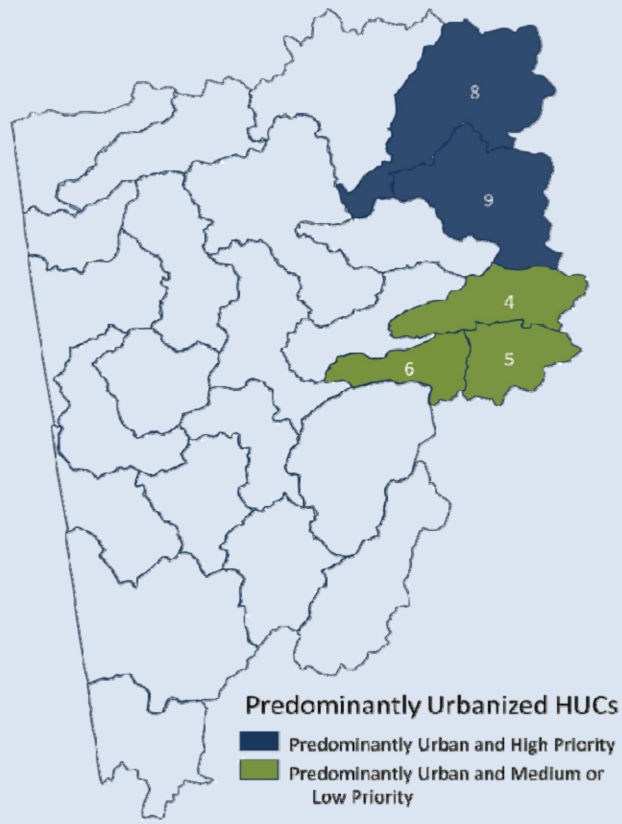


Figure 6.3. Subwatersheds in the Upper Illinois River Watershed where urban is the pre-dominant land use.

Table 6.3. Recommended best management practices for urban areas in the Upper Illinois River Watershed and the estimated area over which the practices should be installed.

HUC No.	HUC 12 Name	Overall Priority	Riparian Vegetation Restoration (acres)	Stormwater Management (mi^2)	Municipal Wastewater Treatment	Septic System Repair or Replace-ment
2	Goose Creek – Illinois River	High	148	6	Fayetteville	Unknown
8	Headwaters Osage Creek – Illinois	High	547	22	Rogers	Unknown
9	Spring Creek – Osage Creek	High	450	18	Springdale	Unknown
10	Little Osage Creek – Illinois River	High	187	7	none	Unknown
16	Headwaters Flint Creek	High	59	3	none	Unknown
17	Sager Creek	High	109	5	Siloam	Unknown
4	Lake Fayetteville—Clear Creek	Medium	217	10	none	Unknown
5	Mud Creek—Clear Creek	Medium	284	12	none	Unknown
11	Brush Creek	Medium	195	7	none	Unknown
24	Headwaters Baron Fork	Medium	56	2	Lincoln	Unknown
6	Hamestring Creek	Low	131	6	none	Unknown
13	Upper Muddy Fork—Illinois River	Low	39	2	Prairie Grove	Unknown

6.5.1 RIPARIAN VEGETATION RESTORATION

Riparian vegetation is the vegetation that grows adjacent to rivers, lakes and other waterbodies. As land in a watershed is developed, natural riparian vegetation is often removed or thinned down to the stream edge which destroys the ecological benefits that natural riparian vegetation can provide. Riparian vegetation slows and filters runoff from roads, parking lots and other paved areas, provides shade to regulate soil and stream temperatures, and stabilizes stream banks. Restoring streams to their natural state with well-managed and healthy riparian buffers can minimize stream impairment, restore healthy stream dynamics, and protect water quality and aquatic wildlife habitat.

6.5.4 STORMWATER MANAGEMENT PROGRAMS FOR MUNICIPALITIES

The more urbanized a municipal area is, the greater the potential for water quality degradation through stormwater contributions. Common pollutants from municipal areas include pesticides, oils, fertilizers, road salt, sediment, bacteria and litter. These pollutants are usually introduced into the landscape through regular day-to-day urban activities such as park and lawn maintenance, roadwork, construction activities, littering and pet care. After pollutants are introduced to the urban landscape, they often remain in place until precipitation washes them into storm drains. Once in the storm drain, polluted stormwater runoff is transported through municipal separate storm sewer systems (MS4s) and discharged untreated into waterbodies.

To prevent harmful pollutants from being discharged or dumped into MS4s, some municipalities are required to follow stormwater permitting as part of the National Pollution Discharge Elimination System

(NPDES). Municipalities in the UIRW that are not required to have a NPDES stormwater permit can still voluntarily protect water quality by properly managing stormwater.

Stormwater BMPs can be implemented to infiltrate and slow urban runoff, reducing the volume of water delivered to MS4s. Examples include green recharge areas, rain gardens, city parks etc. See the *Handbook of Best Management Practices Applicable to the Upper Illinois River Watershed and Other Regional Watersheds* for more information on stormwater BMPs.

6.5.5 MUNICIPAL WASTEWATER TREATMENT

Domestic, commercial and industrial wastewater is generated in the UIRW from homes, businesses, industries, and other entities. The pollutant load discharged by a WWTP depends on the effluent volume, the type of treatment employed by the WWTP, and the contributing sources of wastewater. Minor and cluster WWTPs contribute relatively low effluent discharges (i.e., < 1 million gallons per day (MGD)), but the major WWTP discharges range from 3 MGD to >20 MGD. These WWTPs have likely been a nutrient source in the past, but most have undergone major renovations in recent years and have considerably reduced nutrient (nitrogen and phosphorus) outputs. The treatment processes used at each plant are driven by effluent permit limits established by the ADEQ (see Chapter 3 for more information on wastewater permits). Currently the phosphorus limit for major wastewater treatment plants in the watershed is 1.0 mg L^{-1}; however new facilities should be required to achieve 0.1 mg L^{-1} (e.g., NACA WWTP). The effluent limits should be addressed when permits are issued or renewed by ADEQ and EPA.

The impact of smaller wastewater treatment plants (e.g., Lincoln and Prairie Grove) is minimal. While these plants do have a small impact on the overall load of the watershed, their impact on phosphorus concentrations is not noticeable at the state line.

The Northwest Arkansas Conservation Authority (NACA) Wastewater Treatment Plant is a 4 MGD, regional WWTP that is scheduled to go online in 2010. The plant will serve ten cities currently served by a combination of WWTPs and cluster septic systems, including Rogers, Lowell, Bentonville, Springdale, Tontitown, Centerton, Highfill, Bethel Height, Cave Springs and Elm Springs. A 0.1 mg L^{-1} phosphorus limit will apply to the WWTP. This WWTP will discharge into Osage Creek which will increase phosphorus loading in the system, but decrease the average concentration at Osage Creek.

6.6 Management Practice Efficiencies

Many factors affect the efficiency of BMPS, and there is a great deal of site-specificity for most BMPs which results in a wide range in observed BMP efficiency. The life expectancy of optimal reduction efficiency varies among BMPs, and most require annual maintenance to maintain effectiveness. In addition, the age or maturity of a BMP can also influence the reduction efficiency; for example, newly planted riparian buffers will take several years to mature and to realize maximum reduction effectiveness.

Estimates of nitrogen, phosphorus, sediment and or bacteria reductions are only appropriate to areas where a specific BMP can be implemented. For instance, it would not be effective to construct farm ponds on flat lands where no storm flow reaches a stream. The following table provides estimates of how well specific management practices reduce individual pollutants (i.e., nitrogen, phosphorus, sediment and bacteria).

Table 6.4. Estimated pollutant reduction efficiencies for the recommended best management practices in the Upper Illinois River Watershed.

	Reduction Efficiencies			
Management Practice	Nitrogen	Phosphorus	Sediment	Bacteria
Pasture Management				
1. Filter Strips	12%-81%	4%-67%	50%-70%	Up to 57%
2. Riparian Buffers	20%-82%	40%-93%	70%-90%	80%-100%
3. Stream Fencing & Alternative Water Sources	10%-80%	10%-80%	38%-75%	Up to 100%
4. Farm Ponds	10%-55%	75%-95%	50%-70%	+
5. Legumes	10%-50%	7%-63%	-	-
Forest Management				
1. Forest Conservation	+	+	+	+
2. Streamside Management Zone	40%-100%	50%-100%	70%-90%	+
3. Harvest BMPs	50%	50%	50%	-
Unpaved Road Management				
1. Road Maintenance & Improvements	-	-	50%-95%	-
Lake Management				
1. Dredging	Up to 100%	Up to 100%	Variable	-
2. Physical & Chemical Capping	Up to 100%	Up to 100%	-	-
Urban Management				
1. Riparian Vegetation Restoration	20%-100%	30%-100%	35%-100%	+
2. Stormwater Management	10%- 90%	10%- 90%	35%- 95%	+

+ Some positive effect

- No effect

SUPPORTING INFORMATION ON BMP EFFICIENCIES:

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Education & Outreach 7

7.1 Objectives

The ultimate outcome of this outreach and education strategy is not only to improve and protect watershed water quality, but to do so in such a way that all stakeholders understand their role and obligation to do their part in a way that is economically, socially, and realistically feasible.

7.2 Audience Background

Stakeholders are an important part of this dynamic process, and they have a range of perceptions and knowledge about the Illinois River and its tributaries. For an education and outreach program to be successful, it is important to understand the perceptions and possible knowledge gaps of the target audience. Work has already been done in the UIRW to characterize the perceptions and knowledge of stakeholders in the watershed, including:

- Initial, limited stakeholder interviews to understand basic individual perceptions,
- Pre-education and post-education interview surveys on water pollution education programs,
- A knowledge gap assessment (KGA), and
- Stakeholder interviews.

The knowledge gap assessment results are described in detail in *Illinois River Knowledge Gap Assessment and Dialogue*. The KGA and other stakeholder activities have provided potential focal points for future education and outreach activities conducted within the watershed, and the development of educational materials.

The combination of a spirited and well-defined vision, diverse membership, understanding of stakeholder attitudes, beliefs, and knowledge, and research-based water quality and modeling data form a strong foundation for a successful, adaptive watershed management strategy.

7.3 Relevant Stakeholders

A stakeholder is a person, group, organization or system that affects or can be affected by a series of actions. With-in the concept of watershed management, a stakeholder can be thought of as anyone who has a share or interest in any or all issues related to the watershed, particularly residents. Understanding what stakeholders think, feel and know about the Illinois River and its tributaries is key to establishing a watershed management plan that will guide strategies and implementations. Stakeholder interests in the UIRW are as diverse as its people and include agriculture, business, conservation, construction, government, and technical, research and education interests. There are many benefits to including stakeholders in the development and implementation of watershed management strategies including:

- Building trust and support during development;
- Providing broad input and shared responsibility in strategies; and
- Fostering strong relationships, communication and coordination during implementation.

7.4 Tools for Education and Outreach

7.4.1 COORDINATE WITH OKLAHOMA'S LOWER ILLINOIS RIVER WATERSHED MANAGEMENT AND BEAVER LAKE WATERSHED MANAGEMENT EFFORTS

Common elements of this watershed management plan should be synchronized with the adjacent watershed management resources and programs of the Oklahoma portion of the Illinois River Watershed and the Beaver Lake Watershed. Synergistic success can be realized through efforts such as combined mass media campaigns, educational programming, and long-term funding commitments. And, sharing education and outreach undertakings can free up time for the respective partnerships and their staff to seek financial and programmatic support. While some branding capacity may be lost and current financial support may be stretched initially, economies of scale, social marketing, unified environmental messages, and water quality improvements should be far greater than if the focus is solely on the UIRW.

The organizational dynamics of watershed partnerships change over time, and this is certainly not new. Partnerships often focus on one initial problem then expand interests to other issues, or increase the scope of activities or geographic concern. These changes and the emergence of other regional watershed partnerships, alliances, groups, etc. might cause shifts in organizational structure of existing watershed partnerships, as the roles of these entities are defined and the potential for 'umbrella' partnerships form. Existing watershed partnerships will need to continually re-evaluate organization structure, particularly focused on the responsibilities of the executive director as education and outreach activities grow. These duties might need to be separated within the organizational structure, especially when the scope of activities increases and/or if 'umbrella' watershed partnerships form.

7.4.2 BUILD CAPACITY THROUGH EXPANDED PARTNERSHIPS

Capacity building is an ongoing process connecting individuals, groups, organizations, businesses, and agencies to better identify and address challenges through building and sharing knowledge. Expanding collaborative partnerships will enhance implementation of this watershed management plan through partnering entities whose efforts mirror the vision, mission, and objectives of the IRWP. Continued efforts to seek out partnerships with organizations engaged in water quality improvement education, BMP implementation projects, and water quality monitoring is essential.

Table 7.1. Potential partners that may share common goals for the Upper Illinois River Watershed.

Organization	Affiliation	Common Goal	Resource
All cities in the UIRW	City government/ departments	Water quality protection, education	Potential grant partners and volunteers
Arkansas Game and Fish Commission/ Stream Team	Government agency	Stream conservation, water quality education, volunteerism	Equipment, potential sponsor and technical assistance
Arkansas Forestry Commission	Government agency	Forest and riparian buffer management, Green Infrastructure, urban forestry	Trees, technical assistance, and potential grant partner
Arkansas Natural Resource Commission	Government agency	Water resources planning, grant funding agency	
Arkansas Water Resource Center	Government agency	Water quality monitoring, research, outreach, and education	Water quality research, monitoring, potential grant partner
Benton and Washington County Conservation Districts/NRCS	Government agency	Natural resource conservation	Technical assistance
University of Arkansas Cooperative Extension Service	Government agency	Agricultural production, forest and riparian buffer management, and urban stormwater programs	Educational assistance
Washington County Environmental Affairs	Government agency	Solid waste management, household hazardous waste disposal	Technical help, potential grant partner, outreach and education activity partner
United States Forest Service	Government agency	Forestry education and management	Technical help, potential grant partner
United States Geological Survey	Government agency	Stream gauging, water quality monitoring and modeling	Monitoring, potential grant partner
Audubon Arkansas	Non-governmental organization	Conservation, education and outreach	Technical and education assistance, potential grant partner
Arkansas Canoe Club	Non-governmental organization	Water conservation and recreation	Volunteer resource and potential sponsor
Boy Scouts and Girl Scouts of America	Non-governmental organization	Conservation, outreach and recreation	Volunteer resource
Farm Bureau of Benton and Washington Counties	Non-governmental organization	Agricultural production and water quality interest	Potential grant partner, outreach and education activity partner and sponsor
Fayetteville Natural Heritage Association	Non-governmental organization	Natural resource conservation and recreation	Potential grant partner and volunteer resource
Illinois River Watershed Partnership	Non-governmental organization	Water quality conservation, education, and outreach	Potential grant partner, volunteer resource
Lake Fayetteville Watershed Partnership	Non-governmental organization	Water quality protection	Potential grant partner, volunteer resource

Multi-Basin Regional Watershed Council	Non-governmental organization	Water quality conservation, education, and outreach	Potential grant partner
Ozark Society	Non-governmental organization	Conservation and recreation	Volunteer resource
Poultry Partners	Non-governmental organization	Agricultural water quality interest	Outreach and education activity partner and potential sponsor
Sierra Club	Non-governmental organization	Conservation and recreation	Volunteer resource
The Nature Conservancy	Non-governmental organization	Natural resource conservation, outreach, and education	Potential grant partner and potential sponsor
Watershed Conservation Resource Center	Non-governmental organization	Water quality conservation, education, and outreach	Potential grant partner
Businesses In the UIRW	Business	Water quality conservation interest	Potential sponsors, grant partners, and volunteers
Schools in the UIRW	Schools	Water quality education	Potential Grant Partners and Volunteers

Foster a community of practice by enlisting the help of local conservation, civic, government, social, and other agencies or organizations in watershed activities. Not only will event participation increase, but combined efforts should be synergized toward a common purpose, and existing watershed and water quality knowledge gaps can be diminished.

EXAMPLE: When a combination of agricultural, industrial, and environmental/outdoor interest groups is committed to the IRWP as sponsors and participants, their collaboration evokes mutual respect and appreciation. As a result, *their* colleagues may also begin collaborating with the IRWP, stimulating even more expansive partnerships.

7.4.3 ACKNOWLEDGE PARTNERS AND SPONSORS

When working with other entities in a supporting or lead role there are two common courtesies that will ensure successful collaborations.

- **Recognize Collaborators:** When an entity is supporting or collaborating on a watershed program or event, the lead entity should publicly acknowledge the supporting entity for their contributions.
- **Request Acknowledgement:** When supporting an activity of another entity, supporting entities should expect to be recognized as a sponsoring partner.

These approaches will strengthen existing relationships and encourage new partnerships. Additionally, the general public will see a unified water quality protection and improvement movement among many different groups and interests.

7.4.4 ENGAGE POLICY MAKERS

Engaging local, county, and state officials in watershed management discussions can spark support for water quality protection, preservation, and restoration legislation or policy. The IRWP is rich with diverse Board representatives, membership, and network connections that can influence policies that help meet federal and state point and nonpoint source pollution management goals and support components of this IRWP watershed management plan.

7.4.5 ADVERTISE OPPORTUNITIES FOR INVOLVEMENT AND EDUCATION

A large crowd of participants at a watershed event enhances opportunities to raise awareness and education. Market events to local conservation organizations, IRWP members, and the general public as often as possible at least one month prior to the event so potential partnering organizations or interested volunteers can save the date, increasing the likelihood of their participation. When promoting an informational or educational concept to the public, put the message directly in their path so they can passively see, think about, and absorb the information through indirect contact. Recognize that not all people frequent the same path, so the message or material must be put in a variety of locations and media to reach all stakeholders. Publicizing programs in all possible ways may include inserting messages into utility bill mailings, providing input at public hearings, or developing personal contacts with reporters and being prepared with frequent story and photo opportunities. Additional promotion examples are listed below:

- **E-mail:** E-mail news briefs to the IRWP membership, sponsors, non-member volunteers, and other outdoor or environmental organizations to announce or remind them of an event and can enhance participation.
- **Flyers:** Promotional flyers in local businesses, public places, universities, and other locations can draw in more potential volunteer participants. Enlist the help of IRWP members, partnering organizations, and other volunteers to help post the information and spread the word.
- **Internet:** Listing upcoming events or updates on continuing effort on the www.IRWP.org website or a partner's website is a great tool for those accustomed to surfing the internet for information.
- **Radio:** Radio air time can be purchased and free public service announcement opportunities can be utilized. Alert local stations that can provide free public announcements (KUAF, KURM, KEZA, etc.) about event information that they might distribute to their listeners.
- **Television:** News coverage is free and can help garner further public awareness and viewer participation in events and programs. Local government channels and local community access cable stations also announce events and workshops for free if they are included in their community calendars.
- **Newsletters:** Newsletters support continued efforts, and keep stakeholders informed on upcoming events and past successes and provide encouragement and tips on proactive BMPs for their land, in their home, community, or workplace to improve water quality.
- **Newspapers:** Using local, University, and regional newspapers to advertise upcoming events and share success stories to reach a lot of people can be very cost-effective. Like television, news coverage can be free and many local papers will list local community events.
- **Word-of-Mouth:** Presentations and announcements to local civic and special interest organizations about ongoing efforts or upcoming events fosters broad interaction with watershed stakeholders that are likely to participate in watershed activities and implement positive management actions.

Continually communicating the importance of maintaining and improving the water quality of Upper Illinois River Watershed to, and getting feedback from, the stakeholders in urban and rural communities is critical to protecting and improving water quality.

7.4.6 COLLECT AND REVIEW STAKEHOLDER INFORMATION

To ensure outreach messages and education programs are appropriate for targeted audiences, it is critical to assess:

1. Stakeholder attitudes, understanding, and actions regarding watershed water quality,
2. How and where they get their information,
3. What they might be willing to do to protect water quality, and
4. What might limit their particiation.

THE WATERSHED APPROACH: EPA's 'Watershed Approach' uses sound science and adaptive management to address water quality issues through collaborative, stakeholder-driven processes that foster public participation, equal representation of interests, and geographically-relevant management approaches to maintain, protect, and restore watershed water quality.

SURVEYS: The use of online, phone, or written surveys and polls can greatly aid the IRWP in gauging stakeholder awareness, beliefs, opinions, knowledge, and behaviors regarding watershed water quality. As stakeholder information is captured and analyzed, outreach and education programs can be designed to overcome knowledge gaps and misperceptions and facilitate changes in behavior.

STAKEHOLDER INPUT/FOCUS GROUPS: Stakeholder input helps IRWP accurately prioritize local educational needs, design effective resource materials, and enhance program participation. Focus groups provide insight on how to best initiate public contacts, phrase survey questions, promote programs, and garner participation. Use common rules of engagement at focus group meetings, workshops, and activities:

1. Present only factual and non-biased information considering all sides of the issue,
2. Encourage all present to participate,
3. Listen respectfully to others and suspend judgments,
4. Let group members speak for themselves based on their own experiences, and
5. Avoid generalizations and stereotypes of groups or stakeholder interests.

7.4.7 INCREASE IRWP MEMBERSHIP AND GENERATE VOLUNTEERS

Expanding membership numbers and generating volunteers is a great way to enhance the education and outreach strategy.

MEMBERSHIP: The current IRWP Board and membership already provides a wide social network of contacts and connections that help secure funding, spread the IRWP mission, recruit new members, and generate volunteers. However, there is great potential for IRWP membership to grow and become further embedded in businesses, schools, and communities throughout the UIRW.

BOARD AND MEMBERSHIP INVOLVEMENT: Often, events that are designed to increase outreach and education rely on the involvement of volunteers that aren't even associated with IRWP or groups that organized the program. Whenever a creek cleanup, creek walk, soil drop-off event, riparian planting, or other IRWP event is planned, it is beneficial to have members and Directors engaged in the event. Member participation legitimizes their commitment and increases IRWP visibility and networking potential.

ADVERTISE REASONS FOR SEEKING MEMBERSHIP: The more that IRWP membership is marketed as a means for on-the-ground stewardship opportunities, the more the membership will grow. When trying to foster participation, it is the connection of the participants' actions with their ability to make improvements that causes them to feel responsible or obligated to act. The IRWP should advertise how membership in the organization keeps people connected to the necessary information, tools, events, and other resources available so they can take part in maintaining and improving the water quality of the UIRW.

7.4.8 RECOGNIZE NATIONAL AND STATE PRIORITIES

Educators should maintain an understanding of federal and state program priorities that align with the mission and objectives in the WMP.

EXAMPLE: The Arkansas Natural Resources Commission's Nonpoint Task Force has identified the Illinois River as a Priority Watershed in which the ANRC seeks to implement programming via priority 319(h) grant funding. Additionally, the ANRC has established category priority areas in which education and outreach improvements should have a focus The five priority categories are:

1. Silviculture,
2. Agriculture,
3. Resource extraction,
4. Surface erosion, and
5. Household and business activities.

The previously defined education and outreach actions may be tailored to specifically address one of the five priority categories established by ANRC; these actions are easily transferable between the established priorities.

7.4.9 PROMOTE STEWARDSHIP RECOGNITION PROGRAMS

Watershed stewardship awards serve to publicly acknowledge and thank stakeholders for their outstanding management actions. The IRWP's *Golden Paddle Award* recognizes individuals, businesses, organizations, educational institutions, and agencies for their leadership in successful environmental projects and conservation measures that protect and improve the UIRW. Greater publicity of the nomination process and the recipients can increase IRWP visibility, raise awareness of successful environmental and conservation practices and projects, and serve as an incentive for more stakeholder involvement.

7.5 Strategies for Education and Outreach across the Watershed and all Stakeholder Groups

The Upper Illinois River consists of a very diverse cross-section of urban, sub-urban, and rural areas and communities where stakeholders have live and work, some for a very long time. This diverse watershed landscape and population features many different livelihoods, lifestyles, and levels of understanding for watershed dynamics and water quality issues. Differences among stakeholders can often be related to experiences with career or industry, time spent living in the watershed, connectedness to the issue, and level of education. More often than not, these differences affect the stakeholders' interpretation of who is responsible for water quality impacts and who is responsible for enacting management actions to protect water quality. When a water quality message, program, or activity is planned, it is essential to use a mixture of focused messages, programs, and activities so that span everyone, everywhere.

There should be a continual effort to provide educational programming, conduct educational activities, and broadcast educational messages across the entire watershed, while also tailoring focused activities, messages, or programs within a particular sub-watershed or stakeholder interest.

STRATEGY FOR WORKING WITH MUNICIPALITIES TO IMPROVE WATER QUALITY

- Encourage the development of Master Park Plans or Nutrient Management Plans for City Parks
- Encourage Green Infrastructure Planning as part of an overall growth or development plan
- Encourage preservation or restoration of riparian areas on city or community owned properties
- Encourage Low Impact Development for municipal projects
- Seek partnerships on projects that are mutually beneficial
- Encourage support for county or municipal construction/post construction BMP inspectors
- Ask an IRWP member in local government to coordinate meetings with city and county officials
- Hold watershed workshops for municipal officials and planners
- Engage the Norwest Arkansas Regional Planning Commissioners

STRATEGY FOR WORKING WITH BUSINESSES AND INDUSTRIES TO IMPROVE WATER QUALITY

- Seek out new sponsorships and partnerships
- Encourage existing partners to become leaders in implementing positive management actions
- Ask IRWP members/sponsors to coordinate discussions with fellow business owners and contractors
- Engage local Chambers of Commerce
- Conduct watershed workshops for targeted business sectors and industries
- Encourage riparian preservation or restoration on industrial and business properties
- Encourage the implementation of industrial ecology

STRATEGY FOR WORKING WITH FARMERS TO IMPROVE WATER QUALITY

- Place educational materials in farm supply stores, coffee shops, and sale barns
- Involve agricultural IRWP members in coordinating water quality information meetings for farmers
- Collaborate with the Farm Bureau in Benton and Washington Counties and at the state level

- Seek partnerships with the Benton and Washington County NRCS and Conservation Districts
- Collaborate with the Conservation District Board Benton and Washington Counties
- Collaborate with the County Extension Council in Benton and Washington Counties
- Encourage the participation in the of the Conservation Reserve Enhancement Program
- Conduct watershed workshops

STRATEGY FOR REACHING AND WORKING WITH HOMEOWNERS

- Deliver information through Neighborhood Association newsletters and meetings
- Target creek cleanups in or near neighborhoods and invite the residents
- Initiate neighborhood Stream Teams
- Conduct creek walks and invite neighboring residents
- Ask current members to engage their neighbors and to encourage membership
- Ask current members to coordinate neighborhood meetings
- Hold watershed workshops

Strategy for Reaching Individuals

- Groom relationships with local newspaper and television media
- Utilize local government and community access cable television stations
- Ask to present information at a sponsor's/partner's regular meeting or event
- Use and maintain the IRWP website
- Place fact sheets and event flyers in public places such as libraries and coffee shops
- Utilize the diverse membership base of the IRWP
- Provide in-school education

Budget & Assistance 8

Table 8.1. Estimated costs, technical and monetary assistance, and applicable HUCs where best management practices should be applied in the Upper Illinois River Watershed.

Management Practice	Area where practice is applicable	Cost per Unit	Total Cost	Technical Assistance	Monetary Assistance	Applicable HUCs
Pasture Management						
1. Filter Strips	1097 acres	$30-$50 per acre	$50,000	NRCS UA Cooperative Extension	ANRC 319 NRCS CREP NRCS EQIP NRCS WHIP Private Funds	All
2. Riparian Buffers	10,966 acres	<$500- $2000 per acre	$5,000,000- $20,000000	NRCS UA Cooperative Extension	ANRC 319 NRCS CREP NRCS EQIP NRCS WHIP Private Funds	All
3. Alternate Water Sources	158 mi^2	$350-$2,000 per reservoir	Dependent	NRCS UA Cooperative Extension	ANRC 319 NRCS CRP NRCS EQIP Private Funds	All
4. Stream Bank Fencing	Unknown	<$1-$2 per foot	Dependent	NRCS UA Cooperative Extension	ANRC 319 NRCS CRP NRCS EQIP Private Funds	All
5. Farm Ponds	158 mi^2	$350-$2,000 per pond	Dependent	NRCS UA Cooperative Extension	ANRC 319 NRCS CRP Private Funds	All

6. Legumes	316 mi^2	$640 per mi^2	$192,000	NRCS UA Cooperative Extension	ANRC 319 NRCS CRP Private Funds	All
Forest Management						
1. Forest Conservation	303 mi^2	Variable by easement	Dependent	AFC UA Cooperative Extension	AFC FLP ANRC 319 Private Funds	All
2. Streamside Management Zone	Unknown	Variable by easement	Dependent	AFC NRCS UA Cooperative Extension	NRCS CREP ANRC 319 Private Funds	All
3. Harvest BMPs	Minimal	Variable by land owner	Dependent	AFC UA Cooperative Extension	Private Funds	All
Unpaved Road Management						
1. Road Maintenance & Improvements	1,295 mi	$40 maintenance Variable by BMP practice	$51,800 +	AHTD TNC UA Cooperative Extension	Department of Transportation Washington Co. Road Department Benton Co. Road Department Private Funds	All
Lake Management						
1. Dredging 2. Physical & Chemical Capping	568 acres	To be determined by feasibility study	To be determined by feasibility study	NALMS NALMS	Private Foundation	23 23
Urban Management						
1. Riparian Vegetation	2,421 acres	<$500-$9,000 per acre	$1,210,500-$21,789,000	EPA NRCS	ANRC 319 Municipalities	2, 4, 5, 6, 8, 9, 10,

				UA Cooperative Extension	Private Funds	11, 14, 16, 17, 24
2. Stormwater Management	100 mi^2	Variable by practice	Dependent	EPA TNC NRCS UA Cooperative Extension	Municipalities	2, 4, 5, 6, 8, 9, 10, 11, 14, 16, 17, 24
3. Municipal Wastewater Treatment	All permitted WWTPs	Function of government and municipalities	Function of government and municipalities	ADH ADEQ EPA	ADEQ SRF	2, 8, 9, 13, 17, 24
4. Septic Maintenance & Repair	Low density urban areas where septic systems are prevalent	Function of MDEQ and AR Dept. of Health	Function of MDEQ and AR Dept. of Health	ADH ADEQ	ADH, Private funds	2, 4, 5, 6, 8, 9, 10, 11, 14, 16, 17, 24
Education & Outreach						
1. Education & Outreach Programs	Not Applicable	Variable by Program	Variable by Program	EPA AWAG UA Cooperative Extension ADEQ IRWP	ANRC, Private Foundations, UA Cooperative Extension	All

Implementation Timeline 9

Table 9.1 Implementation timeline for each management strategy component and the groups that are recommended for seeing that the recommended practices are implemented.

Management Strategy Component	Initial Phase Timeline	Recommended Group(s)
Pasture Management	July 2010 – July 2035	Illinois River Watershed Partnership, UA Cooperative Extension Service, Natural Resources Conservation Service,
1. Conduct field survey of priority areas	July 2010-July 2015	
2. Conduct landowner outreach	January 2011-December 2020	
3. Encourage voluntary BMPs	January 2011-ongoing	
4. Secure funding sources	July 2011-ongoing	
5. Implement recommended BMPs	December 2011-ongoing	
6. Conduct necessary BMP maintenance	Ongoing	
Forest Management	July 2010—July 2035	Illinois River Watershed Partnership, UA Cooperative Extension Service, Arkansas Forestry Commission
1. Conserve existing forested areas	Ongoing	
2. Conduct field survey of priority areas	July 2010-July 2015	
3. Conduct landowner and timber producer outreach and education	January 2011-December 2020	
4. Encourage voluntary BMPs	January 2011-ongoing	
5. Secure funding sources	July 2011-ongoing	
6. Implement recommended BMPs	December 2011-ongoing	
7. Conduct necessary BMP maintenance	Ongoing	
Unpaved Road Management	July 2010—July 2035	Local and state governments
1. Conduct field survey of road banks, ditch outlets, road-stream interfaces, and pipes beginning in priority areas	July 2010-July 2015	
2. Implement needed maintenance and improvements	Ongoing	
Lake Management	July 2010—July 2035	Illinois River Watershed Partnership, City of Siloam Springs
1. Monitor phosphorus concentrations upstream and	July 2010-ongoing	

downstream of the lake 2. Conduct a feasibility study for dredging and or chemical treatment 3. Develop lake maintenance/renovation plan 4. Secure funding 5. Implement lake maintenance/renovation plan 6. Conduct necessary BMP maintenance	 July 2010-December 2015 January 2011-December 2020 January 2012-July 2020 July 2020 Ongoing	
Urban Management 1. Encourage Voluntary BMPS 2. Educate stakeholders on LID practices 3. Support and or enforce minimum federal, state and local requirements (construction, wastewater, stormwater) 4. Identify and implement stormwater BMP Retrofits 5. Conduct a field survey to identify impaired septic systems 6. Identify urban stream buffer and channel restoration needs 7. Secure needed restoration permits 8. Secure funding 9. Implement needed stream restoration 10. Conduct necessary BMP maintenance	July 2010—July 2035 July 2010-ongoing July 2010-ongoing July 2010-ongoing July 2011-July 2015 July 2010-July 2015 July 2010-July 2020 July 2011- December 2020 January 2012- July 2020 July 2012-July 2020 Ongoing	Local governments, UA Cooperative Extension Service, MS4s
Education and Outreach 1. Schedule stakeholder forums 2. Coordinate with other partnerships, agencies and services to build on existing education and outreach efforts 3. Build capacity through expanded partnerships 4. Engage policy makers 5. Advertise opportunities for involvement and education 6. Collect and review stakeholder information 7. Increase IRWP membership and generate volunteers	Ongoing July 2010-July 2011 July 2010-Ongoing July 2010-Ongoing July 2010-Ongoing July 2010-Ongoing July 2010-Ongoing July 2010-Ongoing	Illinois River Watershed Partnership, UA Cooperative Extension Service, Lake Fayetteville Watershed Partnership

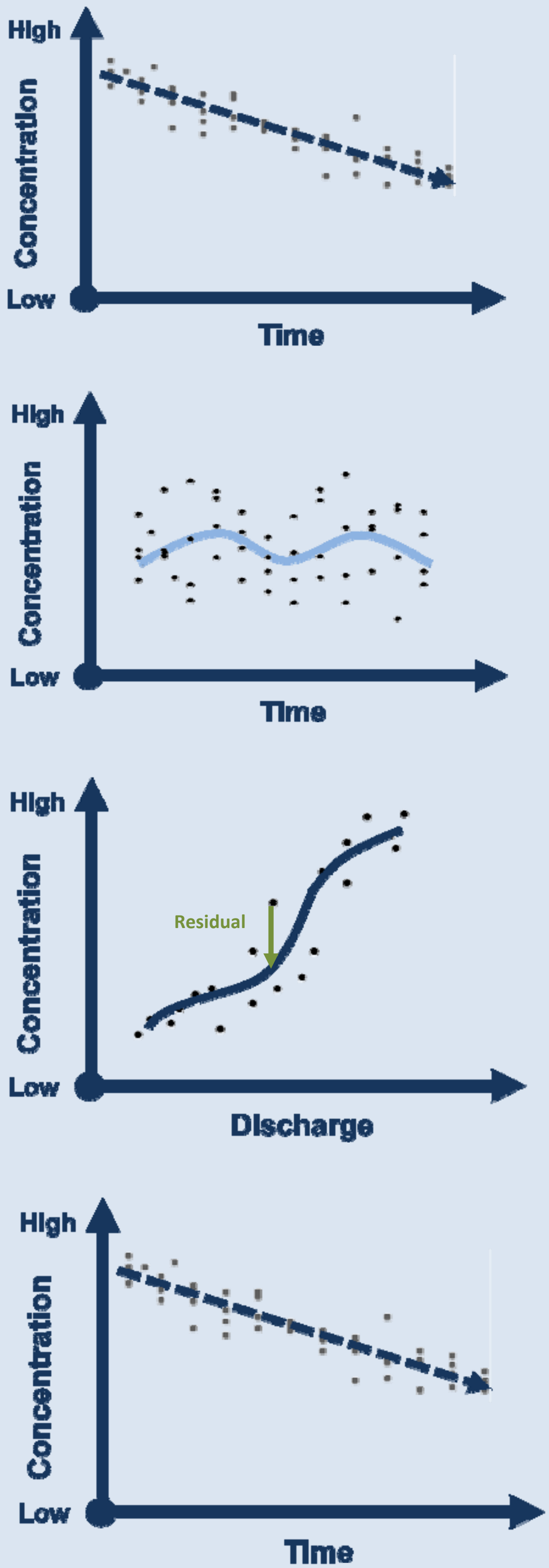
8. Promote stewardship recognition programs	July 2010-Ongoing	
Monitoring for Success 1. Adopt long-term water quality monitoring program 2. Establish biological monitoring program 3. Secure funding 4. Implement monitoring program(s) 5. Review existing monitoring programs (federal, state and local) 6. Identify new monitoring needs 7. Establish criteria/indicators of progress/success per project 8. Establish methods for assessment of project/implementation success 9. Evaluate success of education and outreach efforts 10. Evaluate trends in water quality 11. Evaluate land use/changes in land use 12. Re-set target concentrations for HUC 12s based on land use	July 2010—July 2035 July 2010-January 2020 January 2011-July 2020 July 2010-ongoing July 2011-ongoing Annually Annually Per project-ongoing Per project-ongoing Annually July 2015, and every 5 years July 2015, and with new satellite data July 2015, or following repeat of HUC 12 monitoring	Arkansas Water Resources Center, Illinois River Watershed Partnership, Arkansas Natural Resources Commission, Arkansas DEQ, US Geological Survey

Evaluation Criteria 10

The point of establishing a water sampling program would be to evaluate changes in chemical concentrations or biological conditions over time after the implementation of the management strategies defined for each HUC 12. This purpose needs to be kept in mind, because the recommended water quality monitoring program (described in Chapter 11) is not designed to evaluate chemical loads---loads are extremely dependent on the annual variations in discharge, or really precipitation. With this purpose in mind, the chemical concentrations from the water samples should be evaluated to determine if significant changes (increases↑ or decreases↓) are occurring over the defined time period. Evaluating changes in water quality is not as simple as determining if concentrations have increased or decreased over time, because other factors (e.g., discharge, season, etc.) may influence water quality concentrations. Therefore, to better determine if water quality (e.g., chemical concentrations) are changing in response to the management strategies, trends (i.e., changes over time) should be evaluated in a way that accounts for natural variations.

Factors other than time (e.g., stream discharge) often have a considerable influence on the water quality data (e.g., chemical concentration), and the variation in chemical concentrations with stream discharge needs to be removed to observe true changes in chemical concentrations over time. The removal process involves empirical modeling of how chemical concentrations change with stream discharge, and there are several techniques to accomplish this process. Basically, a line is fit the data to that best represents how concentrations change with increasing discharge. After selecting the appropriate line to adjust for discharge, the next step is to determine the residual value or the difference between the measured chemical concentration and that represented by the line fitted to the data. These residual values represent the flow-adjusted concentrations, and then these flow-adjusted concentrations are plotted over time to determine if chemical concentrations show significant decreasing or increasing trends. The simplest and most straight forward approach is to use simple linear regression to determine if flow-adjusted concentrations are changing over time, where the general statistical assumptions related to regression must be met. There are many techniques to evaluate trends that are defined in the scientific literature and water quality textbooks, but the simplest approach that is statistically sound should be the best way to communicate these results to watershed stakeholders and even government agencies that need to demonstrate the impact of BMPs.

The trends detected in the water quality data (e.g., chemical concentrations) represent simply the period of record used in the analyses, and this aspect should be kept in mind and clearly communicated when reporting trend results. The time period required to see significant changes in water quality is likely a function of how dramatic the change is, or how subtle the change should be. As a good rule of thumb, it usually requires at least five years to see changes in water quality so the monitoring program should be established for the long term. And, trends in water quality (e.g., chemical concentrations) should be evaluated in five years and then every few years or so thereafter by an experienced hydrologist or water-quality specialist.



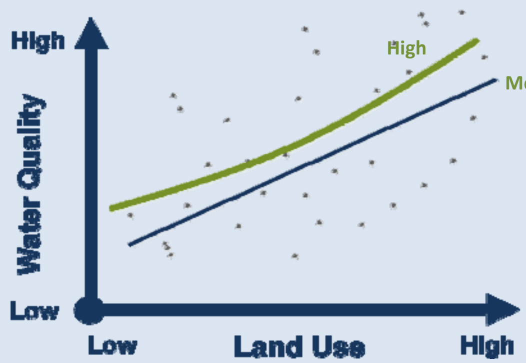
It is possible to see significant changes in chemical concentrations when a major change in management has occurred within a watershed; for example, the graph to the left depicts a chemical concentrations decreasing over time from a major change in watershed management, such as reduced effluent limits at WWTPs.

But, land use change and management might have more subtle effects on chemical concentrations in streams. Often these effects are masked by changes in discharge or other factors that might influence the water quality parameter of concern. The graph to the left shows chemical concentrations that are variable over time.

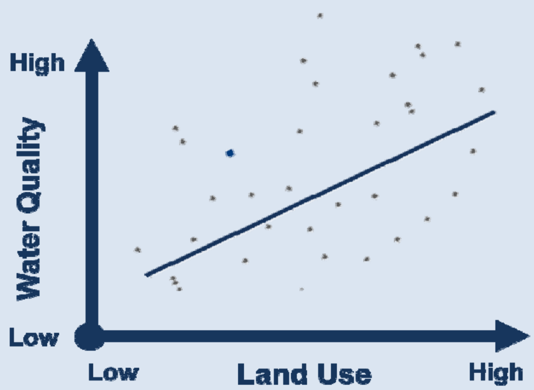
To account for natural variations such as the influence of discharge, chemical concentrations can be plotted against discharge. The difference between the measured concentration and the line representing the best fit to the data is called a residual value. The residuals are the flow-adjusted concentrations, and the flow-adjusted concentrations can be used to determine if significant changes have occurred over time.

After the flow-adjusted concentrations have been estimated, these values may be plotted over time as in the graph to the left. The simplest approach would be to use linear regression to determine if a significant relation between concentration and time exists. If the slope of the line is significant and negative (downward line) then chemical concentrations are decreasing and water quality is improving at this site over this period.

Figure 10.1 Technique to evaluate trends in water quality over time.



This linear regression (blue line) represents the average conditions across the land use gradient, and this should be our target concentration for sites with a given land use.



Our goal should be to move the average water quality (e.g., geomean chemical concentration) of a stream site or HUC 12 from its current state to that below the line representing the average conditions along the land use gradient.

Figure 10.2. Determining target conditions and needed reductions of nutrients according to the methodology outlined in this watershed management plan.

10.1 Nutrients

Water quality changes with land use, where the relation can often be described with simple linear regression as used in the prioritization of the HUC12s. The prioritization methodology suggested that the focus should be on those HUC 12s or sampling sites where the water quality parameter (i.e., geomean chemical concentration) was much higher than what was usually seen at a given land use (e.g., pasture plus urban development). Our goal should be to move the high and eventually medium priority HUC 12s below the linear regression which represents the average conditions across the land use gradient. The methods should follow closely that used to develop these relationships, where approximately 12 samples collected during base flow conditions should be used to determine the data point, or geomean chemical concentration. This data point should be plotted against the most current land use information available, because this methodology allows for chemical concentrations to change along a land use gradient. Once the data point shifts from above the line to below the line, then this site has reached its target chemical condition as defined by the original regression used to determine priorities. This technique to evaluate end points in chemical concentrations should be used for nitrogen and phosphorus. This technique also allows the HUC 12 prioritization to be adaptive to changes in chemical conditions at HUC 12s, because it is conceivable that HUC 12s could shift in priorities resulting from the implementation of manage strategies aimed to improve water quality or land management that adversely influences water quality. So, this technique provides some flexibility to adjust HUC 12 priorities as new data (e.g., water samples and chemical concentrations are collected. However, it would be wise to make sure HUC 12s have consistently changed priority categories (e.g., moved from high to low) over multiple years before assuming the end point has been met.

10.2 Bacteria

Based on the water quality standards for the State of Arkansas, the goal should be to reduce bacterial numbers (i.e., *Escherichia coli* (E. coli)) such that each sampled reach meets water quality standards as interpreted by ADEQ, and remove the streams that are listed for pathogens from the 303(d) list.

10.3 Sediment

The prioritization methodology used to rank sediment was based on the percentage of non-forested area in the riparian zone. The HUCs were ranked and divided into equal groups of high, medium, and low priorities based on the presence or absence of riparian vegetation. The overall goal is that all HUC 12s have an intact riparian zone where at minimum 75% of the buffer area is fully vegetated. Although there is little suspended sediment in the stream water during base flow conditions, sedimentation may still influence aquatic life communities at select HUC 12s. The end point related to sediment should revolve around future biological monitoring, and sedimentation would be assumed not to be problematic if the designated beneficial use of aquatic life is being met.

10.4 Biological Monitoring

Biological monitoring can assist in determining if streams in the UIRW are meeting their designated uses, where certain species (e.g., organisms) and community metrics (e.g., Index of Biotic Integrity, IBI) can be used to evaluate the impact of chemical and physical conditions on aquatic life. The most commonly used bio-indicators for water quality are fish, macroinvertebrates, and algae, because these organisms provide a robust measure of the integrated chemical, physical, and biological condition of the water body. These biota also provide insight into larger ecological processes that are important to ecosystem and watershed management, such as habitat, flow extremes, and changes in catchment land use. The role of streamside management or riparian zones in protecting and maintaining aquatic life use in these systems (i.e., UIRW) is critical. Based on the water quality standards of the State of Arkansas for biological integrity, our goal is for all streams of the UIRW to support biota communities that are not reflective of impaired conditions; these conditions should be established by ADEQ and Arkansas Regulation No. 2.

10.5 303(d) Listings

Our goal is to delist streams from the 303(d) list through use attainability studies and to prevent additional reaches from being listed as impaired; the previously defined chemical and biological monitoring should assist in this goal.

10.6 Education and Outreach

Specific evaluation criteria should be established for each Education and Outreach Project conducted by the IRWP (See Section 12.2). But in general, the success of Education and Outreach Programs can be assessed through public involvement and participation. While participation alone may not directly translate into a measurable water quality improvement, the number of participants can reflect a measure of interest, understanding and or BMP implementation. For example, participants who help plant riparian trees during a bank stabilization project, take trash out of waterways during a clean-up event, or construct and plant a rain garden to mitigate the quality and volume of stormwater runoff should all be counted as having a direct impact on aspects of water quality improvement. Evaluation criteria for different levels of education and outreach are outlined below:

1. Changes in Stakeholder Awareness:
   Through this process, participants initially become conscious of water quality concepts or issues through mass media messages, newsletters, billboards etc. The goal of this education and outreach strategy is to simply reach the stakeholder. While it is often difficult to know who was exposed to the message and how many understood and retained it, some measures of success include circulation or audience numbers for mass media, traffic counts for billboards, and number of materials distributed and can be used to get a count of the potential number of people reached.

2. Changes in Stakeholder Education:

   Through this process, participants gain a deeper knowledge or understanding of water quality issues through hands-on experimental learning in classrooms or camp programs, presentations to civic groups at conferences and specialized workshops or field days (e.g., riparian buffers, litter truck calibration, stream restoration). The goal of this education and outreach strategy is to capture audiences where you have an opportunity to assess a real change in participants' knowledge or skills. Assessments could include pre and post tests, formal written evaluations, and turning point audience remotes. With these assessment techniques you can not only assess changes in participants' immediate knowledge or attitude, but you can also ask how (and how soon) they plant to change their behaviors and implement certain pollution prevention BMPs. This can help make the direct link between outreach and or education programs and anticipated water quality improvements.

3. Stakeholder Involvement and Participation

Through this process, stakeholders are provided opportunities to show up and do something including participating in a committee or public meeting, volunteer during a creek clean up event and or planting and mulching a demonstration rain garden. The goal of this process is to involve stakeholders through physical presence whether giving verbal input or being physically engaged in an organized effort. Participant surveys at the conclusion of events or follow-up questionnaires should be used to provide feedback on the extent to which the participant knew or implemented pollution prevention practices before the day's event and what they plan to do differently in the future. Complied results can be used to track nutrient management BMPs that can be link to water quality improvements.

Monitoring 11

11.1 Existing Monitoring Programs

11.1.1 ARKANSAS DEPARTMENT OF ENVIORNMENTAL QUALITY

ADEQ has been monitoring select reaches of the Illinois River and its tributaries since the early 1990's. ADEQ's surface water quality monitoring stations data files are available on the web at http://www.adeq.state.ar.us/techsvs/water_quality/monitors.asp. ADEQ has eight ambient monitoring stations that are continually monitored in the UIRW. ADEQ collects biological, chemical, and physio-chemical parameters including ammonia, nitrogen, phosphorus, chloride, sulfate, total dissolved solids, siltation (turbidity), pathogen indicators, aluminum, beryllium, cadmium, copper, lead, zinc, mercury, priority organics, dissolved oxygen, pH, and temperature.

11.1.2 United States Geological Survey

The U.S. Geological Survey (USGS) has been monitoring several of the same sites that ADEQ monitors, as well as additional sites in the watershed. The USGS collects flow and water quality parameters total nitrogen, organic nitrogen, ammonia, nitrate, nitrite, ortho-phosphate, phosphate, total phosphorus, hardness, calcium, magnesium, sodium, chloride, sulfate, and fluoride. Data for the UIRW is available online at the USGS National Water Quality Assessment Data Warehouse (NAWQA; http://infotrek.er.usgs.gov/traverse/f?p=NAWQA:HOME:0).

11.1.3 ARKANSAS WATER RESOURCES CENTER

Historically, the AWRC has routinely collected water quality samples at two sites in the UIRW—Ballard Creek and Illinois River South of Siloam Springs. In 2009, the AWRC began collecting data at seven other sites. Funding for these sites must be renewed annually through the Arkansas Natural Resources Commission and EPA 319 funding. The AWRC analyses water samples for nitrate, sulfate, chloride, soluble reactive phosphorus, total phosphorus, dissolved ammonia, total nitrogen, total suspended solids, and turbidity.

11.2 Planned Monitoring Programs

11.2.1 LAND USE/LAND COVER

The landscape and water quality are clearly linked, and several studies have shown that land use and land cover (LULC) influence water quality, including physical, biological and chemical quality. Therefore, it is important to monitor changes in land use and land cover in the UIRW. The use of satellite imagery and geographic information systems (GIS) are specialized and evolving technologies that can determine land use and land cover across the UIRW. The land use categories have been simplified into forest, pasture, and urban for the HCU 12s, where these land use percentages are defined based on 2006 LULC imagery. The University of Arkansas Center for Advanced Spatial Technology (CAST) provided land use analyses for the HUC 12s within the UIRW. The IRWP will work with CAST or another qualified expert to consistently update LULC for the UIRW at least every five years.

Table 11.1. Existing monitoring stations and their location in the Upper Illinois River Watershed, northwest Arkansas.

Monitoring Site Location	ADEQ Station	USGS Station	AWRC Station
Baron Fork on County Road 21 near Dutch Mills	ARK0007A		
Illinois River @ HWY 59, south of Siloam Springs	ARK0006	07195430	Illinois River @AR59
Cincinnati Creek at Highway 244	ARK0141		
Illinois River near Savoy	ARK0040	07194800	Illinois River-Savoy
Flint Creek near West Siloam Springs	ARK0004A	07195855	Flint Creek-W. Siloam Springs
Osage Creek near Elm Springs	ARK0041	07195000	Osage Creek
Osage Creek at HWY 264 Bridge	ARK0155		
Clear Creek below Fayetteville	ARK0010C		
Osage Creek at Logan Arkansas	ARK0082		
Baron Fork at Dutch mills		07196900	Baron Fork
Niokasa Creek at Township at Fayetteville		07194809	Mud Creek Tributary
Illinois River at Hwy 16 near Siloam Springs		07195400	
Flint Creek at Springtown		07195800	Flint Creek-Springtown
Ballard Creek at County Road 76			Ballard Creek

11.2.2 WATER QUALITY

The long-term plan includes water quality monitoring that focuses on physical, biological and chemical conditions. Continuing to monitor water quality throughout the UIRW is the best way to evaluate the effectiveness of implemented BMPs, and to determine if the HUC 12 priorities are changing over time. A comprehensive water quality monitoring program was established by AWRC at the HUC 12 level, and the IRWP will adapt this program to measure water quality responses to implementation of BMPs.

A comprehensive water quality monitoring program should be established to monitor changes in water quality in the UIRW.

The water quality monitoring program will encompass the entire Illinois River drainage area in Arkansas, and the watersheds (HUC 12s) of the selected sites represent a myriad of land use from mostly residential development to that dominated by agriculture. The recommended water quality monitoring program is for water quality sampling and sample analysis at 25 sites (HUC 12 outlets) in the UIRW. Additional sites that bracket the effluent discharges could be added if funding is available. Key chemical parameters indicative of water quality and those considered on the 303 (d) list should be monitored. These parameters include chloride (Cl), nitrate as nitrogen (NO_3-N), soluble reactive phosphorus (SRP), total nitrogen (TN), total phosphorus (TP), turbidity, total suspended sediment (TSS), and bacteria (*E. coli).*

If the goal of the monitoring program is to measure water quality trends, then water samples should be collected 12 times a year with six samples collected during the critical season as defined between May 1st and September 30th; the other six samples should be collected during the primary season. Samples should be collected from the vertical centroid of flow (i.e., the center of the stream where water is well mixed) and analyzed at a certified water quality laboratory or following approved methods with standard quality assurance and quality control practices.

Discharge is an important stream characteristic and is essential for identifying trends in water quality.

Continuous discharge monitoring is expensive; however, for any free flowing stream, there is a specific relationship between depth of water and discharge. Wire weights should be installed at each monitoring site and discharge measurement taken three times a year to establish flow at each monitored sites. Installation of wire weights is approximately $3000 per site and each discharge measurement is approximately $1000, based on estimates from the USGS. With the help of Arkansas State Highway and Transportation Department wire weights should be installed on bridges and stage-discharge curves for each site should be developed with the via the AWRC, USGS or other qualified experts. The chemical concentrations may be related to discharge or depth, and flow-adjusted concentrations can be evaluated for trends over time.

If the goal of the monitoring program is to measure constituent loads, then water samples should be collected at least 12 times during base flow conditions on an approximate monthly basis with supplemental storm events sampled throughout the year. It is recommended that at least six additional water samples should be collected during storms throughout the year, such that these samples represent the range of discharge measured in the storm events. These monitoring sites would require a continuous discharge record in order to estimate loads, using regression techniques by qualified experts.

11.2.3 BIOLOGICAL MONITORING

In addition to measuring the chemical conditions, biological monitoring is also important for determining water quality conditions and trends (i.e., changes in this condition over time). Chemical conditions as well as physical disturbances such as increased discharge extremes, streambank failures, and lack of riparian corridors can influence the aquatic life in streams, which might make stream reaches within HUC 12s have altered aquatic communities. Biological monitoring will assist in determining if streams in the UIRW are meeting their designated uses, where certain species (e.g., organisms) and community metrics (e.g., Index of Biotic Integrity) should be used to evaluate the impact of chemical and physical conditions on aquatic life. The most commonly used bio-indicators for water quality are fish, macroinvertebrates, and algae, because these organisms provide a robust measure of the integrated chemical, physical, and biological conditions of the water body. These biota will provide insight into larger ecological processes that are important to ecosystem and watershed management, such as habitat, flow extremes, and changes in watershed land use. The role of streamside management or riparian zones in protecting and maintaining aquatic life use in these systems (i.e., UIRW) is critical.

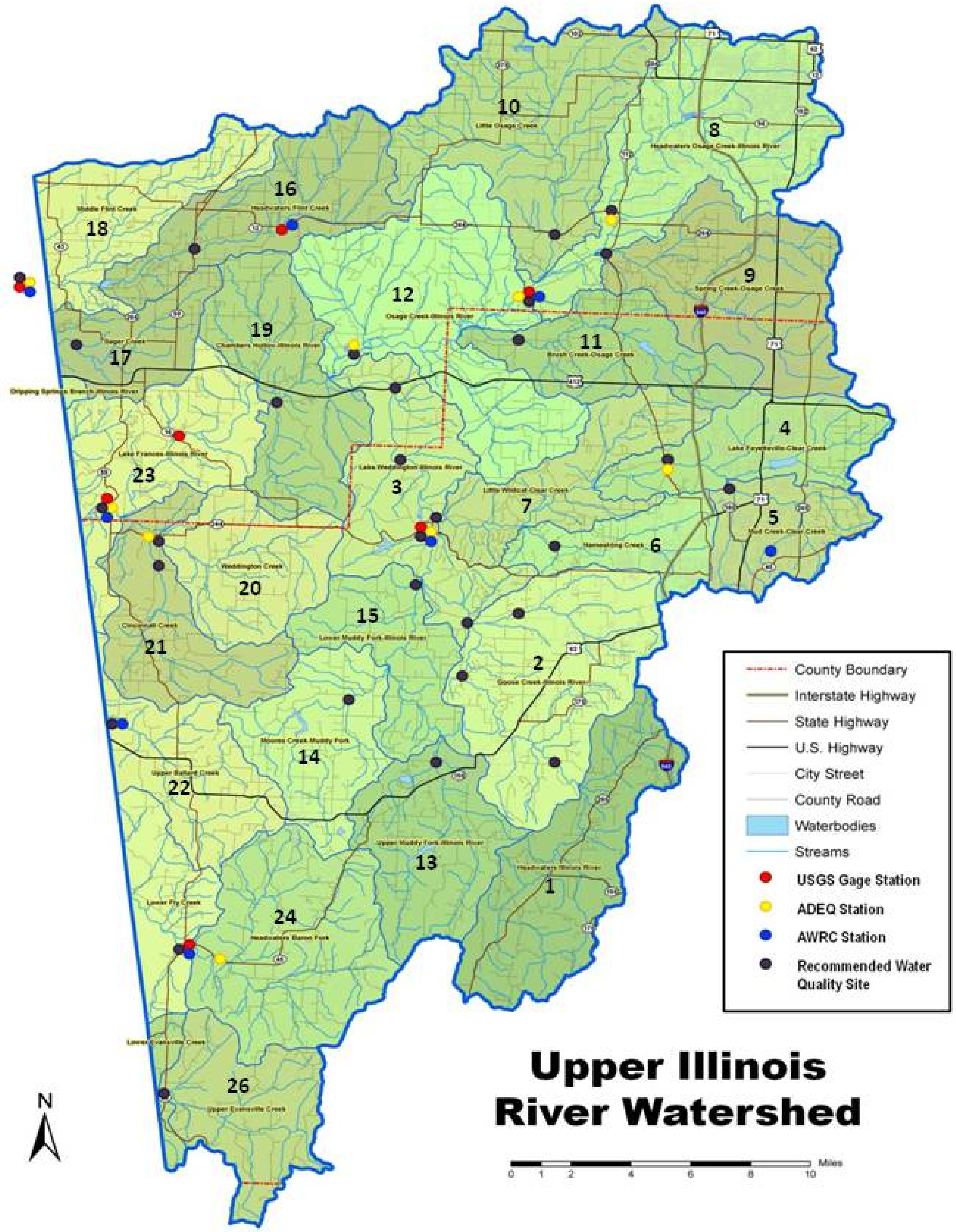


Figure 11.1. Existing and recommended water quality monitoring locations for the HUC12 program in the Upper Illinois River Watershed, northwest Arkansas

Biological sampling is needed to evaluate the aquatic life use of stream reaches.

Streams are composed of structural components that form functional units, where structure is defined as the composition of the biological community including the species, number of organisms, biomass, life history, and spatial distribution of the populations and function includes things like growth rates, respiration, photosynthesis, nutrient cycling, or other ecological processes. Structural and functional characteristics are both required to assess the water quality conditions of a stream when using bio-indicators. The most common approach to integrating structural and functional bio-indicators is Rapid Bioassesment Protocol (Barbour and others, 2002), which uses three different organisms that reflect different levels within the food chain (i.e., algae, macroinvertebrates and fish). Most studies evaluating the aquatic life beneficial use follow these guidelines, and ADEQ should be included in the design of any biological monitoring framework within the UIRW such that this data would be useful in the evaluation of the State's 303(d) list. The framework will target sample collection at least twice during a given year, where one biological sampling should be during the critical season (about May 1st to September 30th) and the other during the primary season (about October 1st though April 30th) per ADEQ Regulation 2; the biological monitoring will target one sampling during summer low flow, and one during elevated base flow in spring. The specifics of the biological monitoring program should be worked out based upon the available funding, but the established framework for biological monitoring should be used consistently so that meaningful comparisons between current and future bio-indicators can be determined. This biological monitoring should be implemented at least every five years, and the stream reaches selected should be in close proximity to sites used the water sampling program such that chemical conditions can easily be tied to biological conditions. It is feasible to rotate between a group of biological monitoring sites, where a subset of sites are monitored annually---this subset of sites should be set up to include sites characteristics of reference conditions (i.e., not impacted) as well as other sites that have increased chemical concentrations each year with some overlap in the sites.

It is also important to understand what nutrient is controlling algal growth in streams, especially if the biological conditions are found to be impaired because of excess algal growth. Passive diffusion periphytometers, a floating apparatus containing bottles that are filled with different solutions which might or might not influence algal growth; will measure the *in situ* (within the actual stream) response of periphyton to nutrient enrichment. Details on this method are available within the scientific literature, but it simply measures how chlorophyll content of algae increases in response to nitrogen and phosphorus enrichment of the solution in the bottles. The solution in the bottles diffuses out of the hole in the lid, which contains a glass fiber filter where the algae grow naturally. The tool gives the answer as to whether it is nitrogen or phosphorus controlling algal growth in the streams.

11.3 Budget

The following provides an estimate of annual budgets for existing and planned monitoring for the UIRW. In addition, potential funding sources are provided for each monitoring component with estimated budget. Budgets associated with water quality monitoring are usually project specific and variable over time.

Table 11.4. Estimated budget and potential funding source for existing and planned monitoring in the Upper Illinois River Watershed.

	No. of Sites	Estimated Annual Cost per Site[1]	Annual Total Cost[1]	Potential Future Funding Sources
ADEQ	8	Unavailable from ADEQ		EPA
USGS[2]	--	$21,000	TBD	ANRC, ADEQ, Cities
AWRC[3]	8	$20,300	$162,400	ANRC, Cities, Private Funds
Land Use	--	--	$10,000	ANRC, CREP, NRCS, Private Funds, Cities
HUC 12 Monitoring[2]	29	$5,800	$145,000	ANRC, CREP, NRCS, Private Funds, Cities
Biological Monitoring	TBD	$1,500	TBD	ANRC, CREP, NRCS, Private Funds, Cities

[1]Annual costs per site are variable based upon the number of sites and the number of water samples collected by each program; the larger the number of sites results in a reduced cost per site.
[2]Estimated cost based upon 6 samples per year at each site.
[3]Estimated cost based upon 52 samples per year at each site.

11.4 Schedule

Consistency in monitoring is key to making meaningful comparisons between historic, current and future water quality. While frequency of water sample collection may be dependent upon available funding, it is important to have a program that consistently collects the same number of samples each year.

11.4.1 ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY

ADEQ monitors their ambient water quality sites monthly.

11.4.2 UNITED STATES GEOLOGICAL SURVEY

The USGS records discharge instantaneously and samples for water quality parameters approximately six times a year, dependent upon annual funding availability.

11.4.3 ARKANSAS WATER RESOURCES CENTER

The AWRC collects samples at least once a week during base flow and storm flow conditions, dependent upon annual funding availability.

11.4.4 LAND USE

The LULC in the HUC 12s should be evaluated at least every five years or when appropriate satellite imagery is available for the UIRW, or Benton and Washington Counties in Arkansas. IRWP can coordinate with technical experts (e.g., CAST) to re-evaluate future land use.

11.4.5 COMPREHENSIVE WATER QUALITY MONITORING PROGRAM

The frequency of water sample collection may be dependent upon available funding, but it is important to have a program that consistently collects the same number of samples each year. It is recommended that 12 water samples be collected per year, with six collected during the critical season as defined between May 1st and September 30th and the other six collected during the primary season. IRWP should finalize and adopt the framework for a comprehensive monitoring plan by January 2011.

11.4.6 BIOLOGICAL MONITORING PROGRAM

Biological samples should be collected at least twice during a given year, where one biological sampling should be during the critical season (about May 1st to September 30th) and the other during the primary season (about October 1st though April 30th) per ADEQ Regulation 2; the biological monitoring will target one sampling during summer low flow, and one during elevated base flow in spring. The specifics of the biological monitoring program will be worked out based upon the available funding, but the established framework for biological monitoring should be used consistently so that meaningful comparisons between current and future bio-indicators can be determined. This biological monitoring should be implemented at least every five years, and the stream reaches selected should be in close proximity to sites used in the water sampling program such that chemical conditions can easily be tied to biological conditions. IRWP will finalize and adopt the framework for a comprehensive monitoring plan by January 2011.

11.4.7 EDUCATION AND OUTREACH PROGRAM

The UIRW is a rapidly changing landscape where water quality challenges, stakeholder composition, and public knowledge also change over time. An interactive review of what works/what is needed keeps outreach and education programs relevant and effective. Annually assess programs by asking the following:

1. What were the intended topics, target audiences, and program methods?
2. What has been conducted to engage and educate watershed stakeholders (outputs)?
3. What has/has not worked in those efforts?
4. What measurable goals were met (outcomes)?
5. What else should be done to meet IRWP's mission and objectives and address stakeholder knowledge gaps?
6. What complementary programs exist in the watershed and how can IRWP partner in those efforts?

If educators track measured changes in stakeholder knowledge and actions, and accompanying water quality improvements it should be easier to adaptively manage the watershed, garner sponsor support, and secure grant funds.

Assessment of Progress 12

12.1 Water Quality

The chemical concentrations from the water samples should be evaluated to determine if significant changes (increases↑ or decreases↓) are occurring over the defined time period. Evaluating changes in water quality is not as simple as determining if concentrations have increased or decreased over time, because other factors (e.g., discharge, season, etc.) may influence water quality concentrations. The variation in chemical concentrations with stream discharge needs to be removed to observe true changes in chemical concentrations over time. There are many techniques to evaluate trends that are defined in the scientific literature and water quality textbooks, but the simplest approach that is statistically sound is the best way to communicate these results to watershed stakeholders and even government agencies that need to demonstrate the beneficial effects and reduction efficiencies of BMPs. The trends detected in the water quality data represent simply the period of record used in the analyses, and this aspect should be kept in mind and clearly communicated when reporting trend results. The time period required to see significant changes in water quality is likely a function of how dramatic or subtle the change is. Trends in water quality should be evaluated in five years and then every few years or so thereafter by an experienced hydrologist or water-quality specialist.

Regarding biological monitoring, a baseline should be established at select sites to know what aquatic species comprise the current communities. These current aquatic communities should be evaluated against the water quality standards defined by ADEQ to determine if the beneficial use of aquatic life is being met. The Illinois River and its headwaters drain a watershed that has changed from its natural state, and this should be considered when evaluating the aquatic community.

12.2 Education and Outreach

The UIRW is a rapidly changing landscape where water quality challenges, stakeholder composition, and public knowledge also change over time. An interactive review of what works/what is needed keeps outreach and education programs relevant and effective. Annually assess programs by asking the following:

- What were the intended topics, target audiences, and program methods?
- What has been conducted to engage and educate watershed stakeholders (outputs)?
- What has/has not worked in those efforts?
- What measurable goals were met (outcomes)?
- What else should be done to meet IRWP’s mission and objectives and address stakeholder knowledge gaps?

- What complementary programs exist in the watershed and how can IRWP partner in those efforts?

If educators track measured changes in stakeholder knowledge and actions, and accompanying water quality improvements it should be easier to adaptively manage the watershed, garner sponsor support, and secure grant funds.

THE LOGIC MODEL. A logic model is a common program planning tool that illustrates the sequence of actions for a public awareness campaign or education program—what it will be composed of and how financial, programmatic, and time investments link to desired results. The logic model focuses on inputs (e.g., resources, contributions, investments that go into the program), outputs (e.g., activities, services, events and products that reach people who participate or who are targeted), and outcomes (e.g., results or changes for individuals, groups, communities, organizations, communities, or systems).

The evaluation of the education and outreach programs should focus on specific measures related to the desired outcomes from the program action, and these measures need to be quantitative in terms that it would be possible to show how outcomes (e.g., knowledge, behavior, or environmental conditions) have changed following the program action. There are several tools that can be repeated to evaluate changing in learning, actions, etc. such as distributed surveys, knowledge gap assessments, and stakeholder dialogues. The main point is that there needs to be some formal measure of how the program actions implemented from the education and outreach strategies have changed the watershed stakeholders.

12.3 What if the Strategy Doesn't Work?

Watershed management is complicated because of the myriad of factors that influence water quality. If the outlined strategy does not have positive effects on the quality of water in the UIRW, then the strategy as implemented should be reviewed and a new course of action established. A continuous comprehensive watershed monitoring project as described in Chapter 12 will identify areas within the watershed that are not improving as planned, and it is within these areas that the following questions should be asked:

1. Were the implemented BMPs properly installed had have they been maintained?
2. Were the selected BMPs appropriate for the water quality issue?
3. Are there new sources of pollution that were previously unknown?
4. Are voluntary BMPs enough or should other practices be considered?

Watershed based strategies should be adaptive to changing water quality conditions, land uses, and priorities.

Citations of Water Quality Studies that have been completed in the UIRW

Appendix-A

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HUC 12 Water Quality Monitoring Program

Appendix-
B

B.1 Quality Assurance Project Plan

B.2 Data Collection Dates

B.3 Summary of Collected Water Quality Data

B.1 Quality Assurance Project Plan

WATER QUALITY MONITORING AT THE HUC 12 LEVEL IN THE UPPER ILLINOIS RIVER WATERSHED

By

Arkansas Water Resources Center

QUALITY ASSURANCE PROJECT PLAN

1. Project/Task Organization

Sample collection and handling was the responsibility of the Arkansas Water Resources Center, where the collection procedures and sample maintenance was reviewed by the laboratory personnel upon receipt of the water samples. All analytical activities were performed by laboratory personnel under the supervision of the Lab Manager. The Director of the Center was responsible for supervising field technicians, lab technicians and quality assurance reviewer, data integrity, and reporting final results.

All results should be provided to any party providing funding for the development of the watershed management plan, including the IRWP, Walton Family Foundation, Arkansas Natural Resources Commission (ANRC) or the US Environmental Protection Agency (USEFP).

Organizational Structure

DIRECTOR AND PRIMARY INVESTIGATOR
Dr. Brian E. Haggard

PROJECT MANAGER
Leslie B. Massey

QUALITY ASSURANCE OFFICER
FIELD SERVICES TECHNICIAN
Stephanie M. Williamson

LAB SUPERVISOR
G. Keith Trost

LAB TECHNICIAN
Jennifer M. Purtle

FIELD SERVICES TECHNICIAN
L. Wade Cash

2. Project/Task Description

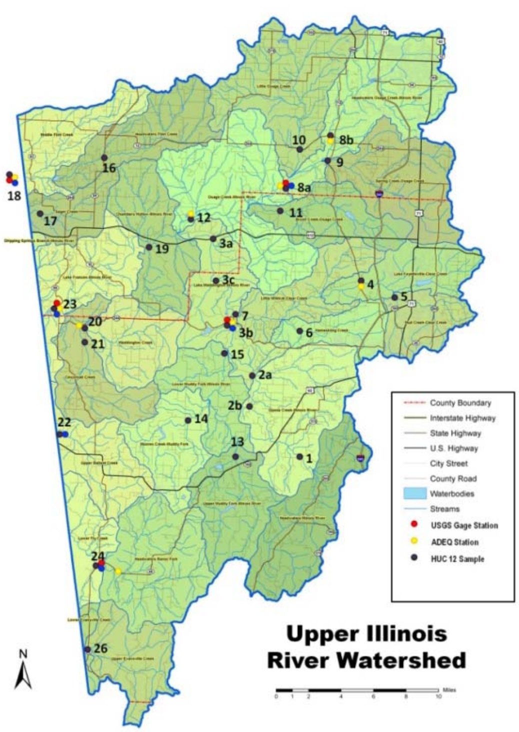
A watershed management plan was contracted for the Upper Illinois River Watershed (UIRW; HUC# 11110103). This 8-digit HUC was sub-divided into 28 smaller HUC 12s which were prioritized for watershed management and restoration activity in the Illinois River Watershed Management Strategy. The prioritization of the HUC 12s was based on the water quality data collected under this QAPP at 29 sites within the UIRW. The decision makers and principal customers for these results include: IRWP, ANRC, Walton Family Foundation, and USEPA.

This project was for water quality sampling and water sample analysis at 29 locations at the HUC12 outlets and the main stem of the Illinois River within the UIRW (See Figure 1). These parameters were analyzed in the collected water samples: nitrate-nitrogen (NO_3-N), sulfate (SO_4), chloride (Cl), fluoride (F), soluble reactive P (SRP), total P (TP), total N (TN), total suspended solids (TSS), total coliform, *E. coli*, and turbidity. The proposed monitoring program encompassed the entire Illinois River drainage area in Arkansas, and the catchments of the selected sites represent a myriad of land uses from mostly residential development to that dominated by pasture. The Arkansas Water Resources Center was responsible for collecting water samples and analyzing the data from collected samples.

All water samples were delivered to and analyzed by the Arkansas Water Resources Center Water Quality Laboratory (WQL) and The WQL followed EPA approved methods using standard laboratory quality assurance and quality control (QA/QC) measures during analyses. Duplicate samples were collected at a frequency of up to 10% throughout the duration of the project, and these duplicate water samples were collected in the same fashion as the original sample and then analyzed at the AWRC WQL for the same parameters.

Task Completion Schedule

Task	Completion Date (2009)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Routine Monitoring		X	X	X	X	X	X	X	X	X	X	
Sample Analysis		X	X	X	X	X	X	X	X	X	X	X



Number	Site Name
1	Illinois River @ County Road 20, 67 and 257
2a	Illinois River @ County Road 66
2b	Illinois River @ County Road 62 and 631
3a	Illinois River @ Highway 412
3b	Illinois River @ Highway 16
3c	Illinois River @ County Road 37
4	Clear Creek @ Highway 112
5	Clear Creek @ Gregg Street (Fayetteville)
6	Hamestring Creek @ County Road 842
7	Clear Creek @ County Road 845
8a	Osage Creek @ County Road 70 and 215
8b	Osage Creek @ Highway 112
9	Spring Creek @ Highway 112
10	Little Osage Creek @ Highway 264
11	Brush Creek @ County Road 60
12	Osage Creek @ Old Highway 68 or County Road 9
13	Upper Muddy Fork @ County Road 64 (Bush Street)
14	Moores Creek @ County Road 33
15	Lower Muddy Fork @ County Road 37
16	Flint Creek @ Highway 12
17	Sager Creek @ Dogwood Street (Siloam Springs)
18	Flint Creek @ West Siloam Springs, Oklahoma
19	Illinois River @ Chambers Hollow Road
20	Weddington Creek @ County Road 25
21	Cincinnati Creek @ County Road 25
22	Ballard Creek near Highway 62
23	Illinois River @ Highway 59
24	Baron Fork @ Highway 59
26	Evansville Creek @ Highway 59

Figure 1. Location of HUC 12 Sampling Sites within the Upper Illinois River Watershed.

3. Data Quality Objectives for Measurement Data

The purpose of this project was to collect 'real, measured' water quality data for the prioritization of HUC 12s. Water samples were collected using a Beta style horizontal sampler near the vertical centroid of flow. Water samples were collected during base flow and storm flow conditions beginning February 2009, and up to 18 samples were collected targeting 12 base flow samples and 6 storm flow samples.

Laboratory Parameters

The quality of data was sufficient to support specific decisions and interpretations. Comparability of data should be assured by using only EPA approved analytical procedures and reporting all data in the required units. The WQL has a separate quality assurance plan detailing the procedures used to evaluate precision and accuracy. The bacteria methods were evaluated by comparing lab results across the WQL, Beaver Water District, and the US Geological Survey. A separate proficiency test for bacteria was performed and results were acceptable.

Parameter	Source/Method	Units	PQL	% Recovery of outside Standards
Nitrate-Nitrogen	EPA/300.0	mg/L	0.01	±10%
Soluble Reactive Phosphorus	EPA/365.1	mg/L	0.01	±10%
Total Phosphorus	APHA 4500PJ	mg/L	0.02	±10%
Dissolved Ammonia	EPA/350.2	mg/L	0.10	±10%
Total Nitrogen	APHA 4500PJ	mg/L	0.10	±10%
Total Suspended Solids	EPA/160.2	mg/L	12.40	±10%
Turbidity	EPA 180.1	NTU	--	
Chloride	EPA/300.0	mg/L	0.35	±10%
Fluoride	EPA/300.0	mg/L	0.13	±10%
Sulfate	EPA/300.0	mg/L	0.14	±10%
Total Coliform	IDEXX Colilert	col/100 mL	--	
E. coli	IDEXX Colilert	col/100 mL	--	

Sample Handling

The precision and bias of sample handling was assessed using field blanks and field duplicates. The data quality objectives for sample handling are as follows:

QC test	Frequency	Results	Objective
Field blanks	Once per quarter	Accuracy bias	< 125% MDL
Field duplicates	10% of sampling	Standard Deviation	± 15% (except bacteria)

Eighty-five percent of samples must meet data quality objectives for sample analysis and sample handling.

Sampling

The water samples were collected using a Beta style horizontal sampler near the vertical centroid of flow, and water samples were collected at these 29 sites starting February 2009 targeting 12 base flow events and 6 storm flow events throughout CY 2009. The last water sample was collected in November 2009.

4. Special Training Requirements/Certification

The field service technicians of the Arkansas Water Resources Center collected all water samples using proper sample collection, sample handling, and sample custody procedures. The current technicians have been conducting this type of field work for over five years. All water samples were generally collected within the same period on each sampling data, and delivered to the WQL within acceptable time for bacterial analysis.

5. Documentation and Records

Sample collection information was documented, including date and time of collection, name of person collecting samples, and any problems encountered. All laboratory data was stored electronically and backed up on CD/RW disks once per week. In addition, paper copies of all data generated were stored in the lab and should be kept on file for up to six years.

6. Sampling Methods Requirements

The water samples were collected using a Beta style horizontal sampler near the vertical centroid of flow, i.e. middle of channel where water was actively moving. Water samples were collected at the 29 sites starting February 2009 and targeting 12 base flow samples and 6 storm flow samples. Collected samples were immediately transported to the WQL. The samples were filtered and acidified when appropriate by WQL employees and analyzed immediately or stored at 4 ^oC until analysis. Appropriate containers and holding times were used in sample processing, storage and analysis.

Sample bottles were decontaminated by rinsing, soaking in an acidified water bath for four hours, rinsing with tap water and finally rinsing with deionized water. Bottles were dried and stored with tops on until ready for use in the field. Lab containers were decontaminated according to the WQL quality assurance plan. Only sterile bottles were used for water samples that were analyzed for bacteria.

PARAMETER	HOLDING TIME	HANDLING	PRESERVATION
Nitrate-Nitrogen	2 days	Filtered, HDPE	Cool ≤6 ^oC
Sulfate	28 days	Filtered, HDPE	Cool ≤6 ^oC
Chloride	28 days	Filtered, HDPE	none
Fluoride	28 days	Filtered, HDPE	none
Soluble Reactive Phosphorus	2 days	Filtered, HDPE	Cool ≤6 ^oC
or	28 days	Filtered, HDPE	Cool ≤6 ^oC, H_2SO_4 , pH < 2
Total Phosphorus	28 days	HDPE	Cool ≤6 ^oC, H_2SO_4 , pH < 2
Dissolved Ammonia	28 days	Filtered, HDPE	Cool ≤6 ^oC, H_2SO_4 , pH < 2
Total Nitrogen	28 days	HDPE	Cool ≤6 ^oC, H_2SO_4 , pH < 2
Total Suspended Solids	7 days	HDPE	Cool ≤6 ^oC
Turbidity	2 days	HDPE	Cool ≤6 ^oC
Total Coliform	6 hours	PP	Cool 4^oC, $Na_2S_2O_3$
E. coli	6 hours	PP	Cool 4^oC, $Na_2S_2O_3$

7. Sample Handling and Custody Requirements

All samples were collected and possessed by WQL staff, and collected samples were immediately transported to the WQL with lids in place. The samples were split into an acidified portion, a non-acidified portion and a filtered portion, which were labeled and analyzed immediately or stored at 4 ^{o}C until analysis. All bacteria samples were collected in a separate, sterile container. Appropriate acids, containers and holding times were used in sample processing, storage and analysis within the WQL.

The field service technicians collected all samples in the field and documented anything needed. Samples were labeled immediately with a field identification number. Sample collection entries included field identification number, date and time of sample collection, name of person collecting samples, problems encountered and maintenance performed. Samples were transported from the field to the WQL by the person who collected the sample and were logged in as soon as delivered to the WQL. The log in sheets documented field identification numbers, date and time of sampling, corresponding lab identification numbers, date and time of log in, name of field technician and name of lab technician accepting samples. The WQL technicians were responsible for samples received at the laboratory after log in, and the WQL has its own chain of custody procedure and sample tags. The chain of custody followed the procedure described in the WQL quality assurance plan available upon request.

8. Analytical Methods Requirements

All procedures used for analyzing chemical and bacterial parameters of water quality for reporting purposes followed Standard Methods for the Examination of Water and Wastewater 16th edition or later, and USEPA approved methodology was also acceptable. Analytical methods are listed below, along with specific performance requirements. All analytical methods followed a specific standard operating procedure for each method as defined in the WQL quality assurance plan. The AWRC WQL should be responsible for taking corrective action in the event of any failure in the analytical systems.

Laboratory Parameters

Parameter	Source/Method	Units	PQL	HOLDING TIME
Nitrate-Nitrogen	EPA/300.0	mg/L	0.01	2 days
Sulfate	EPA/300.0	mg/L	0.14	28 days
Chloride	EPA/300.0	mg/L	0.35	28 days
Fluoride	EPA/300.0	mg/L	0.13	28 days
Soluble Reactive Phosphorus	EPA/365.1	mg/L	0.01	2 days
Or	EPA/365.1	mg/L	0.01	28 days*
Total Phosphorus	APHA/4500PJ	mg/L	0.02	28 days
Dissolved Ammonia	EPA/351.2	mg/L	0.10	28 days
Total Nitrogen	APHA/4500PJ	mg/L	0.10	2 days
Total Suspended Solids	EPA/160.2	mg/L	12.40	7 days
Turbidity	EPA/180.1	NTU	--	2 days
Total Coliform	EPA/9223	col/100 mL	--	6 days
E. coli	EPA/9223	col/100 mL	--	6 days

*Holding time is dependent upon preservation of collected sample

9. Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Sample bottles were decontaminated by rinsing, soaking in an acidified water bath for four hours, rinsing with tap water and finally rinsing with deionized water. Bottles were dried and stored with tops on until ready for use in the field; only sterile bottles were used for water sampled collected for bacterial analysis. All WQL equipment maintenance was conducted within the quality assurance plan, which is available upon request.

10. Validation and Verification Methods

The Arkansas Water Resources Center was responsible for collection of water quality samples, analysis of water quality samples, and compilation of the data and its analysis. The WQL was responsible for the chain of custody of the samples, validation and verification of the resulting data.

Data Validation

The integrity of the data generated was validated at several points during the collection and reporting process. The two principal check points are the laboratory quality control checks and the data processing checks made during the reporting of the data. (1) The laboratory control checks consisted of the use of field duplicates, laboratory duplicates, and laboratory spikes to monitor the levels of precision and accuracy of the collection and analytical processes. (2) The data processing checks assured the accurate transfer of the data from the laboratory report forms to the computer system. The data was checked after the initial data entry, a printout of the data stored in the computer was manually checked against the laboratory report forms.

Outliers

Outliers from the laboratory quality control checks indicated sampling or analytical problems. All samples in these out-of-control situations were reanalyzed or, if reanalysis was not possible, the data was, with the consent of the quality assurance officer, validated. All outliers from the data processing checks were checked against the laboratory report forms and or the raw data sheets.

Data Flow

Water samples were collected by field service technicians, and the field data identification number and certain other data were recorded on the sample tag and in a field notebook. All samples received in the laboratory followed the chain of custody procedure previously described in Element 7. All of the field data was transferred to the bench sheets where analytical data was recorded. Precision and accuracy of data checked and results were recorded with each data report. Data was reviewed for completeness and arithmetical errors and prepared for data processing.

Data Processing

Data was entered into a computer file, and a printout of entered data was manually checked against laboratory forms; data was scanned for out-of-range values. The data was then transferred to the project manager and Center Director, and the values were evaluated again. Only the data from water samples collected ruing base flow conditions were used to prioritize the HUC 12s. The geometric mean of the data from individual sample site was used in this prioritization scheme.

B.2 Data Collection Dates

Dates of water sample collection during base flow (e.g., low flow) conditions at each of the 29 sampling sites in the Upper Illionis River Watershed.

02/19/2009
02/26/2009
03/10/2009
04/09/2009
04/23/2009
04/27/2009
06/18/2009
07/07/2009
07/27/2009
08/31/2009
09/24/2009
11/05/2009

B.3 Summary of Collected Water Quality Data

Table B.3.1. Minimum, mean (geometric mean), maximum, and applicable criteria for chloride (mg L^{-1}) in water samples collected during base flow conditions at 29 sites in the Upper Illinois River Watershed during 2009.

Site	HUC Name	GPS Coordinates	n	Min mg L^{-1}	Mean mg L^{-1}	Max mg L^{-1}	Criteria mg L^{-1}
1	Headwaters Illinois	35°58'44"N 94°15'50"W	12	3.9	5.4	8.0	20
2a	Goose Creek-Illinois River	36°03'16"N 94°19'07"W	12	7.2	12.8	23.4	20
2b	Goose Creek-Illinois River	36°01'29"N 94°19'17"W	12	4.6	6.9	10.0	20
3a	Lake Wedington-Illinois River	36°10'15"N 94°25'44"W	12	6.2	8.8	12.7	20
3b	Lake Wedington-Illinois River	36°06'11"N 94°20'40"W	12	6.5	10.7	18.4	20
3c	Lake Wedington-Illinois River	36°08'06"N 94°21'29"W	12	6.4	9.0	13.4	20
4	Lake Fayetteville-Clear Creek	36°08'05"N 94°12'09"W	12	6.6	8.2	9.8	20
5	Mud Creek-Clear Creek	36°07'40"N 94°09'47"W	12	4.7	5.9	6.9	20
6	Hamestring Creek	36°06'01"N 94°16'60"W	12	7.0	8.7	11.0	20
7	Little Wildcat-Clear Creek	36°06'14"N 94°20'13"W	12	6.4	9.0	13.4	20
8a	Headwaters Osage Creek-Illinois River	36°13'20"N 94°17'14"W	12	23.5	36.1	52.9	20
8b	Headwaters Osage Creek-Illinois River	36°16'55"N 94°13'41"W	12	13.6	19.8	29.9	20
9	Spring Creek-Osage Creek	36°14'38"N 94°14'20"W	12	14.8	20.7	33.8	20
10	Little Osage Creek	36°15'14"N 94°16'14"W	12	5.3	6.4	7.6	20
11	Brush Creek-Osage Creek	36°11'56"N 94°16'02"W	12	5.4	6.3	7.0	20
12	Osage Creek-Illinois River	36°11'30"N 94°23'17"W	12	11.2	15.9	24.2	20
13	Upper Muddy Fork-Illinois River	36°08'05"N 94°12'09"W	12	5.2	7.7	14.1	20
14	Moores Creek-Muddy Fork	36°00'25"N 94°23'34"W	12	5.4	6.8	8.4	20
15	Lower Muddy Fork-Illinois River	36°04'12"N 94°20'55"W	12	6.0	9.1	13.2	20
16	Headwaters Flint Creek	36°14'33"N 94°29'13"W	12	6.2	7.2	8.4	20
17	Sager Creek	36°11'20"N 94°33'16"W	12	7.1	9.0	11.3	20
18	Middle Flint Creek	36°13'02"N 94°36'09"W	12	7.1	9.6	12.1	20
19	Chambers Hollow-Illinois River	36°10'00"N 94°26'02"W	12	9.2	12.5	20.3	20
20	Wedington Creek	36°05'27"N 94°30'17"W	12	7.9	9.4	10.3	20
21	Cincinnati Creek	36°04'41"N 94°30'17"W	12	6.8	8.7	11.0	20
22	Upper Ballard Creek	35°59'49"N 94°31'37"W	12	8.2	11.3	13.4	20
23	Lake Frances-Illinois River	36°06'31"N 94°32'00"W	12	8.4	11.9	20.1	20
24	Upper Baron Fork	35°52'48"N 94°29'12"W	12	5.3	7.2	10.5	20
26	Upper Evansville Creek	35°48'18"N 94°29'43"W	12	2.6	3.9	6.3	20

Table B.3.2. Minimum, mean (geometric mean), maximum, and applicable criteria for total nitrogen (TN; mg L^{-1}) in water samples collected during base flow conditions at 29 sites in the Upper Illinois River Watershed during 2009.

Site	HUC Name	GPS Coordinates	n	Min mg L^{-1}	Mean mg L^{-1}	Max mg L^{-1}	Criteria mg L^{-1}
1	Headwaters Illinois	35°58'44"N 94°15'50"W	12	0.16	0.74	3.35	NA
2a	Goose Creek-Illinois River	36°03'16"N 94°19'07"W	12	2.63	3.37	5.00	NA
2b	Goose Creek-Illinois River	36°01'29"N 94°19'17"W	12	0.44	1.59	2.87	NA
3a	Lake Wedington-Illinois River	36°10'15"N 94°25'44"W	12	1.74	2.20	4.57	NA
3b	Lake Wedington-Illinois River	36°06'11"N 94°20'40"W	12	1.33	2.34	3.69	NA
3c	Lake Wedington-Illinois River	36°08'06"N 94°21'29"W	12	1.97	2.29	4.88	NA
4	Lake Fayetteville-Clear Creek	36°08'05"N 94°12'09"W	12	0.04	1.28	2.04	NA
5	Mud Creek-Clear Creek	36°07'40"N 94°09'47"W	12	0.75	1.03	3.25	NA
6	Hamestring Creek	36°06'01"N 94°16'60"W	12	1.45	2.11	3.26	NA
7	Little Wildcat-Clear Creek	36°06'14"N 94°20'13"W	12	1.97	2.29	4.88	NA
8a	Headwaters Osage Creek-Illinois River	36°13'20"N 94°17'14"W	12	3.71	4.29	5.38	NA
8b	Headwaters Osage Creek-Illinois River	36°16'55"N 94°13'41"W	12	3.62	4.52	5.21	NA
9	Spring Creek-Osage Creek	36°14'38"N 94°14'20"W	12	2.59	3.99	4.76	NA
10	Little Osage Creek	36°15'14"N 94°16'14"W	12	2.91	4.50	5.71	NA
11	Brush Creek-Osage Creek	36°11'56"N 94°16'02"W	12	2.39	3.13	4.43	NA
12	Osage Creek-Illinois River	36°11'30"N 94°23'17"W	12	2.81	3.72	4.80	NA
13	Upper Muddy Fork-Illinois River	36°08'05"N 94°12'09"W	12	0.85	1.55	3.41	NA
14	Moores Creek-Muddy Fork	36°00'25''N9 4°23'34"W	12	0.46	1.18	2.36	NA
15	Lower Muddy Fork-Illinois River	36°04'12"N 94°20'55"W	12	1.62	2.22	5.11	NA
16	Headwaters Flint Creek	36°14'33"N 94°29'13"W	12	2.58	4.04	5.19	NA
17	Sager Creek	36°11'20"N 94°33'16"W	12	1.86	2.58	3.30	NA
18	Middle Flint Creek	36°13'02"N 94°36'09"W	12	0.81	2.15	4.21	NA
19	Chambers Hollow-Illinois River	36°10'00"N 94°26'02"W	12	2.32	2.97	3.47	NA
20	Wedington Creek	36°05'27"N 94°30'17"W	12	2.77	4.04	5.43	NA
21	Cincinnati Creek	36°04'41"N 94°30'17"W	12	1.81	3.19	5.15	NA
22	Upper Ballard Creek	35°59'49"N 94°31'37"W	12	2.10	2.94	4.02	NA
23	Lake Frances-Illinois River	36°06'31"N 94°32'00"W	12	1.45	2.89	5.00	NA
24	Upper Baron Fork	35°52'48"N 94°29'12"W	12	0.69	2.10	3.75	NA
26	Upper Evansville Creek	35°48'18"N 94°29'43"W	12	0.19	0.68	2.37	NA

Table B.3.3. Minimum, mean (geometric mean), maximum, and applicable criteria for nitrate as nitrogen (NO_3-N; mg L^{-1}) water samples collected during base flow conditions at 29 sites in the Upper Illinois River Watershed during 2009.

Site	HUC Name	GPS Coordinates	n	Min mg L^{-1}	Mean mg L^{-1}	Max mg L^{-1}	Criteria mg L^{-1}
1	Headwaters Illinois	35°58'44"N 94°15'50"W	12	0.01	0.21	1.14	NA
2a	Goose Creek-Illinois River	36°03'16"N 94°19'07"W	12	2.46	3.13	4.87	NA
2b	Goose Creek-Illinois River	36°01'29"N 94°19'17"W	12	1.11	1.49	1.79	NA
3a	Lake Wedington-Illinois River	36°10'15"N 94°25'44"W	12	1.53	1.95	2.49	NA
3b	Lake Wedington-Illinois River	36°06'11"N 94°20'40"W	12	1.79	2.32	2.67	NA
3c	Lake Wedington-Illinois River	36°08'06"N 94°21'29"W	12	1.72	2.04	2.49	NA
4	Lake Fayetteville-Clear Creek	36°08'05"N 94°12'09"W	12	1.33	1.63	1.83	NA
5	Mud Creek-Clear Creek	36°07'40"N 94°09'47"W	12	0.49	0.72	1.06	NA
6	Hamestring Creek	36°06'01"N 94°16'60"W	12	1.42	1.85	2.33	NA
7	Little Wildcat-Clear Creek	36°06'14"N 94°20'13"W	12	1.72	2.04	2.49	NA
8a	Headwaters Osage Creek-Illinois River	36°13'20"N 94°17'14"W	12	3.57	4.16	4.90	NA
8b	Headwaters Osage Creek-Illinois River	36°16'55"N 94°13'41"W	12	3.38	4.38	5.02	NA
9	Spring Creek-Osage Creek	36°14'38"N 94°14'20"W	12	3.41	3.90	4.40	NA
10	Little Osage Creek	36°15'14"N 94°16'14"W	12	3.42	4.58	5.32	NA
11	Brush Creek-Osage Creek	36°11'56"N 94°16'02"W	12	2.21	2.96	3.42	NA
12	Osage Creek-Illinois River	36°11'30"N 94°23'17"W	12	3.10	3.73	4.45	NA
13	Upper Muddy Fork-Illinois River	36°08'05"N 94°12'09"W	12	0.61	0.96	1.69	NA
14	Moores Creek-Muddy Fork	36°00'25"N9 4°23'34"W	12	0.34	0.65	1.29	NA
15	Lower Muddy Fork-Illinois River	36°04'12"N 94°20'55"W	12	1.27	1.91	2.68	NA
16	Headwaters Flint Creek	36°14'33"N 94°29'13"W	12	3.18	4.13	5.31	NA
17	Sager Creek	36°11'20"N 94°33'16"W	12	1.94	2.50	3.19	NA
18	Middle Flint Creek	36°13'02"N 94°36'09"W	12	0.71	2.17	4.21	NA
19	Chambers Hollow-Illinois River	36°10'00"N 94°26'02"W	12	2.05	2.86	3.34	NA
20	Wedington Creek	36°05'27"N 94°30'17"W	12	2.54	4.08	5.28	NA
21	Cincinnati Creek	36°04'41"N 94°30'17"W	12	1.62	3.11	4.22	NA
22	Upper Ballard Creek	35°59'49"N 94°31'37"W	12	2.00	2.83	3.75	NA
23	Lake Frances-Illinois River	36°06'31"N 94°32'00"W	12	1.95	2.68	3.30	NA
24	Upper Baron Fork	35°52'48"N 94°29'12"W	12	0.49	1.70	2.94	NA
26	Upper Evansville Creek	35°48'18"N 94°29'43"W	12	0.12	0.40	0.71	NA

Table B.3.4. Minimum, mean (geometric mean), maximum, and applicable criteria for total phosphorus (TP; mg L^{-1}) in water samples collected during base flow conditions at 29 sites in the Upper Illinois River Watershed during 2009.

Site	HUC Name	GPS Coordinates	n	Min mg L^{-1}	Mean mg L^{-1}	Max mg L^{-1}	Criteria mg L^{-1}
1	Headwaters Illinois	35°58'44"N 94°15'50"W	12	0.01	0.03	0.09	NA
2a	Goose Creek-Illinois River	36°03'16"N 94°19'07"W	12	0.04	0.10	0.20	NA
2b	Goose Creek-Illinois River	36°01'29"N 94°19'17"W	12	0.01	0.04	0.09	NA
3a	Lake Wedington-Illinois River	36°10'15"N 94°25'44"W	12	0.04	0.06	0.14	NA
3b	Lake Wedington-Illinois River	36°06'11"N 94°20'40"W	12	0.03	0.08	0.15	NA
3c	Lake Wedington-Illinois River	36°08'06"N 94°21'29"W	12	0.04	0.07	0.14	NA
4	Lake Fayetteville-Clear Creek	36°08'05"N 94°12'09"W	12	0.02	0.03	0.05	NA
5	Mud Creek-Clear Creek	36°07'40"N 94°09'47"W	12	0.03	0.05	0.09	NA
6	Hamestring Creek	36°06'01"N 94°16'60"W	12	0.02	0.05	0.09	NA
7	Little Wildcat-Clear Creek	36°06'14"N 94°20'13"W	12	0.04	0.07	0.14	NA
8a	Headwaters Osage Creek-Illinois River	36°13'20"N 94°17'14"W	12	0.08	0.10	0.14	NA
8b	Headwaters Osage Creek-Illinois River	36°16'55"N 94°13'41"W	12	0.05	0.10	0.27	NA
9	Spring Creek-Osage Creek	36°14'38"N 94°14'20"W	12	0.10	0.17	0.27	NA
10	Little Osage Creek	36°15'14"N 94°16'14"W	12	0.03	0.04	0.06	NA
11	Brush Creek-Osage Creek	36°11'56"N 94°16'02"W	12	0.02	0.03	0.07	NA
12	Osage Creek-Illinois River	36°11'30"N 94°23'17"W	12	0.06	0.09	0.13	NA
13	Upper Muddy Fork-Illinois River	36°08'05"N 94°12'09"W	12	0.03	0.05	0.09	NA
14	Moores Creek-Muddy Fork	36°00'25''N9 4°23'34"W	12	0.02	0.12	0.23	NA
15	Lower Muddy Fork-Illinois River	36°04'12"N 94°20'55"W	12	0.03	0.09	0.17	NA
16	Headwaters Flint Creek	36°14'33"N 94°29'13"W	12	0.05	0.07	0.08	NA
17	Sager Creek	36°11'20"N 94°33'16"W	12	0.03	0.07	0.14	NA
18	Middle Flint Creek	36°13'02"N 94°36'09"W	12	0.03	0.04	0.05	NA
19	Chambers Hollow-Illinois River	36°10'00"N 94°26'02"W	12	0.05	0.08	0.14	NA
20	Wedington Creek	36°05'27"N 94°30'17"W	12	0.05	0.07	0.11	NA
21	Cincinnati Creek	36°04'41"N 94°30'17"W	12	0.03	0.06	0.10	NA
22	Upper Ballard Creek	35°59'49"N 94°31'37"W	12	0.05	0.09	0.20	NA
23	Lake Frances-Illinois River	36°06'31"N 94°32'00"W	12	0.05	0.09	0.15	NA
24	Upper Baron Fork	35°52'48"N 94°29'12"W	12	0.04	0.06	0.10	NA
26	Upper Evansville Creek	35°48'18"N 94°29'43"W	12	0.01	0.02	0.05	NA

Table B.3.5. Minimum, mean (geometric mean), maximum, and applicable criteria for dissolved phosphorus (mg L^{-1}) in water samples collected during base flow conditions at 29 sites in the Upper Illinois River Watershed during 2009.

Site	HUC Name	GPS Coordinates	n	Min mg L^{-1}	Mean mg L^{-1}	Max mg L^{-1}	Criteria mg L^{-1}
1	Headwaters Illinois	35°58'44"N 94°15'50"W	12	0.00	0.01	0.02	NA
2a	Goose Creek-Illinois River	36°03'16"N 94°19'07"W	12	0.04	0.07	0.16	NA
2b	Goose Creek-Illinois River	36°01'29"N 94°19'17"W	12	0.01	0.02	0.03	NA
3a	Lake Wedington-Illinois River	36°10'15"N 94°25'44"W	12	0.02	0.04	0.07	NA
3b	Lake Wedington-Illinois River	36°06'11"N 94°20'40"W	12	0.01	0.04	0.09	NA
3c	Lake Wedington-Illinois River	36°08'06"N 94°21'29"W	12	0.03	0.04	0.07	NA
4	Lake Fayetteville-Clear Creek	36°08'05"N 94°12'09"W	12	0.01	0.02	0.03	NA
5	Mud Creek-Clear Creek	36°07'40"N 94°09'47"W	12	0.01	0.02	0.03	NA
6	Hamestring Creek	36°06'01"N 94°16'60"W	12	0.01	0.02	0.04	NA
7	Little Wildcat-Clear Creek	36°06'14"N 94°20'13"W	12	0.03	0.04	0.07	NA
8a	Headwaters Osage Creek-Illinois River	36°13'20"N 94°17'14"W	12	0.06	0.08	0.11	NA
8b	Headwaters Osage Creek-Illinois River	36°16'55"N 94°13'41"W	12	0.03	0.06	0.23	NA
9	Spring Creek-Osage Creek	36°14'38"N 94°14'20"W	12	0.10	0.16	0.25	NA
10	Little Osage Creek	36°15'14"N 94°16'14"W	12	0.02	0.03	0.05	NA
11	Brush Creek-Osage Creek	36°11'56"N 94°16'02"W	12	0.01	0.02	0.03	NA
12	Osage Creek-Illinois River	36°11'30"N 94°23'17"W	12	0.04	0.08	0.10	NA
13	Upper Muddy Fork-Illinois River	36°08'05"N 94°12'09"W	12	0.01	0.02	0.05	NA
14	Moores Creek-Muddy Fork	36°00'25"N9 4°23'34"W	12	0.02	0.06	0.13	NA
15	Lower Muddy Fork-Illinois River	36°04'12"N 94°20'55"W	12	0.02	0.06	0.09	NA
16	Headwaters Flint Creek	36°14'33"N 94°29'13"W	12	0.04	0.07	0.51	NA
17	Sager Creek	36°11'20"N 94°33'16"W	12	0.02	0.05	0.11	NA
18	Middle Flint Creek	36°13'02"N 94°36'09"W	12	0.02	0.03	0.05	NA
19	Chambers Hollow-Illinois River	36°10'00"N 94°26'02"W	12	0.03	0.06	0.09	NA
20	Wedington Creek	36°05'27"N 94°30'17"W	12	0.04	0.06	0.09	NA
21	Cincinnati Creek	36°04'41"N 94°30'17"W	12	0.03	0.05	0.07	NA
22	Upper Ballard Creek	35°59'49"N 94°31'37"W	12	0.02	0.05	0.13	NA
23	Lake Frances-Illinois River	36°06'31"N 94°32'00"W	12	0.03	0.05	0.09	NA
24	Upper Baron Fork	35°52'48"N 94°29'12"W	12	0.02	0.04	0.07	NA
26	Upper Evansville Creek	35°48'18"N 94°29'43"W	12	0.00	0.00	0.02	NA

Table B.3.6. Minimum, mean (geometric mean), maximum, and applicable criteria for turbidity (NTU) in water samples collected during base flow conditions at 29 sites in the Upper Illinois River Watershed during 2009.

Site	HUC Name	GPS Coordinates	n	Min NTU	Mean NTU	Max NTU	Criteria NTU
1	Headwaters Illinois	35°58'44"N 94°15'50"W	12	2.8	4.7	10.3	10
2a	Goose Creek-Illinois River	36°03'16"N 94°19'07"W	12	3.3	6.0	18.7	10
2b	Goose Creek-Illinois River	36°01'29"N 94°19'17"W	12	2.8	6.6	18.2	10
3a	Lake Wedington-Illinois River	36°10'15"N 94°25'44"W	12	3.9	6.9	22.3	10
3b	Lake Wedington-Illinois River	36°06'11"N 94°20'40"W	12	4.8	8.6	29.0	10
3c	Lake Wedington-Illinois River	36°08'06"N 94°21'29"W	12	3.0	6.8	24.9	10
4	Lake Fayetteville-Clear Creek	36°08'05"N 94°12'09"W	12	2.1	2.8	3.3	10
5	Mud Creek-Clear Creek	36°07'40"N 94°09'47"W	12	2.2	3.2	5.5	10
6	Hamestring Creek	36°06'01"N 94°16'60"W	12	1.9	4.8	9.4	10
7	Little Wildcat-Clear Creek	36°06'14"N 94°20'13"W	12	3.0	6.8	24.9	10
8a	Headwaters Osage Creek-Illinois River	36°13'20"N 94°17'14"W	12	2.1	3.5	6.4	10
8b	Headwaters Osage Creek-Illinois River	36°16'55"N 94°13'41"W	12	1.5	3.5	7.5	10
9	Spring Creek-Osage Creek	36°14'38"N 94°14'20"W	12	0.6	1.7	3.2	10
10	Little Osage Creek	36°15'14"N 94°16'14"W	12	3.6	6.2	47.9	10
11	Brush Creek-Osage Creek	36°11'56"N 94°16'02"W	12	1.3	2.3	4.9	10
12	Osage Creek-Illinois River	36°11'30"N 94°23'17"W	12	3.1	5.3	9.9	10
13	Upper Muddy Fork-Illinois River	36°08'05"N 94°12'09"W	12	2.9	5.8	13.4	10
14	Moores Creek-Muddy Fork	36°00'25''N9 4°23'34"W	12	3.4	9.4	19.8	10
15	Lower Muddy Fork-Illinois River	36°04'12"N 94°20'55"W	12	3.8	7.7	25.9	10
16	Headwaters Flint Creek	36°14'33"N 94°29'13"W	12	1.4	2.2	3.7	10
17	Sager Creek	36°11'20"N 94°33'16"W	12	2.0	5.7	21.6	10
18	Middle Flint Creek	36°13'02"N 94°36'09"W	12	1.4	2.8	4.5	10
19	Chambers Hollow-Illinois River	36°10'00"N 94°26'02"W	12	4.6	7.1	19.4	10
20	Wedington Creek	36°05'27"N 94°30'17"W	12	1.1	2.3	8.9	10
21	Cincinnati Creek	36°04'41"N 94°30'17"W	12	1.2	2.6	12.8	10
22	Upper Ballard Creek	35°59'49"N 94°31'37"W	12	2.7	4.9	9.6	10
23	Lake Frances-Illinois River	36°06'31"N 94°32'00"W	12	2.0	5.8	22.6	10
24	Upper Baron Fork	35°52'48"N 94°29'12"W	12	1.3	2.9	5.2	10
26	Upper Evansville Creek	35°48'18"N 94°29'43"W	12	0.9	2.4	8.0	10

Table B.3.7. Minimum, mean (geometric mean), maximum, and applicable criteria for bacteria (E. coli; colonies per 100 mL) in water samples collected during base flow conditions at 29 sites in the Upper Illinois River Watershed during 2009.

Site	HUC Name	GPS Coordinates	n	Min col 100 mL^{-1}	Mean col 100 mL^{-1}	Max col 100 mL^{-1}	Criteria col 100 mL^{-1}
1	Headwaters Illinois	35°58'44"N 94°15'50"W	12	33	164	1090	126, 630
2a	Goose Creek-Illinois River	36°03'16"N 94°19'07"W	12	148	361	921	126, 630
2b	Goose Creek-Illinois River	36°01'29"N 94°19'17"W	12	32	165	770	126, 630
3a	Lake Wedington-Illinois River	36°10'15"N 94°25'44"W	12	15	81	630	126, 630
3b	Lake Wedington-Illinois River	36°06'11"N 94°20'40"W	12	26	171	727	126, 630
3c	Lake Wedington-Illinois River	36°08'06"N 94°21'29"W	12	102	230	770	126, 630
4	Lake Fayetteville-Clear Creek	36°08'05"N 94°12'09"W	12	22	62	630	126, 630
5	Mud Creek-Clear Creek	36°07'40"N 94°09'47"W	12	13	44	200	126, 630
6	Hamestring Creek	36°06'01"N 94°16'60"W	12	43	185	488	126, 630
7	Little Wildcat-Clear Creek	36°06'14"N 94°20'13"W	12	25	168	1200	126, 630
8a	Headwaters Osage Creek-Illinois River	36°13'20"N 94°17'14"W	12	39	106	231	126, 630
8b	Headwaters Osage Creek-Illinois River	36°16'55"N 94°13'41"W	12	26	146	3100	126, 630
9	Spring Creek-Osage Creek	36°14'38"N 94°14'20"W	12	22	80	260	126, 630
10	Little Osage Creek	36°15'14"N 94°16'14"W	12	50	194	630	126, 630
11	Brush Creek-Osage Creek	36°11'56"N 94°16'02"W	12	28	107	520	126, 630
12	Osage Creek-Illinois River	36°11'30"N 94°23'17"W	12	11	109	1149	126, 630
13	Upper Muddy Fork-Illinois River	36°08'05"N 94°12'09"W	12	96	552	5935	126, 630
14	Moores Creek-Muddy Fork	36°00'25''N 94°23'34"W	12	53	853	6115	126, 630
15	Lower Muddy Fork-Illinois River	36°04'12"N 94°20'55"W	12	201	458	1300	126, 630
16	Headwaters Flint Creek	36°14'33"N 94°29'13"W	12	866	1962	12000	126, 630
17	Sager Creek	36°11'20"N 94°33'16"W	12	38	152	620	126, 630
18	Middle Flint Creek	36°13'02"N 94°36'09"W	12	2	48	200	126, 630
19	Chambers Hollow-Illinois River	36°10'00"N 94°26'02"W	12	29	102	750	126, 630
20	Wedington Creek	36°05'27"N 94°30'17"W	12	5	107	840	126, 630
21	Cincinnati Creek	36°04'41"N 94°30'17"W	12	86	303	9590	126, 630
22	Upper Ballard Creek	35°59'49"N 94°31'37"W	12	100	701	2980	126, 630
23	Lake Frances-Illinois River	36°06'31"N 94°32'00"W	12	10	75	630	126, 630
24	Upper Baron Fork	35°52'48"N 94°29'12"W	12	96	215	800	126, 630
26	Upper Evansville Creek	35°48'18"N 94°29'43"W	12	19	99	1220	126, 630