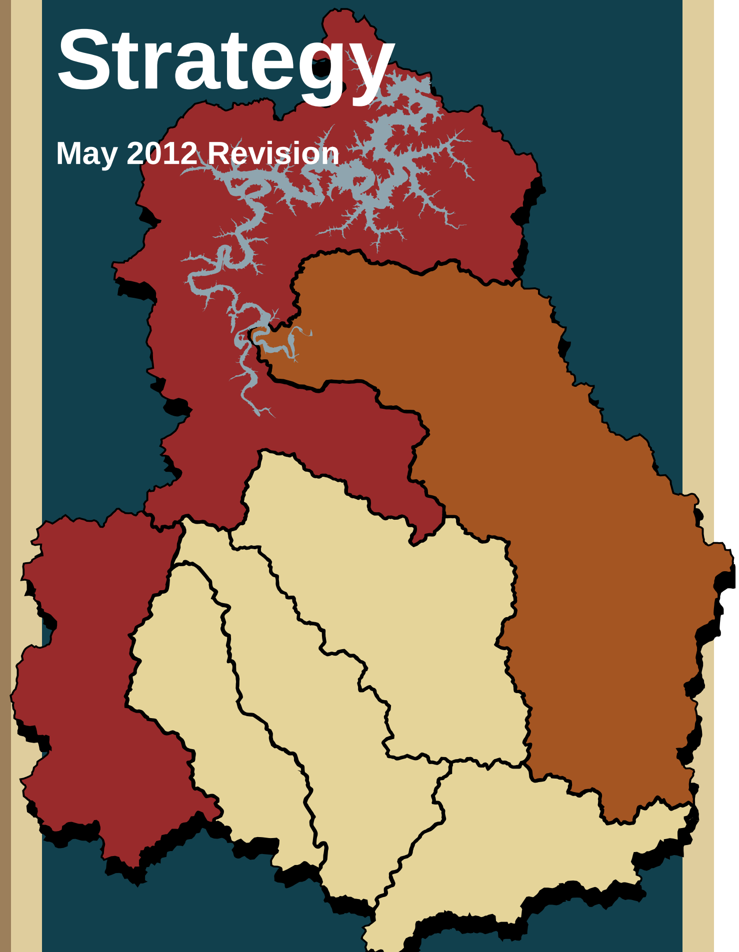




Beaver Lake Watershed Protection Strategy

May 2012 Revision



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Cover Page Photographs

Photograph Courtesy of Hawkins Aerial Photography – Movement of sediment south-to-north toward the dam in Beaver Lake following Spring 2011 rains. Lost Bridge, with clear water, is to the north and Rocky Branch, with sediment-laden water, lies to the south of County Road 920.

Photograph Courtesy of D. Neely – House on a karst limestone bluff above War Eagle Creek.

Photograph Courtesy of Beaver Water District – Brad Hufhines, a Beaver Water District lab technician, measures stream flow in the White River tributary of Beaver Lake to determine the capacity of the stream to assimilate pollutants, especially nutrients (BWD The Source Newsletter – Summer 2006).

Photograph Courtesy of Audubon Arkansas – Installation of a watershed kiosk at Riverside Park in West Fork, AR on May 12, 2007 (BWD The Source Newsletter – Summer 2007).

Photograph Courtesy of Beaver Water District –War Eagle Appreciation Day participants (http://www.bwdh2o.org/war-eagle-appreciation-day/).

ACKNOWLEDGEMENTS

Many individuals contributed their time, energy, and expertise to the development of the Final Report of the Beaver Lake Watershed Protection Strategy. Deserving special credit are members of the Policy Advisory Group, the Technical Advisory Group, and the Northwest Arkansas Council Board and staff.

Funding for the May 2012 revision was provided by the U.S. EPA and the Arkansas Natural Resources Commission via the Clean Water Act, Section 319(h).

(Note: The Policy Advisory Group was initially a 23-member advisory body formed for the development of the original watershed protection strategy. However, certain organizations and agencies had different primary members serving over the course of the project. In addition, some organizations had alternate members who served in the absence of their primary representatives. The 2012 revision process included original Policy and Technical Advisory Group members whenever possible, as well as new stakeholders in the watershed. The tables below list all Policy Advisory Group and Technical Advisory Group participants.)

Policy Advisory Group Participants

Member	Agency/Organization
Doug Timmons	Association for Beaver Lake Environment
Tony Miltich	Association for Beaver Lake Environment
Bob Morgan	Beaver Water District, Beaver Watershed Alliance
Bob Caulk	Fayetteville Natural Heritage Association, Beaver Watershed Alliance
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Ed Clifford	Bentonville Chamber of Commerce-Northwest Arkansas Council
Frank Winscott	Benton County Justice of the Peace
Dan Douglas	Benton County
Scott Borman	Benton/Washington Regional Public Water Authority
Scott Bounds	Benton/Washington Regional Public Water Authority
Richard Williams	Carroll County Judge
George Phillips (observer)	Carroll County
Mike Dodge	Carroll Electric
Susan Thomas	City of Fayetteville
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Patsy Christie	City of Springdale, Beaver Watershed Alliance

Hunter Haynes	Haynes Limited
Larry Garrett	Huntsville Wastewater Treatment Plant
Clarence Carson	Madison County Farm Bureau
Steven Ford	Madison County USDA Conservation Officer
Don Day	Northwest Arkansas Property Rights Association
Jeff Hawkins	Northwest Arkansas Regional Planning Commission
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Craig Smith	Prairie Creek Marina
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Larry Beals	Superior Industries
Tim Snell	The Nature Conservancy
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Henry Griffith	West Fork Environmental Protection Association
Jane Bryant	West Fork Watershed Alliance
Mike Faupel	University of Arkansas

Technical Advisory Group

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Robert Hart	Arkansas Department of Health
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Bob Morgan	Beaver Water District, Beaver Watershed Alliance
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Section 1

Introduction

1.1 Why Are These Protection Measures Needed?

Beaver Lake is the primary drinking water source for more than 350,000 Arkansans, and a major recreational destination for people interested in boating, fishing, swimming, and picnicking. As the principal water supply for the Northwest Arkansas region, the lake is recognized as a lifeline for current citizens and businesses, and for the projected growth of the region. People in Northwest Arkansas also enjoy the beauty of the lake – the large open water and surrounding hills. Beaver Lake is a key to the region's quality of life. Clean water and quality of life are at the top of the list for businesses looking to start-up or relocate, and help sustain the region's economic vitality.

Beaver Lake is recognized as a lifeline for current citizens and businesses and for projected growth.

A recent study (Kemper, 2008) by the University of Arkansas highlighted Beaver Lake's economic contribution to the region: approximately 2.5 million visitors spend about $43 million annually in the region surrounding the lake, with about $24.5 million of that captured in the local economy. The spending generates 600 jobs and approximately $13 million in income for the region.

People appreciate that most areas of Beaver Lake are clean the majority of the year and meet the State's water quality standards. However, the upper end of the lake is impacted by sediment and algae. This in turn affects drinking water quality, recreation, and aquatic habitat in the upper lake. For example, customers of the Beaver Water District regularly experience taste and odor problems in their water during September to October (and occasionally during other months of high algal production). Without responsible water quality protection measures, the projected growth and development in the watershed will likely worsen this and other problems.

Most areas of the lake are clean the majority of the year, however the upper lake area is impacted by sediment and algae.

Projected growth could also cause economic impacts. For example:

- Under a do-nothing scenario[1], there would be a 14 percent increase in algae-feeding nutrients to the lake. The Beaver Water District conducted a study to evaluate different methods to control taste and odor problems and their associated costs related to excessive algae. The recommended alternative had a capital cost of $42.2 million and an annual operating and maintenance cost of $790,000. While the public may wish to invest in these upgrades just to address existing taste and odor problems, the need would increase substantially with increases in algae growth. Other water suppliers may also need to upgrade their facilities to address taste and odor problems associated with increased nutrient loading and subsequent algae growth.

- Doing nothing[1] would result in a 21 percent increase in sediment load to the lake. It would also contribute to further erosion of stream banks along the tributaries that feed into the lake, and increase loss of property. This would add to the list of "impaired streams" in the watershed, increasing stream restoration requirements and costs.
- Neglecting water quality measures would also impact the lake's local tourism and recreation industry including revenue, jobs, and income.

Without responsible protection measures, growth will worsen these problems.

In an effort to proactively address the potential for problems and protect water quality, the Northwest Arkansas Council initiated the development of a Beaver Lake Watershed Protection Strategy.

1.2 How Was the Protection Strategy Developed?

The Council contracted with Tetra Tech to develop the Protection Strategy. Tetra Tech worked closely with a 23-member Policy Advisory Group (PAG) representing diverse interests and a Technical Advisory Group (TAG) throughout the lake protection planning process (see Acknowledgements Pages for lists of members). The PAG represented a wide variety of stakeholder groups from the public and private sectors including local elected officials, farmers, developers, water providers, landowners, large industries, property rights advocates, conservation groups, chambers of commerce, lake marinas, and planners. Although PAG Members were encouraged to consider issues from a watershed-wide perspective, they were also asked to represent the issues and concerns of their constituencies in the four counties of the watershed, as well as water users outside the watershed. In addition, Tetra Tech held more than 10 focus group meetings throughout the four-county area with key constituencies to gain input and gather additional information for the PAG to consider.

To proactively address potential problems and protect water quality, the Northwest Arkansas Council initiated development of the Beaver Lake Watershed Protection Strategy.

[1] The data for both of these estimates were generated using SWAT modeling analyses. The methodological description is given in the technical document titled "SWAT Model Recalibrations", with "do-nothing scenario" used synonymously with "2055 Scenario" (document can be accessed at http://www.beaverlakewatershedstrategy.com/index.php?option=com_content&view=article&id=46&Itemid=54). TetraTech, utilizing a modified modeling method, generated land use/land cover (LULC) estimates for the year 2055 based on LULC data from 2006. Sediment loading estimates were extrapolated utilizing the estimated LULC changes and known/measured water quality parameters.

Early on, the PAG established guiding principles, goals and objectives for the Beaver Lake Watershed Protection Strategy (see Figure 1-1 and Figure 1-2). The PAG served as a sounding board for watershed characterization results and possible solutions to existing water quality impairments and threats. Importantly, the PAG selected the elements of the protection strategy – the combination of water quality enhancement techniques – that are believed to be the best starting point for accomplishing the lake protection goals.

Guiding Principles

- Success depends on a technical foundation and community support
- Recommendations
  - Address specific issues
  - Support diverse economy
  - Be cost-effective
  - Respect private property rights
- Implement primarily through
  - Outreach and education
  - Stewardship
  - Resource management
  - Compliance with existing regulations

Figure 1-1. Guiding Principles

A diverse Policy Advisory Group and Technical Advisory Group worked throughout the lake protection planning process.

Tetra Tech also met with focus groups representing property rights advocates, livestock and poultry producers, poultry integrators, developers, drinking water utilities, environmental and conservation groups, recreational interests, and local governments. These meetings elicited valuable input about Beaver Lake, the water quality protection goals, and solutions. The results of these discussions were shared with the PAG in their deliberations.

The TAG reviewed research, water quality data, and other scientific and technical information and provided input on the most important technical issues related to watershed and lake protection. The TAG also provided advice on water quality indicators and targets, linked to the lake protection goals, to help evaluate different options.

Tetra Tech worked with technical partners to develop a watershed modeling tool and lake response modeling tool that could help to evaluate existing conditions and predict future conditions (year 2055) under current policies. These initial modeling results are collectively referred to as the Baseline Conditions Analysis (methodology described in "SWAT Model

Recalibration"). The modeling framework was subsequently used to predict future conditions under different water quality protection alternatives. Results were evaluated and reported in light of the lake protection goals and targets. Costs for different management techniques were reviewed and evaluated to screen for the most cost-effective solutions (analyses can be viewed in Technical Reports "Management Options Cost Effectiveness – Phase 1 and Phase 2").

The Beaver Watershed Alliance was formed in 2011 to facilitate implementation of the Protection Strategy and adopt measures as conditions change in the future.

The Policy Advisory Group selected a combination of water quality enhancement techniques that are believed to be the best starting point for meeting the lake protection goals.

Overarching Goals

Three overarching goals were the result of discussion and consensus-building among the Policy Advisory Group (PAG), which was the stakeholder group that assisted in development of the management plan. One of the stated goals of the group was to utilize watershed protection strategies that were voluntary and/or did not impose additional regulation on landowners or municipalities. If water quality continues to degrade in the watershed, it was assumed that additional costs for drinking water treatment and potential regulatory compliance would exceed the preventative strategies recommended in this Plan.

- Maintain a long-term, high-quality drinking water supply to meet present needs and continuing growth of the region.
- Restore water quality of impaired stream and lake areas (as listed on ADEQ's list of impaired waters).
- Minimize additional costs and regulations for people living and working in the watershed.

Objectives for Beaver Lake

- Minimize risks to public health and safety.
- Minimize taste, odor, and color problems in the public drinking water supplies.
- Minimize impact on water supply intakes and treatment operations.
- Meet long-term needs for water supply in the region.
- Maintain recreation enjoyment and ensure that recreation reflects environmentally sound stewardship of the lake.
- Restore water quality in impaired areas to meet water quality standards.
- Provide an economically priced water supply.

Figure 1-2. Overarching Goals

Finally, solutions were also screened that could do the "double duty" of protecting Beaver Lake and addressing existing impairment in the West Fork and Lower White subwatersheds. These subwatersheds have Total Maximum Daily Load sediment allocations, which require significant reductions from existing levels.

In summation, the Northwest Arkansas Council engaged diverse stakeholders throughout the process to ensure meaningful input and support, and conducted a technical analysis based on sound science and good engineering practices. The Beaver Lake Watershed Protection Strategy presented in the following sections is a starting point for action. While receiving broad support, it is recognized that the strategy is not fully endorsed by every stakeholder group. Continuing to work with stakeholders to find solutions that address environmental, economic, and social concerns in the region remains important. The PAG recommended that a new group (a Watershed Council) be formed locally to help facilitate the implementation of the Watershed Protection Strategy and adapt the protection measures in the future as conditions change.

The Technical Foundation for the Beaver Lake Watershed Protection Strategy

This Beaver Lake Watershed Protection Strategy is built on a strong technical foundation of quality assured assessments and reports. This document is intended to synthesize the main findings and recommendations of the technical reports in a way that is more inviting and understandable to most readers. For readers who would like more detailed information regarding the project's technical foundation, please contact the Northwest Arkansas Council and request one or more of the following documents:

- Beaver Lake SWAT Model Recalibration, February 12, 2009, Tetra Tech
- Beaver Lake Watershed Baseline Analysis – Supplemental Pollutant Loading Analysis, February 16, 2009, Tetra Tech
- Beaver Lake Watershed Water Quality Targets/Benchmarks Analysis, February 18, 2009, Tetra Tech.
- Management Option Cost-Effectiveness Phase I, March 13, 2009, Tetra Tech
- Management Option Cost-Effectiveness Phase II, March 20, 2009, Tetra Tech
- Onsite Wastewater Analysis, November 13, 2008, Tetra Tech

1.3 Development of the 2012 Revision

In Spring 2012, the Beaver Watershed Alliance (formed following the recommendations in the original 2009 Beaver Lake Watershed Protection Strategy) solicited the original PAG and TAG organizations to revise and update the Strategy. The goal of the 2012 revision is to (a) address gaps identified in the 2009 document and (b) facilitate and clarify correlation with the 9 Elements identified in the U.S. EPA's Handbook for Developing Watershed Management Plans to Restore and Protect Our Waters (2008). The PAG and TAG members reconvened to suggest revisions, discuss the relevancy of the document, and to inform the Beaver Watershed Alliance of new and emerging issues on the watershed.

Funding for the 2012 revision of the Beaver Lake Watershed Protection Strategy was provided by the U.S. EPA and the Arkansas Natural Resources Commission.

1.4 The EPA's 9 Elements for Watershed Management Plan Development

The Beaver Lake Watershed Protection Strategy was developed using guidance from the U.S. EPA's Handbook for Developing Watershed Management Plans to Restore and Protect Our Waters (2008). Throughout the document, the reader can find references to the 9 Elements in the margins (highlighted in green text) corresponding to the text in the Strategy that addresses a specific EPA element. Additionally, the appendices contain a detailed and expanded cross-reference table of the 9 Elements with information on how the Protection Strategy addresses those elements and where the topics may be found in the document itself. For a quick reference, see Table 1.1.

References to the EPA's 9 Elements for Watershed Management Plan Development can be found in the margins in green text.

Table 1-1. EPA 9 Element - Beaver Lake Watershed Protection Strategy Component Correlation Quick Reference

Note – EPA Watershed Management Plan Elements in first column are linked to an expanded correlation table in Appendix D.

Required EPA 319 Element	Quick Reference Listing: BLWSPS Report Content Correlation to EPA 9		BLWSPS Report Section Description	ADDITIONAL REFERENCE DOCUMENT(S)
	PAGE	SECTION/TITLE		
a. Impairment Cause and Source Identification	16 - 21	**Section 2.3:** Existing and Future Loading to the Lake	**Section 2.3:** Existing and Future Loading to the Lake for a discussion of causes and sources.	"Beaver Lake SWAT Modeling Baseline Analysis" "Supplementary Pollutant Loading Analysis" technical document
	B-3	**Tables B-1 and B-2.** Core Voluntary BMPs and Estimated Total Sediment for the West Fork and Lower White River Reporting Subwatersheds	**Tables B-1 and B-2** in this **Appendix (B)** include estimated stream lengths and land acres with management opportunities	
b. Load Reduction Estimates Expected Per Management Measures	B-3	**Tables B-1 and B-2.** Core Voluntary BMPs and Estimated Total Sediment for the West Fork and Lower White River Reporting Subwatersheds	**Tables B-1 and B-2** in this **Appendix (B)** include estimated load reductions to be achieved through management measures.	"Cost-Effectiveness of Management Option – Phase 1" technical document
c. NPS Management Measures Descriptions and Critical Implementation Areas Identifications	37 - 50	**Section 4.2.2: #2.** Core Best Management Practices	**Section 4.2.2 #2.** Core Best Management Practices for descriptions of NPS management measures and maps of critical areas.	
d. Technical/Financial Assistance and Associated Costs Estimates and/or Implementation Plan Support Sources and Authorities.	37 - 57	**Section 4.2:** Five Components of Protection Strategy	**Section 4.2** Five Components of Protection Strategy and Appendix A for cost information; See **Section 5** Beaver Lake Watershed Protection Implementation Summary for potential sources of funding and assistance.	
	A1-11	**Appendix A**		
	61 - 73	**Section 5:** Beaver Lake Watershed Protection Implementation Summary		
e. Public Information & Education Component	37 - 50	**Section 4.2.2: #2.** Core Best Management Practices	See **Section 4.2.2 #2** Core Best Management Practices, **Section 4.2.3 #3** Developer and Contractor Lake Protection Certification Program and **Section 4.2.4 #4** Education and Stewardship Program for training, education, and outreach components.	
	50 - 53	**Section 4.2.3: #3** Developer and Contractor Lake Protection Certification Program		
	53	**Section 4.2.4: #4** Education and Stewardship Program		

Required EPA 319 Element	Quick Reference Listing: BLWSPS Report Content Correlation to EPA 9		BLWSPS Report Section Description	ADDITIONAL REFERENCE DOCUMENT(S)
f. NPS Management Measures Implementation Schedule	61 – 73 70 - 73	**Section 5:** Watershed Implementation Timeline **Table 5-2.** Beaver Lake Watershed Protection Strategy Implementation Timeline	**Section 5** Watershed Implementation Timeline **Table 5-2.** Beaver Lake Watershed Protection Strategy Implementation Timeline: Assuming five-year Adaptive Management cycle beginning January 2012 or at hiring of Council Executive Director	"Beaver Lake Water Quality Targets and Benchmark Analysis"
g. Interim "Milestone" Descriptions for NPS Management Measures Implementation				
h. Loading Reductions Achievement and Water Quality Standards Attainment Progress Criteria	21 - 25	**Section 2.4:** Water Quality Targets	**Section 2.3** Water Quality Targets for a discussion of criteria to measure progress.	"Beaver Lake Water Quality Targets and Benchmark Analysis"
i. Temporal Implementation Effort Efficacy Monitoring Component	54 - 59	**Section 4.2.5: #5** Monitoring and Adaptive Management	**Section 4.2.5** #5 Monitoring and Adaptive Management	

Section 2

Description of the Watershed

2.1 Watershed Size, Location, and Natural Features

Beaver Lake is located in the Ozark Highlands of northwest Arkansas's Benton, Carroll, and Washington counties in the headwaters of the White River. The U.S. Army Corps of Engineers constructed the multipurpose reservoir in the mid-1960s for flood control, generation of hydroelectric power, and public water supply. The Beaver Lake watershed is 1,192 square miles, and includes portions of Benton, Carroll, Washington, and Madison counties and 17 incorporated municipalities or villages (see Figure 2-1). A small fraction of the watershed lies in Crawford and Franklin counties. As defined by the PAG, the watershed was defined as only the tributaries/reservoir located upstream from the Beaver Lake Dam. This management plan was analyzed at the 10-digit HUC scale, which included 1101000101 (Headwaters - White River), 1101000102 (Middle Fork – White River), 1101000103 (Lake Sequoyah – White River), 1101000104 (West Fork – White River), 1101000105 (Richland Creek), 1101000106 (War Eagle Creek), 1101000107 (Beaver Lake – White River).

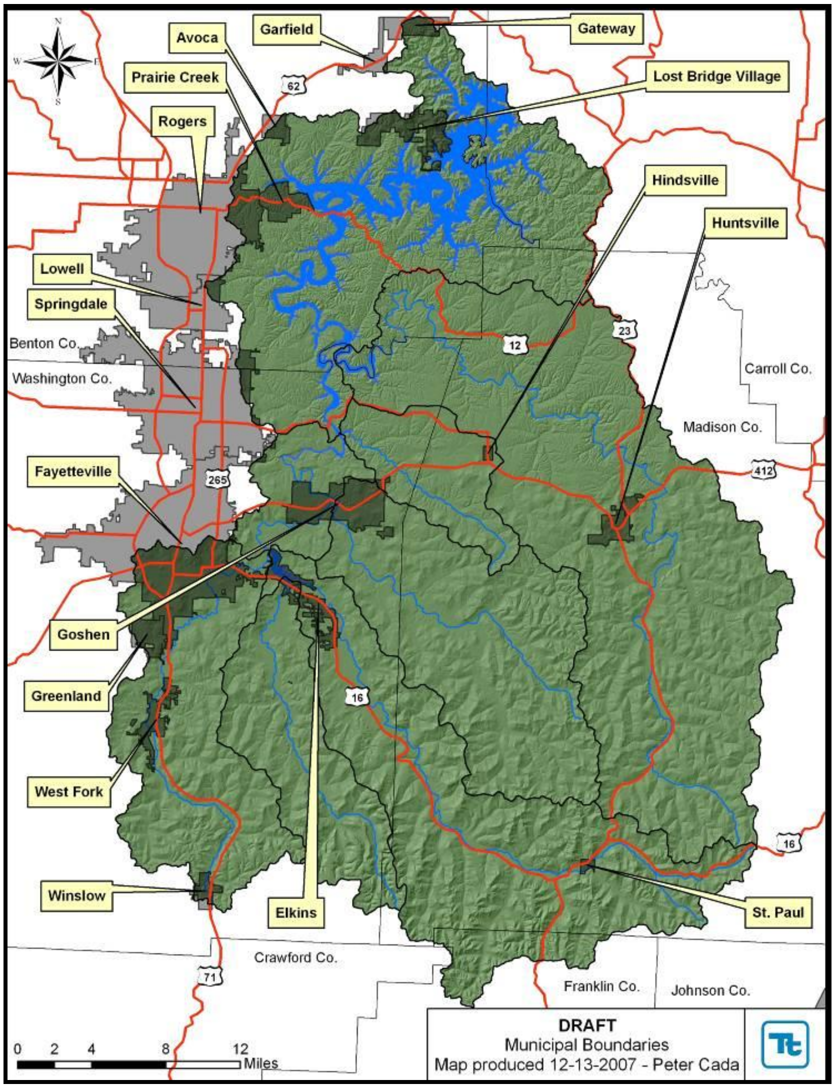


Figure 2-1. Beaver Lake Watershed Local Jurisdictions, includes HUC's 1101000101 (Headwaters - White River), 1101000102 (Middle Fork – White River), 1101000103 (Lake Sequoyah – White River), 1101000104 (West Fork – White River), 1101000105 (Richland Creek), 1101000106 (War Eagle Creek), 1101000107 (Beaver Lake – White River).

Major streams in the watershed draining to the lake include the White River, War Eagle Creek, Richland Creek, and Brush Creek. These were divided into eight subwatersheds for the purposes of evaluating existing and future watershed conditions and developing the Protection Strategy (see Figure 2-2).

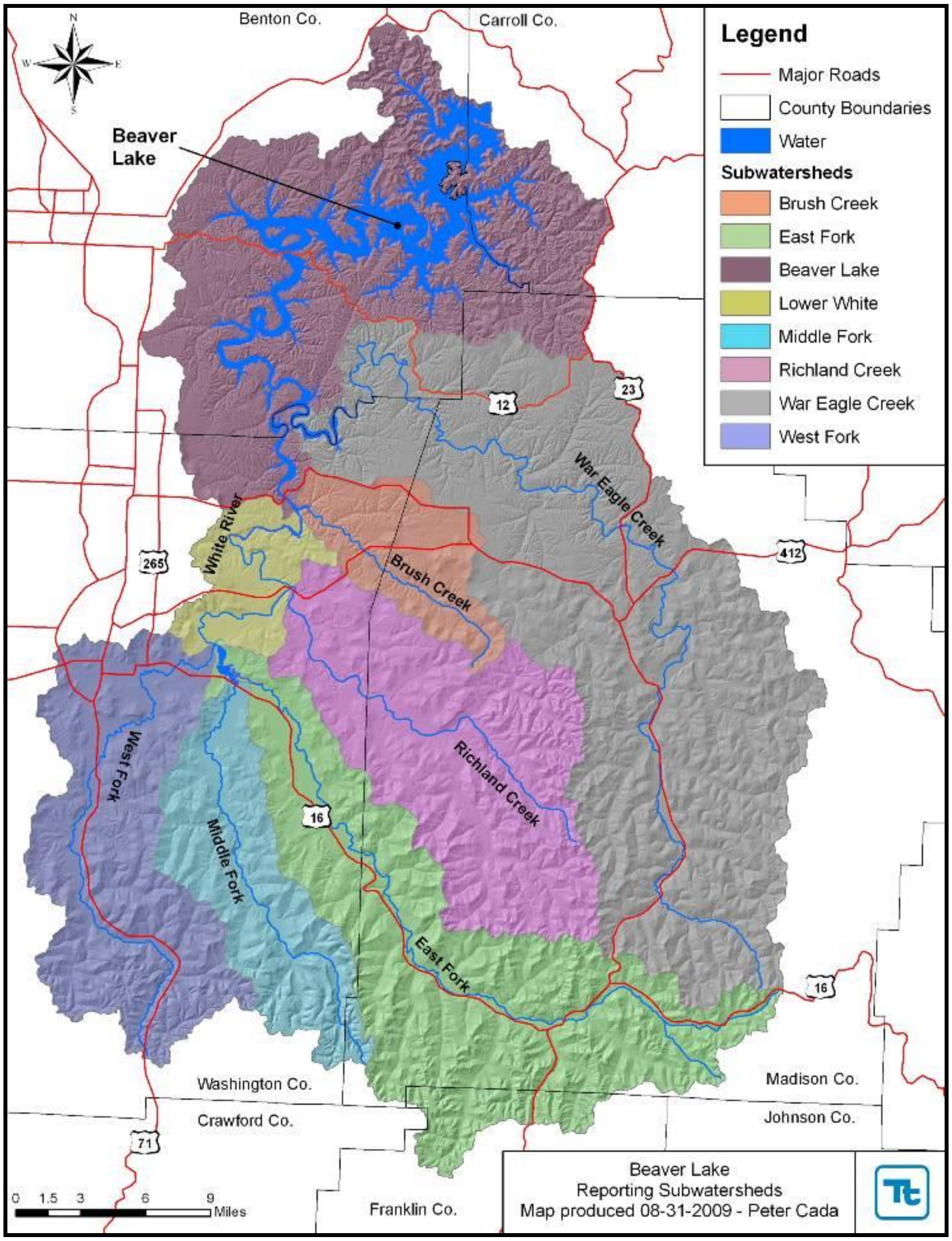


Figure 2-2. Beaver Lake Subwatersheds

The surface area of the lake covers approximately 44 square miles and its length is about 50 miles. The lake contains, on average, 539 billion gallons of water. The depth of the lake at the dam is about 200 feet, but average depth throughout the lake is 60 feet. The mean retention time for water in the reservoir is 1.5 years (i.e., the time for water to move from the upper lake to the lower lake and flow through the dam). Operated by the Corps of Engineers as part of a chain, Beaver Lake is the most upstream and youngest in the series of major reservoirs on the White River mainstem.

Beaver Lake is the most upstream and youngest in the series of major reservoirs on the White River mainstem.

Downstream from Beaver Lake are Table Rock Lake, Lake Taneycomo, and Bull Shoals Lake.

One striking feature of the watershed is its steep topography.

One of the striking features of the watershed is its relatively steep topography: 41 percent of the Beaver Lake subwatershed nearest the lake, 40 percent of the East Fork drainage area, and 29 percent of the Middle Fork subwatershed are classified as having moderate to steep slopes (12 percent slope or higher). The soils in the watershed also can pose challenges for new development. Over 45 percent of the watershed is ranked moderate to severe in soil erosion hazard potential and over 78 percent of the watershed is considered very limited for conventional septic system suitability. The presence of highly porous karst topography in the watershed presents special challenges to water quality protection.

Soils in the watershed can pose challenges for new development.

In recent years, the Northwest Arkansas region has been the fastest growing area of the state—led by the Fayetteville-Springdale-Rogers Metropolitan Area located along the western boundary of the watershed. The regional planning agency and cities provided projections of future planned municipal boundaries (i.e., planning area boundaries). The current municipal area within the watershed is the solid red in Figure 2-3. The red cross-hatched area represents the future municipal boundaries and a quadrupling of municipal area in the coming decades (20 to 30 years). (Note: Official projections were not obtained for the City of Huntsville. Therefore a 2-mile radius around the City was used reflecting a typical planning area boundary. This corresponds to projected population and impervious area data.)

Where will the people live? How is the land currently used and how will it be used in the future? What are the implications for lake water quality? The following subsections answer these questions.

In recent years, the Northwest Arkansas region has been the fastest growing area of the State.

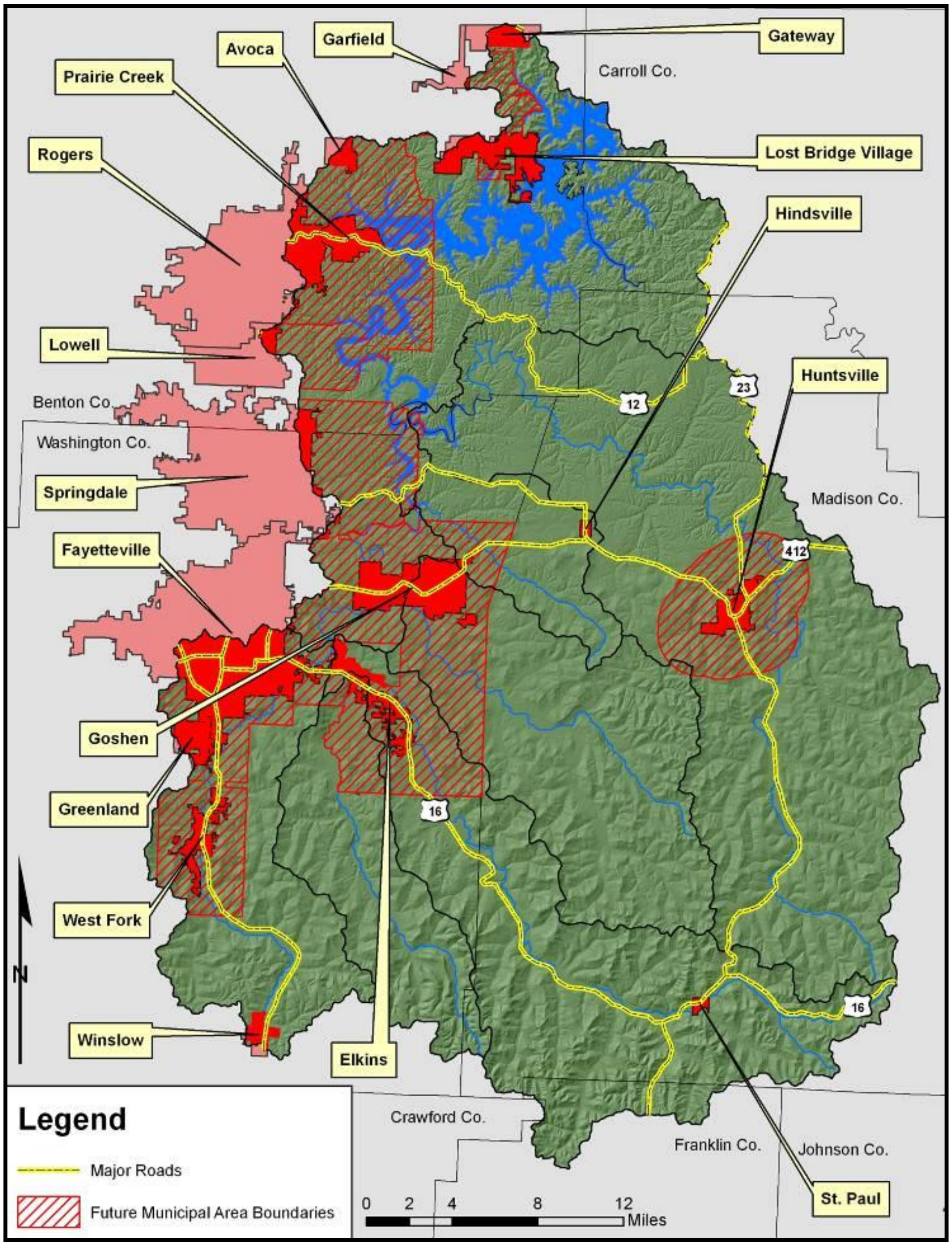


Figure 2-3. Comparison of Existing and Planned Future Municipal Boundaries

Planning projections show a quadrupling of existing municipal area in the coming decades.

LAND USE AND LAND COVER

Where do people live now in the watershed and where will new houses be built in the future? Figure 2-4 compares population density in the year 2000 with projections for 2055 based on data from the Beaver Water District. Population is expected to grow by more than 80 percent in the coming decades, with the majority of people living in the planned municipal areas and around Huntsville.

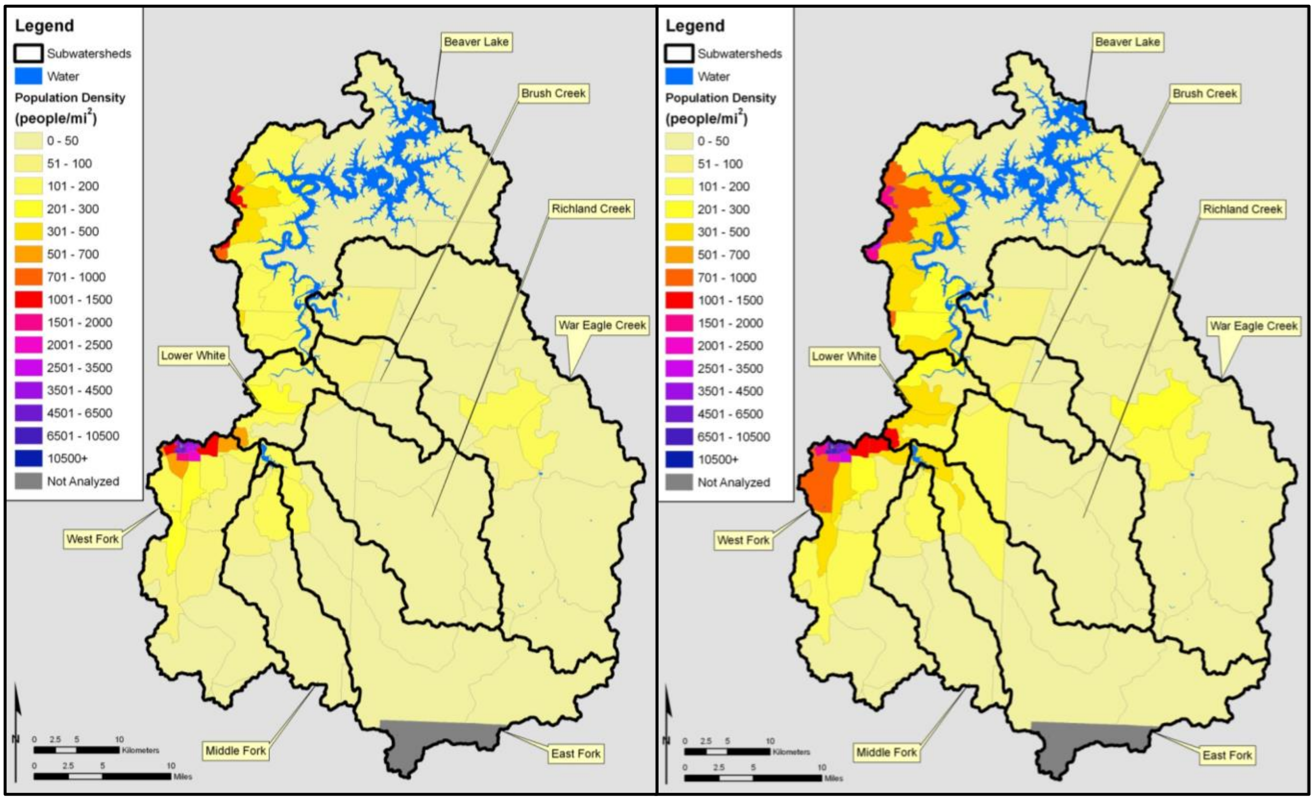


Figure 2-4. Comparison of 2000 and Projected 2055 Population Densities

Population in the watershed is expected to grow by more than 80 percent in the coming decades.

Local planners provided information about the types of future development expected in the watershed, based on existing land use plans and trends. Existing land use/land cover conditions were also supplied by the University of Arkansas' CAST Department, and baseline population statistics were from Census 2000. That information was used to estimate the amount of future impervious area (e.g., rooftops, driveways, streets, parking areas) in the watershed. Impervious areas are important because they channel rainfall quickly into streams, causing bank erosion and sediment inputs to the lake. Figure 2-5 compares the percentage of impervious area in 2001 and 2055. Impervious areas of 12 percent or less are shown in shades of green on the maps. Based on studies conducted by the Center for Watershed Protection and other groups, when watersheds have greater than 10 percent impervious area most indicators of stream water quality decline (Center for Watershed Protection, 2003). In some watersheds, degradation begins with as little as 5 or 6 percent imperviousness. Severe degradation is typically found in watersheds approaching 25 to 30 percent imperviousness or greater (shown in the orange, red, and purple tones). Figure 2-5 demonstrates that there is expected to be a significant growth in this level of imperviousness in the western portion of the watershed and the Huntsville area, coinciding with the growth in the municipal planning areas.

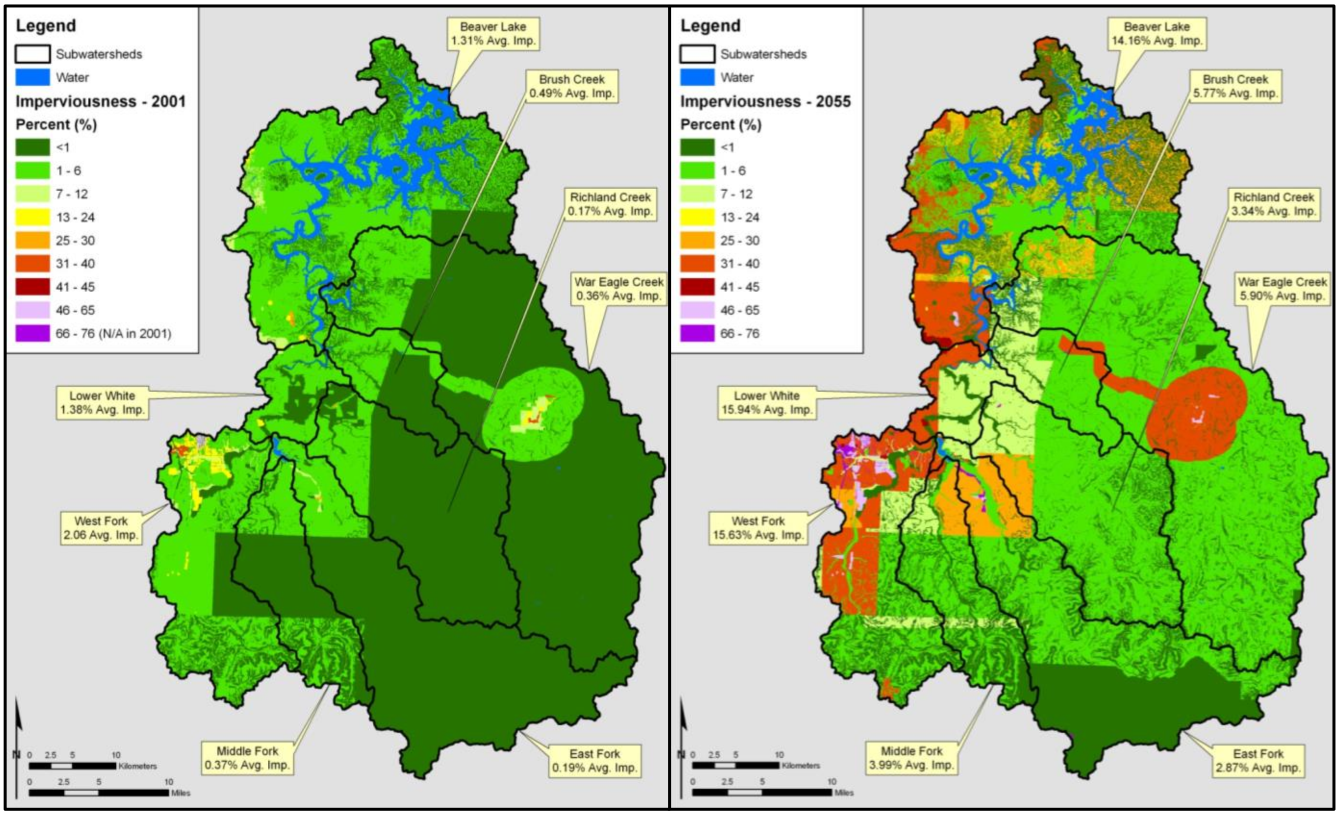
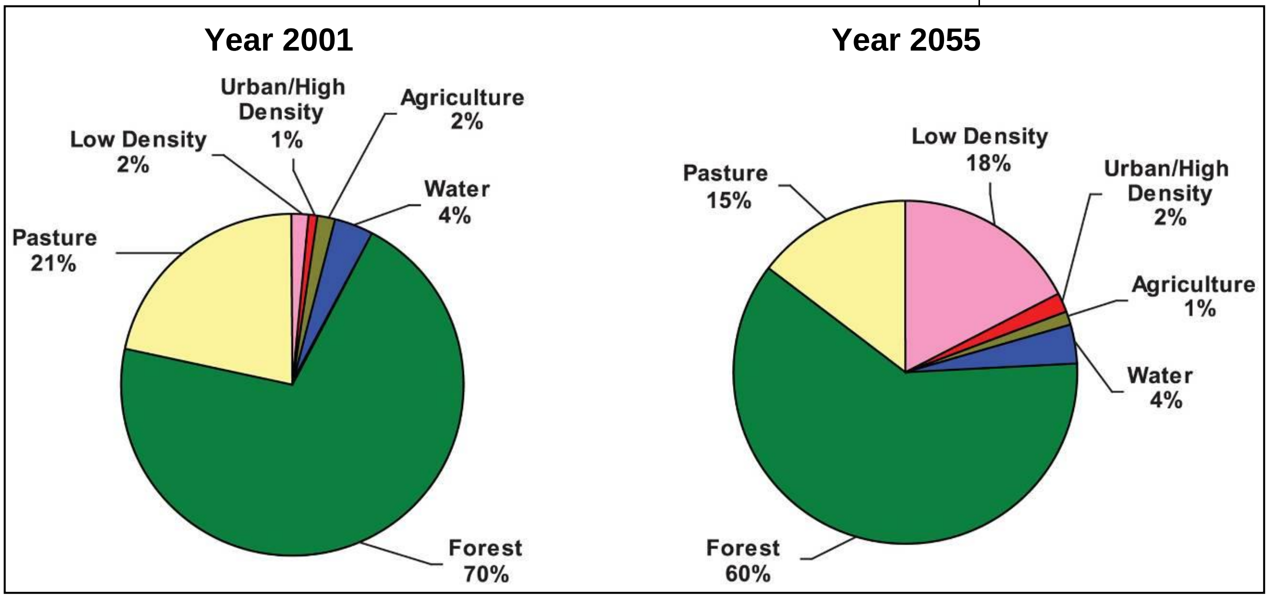


Figure 2-5. Comparison of 2001 and Projected 2055 Imperviousness

Figure 2-6 shows how land use and land cover is projected to change between 2001 and 2055. There are three key trends that have a bearing on water quality: forested areas drop from 70 percent to 60 percent of the total watershed; pasture decreases from 21 percent to 15 percent; and low density development (defined as development with impervious area of 35 percent or less) jumps from 2 percent to 18 percent. As noted previously, these predictions are based on existing plans, trends, and development models, and contain a degree of uncertainty. But if trends continue, these are the types of changes the watershed likely faces in the coming decades.

Low Density Development (i.e., development with 35 percent impervious area or less) will jump from 2 to 18 percent of the watershed.



Where can I find more information on the impervious area and land use analysis?

– Beaver Lake SWAT Modeling Baseline Analysis, February 12, 2009, Tetra Tech

Figure 2-6. Comparison of Year 2001 and Year 2055 Projected Land Uses in the Beaver Lake Watershed

2.2 Existing and Future Loading to the Lake

The Baseline Conditions Analysis addressed the question: How will projected growth under current water quality controls affect pollutant loading to the lake? Below are the study's estimates of loading for sediment, phosphorus and nitrogen predicted for existing and future land uses in the watershed and the expected corresponding changes in hydrology. Relative comparisons for pollutant loading are shown for the largest sources, along with the areas of the watershed posing the greatest threat to water quality.

Future annual sediment load is estimated to increase 21 percent.

Currently, and in the future, the Beaver Lake subwatershed is estimated to generate about 45 percent of the total sediment load to the lake.

Sediment

The future annual sediment loading is estimated to increase 21 percent or almost 50,000 tons per year. Without additional protective measures, stream channel erosion is estimated to contribute most (approximately 60 percent) of the sediment load to Beaver Lake. While the decrease in areas categorized as agriculture, pasture, and forest will reduce sediment loading by around 18,400 tons/year from those sources, channel erosion and land developed as low density residential tracts are estimated to increase sediment contributions by approximately 28,850 and 36,700 tons/year, respectively (see Figure 2-7, Comparison of Existing (Year 2006) and Future (Year 2055) Sediment Loading). The near-lake drainage area, defined as the 10-digit HUC that immediately surrounds Beaver Lake (1101000107), exhibits the highest relative rate of pollutant delivery to the lake. This is due to proximity to the lake as well the topography and soils of the area. Currently the Beaver Lake subwatershed generates about 45 percent of the total sediment load to the lake; and it will increase to about 46 percent in the future. By 2055, residential low density land uses, construction sites, and channel erosion in the near lake area are predicted to generate 102,930 tons per year of sediment, constituting 37 percent of the total watershed sediment load to the lake. It is important to note that the rate of construction is predicted to stay the same, but will result in significant increases in the amount of low-density, urban development. Loading estimates in Figure 2-7 are not cumulative over time, but are a snap-shot at the estimated 2055 condition.

By 2055, low density development, construction sites, and channel erosion in the near lake area are predicted to constitute 37 percent of the total watershed sediment load to the lake.

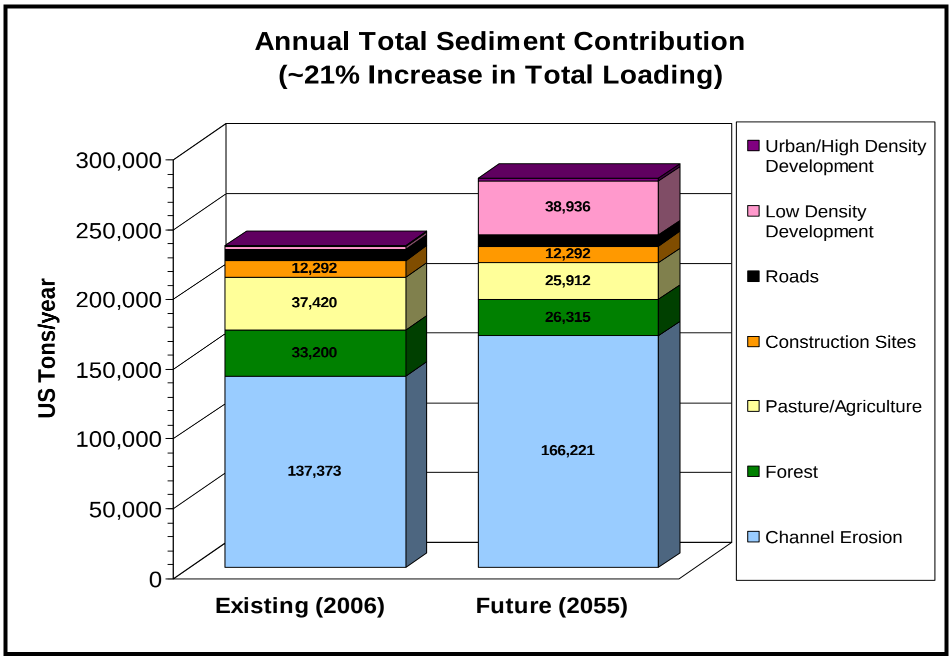


Figure 2-7. Comparison of Existing and Future Sediment Loading (methodology and results described in Supplemental Pollutant Loading Analysis)

The future projected Municipal Planning Area, where most of the development is predicted to occur, is also a key area of concern.

The future projected Municipal Planning Area is also a key area of concern for sediment loading. This area comprises the western portion of the watershed, where most of the development is predicted to occur, as well as the projected growth area around Huntsville. It includes portions of

West Fork, Middle Fork, East Fork, Lower White, Richland Creek, War Eagle, and the Beaver Lake subwatersheds. The Watershed Protection Strategy aims to mitigate projected future increases in sediment loading to the lake from these growth areas.

The West Fork and Lower White River subwatersheds also have Total Maximum Daily Load (TMDL) sediment allocations requiring significant reductions from existing levels (greater than 53 percent reduction for the West Fork and greater than 32 percent reduction for the Lower White). Multiple management practices will need to be applied throughout these watersheds to address the projected increase in sediment loads, in addition to the required TMDL decreases. Figure 2-8 shows the locations of the subwatersheds that are lake protection priorities, because they are 303d-listed, impaired subwatersheds. (Note: Appendix B lists the BMPs recommended for West Fork and Lower White subwatersheds to support TMDL reduction requirements. It also highlights how this Protection Strategy meets the U.S. Environmental Protection Agency's nine minimum elements for watershed plans for impaired waters.)

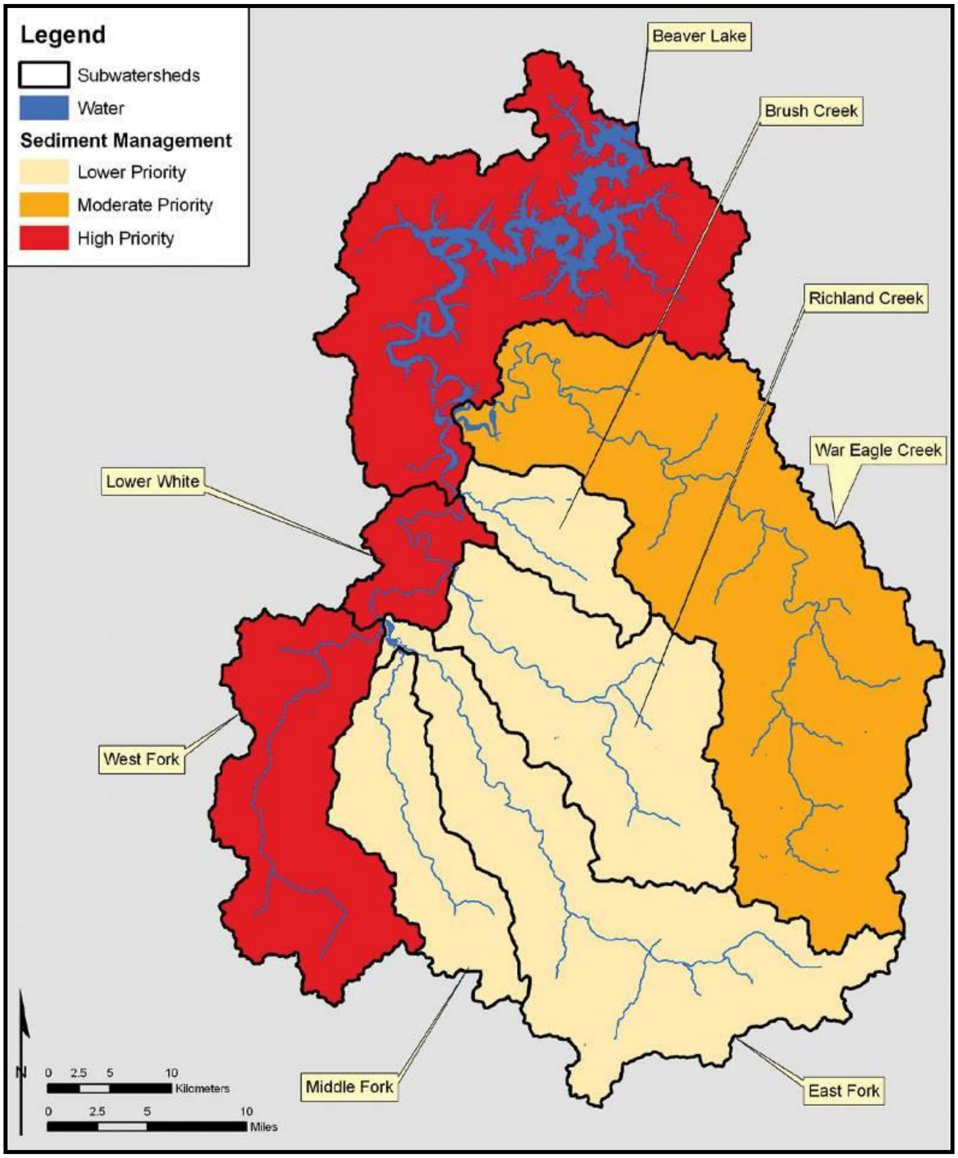


Figure 2-8. High, Moderate, and Low Priority Areas for Sediment Control

Phosphorus

Soil-borne phosphorus from stream channel erosion is the major contributor of phosphorus for existing and future conditions.

By 2055, the total phosphorus in the lake is expected to increase by approximately 24,000 pounds per year (see Figure 2-9, Comparison of Existing and Future Phosphorus Loading). Phosphorus is a concern because it feeds algal growth, which can lead to taste and odor problems. Soil-borne phosphorus from stream channel erosion is the major contributor of phosphorus within the Beaver Lake watershed for both existing and future scenarios (50 percent and 54 percent, respectively). Wastewater treatment plants (WWTPs) and pasture land, which are the second and third largest sources of the phosphorus in the watershed, are predicted to decrease in their relative phosphorus contributions in the future, while low density development yields the greatest relative increase in phosphorus. As with sediment, the Beaver Lake and War Eagle Creek subwatersheds are predicted to be the largest sources of phosphorus to the lake. This is not surprising, given that sediment and phosphorus are closely associated.

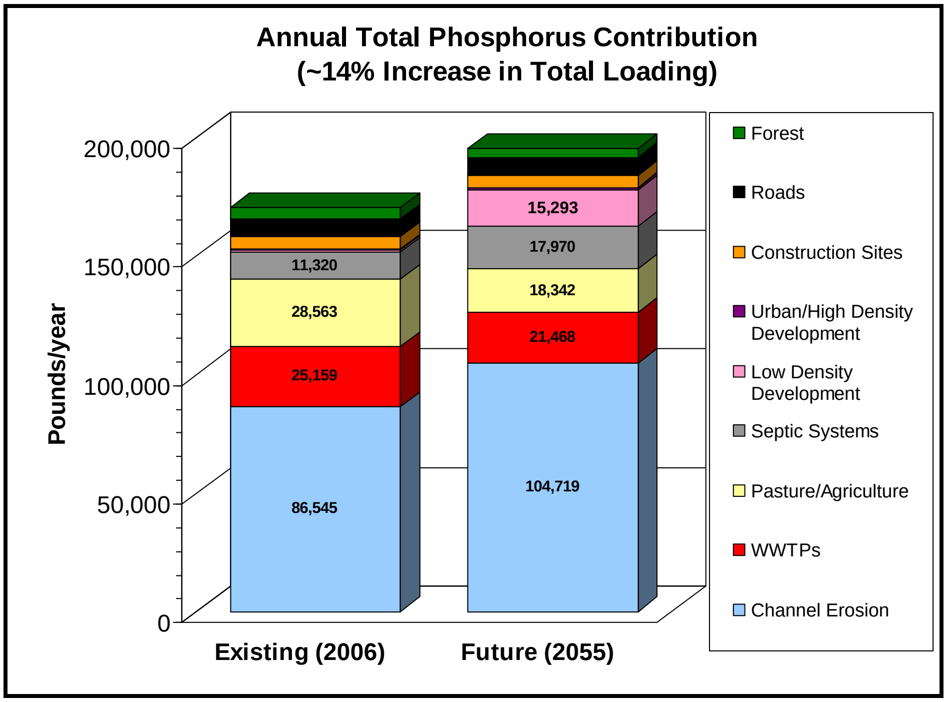


Figure 2-9. Comparison of Existing and Future Phosphorus Loading (methodology and results described in Supplemental Pollutant Loading Analysis)

Nitrogen loading to the lake is only expected to increase by about 4 percent.

Nitrogen

Overall, total nitrogen loading to the lake is only expected to increase by about 4 percent to approximately 267,000 pounds per year in the future (see Figure 2-10), Comparison of Existing and Future Nitrogen Loading). Under existing conditions, pasture land contributes more than half of the total nitrogen load to Beaver Lake (56 percent), followed by forest land (31 percent). As urban development occurs through 2055, pasture is predicted to remain the leading nitrogen contributor – but its relative load decreases considerably to 36 percent of the total load. Nitrogen from forest sources drops to 25 percent, but low density urban development becomes a significant contributor according to the 2055 land use scenario (24 percent). The War Eagle Creek subwatershed is predicted to deliver the largest nitrogen load under both existing and future scenarios. The Beaver Lake subwatershed is estimated to be the second leading contributor of nitrogen to the lake based on future land use conditions.

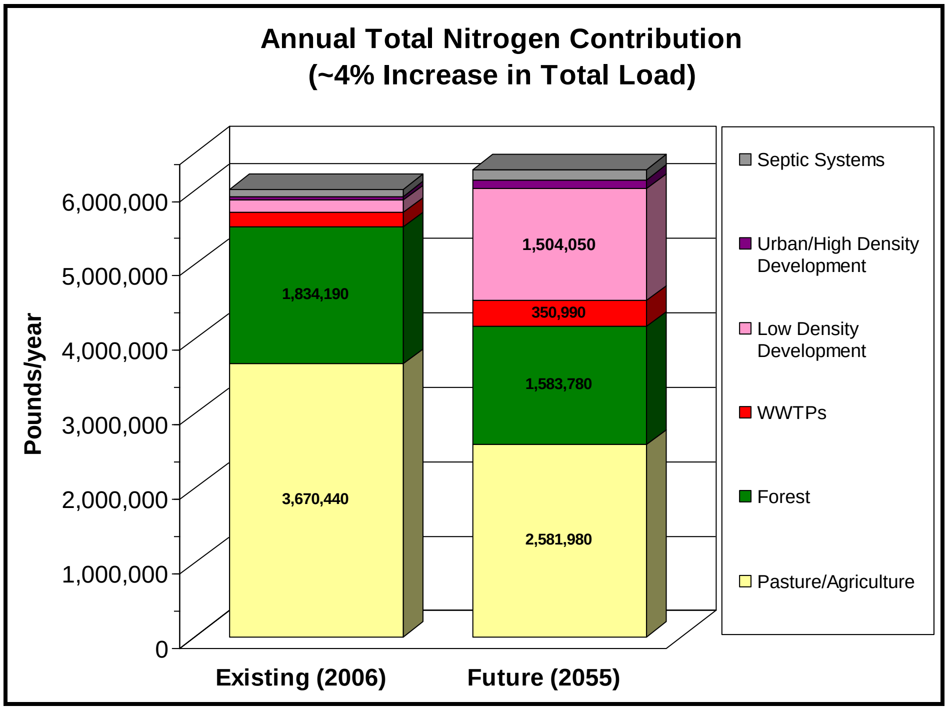


Figure 2-10. Comparison of Existing and Future Nitrogen Loading (methodology and results described in Supplemental Pollutant Loading Analysis)

Where can I find more information about the existing and future loading to the lake?

- Beaver Lake SWAT Modeling Baseline Analysis, February 12, 2009, Tetra Tech
- Beaver Lake Watershed Baseline Analysis – Supplemental Pollutant Loading Analysis, February 16, 2009, Tetra Tech

Riparian Areas

Another key finding is that 25% of the riparian area in the watershed lacks adequate vegetation along streams (results given in Supplemental Pollutant Loading Analysis). This contributes to channel erosion and reduces the capacity of the riparian area to filter nutrients and sediment before they reach the streams.

Twenty-five percent of the riparian area in the watershed lacks adequate vegetation along streams.

2.3 Water Quality Targets

Given the level of population growth and new construction anticipated in the watershed, Tetra Tech worked with the project's Technical Advisory Group to develop future water quality targets and benchmarks for Beaver

EPA Watershed Management Plan Element H: Load Reduction Criteria = See Sections 2.3 and 2.4

Lake. A target is based on a current (or currently proposed) regulation or standard, and a benchmark is a non-regulatory objective. Both are quantitative – they can be measured. The benchmarks are proposed when there are no regulatory targets, but certain conditions are desired in the lake, or as a safety factor for a regulatory target's minimum threshold.

Two locations are proposed for meeting the water quality targets and benchmarks: the Hickory Creek monitoring station and a monitoring station L3 near Lowell and the Beaver Water District's raw water intake (Figure 2-11). The Hickory Creek station is at the confluence of the major tributaries to Beaver Lake and the lake's "plunge point," where incoming water from the White River moves below the existing pool of impounded water in the lake. It is also upstream of the Beaver Water District intake. The Hickory Creek station was chosen as an early warning indicator for the rest of the lake. Also, if the Watershed Protection Strategy is protective of conditions in the lake at Hickory Creek, it is expected to be protective of the rest of the lake.

Water quality monitored by the USGS for three key indicators – Chlorophyll *a*, Secchi depth, and Total Organic Carbon – is summarized at Station L3 (near Lowell) for the period of 2001-2008 (Table 2-1).

Table 2-1. Water Quality Monitored by USGS at Beaver Lake Station L3

Monitoring Year	Chlorophyll *a* (µg/L – seasonal geometric mean)	Secchi Depth (m – seasonal mean)	Total Organic Carbon (TOC) (mg/L – seasonal mean)
2001	6.1	2.3	2.3
2002	4.5	2.0	3.2
2003	4.9	2.2	2.2
2004	5.3	1.3	5.0
2005	3.7	2.4	2.7
2006	4.2	2.2	3.6
2007	5.9	2.0	3.0
2008	8.1	1.1	3.9

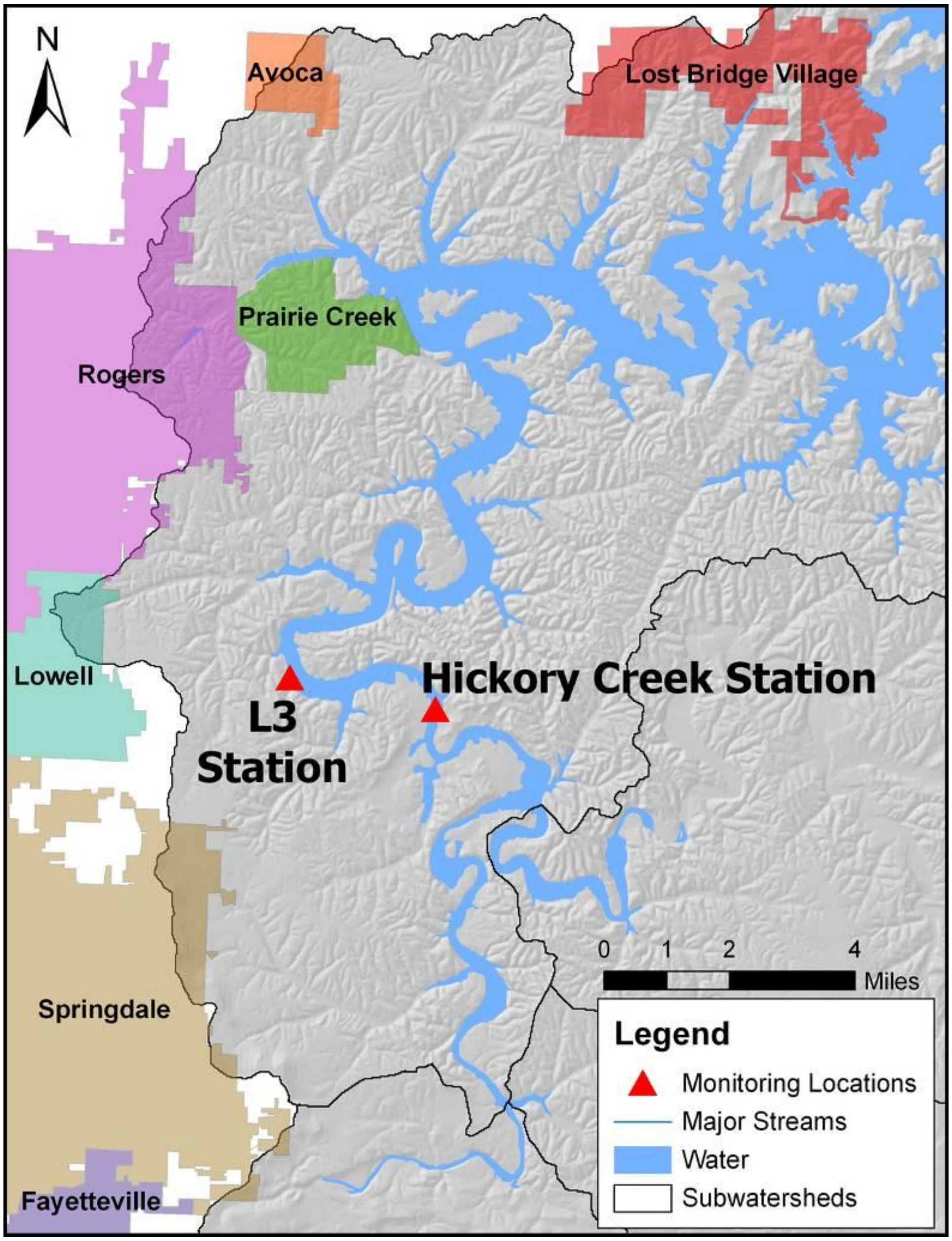


Figure 2-11. Lake Monitoring Stations for Targets and Benchmarks

The project's Technical Advisory Group helped develop future water quality targets and benchmarks for the Hickory Creek monitoring station and at Station L3 near the Beaver Water District's intake.

Proposed Chlorophyll-a Target *(linked to drinking water safety, taste, and odor; treatment operations; and lake recreation)*

USGS monitoring of Chlorophyll-a in the upper lake shows conditions were approaching the precautionary benchmark in 2001 and 2007, and at the target threshold in 2008.

Under a separate study commissioned by Arkansas Department of Environmental Quality (ADEQ), a Technical Workgroup has developed and recommended a site specific chlorophyll *a* water quality criterion for Beaver Lake: 8 micrograms per liter (µg/L) at the Hickory Creek station, measured as a growing season geometric mean. Tetra Tech and the project's TAG recommended using 8 µg/L as a target for the watershed protection strategy, along with a benchmark of 6.4 µg/L at the same station. The benchmark represents a safety factor (USEPA recommends using 80 percent of a criterion as a safety cushion, to increase likelihood of staying below the criterion), and addresses variability between the modeling and monitoring. Lake monitoring conducted by the USGS from 2001 to 2008 at monitoring station L3 shows that chlorophyll *a* seasonal geometric mean concentrations have ranged from 3.7 to 8.1 µg/L. Conditions in 2001 and 2007 were approaching the benchmark, and conditions in 2008 were measured at the target level. Therefore, it would appear prudent to develop and implement a strategy to achieve no or relatively little increase in total phosphorus and total nitrogen loading to the lake.

Proposed Total Organic Carbon Target *(linked to drinking water safety, taste, and odor; treatment operations)*

USGS Monitoring of TOC in the upper lake shows that average concentrations exceeded the benchmark threshold in 2002, 2004, 2006, and 2008.

The total organic carbon (TOC) target is based on meeting the Safe Drinking Water Act *Disinfection By-Products Rule* for finished (treated) water. The recommended TOC target is 3 milligrams per liter (mg/L) at the BWD drinking water intake, and the suggested benchmark is 3 mg/L at Hickory Creek. The USGS monitoring shows that the upper lake at station L3 averaged from 2.2 to 5.0 mg/L TOC between 2001 and 2008. Average TOC concentrations exceeded the benchmark in 2002, 2004, 2006 and 2008. Meeting the target on a consistent basis would mean developing a strategy to achieve relatively little or no increase in TOC loading to the lake.

Proposed Turbidity and Sediment Target *(linked to public safety; drinking water aesthetics; treatment operations; recreation; restoration of impaired waters; and loss of private land)*

The sediment and turbidity targets are based on ADEQ water quality criteria for turbidity in streams, as well as the Total Maximum Daily Loads (TMDLs) for the West Fork and Lower White River. The targets are to meet instream turbidity criteria to address stream and lake turbidity. In addition, ADEQ TMDLs require a 53 – 58 percent (depending on flow category) reduction of the sediment load in the West Fork of the White River and a 32 – 40 percent reduction in the Lower White River subwatersheds.

Water quality in Beaver Lake is still good, but under stress due to sediment and algae feeding nutrients.

The recommended benchmark related to turbidity in Beaver Lake is an average Secchi depth (water clarity) of 1.1 meters at Hickory Creek. A Secchi depth target of 1.1 meters was also recommended by the ADEQ commissioned Technical Workgroup developing site specific water quality criteria for Beaver Lake related to protection from excessive algae. Using Secchi depth as a benchmark to also address impacts of sediment would mean looking for protection measures that would result in relatively little or no increase in existing levels of sediment/turbidity loading to the lake.

Where can I find more information about targets and benchmarks?

– Beaver Lake Watershed Water Quality Targets/Benchmarks Analysis, February 18, 2009, Tetra Tech

2.4 PRIORITY WATERSHED ISSUES

Water quality in Beaver Lake is still good, but under stress due to increasing levels of sediment and algae-feeding nutrients. Although some degradation in water quality has occurred, people in the region can act in the coming decades to ensure high quality drinking and recreational waters.

Although some degradation in water quality has occurred, people in the region can act in the coming decades to ensure high quality drinking and recreational waters.

The Baseline Conditions Analysis indicates that sediment is the key parameter of concern in the coming decades, both for lake water quality and localized stream impacts. Lake protection actions taken to mitigate sediment loading should also address much of the projected increase in phosphorus. Through the study, Tetra Tech identified priority actions for lake protection that maximize water quality benefits for the region:

- *Managing the quality and volume of runoff from new development* – Target additional water quality protection measures for new development in the Municipal Planning area with 12 percent or greater imperviousness (e.g., 1-acre lots).
- *Managing construction site runoff* – Employ best management practices to control sediment and pollutant runoff on construction sites throughout the watershed.
- *Preserving and restoring vegetation in stream buffers and along stream channels* – High priority opportunities are the Beaver Lake, Lower White, and West Fork subwatersheds. Medium priority is in the lower portion of Middle Fork, East Fork, Richland Creek, Brush Creek, and War Eagle Creek due to their proximity to Beaver Lake.
- *Enhancing pasture best management practices* – The priority opportunities are the existing pasture lands in the Beaver Lake, Lower White, and West Fork subwatersheds. Medium priority is pasture land in War Eagle Creek.
- *Improving unpaved roads* – The high priority subwatershed is Beaver Lake. Medium priority watersheds are West Fork, Lower White, and War Eagle Creek.

Emphasis on these priority actions assumes that key existing protection programs will continue and be strengthened including local stormwater regulation, nutrient management plans, and wastewater management with particular emphasis on phosphorus reduction from the largest point source discharges.

Section 3

Building Blocks and Gaps for Lake Protection

Efforts to protect and improve water quality have been ongoing for years.

A review of current regulations within the Beaver Lake watershed revealed a number of potential building blocks – and some gaps – for the Protection Strategy. Efforts to protect and improve water quality within the watershed have been ongoing for years. This section highlights three key water quality protection building blocks: local stormwater permits, nutrient management plans, and wastewater management. Gaps in these existing programs are also highlighted.

3.1 Local Stormwater Regulation

Stormwater discharges for large and medium size communities are regulated by federal Clean Water Act rules for the National Pollutant Discharge Elimination System (NPDES) permit program, but administered and enforced by ADEQ. This program regulates all major discharges of stormwater (i.e., polluted runoff from municipal areas) to surface waters. The purpose of the NPDES permits is to reduce pollutants in stormwater runoff from certain municipal separate storm sewer systems (MS4s), construction sites, and industrial activities by requiring the development and implementation of stormwater pollution prevention plans and programs.

The purpose of the NPDES stormwater permits is to reduce pollutants in the stormwater runoff from certain municipal separate storm sewer systems (MS4s), construction sites, and industrial activities.

ADEQ has designated certain communities with MS4s as regulated stormwater dischargers and has issued a general permit with stormwater management conditions that all regulated MS4 communities were supposed to meet by 2008, including:

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

In the Beaver Lake watershed, regulated MS4 communities include portions of Benton County, Washington County, and Elkins, Fayetteville, Greenland, Lowell, Prairie Creek, Rogers, Springdale, 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-Rogers" urbanized area. This program is designed to address the public education and involvement requirements of the MS4 permits through development of educational materials for the general public and schools (fact sheets, brochures, and posters), conducting public outreach and youth education, and hosting workshops and training events.

Tetra Tech evaluated stormwater programs in place and found they would need to be strengthened to meet lake protection goals.

Based on a review of the latest annual reports from the MS4s, several of the MS4s met the 2008 deadline for adopting a construction site runoff control ordinance or plan and an ordinance or plan for controlling post-construction runoff. Tetra Tech evaluated the stormwater programs in place and found that they would need to be strengthened in order to meet the lake protection goals. A number of the MS4s have not been able to develop and enforce construction and post-construction requirements, citing a lack of resources. There is an additional gap in the designation of regulated MS4 areas. Regulated areas are based on the census survey every 10 years and determined by population density. Densely populated areas are called urbanized areas for the purposes of future stormwater regulation. However, by the time the area has been designated as "urban," a significant amount of uncontrolled stormwater runoff has been generated which would not be covered by the regulations. In these situations, development designers do not incorporate appropriate stormwater best management practices into their projects and the cities and counties are forced to deal with stream channel erosion, water quality degradation, and other consequences linked to rapid stormwater runoff, low rates of infiltration and groundwater recharge, and a general absence of stormwater pollution controls.

A number of MS4 communities have been unable to develop and enforce construction and post-construction requirements, citing a lack of resources.

In terms of construction phase impacts, it is important to note that federal stormwater regulations require that all construction sites disturbing more than one acre, regardless of their location, must have sedimentation and erosion controls. If this land disturbance falls outside of a designated MS4 community, the Arkansas Department of Environmental Quality is required to administer and enforce the stormwater NPDES requirements unless a local government voluntarily enacts an ordinance. However, the state does not have adequate resources to enforce these requirements. Several Beaver Lake Focus Groups commented on the relative absence of enforcement of the construction phase stormwater rules.

In terms of construction phase impacts, if land disturbance of more than one acre falls outside a MS4 jurisdiction, the state is required to enforce stormwater requirements.

Arkansas Highway and Transportation Department (AHTD) construction projects and certain facilities and roadway drainage systems managed by the AHTD must also comply with the federal and state stormwater permitting and management regulations discussed in the previous sections. Roads, ditches, and drainage facilities on public property managed by the AHTD are considered to be MS4s under the stormwater permitting program. AHTD construction activities with a disturbed area of one acre or more and AHTD facilities (e.g., equipment and materials storage yards) draining to other municipal separate storm sewer systems – such as those owned and managed by cities and/or counties – are also regulated by the ADEQ MS4 permit and the ADEQ Construction Stormwater General permit. These permits require the reduction of stormwater impacts on surface waters "to the maximum extent practicable," through the following enforceable permit requirements:

- Development and implementation of an ordinance requiring erosion and sedimentation controls with sanctions necessary to ensure compliance.
- Implementation of appropriate erosion and sediment control best management practices.
- Control of waste materials that may adversely impact water quality such as building materials, truck washout, chemicals, litter, and sanitary waste.
- Site plan reviews that consider water quality impacts of project activities.
- Communication with the public.
- Site inspections and enforcement of control measures.

The AHTD stormwater program needs to be strengthened along with ADEQ enforcement.

The ADEQ Construction Stormwater General permit requires that operators (i.e., property owners, general contractors, etc.) of construction sites disturbing one acre or more develop and implement a Storm Water Pollution Prevention Plan (SWPPP), which must be maintained until site stabilization is complete. Projects disturbing more than five acres must meet more stringent permit requirements.

Windshield surveys of the watershed indicate that the AHTD stormwater program needs to be strengthened in the watershed along with ADEQ enforcement. Poor erosion, sediment, and stormwater controls were clearly visible at the majority of construction sites surveyed by Tetra Tech staff during 2008-2009. Problems included failure to quickly seed and/or mulch cleared areas, poor silt fence / sediment barrier installation and maintenance, lack of sediment traps, poor or no inlet protection, poor housekeeping practices, and no stabilization of ditches until late in the construction process.

Beaver Lake watershed has been designated as a Nutrient Surplus Area.

3.2 Nutrient Management Plans

The Beaver Lake watershed has been designated as a *Nutrient Surplus Area* under Arkansas Acts 1059 and 1061 of 2003, 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 to soils or residential/ non-residential land areas greater than 2.5 acres within a Nutrient Surplus Area must comply with a nutrient management plan or poultry litter management plan. Requirements for soil testing, record-keeping, placement and timing of litter application, and other elements of nutrient management plans are specified in the rules. Although the rules require the maintenance of records for five years and require their availability for inspection by Commission or Conservation District employees, there is no opportunity for review by other agencies or by the public.

The purpose of the nutrient management rules is to maintain the benefits derived from use of fertilizers and poultry litter while avoiding undesirable effects.

Specifically, 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 residential and nonresidential development 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 if within nutrient surplus areas, except on residential lands of 2.5 acres or less.
- 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 Arkansas Natural Resources Commission (ANRC).
- The poultry litter management planner shall by certified by ANRC in planning.

Although the rules require the maintenance of records for five years, there is no opportunity for review by other agencies or by the public.

Additional legislation supports Act 1061, including:

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

Nutrient management plans for poultry litter in the Beaver Lake watershed are currently estimated using the Arkansas P index, which bases application rates on crop nitrogen requirements when a site is in the low or moderate risk category for phosphorous loading.

Interviews with resource agencies and poultry integrators indicated a high level of compliance with the Nutrient Management Plan requirements. Based on this, the watershed model assumed nutrient management plan implementation now and decades into the future. Without such long-term compliance, the lake protection goals would not be achieved. Thus, the Beaver Lake Watershed Protection Strategy emphasizes the importance of maintaining high compliance with Nutrient Management Plan requirements.

Interviews with resource agencies and poultry integrators indicated a high level of compliance with nutrient management plan requirements. Based on this, the watershed model assumed nutrient management plan implementation now and decades into the future. Without such long-term compliance, the lake protection goals would not be achieved.

3.3 Wastewater Management

The Clean Water Act requires the control of wastewater discharges to surface waters under the National Pollutant Discharge Elimination System (NPDES) program. The Arkansas Department of Environmental Quality, which has the delegated authority to administer the program, issues permits to treated effluent dischargers with limitations on wastewater flow and pollutants in order to protect surface water quality and the beneficial uses of the water. These permits must be renewed every five years. Dischargers must also obtain a permit from ADEQ to construct any waste collection, treatment, or discharge facility to ensure that proper engineering design is used. Dischargers are required to perform self monitoring, and those records, along with periodic inspections and monitoring by ADEQ, are used to determine compliance with permit requirements. Enforcement measures, including fines and revoking permits, are available to ADEQ when addressing noncompliance by dischargers.

There are currently two major active NPDES permits to discharge wastewater within the watershed (Fayetteville's Noland Plant and Huntsville's Plant), and several minor effluent discharger permits near Beaver Lake and West Fork. Much of the municipal wastewater is generated along the far western boundary of the Beaver Lake drainage area, in the cities of Fayetteville, Springdale, Lowell, Rogers, and Pea Ridge, which lie south-to-north along US 71. These cities are served mostly by the centralized Wastewater Treatment Plants (WWTPs) that discharge to surface waters of the Beaver Lake and the Upper Illinois watersheds, but adjacent subdivisions are increasingly served by smaller clustered (decentralized) facilities that discharge to the soil. Outlying and rural areas of the watershed are served mostly by individual or small clustered systems with soil discharges. The Fayetteville WWTP and its sewage collection system, which have likely been nutrient sources in years past due to collection system overflows and other problems, have completed major renovations which include construction of a new WWTP on the west side of Fayetteville. Since 1990, the City of Fayetteville's Noland WWTP has had a discharge permit limit of 1.0 mg/L for Total Phosphorus for discharge to the White River. The watershed model assumed that at least the same limit would be applied to future plant upgrades and expansion at the Huntsville and West Fork plants. If this or more protective limits are not used, then the lake protection goals will not be met. Therefore, the Beaver Lake Watershed Protection Strategy highly recommends continuance of the state regulation of phosphorus concentration through effluent limitations for the larger wastewater discharge permits. It is important to note that the City of Fayetteville and the Beaver Water District have an Agreement for the Protection of the Beaver Lake Watershed whereby Fayetteville agrees to maintain an average TP discharge concentration of 0.5 mg/L year round and will not exceed 93.4 pounds per day TP from July through October. In addition, the City of Fayetteville has made commitments to reduce nonpoint source loading of Total Phosphorus. The City of Fayetteville has taken a number of major steps to implement the Agreement.

Fayetteville's Noland WWTP is undergoing major renovations. Since 1990 it has had a discharge permit limit of 1.0 mg/L for Total Phosphorus. The watershed model assumed that at least the same limit would be applied to future plant upgrades of Huntsville and West Fork. If this or more protective limits are not used, then the lake protection goal will not be met.

In addition to loads from WWTPs, malfunctioning individual residential wastewater (septic) systems may be causing localized surface water quality problems in some areas. Wastewater treatment systems discharging to the soil can pose a threat to the White River, the lake, and its tributaries in areas where high densities of older, heavily used systems are located near surface streams or karst topography. Current rules specify the types of legally acceptable tanks, infiltration system components, and other devices, and provide for evaluation of the installation site, training and licensing of service providers, and the management of systems that serve multiple homes or other facilities. Individual home wastewater treatment systems in Arkansas are regulated by the Arkansas Department of Health (ADH) if they discharge to the soil on the system owner's property. Systems that discharge to the soil offsite, or to a surface waterbody, or that discharge to soil onsite with flows greater than 5,000 gallons per day are regulated by the Arkansas Department of Environmental Quality (ADEQ) under its NPDES discharge permit and other programs. In general, ADH will approve individual home systems with septic tanks and soil absorption fields if adequate space is available, soils are suitable (i.e., acceptable percolation rate), and setbacks can be met from groundwater tables, wells, public water supply intakes, streams, lakes, ponds, property lines, etc. Drain fields are sized in accordance with soil percolation rates: the slower the percolation rate, the larger the required drain field.

An enhanced monitoring program for individual onsite wastewater systems is recommended, along with enhanced landowner education regarding system maintenance.

Individual wastewater systems require regular maintenance, such as pumping every 3 to 5 years, in order to function as designed. There are no provisions for checking or reporting maintenance or malfunctioning systems. A monitoring program can help detect elevated bacteria and trace sources of problems. Such monitoring would be particularly important in Beaver Lake's coves and associated tributaries. An enhanced monitoring program is recommended in this Protection Strategy as well as enhanced landowner education regarding wastewater treatment and system maintenance.

Summary

It is important to note that this Strategy does not recommend phosphorus regulations that are more stringent than those of ADEQ. Of the municipalities that are MS4 permittees, most have done well at implementing the education component of the permitting requirements. On the other hand, other requirements of the MS4 permits have been implemented with less success. At all levels (cities, counties, and the state), lack of resources was cited as a reason for the lack of enforcement or conformation to MS4 requirements. The function of this strategy is to highlight these gaps and suggest solutions, but it is the responsibility of the municipality to conform to and enforce the requirements of their respective permits.

There are several major building blocks for the Beaver Lake Watershed Protection Strategy. ADEQ has issued stormwater permits for highly populated urbanized areas in Washington and Benton counties. This requires a local regulatory mechanism for erosion and sediment controls and enforcement capability, and a program to address stormwater runoff from new development and redevelopment after construction has been completed. Local governments currently have a strong education program, but for most there is a gap in regulation and enforcement. Also, the ADEQ/state minimum requirements do not cover a significant amount of development in urbanizing areas within the lake drainage area. For other counties, ADEQ has construction site management requirements for activities disturbing greater than one acre. Currently there is a significant gap in ADEQ inspection and enforcement. Filling these gaps to carry out the existing stormwater management regulations as intended is recommended under the Beaver Lake Watershed Protection Strategy.

The State Nutrient Management Plan Requirements for development and farmland appear to have a high rate of compliance according to interviewees. Continued compliance is essential in meeting the lake protection goals.

Protective phosphorus limits on municipal WWTPs are needed to meet the lake protection goals. As the smaller WWTPs plants expand, it will be critical for ADEQ to require at least the same protective limits as those currently at the Noland Plant in order to meet the lake protection targets.

Proposed Beaver Lake Watershed Protection Strategy

The building blocks listed in the preceding section will serve as the foundation for the Beaver Lake Watershed Protection Strategy described below. Measures that address the gaps in watershed protection and further enhance efforts to reduce nutrient and sediment inputs to the lake round out the proposed approach. The elements of this Strategy represent the level of effort required to improve the quality of impaired waters and maintain water quality on unimpaired areas of the main body of the lake.

The elements of this strategy represent the effort required to improve quality of impaired waters and maintain water quality on unimpaired areas of the lake.

4.1 Overview of the Beaver Lake Watershed Protection Strategy

The function of this plan is to identify gaps in enforcement of current regulations.

- Increase enforcement of existing federal, state, and local requirements. This could be accomplished in two ways: 1) to educate cities, counties and possibly the state on existing enforcement gaps, and 2) be a method of local enforcement that would utilize volunteer efforts to work with and educate individuals who may be violating current regulations, ordinances or laws.
- Provide guidance and support for adoption of voluntary BMPs
  - Basic voluntary water quality protection BMPs
  - Guidance and incentives to go beyond core BMPs
- Create a mechanism for implementing the Protection Strategy
- Adapt management efforts when trigger points indicate that changes are needed

The Beaver Lake Watershed Protection Strategy has five complementary components:

Beaver Lake Watershed Council: A diverse group representing different interests that would provide sustained leadership for lake protection, including the facilitation of the implementation and adaption of the Beaver Lake Watershed Protection Strategy.

Core Best Management Practice (BMPs): Voluntary BMPs that do double duty of reducing sediment and phosphorus load to the lake and help reduce current sediment loading in existing impaired streams.

Developer and Contractor Lake Protection Certification Program: For local governments, site design engineers, developers, and contractors willing to implement protective stormwater controls for new development in the Municipal Planning Area and sign a Lake Protection Pledge.

Education and Stewardship Program: Community outreach to teach property owners about lake protection efforts and how they can help.

Monitoring and Adaptive Management: To address uncertainty and changing conditions and provide early warning signs for needed changes.

The following sections provide more details about these five components as well as implementation actions for each.

EPA Watershed Management Plan Element C: NPS Management Measures descriptions and Critical Implementation Areas – See Section 4.2.2 #2.

4.2 Five Components of Protection Strategy

4.2.1 Component #1 – Beaver Lake Watershed Council

Stewardship and protection of the Beaver Lake watershed depends on the organized, collective, targeted efforts of citizens, businesses, property owners, managers, non-governmental organizations (NGOs) and governmental agencies. A Beaver Lake Watershed Council is recommended as a way to establish and support a strong partnership among those organizations which have significant authority or resources for protecting the watershed. The purpose of the Beaver Lake Watershed Council would be to provide sustained leadership, ensure that the partnership is strong, coordinate protection practices, and allocate resources necessary to implement Strategy recommendations as needed. In the context of the Overarching Goal of minimizing regulations, the Council's function will be to implement educational and voluntary programs. The Council would also ensure meaningful public participation in the decision-making. Any changes in the functionality of the Council will be at the discretion of the Board of Directors. A Watershed Council Director should be hired to staff the Council and ensure implementation of the measures needed to protect lake water quality.

The purpose of the Watershed Council would be to coordinate policy and resource allocations, provide sustained leadership, ensure that the partnership is strong, and adapt practices as needed.

Watershed management should be adaptive—a living process that responds to changing conditions, needs, and information. Instituting a Watershed Council establishes an approach that can adapt to changing needs and will allow current and future issues to be addressed in ways that are both environmentally sound and fiscally responsible. It is an approach in which all stakeholders can pool and coordinate their technical and financial resources to achieve the watershed management goals.

The Beaver Lake Watershed Council could be modeled on the region's existing Illinois River Watershed Partnership, and efforts of the two groups could be coordinated as it makes sense from a policy and cost-savings perspective. The Watershed Council would not have regulatory authority. Rather, it would be a non-profit organization allowing interested parties to work together, carry out mutually beneficial projects, track progress, and make recommendations as needed. It is important to recognize that expert organizations exist that would logically be partners or leaders in specific BMP implementation; the Watershed Council would actively identify and fill gaps in implementation or programming and facilitate the execution of the Protection Strategy.

Potential costs: $200,000 for salary and annual operating expenses for a Beaver Lake Watershed Council and Director, based on profit-and-loss statements from other watershed partnership organizations.

Note: The recommendation of the formation of a watershed council resulted in the development and launch of the Beaver Watershed Alliance in 2011. Hereafter, the group will be referred to as the Beaver Watershed Alliance (or, "the Watershed Alliance" where appropriate).

4.2.2 Component #2 – Core Best Management Practices

EPA Watershed Management Plan Element D: Estimates of Technical/Financial Costs of Implementation – See also Appendix A.

The Core Best Management Practices were screened and evaluated against a large number of potential BMPs and determined to be the most cost-effective in meeting the Goals and Objectives. The Core Voluntary Best Management Practices hinge on a voluntary and targeted land conservation program. They also include improved construction site management, riparian buffer and bank restoration, pasture BMPs, buffer preservation, unpaved road improvements, and stormwater BMP retrofits in developed areas. A number of these voluntary BMPs do "double duty" in reducing sediment and phosphorus loads to the lake and helping to mitigate current sediment loading in the existing impaired streams (West Fork of the White River and Lower White River subwatersheds). Below are descriptions of the core BMPs and where in the watershed it is most important to gain participation from land owners and local governments.

The land conservation program involves conservation easements or conservation agreements achieved through donation or purchase, a voluntary carbon credit program, a voluntary Transfer of Development Rights program, or other voluntary measures.

Land Conservation

The voluntary land conservation program involves conservation easements or conservation agreements. Easements can be achieved through donation or purchase, a voluntary carbon credit program, and/or a voluntary Transfer of Development Rights program. Currently, there are federal and state tax incentives for donating conservation easements on land that meet necessary criteria. Conservation agreements are for a shorter period of time (e.g., 20 years) rather than easements which typically last in perpetuity. There are a number of federal and state programs, particularly agriculture and wildlife programs that provide incentives and financing to purchase easements and enter into conservation agreements.

The City of Fayetteville is exploring development of a Transfer of Developments Rights (TDR) program that could be a model for voluntary land preservation in the watershed. In a TDR program, areas in the watershed are identified where less development is desired (called development rights "sending areas") and areas where more intense development is appropriate (called development rights "receiving areas"). On a market driven, voluntary basis, property owners in the receiving area pay property owners in the sending area for development rights, and transfer those development rights to parcels in the receiving area. The landowner in the sending area can continue to live on and enjoy the use of his or her property, but there can be no additional development on the property in the future beyond that associated with the current use.

A carbon credit program is another way to provide incentives for establishing conservation easements in the watershed. In this program, businesses that need or desire to become more carbon neutral could establish conservation easements on land in the Beaver Lake watershed. A program would need to be established to determine which land should be targeted (e.g., riparian buffer areas, highly erodible lands) and the amount of carbon credit available per acre of conservation easement.

The Environmental Quality Incentives Program (EQIP) and the Conservation Reserve Enhancement Program (CREP) provide incentives and funding for entering into conservation agreements. EQIP is administered by the Natural Resources Conservation Service (NRCS) and CREP is administered by the Farm Service Agency.

In both the conservation easement and conservation agreement programs, there are financial incentives and rewards for businesses and landowners to establish conservation areas. Easements or agreements would prohibit development or any disturbance of vegetation within the easement area while providing the landowner continued use of the property. For conservation easements, successful land conservation will also require stewardship funds set aside for maintaining the easement in perpetuity and covering any legal expenses after the easement has been purchased. Figure 4-1 shows that those lands closest to the lake, in the Beaver Lake subwatershed, have the highest priority for land conservation. Lands in the Lower White and West Fork subwatersheds are also high priority due to TMDL requirements.

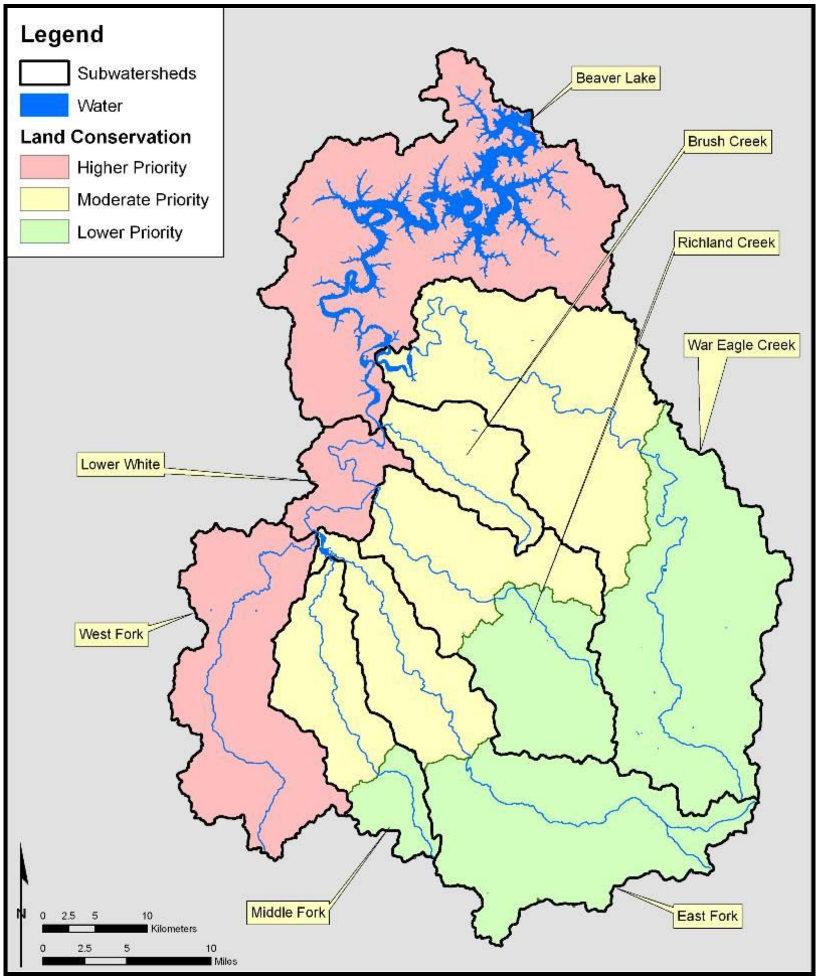


Figure 4-1. Priority Conservation Area

Under the Protection Strategy, cities and counties in the Beaver Lake watershed will enhance their construction oversight programs throughout the areas that drain into Beaver Lake.

EPA Watershed Management Plan Element C: NPS Management Measures, descriptions, and Critical Implementation Areas

Improved Construction Site Management

A key aspect of the Beaver Lake Watershed Protection Strategy will be to address the runoff of sediment and other pollutants from active construction sites as development continues in the lake's watershed. In the built-out areas regulated under the Arkansas Department of Environmental Quality's Stormwater Permit Program, cities and counties with municipal separate storm sewer systems (MS4s) are responsible for overseeing construction sites and implementing measures to prevent water quality degradation to the maximum extent practicable. This responsibility, which is a requirement of their state MS4 Stormwater Permit, will help to address construction site runoff in the MS4 communities in the watershed.

Construction sites with a disturbed area of one acre or more that are not in the ADEQ MS4 permit areas are still subject to regulation under the Arkansas Pollutant Discharge Elimination System (APDES) program for construction sites. Under the approach described in this Protection Strategy, cities and counties in the Beaver Lake watershed will enhance their construction oversight programs throughout the areas that drain into Beaver Lake, to protect long-term drinking water quality and aquatic life. Cities and counties will adopt a consistent set of enhanced measures in their jurisdictions and directly enforce them in their MS4 permit areas. At the option of the local governments, polluting construction sites not in the MS4 area may be subject to city or county enforcement or referred to ADEQ in the event of violations of construction site permit rules. ADEQ has been advised of this approach, and has noted that construction site operators have a number of responsibilities regarding their operations. The following text from the ADEQ statewide permit for construction sites was provided by ADEQ in response to questions about enforcement of erosion, sediment, and stormwater requirements:

> "Responsibilities of the Operator. Permittees with operational control are responsible for compliance with all applicable terms and conditions of this permit as it relates to their activities on the construction site, including protection of endangered species and implementation of BMPs and other controls required by the Stormwater Pollution Prevention Plan (SWPPP). Receipt of this general permit does not relieve any operator of the responsibility to comply with any other applicable federal, state or local statute, ordinance or regulation."

ADEQ also confirmed that local ordinances may go beyond the state's minimum requirements pursuant to protection of Beaver Lake and local stream conditions. The Protection Strategy recommends implementing a program that goes beyond the minimum state standards in two ways:

The Arkansas Department of Environmental Quality has confirmed that local ordinances may go beyond the State's minimum requirements pursuant to protection of Beaver Lake and local stream conditions.

(1) First, the Strategy recommends that all local governments in the watershed have a local enforcement program, to the extent feasible, even in the non-urbanized area where there is currently state jurisdiction. It is assumed that local governments are enforcing their current regulations to the greatest extent possible, but (some) are not in compliance with the NPDES requirements. It is important to note that enforcement has been an issue for some municipalities, citing a lack of resources and manpower. Where local governments outside the MS4 area cannot take on enforcement, it is recommended that problem sites be identified and referred to the ADEQ for follow-up and possible enforcement. A voluntary construction site monitoring program could help to support local governments in this effort.

(2) Second, the Strategy recommends more protective controls than those found in the minimum state requirements. The recommended controls include silt fencing with other controls and sediment basins for all sites that will disturb five acres or more during the construction period, with project phasing and rapid stabilization of bare areas at final grade (i.e., no more than 33 percent of the site bare at any time and stabilization within 10 days of reaching final

grade). Disturbed areas inactive for 14 days would also be stabilized with mulch until grading resumes.

A Construction Site Compliance Assistance Program should be developed that would target all jurisdictions in the Beaver Lake watershed, both MS4 and non-MS4 communities. There are several non-profit watershed partnerships that have instituted similar types of programs. For example, the Upper Chattahoochee River Keepers have the "Get the Dirt Out" program (http://geththedirtout.org), which educated developers and contractors across Georgia on permit requirements and assisted these business owners with compliance issues. The function of the proposed program is to identify gaps between current regulations and on-the-ground practices. The Beaver Lake Watershed Council would own the program and recruit volunteer inspectors. Development and implementation of the Program would include the following:

- Develop inspection protocols and a BMP manual that can be used by local staff and contractors.
- Develop a "Compliance Assistance Inspection Program," and recruit and train volunteer retired engineers and/or others experienced in construction site runoff controls. The volunteer inspectors would inspect construction sites, evaluate the BMPs, report to the contractor any site deficiencies, and provide consultation on how to address the deficiencies.
- The volunteer inspectors acting on behalf of the MS4s should be authorized to conduct inspections of regulated construction sites in the MS4 jurisdiction. Refusal to allow entry of the inspector may constitute grounds for issuance of a warning, a stop work order or monetary fine. The volunteers would supplement the work of existing county and municipal staff.
- Inspections will be conducted under a "compliance assistance inspection" protocol, whereby the inspector identifies conditions that do not comply with construction site stormwater regulations, provides consultation and recommendations regarding compliance approaches, and conducts re-inspections several days later to determine whether or not noncompliant conditions have been addressed. Failure to correct noncompliant conditions may result in a referral to the MS4 and ADEQ for enforcement action, such as a fine or stop work order. The main goal of this program, however, is to be completely transparent in working with developers, contractors, and businesses.
- Inspections will focus on permit documents – stormwater pollution prevention plan, ADEQ notice of permit coverage, inspection reports, local grading/other permits; and a field inspection – drainage system controls (ditches, traps, ponds, etc.), protection measures for slopes and bare areas, and housekeeping controls

A Construction Site Compliance Assistance Program should be developed that would target all jurisdictions in the Beaver Lake watershed.

Volunteer inspectors would inspect construction sites, evaluate the BMPs, report to the contractors any deficiencies, and provide consultation on how to address them.

(rock pad exit, concrete washout, materials storage, fueling areas, etc.).

- Volunteer inspector training would be consistent and coordinated. This training would build on the existing UA education/training program. The inspector training session would last two days. Successful completion of the training would allow the trainee to be added to the list of Certified Volunteer Inspectors. Continuing education would also be provided. The Compliance Assistance Program Administrator would keep the list of certified volunteers up-to-date. The Program Administrator or the local staff could assign the inspectors to sites that need inspections, depending on program inspection implementation in each jurisdiction.

EPA Watershed Management Plan Element E: Education and Information Component

- A Voluntary Contractor Certification Program. Training would be available to familiarize design engineers and contractors with how to prepare the stormwater pollution prevention plans, how to select/install/maintain the controls, how to conduct their inspections, and how to comply with the permit program. In order to get a high participation rate with contractors, it is recommended that the training sessions be held in the winter months, with an 8-hour training event broken into two 4-hour sessions. Incentives for participation could include allowing contractors to advertise as “Certified,” working with suppliers of erosion control products to provide discounts to Certified Contractors, and publicly recognizing certified design engineers and contractors and their outstanding projects.

Training would be available to familiarize design engineers and contractors with how to comply with construction site requirements.

- Draw from the experience of Wal-Mart and the City of Hot Springs, which have existing successful certification programs.

EPA Watershed Management Plan Element C: NPS Management Measures, Descriptions, and Critical Implementaion Areas

Riparian Buffer and Bank Restoration

Streambank restoration, as considered in this Protection Strategy, involves the conversion of eroded vertical banks to gradually sloping banks, which are then stabilized and vegetated. Streambank restoration is needed to significantly reduce bank and channel erosion rates along streams without bank vegetation; vegetation restoration will also be required to maintain the stability of the restored banks. Restoration of vegetation will also provide nutrient and sediment removal from upland runoff. The vegetation restoration is termed “riparian buffer restoration” because vegetation would be restored in riparian areas (land near streams) that provide a protective buffer for streambanks and water quality. Priority areas for riparian buffer and bank restoration are shown in Figure 4-2. The streams colored red currently have impacted buffers. Impacted buffers are defined as having less than 30 percent vegetation (such as trees and wild shrubs) along the stream (Roy, 2005). The streams closest to the lake and existing impaired streams have the highest priority for restoration because

Streambank restoration involves the conversion of eroded vertical banks to gradually sloping banks, which are then stabilized and vegetated.

they are most effective in meeting lake protection and TMDL requirements.

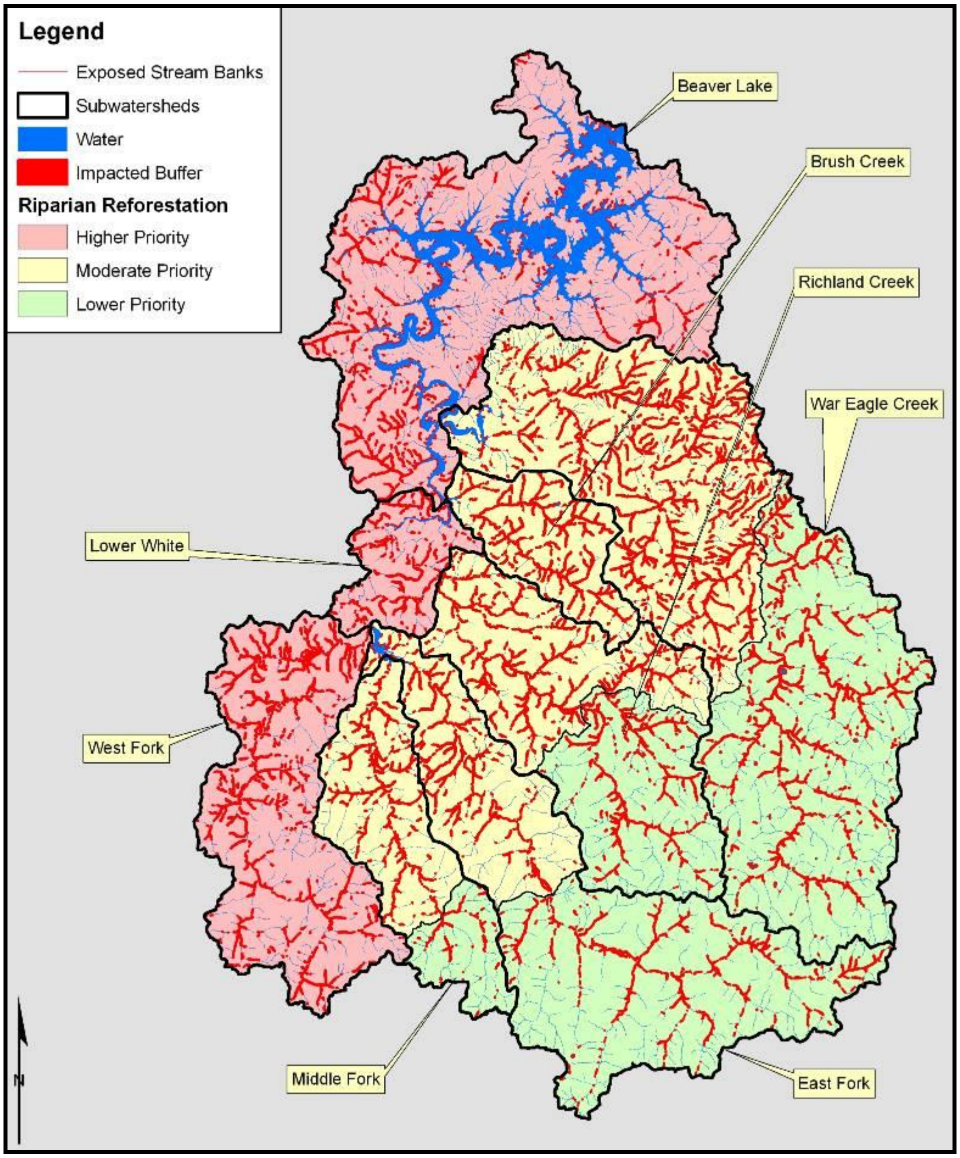


Figure 4-2. Riparian Reforestation and Restoration Priority

Pasture Management BMPs

EPA Watershed Management Plan Element C: NPS Management Measures, Descriptions, and Critical Implementation Areas

Cattle manure can be a source of nutrient and bacteria loading to streams, particularly where direct cattle access is not restricted and/or where cattle feeding structures are located adjacent to riparian areas. Direct deposition of feces into streams may be a primary mechanism of pollutant loading during baseflow periods. During storm events, overbank and overland flow may entrain manure accumulated in riparian areas, resulting in pulsed loads of nutrients and other pollutants. In addition, cattle with unrestricted stream access typically cause severe streambank erosion. Recommended pasture BMPs involve excluding cattle from streams using fencing, providing an alternative water source, and providing stream crossings where necessary.

Recommended pasture BMPs involve excluding cattle from streams, providing alternative water sources, providing stream crossings, and pasture renovation.

Pasture renovation can also be a cost-effective strategy to reduce nutrient and sediment loading from pastures. Pasture renovator equipment uses large spikes (found in various shapes and sizes) to create many small indentions in the ground that hold water and nutrients. Pasture areas along slopes leading to surface waters and pasture streamside zones are high priority areas for treatment by the renovator. This practice produces multiple benefits to forage growth and water quality. The green areas highlighted in Figure 4-3 show the existing agricultural areas in the watershed, with the Beaver Lake, Lower White, West Fork, and War Eagle Creek watersheds having the priority for pasture management BMPs.

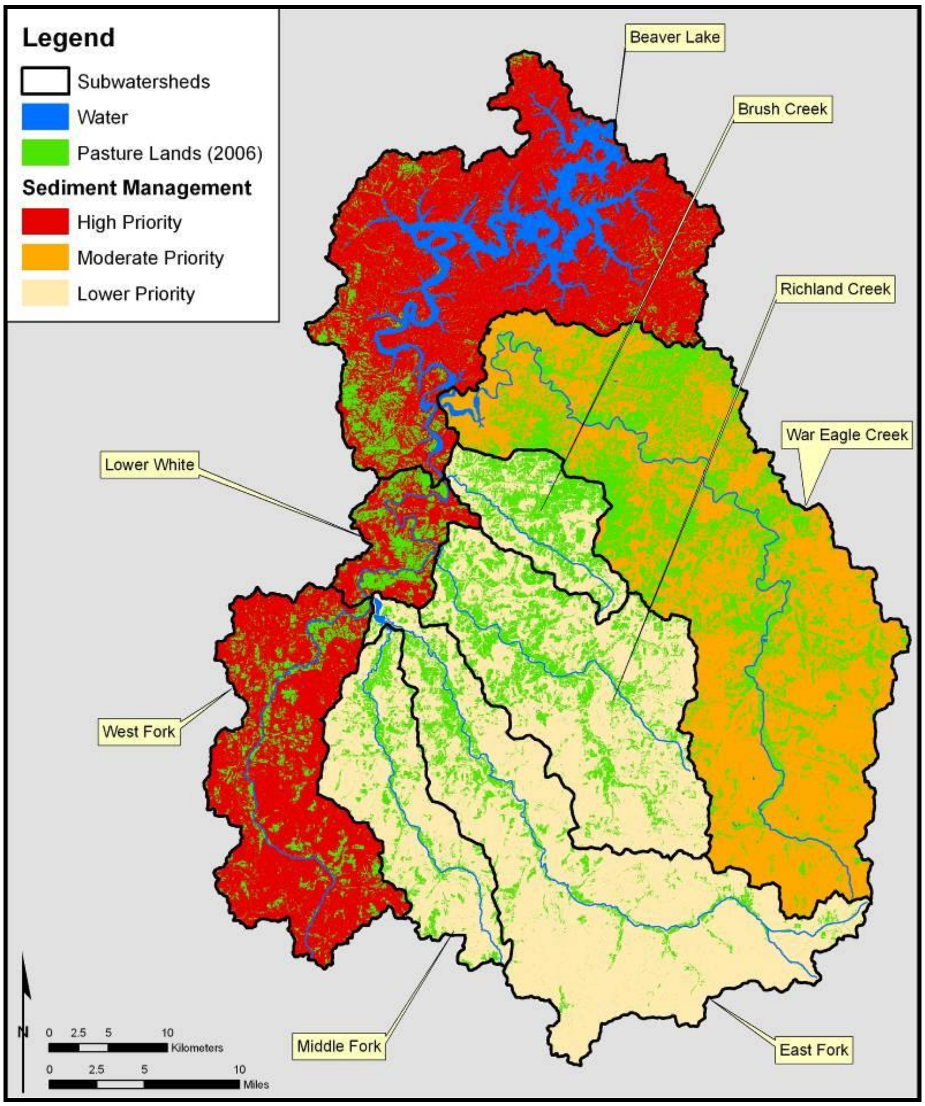


Figure 4-3. Pasture Management Priority Areas

Buffer Preservation

Like riparian buffer restoration, preservation of existing riparian buffers will help maintain the existing stability of streambanks and provide pollutant removal from upland runoff. The preservation of riparian buffers involves voluntary protection and/or the purchase of a conservation easement/agreement, which prohibits development or any disturbance of vegetation in the riparian area, while providing the landowner continued use of the property. Successful preservation may also require stewardship funds set aside for maintaining the easement in perpetuity and covering any legal expenses after the easement has been purchased. The priority areas for buffer preservation are the same as those for land conservation (Figure 4-1).

Preservation of riparian buffers involves the voluntary protection and/or purchase of conservation easements, which prohibits development or disturbance of vegetation on a property along the stream.

Unpaved Road Improvements

EPA Watershed Management Plan Element C: NPS Management Measures, Descriptions, and Critical Implementation Areas

Studies nationally and in Arkansas have documented that roads can be a major source of sediment and associated pollutant loading through both direct and indirect means. Unstabilized roadside ditches are often a significant source of sediment load. In addition, unpaved roads are a major direct source of sediment loading including fine sediment that leads to elevated turbidity in Beaver Lake and its tributary streams. Traffic continuously grinds the bed material of unpaved roads, resulting in a source of fine sediment that may be washed off or eroded by storms. Paving the road surface reduces direct erosion, but can still result in large sediment loads as runoff from paved roads generates high energy flows that can erode road margins and ditches.

The Beaver Lake Watershed Protection Strategy recommends several types of improvements to unpaved roads. These include wing ditches and turnouts that direct runoff from the road into undisturbed (vegetated) areas, hydroseeding ditches, and stabilizing stream crossings. Culverts should also be installed at regular intervals that pass drainage from adjacent land underneath roads and reduce stormwater flow passing across road surfaces. The black lines in Figure 4-4 indicate unpaved roads in the watershed, with the Beaver Lake, Lower White and West Fork subwatersheds having the highest priority for road improvements. Beaver Lake subwatershed is critical to reducing existing loading to the lake. Improvements in the Lower White and West Fork are important to helping meet TMDL requirements.

The Protection Strategy recommends several types of improvements to unpaved roads: wing ditches and turnouts, hydroseeding ditches, and stabilizing stream crossings.

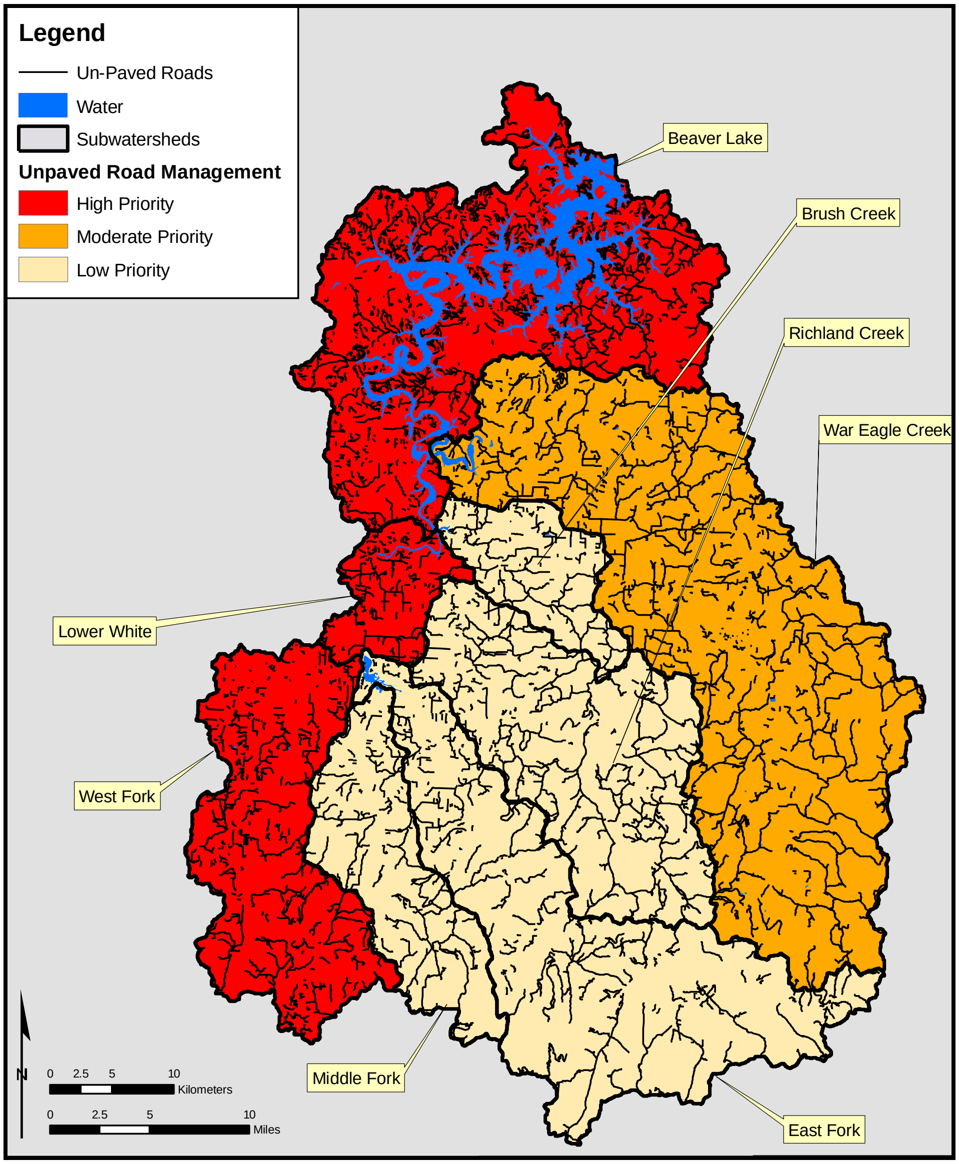


Figure 4-4. Unpaved Road Improvement Priorities

Stormwater BMP retrofits would include retrofitting existing stormwater ponds to improve pollutant removal and stormwater volume control. They also involve construction of new stormwater facilities to control and treat runoff from existing development.

Stormwater BMP Retrofits

Implementation of additional stormwater BMPs would include retrofitting existing stormwater ponds to improve pollutant removal and provide additional volume and peak control. Retrofit projects would also involve the targeted construction of new stormwater facilities to treat and control runoff from existing development. New stormwater facilities may include wet detention, dry detention, stormwater wetlands, bioretention, or other similar facilities. Drainage areas in the existing impaired watersheds (West Fork and Lower White) with high percentages of impervious area should

EPA Watershed Management Plan Element C: NPS Management Measures, Descriptions, and Critical Implementation Areas be prioritized for BMP retrofits, especially if these drainage areas lack stormwater treatment and control facilities (see orange and red areas in Figure 4-5).

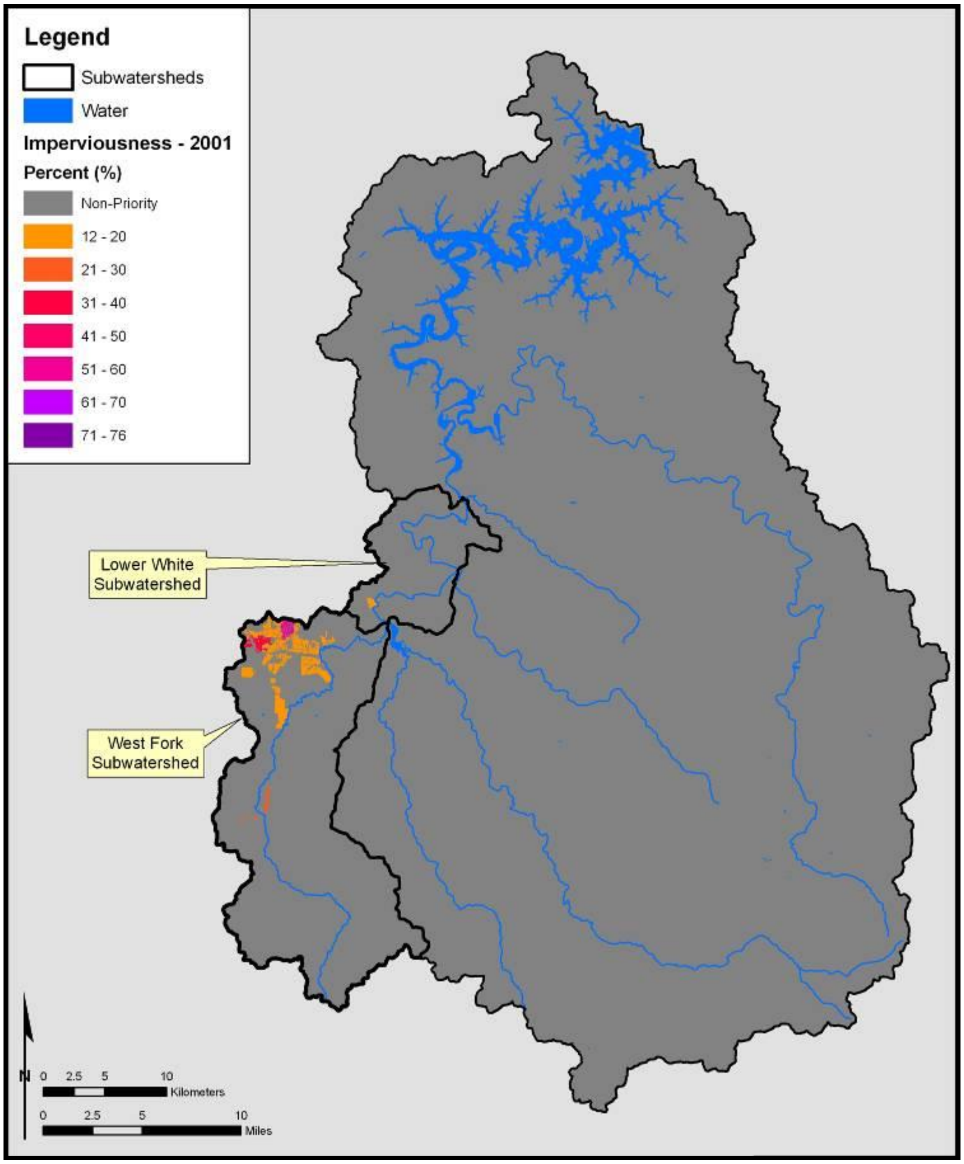


Figure 4-5. Stormwater BMP Retrofit Priority Areas

Table 4-1 shows the minimum BMPs and total load reductions associated with this Protection Strategy. Note that these core BMPs could be implemented over the next 40 years. Other BMPs may be substituted for portions of the core BMPs. For example, if it is difficult to achieve the participation rate for conservation easements/agreements, then additional acres of pasture renovation or other practices on the core BMP menu could be targeted.

The potential cost for Core BMPs is $15 million annualized, using a combination of local pricing sources and national cost averages (see

"Management Options Cost Effectiveness, Phase 1 and Phase 2"). However, a significant portion of this cost is associated with meeting existing ADEQ requirements, such as construction site stormwater management and TMDLs. Appendix A provides details on the cost-per-unit and the cost-effectiveness of each BMP.

Table 4-1. Core Voluntary BMPs and Estimated Total Sediment and Phosphorus Load Reduction (by 2055; methodology here)

BMP	Land Area Assumed to Participate in BMP Program	Reduction in Future Sediment Load to Lake
Land Conservation Program – Existing Pasture	7,930 acres	3,920 tons/year
Land Conservation Program – Existing Forest	12,810 acres	6,760 tons/year
Improved Construction Site Management	1,060 acres per year	3,440 tons/year
Buffer/Bank Restoration in Developed Areas Non-lakefront (non-pasture land uses)	410,100 feet of stream	2,800 tons/year
Pasture Buffer/Bank Restoration Non-lakefront	94,450 feet of stream	620 tons/year
Alternative Water Source and Fencing	8,670 acres	220 tons/year
Pasture Renovation	41,040 acres	3,450 tons/year
Buffer Preservation, Non-lakefront (developed areas)	1,446,490 feet of stream	1,150 tons/year
Unpaved Road Improvements	680 miles of road	810 tons/year
Stormwater BMP Retrofits	990 acres	280 tons/year
Estimated Total Reduction in Sediment Load	**23,450 tons/year**	
Estimated Total Reduction in Phosphorus Load	**14,780 lbs/year**	

Table 4-2 compares existing conditions to predicted water quality conditions in the future if the core BMPs are implemented. The modeling results show that Total Suspended Solids (TSS) concentrations are slightly higher in the upper portion of the lake (stations L1 – L3) and that the corresponding chlorophyll *a* concentrations are predicted to be the same or slightly lower (due to slightly lower light availability affecting chlorophyll *a* production). Middle Lake main stem conditions are expected to be about the same as existing conditions under these core BMPs, whereas Lower Lake chlorophyll *a* concentrations are expected to increase slightly.

Table 4-2. Predicted Lake Water Quality Indicators Under Existing Conditions and Future Core BMPs

Modeled Scenario: Indicator	Upper Lake Stations				Mid Lake Station	Lower Lake Station
	L1	L2	Hickory Creek	L3	L4	L5
Existing Conditions: TSS (mg/L) [1]	16.7	7.8	4.7	4.5	3.8	2.4
Future BMPs: TSS (mg/L) [1]	17.4	8.1	4.7	5.8	3.8	2.4
Existing Conditions: Chl *a* (µg/L) [2]	3.2	8.3	6.3	6.1	4.9	2.7
Future BMPs: Chl *a* (µg/L) [2]	3.2	6.7	6.3	5.8	4.9	3.1

[1] Modeled growing season average concentration
[2] Modeled growing season geometric mean concentration

Given these results, how well do the core BMPs in this alternative meet the lake water quality objectives? Table 4-3 summarizes the estimated protection levels. Tetra Tech recommended lake water quality targets and benchmarks at the Hickory Creek station based on the findings of the ADEQ Technical Work Group of regional water quality experts. Modeling results for the main stem of the mid and lower lake segments indicate that water supply and recreational objectives would be met in the main stem under this alternative, given the limited change expected from existing conditions.

The core voluntary BMPs would enable communities to meet the water supply and recreational objectives in the main stem of the lake.

Protection of the mid and lower lake areas below the Hickory Creek station is less clear regarding meeting recreational objectives in the small tributary and cove areas. The roughly 12 percent increase in both sediment and phosphorus is likely to manifest itself in the small tributaries and coves, which may, in turn, result in more turbid waters in these cove areas immediately following storm events, followed by more algae growth as sediment settles to the bottom of the water column. Some additional algae growth may be considered desirable for fishing use, whereas too much turbidity and algae might detract from other recreational uses (e.g., canoeing and lakeshore viewing). The lake model is not calibrated for the tributary coves so magnitude of impact in these portions of the lake cannot be analyzed reliably at this time. Thus, Table 4-3 shows a range reflecting this localized uncertainty.

The lake model is not calibrated for the tributary coves in the mid and lower lake areas. Recreational impacts in these cove areas cannot be analyzed reliably at this time.

The core BMPs also support meeting ADEQ TMDL requirements for the West Fork and Lower White watersheds. Appendix B provides more detail on BMPs recommended and sediment reduction achieved for each watershed. It also demonstrates how this Protection Strategy meets EPA's nine minimum elements for watershed plans for impaired waters. This is essential for securing funding for projects under EPA's 319 grant program.

Because there is some uncertainty regarding planning and modeling projections, additional protection measures are recommended in the final three components of the Protection Strategy.

Table 4-3. How Well do the Core BMPs Meet Lake Water Quality Objectives?

Lake Area	Water Supply	Recreation
Upper Lake (Hickory Creek)	●	●
Mid and Lower Lake	●	◐ - ●

Key to Symbols:
- ● Protection of Objectives Expected
- ◐ Protection of Objectives Uncertain
- ○ Protection of Objectives Not Expected

Where can I find more information about the cost and cost-effectiveness of BMPs?

- Management Option Cost-Effectiveness Phase I, March 13, 2009, Tetra Tech
- Management Option Cost-Effectiveness Phase II, March 20, 2009, Tetra Tech
- Appendix A

4.2.3 Component #3 – Developer and Contractor Lake Protection Certification Program (for all communities and developers willing to participate)

The Center for Watershed Protection reports those watersheds with 10 percent or more impervious area exhibit degradation of stream conditions. Other studies have shown degradation of streams at imperviousness levels as low as 5 to 6 percent. To help mitigate post-construction stormwater impacts from new development, Tetra Tech is recommending that, to the extent practicable, channel protection dry detention basins or Low Impact Development techniques be used for all new development in the Beaver Lake Watershed Municipal Planning Areas (see Figure 4-6) with imperviousness that is 12 percent or greater. This would include new commercial and industrial development and subdivisions with lots of 1 acre or less per house. Appendix C provides cost information regarding implementation of channel protection basins

Tetra Tech recommends that, to the extent practicable, channel protection dry detention basins or Low Impact Development techniques be used for all new development in the Municipal Planning Area with imperviousness that is 12 percent or greater.

and LID for different types of development. Ideally, design standards for new construction would require that stormwater flows from developed areas would not exceed preconstruction characteristics.

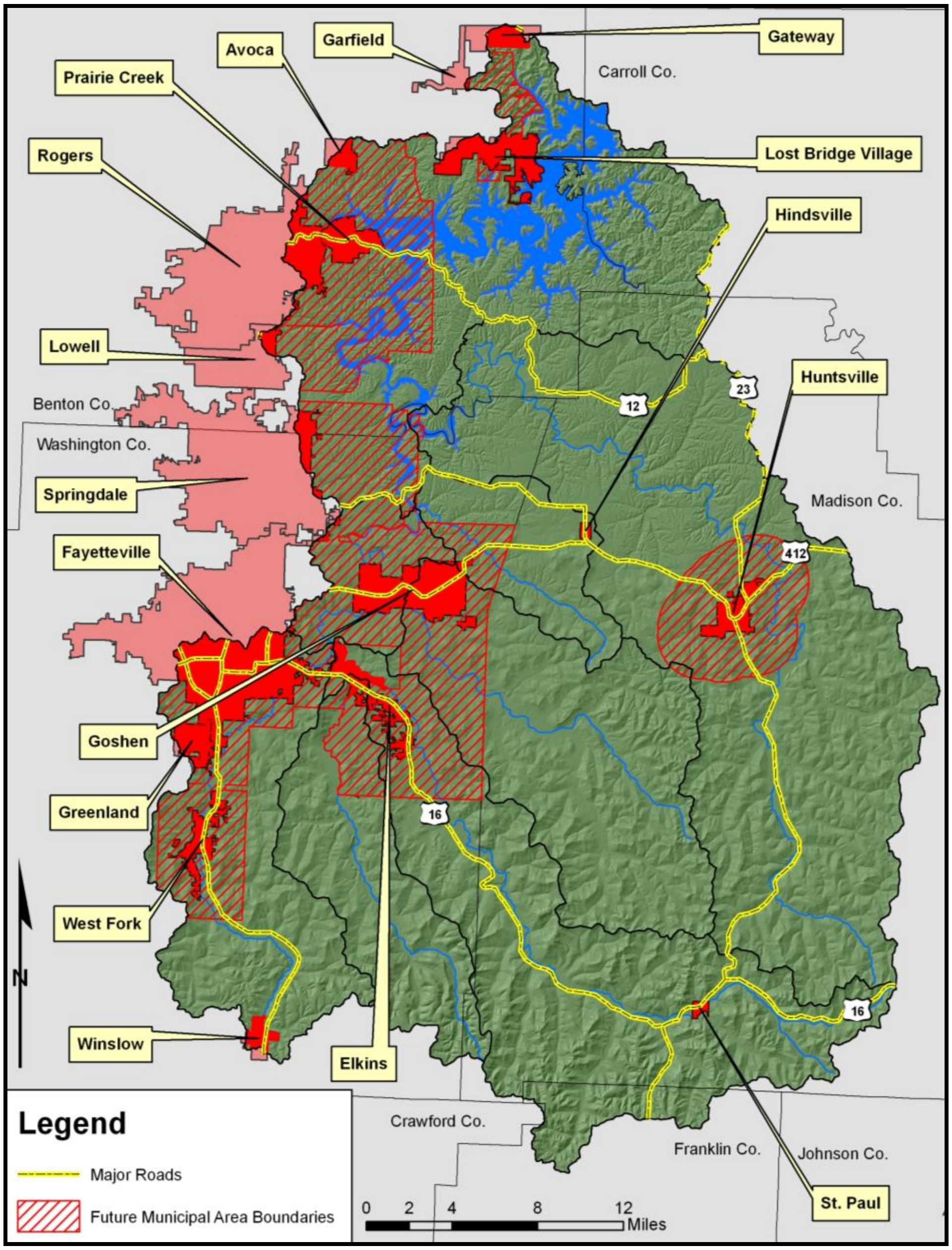


Figure 4-6. Priority Area for Lake Protection Certification Program – Planned Municipal Area

Management of post-construction stormwater runoff could be accomplished though a Developer and Contractor Lake Protection Certification Program. Local governments, site design engineers, developers, and contractors who are willing and able to participate in the program would sign a Lake Protection Pledge. To help meet the pledge,

Management of post-construction stormwater runoff could be accomplished through a Developer and Contractor Lake Protection Certification Program.

the Beaver Lake Watershed Council and University of Arkansas-Fayetteville (UA-Fayetteville) could implement a Stormwater Compliance Assistance Program, which is educational in nature and includes a volunteer-driven outreach effort. Similar to the Construction Site Management Compliance Assistance Program described above, the components of the Post-Construction Stormwater Compliance Assistance Program would include:

- Development of site design standards, inspection protocols, and a channel protection/LID BMP manual that can be used by local staff, developers, and contractors. The site design standards would seek to eliminate or minimize increases in stormwater flow and pollutant runoff from newly developed and redeveloped sites. Note that UA-Fayetteville has received a grant to develop a LID Manual for NW Arkansas.
- Training local staff in participating local governments on how to review plans for new development and redevelopment in order to calculate stormwater flow and projected pollutant runoff from the site.
- Development of a "Compliance Assistance Inspection Program," recruiting and training volunteer retired engineers. The volunteer engineers would inspect installation of channel protection dry detention basins and LID BMPs and report to the contractor any site deficiencies. The volunteer engineers would also conduct routine inspections of channel protection basins and LID BMPs to ensure long-term maintenance. The volunteers would supplement the work of existing staff.
- BMP installation inspections will be conducted under a "compliance assistance inspection" protocol, whereby the inspector identifies conditions that do not comply with the BMP manual or the site permit, provides consultation and recommendations regarding compliance approaches, and conducts re-inspections to determine whether or not noncompliant conditions have been addressed. Prolonged failure to correct noncompliant conditions may result in decertification in the Lake Protection Certification Program for the developer and/or contractor.
- Routine post-construction BMP inspections would also be conducted under a compliance assistance inspection protocol, whereby the volunteer inspector checks for routine maintenance and proper functioning of the BMP, provides recommendations to the homeowners' association or other responsible BMP owner/operator, and conducts re-inspections to determine whether noncompliant conditions have been addressed. Prolonged failure to

Local governments, site design engineers, developers, and contractors who are willing and able to participate would sign a Lake Protection Pledge.

EPA Watershed Management Plan Element E: Education and Information Component.

correct noncompliant conditions may result in a referral to participating local government.

- Volunteer Inspector training would be consistent and coordinated. This training would build on the existing UA-Fayetteville education/training program and be coordinated through the University and Beaver Lake Watershed Council. The training session would last two days. Successful completion of the training would allow the trainee to be added to the list of Certified Volunteer Inspectors. Continuing education would also be provided. The Compliance Assistance Program administrator would keep the list of certified volunteers up-to-date. The Program Administrator or the local staff could assign the inspectors to sites that need inspections.
- Develop a Voluntary Contractor Certification Program. Training would be available to familiarize design engineers and contractors with how to select/design/install/maintain channel protection and LID BMPs. It is recommended that the sessions be held in the winter months, with an 8-hour training event broken into two 4-hours sessions. To provide incentives to participate, the Program would allow contractors to advertise as "Lake Protection Certified," work with suppliers of BMP construction products to provide discounts to Certified Contractors, and publicly recognize certified design engineers and contractors and their outstanding projects. One example of a program that recognizes outstanding development projects is the Lower Cape Fear Stewardship Development program in North Carolina, which awards two levels of recognition for development projects that protect water quality and other natural resources (www.stewardshipdev.com).

Building on existing education programs, an outreach program should be established to educate landowners about lake protection efforts and how they can participate.

It is estimated that a regional Developer and Contractor Lake Protection Certification Program would have a startup cost of approximately $66,000 and recurring annual cost of approximately $35,000.

4.2.4 Component #4 – Education and Stewardship Program

EPA Watershed Management Plan Element E: Education and Information Component – See Section 4.2.4 #4.

Building on existing educational programs, an outreach program should be established to educate landowners about the lake protection efforts and how they can participate. This should include reaching out to landowners and businesses in the priority watersheds for land conservation, buffer/bank restoration, buffer preservation, and pasture BMPs. The message should stress that "doing it for the lake" also protects your local streams, and helps maintain a high quality of life for the region. Other messages might include "Protect Your Private Property – Keep Your Land Out of the Lake!" and "White River ♥s Green Buffers."

In addition, there are "good housekeeping" practices that should be encouraged for all homeowners including proper fertilizing of lawns, maintenance of septic systems (and use of enhanced onsite wastewater systems for new development), and maintaining vegetation along streams.

4.2.5 Component #5 – Monitoring and Adaptive Management

Additional monitoring and assessment efforts are needed to protect Beaver Lake's water supply and recreation in the coming decades.

The Beaver Lake Watershed Protection Strategy was developed based on historical monitoring data for the watershed and lake, projections of future development through the year 2055, and modeling that predicted the watershed processes and lake responses to that new development. While monitoring data provide information on current conditions, we cannot monitor future conditions in advance of when they occur – for prediction of future conditions we rely on models. There is uncertainty in all long-range growth projections and in modeling, and conditions change: new water quality protection technologies will emerge, climate conditions may change, and lake water quality may improve or decline. Historical and ongoing monitoring efforts provide critical information in characterizing the current stressors and impacts within the Beaver Lake watershed. However, additional monitoring and assessment efforts are needed to protect Beaver Lake's water supply and recreation in the coming decades. This Strategy recommends an annual formulation and evaluation of programs at the organizational level for the Watershed Alliance and participating stakeholder organizations, along with a five-year cycle of adaptive management as Strategy implementation occurs. Monitoring can occur either continuously or at the end of a management cycle, depending on resources and funding.

EPA Watershed Management Plan Element I: Monitoring of Implementation Efforts and Their Efficacy

It is important a long-term monitoring program exists to provide a technical foundation for an adaptive management process. As a part of the iterative adaptive management approach, Tetra Tech recommends several types of additional monitoring to serve as early warning indicators:

- *Water Quality Monitoring.* Are water quality targets being met at the Hickory Creek station? Monitoring should be conducted at the Hickory Creek station, which was chosen by the Technical Workgroup as an early warning indicator site for the Beaver Water District water supply and the rest of the lake. In addition, studies have determined that there is potential for significant loading of sediment and phosphorus from the Beaver Lake subwatershed downstream from the Hickory Creek station, which could pose threats to recreational uses and water supplies in the mid and lower lake areas.

  As of Spring 2012, there are 46 monitoring stations located throughout the watershed (Table 4-4); while these stations do not all monitor every parameter necessary to detect changes in water quality with program implementation, the list collectively

There is uncertainty in all long-range growth projections and in modeling. Also, conditions change.

represents a level of monitoring that may be helpful in evaluating program and BMP impact.

Table 4-4. Water Quality Monitoring Stations on the Beaver Lake Watershed

Count	Station ID	Description	Latitude	Longitude	Host Agency	Funding Source	Monitoring Type	Monitoring Frequency
1	BUFET003	Hock Creek near Wesley, Arkansas	36.0223	-93.8602	ADEQ	ADEQ	Water Quality	6 times/year
2	BUFS702	Hurricane Cave Spring	36.0547	-93.9333	ADEQ	ADEQ	Water Quality	6 times/year
3	LWHI009A	Lake Sequoyah near dam	36.0658	-94.0667	ADEQ	ADEQ	Water Quality	6 times/year
4	LWHI013B	Beaver Lake near War Eagle Park	36.2088890 1	-94.01583099	ADEQ	ADEQ	Water Quality	6 times/year
5	LWHI013C	Beaver Lake near Hwy. 12 Access - upper site	36.3333168	-94.01785278	ADEQ	ADEQ	Water Quality	6 times/year
6	WHI0051	West Fork White River east of Fayetteville, Arkansas	36.053889	-94.083056	ADEQ	ADEQ	Water Quality	6 times/year
7	WHI0052	White River near Goshen, Arkansas	36.106	-94.0114	ADEQ	ADEQ	Water Quality	6 times/year
8	WHI0070	Holman Creek below Huntsville, Arkansas	36.1248	-93.7339	ADEQ	ADEQ	Water Quality	6 times/year
9	WHI0098	West Fork White River at Co. Rd. 240 above Dye Creek	35.9422	-94.1853	ADEQ	ADEQ	Water Quality	6 times/year
10	WHI0101	Middle Fork White River at Co. Rd. 1-1/2 mi. NW of Hazel Valley	35.86938	-94.01097	ADEQ	ADEQ	Water Quality	6 times/year
11	WHI0102	Middle Fork White River at Co. Rd. Bridge 1 mi. S of Sulfphur City	35.95147	-94.05894	ADEQ	ADEQ	Water Quality	6 times/year
12	WHI0103	Middle Fork White River southwest of Elkins, Arkansas	36.0142	-94.0644	ADEQ	ADEQ	Water Quality	6 times/year
13	WHI0105	White River at Co. Rd. near Crosses, adjacent to AR Hwy 16	35.8778	-93.9083	ADEQ	ADEQ	Water Quality	6 times/year
14	WHI0106	White River at Durham, Arkansas	35.9561	-93.9769	ADEQ	ADEQ	Water Quality	6 times/year
15	WHI0109	Richland Creek at Co. Rd. 1-1/4 mi. N of AR Hwy 74 near Tuttle	36.0483	-93.9728	ADEQ	ADEQ	Water Quality	6 times/year
16	WHI0112	Brush Creek off AR Hwy 303	36.1336	-93.9519	ADEQ	ADEQ	Water Quality	6 times/year
17	WHI0113	War Eagle Creek at Co. Rd. bridge 1/4 mi. W of Ar Hwy 23	36.0069	-93.7111	ADEQ	ADEQ	Water Quality	6 times/year
18	WHI0114	War Eagle Creek at AR Hwy 412	36.1214	-93.695	ADEQ	ADEQ	Water Quality	6 times/year
19	WHI0116	War Eagle Creek at Hwy. 45	36.2017	-93.8569	ADEQ	ADEQ	Water Quality	6 times/year
20	RC45	Richland Creek at Goshen, AR	36.104167	-94.0075	AWRC	ANRC 319	Water Quality	46 times/year

Count	Station ID	Description	Latitude	Longitude	Host Agency	Funding Source	Monitoring Type	Monitoring Frequency
21	TB 16	Town Branch Trib at Hwy 16 at Fayetteville, AR	36.098333	-94.162222	AWRC	ANRC 319	Water Quality	46 times/year
22	TB 62	Town Branch at BR 62 at Fayetteville, AR	36.056944	-94.176111	AWRC	ANRC 319	Water Quality	46 times/year
23	WEC	War Eagle Creek near Hindsville, AR	36.2017	-93.8569	AWRC	ANRC 319	Water Quality	46 times/year
24	WFWR	West Fork White River east of Fayetteville, AR	36.053889	-94.083056	AWRC	ANRC 319	Water Quality	46 times/year
25	WR45	White River near Fayetteville, AR	36.073056	-94.081111	AWRC	ANRC 319	Water Quality	46 times/year
26	BWD 05	White River at Elkins, AR	36.000783	-94.003992	BWD	BWD	Water Quality	Monthly
27	BWD 07	MF White River at Black Oak, AR	35.995739	-94.072739	BWD	BWD	Water Quality	Monthly
28	BWD 09	War Eagle Creek at War Eagle, AR	36.267628	-93.943444	BWD	BWD	Water Quality	Monthly
29	BWD 10	White River Near Fayetteville, AR	36.073056	-94.081111	BWD	BWD	Water Quality	Monthly
30	BWD 12	Pond Overflow East of Parson's Landfill	36.181167	-94.049417	BWD	BWD	Water Quality	Monthly
31	BWD 13	White River near Wyman, AR	36.087806	-94.069806	BWD	BWD	Water Quality	Monthly
32	BWD 15	War Eagle Creek near Huntsville, AR	36.121569	-94.694111	BWD	BWD	Water Quality	Monthly
33	BWD 16	WF White River near Fayetteville, AR	36.053889	-94.083056	BWD	BWD	Water Quality	Monthly
34	BWD 17	Nelson Hollow at Rogers Group Lowell Quarry	36.22775	-94.075167	BWD	BWD	Water Quality	Monthly
35	USGS 07048480	Town Branch at BR 62 at Fayetteville, AR	36.056944	-94.176111	USGS	City of Fayetteville	Discharge	Instantaneous
36	USGS 07048490	Town Branch Trib at Hwy 16 at Fayetteville, AR	36.098333	-94.162222	USGS	City of Fayetteville	Discharge	Instantaneous
37	USGS 07048550	West Fork White River east of Fayetteville, AR	36.053889	-94.083056	USGS	ANRC, ADEQ, OWW	Discharge	Instantaneous
38	USGS 07048600	White River near Fayetteville, AR	36.073056	-94.081111	USGS	US ACE Little Rock, BWD, ANRC	Discharge	Instantaneous
39	USGS 07048800	Richland Creek at Goshen, AR	36.104167	-94.0075	USGS	BWD, OWW	Discharge	Instantaneous
40	USGS 07049000	War Eagle Creek near Hindsville, AR	36.2017	-93.8569	USGS	UA ACE Little Rock, BWD	Discharge	Instantaneous

Count	Station ID	Description	Latitude	Longitude	Host Agency	Funding Source	Monitoring Type	Monitoring Frequency
41	USGS 7048910	Beaver Lake at HWY 412 Bridge near Sonora	36.103889	-94.007222	USGS	BWD	Water Quality	6 times/year
42	USGS 7049160	White River at Beaver Dam near Eureka Springs	36.420833	-93.847222	USGS	BWD	Water Quality	6 times/year
43	USGS 7049187	Beaver Lake ds Hickory Ck Landing nr Springdale,AR	36.250278	-94.026333	USGS	USGS, BWD	Water Quality	6 times/year
44	USGS 7049200	Beaver Lake near Lowell	36.259167	-94.068889	USGS	USGS, BWD	Water Quality	6 times/year
45	USGS 7049500	Beaver Lake @ Hwy 12 bridge near Rogers, AR	36.332222	-94.018889	USGS	USGS, BWD	Water Quality	6 times/year
46	USGS 7049690	Beaver Lake near Eureka Springs, AR	36.420833	-93.847222	USGS	USGS, BWD	Water Quality	6 times/year

A group of experts should be organized to identify other appropriate monitoring locations, review data on a regular basis, and develop recommended criteria (as needed to go beyond that recommended at the Hickory Creek and L3 stations). The group's responsibilities would include the determination of appropriate water quality "triggers" for the mid and lower portions of the lake (to go along with the benchmarks and targets already recommended for the upper lake) that would stimulate implementation of an adapted protection strategy, which could include enhanced oversight of development projects, advanced wastewater treatment, and focused promotion of lake-friendly lawn and property management practices.

EPA Watershed Management Plan Element I: Monitoring of Implementation Efforts and Their Efficacy

It should be noted that in 2008, the Arkansas Department of Environmental Quality listed the White River, segment 11010001-27, and the War Eagle Creek, segment 11010001-34, as not supporting the drinking water supply designated use because of Beryllium (ADEQ, 2008 Integrated Water Quality Monitoring and Assessment Report). The White River was previously listed for the same pollutant in 2004 and 2006. The War Eagle Creek had been previously listed in 2006. At the time, the source of the Beryllium was not known. Starting with the 2010, and continuing into the 2012 draft 305(b) report, Beryllium was no longer identified as a source of impairment for any stream segments tributary to Beaver Lake. The State continues to monitor stream segments for Beryllium. Should segments in the Beaver Lake watershed re-appear on future section 305(b) reports, a management plan for that pollutant will be developed.

- *Observational monitoring.* Are there increasing frequencies of algae blooms, sediment plumes, and/or beach closings in the upper lake and lower lake cove areas? If so, monitoring personnel would track upstream to identify sources of the problem. Are stream channels widening and deepening in urbanizing areas and are sediment islands forming instream? This information would also be fed into the Watershed Council to determine if the current protection strategy needs to be adapted.
- *Programmatic Monitoring for Core BMPs.* Are core BMP and other voluntary participation programs working as anticipated? Are landowners participating in conservation and stewardship programs at levels anticipated in the Beaver Lake Watershed Protection Strategy? Are developers and local governments participating at a high rate in the Beaver Lake protection efforts, installing stormwater and channel protection controls on construction sites and new development areas?

These early warning indicators, used together, would indicate when the lake's protection targets are not being met and voluntary efforts are not sufficient, and determine when the Protection Strategy needs to be adjusted. These efforts would be part of the Council's adaptive process for management of the watershed.

Early warning indicators would indicate when the lake's protection targets are not being met and voluntary efforts are not sufficient, and determine when the Protection Strategy needs to be adjusted.

Citizen- and volunteer-level programs may play an increasing role in water quality monitoring. For example, Beaver Lake Secchi Day, which is organized by the Beaver Water District, provides invaluable turbidity data on the lake. It is both an important monitoring tool and community engagement effort. Furthermore, in 2012 a voluntary citizen science based monitoring program will launch that will increase the extent and frequency of water quality monitoring in the Beaver Lake Watershed. This program, called *StreamSmart*, was developed by the Beaver Water District, Audubon Arkansas, and the Arkansas Water Resources Center (AWRC). The steering committee also includes the newly formed Beaver Watershed Alliance. The goal of the program is to eventually gather seasonal data on water quality at an additional 30 locations throughout the watershed. Citizen volunteers will undergo training and then collect data at predetermined monitoring sites. Data and samples will be analyzed by the AWRC. Quality assurance protocols include data quality verification through random duplicate sampling by the AWRC staff.

Section 5

Implementation Summary

There is much work to do and success will depend on many agencies, community leaders, and landowners.

The Protection Strategy is not a new law or regulation. It depends on enforcing existing regulations and/or voluntary actions hinging on good stewardship.

5.1 Overall Prioritization of Subwatersheds

Subwatershed prioritization for sediment, nutrients, and recommended BMPs has been described above in the Protection Strategy. While it is clear that partnering organizations will ultimately determine which subwatersheds they will focus on to meet their own organizational goals, some overall prioritization of watersheds for work must be established. The following represents the overall cumulative ranking of subwatersheds per recommended contaminant and BMP:

1. West Fork and Lower White River subwatersheds
2. Beaver Lake subwatershed
3. War Eagle Creek subwatershed
4. Brush Creek, East Fork, Middle Fork, and Richland Creek subwatershed

It should be recognized that directing programs and projects along this overall suggested prioritization should not preclude any organization from seizing opportunities that may arise (due to funding, emerging needs, or otherwise).

5.2 Implementation Timeline

EPA Watershed Management Plan Element F & I: NPS Management Measures Implementation Schedule and Milestones – See also Table 5-2.

The timeline suggested for implementation of components of this strategy include short-term (i.e., ~2 year), mid-term (~5-8 year), and longer-term or ongoing actions. Implementation of the 5 key components of the Protection Strategy constitute the short-term actions: (1) development of the Beaver Watershed Alliance; (2) implementation of key best management practices; (3) creation of a Developer and Contractor Lake Protection Certification Program; (4) initiation of an educational and stewardship program; and (5) establishing a monitoring and adaptive management program. The formation of and onboarding of staff for the Beaver Watershed Alliance would be an appropriate beginning milestone for short-term actions, though this watershed group certainly is not the only organization that should implement the Protection Strategy.

Mid-term actions will be the further development, refinement, and operation/maintenance of the 5 key components. Long-term actions will be the ongoing operation/maintenance of the key components and related programs as described above, and will also include new programs and actions, such as monitoring and adapting the stragy.

Table 5-1 provides a snapshot of the key actions recommended in the Protection Strategy, the potential funding and assistance, who needs to take the lead, and other groups responsible for implementation. As can be seen, there is much work to do and success will depend on many agencies, community leaders, and landowners. Table 5-2 provides an estimated timeline or schedule for taking action, with shorter-term priority actions denoted. Implementation capability will depend on many factors, including available funding and resources and other community priorities requiring attention. In this regard, this section should be viewed as a starting point and a guide to help the Beaver Lake Watershed Alliance and others implementing the Strategy. Estimated timelines are not absolute, rather based on best available information.

Implementation capability will depend on many factors, including available funding and resources, and other community priorities requiring attention.

5.3 Adaptive Management

Because priorities can and will shift as new data are acquired and new water quality issues emerge, the Watershed Alliance and partnering organizations will utilize an adaptive management approach, where the goals of the organization and programming will be assessed every five years, approximately. Annual or biannual workplans and program agendas should be developed and evaluated organizationally. For example, for each project or program implemented, the Alliance's staff and Board of Directors will need to determine success criteria in terms of community involvement and water quality improvement, and adjust programmatic goals and focus in the shorter terms. The Beaver Watershed Alliance has adopted the Protection Strategy and is committed to ongoing review and updating of the document to ensure long-term relevancy. On a 5-year basis, the Policy and Technical Advisory Groups should reconvene to examine and discuss new trends in water quality and to identify emerging issues on the watershed in order to evaluate and revise the Protection Strategy. Furthermore, as opportunity or need arises, the Protection Strategy should be amended through notification and engagement of

Annual work plans should be developed organizationally, and the Watershed Council and its partners will periodically review the key actions and timeline and update them when new information is available and success is achieved.

stakeholders and program partners. In summary, this is a living document that provides a starting point for the long-term protection of Beaver Lake and the restoration of the West Fork and Lower White rivers. It is anticipated that the Watershed Council and its partners will review the key actions and timeline and revise them as new information is available, experience is gained, and success is achieved.

Table 5-1. Beaver Lake Watershed Protection Strategy Implementation Summary

Protection Strategy Component	Potential Funding/ Technical Assistance	Responsible Group(s)
Core Voluntary Best Management Practices		
Land Conservation Program - Conservation Easements for Stream Buffers and Upland Areas • Conduct screening and field evaluation of priority areas • Conduct landowner outreach • Secure funding sources • Identify/secure stewardship organizations • Develop stewardship plan • Explore Transfer of Development Rights Program • Explore Carbon Credit Program	State and federal tax credits Conservation Reserve Program Environmental Quality Incentives Program Local water suppliers Local businesses Local governments Trust for Public Lands (technical assistance only) The Nature Conservancy (technical assistance only)	Lead: Beaver Watershed Alliance County Farm Service agencies Natural Resources Conservation Service Local water suppliers Local governments Arkansas Game and Fish Commission Arkansas Forestry Commission Land trusts
Improved Construction Site Management • Enforce minimum federal, state, and local requirements • Develop and administer compliance assistance program • Require silt fencing, detention ponds, and phased land disturbance • Note: This Protection Strategy recommends going beyond minimum standards where feasible to have local enforcement in non-urbanized area where there is currently state jurisdiction	Stormwater impact fee on new development via local governments or stormwater utility Fines for noncompliance Local water suppliers Volunteer construction site monitoring program (e.g., Upper Chattahoochee Riverkeeper; KY Waterways Alliance) (technical assistance only)	Lead: MS4 permittees in designated urbanized areas and Beaver Watershed Alliance ADEQ in non-urbanized areas UA-Fayetteville Extension Service

Protection Strategy Component	Potential Funding/ Technical Assistance	Responsible Group(s)
Stream Buffer and Bank Restoration • Conduct field evaluation • Conduct landowner outreach • Contact COE and other permitting agencies • Coordinate with trails and infrastructure • Develop preliminary design and cost estimate • Secure needed permits • Secure funding • Secure stewardship organizations • Final planning and design • Develop stewardship plan	Conservation Reserve Program Conservation Reserve Enhancement Program (CREP) Arkansas Stream Team Arkansas Forestry Commission Environmental Quality Incentives Program (EQIP) Wildlife Habitat Incentives Program 319 Grants/ANRC Local water suppliers Federal Stimulus Funds	Lead: Beaver Watershed Alliance County Farm Service agencies Arkansas Game and Fish Commission Natural Resource Conservation Service Local governments (cost share) Local water supplier (cost share) Land trusts US Army Corps of Engineers (COE)
Farm Best Management Practices	Water Users/Local Governments using Beaver Lake water supply Environmental Quality Incentives Program 319 Grants/ANRC The Poultry Federation UA-Fayetteville Extension Service	Lead: Natural Resource Conservation Service UA-Fayetteville Extension Service Beaver Lake Watershed Council
Unpaved Road Improvements (emphasizing BMP retrofits including ditch hydroseeding, wing ditches, and stream crossing stabilization)	Legislative appropriations Local government road maintenance fund	Lead: Local governments
Stormwater BMP Retrofits	Stormwater impact fee on impervious area	Lead: Local governments

Protection Strategy Component	Potential Funding/ Technical Assistance	Responsible Group(s)
Beaver Lake Watershed Council: Please note, the stakeholder-driven Beaver Watershed Alliance had bylaws approved in December of 2010		
Form Watershed Council Develop recommended draft structure, group membership, funding mechanism(s) and by-laws Form task force to review draft Send invitation to groups to appoint representative Establish non-profit status	Local businesses Local governments Local water suppliers Foundations ANRC	Lead: Northwest Arkansas Council Task Force (similar to PAG) Local governments
Hire Watershed Council Coordinator/Director Identify dedicated funding source Draft job description and post position Interview and hire coordinator/director	Local businesses Local governments Local water suppliers Foundations ANRC	Lead: Beaver Watershed Alliance
Developer/Contractor Lake Protection Certification Program		
Conduct outreach to communities, developers and contractors Educate on importance of implementing MS4 requirements for post-construction stormwater management Identify communities, developers and contractors willing to sign "Lake Protection Pledge" to use stormwater Best Management Practices Note: This plan recommends going beyond state minimum stormwater requirements where feasible to include engineered stormwater controls for new intensive development in the Municipal Planning Area and conservation design for development in the rural area.	Local water suppliers Local stormwater programs Homebuilders Association ADEQ	Lead: Beaver Watershed Alliance Northwest Arkansas Council Local governments UA-Fayetteville Extension Service

Protection Strategy Component	Potential Funding/ Technical Assistance	Responsible Group(s)
Develop site design standards, inspection protocols, and a channel protection/Low Impact Development Manual	319 Grant/ANRC	Lead: Beaver Watershed Alliance Local governments UA-Fayetteville
Develop incentives for program participation Advertise participants Work with suppliers of construction products to provide discounts Establish annual awards program	319 Grant/ANRC Homebuilders Association	Lead: Beaver Lake Watershed Council Northwest Arkansas Council Homebuilders Association
Develop and administer compliance assistance/certification program for developers and contractors	Local stormwater impact fee on new development via local governments or stormwater utility	Lead: Beaver Lake Watershed Council Local governments UA-Fayetteville Extension Service
Education and Stewardship Program		
Coordinate with other Partnerships and UA-Fayetteville to build on existing education efforts	Capacity-building and education/awareness grant programs	Lead: Beaver Watershed Alliance UA-Fayetteville Extension Service Illinois River Watershed Partnership Ozark Water Watch Kings River Watershed Partnership NRCS
Educate communities, developers, and contractors on importance of implementing MS4 requirements for construction and post-construction stormwater management (see above)	Local stormwater impact fee on new development	Lead: Beaver Watershed Alliance UA-Fayetteville Local governments

Protection Strategy Component	Potential Funding/ Technical Assistance	Responsible Group(s)
Adapt "Landowner's Guide to Streamside Living" by Kings River Watershed Partnership to Beaver Lake watershed. Distribute online and hardcopies. Address such issues as: Finalize and use "Lake Smart," good stewardship providers for landowners around the lake. Property and stream modification Gravel mining Onsite wastewater treatment Floodplain development Nutrient management Streambank erosion Riparian buffers Riparian restoration	319 Grant/ANRC UA-Fayetteville Extension Service Local water suppliers	Lead: Beaver Watershed Alliance UA-Fayetteville Extension Service Conservation groups Landowners
Develop Conservation Design guidelines and examples for new development in rural areas Develop guidelines Revise local ordinances to allow conservation design as an alternative to traditional subdivisions	319 Grant Northwest Arkansas Regional Planning Commission (technical assistance only) UA-Fayetteville	Lead: Beaver Watershed Alliance UA-Fayetteville Local governments
Continue educational efforts to stress implementation of farm Nutrient Management Plans and to highlight innovative practices	Natural Resources Conservation Service UA-Fayetteville Extension Service	Lead: Natural Resources Conservation Service and UA-Fayetteville Extension Service Beaver Watershed Alliance

Protection Strategy Component	Potential Funding/ Technical Assistance	Responsible Group(s)
Continue and enhance good lake management practices Shoreline maintenance and erosion control Buffer for nutrient sources Draw down lake elevation slowly to minimize impacts on water supply intakes	Local water suppliers US Army Corps of Engineers	Lead: US Army Corps of Engineers Beaver Watershed Alliance Arkansas Game & Fish Commission UA-Fayetteville Extension Service
Monitoring and Adaptive Management*: *Please note a Beaver Watershed Alliance Technical Advisory Group has formed and is in the process of designing a watershed-wide, HUC 12 scale monitoring plan.		
Develop overall assessment program, including stewardship report Establish questions that should be answered by ongoing assessment to evaluate performance Establish indicators that will be tracked Establish appropriate methods and procedures for assessment Produce triennial stewardship report *Assume five-year adaptive management cycle	Local water suppliers ADEQ ANRC US Geological Survey	Lead: Beaver Watershed Alliance Local water suppliers UA-Fayetteville US Geological Survey
Enhance long-term watershed and lake monitoring Review current state, local, and UA-Fayetteville monitoring programs in context of Protection Strategy and corresponding assessment program to clarify gaps Identify monitoring needed Develop monitoring plan and estimated costs Secure funding Implement monitoring program, which addresses five-year adaptive management cycle	Local water suppliers ADEQ ANRC US Geological Survey Farm Stewardship Council	Lead: Beaver Watershed Alliance Local water suppliers UA-Fayetteville US Geological Survey

Table 5-2. Beaver Lake Watershed Protection Strategy Implementation Timeline: Assuming five-year Adaptive Management cycle beginning January 2012 or at hiring of Council Executive Director

Protection Strategy Component	Timeline*	Short Term Priority (Y=Yes)
Core Voluntary Best Management Practices		
Land Conservation Program - Conservation Easements for Stream Buffers and Upland Areas • Conduct screening and field evaluation of priority areas • Conduct landowner outreach • Secure funding sources • Identify/secure stewardship organizations • Develop stewardship plan • Implement • Explore Transfer of Development Rights Program • Explore Carbon Credit Program	Initial Phase July 2012-2016 July 2012-July 2013 January 2013-December 2013 July 2012-July 2014 July 2014-December 2015 July 2014 – December 2015 January 2016 – January 2017 July 2015 – January 2017 July 2015 – July 2016	 Y Y Y Y Y Y
Improved Construction Site Management • Enforce minimum federal, state, and local requirements • Develop and administer compliance assistance program • Require silt fencing, detention ponds, and phased land disturbance • Note: This Protection Strategy recommends going beyond minimum standards where feasible to have local enforcement in non-urbanized area where there is currently state jurisdiction	Initial Phase July 2011 -2014 July 2011 – July 2013 January 2014	Y Y Y
Stream Buffer and Bank Restoration • Conduct field evaluation • Conduct landowner outreach • Contact COE and other permitting agencies • Coordinate with trails and infrastructure • Develop preliminary design and cost estimate • Secure needed permits • Secure funding • Secure stewardship organizations • Final planning and design • Develop stewardship plan • Implement	Initial Phase July 2013 – July 2018 July 2013 – July 2014 January 2015 – December 2015 January 2015 – March 2016 January 2015 – March 2016 July 2015 – July 2016 July 2016 – July 2017 July 2013-July 2018 July 2016 – July 2017 July 2016- December 2017 July 2016 – December 2017 July 2018 – January 2020	
Farm Best Management Practices	January 2012 – January 2017	
Unpaved Road Improvements (emphasizing BMP retrofits including ditch hydroseeding, wing ditches, and stream crossing stabilization)	Initial Phase July 2019-July 2020	
Stormwater BMP Retrofits	Initial Phase July 2012 – July 2017	

Protection Strategy Component	Timeline*	Short Term Priority (Y=Yes)
Beaver Lake Watershed Council (currently called Beaver Watershed Alliance)		
Form Watershed Council • Send invitation to groups to appoint representative • Form task force to review draft; solicit input • Develop recommended draft structure, group membership, funding mechanism(s) and by-laws • Establish non-profit status	Completed December 2011 Completed April 2010 Completed November 2010 Completed December 2010 Completed July 2011 Completed September 2011	Y Y Y Y Y
Hire Watershed Council Coordinator/Director • Identify dedicated funding source • Draft job description and post position • Interview and hire coordinator/director	Completed December 2011 Completed March 2011 Completed May 2011 Completed November 2011	Y Y Y Y
Developer/Contractor Lake Protection Certification Program		
Conduct outreach to communities, developers and contractors • Educate on importance of implementing MS4 requirements for post-construction stormwater management • Identify communities, developers and contractors willing to sign "Lake Protection Pledge" to use stormwater Best Management Practices • Note: This Plan recommends going beyond state minimum stormwater requirements where feasible to include engineered stormwater controls for new intensive development in the Municipal Planning Area and conservation design for development in the rural area.	March 2012 – January 2017 January 2012 – January 2017 March 2012 –June 2012	Y Y
Develop site design standards, inspection protocols, and a channel protection/Low Impact Development Manual	July 2011 – July 2014	
Develop incentives for program participation • Advertise participants • Work with suppliers of construction products to provide discounts • Establish annual awards program	March 2012 and January 2017	Y Y
Develop and administer compliance assistance/certification program for developers and contractors (in conjunction with construction site compliance assistance program)	July 2011-July 2013	Y
Education and Stewardship Program		
Coordinate with other Partnerships and UA-Fayetteville to build on existing education efforts	January 2012 – January 2017	

Protection Strategy Component	Timeline*	Short Term Priority (Y=Yes)
Educate communities, developers, and contractors on importance of implementing MS4 requirements for construction and post-construction stormwater management (see above)	January 2012 – January 2017	
Education and Stewardship Program (con't.)		
Adapt "Landowner's Guide to Streamside Living" by Kings River Watershed Partnership to Beaver Lake watershed. Distribute online and hardcopies. Address such issues as: • Property and stream modification • Gravel mining • Onsite wastewater treatment • Floodplain development • Nutrient management • Streambank erosion • Riparian buffers • Riparian restoration	July 2012 – December 2012	
Develop Conservation Design guidelines and examples for new development in rural areas • Develop guidelines • Revise local ordinances to allow conservation design as an alternative to traditional subdivisions	July 2014- July 2017	
Continue educational efforts to stress implementation of Nutrient Management Plans and to highlight innovative practices	January 2012 – January 2017	Y
Continue and enhance good lake management practices • Shoreline maintenance and erosion control • Buffer for nutrient sources • Draw down lake elevation slowly to minimize impacts on water supply intakes	January 2012 – January 2017	
Monitoring and Adaptive Management		
Develop overall assessment program, including stewardship report • Establish questions that should be answered by ongoing assessment to evaluate performance • Establish indicators that will be tracked • Establish appropriate methods and procedures for assessment • Produce triennial stewardship report	Initial Phase March 2012- July 2014 March 2012 – July 2013 March 2012 – July 2013 January 2013 – July 2013 July 2013-July 2014	

Protection Strategy Component	Timeline*	Short Term Priority (Y=Yes)
Enhance long-term watershed and lake monitoring	Initial Phase July 2012 – 2013	
• Review current state, local, and UA-Fayetteville monitoring programs in context of Protection Strategy and corresponding assessment program to clarify gaps	Completed	Y
• Identify monitoring needed	Completed	Y
• Develop monitoring plan and estimated costs	In progress	Y
• Secure funding	March 2013- July 2013	Y
• Implement monitoring program	October 2013 – January 2017	Y

*Assume five-year cycle Adaptive Management plan, beginning May 2012

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Appendix A. BMP Cost and Cost Effectiveness

EPA Watershed Management Plan Element D: Estimates of Technical/Financial Costs of Implementations – See Table A-1-9

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Table A-1. Core BMPs Unit Cost and Cost-effectiveness Summary Table

	20-Year Cost per Unit			Annualized Cost per Unit			Cost per Ton Sediment Load Reduced To Lake		
BMP	**Low**	**High**	**Median**	**Low**	**High**	**Median**	**Low**	**High**	**Median**
Land Conservation Program -- Existing Pasture	$2,000	$3,000	$2,500	$100	$150	$125	$200	$300	$250
Land Conservation Program -- Existing Forest	$2,000	$3,000	$2,500	$100	$150	$125	$200	$300	$250
Improved Construction Site Management	$24,180	$32,080	$28,100	$1,209	$1,609	$1,409	$400	$500	$450
Buffer/Bank Restoration in Developed Areas Non-Lakefront (non-pasture land uses)	$188	$273	$231	$9	$14	$12	$1,400	$2,000	$1,700
Pasture Buffer/Bank Restoration Non-lakefront	$188	$273	$231	$9	$14	$12	$1,400	$2,100	$1,750
Alternative Water Source and Fencing	$820	$1,110	$970	$41	$56	$48	$1,600	$2,100	$1,850
Pasture Renovation	$479	$739	$609	$24	$37	$30	$300	$400	$350
Buffer Preservation, Non-lakefront (in developed areas)	$10	$30	$20	$0.5	$1.5	$1.0	$600	$1,900	$1,250
Unpaved Road Improvements	$16,910	$23,090	$20,000	$846	$1,155	$1,000	$700	$1,000	$850
Stormwater BMP Retrofits	$8,020	$28,040	$18,000	$401	$1,402	$902	$1,400	$4,900	$3,150
Total	--	--	--	--	--	--	$500	$800	$600

Table A-2. Cost Estimates for Land Conservation Program (Both Pasture and Forest)

	Cost per Acre				
Practice	**Low**	**High**	**Median**	**Potential Funding Sector(s)**	**Notes**
Stewardship Endowment	$2,000	$3,000	$2,500	Federal, State, Local Water Suppliers	To maintain easement in perpetuity or for given term.

Sources: T. Snell, The Nature Conservancy, Personal Communication to H. Fisher, January 13, 2009

Table A-3. Cost Estimates for Improved Construction Site Management

Practice	Cost per Acre Disturbed			Potential Funding Sector(s)	Notes
	Low	High	Median		
Upfront Administrative Cost (first year)	$70	$90	$80	Federal, State, Local	Inspection protocols, BMP guidance, volunteer inspector training, construction contractor training, program management
Annual Administrative Cost (after first year)	$30	$40	$40	Local	Same as above
20-year Administrative Present Value Cost ($/acre)	$450	$600	$530	Local	
Silt fencing and related controls – existing control costs subtracted ($/acre/year)	$560	$740	$650	Developer	Correctly sited, installed, and maintained; other minimum controls (i.e., inlet/outlet protection, rock exit pad)
Sediment Basins ($/acre/year)	$650	$850	$750	Developer	Basins, transitioned to permanent stormwater basins after construction
Phasing ($/acre/year)	$380	$520	$450	Developer	Project phasing with rapid seeding of disturbed areas after final grade is reached
Total Developer Costs ($/acre/year)	$1,590	$2,110	$1,850	Developer	
20-year Developer Present Value Costs ($/acre)	$23,660	$31,390	$27,500	Developer	
Total Present Value Costs ($/acre)	$24,180	$32,080	$28,100	Federal, State, Local, Developer	

Sources: USEPA (2008a); US EPA (2008b); USEPA (2009b); Mason (2009); Wisconsin DNR (2001); Knoxville/Knox County (2006)

Table A-4. Buffer and Bank Restoration Cost Estimates (Both Pasture and Non-Pasture)

Practice	Cost per Foot			Potential Funding Sector(s)	Notes
	Low	High	Median		
Upfront cost of streambank and buffer restoration	$160	$220	$190	Federal, state, local water suppliers	50-ft buffer, both sides of stream
Upfront cost of conservation easement, lakefront	$29	$78	$54	Federal, state, local water suppliers	Property is on or within view of Beaver Lake
Upfront cost of conservation easement, non-lakefront	$5	$23	$14	Federal, state, local water suppliers	Property is not within view of Beaver Lake
Monitoring Endowment	$18	$23	$21	Federal, state, local water suppliers	Monitoring should occur annually during the first five years following restoration
Stewardship Endowment	$5	$7	$6	Federal, state, local water suppliers	To maintain easement in perpetuity
Total Upfront Cost, lakefront	$212	$328	$270	Federal, state, local water suppliers	
Total Upfront Cost, non-lakefront	$188	$273	$231	Federal, state, local water suppliers	

Sources: AFC (2008), Faucette Real Estate (2009); NCEEP (2004);

David Evans, Arkansas Game and Fish Commission, Region 1 Stream Team, personal communication to H. Fisher, January and February 2009;

T. Heisel, Ozark Regional Land Trust, Inc., Personal Communication to H. Fisher, October 13, 2008;

T. Snell, The Nature Conservancy, Personal Communication to H. Fisher, January 13, 2009.

Table A-5. Cost Estimates for Pasture Alternative Water Source and Fencing

Practice	Cost per Acre			Potential Funding Sector(s)	Notes
	Low	High	Median		
Paddock Fencing	$30	$40	$35	Federal, State, Farmer	2 strand electric fencing, including fencing, energizer, and gate
Water Development	$480	$650	$565	Federal, State, Farmer	Well, pump, wellhead protection, piping, gravel pad, geotextile, tank and trough system

Practice	Cost per Acre			Potential Funding Sector(s)	Notes
	Low	High	Median		
Stream Crossing	$60	$80	$70	Federal, State, Farmer	Fence, geotextile cloth, stone
Upfront Total	$570	$770	$670	Federal, State, Farmer	
Annual Maintenance	$17	$23	$20	Farmer	
20-year Present Value Maintenance	$250	$340	$300	Federal, State, Farmer	
Total Present Value Cost	$820	$1,110	$970	Federal, State, Farmer	

Sources: Tetra Tech (2004); Ron Morrow, State Grasslands Specialist, Natural Resources Conservation Service-Arkansas, Little Rock, AR, personal communication to B. Tucker, November 2008.

Table A-6. Pasture Renovation Cost Estimates

Practice	Cost per Acre			Potential Funding Sector(s)	Notes
	Low	High	Median		
Upfront program setup cost	$29	$39	$34	Federal, state, local water suppliers	Purchase of equipment and setup of program administration
Annual operating cost	$20	$27	$23	Local	Operation of program and equipment maintenance
20-year Present Value operating cost	$300	$400	$350	Local	
Annual farmer cost	$10	$20	$15	Farmer	Operation of farmer-owned tractor and city-owned equipment
20-year Present Value farmer cost	$150	$300	$225	Farmer	
Total Present Value Cost	$479	$739	$609	Federal, state, local, local water suppliers, farmer	

Sources: Geosyntec (2008); RS Means (2009)

Table A-7. Riparian Buffer Preservation Cost Estimates (assuming 50-ft buffer preserved on both sides of the stream)

Practice	Cost per Foot[1]			Potential Funding Sector(s)	Notes
	Low	High	Median		
Upfront cost of conservation easement, lakefront	$29	$78	$54	Federal, state, local water suppliers	Property is on or within view of Beaver Lake
Upfront cost of conservation easement, non-lakefront	$5	$23	$14	Federal, state, local water suppliers	Property is not within view of Beaver Lake
Stewardship Endowment	$5	$7	$6	Federal, state, local water suppliers	To maintain easement in perpetuity
Total Upfront Cost, lakefront	$34	$85	$60	Federal, state, local water suppliers	
Total Upfront Cost, non-lakefront	$10	$30	$20	Federal, state, local water suppliers	

[1]Assuming that a 50-ft buffer is preserved on both sides of the stream.

Sources: Faucette Real Estate (2009); T. Heisel, Ozark Regional Land Trust, Inc., Personal Communication to H. Fisher, October 13, 2008;

T. Snell, The Nature Conservancy, Personal Communication to H. Fisher, January 13, 2009.

Table A-8. Unpaved Road BMP Cost Estimates

Practice	Cost per Mile			Potential Funding Sector(s)	Notes
	Low	High	Median		
Install Drainage Practices	$14,400	$19,600	$17,000	Local Government	Install wing ditches/turnouts and culverts at Arkansas Forestry Commission recommended spacing
Repair Existing Drainage	$260	$350	$310	Local Government	Remove material from wing ditches.
Hydroseed Ditches	$1,800	$2,400	$2,100	Local Government	
Total Upfront Cost	$16,460	$22,350	$19,410	Local Government	
Annual Maintenance	$30	$50	$40	Local Government	Inspect, reseed, repair during quarterly grading
20-year Present Value Maintenance	$450	$740	$600	Local Government	
Total Present Value Cost ($/mile)	$16,910	$23,090	$20,000	Local Government	

Sources: USDA (2008); RS Means (2009)

Table A-9. Stormwater BMP Retrofit Cost Estimates

Practice	Cost per Mile			Sector(s)	Notes
	Low	High	Median		
Stormwater BMP Retrofits (based on Stormwater Retention Pond costs)	$8,000	$27,000	$18,000	Local Government	Includes construction, design, engineering, and 20-year maintenance.

Source: Previous Tetra Tech cost estimates for BMP retrofits

Cost-effectiveness Results

Tetra Tech's Supplemental Pollutant Loading Analysis indicated that the greatest increases in pollutant loading to Beaver Lake in the future will come from sediment and phosphorus loading. Total nitrogen is only expected to increase by 4.4 percent by 2055, whereas sediment and phosphorus loading are expected to increase by 21 and 14 percent, respectively, by 2055. Upland loading from new development and channel erosion are estimated to contribute to the majority of the sediment and phosphorus load increases, and a significant majority of the total future loading. Since phosphorus load increases are largely tied to sediment load increases, Tetra Tech focused on evaluating management options by cost-effectiveness for sediment reduction. Management options that are cost-effective for sediment reduction are expected to also be cost-effective for phosphorus. Figure A-1 illustrates the cost-effectiveness ratios for sediment reduction across the management options. The high and low cost-effectiveness estimates are based on the high and low cost-estimates documented above, and the median estimate is the average of the high and low estimates.

Since the Beaver Lake subwatershed has substantially different loading rates to the lake, as well as topography and soils, Tetra Tech calculated cost-effectiveness ratios separately for the Beaver Lake subwatershed (BL) and the other subwatersheds in the municipal planning area (represented by WFLW).

The Centralized Wastewater management options provide a cost-effective option for phosphorus reduction but do not provide sediment reduction benefits. Tetra Tech recommends that management options for sediment reduction be prioritized for protection of Beaver Lake. The WWTP upgrades and decentralized alternatives could be considered to achieve additional improvement in phosphorus loading beyond what can be achieved by sediment reduction.

To streamline the evaluation process, management options with similar cost-effectiveness ratios were combined. Post-construction options in karst areas are not shown but exhibited roughly 10 to 60 percent increases in cost per ton removed above non-karst management options. Buffer preservation (non-lakefront) and buffer/bank restoration in developed areas were combined, and the unpaved road and stream crossing improvements were also combined. Figure A-1 shows the combined cost-effectiveness ranges for these options.

Post-construction Cost-effectiveness

Upland sediment from new development and new development impacts on channel erosion generate the highest increase in sediment loading to the Lake. Channel erosion and future development represent 75 percent of the total future sediment loading to the Lake. Therefore, evaluation of the cost-effectiveness of post-construction stormwater controls is critical to the Beaver Lake Watershed Protection Strategy.

In the post-construction management options for the 1-acre and ¼-acre lot, the conventional options were the least cost-effective for sediment reduction. This effect is partially attributed to the assumptions for instream loading reduction, but similar trends are seen when cost-effectiveness due to upland load treatment is reviewed separately. For example, conventional development cost-effectiveness would range from $1,800 to $3,200 per ton of upland sediment reduction, while the corresponding ratios for LID would range from $500 to $900 per ton of upland sediment reduction.

The conventional options range from $600 to $1,700 per ton of sediment removed, whereas most of the channel protection and LID options were under $800 per ton of sediment removed. For the 1-acre lot BL and WFLW management options, the 1/2-acre cluster option was the most cost-effective, but the ranges overlap between the channel protection, LID non-cluster, and LID cluster options, indicating that some channel protection and LID-non-cluster designs may be as cost-effective as the cluster option.

Trends in cost-effectiveness differ between the BL and WFLW ¼-acre options. In BL, channel protection is the most cost-effective option, while in WFLW, channel protection and LID are estimated to have similar cost-effectiveness. This occurs because greater upland loading, resulting in greater pollutant reductions, is estimated for BL, and this results in more pronounced differences in cost-effectiveness across BL options compared to WFLW.

The channel protection option was estimated as most cost-effective among the mixed-use management options. The LID option was estimated to be least cost-effective, which is due to the higher costs for bioretention in high density development as well as the lack of opportunity to reduce clearing and grading costs compared to the lower density options.

In addition to pollutant load reduction benefits, the post-construction options also provide hydrology benefits. These benefits could not be addressed in the cost-effectiveness analysis, but the hydrologic performance of the options is compared below using SET results.

Other Management Options Cost-effectiveness

Buffer preservation on lakefront properties is estimated to be similar in cost-effectiveness to many of the post-construction management options as shown in Figure A-1. The non-lakefront buffer preservation and the buffer/bank restoration options (in developed areas) were more cost-effective, similar to the most cost-effective post-construction options, ranging from about $60 to $220 per ton of sediment loading reduced. The pasture alternative water source and fencing and the unpaved road management options exhibited a similar range of cost-effectiveness.

Across all management options, pasture renovation, pasture buffer/bank restoration, and improved construction site management present the most cost-effective options for sediment reduction. However, the pasture management options, other than buffer/bank restoration, only reduce upland loading, which represents a small percentage of the future sediment load to the Lake. It should be noted that on most pasture land, alternative water sources and fencing will be needed in order to implement buffer/bank restoration; therefore, the cost-effectiveness of both options combined will likely fall between $20 and $140 per ton of sediment removed.

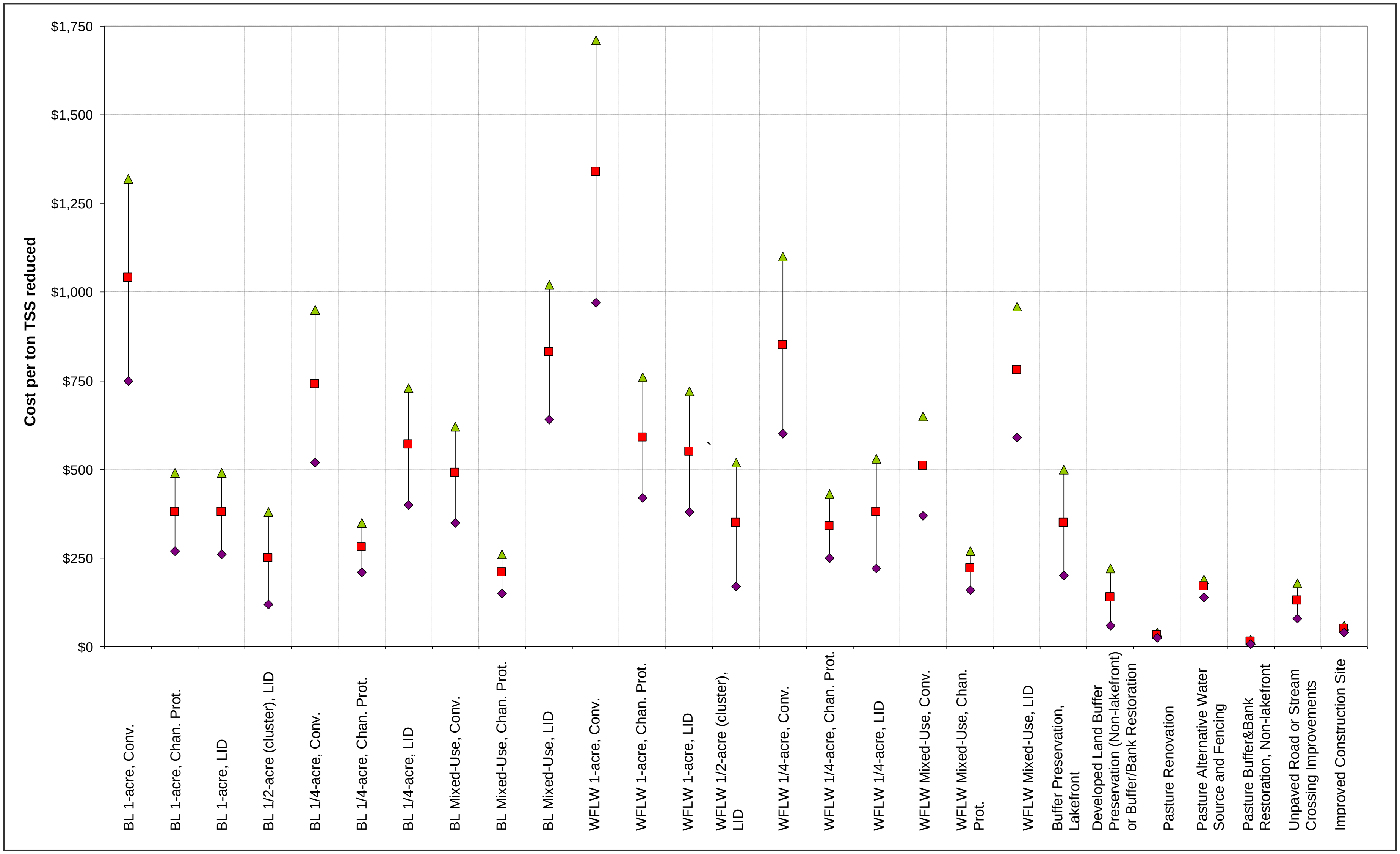

Figure A-1. Cost-effectiveness Ratios for Sediment

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Appendix B. Information for TMDL Implementation Efforts in the West Fork and Lower White River Reporting Subwatersheds

EPA Watershed Management Plan Element A: Identification of Impairment Cause and Source – See Tables B-1 and B-2

EPA Watershed Management Plane Element B: Load reduction estimates expected per management measure – See Tables B-1 and B-2

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Table B-1. Core Voluntary BMPs and Estimated Total Sediment for the West Fork of the White River Reporting Subwatershed

BMP	Land Area Assumed to Participate in BMP Program	Reduction in Future Sediment Load to Stream
Improved Construction Site Management	200 acres per year	5,480 tons/year
Buffer/Bank Restoration in Developed Areas Non-Lakefront (non-pasture land uses)	88,930 feet of stream	6,750 tons/year
Pasture Buffer/Bank Restoration Non-lakefront	9,890 feet of stream	740 tons/year
Alternative Water Source and Fencing	910 acres	270 tons/year
Pasture Renovation	5,520 acres	5,140 tons/year
Unpaved Road Improvements	110 miles of road	1,190 tons/year
Stormwater BMP Retrofits	920 acres	3,010 tons/year
Estimated Total Reduction in Sediment Load		22,580 tons/year

Table B-2. Core Voluntary BMPs and Estimated Total Sediment for the Lower White River Reporting Subwatershed

BMP	Land Area Assumed to Participate in BMP Program	Reduction in Future Sediment Load to Stream
Improved Construction Site Management	60 acres per year	2,020 tons/year
Buffer/Bank Restoration in Developed Areas Non-lakefront (non-pasture land uses)	13,800 feet of stream	1,070 tons/year
Pasture Buffer/Bank Restoration Non-lakefront	4,370 feet of stream	340 tons/year
Alternative Water Source and Fencing	400 acres	120 tons/year
Pasture Renovation	3,180 acres	2,960 tons/year
Unpaved Road Improvements	40 miles of road	380 tons/year
Stormwater BMP Retrofits	70 acres	210 tons/year
Estimated Total Reduction in Sediment Load		7,090 tons/year

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Appendix C. Supplemental Information on Post-construction Stormwater Management

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Post-construction stormwater management can reduce loading from roofs, streets, lawns, and other developed land uses as well as reduce stormwater flow and volume that degrades downstream channels. Three approaches to stormwater management were considered: conventional, channel protection, and low impact development (LID). In the conventional option, Tetra Tech assumes that communities and developers in the watershed using stormwater BMPs in the future will employ conventional dry detention basins for flood control and design those basins using the City of Fayetteville's current stormwater regulations, which specify that post-development flow rate not exceed pre-development flow rates for the 2-yr, 10-yr, 25-yr, 50-yr, and 100-yr 24-hour storm events. The channel protection option uses extended dry detention basins both to meet the flood control goals of the conventional option and to greatly reduce degradation of channels downstream of the development. The LID option uses infiltration practices, rainwater harvesting techniques, impervious surface reduction, land preservation, and extended dry detention basins to meet the goals of the preceding options and achieve additional pollutant load reduction and annual hydrology benefits. Appropriate LID techniques were selected based on development density and through consultation with local engineers.

Why is channel protection important, and why does it have its own option? Stream channel erosion has been identified as one of the largest contributors to sediment delivery to Beaver Lake under the future development option and also would result in degraded integrity of stream biology. Development – even at relatively low densities – changes the flow regime of streams. Disturbance of land cover and addition of impervious surfaces increases runoff volume and decreases the amount of time that it takes for runoff to reach streams. Simply reducing peak flow to pre-development levels for flood control is not sufficient to protect streams in areas experiencing development. Instead, flows are reduced but are released from detention basins for an extended period of time. When many peak-matching detention basins are present in a watershed, their combined discharge leads to a large increase in the duration of midbank and bankfull channel forming flows, which typically occur across a range of small storm events (e.g., 0.5-year storm events to 3-year storm events). For example, MacCrae (1997) found that in a 21 km^2 urbanizing watershed with stormwater control facilities, the frequency of midbank flows increased by more than four times, while the bankfull cross-sectional area increased by a factor of three. With proper basin sizing and outlet design, a detention basin's stage-discharge relationship can be optimized to minimize changes to channel forming flows. An additional benefit of a basin designed specifically to reduce downstream channel erosion is that these basins typically achieve much greater pollutant removal than a basin designed for flood control. The channel protection option was designed to test the influence of an enhanced basin design on cost, pollutant removal, and mitigation of downstream channel erosion.

The LID option incorporates the enhanced basin design, but in addition uses LID practices to enhance pollutant removal and improve annual water balance. Development often alters the way rainfall is partitioned between runoff, infiltration, and evapotranspiration; urbanizing areas often experience higher stream flashiness paired with lower baseflow, all of which contributes to impaired stream aquatic communities. LID practices work together to restore much of the lost infiltration and evapotranspiration.

Across all approaches, the following structural stormwater BMPs were considered:

Conventional Dry Detention Basin

Dry detention basins are typically grass-lined basins that are dry between storm events. These devices store stormwater runoff and reduce stormwater peak flow rates. Stormwater enters the device through an inlet, which may be a grass-lined channel or stormwater pipe. An embankment detains stormwater, and an outlet riser controls the downstream release rate of the impounded water. Conventional dry detention basins are generally designed to allow post-development peak flow rates to match pre-developed conditions (for flood control), usually for a series of large design storm events. While not designed specifically for pollutant removal, grass-lined conventional dry detention basins do remove some pollutants via filtration and nutrient transformation/uptake.

Extended Dry Detention Basin

Extended dry detention basins are designed to detain stormwater for a longer period of time than conventional dry detention basins (between one to three days); the longer detention time allows for more removal of TSS and nutrients from the stormwater. Extended dry detention basins can also be designed to reduce not only the peak flow but also the duration of elevated flows during storm events. A well-designed basin and outlet structure can more closely mimic the pre-development storm event hydrograph. Channel-forming flows extend across a range of small storm events, including those occurring more frequently than once per year. For these small storms that contribute to the greatest in-stream sediment transport, limiting the period of time that the post-development hydrograph greatly exceeds the pre-development hydrograph reduces the risk of channel erosion and bank failure. The basin in the picture doubles as a volleyball court.

Urban Bioretention

Bioretention areas are depressions filled with two to four feet of sandy soil and planted with drought and flood tolerant plants. Stormwater drains into the surface of the bioretention area and, as the water infiltrates through the sandy soil, the soil and plants remove a portion of pollutants. In areas with permeable soils, the water treated by the bioretention cell will infiltrate into the native soil. In areas that have soils with low permeability (typically clay-dominated soils) or in areas with groundwater vulnerability concerns (such as karst areas), a gravel layer and underdrain pipe are placed below the sandy soil layer. Once the stormwater infiltrates through the treatment cell's sandy soil, it is drained out through the underdrain pipe. Bioretention areas are designed so that a particular depth of water can pond in the cell during a rain event; the storage depth varies from 6 to 12 inches depending upon local design standards. Sometimes a weir is included in the bioretention area to bypass excess water above the ponding depth; other installations allow excess water to filter onto adjacent pervious areas. Since bioretention areas use mulch and a variety of shrubs and small trees, they can be easily incorporated into existing landscaping.

Cisterns with Irrigation Systems

Cisterns are tanks that hold rainwater for irrigation and other uses. The cistern pictured to the right can hold over 200 cubic feet of water. They are generally configured to capture roof runoff and can be incorporated inconspicuously into the side of a building. If enough storage volume is provided and if water is reused frequently, they can be used to control stormwater runoff, reduce stormwater flow, and remove pollutants by preventing them from entering runoff. Providing a consistent use of cistern water is one way to ensure stored water is used. One effective method involves a co-installation of an underground irrigation system, which uses cistern water as a primary source, and potable water as a secondary source if the cistern runs dry.

Bump-out Bioretention and Roadside Bioswales

Bump-out Bioretention cells and Roadside Bioswales are generally located between the street and sidewalk, and contain shrubs and other vegetation to slow runoff, take up pollutants, and improve soil infiltration. When properly designed and maintained, they can reduce peak flows, and infiltrate and treat a large percentage of annual runoff. They can be integrated with new development, and also as retrofit projects in urban areas. Municipalities have documented significant cost savings for controlling flooding and sewer overflow problems when compared to traditional engineering approaches, as well as high rates of infiltration and pollutant removal.

Dry Well

A dry well, also called a French drain, seepage pit, or Dutch drain, is a gravel-filled pit or trench designed primarily to capture and infiltrate roof runoff, usually by directing the downspout into the well. Dry wells have been used for decades to solve drainage problems, but are also a practical stormwater BMP. Design recommendations call for locating dry wells a safe distance away from the building, ensuring they are separated from the water table and that soils support infiltration, and providing a way to safely pass large storms. While rooftops usually have lower pollutant loads than other impervious surfaces, dry wells do effectively store and treat a significant volume of runoff.

Grass Swale

A vegetated or grass swale is a grass-lined channel with sloped banks. Culverts are used to pass stormwater under driveways and streets. Vegetated swales are used to convey stormwater runoff and slow stormwater flow. They are an alternative to storm sewer pipes, which produce higher stormwater flows than vegetated swales, especially for smaller storm events. Vegetated swales also remove some sediment if the stormwater flow is controlled.

These techniques were applied to representative development densities that were considered important for addressing impacts from new development. To select representative development densities, Tetra Tech reviewed the common impervious surface distributions within the municipal planning area where most development is projected to occur that would require stormwater BMPs. Residential developments with 1-acre and ¼-acre lots were among the most common development densities projected for future, new development. Subdivision lots of one acre or less (or 18 percent impervious or more) were assumed to trigger the need for structural stormwater controls due to their greater pollutant loading or hydrologic impacts. A significant number of larger lot developments are also projected to occur, particularly outside the municipal planning area. Given that many of the larger lot developments are projected to be in 5-, 10-, or 15-acre lots, Tetra Tech assumed these densities would reflect runoff of LID management using conservation design. Management for mixed-use development was also included as a representative density for high density development. High density development (>36 percent impervious) is projected to represent less than two percent of the watershed in the future, but this density may become more important if land use planning strategies change and favor more dense development. Table C-1 outlines the techniques used for each development density and approach.

To estimate detention basin volume for each of the options, a spreadsheet tool was developed to aid in the simulation of storm event hydrology and basin design. Storm event hydrology was simulated for each development density (18 percent, 33 percent, and 65 percent impervious area) for an assumed 15 acres of contributing development area to a detention basin. Hydrographs were generated using a method that combines TR-55 (USDA, 1986) with a Soil Conservation Service method (USDA, 1972) that uses unit hydrographs to simulate incremental runoff from excess rainfall. Hydrographs were simulated for both pre- and post-development conditions on a one-minute timestep, for a series of storms: 0.5-yr, 1-yr, 1.5-yr, 2-yr, 3-yr, 5-yr, 10-yr, 25-yr, 50-yr, and 100-yr 24-hr storm events. Available storm event depths were estimated from the Rainfall Frequency Atlas of the United States (USDA, 1961); the remaining storm event depths were extrapolated from a curve of depth versus year. The series of high occurrence storms (≤ 5-yr) were needed for designing for channel protection, while the low occurrence storms (≥ 10-yr) were necessary for flood control design. The post-development hydrographs were routed through a conceptual basin, where stage, storage, basin dimension, and multiple outlet (both orifices and weirs) were simulated. An optimization was performed to minimize basin volume while maintaining a maximum stage of four feet and meeting the goals of the option. Estimated basin volume was then used for the cost analysis; figures showing example hydrographs from the analysis are shown in the results. A separate analysis was not performed for the LID option; however, the LID detention basin volume was estimated by reducing the channel protection option detention basin volume by the storage volume of the LID practices.

Table C-1. Densities, Approaches, and Techniques for Post-Construction Stormwater Management Options

Density	Approach	Techniques
1-acre lots	Conventional	Conventional dry detention used to meet design standards for flood control.
	Channel Protection	Extended dry detention used to meet design standards for flood control and to protect downstream channel conditions.
	LID	Reduced impervious surface and disturbed area, replacement of curb and gutter with grass swales, dry wells draining rooftops, and extended dry detention, combined to meet design standards for flood control, protect downstream degradation, and further reduce pollutant loading and hydrologic impacts.
	LID Cluster (1/2-acre lots)	Lot size reduced to ½-acre, lots clustered to preserve undisturbed forested area, reduced impervious surface and disturbed area, dry wells draining rooftops, and extended dry detention, combined to meet design standards for flood control, protect downstream degradation, and further reduce pollutant loading and hydrologic impacts.
1/4-acre lots	Conventional	Conventional dry detention used to meet design standards for flood control.
	Channel Protection	Extended dry detention used to meet design standards for flood control and to protect downstream channel conditions.
	LID	Reduced impervious surface and disturbed area, roadside bioswales or bump-out rain gardens, cisterns and underground sprinklers used to treat roof runoff, and extended dry detention, combined to meet design standards for flood control, protect downstream degradation, and further reduce pollutant loading and hydrologic impacts.
Mixed-Use	Conventional	Conventional dry detention used to meet design standards for flood control.
	Channel Protection	Extended dry detention used to meet design standards for flood control and to protect downstream channel conditions.
	LID	Reduced impervious surface, urban bioretention, cisterns and underground sprinklers used to treat roof runoff, and extended dry detention, combined to meet design standards for flood control, protect downstream degradation, and further reduce pollutant loading and hydrologic impacts.

The presence of karst topography in the Beaver Lake watershed presents a special challenge for stormwater management. While ground subsidence is not known to be an issue, the risk of groundwater contamination remains high in some areas. Site grading and the addition of impervious surfaces changes flow patterns at developed sites and alters the way water moves across the landscape and infiltrates into the ground. Practices that store and infiltrate runoff in one location allow pollutants to be concentrated in one location. The pollutants can move into the aquifer and affect multiple resources, including well-water, connected surface waters, and rare and endangered species in caves. For infiltration practices, pervious geotextile and extra stone were added to the cost estimates to account for a design that would prevent sediment intrusion into karst areas. For detention basins, a plastic liner was assumed to prevent infiltration and potential groundwater contamination. For each post-construction management option considered, separate costs were estimated for development in karst and non-karst areas.

Unit cost assumptions are listed in Table C-2. These costs were applied to estimated development dimensions (e.g., square feet of roadside bioswales) to estimate the total cost for each type of practice. Cost savings from reduction in impervious surface and disturbed area were also estimated, considering reduction in clearing, grading, paving, and curb and gutter costs. The cost savings were conservatively estimated and additional cost savings are likely to be realized through LID; in particular, the LID cluster option is likely to achieve greater cost savings than estimated since storm drain and catch basin costs would also be reduced (these costs could not be estimated due to high variability in design). Annual maintenance costs were estimated for all structural stormwater BMPs, as documented in Table C-2.

For a stormwater program to be successful, education and training would need to be provided to development professionals. The application of the stormwater techniques listed above were considered voluntary for the purposes of this analysis. The costs for a voluntary compliance assistance program were estimated through interviews with local government representatives, local engineers, and Tetra Tech's experience in other communities. The cost estimates for the first year (upfront) and subsequent years (annual) are provided in Table C-2. These costs include development of inspection protocols and BMP guidance, volunteer inspector training (up to 10 trainees), construction contractor training (up to 80 trainees in each class), and program management. To calculate a cost per acre of development, the total costs for the program were divided by 5 percent of the acres projected annually for development within the municipal planning area (5 percent of 1,494 acres, or 75 acres). The 5 percent assumption was based on discussions with Center for Watershed Protection (CWP) staff regarding their experience with voluntary compliance for stormwater management practices (M. Novotny, Center for Watershed Protection, personal communication to H. Fisher, December 2008). This is consistent with Tetra Tech's observations as well. Tetra Tech's recommendations for the compliance assistance program are described in more detail in *Preliminary Draft Alternatives for Beaver Lake Watershed Construction Site and Post Construction Stormwater Management Compliance Assistance Program*, February 25, 2009.

The application of low impact development involves a detailed site assessment and identification of the most beneficial locations for site elements, including infiltration practices, preserved areas, buildings, infrastructure, and detention facilities. To evaluate these costs, Tetra Tech interviewed several development professionals who are experienced in LID site assessment, and they provided the following information (C. Hinman, Washington State University; J. Cox, Triad Associates; Catherine Benotto, Weber Thompson; Paul Hans Thompson, Arborea Consultants, LLC; personal communication to H. Fisher, February 2009). An LID site assessment may take more time than a site assessment for a conventional development; however, LID site assessments often provide information and insight into development design that can help prevent problems during construction and may reduce overall development costs compared to a conventional design. During construction, the application of LID may also increase time spent coordinating development layout and construction activities. Fencing around preserved areas would be required, and the construction of infiltration practices would need to be timed so that other construction activities would not introduce sediment to the filter media. The cost of this increased time is difficult to estimate and would vary depending on the experience and training of the project staff. These costs could not be quantified for this analysis, but the recommended compliance assistance program would help reduce the time required for LID site assessment and construction activities.

Tetra Tech also interviewed local engineers about the difference between LID and conventional design costs. The application of LID stormwater BMPs like bioretention, tend to increase design costs by 40 to 50 percent (T. Jacobs, Appian Centre for Design, personal communication to Scott Job, February 2009). The design costs assumed in this analysis reflect, at a minimum, this increase. The design costs for most LID options were estimated to increase to a greater degree because the LID designs are achieving improved stormwater treatment and control, and the design costs assumptions are tied to construction costs, which are higher for the LID options (prior to subtracting cost savings).

Local staff and professionals interviewed also stressed the obstacles in current regulations and procedures, necessitating multiple variances. This adds time and costs to LID projects in the region. Tetra Tech assumed that such barriers would be addressed in the future and did not include these costs in the analysis.

Table C-2. Unit Costs for Post-Construction Options

Element	Unit	Low	High	References
Roadside grass swales	square foot	$0.4	$0.5	USEPA, 2009a
Culverts for grass swales	number of houses	$530	$710	RS Means, 2009
Roadside bioswales or bump-out bioretention (with underdrain)	square foot (filter media portion)	$5	$12	USEPA, 2009a; C. Suneson, McClelland Consulting Engineers, Inc., personal communication to H. Fisher, February 2009.
Urban bioretention with underdrain	square foot (filter media portion)	$20	$30	M. Matlock, University of Arkansas Department of Biological and Agricultural Engineering, personal communication to H. Fisher, December 2008.
Dry wells	cubic feet of storage	$4.00	$5.00	USEPA, 2009a
1,500-gallon cistern	number of units	$1,000	$1,500	Low Impact Development Center, 2003; The Tank Depot, 2009

Element	Unit	Low	High	References
5,000-gallon cistern	number of units	$4,000	$6,000	Best professional judgment based on range of per cubic foot cistern costs.
Sprinkler system	square foot	$0.5	$0.7	RS Means, 2009
Conventional and Extended Dry Detention[1]	V=cubic foot of detention volume	$8.16V^{0.78}$		Center for Watershed Protection, 2000
Increase in cost for infiltration practices in karst areas	percent of infiltration practice cost	15%	15%	M. Matlock, University of Arkansas Department of Biological and Agricultural Engineering, personal communication to Heather Fisher, December 2008.
Pond HDPE liner (for detention in karst areas)	square foot of pond	$0.90	$1.20	RS Means, 2009
Cost savings from reduced clearing and grubbing	reduced acre disturbed	-$9,800	-$7,300	RS Means, 2009
Cost savings from reduced grading	reduced acre disturbed	-$670	-$490	RS Means, 2009
Cost Savings from replacing curb and gutter with grass swales	acre of low-density development	-$500	-$400	RS Means, 2009; past Tetra Tech case studies.
Cost savings for reducing impervious surface	square feet of reduced impervious surface	-$4.00	-$3.50	RS Means, 2009; B. Cook, Ozark Patterned Concrete, personal communication to H. Fisher, February 2009.
Upfront administrative and education cost	acre of development	$800[2]	$1,000[2]	Interviews with local government staff
Annual administrative and education cost	acre of development	$400[2]	$500[2]	Interviews with local government staff
Annual maintenance of structural stormwater BMPs	percent of construction cost	5%	5%	W. F. Hunt, North Carolina State University Department of Biological and Agricultural Engineering, personal communication to H. Fisher, 2004.

[1] Cost range was calculated using plus or minus 15 percent of the equation result. Cost range and volume estimates will account for the potential differences in cost between conventional and extended dry detention; some extended dry detention designs may not be more expensive than conventional dry detention.

[2] The administrative and education costs are spread over a small number of developments assuming a 5 percent participation rate. If BMPs are required for new development, we would assume a 100 percent participation rate for sites with 18 percent impervious or greater. This substantially reduces the cost per acre of development.

Table C-3 presents the upfront and annual maintenance costs estimated for the post-construction stormwater management options. These costs are reported per acre of development. The cost estimates indicate that the LID cluster option in non-karst areas may result in a net cost savings for the developer. Developers may save up to $3,000 per acre by clustering 1-acre lots into 1/2-acre lots.

Costs estimated for karst areas resulted in an increase of between about 10 to 60 percent above costs in non-karst areas. Cost-effectiveness ratios were not specifically calculated for karst areas, but it should be noted that stormwater management cost per load removed would likely increase by a percent within this range if karst areas require protection from groundwater contamination.

Table C-3. Upfront and Maintenance Cost Estimates per Acre of Development (does not include compliance assistance costs, which are constant across all options)

Management Option	Upfront Cost per Acre (Design, Engineering, and Construction)			Annual Maintenance (per acre)		
	Low	High	Median	Low	High	Median
1-acre, Conv.	$5,000	$6,000	$5,500	$190	$250	$220
1-acre, Conv., Karst	$7,000	$9,000	$8,000	$190	$250	$220
1-acre, Chan. Prot.	$6,000	$9,000	$7,500	$260	$350	$305
1-acre, Chan. Prot., Karst	$9,000	$12,000	$10,500	$260	$350	$305
1-acre, LID	$5,000	$10,000	$7,500	$410	$540	$475
1-acre, LID, Karst	$12,000	$19,000	$15,500	$410	$540	$475
1/2-acre (cluster), LID	-$3,000	$2,000	-$500	$270	$400	$335
1/2-acre (cluster), LID, Karst	$2,600	$10,100	$6,350	$270	$400	$335
1/4-acre, Conv.	$5,000	$7,000	$6,000	$210	$280	$245
1/4-acre, Conv., Karst	$7,000	$10,000	$8,500	$210	$280	$245
1/4-acre, Chan. Prot.	$7,000	$9,000	$8,000	$270	$370	$320
1/4-acre, Chan. Prot., Karst	$10,000	$13,000	$11,500	$270	$370	$320
1/4-acre, LID	$16,000	$30,000	$23,000	$940	$1,470	$1,205
1/4-acre, LID, Karst	$23,000	$45,000	$34,000	$940	$1,470	$1,205
Mixed-Use, Conv.	$6,000	$8,000	$7,000	$250	$340	$295
Mixed-Use, Conv., Karst	$9,000	$12,000	$10,500	$250	$340	$295
Mixed-Use, Chan. Prot.	$8,000	$11,000	$9,500	$340	$460	$400
Mixed-Use, Chan. Prot., Karst	$12,000	$16,000	$14,000	$340	$460	$400
Mixed-Use, LID	$47,000	$74,000	$60,500	$2,210	$3,260	$2,735
Mixed-Use, LID, Karst	$96,000	$147,000	$121,500	$2,210	$3,260	$2,735

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Appendix D. Correlation of Beaver Lake Watershed Protection Strategy Components to EPA 9 Required Elements for Watershed Plans under Section 319 of the Federal Clean Water Act

Table D-1. Correlation of Beaver Lake Watershed Protection Strategy Components to EPA 9 Required Elements for Watershed Plans under Section 319 of the Federal Clean Water Act

EPA 319 Required Element	Quick Reference Listing: BLWSPS Report Content Correlation to EPA 9		BLWSPS Report Section Description	ADDITIONAL REFERENCE DOCUMENT(S)
	PAGE(S)	SECTION/TITLE		
a. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X numbers of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).	16 - 21	**Section 2.3:** Existing and Future Loading to the Lake	**Section 2.3:** Existing and Future Loading to the Lake for a discussion of causes and sources.	"Beaver Lake SWAT Modeling Baseline Analysis" "Supplementary Pollutant Loading Analysis" technical document
	B-3	**Tables B-1 and B-2.** Core Voluntary BMPs and Estimated Total Sediment for the West Fork and Lower White River Reporting Subwatersheds	**Tables B-1 and B-2** in this **Appendix (B)** include estimated stream lengths and land acres with management opportunities	
b. An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded streambanks).	B-3	**Tables B-1 and B-2.** Core Voluntary BMPs and Estimated Total Sediment for the West Fork and Lower White River Reporting Subwatersheds	**Tables B-1 and B-2** in this **Appendix (B)** include estimated load reductions to be achieved through management measures.	"Cost-Effectiveness of Management Option – Phase 1" technical document
c. A description of the NPS management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.	37 - 50	**Section 4.2.2: #2.** Core Best Management Practices	**Section 4.2.2 #2.** Core Best Management Practices for descriptions of NPS management measures and maps of critical areas.	

<table>
<tr><th rowspan="2">EPA 319 Required Element</th><th colspan="2">Quick Reference Listing: BLWSPS Report Content Correlation to EPA 9</th><th rowspan="2">BLWSPS Report Section Description</th><th rowspan="2">ADDITIONAL REFERENCE DOCUMENT(S)</th></tr>
<tr><th>PAGE(S)</th><th>SECTION/TITLE</th></tr>
<tr><td>d. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, USDA's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.</td><td>37 - 57

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61 - 73</td><td>Section 4.2: Five Components of Protection Strategy

Appendix A

Section 5: Beaver Lake Watershed Protection Implementation Summary</td><td>Section 4.2 Five Components of Protection Strategy and Appendix A for cost information; See Section 5 Beaver Lake Watershed Protection Implementation Summary for potential sources of funding and assistance.</td><td></td></tr>
<tr><td rowspan="3">e. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.</td><td>37 - 50</td><td>Section 4.2.2: #2. Core Best Management Practices</td><td rowspan="3">See Section 4.2.2 #2 Core Best Management Practices, Section 4.2.3 #3 Developer and Contractor Lake Protection Certification Program and Section 4.2.4 #4 Education and Stewardship Program for training, education, and outreach components.</td><td rowspan="3"></td></tr>
<tr><td>50 - 53</td><td>Section 4.2.3: #3 Developer and Contractor Lake Protection Certification Program</td></tr>
<tr><td>53</td><td>Section 4.2.4: #4 Education and Stewardship Program</td></tr>
<tr><td>f. A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.</td><td rowspan="2">61 – 73

70 - 73</td><td rowspan="2">Section 5: Watershed Implementation Timeline

Table 5-2. Beaver Lake Watershed Protection Strategy Implementation Timeline</td><td rowspan="2">Section 5 Watershed Implementation Timeline

Table 5-2. Beaver Lake Watershed Protection Strategy Implementation Timeline: Assuming five-year Adaptive Management cycle beginning January 2012 or at hiring of Council Executive Director</td><td rowspan="2">“Beaver Lake Water Quality Targets and Benchmark Analysis”</td></tr>
<tr><td>g. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.</td></tr>
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EPA 319 Required Element	Quick Reference Listing: BLWSPS Report Content Correlation to EPA 9		BLWSPS Report Section Description	ADDITIONAL REFERENCE DOCUMENT(S)
	PAGE(S)	SECTION/TITLE		
h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS TMDL has been established, whether the NPS TMDL needs to be revised.	21 - 25	**Section 2.4:** Water Quality Targets	**Section 2.3** Water Quality Targets for a discussion of criteria to measure progress.	"Beaver Lake Water Quality Targets and Benchmark Analysis"
i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.	54 - 59	**Section 4.2.5: #5** Monitoring and Adaptive Management	**Section 4.2.5** #5 Monitoring and Adaptive Management	