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Table Rock Lake 9-Element Nonpoint Source Watershed Management Plan

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Completed for:
Section 319 Nonpoint Source Unit
Missouri Department of Natural Resources
Project Number: G22-NPS-03

April 2026

OEWRI EDR-26-00X

EXECUTIVE SUMMARY

The Table Rock Lake (TRL) is a crucial natural resource within the Upper White River Basin (HUC: 110100). Spanning 42,560 acres (at the top of the conservation pool) across the Missouri and Arkansas boundary, the TRL supports diverse ecosystems and recreation, serves as a vital source of hydroelectric power, and is an economic driver for the region. However, the TRL (WBID 7313) is designated as impaired on Missouri's 303(d) Impaired Waters List due to elevated levels of pollutants such as Chlorophyll-A (Chl-a) and Total Nitrogen (TN), which exceed water quality standards set for supporting Aquatic Life (AQL) within TRL (MODNR, 2021a). The 303(d) listing notes that the pollutants originate from both municipal point source discharges (e.g., wastewater treatment plants) and nonpoint sources (e.g. agricultural runoff and urban development) within the TRLW. To address these water quality concerns, the Ozarks Environmental and Water Resources Institute (OEWRI) at Missouri State University and H2Ozarks are developing a comprehensive watershed management plan (WMP) under the guidance of the US Environmental Protection Agency (EPA) and Missouri Department of Natural Resources (MODNR). The plan aims to identify key sources of nonpoint source pollution and implement strategies to mitigate these impacts. By focusing on best management practices (BMPs) and collaborative efforts among various stakeholders, the goal is to improve water quality conditions and sustainably manage the resources of Table Rock Lake and its surrounding areas, ultimately benefiting local communities and the environment.

Element 1: Causes and Sources of Pollution

STEPL modeling estimated that pastureland is the dominant source of TN, TP, and S across most HUC-12 subwatersheds, accounting for 46% of total N, 45% of total P, and 49% of total S in the TRLW. Urban land is the second-largest contributor of nitrogen (31%), while forested land contributes the next largest shares of phosphorus and sediment (33% and 45%, respectively). Between subwatersheds, the highest yields for nitrogen (N), phosphorus (P), and sediment (S) result from the Yocum Creek HUC-12, which has the smallest drainage area among the modeled HUC-12s and features significant agricultural land use, primarily poultry operations. Approximately 4% (1,080 acres) of the total Yocum Creek watershed acreage lies within Missouri, with the remaining portion omitted from modeling. Owl Creek (5.1 lb/ac/yr TN; 1.20 lb/ac/yr TP; 0.72 t/ac/yr S) was estimated to contribute the second highest N, P, and S to yields the TRLW.

Element 2: Expected Load Reductions

Overall, the modeling results indicate that required nutrient load reductions vary across the watershed, with total nitrogen reduction targets ranging from 0 to 73% depending on the HUC-

12. The greatest nitrogen reduction needs are concentrated in subwatersheds such as Yocum Creek and Owl Creek, identifying these areas as priorities for implementation. In contrast, phosphorus reductions are needed across all 16 HUC-12s, with an average reduction of approximately 57% required to achieve all-forested background conditions, which will serve as the phosphorus goal for this project.

Element 3: Proposed Management Measures

This plan identifies a suite of pastureland, urban, and streambank management measures designed to reduce nutrient and sediment loads over the 20-year planning horizon (Executive Summary Table 1). BMPs were selected and modeled using STEPL to estimate planning level load reductions, with an emphasis on practices that address primary nonpoint source pathways such as livestock access to streams, soil disturbance, and urban stormwater runoff. Modeled BMPs represent a strategic implementation framework rather than an exhaustive list and are intended to guide prioritization while allowing flexibility to incorporate additional or alternative practices that meet watershed goals. Many BMPs are most effective when implemented in

Executive Summary Table 1. Twenty-year BMP implementation plan to achieve target load reductions.

Milestone	Year	Pastureland				Urban				Streambank			
		Acres Treated	% Reduction			Acres Treated	% Reduction			Feet Treated	% Reduction		
			N	P	S		N	P	S		N	P	S
Short-Term	1	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	2	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	3	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	4	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	5	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	TOTAL	**2,252**	**1.4**	**1.5**	**1.8**	**1,288**	**1.6**	**1.0**	**0.3**	**625**	**0.4**	**0.4**	**0.5**
	lb/ac/yr		**8,470**	**2,117**	**1,464**	**lb/ac/yr**	**10,146**	**1,466**	**246**	**lb/ac/yr**	**2,679**	**591**	**591**
Medium-Term	6	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	7	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	8	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	9	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	10	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	TOTAL	**4,504**	**2.7**	**3.0**	**3.6**	**2,577**	**3.3**	**2.1**	**0.7**	**1,250**	**0.9**	**0.9**	**0.9**
	lb/ac/yr		**16,940**	**4,234**	**2,928**	**lb/ac/yr**	**20,292**	**2,933**	**493**	**lb/ac/yr**	**5,359**	**1,182**	**1,182**
Long-Term	11	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	12	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	13	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	14	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	15	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	16	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	17	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	18	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	19	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	20	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	TOTAL	**9,007**	**5.4**	**6.0**	**7.1**	**5,153**	**6.5**	**4.1**	**1.3**	**2,500**	**1.7**	**1.7**	**1.8**
	lb/ac/yr		**33,880**	**8,468**	**5,856**	**lb/ac/yr**	**40,584**	**5,865**	**985**	**lb/ac/yr**	**10,717**	**2,364**	**2,364**

combination, and non-modeled practices such as nutrient management planning, education, and retrofit screening are expected to complement structural measures by addressing site specific conditions and long-term behavior change. Collectively, these management measures provide a scalable and adaptive approach to improving water quality in the watershed.

Element 4: Technical, Financial, and Regulatory Assistance Needs

Final BMP cost estimates are shown in Tables 21 and 22. Treating 25% of urban areas and pastureland, including 12 alternative water systems (355 animal units/year), would cost an estimated $338,000 to $6 million for pastureland BMPs over 20 years, depending on selected practices. The treatment of 2,500 ft of streambank is estimated at over $152,000 in cost, while urban stormwater detention retrofits could exceed $43 million, depending on design and site conditions.

Element 5. Information and Education

A variety of technical and financial assistance sources are available to support implementation of watershed monitoring, education, and BMP projects. Key programs include state and federal grant opportunities, cost-share programs, and voluntary conservation initiatives that help reduce nonpoint source pollution, protect water quality, and promote sustainable land use. Engaging these resources allows communities, landowners, and organizations to leverage funding and expertise for both urban and agricultural BMP implementation and long-term watershed protection. Technical and financial assistance can be obtained from federal agencies such as the USDA and EPA, state programs through MODNR and MDC, local Soil and Water Conservation Districts, and nonprofit organizations like Forest ReLeaf and the National Fish and Wildlife Foundation.

Element 6: Implementation *Schedule*

Using the STEPL model, BMP implementation was evaluated assuming treatment of: (1) 25% of pastureland areas; (2) 25% of urban land uses; and (3) 2,500 ft of eroding streambanks. Under this planning scenario, pastureland BMP implementation would average approximately 450 acres per year, urban BMP implementation approximately 260 acres per year, and streambank stabilization approximately 125 feet per year over the 20-year planning horizon.

Element 7: Measurable *Milestones and Project Outcomes*

By the short-term milestone (Year-5), BMPs are projected to treat roughly 2,252 acres of pastureland, 1,288 acres of urban land, and 625 feet of eroding streambanks, reducing nitrogen, phosphorus, and sediment loads by approximately 21,295 pounds, 4,174 pounds, and 2,301 tons, respectively. Continued BMP implementation through the medium- and long-term milestones is expected to increase treated acreage and streambank stabilization, cumulatively reducing nitrogen by 14%, phosphorus by 12%, and sediment by 10% across the watershed by Year 20. In addition to structural practices, ongoing education and outreach will occur annually, with a minimum of twenty activities conducted over the 20-year planning period to support watershed stewardship and BMP adoption.

Element 8: Evaluation Criteria

Progress toward the watershed management objectives will be tracked using both implementation and water quality indicators. Implementation indicators include acres of pastureland and urban land treated, streambank stabilization, and other BMPs, providing a direct measure of pollutant load reductions relative to short-, medium-, and long-term milestones. Water quality indicators, including total nitrogen and phosphorus concentrations during runoff and baseflow, will be monitored over time to assess watershed response, establish baseline conditions, and guide adjustments to management strategies if BMP targets or expected improvements are not achieved.

Element 9: Monitoring

Water quality monitoring is essential to evaluate the effectiveness of BMP implementation and validate modeled pollutant reductions. Long-term monitoring will focus on both tributary streams and the Table Rock Lake waterbody, using existing programs such as USGS gages and the Lakes of Missouri Volunteer Program to track trends in nutrients, sediment, and other water quality parameters. Short-term monitoring at BMP implementation sites, particularly during runoff events, will assess early responses to practices, including reductions in pathogens, nutrients, and sediment. Key parameters include total nitrogen and phosphorus, TSS, dissolved oxygen, chlorophyll a, microbial indicators, pH, temperature, and specific conductance, with additional measures added as needed to support watershed goals.

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TABLE ROCK LAKE WATERSHED MANAGEMENT PLAN

INTRODUCTION

Purpose

This nonpoint source Water Management Plan (WMP) for the Table Rock Lake Watershed (TRLW) describes the measures required to obtain, uphold, and preserve water quality standards within the watershed. It serves as a comprehensive resource for stakeholders, local entities, and governmental bodies, offering a systematic approach to mitigate nonpoint source pollutants within the watershed, ensuring compliance with both state and federal water quality standards. This WMP is designed to adapt to changes in both the sources of nonpoint pollutants and water quality regulations over time, ensuring its status as a living document with regular updates and amendments.

Watershed Planning

Table Rock Lake was first listed on Missouri's 303(d) Impaired Waters List in 2001 for elevated levels of chlorophyll-a (Chl-a) and total nitrogen (TN) exceeding water quality standards established to protect the lake's designated Aquatic Life Use (MODNR, 2002). Under the Clean Water Act, waters identified as not meeting applicable water quality standards for their designated uses are prioritized for management actions to address pollutant sources. To address this, 9-Element Watershed Management Plans are used as an effective way of coordinating nonpoint source load reduction, stakeholder engagement, and restoration strategies for protection of impaired waters (USEPA, 2024a; MODNR, 2021).

Watershed management plans were previously prepared for the TRLW, split into eastern and western portions. Both plans were conditionally accepted by MODNR in 2012, with a memorandum noting that a revision should include additional detail covering the required EPA 9-elements. Due to time constraints with funding, the 9-elements were unable to be completed at that point. However, through a current agreement with the Missouri Department of Natural Resources (MODNR), Ozarks Environmental and Water Resources Institute (OEWRI) and H_2Ozarks an updated comprehensive watershed management plan that meets the guidelines of the EPA Nine Key Element Watershed Management Plans with the use of Section 319 grant funds was developed. This watershed management plan updates and expands the previous plans and includes the additional required elements. According to the United States

Environmental Protection Agency (USEPA), the guidelines for a 9-element watershed management plan consists of the following elements:

1) Identify causes and sources of pollution,
2) Estimate expected load reductions,
3) Describe management measures and targeted critical areas,
4) Determine technical, financial, and regulatory assistance needed,
5) Develop an information and education component,
6) Develop an implementation schedule,
7) Describe interim, measurable milestones,
8) Identify indicators to measure improvement, and
9) Develop a monitoring component to measure progress.

From 2024 through 2026, TRLW stakeholders met virtually and in person with members of OEWRI and H_2Ozarks. The stakeholders consisted of a wide range of participants including landowners, city and town staff members, business owners, agency personnel, and other interested individuals. Contributing to the development of a watershed management plan, stakeholder meetings were held to garner input on local concerns noted within the watershed. Stakeholders' concerns focused on nutrient pollution, bank erosion, and excessive algae/plant growth within Table Rock Lake.

Watershed Planning Goals

The goals of the Table Rock Lake Watershed Plan are to:

1. Identify areas of poor water quality within the TRLW and potential nonpoint pollutant sources.
2. Present viable solutions to remediate water quality impairments.
3. Provide an implementation plan for remediation of impaired waters, protection for at risk areas, and preservation of areas meeting water quality standards.

The objectives of the Table Rock Lake Watershed Plan are to:

1. Model nonpoint source pollutants using the USEPA's Spreadsheet Tool for Estimating Pollutant Loads (STEPL) from all XX HUC-12 watershed areas
2. Target effective Best Management Practices (BMPs) and estimate nonpoint source load reductions from BMP implementation.
3. Encourage stakeholder input and public involvement through meetings, surveys, and public outreach.

Point / Nonpoint Source Pollutants

This Watershed Management Plan (WMP) will address nonpoint source pollution, contrasting it with point source pollution. According to the USEPA, point source pollution is characterized by contaminants entering the environment from clearly identifiable and confined locations (USEPA, 2020). Examples of such pollutants include sewage effluent discharged from pipes into water bodies, emissions from smokestacks, and drainage from specific ditches. Nonpoint source pollution is defined by the USEPA as any source of pollution that is not specifically a point source pollutant, and generally is a result of land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification (USEPA, a). In the TRLW, nonpoint source pollution concerns are related to urban expansion and development, agricultural practices, and increased stormwater runoff throughout the watershed (TRLWQI, 2007).

WATERSHED SETTING

The Table Rock Lake Watershed (TRLW) (HUC 11010001) is part of the Upper White River Basin (HUC 6: 110100), within the larger Arkansas Red White River Basin (HUC 11) which ultimately drains into the Mississippi River and then the Gulf of Mexico (Figure 1) (USGS, n.d.). Located in southwestern Missouri, the TRLW is a subwatershed of the Upper White River Basin (HUC-6: 110100), which drains the Ozark Highlands in southern Missouri and northern Arkansas, including approximately 523 square miles from Stone, Taney, and Barry counties (Figure 2). As a large impoundment within the basin, Table Rock Lake is the primary receiving waterbody for nutrient and sediment loads generated throughout the watershed from a network of tributaries. Historical water quality assessments have documented excessive algal growth, reduced water clarity, and altered ecological conditions within Table Rock Lake, which have been attributed to elevated nutrient inputs from both municipal point sources and nonpoint sources, including agricultural runoff and urban stormwater, throughout the watershed (TRLWQI, 2007). Given that nutrient and sediment loads are delivered from multiple sources across the watershed, addressing these impairments requires coordinated planning at the watershed scale that focuses on reducing pollutant inputs at their sources rather than isolated, site-specific actions.

Hydrologic Unit Codes (HUCs) are part of a classification system developed by the U.S. Geological Survey (USGS) to organize watersheds across the United States (USGS, n.d.). These codes begin with large regional designations (HUC-2) and progressively narrow in scale to more localized levels, including HUC-6, HUC-10, and HUC-12, which are the smallest unit used in this plan. Sixteen HUC-12 subwatersheds comprising the TRLW will be included in this plan (Table 1, Figure 3). The James River Arm subwatershed (Table Rock Lake – James River, HUC

110100020603), falls within the James Subbasin (HUC 11010002) rather than the Beaver Reservoir Subbasin (HUC 11010001) that encompasses the remainder of the HUCs within the TRLW. Additionally, both a Total Maximum Daily Load (TMDL) and 9-element watershed management plan have been previously published for the James River (MODNR, 2004a) and James River Watershed (SMCOG, 2023), which are summarized briefly within this WMP (p.41). Therefore, the James River HUC-12 has been excluded from the scope of this Watershed Management Plan.

Table 1. Land area for HUC-12 subwatersheds within the TRLW.

Site	HUC-12	Total Area (acres)	MO Area (acres; % of total area)
Big Creek	110100011204	30,668	30,668 (100%)
Brush Creek	110100011403	22,887	21,890 (96%)
Butler Creek	110100010801	16,698	11,110 (67%)
Cedar Creek	110100010803	22,167	3,753 (17%)
Cow Creek	110100011401	26,016	26,016 (100%)
Cricket Creek	110100011402	21,441	5,352 (25%)
Haddock Creek	110100010804	10,520	6,287 (60%)
Indian Creek	110100011202	12,998	10,439 (80%)
Little Indian Creek	110100011203	17,396	10,574 (61%)
Owl Creek	110100010806	11,168	6,355 (57%)
Roaring River	110100010805	43,377	43,377 (100%)
Rock Creek	110100010807	23,261	23,261 (100%)
Sweetwater Creek	110100011107	21,339	15,238 (71%)
Table Rock Lake Dam	110100011404	17,211	17,211 (100%)
Viney Creek	110100010808	11,847	11,846 (100%)
Yocum Creek	110100011307	25,276	1,080 (4%)
Total	**-**	**334,270**	**244,457 (73%)**

Table Rock Lake Importance

Table Rock Lake provides significant environmental, recreational, and economic benefits to the region as a primary drinking water supply, a source of hydroelectric power, and a major destination for outdoor recreation. The lake supports fishing, boating, swimming, camping, hiking, biking, and other recreational uses that contribute substantially to local and regional economies. Table Rock Lake is widely recognized as a premier fishing destination, hosting numerous bass fishing tournaments each year (USACE, 2020). Among the U.S. Army Corps of

Engineers reservoirs in the upper White River Basin, Table Rock Lake attracts the highest number of visitors. A 2010 economic analysis estimated approximately 2.1 million annual visitors, supporting nearly 5,000 jobs and generating over $300 million in economic activity, with the majority of impacts driven by non local visitors (USACE, 2010). Its proximity to Branson, Missouri, and major transportation corridors enhances accessibility and amplifies the importance of maintaining water quality to support tourism, recreation, and community well-being.

Table Rock Lake History

Table Rock Lake was created in 1958 following construction of Table Rock Dam on the White River in southwestern Missouri, approximately eight miles upstream of Branson (USACE, 2020). The dam was constructed and is operated by the U.S. Army Corps of Engineers to provide flood control, hydroelectric power generation, recreation, water supply, and support for fish and wildlife resources, including a state operated fish hatchery. Public use of the lake began in 1960. Today, Table Rock Lake encompasses more than 40,000 acres across the Missouri and Arkansas border, with approximately 742 miles of shoreline (USACE, 2014). The lake is managed under the Table Rock Lake Shoreline Management Plan, which balances environmental protection with public and private shoreline use. Its location within the karst dominated Ozark Highlands presents unique water quality management challenges, reinforcing the need for watershed scale planning and coordinated nonpoint source pollution reduction efforts.

Hydrology

The hydrology of the Table Rock Lake watershed is shaped by a combination of tributary inflows, spring-fed inputs, and groundwater-surface water interactions (USACE, 2014). Major tributaries include the James River entering from the north, and the Kings River and Long Creek flowing in from the south. These tributaries originate in steep headwaters that transition to gentler slopes near the White River mainstem and are susceptible to flash flooding following intense rainfall events, consistently providing baseflow for some tributaries. In addition to surface tributaries, the lake is fed by several large springs, including Reeds Spring in Stone County, Crystal Springs just north of Cassville in Barry County, and Roaring River Spring located within Roaring River State Park in Barry County. Fractured and weathered bedrock formations that underlay the region, paired with leaky aquifers, results in exchange between surface and groundwater (TRLWQI, 2007).

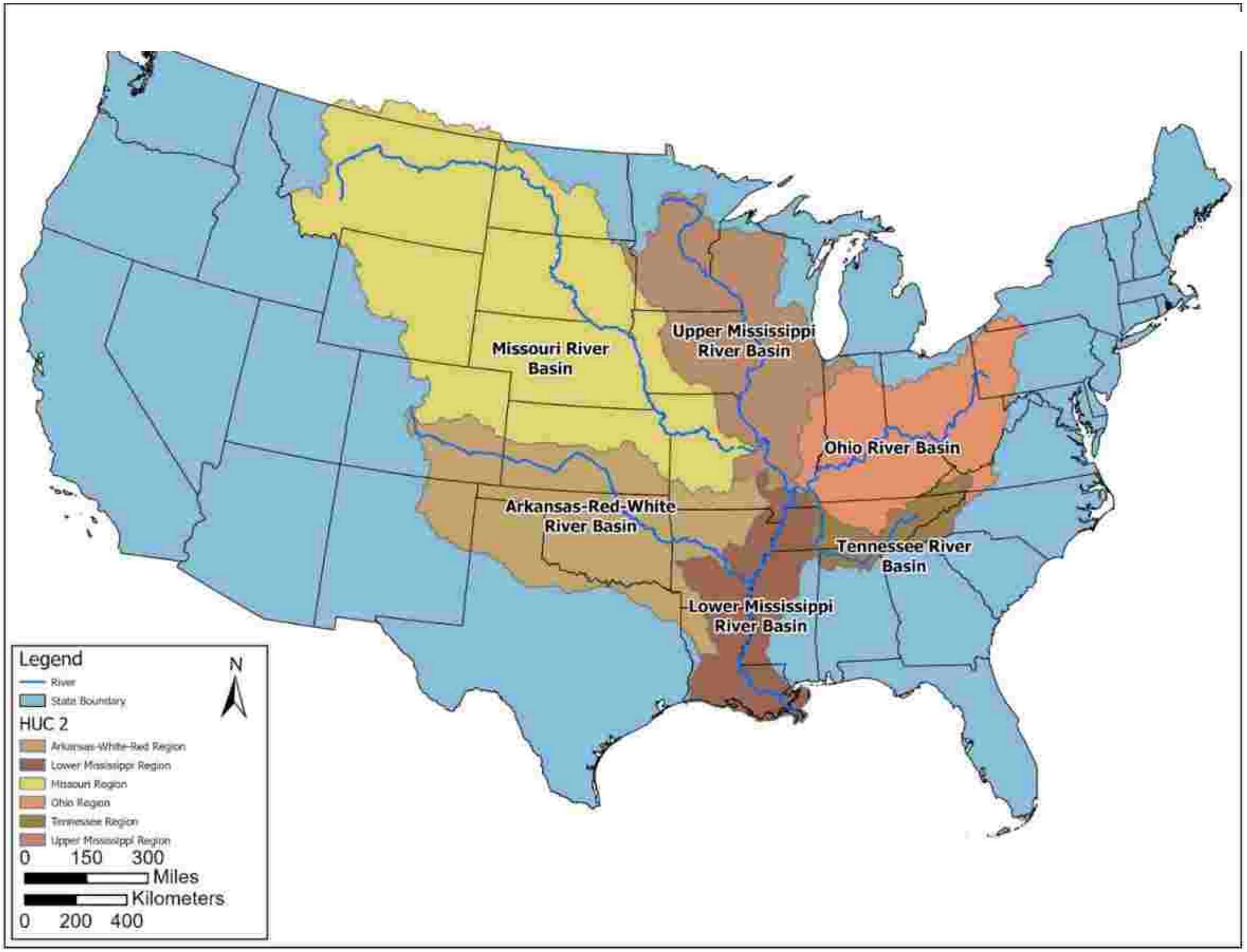

Figure 1. Map of the Mississippi River Basin.

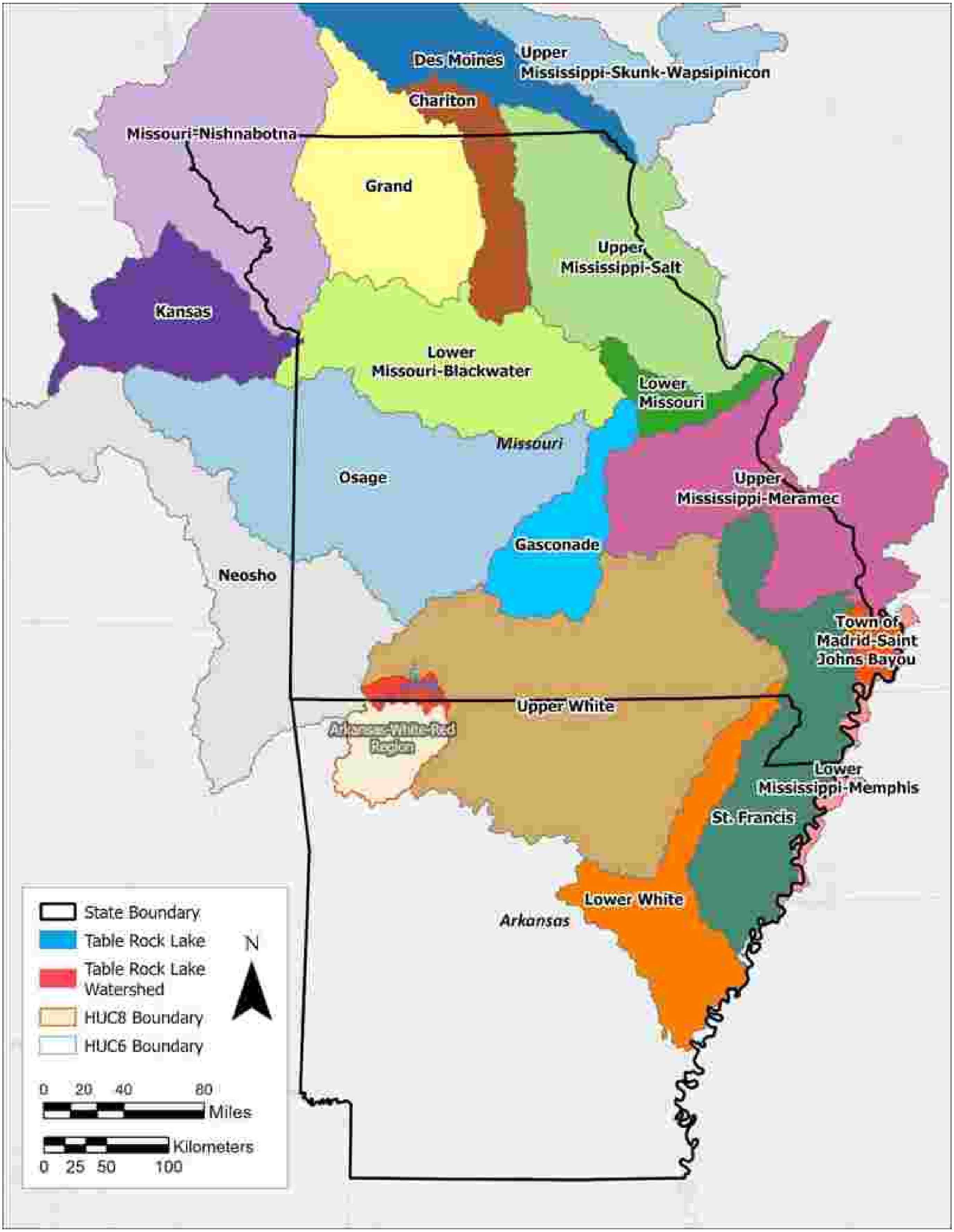

Figure 2. Map of the Missouri HUC6 watershed boundaries, alongside the HUC8 Arkansas-White River HUC8 within Missouri/Arkansas state boundaries.

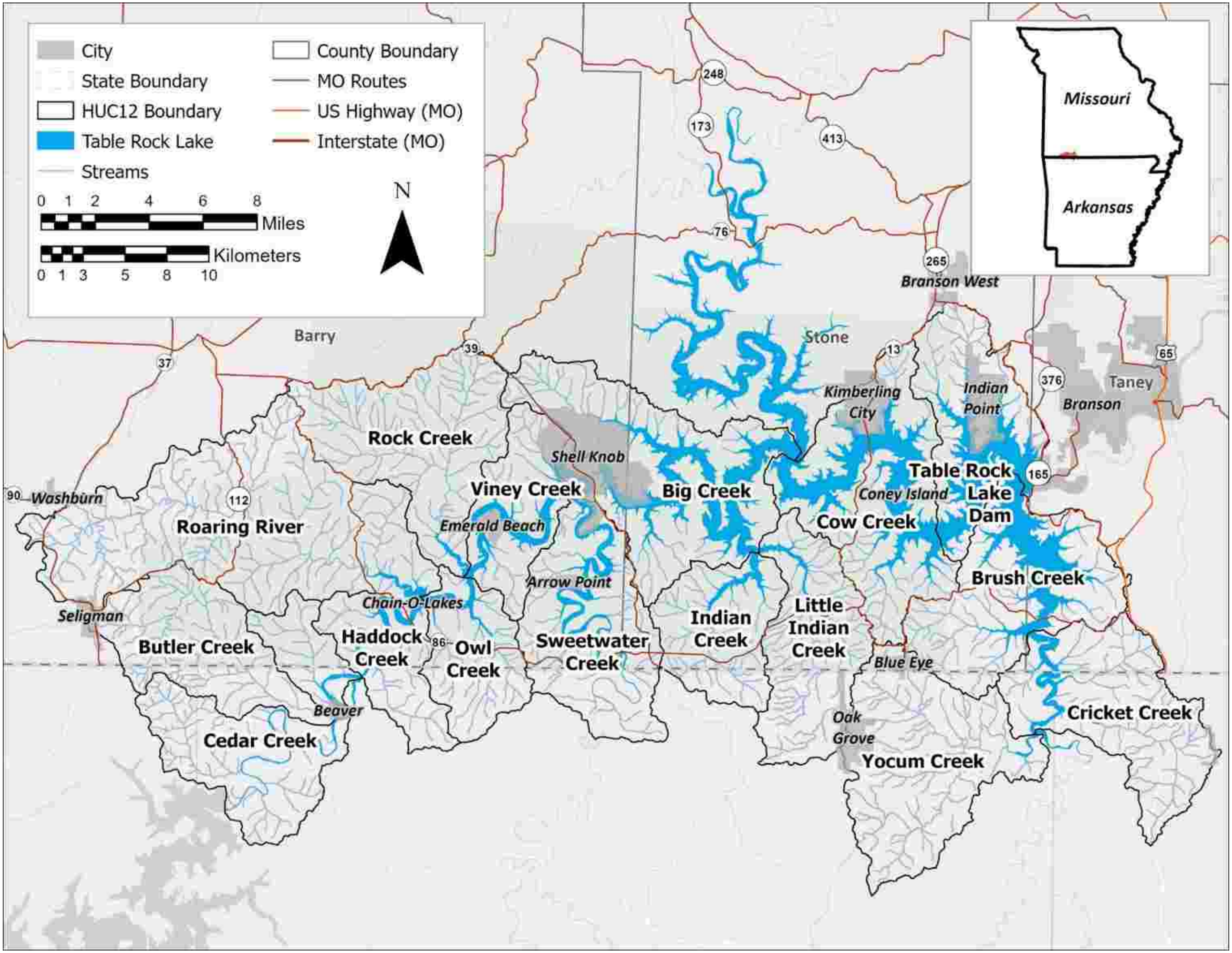

Figure 3. Map of HUC-12 subwatersheds within the Table Rock Lake Watershed.

Land Use

The Missouri portion of the Table Rock Lake Watershed (244,456 acres) is predominantly forested (64%), with agricultural land covering approximately 15%, open water 13%, and urban areas 8% (Figure 4) (NLCD, 2023). Herbaceous or shrub/scrub areas account for less than 1% of the watershed. Viney Creek is the only HUC-12 subwatershed containing cropland, though it represents less than 1% (36 acres) of the total HUC-12 land area. Forest is the dominant land use in all Missouri TRLW HUC-12s except Yocum Creek, which is primarily pastureland (83%) (Table 2). Urban development is concentrated in the northeastern subwatersheds, including Table Rock Lake Dam, Brush Creek, and Yocum Creek, located near the dam and downstream Lake Taneycomo. The westernmost subwatersheds (Yocum Creek, Indian Creek, Sweetwater Creek, and Owl Creek) have the highest proportion of pastureland, exceeding 20% of their total land area. Portions of the TRLW also lie within the Ava–Cassville–Willow Springs Ranger District Mark Twain National Forest (USDA-FS, n.d.). The TRLW has featured an overall 7% increase in urban land development between the years 1992 and 2021 (Figure 5) (NLCD, 1992).

Table 2. NLCD Land Use by TRLW HUC-12 Acreage and percentage of MO land area.

HUC-12	Urban (Ac)	Urban (%)	Pasture (Ac)	Pasture (%)	Forested (Ac)	Forested (%)	Water (Ac)	Water (%)
Big Creek	2,919	10	3,100	10	17,256	56	7,309	24
Brush Creek	2,760	13	2,903	13	11,194	51	4,919	22
Butler Creek	559	5	1,045	9	9,505	86	0	0
Cedar Creek	64	2	139	4	3,553	95	0	0
Cow Creek	3,379	13	1,355	5	13,963	54	7,148	27
Cricket Creek	481	9	823	15	3,533	66	458	9
Haddock Creek	510	8	1,302	21	3,556	57	915	15
Indian Creek	767	7	2,690	26	6,315	60	658	6
Little Indian Creek	742	7	882	8	85,44	81	385	4
Owl Creek	558	9	2,169	34	2,996	47	624	10
Roaring River	1,903	4	8,973	21	32,051	74	365	1
Rock Creek	482	2	1228	5	21,302	92	235	1
Sweetwater Cr.	1,390	9	4,038	26	7,730	51	2,071	14
TRL Dam	2,691	16	1,048	6	8,373	49	4,951	29
Viney Creek*	1,291	11	3,294	28	5,332	45	1,849	16
Yocum Creek	113	10	893	83	75	7	0	0

*Yocum Creek is the only HUC-12 within the TRLW featuring cropland (35 acres; 0.3%).

Topography and Karst Features

The Ozark Highlands ecoregion is characterized by its varied topography and dense forest cover, which is more extensive than in neighboring areas, except for the Boston Mountains to the south (Chapman et al., 2002). Soils predominantly originate from cherty carbonate rocks, with shallow limestone and dolomite bedrock that contributes to karst features, including springs, caves, and sinkholes. Within the Ozark Highlands, the White River Hills IV ecoregion, features highly dissected terrain with local relief of 200–600 feet and high-gradient streams (Chapman et al., 2002). Within this ecoregion, bedrock is primarily limestone, dolomite, and sandstone, contributing to step-like topography featuring benches, and bottomlands. Shallow, fractured subsurface bedrock, including Burlington Limestone, supports karst features such as springs, caves, sinkholes, and extensive groundwater movement (Casaletto et al., 2007). Vegetation is dominated by oak and oak-pine forests, woodlands, and limestone or dolomite glades. Rugged terrain and thin soils limit arable land, leaving much of the watershed forested and within protected public lands. Major reservoirs, including Table Rock Lake, Bull Shoals Lake, and Lake Taneycomo, further influence local hydrology and land use.

Soils

Soils in the Missouri portion of the TRLW are generally shallow, well-drained, and derived from cherty limestone and dolomite. They vary in texture from loams to silt loams, with localized areas of clay or sandy soils, and are often underlain by fractured bedrock (Casaletto et al., 2007). Hydrologic soil groups (HSG) within the watershed range from moderate to low infiltration capacity (B–D), influencing runoff, infiltration, and nutrient transport (Figure 6) (USDA-NRCS, 2019). These characteristics increase the susceptibility of some areas to surface runoff, erosion, and groundwater contamination. Shallow soils over fractured bedrock also pose challenges for onsite wastewater treatment systems (OWTS), as effluent can more readily reach groundwater and surface waters. Understanding soil distribution and hydrologic properties is essential for targeting BMP implementation, prioritizing critical areas, and modeling the movement of nutrients and pathogens throughout the watershed.

Rainfall and Runoff

Precipitation at Table Rock Dam has been recorded since 2000 (MRCC, n.d.), averaging 36 inches per year (2000–2023), with lowest monthly averages in winter and peaks in spring (Figure 7). Annual precipitation has increased over time, from 26 inches (2000–2011) to 45 inches (2012–2023), with greater year-to-year variability (CV 22% vs. 30%). Within the TRLW, a single USGS stream gage (#0705012) at Roaring River State Park, MO, has monitored discharge since 2008. Discharge generally mirrors precipitation, with higher flows in winter and spring and lower flows in summer and fall (Figure 8). Mean seasonal discharge has increased from 2008–2015 to 2016–2023, particularly in spring, consistent with regional trends of more frequent and intense precipitation events, which can increase runoff and drive transport of nonpoint source pollutants (Heimann et al., 2018).

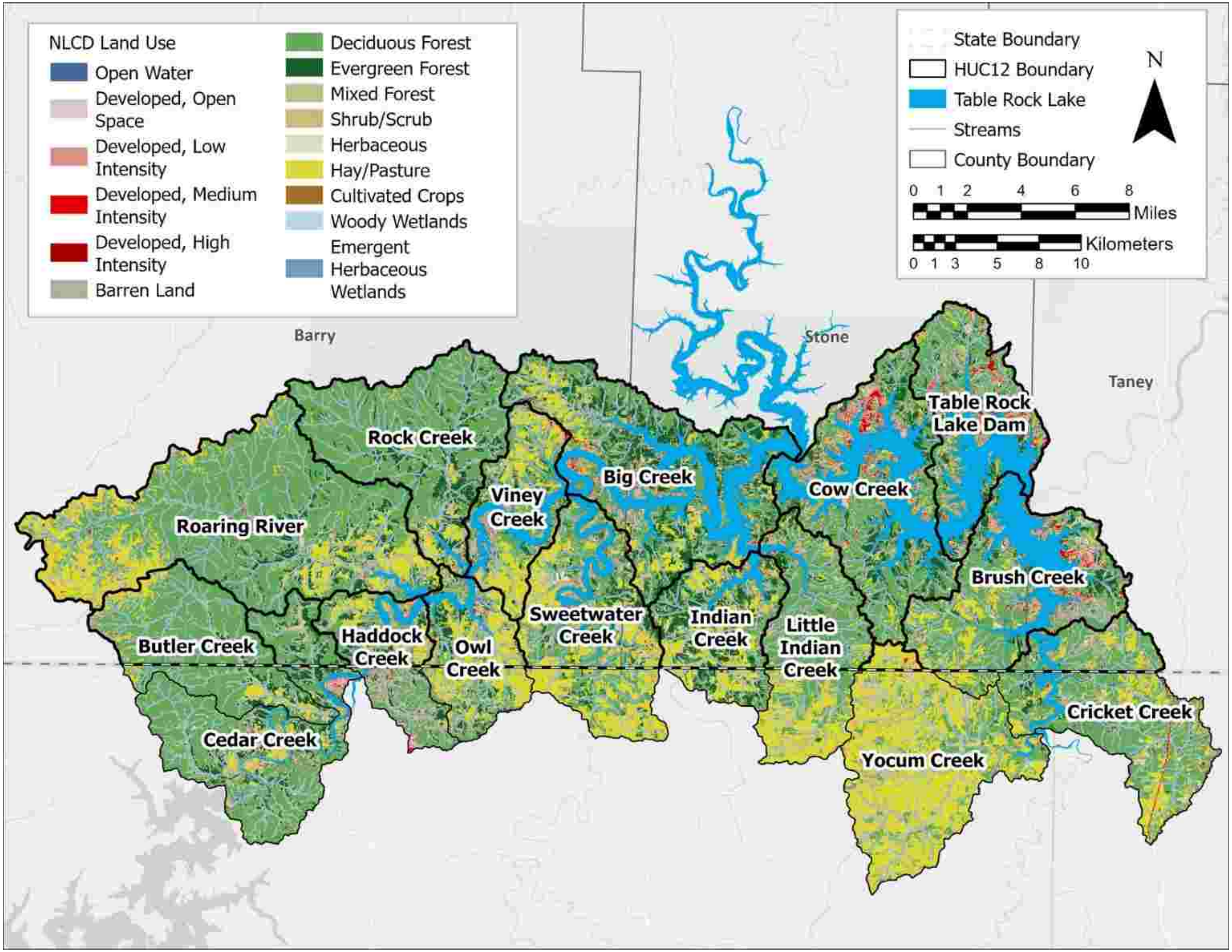

Figure 4. Map of NLCD Land Use within the Table Rock Lake Watershed.

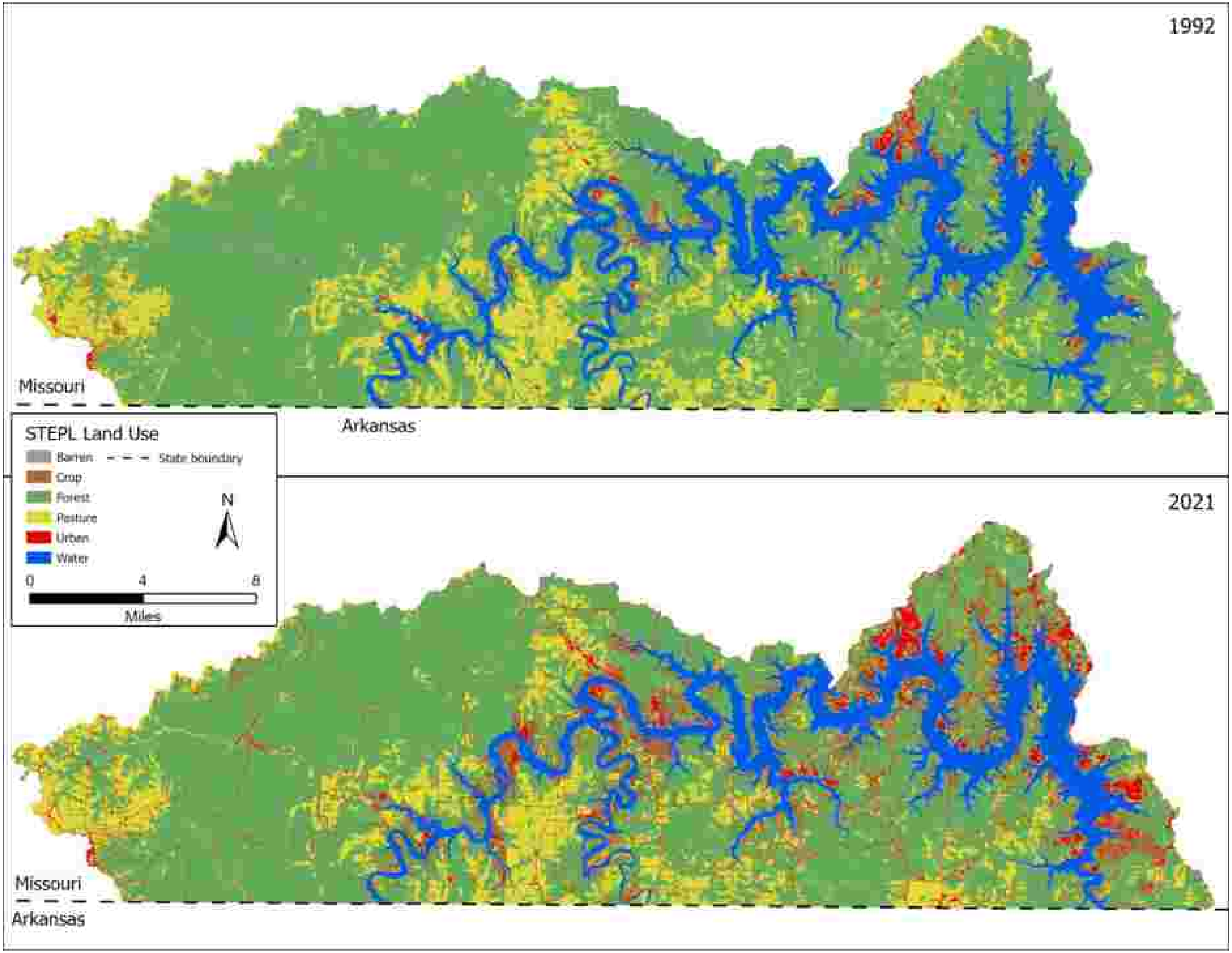

Figure 5. Map of Land Use change between 1992 and 2021 within the Table Rock Lake Watershed, derived from the NLCD Database.

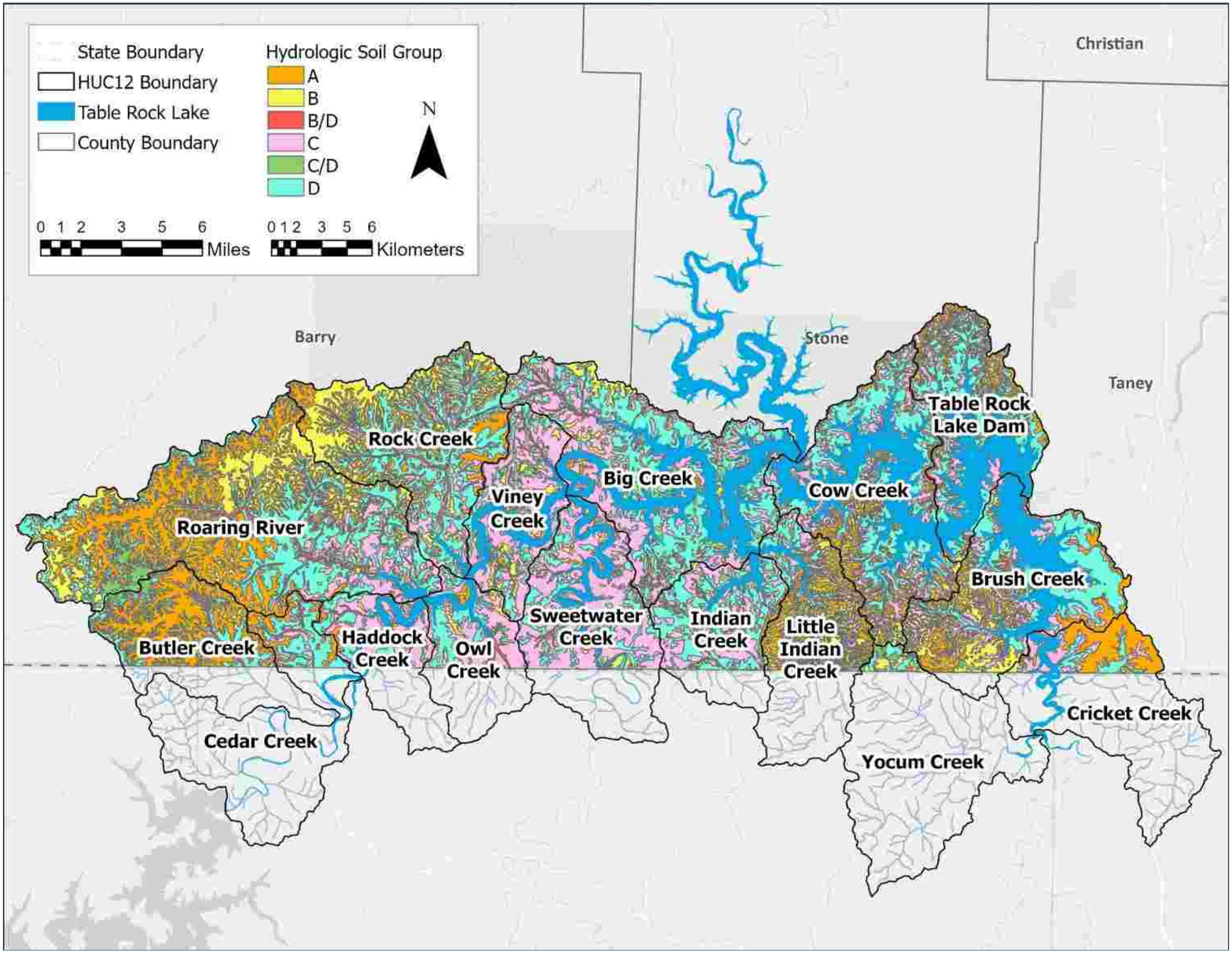

Figure 6. Map of Hydrologic Soil Groups (HSG) within the TRLW (USDA-NRCS, 2019).

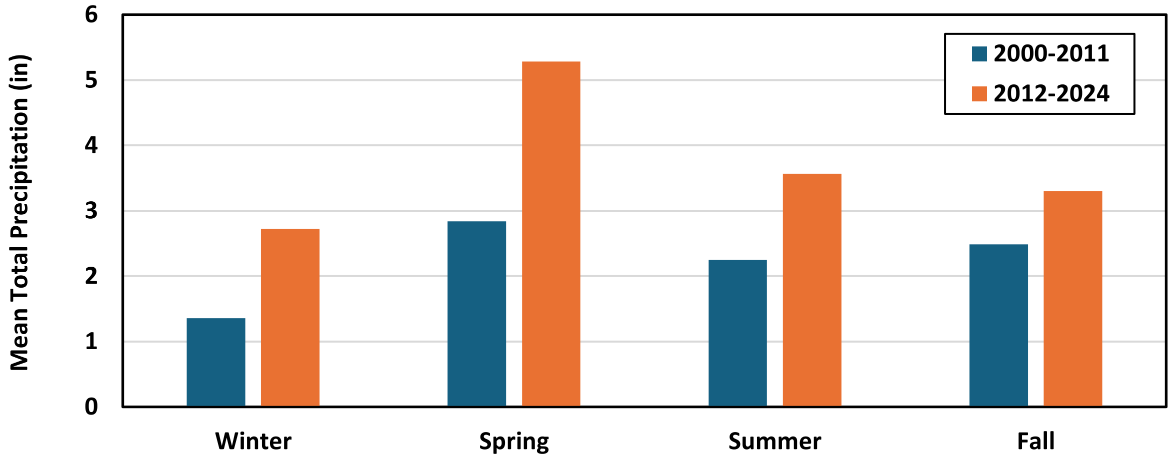

Figure 7. Mean Seasonal Precipitation at Table Rock Dam, 2000-2023. Created with data from the Midwest Regional Climate Center (MRCC, n.d.).

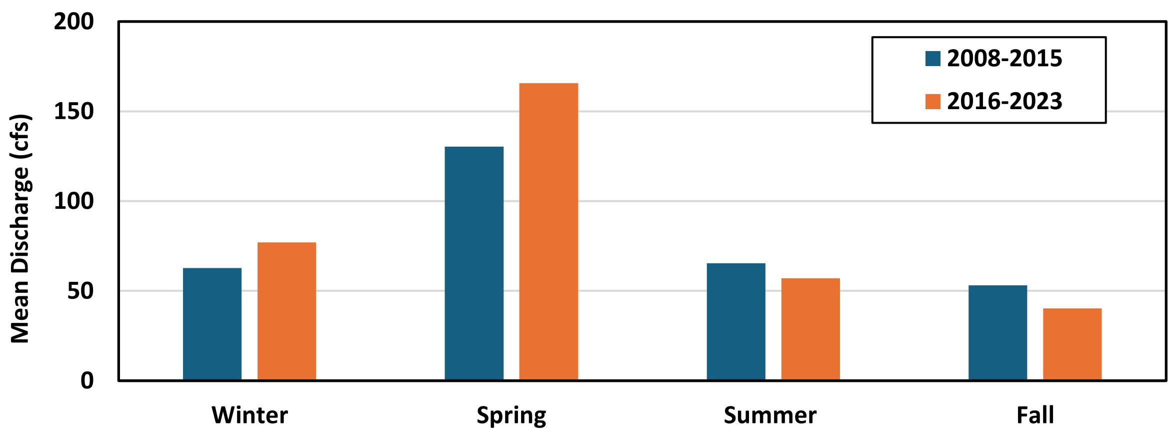

Figure 8. Mean Seasonal Discharge at USGS Gage #07050152 – Roaring River at Roaring River State Park, MO from 2008 – 2023.

Population

The TRLW contains twelve communities in Missouri: Indian Point, Kimberling City, Shell Knob, Arrow Point, Emerald Beach, Chain-O-Lakes, Coney Island, and small portions of Branson, Branson West, Blue Eye, Washburn, and Seligman (Table 3). These communities have a combined population of 19,219 according to 2022 United States Census Bureau estimates (USCB, 2022). As of 2020 estimates, the city of Branson has the largest population (12,638), followed by Kimberling City (2,344) and Shell Knob (1,254). The remaining communities each have populations less than 1,000 people each. The population within the MO portion of the

TRLW has been growing, increasing by 1,946 people between 2010 and 2020 estimates. Population growth in the TRLW is mainly occurring in the largest city of Branson, which accounts for 93% of the population growth from 2010-2020, doubling in population between 1990 and 2000, with continued increases (BCP, 2012). However, only 1.5% of the city of Branson land area is included in the TRLW. As a general trend, population density increases from West to East within the TRLW, with the most populated communities belonging to the Eastern subwatersheds (Figure 9)(USCB, 2022).

Several communities within the TRLW are considered disadvantaged according to the Climate and Economic Justice Screening Tool (CEJEST) (CEQ, n.d.). The CEJEST uses datasets to indicate areas of burden in eight categories, including climate change, energy, housing, legacy pollution, transportation, water and wastewater, and workforce development. A community is considered disadvantaged if it is in a census tract that is at or above the threshold for burden in at least one of the eight categories. Seven census tracts that are at least partially within the TRLW are considered disadvantaged in at least one of the following categories, climate change, energy, transportation, housing, and health. The criteria for “disadvantaged” status for the categories affecting the TRLW are described in Table 4.

Table 3. Population and income data for cities with land area in the TRLW.

Name	2022 Median Household Income	2020 Total Population	2010 Population	Growth/Loss	% Change
Branson, Missouri	49,790	12,638	10,520	2,118	20%
Blue Eye, Missouri	35,714	289	167	122	73%
Indian Point, Missouri	75,625	550	528	22	4%
Branson West, Missouri	30,893	484	478	6	1%
Arrow Point, Missouri	56,250	75	86	-11	-13%
Emerald Beach, Missouri	45,500	212	228	-16	-7%
Chain-O-Lakes, Missouri	25,950	106	126	-20	-16%
Washburn, Missouri	59,643	407	435	-28	-6%
Coney Island, Missouri	53,750	47	75	-28	-37%
Seligman, Missouri	35,972	813	851	-38	-4%
Kimberling City, Missouri	51,458	2,344	2,400	-56	-2%
Shell Knob, Missouri	49,853	1,254	1,379	-125	-9%
TOTAL	**45,533**	**19,219**	**17,273**	**2,268**	**11%**

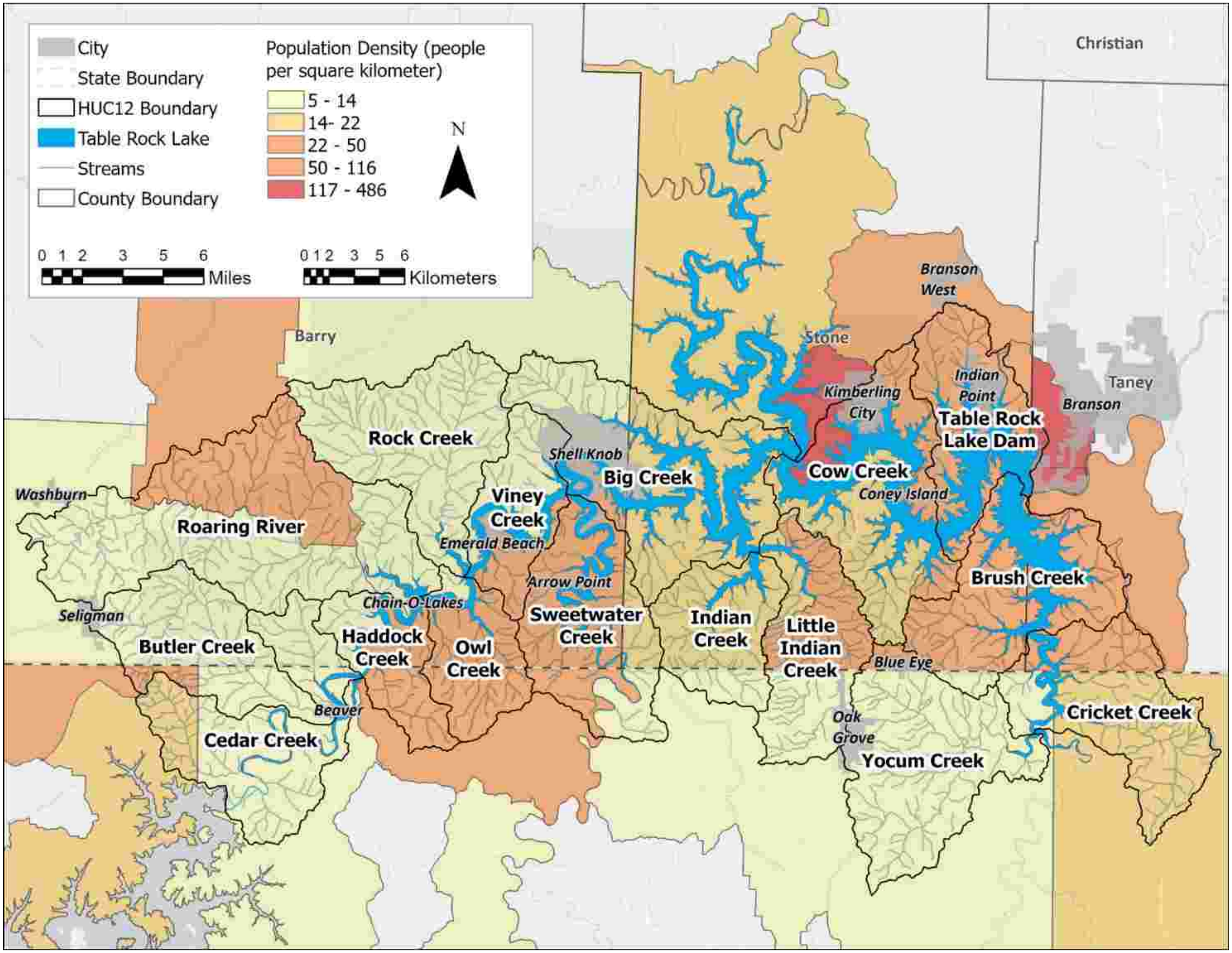

Figure 9. Population density (people per square kilometer) within the TRLW (USCB, 2022).

Table 4. Census track disadvantaged categories (CEQ, a).

Category	Census Tracts Considered Disadvantaged If…
Climate Change	they are at or above the 90th percentile for expected agriculture loss rate, expected building loss rate, expected population loss rate, projected flood risk, or projected wildfire risk and are at or above the 65th percentile for low income.
Energy	they are at or above the 90th percentile for energy cost or PM2.5 (fine inhalable particles) in the air and are at or above the 65th percentile for low income.
Transportation	are at or above the 90th percentile for diesel particulate matter exposure, transportation barriers, or traffic proximity and volume, and are at or above the 65th percentile for low income.
Housing	they have experienced historic underinvestment or are at or above the 90th percentile for housing cost, lack of green space, lack of indoor plumbing, or lead paint, and are at or above the 65th percentile for low income.
Health	they are at or above the 90th percentile for asthma, diabetes, heart disease, or low life expectancy and are at or above the 65th percentile for low income.
Legacy pollution	they have at least one abandoned mine land, Formerly Used Defense Sites, are at or above the 90th percentile for proximity to hazardous waste facilities, proximity to Superfund sites (National Priorities List (NPL)), or proximity to Risk Management Plan (RMP) facilities and are at or above the 65th percentile for low income.
Workforce Development	they are at or above the 90th percentile for linguistic isolation, median income, poverty, or unemployment, and more than 10% of people older than 25 years have a high school education of less than a high school diploma.

In the Table Rock Lake Watershed (TRLW), various factors contribute to the challenges faced by disadvantaged communities (CEQ, n.d.). Climate change is anticipated to result in significant losses in population, buildings, and agricultural lands. Energy-related concerns primarily revolve around the high costs, which can be a financial strain on residents. Transportation issues add to these burdens by creating both cost and time barriers for accessing essential services. Housing challenges include the lack of indoor plumbing in some areas, impacting residents' quality of life. Health issues are prevalent, with notable concerns about high rates of heart disease and diabetes. Additionally, legacy pollution is a significant problem due to the proximity to abandoned mine lands and Superfund sites, which pose environmental and health risks. Workforce development is also a concern, with low median income affecting economic opportunities and stability. Among these challenges, the most prominent issues in the disadvantaged census tracts are the high cost of energy and the anticipated loss of population.

Public Water Supplies

The Table Rock Lake watershed primarily relies on groundwater from the Ozark aquifer, which is the largest aquifer in the Salem and Springfield Plateau groundwater provinces (MODNR, 2021). The City of Branson uses both groundwater and surface water for its water supply (MDC, 2022). Across the watershed, public water supplies come from a combination of surface water and more than 3,200 wells, most of which are used for household purposes (MODNR, 2020). Rapid growth in the Branson and Table Rock Lake area has raised concerns about the availability and quality of groundwater. Seasonal changes and areas of lowered groundwater levels, known as cones of depression, have been observed in the aquifer (MDC, 2022). Table Rock Lake also plays an important role in replenishing Branson's groundwater supply, and water use is expected to increase as development continues (MDC, 2022). In addition to residential needs, there are high water demands for livestock and for facilities such as the Roaring River Fish Hatchery, which adds further pressure on local water resources (MDC, 2022). Since wells provide a direct connection to groundwater, they can allow surface contaminants to enter the water supply. Properly sealing abandoned wells is essential to protect groundwater quality and reduce safety risks (MODNR, 2020).

Point and Nonpoint Source Pollutants

This WMP will primarily address nonpoint source pollution, contrasting it with point source pollution. According to the USEPA, point source pollution is characterized by contaminants entering the environment from clearly identifiable and confined locations (EPA, a). Examples of such pollutants include sewage effluent discharged from pipes into water bodies, emissions from smokestacks, and drainage from specific ditches.

Point Sources

Point sources are discrete conveyances, such as pipes or ditches, that discharge pollutants directly into waters of the United States. Discharges from these sources are typically regulated under the National Pollutant Discharge Elimination System (NPDES) permit program, which regulates the types and quantities of pollutants that can be released (USEPA, 2020). Municipal separate storm sewer systems (MS4) permits constitute another regulatory mechanism for point sources. MS4s encompass a network of roads, drainageways, basins, and ditches designed to manage stormwater. These permits are mandatory for urban areas with populations exceeding 50,000 or urban areas with populations exceeding 10,000 and a population density of 1,000 individuals per square mile (USEPA, 2020; MODOT, 2023a). Within the TRLW, the only two cities with an MS4 permit are Oak Grove, located along the Arkansas state line, and Branson, primarily situated within the TRLW but extending downstream into the Lake Taneycomo Watershed (MODNR, 2023a). Additionally, 2023 Missouri Effluent Regulations (MODNR, 2023b; [10 CSR 20-7.015) set a monthly average phosphorus limit of 0.5 mg/L for discharges to Table Rock Lake Watershed, in addition to existing Class L2 lake and other waterbody requirements, with exceptions for pre-1999 permits and discharges under 22,500 gallons per day.

National Pollutant Discharge Elimination Systems (NPDES). Point source outfalls, which discharge into waterways, are subject to regulation under the National Pollutant Discharge Elimination System (NPDES) permit program. This program governs the types and quantities of pollutants permitted to enter water bodies and mandates the monitoring and reporting of such pollutants (USEPA, 2020). As these outfalls fall within a regulatory framework, they are ineligible for funding through federal 319 nonpoint source grant funds. Nonetheless, it is crucial to acknowledge that point source pollutants still exert a significant influence on the water quality within the TRLW. Facilities discharging within the Table Rock Lake watershed must monitor total phosphorus (TP) monthly, meeting a limit of 0.5 mg/L as a monthly average, with exemptions for facilities with design flows under 22,500 gpd permitted before November 30, 1999, unless design flow increases, as per 10 CSR 20-7.015(3)(G) (MODNR, 2023b). There are approximately 370 NPDES permitted outfalls within a 20-mile radius of the TRLW for stormwater (112 permits) and wastewater (258 permits), the majority of which are for Minor Non-Municipal Wastewater Outfalls or Industrial/Land Disturbance Stormwater Outfalls (Figure 10) (MODNR, 2024a).

Animal Feeding Operations. MODNR defines an animal feeding operation (AFO) as an establishment that confines, stables, or feeds animals for a duration of 45 days or longer within a 12-month span, and where a ground cover of vegetation is not sustained over at least 50 percent of the confinement area. Concentrated animal feeding operations (CAFOs) are identified as AFOs with over 1,000 animal units (MODNR, 2023b). MODNR regulates both AFOs and CAFOs through NPDES permitting. Currently, there are no documented AFOs or CAFOs within the TRLW. However, there are 172 CAFOs permitted within 20 miles of the TRLW in Missouri, primarily in Barry County (Figure 10)(MODNR, 2024b). In addition, there are 188 permitted CAFOs within 20 miles of the TRLW across the Arkansas State line (ARDEQ, 2024). While these facilities are outside the TRLW, upstream CAFOs in Arkansas and nearby Missouri subwatersheds may contribute nutrients and oxygen demanding materials through runoff and tributary inflows, which can influence nutrient loads, algal growth, and overall water quality within TRL.

Nonpoint Sources

Nonpoint source pollution originates from diffuse sources rather than a single, identifiable discharge point. The USEPA defines nonpoint source pollution as any contamination that does not come from a specific, regulated point, and is generally caused by land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification (USEPA, n.d.). In the Table Rock Lake Watershed, phosphorus loading is primarily associated with nonpoint sources, including agricultural activities such as poultry farming and nutrient contributions from onsite wastewater systems in urban and suburban areas (TRLWQI, 2007). These diffuse inputs present a significant threat to water quality and the ecological health of the lake.

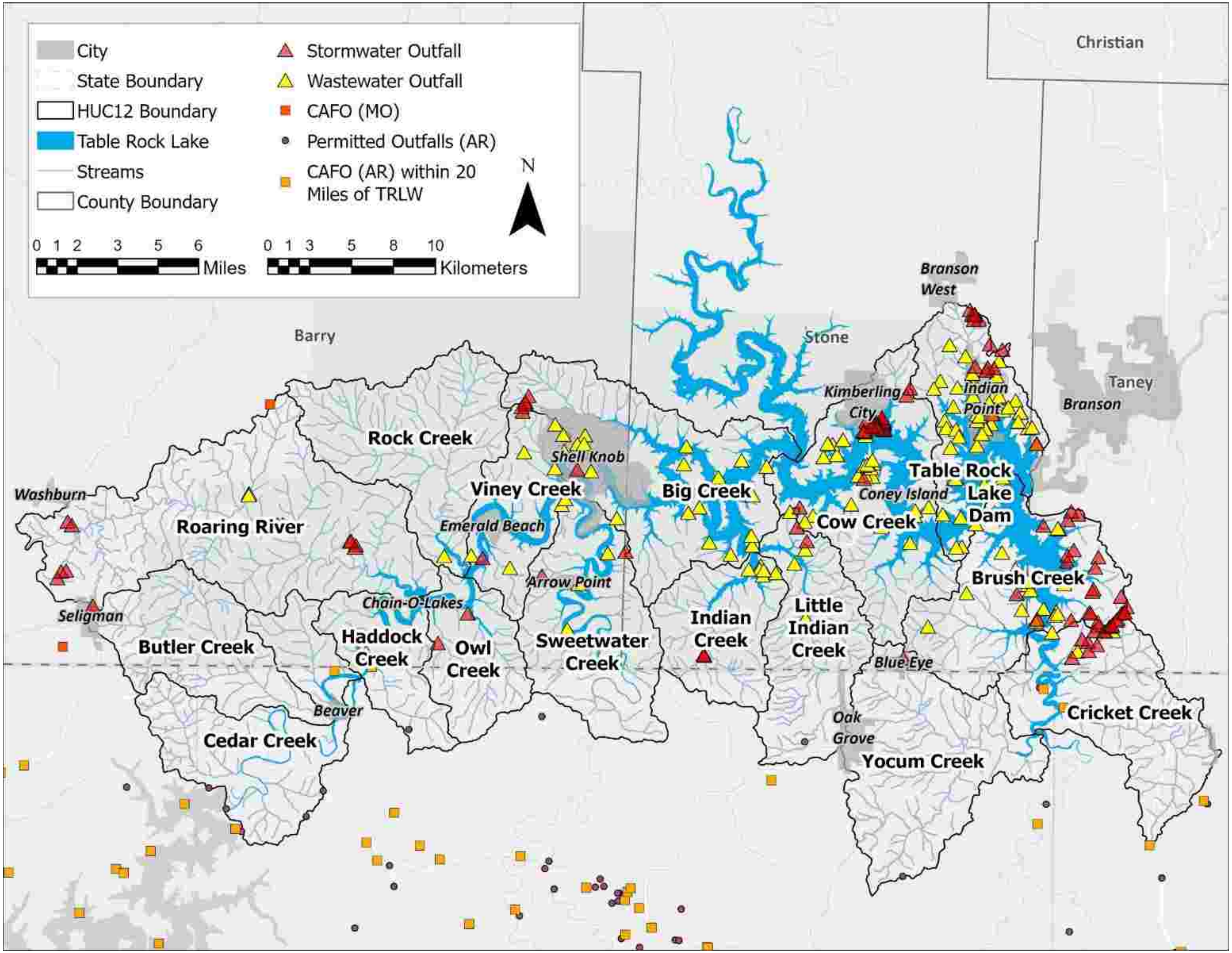

Figure 10. NPDES permitted outfalls and CAFOs within the TRLW and surrounding area.

Onsite Wastewater Treatment Systems

Much of the TRLW lacks a consolidated wastewater conveyance system, with many locations relying on onsite wastewater treatment systems (OWTS) (TRLWQI, 2007; MODNR, 2010). Failing OWTS can contribute substantial nutrient loads and untreated contaminants to both groundwater and Table Rock Lake through runoff and infiltration, a risk exacerbated by the thin, rocky soils and karst topography of the region (TRLWQI, 2007). Conventional septic systems, a type of OWTS, were noted as a significant water quality threat in the early 1980s (TRLWQI, 2007), posing risks to both surface waters and groundwater, including drinking wells (SCPC, 2013).

Nutrients from failing onsite wastewater treatment systems, particularly phosphorus, fuel algal growth and can reduce water clarity. This trend was evident between 1974 and 1994, when water clarity near Table Rock Dam decreased by 0.82 meters (TRLWQI, 2007). During this period, three primary nutrient sources to Table Rock Lake were identified: municipal sewage from treatment plants, residential septic systems, and agricultural runoff (TRLWQI, 2007). In response to declining water clarity and increasing population pressures, Table Rock Lake Water Quality Inc. (TRLWQI) was established in 1998 to address nonpoint source pollution within the watershed.

2001 Study. In 1999, it was reported that approximately 24% of houses within Missouri were served by onsite wastewater treatment systems (USEPA, 2002). A 2001 MDNR study, funded by the USEPA, used a portable fluorometer to detect optical brighteners along shorelines of Table Rock Lake (TRLWQI, 2007). Optical brighteners serve as chemical indicators of laundry effluent and can indicate septic system contributions if elevated levels are detected near developed areas relying on septic systems (TRLWQI, 2007). The study concluded that septic systems were the dominant nutrient source in developed coves, where water clarity was found to be significantly lower than in undeveloped areas (TRLWQI, 2007). Failure rates for septic systems were estimated to be between 30 – 50% in 2002 (USEPA, 2002). However, insufficient records and data leads to challenges in accurately quantifying the extent of septic system failures, as it was later estimated that 75 – 90% of existing septic systems older than 5 years were failing (TRLWQI, 2007).

Local Background & Regulation. OWTS are the primary method of sewage treatment in much of the Table Rock Lake Watershed, making onsite wastewater management central to protecting groundwater and surface water quality (SCPC, 2013). Local conditions, including soil type, geology, and development density, as well as regulatory oversight, affect the risk of contamination. Ongoing development within the TRLW is expected to increase risks to both groundwater and surface water. Effective, coordinated management across counties will be critical to mitigating OWTS-related contamination and safeguarding water quality throughout the watershed.

Stone County

In Stone County, septic systems are widely used, with 1,407 active permitted systems as of 2024 (SCHD, 2024). Groundwater studies indicate that water quality declines as development increases, highlighting septic system density as a key stressor (SCPC, 2013). The Stone County Health Department administers a Wastewater Treatment Systems Ordinance, which requires permits for the construction, installation, modification, and operation of septic systems (SCPC, 2013). The permitting process includes site evaluations to ensure systems are appropriate for local soils and geologic conditions. This is particularly important in Stone County, where many soils have high infiltration potential, increasing the risk of contaminating drinking water wells, groundwater, and nearby surface waters if systems are improperly designed or maintained (TRLWQI, 2007). Older or unapproved systems must be inspected or brought into compliance during property transfers to maintain long-term public health protection (SCHD, 2009).

Barry and Taney Counties

In Taney County, a permit is required before installing, repairing, or modifying any onsite wastewater system. Once approved, permits do not require renewal unless additional construction or repairs occur, at which point a new site evaluation and system inspection are conducted (TCES, n.d.). Barry County requires permits from the county health department for the construction, installation, or modification of any wastewater treatment system (BCHD, 2008). A comparable ordinance to that implemented in Stone County was previously proposed in Barry County but was not enacted.

Decentralized Wastewater Demonstration Project. In 2002, the USEPA funded the Decentralized Wastewater Demonstration Project within the TRLW to address nutrient pollution from failing OWTS, which contribute high levels of ortho-phosphate and ammonia to the lake (TRLWQI, 2007). The main goals of the project were to install and evaluate various advanced OWTS for their effectiveness in the unique soils around Table Rock Lake and match them with appropriate dispersal fields. Additionally, the project aimed to develop a long-term management program based on EPA models and address legal and industry barriers to broader adoption of advanced OWTS in Missouri. The project successfully remediated over 25 failing OWTS, achieving reductions in phosphorus, biochemical oxygen demand (BOD), and total suspended solids (TSS). It also advanced wastewater management through the formation of the Ozarks Clean Water Company, which shifted maintenance responsibilities from homeowners to a centralized organization. Regulatory changes followed, including new ordinances requiring renewable operating permits for advanced OWTS in certain areas.

Data Needs. To reduce uncertainty in OWTS-related pollutant loads, improve modeling accuracy, and guide effective onsite wastewater management, updated data are needed. This includes current information on system location, density, age, failure rates, and site-specific soil and hydrogeologic conditions, as existing inputs are largely based on 1990s data (Tetra Tech, 2022). Additionally, microbial source tracking should be conducted in areas where OWTS contributions are suspected to better distinguish human sources from other fecal inputs, improve spatial understanding of *E. coli* sources, identify priority sites for system upgrades or repairs, and inform targeted outreach and education efforts for watershed residents.

Construction & Development

Population growth and increasing urban development have significantly shaped the region surrounding Table Rock Lake. Between 1990 and 2010, the City of Branson's population nearly tripled, growing from approximately 3,700 to 10,520 residents. Additionally, Taney County's population is forecasted to increase by 29 percent by 2030, with Branson expected to add nearly 3,000 more residents during that period, which could put a strain on infrastructure and water quality of the area. The 2014 revised Master Plan for Table Rock Lake, developed by the U.S. Army Corps of Engineers (USACE), updates a previous plan to guide how development occurs around the lake (USACE, 2014). The updated plan provides a strategic framework for managing the reservoir's recreational, natural, and cultural resources throughout the project's lifespan. In addition, the Table Rock Lake Chamber of Commerce's has published an Economic Development Plan for Stone County, which focuses on business growth, workforce and housing development, visitor marketing, and community advancement to promote sustainable economic growth and improve quality of life in the Table Rock Lake watershed (TRLCC, 2023). Although this watershed management plan sets broad goals for resource stewardship, it does not address specific regional water quality or shoreline management issues, which are handled separately by related plans and agencies outlined above.

Shoreline Management Plan

The U.S. Army Corps of Engineers (USACE) published a Shoreline Management Plan for Table Rock Lake, the White River, and their tributaries within Arkansas and Missouri in 2020 (USACE, 2020). The Shoreline Management Plan for Table Rock Lake provides guidelines to protect the shoreline's environmental characteristics while balancing public and private use, focusing on private use restoration and management strategies without addressing public uses like commercial leases and utilities. The Table Rock Lake Oversight Committee, established in 2019, now ensures the SMP is reviewed at least every five years as per current regulations. The major changes to the Shoreline Management Plan published in 2020 include reclassification of zoning areas, adjustments to public recreation and limited development areas, reduced restrictions on certain dock locations, guidelines for dock construction, and updates to zoning classifications, permitting processes, and vegetation management. These revisions aim to balance recreational use with environmental stewardship, streamline permit procedures, and adapt infrastructure guidelines to modern standards, ensuring the sustainable use and enjoyment of Table Rock Lake.

Streambank Erosion

No quantitative streambank erosion inventory was identified within the TRLW. However, existing assessments indicate that erosion related to land disturbance remains a significant nonpoint source concern within the broader White River watershed (MDC, 2022). Soil erosion associated with land clearing and development was noted as one of the largest nonpoint source pollution issues in the watershed and established reduction of streambank erosion as a key management goal (MDNR, 1995; MDC, 2022). Concerns related to streambank erosion were also raised by watershed stakeholders during project meetings. Local stabilization efforts further demonstrate ongoing erosion concerns, including recent riprap installation along Campground 2 at Roaring River State Park to address active bank erosion and protect infrastructure (Troutman, 2022). These findings suggest that streambank erosion is a contributing stressor within the watershed and may warrant further assessment and targeted stabilization where feasible.

WATERSHED CONDITIONS

Designated Uses

The designated use of a water body refers to its intended purpose as defined by the MODNR and the USEPA and outlined in the Missouri Water Quality Standards (MODNR, 2023b; [10 CSR 20-7.031]). Table Rock Lake, classified as one of Missouri's thirteen Class L2 Major Reservoirs, is designated for Aquatic Life Protection (AQL), Human Health Protection (HHP), Livestock and Wildlife Watering (LWW), Protection of Warm Water Habitat, Whole Body Contact Recreation Category A (WBC-A), Secondary Contact Recreation (SCR), and Irrigation (IRR) (MODNR, 2024c). Water bodies failing to meet water quality criteria for their designated uses are deemed impaired and are included on the MODNR 303(d) List of Impaired Waters. The entire waterbody of TRL, encompassing 41,747 acres, is listed as impaired (WBID 7313) due to exceeding TN and Chl-a standards related to its AQL designation, as a result of both municipal point source discharges and nonpoint sources (MODNR, 2021a).

Water Quality Criteria

The Table Rock Lake Watershed is governed by various nutrient benchmarks and criteria established to protect water quality. The MODNR has published threshold values and numeric nutrient criteria within the Missouri Water Quality Standards (Code of State Regulations) that apply to tributaries within the watershed (MODNR, 2023b). Additionally, the regulations include site-specific nutrient criteria for the TRL waterbody (based on the geometric mean of a minimum 3 years of data and water body characteristics), which represents the maximum ambient concentrations of TP, TN, and Chl-a for Table Rock Lake, and effluent criteria that set limits on discharges into the watershed (MODNR, 2005; MODNR, 2023b). Additionally, the USEPA has established eutrophic threshold values applicable to streams, complemented by EPA Region 7 Technical Assistance Group (RTAG) benchmark values. These criteria are summarized in Table 5 for reference (USEPA, 2016).

Table 5. Nutrient and effluent criteria applicable to waters within the Table Rock Lake watershed.

Reference	**Applicable**	**TN**	**TP**	**Chl-a**
		µg/L		
EPA Eutrophic Threshold* (EPA, 2000)	Streams	1,500	75	-
TRL Site-Specific Criteria (MODNR, 2023)	Lake	253	9	2.6
EPA Lakes and Reservoir Criteria (Eutrophic) (EPA, 2000)	Lake	1,900	84	14
Effluent Limitations for Table Rock Lake (MODNR, 2005)	Effluent	-	500	-

*EPA Eutrophic Threshold Values (EPA, 2000) used as target concentrations for STEPL load reduction analysis.

MODNR Water Quality Data

Water quality has been monitored at multiple tributary stream locations within the TRLW, starting in the 1970s (Table 6). Monitoring water quality parameters such as TN, TP, TSS, Cl, DO, and *E. coli* has been conducted in the watershed, but most records lack spatial and temporal continuity. The longest running record of monitoring within the watershed is at Roaring River Spring (USGS Gage # 07050150), with 178 total samples collected between 1992 and 2020. At this site, TN and TP were continuously monitored from 1994 to 2020, though only gage height and discharge are currently monitored. The average TN value from 1993-2020 at the Roaring River Spring site (3.1 mg/L) exceeded the eutrophic threshold value of 1.5 mg/L, with 99% of the 167 TN samples collected in exceedance of the that threshold (Figure 11. Mean annual a) Total Nitrogen and b) Total Phosphorus concentrations for the TRLW from 1992-2020 for Roaring River Spring. Data obtained from the MODNR Water Quality data portal.). Average TN and TP concentrations for the other TRLW sites were below the eutrophic threshold. TN concentrations have been increasing at this site while average TP concentrations have decreased slightly from 1994 to 2020 (Figure 11). Outside of the TRLW, at the James River at Galena site, average TN and TP values from 1992-2020 exceeded the eutrophic threshold, with 96% of TN and 49% of TP samples collected in exceedance.

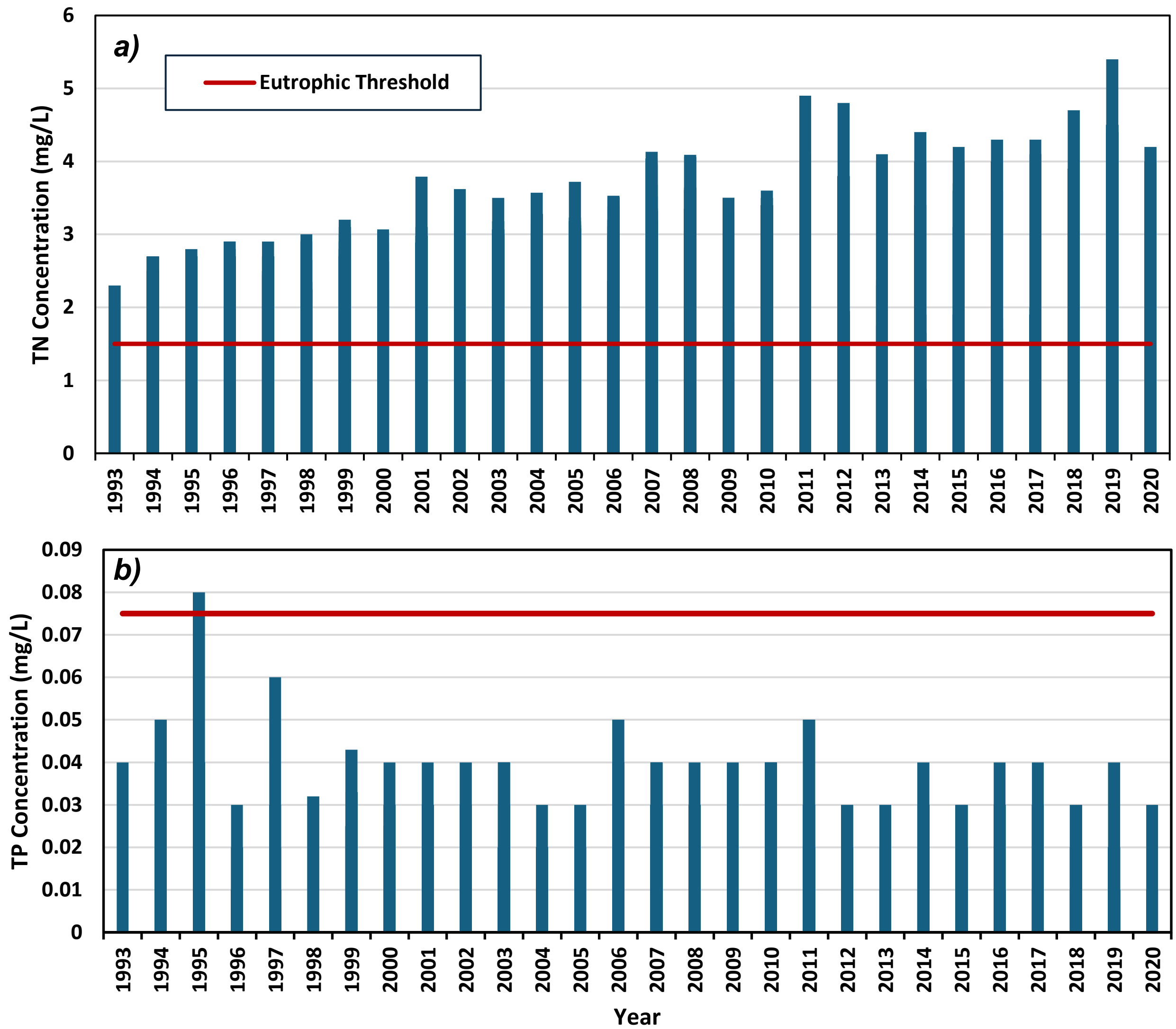

Figure 11. Mean annual a) Total Nitrogen and b) Total Phosphorus concentrations for the TRLW from 1992-2020 for Roaring River Spring. Data obtained from the MODNR Water Quality data portal.

Lakes of Missouri Volunteer Program Data

The Lakes of Missouri Volunteer Program (LMVP) has monitored water quality at 32 sites within the Table Rock Lake (TRL) waterbody since 1992, analyzing TN, TP, water clarity, and chlorophyll-a (Chl-a) from water samples (LMVP, 2023) (Figure 12). Data from the LMVP were compared to the site-specific nutrient criteria for TRL (9 µg/L TP, 253 µg/L TN, and 2.6 µg/L Chl-a) established by the MODNR (MODNR, 2023b). These criteria were calculated as a geometric mean of at least three years of data. Consequently, LMVP sampling sites with fewer than three consecutive years of data were excluded from the geometric mean (geomean) analysis. In addition, sampling sites located within the James River arm, which is excluded from this plan,

Table 6. Mean water quality results from MODNR water sampling sites within the TRLW.

Agency	Site	Active Years	Mean TN (mg/L)	Mean TP (mg/L)	Mean TSS (mg/L)	Mean *E. coli** (cfu/100mL)	Mean Specific Conductance (uS/cm)	Mean Chloride (mg/L)	Mean Chl-a (µg/L)	Mean DO (mg/L)
MODNR	Natural Bridge Hollow, 0.7 mi above confl w Rock Ck	2015-2016	0.091 (n=2)	0.005 (n=2)	2.5 (n=2)	(n=0)	427.5 (n=2)	1.1 (n=2)	(n=0)	8.2 (n=2)
MODNR/USGS	Roaring River 0.8 mi.bl. Spring	1992-2009	1.36 (n=8)	0.02 (n=10)	2.3 (n=6)	(n=0)	312.1 (n=7)	3.9 (n=8)	(n=0)	11.1 (n=6)
MODNR/USGS	Roaring River Spring	1970-2020	3.10 (n=167)	0.03 (n=162)	6.3 (n=135)	38.56 (n=144)	339.1 (n=177)	7.7 (n=78)	(n=0)	8.1 (n=173)
MODNR	Ketchum Hollow near mouth	2000-2023	0.26 (n=20)	0.01 (n=20)	(n=0)	(n=0)	(n=0)	2.3 (n=20)	(n=0)	(n=0)
MODNR, USGS, SPFDPW, SCHD, MSU	James R. at Galena	1992-2020	2.81 (n=408)	0.16 (n=461)	13.3 (n=277)	11.07 (n=410)	424.8 (n=470)	26.4 (n=252)	5.3 (n=39)	10.2 (n=444)

SPFDPW = City of Springfield Department of Public Works, SCHD = Stone County Health Department, MSU = Missouri State University, DO = Dissolved Oxygen, TP = Total Phosphorus, TN = Total Nitrogen, TSS = Total Suspended Solids. **E. coli* value expressed as a geometric mean to align with MO standards.

were removed from this analysis. Data generated by the LMVP are said to be consistent in quality with university collected samples (Obrecht et al., 2009).

Total Nitrogen. Concentrations of TN within the TRL waterbody were variable across sites, with site averages ranging between 0.38 – 0.84 mg/L. Of the nearly 550 samples collected since 1992 within the TRLW, 99.8% of samples exceeded the TRL site-specific criterion of 0.253 mg/L. Rolling 3-year geomean values ranged from 0.466 – 0.820 mg/L, with an overall average of 0.580 mg/L (Figure 13;Table 7). Since 1994, the geomean values have generally increased, with each annual geomean exceeding the TN site-specific criterion. The highest observed annual site averages occurred at LMVP sites 16 within the Roaring River HUC-12 and site 7.1 within the Sweetwater Creek HUC-12, with the lowest values observed at LMVP site 6 in the main channel of the TRL within the Big Creek HUC-12 (Figure 12 & Figure 14). According to the 2023 LMVP report, the TRL ranks 7th lowest in long-term average TN concentrations among monitored lakes (LMVP, 2024).

Total Phosphorus. Of the 549 TRL waterbody samples analyzed for TP, 79.8% exceeded the site-specific criterion for TP (0.009 mg/L), with average site concentrations ranging from 0.009 – 0.058 mg/L. The highest average site TP value was observed at LMVP sites 7.1 and 7 within the Sweetwater Creek HUC-12, similar to TN concentrations (Figure 13). The lowest observed site averages occurred at LMVP site 1 near the Dam, and sites CC and SC within the Cow Creek HUC-12 (Figure 12). Rolling 3-year geomean values ranged from 0.014 – 0.031 mg/L, with an overall average of 0.020 mg/L (Table 7). Since 1994, geomean values have generally increased, with each annual geomean exceeding the TP site-specific criterion of 0.009 mg/L. Among the 42 Missouri public lakes monitored by the LMVP in 2022, TRL had the lowest long-term phosphorus trend and the lowest annual TP concentration (LMVP, 2023).

Water Clarity. Water clarity, measured using a Secchi disk, quantifies the depth to which sunlight penetrates the water column, serving as an indirect measure of suspended material affecting light transmission. (USEPA, 2024b). While Missouri does not have state standards for Secchi depth, lower Secchi depth values can indicate reduced clarity due to suspended sediments from runoff and erosion or increased algal growth from excess nutrients, such as fertilizer runoff. In contrast, higher Secchi depths suggest clearer water with lower levels of suspended sediment and algal productivity. Table Rock Lake ranks among the clearest lakes monitored by LMVP, with the highest long-term water clarity and the 3rd highest Secchi depth in 2023 (LMVP, 2024). However, Secchi depth values have generally declined between 1992 and 2023, indicating a long-term decrease in water clarity. Similarly, the annual average Secchi depth has shown a gradual decline. A satellite imagery assessment conducted on Table Rock Lake by the USGS noted a decrease in water clarity between 2003 and 2005 imagery, as well as decreased water clarity in the main tributaries compared to the main channel of the reservoir

(USGS, 2009). Despite this, TRL had the second highest Secchi depth among the 37 LMVP-monitored lakes in 2023, maintaining the highest long-term clarity ranking (LMVP, 2024).

Chlorophyll-a. Concentrations of Chl-a in the TRL were variable across sites, with site averages ranging between 4.7 - 33.2 µg/L. Of the 543 TRL samples analyzed for Chl-a, 95.4% exceeded the site-specific criterion of 0.0026 mg/L. Rolling 3-year geomean values ranged from 0.007 – 0.013 mg/L, with an overall average of 0.010 mg/L (Table 7). Since 1994, geomean values have shown a slight increase, with each annual geomean exceeding the TRL site-specific Chl-a criterion of 2.6 µg/L. The highest observed annual site average concentrations occurred at LMVP sites 7 and 7.1 within the Sweetwater Creek HUC-12, with the lowest values were observed at LMVP site 6 in the main channel of the TRL within the Big Creek HUC-12 (Figure 12). The LMVP report for 2023 indicates that TRL ranked 5th lowest in long-term chlorophyll trends among the 40 public lakes monitored (LMVP, 2024).

Water Quality Impairments

Table Rock Lake is listed on Missouri's 303(d) Impaired Waters List for the protection of Aquatic Life (AQL), primarily due to elevated levels of Chl-a and TN originating from Municipal Point Source Discharges and Nonpoint Sources (MODNR, 2021a). Nutrient problems within the TRLW pose significant threats to water quality, with excess nitrogen and phosphorus fueling algal blooms (indicated by increases in Chl-a) that reduce water clarity and deplete oxygen levels crucial for aquatic life. Sources contributing to nutrient enrichment include OWTS, agricultural runoff, and urban development.

Table Rock Lake was first listed as impaired in 2002 for nutrient pollution from both point and nonpoint sources, initially classified as a low priority (MODNR, 2004b). In 2011, USEPA specified impairments within Table Rock Lake, identifying the James, Kings, and Long Creek arms impaired by nutrients, with the White River arm additionally impacted by chlorophyll-a, sediment, and nitrogen (USEPA, 2011). By 2022, the TRL impairments were specifically listed as Chl-a and TN, prompting a medium TMDL priority. Development of the Table Rock Lake TMDL, scheduled by MODNR in 2014, remains pending under Clean Water Act mandates.

In the United States, nonpoint source pollutants cause significant impairments of water quality causing them to not meet their designated uses (Baker, 1992). Nonpoint source pollutants enter waterways through precipitation events that generate runoff and carry pollutants from their source (livestock grazing areas, cropland, roads, etc.) into streams and downstream receiving water bodies such as TRL. Nitrogen and phosphorus exist naturally in the environment; however, higher nutrient and sediment loads in waterways can cause

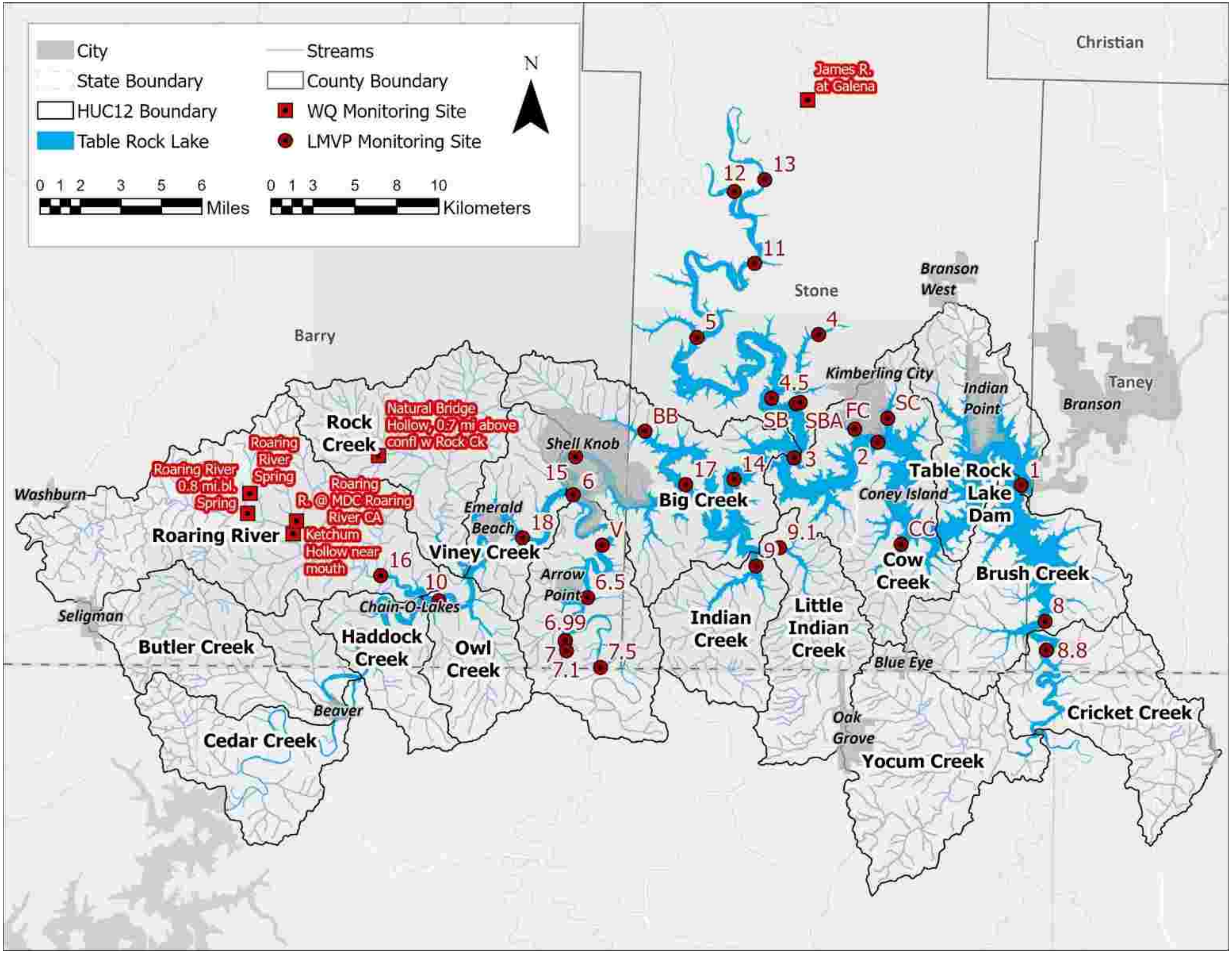

Figure 12. Map of WQ sampling sites within the TRLW from both the MODNR and LMVP.

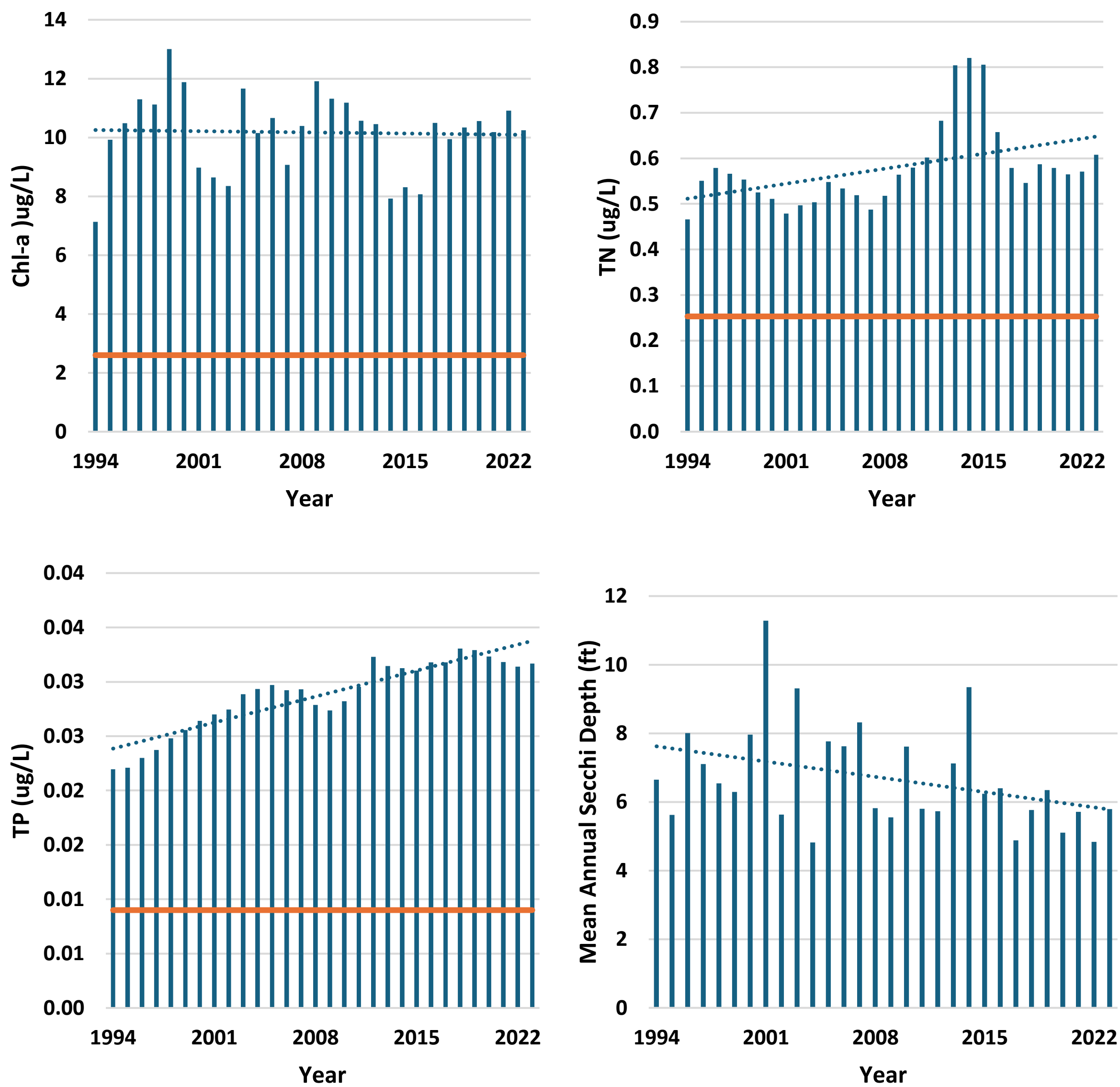

Figure 13. Rolling 3-year geomean values for a) Chl-a, b) TN, c) TP, and d) average annual Secchi depth, collected by LMVP. The orange line represents the Site-Specific Nutrient Criteria for Table Rock Lake.

Table 7. Table Rock Lake WQ samples collected by the LMVP, expressed as a rolling 3-year geomean value. Standard values included outline the Site-Specific Nutrient Criteria for Table Rock Lake (MODNR, 2023b).

3-Year Geomean			
Year	**Chl-a (mg/L)**	**TN mg/L**	**TP mg/L**
1994	0.007	0.466	0.022
1995	0.010	0.551	0.028
1996	0.010	0.579	0.029
1997	0.011	0.566	0.031
1998	0.011	0.554	0.030
1999	0.013	0.525	0.028
2000	0.012	0.511	0.025
2001	0.009	0.479	0.018
2002	0.009	0.497	0.018
2003	0.008	0.504	0.016
2004	0.012	0.548	0.021
2005	0.010	0.534	0.017
2006	0.011	0.519	0.017
2007	0.009	0.487	0.014
2008	0.010	0.518	0.017
2009	0.012	0.564	0.018
2010	0.011	0.580	0.018
2011	0.011	0.602	0.021
2012	0.011	0.683	0.022
2013	0.010	0.804	0.023
2014	0.008	0.820	0.018
2015	0.008	0.806	0.018
2016	0.008	0.658	0.017
2017	0.010	0.579	0.020
2018	0.010	0.546	0.018
2019	0.010	0.587	0.019
2020	0.011	0.579	0.017
2021	0.010	0.565	0.017
2022	0.011	0.571	0.017
2023	0.010	0.608	0.018
Min	0.007	0.466	0.014
Max	0.013	0.820	0.031
St. Dev.	0.001	0.090	0.005
Mean	0.010	0.580	0.020
CV	0.13	0.16	0.22
n	543	549	549
Standard	0.0026	0.253	0.009

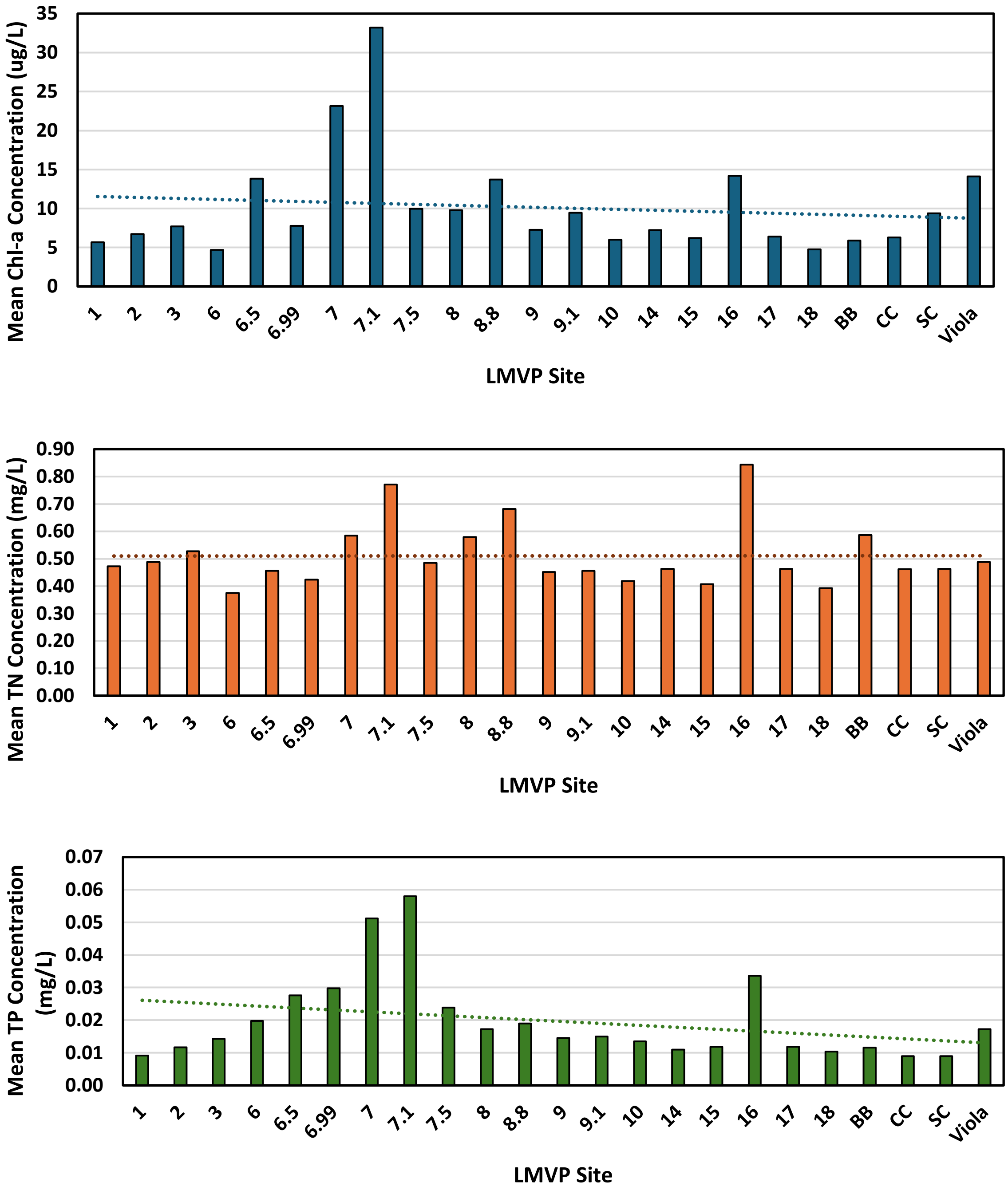

Figure 14. Lakes of Missouri Volunteer Program (LMVP) overall mean site concentrations for Table Rock Lake from 1992-2023.

eutrophication, groundwater contamination, and have other negative impacts on water quality (Baker, 1992). Due to their nature, nonpoint source pollutants are more difficult to manage than point sources. This watershed management plan will identify key measures needed to effectively reduce nonpoint source pollution in the watershed.

Surrounding Impairments

James River Arm Total Maximum Daily Load (TMDL). The James River (HUC:11010002; WBID 2365), a significant tributary to Table Rock Lake, has been identified as a major contributor of nutrients to Table Rock Lake, with wastewater discharges found to contribute up to 27% of daily phosphorus loading into Table Rock Lake (MODNR, 2004a). The James River was placed on Missouri's 303(d) Impaired Waters list in 1998 due to excessive nutrients, notably, phosphorus (SMCOG, 2023). In 1999, there was a large algal bloom within the James River Arm of Table Rock Lake (SMCOG, 2023). Following its 303(d) listing, a total maximum daily load (TMDL) was approved by the USEPA in 2001 and published in 2004 for the James River (MODNR, 2004b) in effort to reduce elevated nutrient levels and resulting algal growth. As of 2024, approximately 58 miles of the James River from the headwaters to Table Rock Lake are deemed impaired (segment IDs: 2347, 2362, 2365).

Historically, the James River Subwatershed (31,536 acres) has exhibited low water clarity and elevated levels of suspended algae, primarily due to discharges and runoff from the cities of Springfield and Nixa, Missouri, both of which have WWTPs that discharge in the water system (TRLWQI, 2007). Effluent regulations have been established for facilities discharging into both the James River and Table Rock Lake to mitigate these impacts (MODNR, 2004a; MODNR, 2023). The goal of the TMDL is to restore the James River to compliance with Missouri's water quality standards. This will be achieved by reducing the occurrence of significant algal blooms through targeted in-stream nutrient limits of 0.075 mg/L for TP and 1.5 mg/L for TN, with point sources discharging into the TRLW limited to a monthly average of 0.5 mg/L phosphorus, as outlined in 10 CSR 20-7.015(3)(F) (MODNR, 2023b). In 2020, the entire waterbody of the James River (39 miles) was included on Missouri's 303(d) list for *E. coli* pollution resulting from an unknown source (MODNR, 2021a).

Lake Taneycomo TMDL and WMP. Portions of Table Rock Lake experience low dissolved oxygen (DO) levels, particularly from July to November, due to chemical and thermal stratification (USACE, 2014). To improve DO levels in hydropower releses, management measures include turbine aeration modifications and oxygen injection systems. Monitoring and adjustments are coordinated through the White River DO Committee to ensure adequate DO levels for downstream aquatic life, including a trout nursery in Lake Taneycomo, downstream of the Table Rock Lake Dam. Lake Taneycomo (WBID 7314; 2,119 acres) has an approved TMDL for

DO (MODNR, 2010), as well as a 9-Element WMP which was accepted by both MODNR and EPA in 2024 and outlines the necessary actions for improving water quality impairments within the watershed to meet state water quality standard criteria (Hess et al., 2024). The TMDL identified Table Rock Dam as the cause of low DO concentrations, due to the release of hypolimnetic waters from Table Rock Lake (MODNR, 2010). However, the TMDL also acknowledges that nutrients and organic materials originating in the surrounding watersheds can also contribute to lower DO concentrations (MODNR, 2010).

Outstanding State Resource Waters

Ketchum Hollow (WBID 10028), located 3 miles upstream of TRL along Roaring River and within the Roaring River-Table Rock Lake HUC-12, is recognized as an Outstanding State Resource Water. Waters with an Outstanding State Resource Water designation are high quality waters with a significant aesthetic, recreational, or scientific value which are specifically designated as such by the Clean Water Commission (10 CSR 20-7.031(1)(U)). The 1.5-mile segment of Ketchum Hollow designated as an Outstanding State Resource Water is located within the Roaring River State Park in Barry County, with Roaring River serving as a tributary to TRL.

Biological Monitoring and Conservation

The Table Rock Lake Watershed supports diverse aquatic and terrestrial biological communities that are sensitive to changes in water quality and habitat conditions. Several state and federally listed threatened or endangered species occur within or near the watershed, including aquatic species such as the Neosho mucket and Ozark cavefish, as well as species dependent on high quality riparian and aquatic habitats, such as the Indiana bat and Gray bat (MDC, 2022; MDC, n.d.; Nigh & Schroeder, 2002; USACE, 2014). The presence of these species emphasizes the need for stable dissolved oxygen levels, low sedimentation, and reduced nutrient inputs, all of which can be directly affected by nonpoint source pollution. This biological context may facilitate coordination with state and federal conservation programs that address both water quality and species protection.

METHODOLOGY FOR DETERMINING NONPOINT POLLUTANT SOURCES

STEPL Analysis

Nutrient and sediment loads from sixteen HUC-12 watersheds in the TRLW were estimated using the USEPA's Spreadsheet Tool for Estimating Pollutant Load (STEPL) (Tetra Tech, 2018) according to the MODNR approved STEPL modeling QAPP for this project (OEWRI, 2024). STEPL applies deterministic algorithms to calculate pollutant loads in runoff from individual land uses and eroding streambanks (Tetra Tech, 2018). Each HUC-12 watershed was modeled using a combination of STEPL inputs outlined in the User Guide (Tetra Tech, 2018) and additional site-specific data described below. Inputs included drainage area, rainfall, land use, agricultural animals, septic systems, and soil characteristics (hydrologic group, K factor, and LS factor), as well as adjustments to model input defaults.

STEPL Data Inputs

Land use for each of the sixteen HUC-12 watersheds (Appendix Table A1) was calculated using ArcGIS and the 2021 National Land Cover Database (NLCD, 2023). The EPA Pollutant Load Estimation Tool (PLET) database contains types and counts of livestock for each watershed, as well as estimates of the number of septic systems, population per system, and the septic system failure rate for each HUC-12. Livestock and septic system estimates were obtained from PLET, which allocates county-level agricultural census data to each HUC-12 subwatershed based on the proportion of county area contained within that watershed. PLET-generated values were adjusted to reflect only the portion located within Missouri for subwatersheds spanning across the Missouri-Arkansas state line. High-resolution aerial imagery viewed in ArcGIS Pro was used to improve the accuracy of poultry estimates by manually identifying the number and location of poultry houses/plants/barns. The livestock and septic values were then incorporated into the STEPL model (Appendix Tables A2 and A3). All adjustments to improve model accuracy are discussed in detail within the Modeling Report completed for this project (OEWRI, 2025).

Soil data for the TRLW was acquired from the Web Soil Survey (USDA-NRCS, 2019). Soil data inputs to STEPL include K- and LS- factors, and hydrologic soil group (HSG), which the STEPL model incorporates for use into the Universal Soil Loss Equation (USLE). The K-factor represents soil erodibility and measures the susceptibility of soil particles to separate and become mobilized by rainfall and runoff (USLE, 2012). The hydrologic soil group (HSG) shows the runoff potential for a soil, as Group A soils have the smallest runoff potential while Group D soils have the greatest runoff potential. Only a single HSG value is allowed in STEPL for each HUC-12, therefore, it was determined that HSG-C covered the largest land area in each HUC-12 and was used as the HSG input for each HUC-12 (Appendix Table A4).

Evaluation of Model Accuracy

Typically, model uncertainty, or accuracy, is evaluated by comparing results to observed values (White et al. 2015). However, when no observed values are available, model output can be validated by comparing values to those found in the literature or by comparing to results of other models (Alewell et al. 2019, USEPA 2008). For this study, STEPL model accuracy was assessed using three separate techniques, comparing: 1) annual runoff volume to regional USGS gaging station records; 2) nutrient and sediment yields to published Ecoregion specific export coefficients by land use type; and 3) annual yields for the watershed to USGS SPARROW model outputs for the smallest available watershed area. Accuracy and variability of the model compared to each alternative method are discussed in detail within the Modeling Report (OEWRI, 2025) and summarized below.

Hydrology Verification and Base Flow Estimation. To verify the calculated runoff volumes from the STEPL model, estimated annual runoff volumes for each HUC-12 were compared with runoff values derived from a regression analysis relating annual mean discharge to drainage area from regional USGS gaging stations (Appendix Table A5), and subsequently adjusted to improve model performance (Tetra Tech, 2018). The final relative percent difference (RPD) between runoff volume estimates from the STEPL model and USGS gage data was 10.5% after adjustments to STEPL curve numbers. The STEPL-estimated runoff exhibited the same linear trend and slope as gage data, indicating consistency with regional flow patterns (Appendix Figure A1).

Export Coefficient Comparison. Export coefficients represent pollutant mass loading per unit area from individual land use types and are derived from field-based monitoring and published literature (USEPA 2008). In this study, STEPL derived nutrient yields by land use were compared to regional export coefficients developed for the Ozark Highlands ecoregion by White et al. (2015). Where modeled values fell outside published ranges, nutrient concentrations assigned in STEPL were adjusted within literature supported limits to improve consistency with regional data. Overall, STEPL derived nutrient yields generally fell within reported literature ranges (Appendix Table A6), indicating that modeled land use contributions are representative of observed regional conditions.

SPARROW Model Comparison. Annual yields by each HUC-12, as well as the total TRLW, were compared to outputs from the USGS SPARROW model for the midwestern U.S. (Robertson and Saad, 2019). SPARROW is a hybrid-type model which combines physically based simulations of stream flow, N, P, and suspended sediment with data collected from long-term monitoring stations throughout the Midwest. SPARROW modeled nutrient and sediment yields from the entire Beaver Reservoir watershed (HUC-8: 11010001) were compared to STEPL modeled yields for the TRLW. Results indicated that our modeled values fall well within the documented error range for the SPARROW model, indicating that the STEPL model is well aligned and produces realistic load estimates for the watershed.

Load Reduction Goal Setting and Determination of Target Concentrations

Nutrient concentrations in baseflow and runoff were estimated using a combination of STEPL modeling, pre-existing data, and hydrologic analysis to support load reduction goal setting for the TRLW. Given the existing nitrogen impairment for Table Rock Lake, modeled in-stream nutrient concentrations were evaluated against the EPA's recommended eutrophication thresholds for TN (1.5 mg/L) and TP (0.075 mg/L) (USEPA, 2000). Concentrations of pollutants contributed under baseflow conditions were estimated, as well as an evaluation of two potential water quality targets for N and P. This assessment defines the extent of nutrient reductions needed to achieve water quality targets.

Baseflow Load Estimation. While STEPL estimates the pollutant loads in runoff, the following analysis was performed to estimate concentrations of pollutants under baseflow conditions for each HUC-12. Water quality data collected by the USGS at Yocum Creek near Oak Grove, AR (Gage 07053250) from 1993–2018 were used to estimate baseflow nutrient concentrations for the Yocum Creek HUC-12. For the purposes of this analysis, a flow at or greater than 75% exceedance was assumed to represent baseflow conditions. Under this assumption, discharges at or below approximately 11 cubic feet per second were considered representative of baseflow at this site during the sampling period. Samples collected under these baseflow conditions (11 cfs) yielded average concentrations of 3.4 mg/L of nitrogen and 0.05 mg/L phosphorus (Appendix Tables A7 & A8). The TN concentration aligns with prior results from 2005 baseflow sampling, which ranged from 1.3–17.4 mg/L (Owen et al., 2006; Borchelt, 2007), and with previous reports of elevated nitrogen in Yocum Creek (OWW, 2014).

For the Roaring River HUC-12, nutrient data were available from the Roaring River at Roaring River State Park gage (07050152) from only 1992–1993, limiting direct baseflow analysis through flow duration. As an alternate approach, the Base Flow Index (BFI) calculated in the *Hydrology Verification and Baseflow Estimation* section was applied to the estimated runoff volume for the Roaring River HUC-12, which was then converted into cubic feet per second to estimate the baseflow discharge for the Roaring River HUC-12 (15.3 cfs). TN and phosphorus data from the MODNR Water Quality Database for Roaring River Spring (1993–2020) were downloaded and filtered for samples collected under the estimated baseflow discharge (Appendix Table A9). The resulting average baseflow concentrations for the Roaring River HUC-12 were 3.2 mg/L TN and 0.03 mg/L TP. For the remaining 14 HUC-12s, no existing baseflow data could be identified. Therefore, to estimate baseflow concentrations for the remaining HUC-12s, baseflow data from the Lake Taneycomo WMP (Hess et al., 2024) were used in a land use comparison approach. Regression analyses were performed between land use percentages (urban, forest, and pasture) and measured concentrations of TN and TP (Appendix Figure A2). The resulting equations were then applied to estimate TN and TP concentrations for each Table

Rock Lake Watershed (TRLW) HUC-12, excluding Yocum Creek and Roaring River. Average concentrations for each HUC-12 were subsequently used to calculate baseflow loads, total loads, and required load reductions, with TN concentrations ranging from 1.1 – 1.2 mg/L and TP concentrations ranging from 0.02 – 0.07 mg/L (Appendix Table A10).

Load Reduction Targets & Required Load Reductions

Eutrophic Threshold Target. Once the baseflow volume was estimated using the BFI and modeled runoff volume, it was multiplied by the average baseflow sample concentration of TN and TP to get a baseflow load (lb/yr) of the nutrients from each HUC-12. The baseflow load and runoff load were combined to get the total annual load from each HUC-12. Further, the total water volume (runoff plus baseflow) for each HUC-12 was multiplied by the eutrophic threshold (USEPA, 2000) for TN (1.5 mg/L) and TP (0.075 mg/L) to get an average target load of TN and TP by HUC-12. The baseflow load was then subtracted from the target load to set a target for the runoff load (i.e., the load generated from NPS) to reach the eutrophic threshold.

Background Yields (All-Forested). STEPL modeling of background loads for each HUC-12 was conducted using an all-forested land use scenario and current soil conditions, consistent with the approach applied in the Lake Taneycomo WMP (Hess et al., 2024). This all-forested scenario represents the estimated background nitrogen, phosphorus, and sediment yields prior to historical and present-day land use development. Modeled loads were divided by drainage area to calculate yields expressed as mass per unit area. These conditions represent an estimated baseline for nutrient yields within the watershed and may serve as a realistic target for nutrient reductions for certain HUC-12s. To focus NPS load reduction goals, STEPL model outputs were used to rank HUC-12 watersheds by comparing present-day NPS yields to background yields estimated under an “all forest” scenario. Ratios of present-day to background yield indicate the degree of land use impact, with higher ratios reflecting greater departures from baseline conditions (Figure 15). For example, a ratio of 2 means current yields are twice those expected under all-forested conditions, signifying substantial increases in pollutant loads due to land use change.

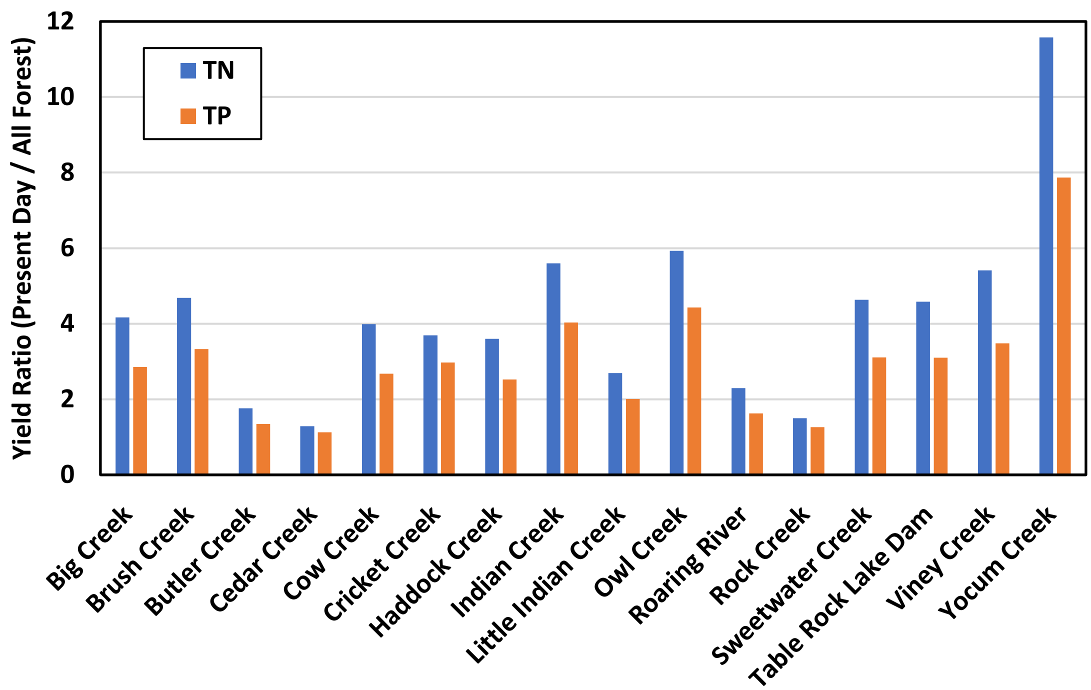

Figure 15. Yield Ratio of Present-day to Background (all-forested) nutrient loads for HUC-12s within the TRLW. Higher ratios indicate greater load contributions as a result of land use change

ELEMENT 1: CAUSES AND SOURCES OF POLLUTANTS

STEPL Nonpoint Source Yields

STEPL estimates annual nitrogen and phosphorus loads in pounds (lb/yr) and sediment loads in tons (t/yr) for each sub-watershed and land use type, based on runoff volume and pollutant concentrations. The NPS load values reflect the total mass of a pollutant delivered to the watershed outlet. Load values are affected by watershed size and not necessarily pollution rate, thus larger watersheds have greater loads (if all other variables are the same). Therefore, to accurately compare NPS rates among watersheds of varying sizes, the load values were divided by area of the watershed (or specific land use) to report annual NPS *yields* as mass per unit area. NPS yield values are more indicative of pollution risk, as they reflect the intensity or rate of pollutant delivery from a watershed in units of mass per land area. In this report, yields are reported in units of pounds per acre per year (lb/ac/yr) for TN and TP, and tons per acre per year (t/ac/yr) for sediment. Both NPS load and yield provide quantitative information about NPS pollutants and their origins.

Background Yields. Background nitrogen yields across the HUC-12 subwatersheds ranged from 0.6 lb/ac/yr in Yocum and Indian Creek to 1.4 lb/ac/yr in Butler Creek (Table 8; Figure 15). Phosphorus yields ranged from 0.16 lb/ac/yr in Indian Creek to 0.48 lb/ac/yr in Butler Creek, while sediment yields ranged from 0.11 t/ac/yr in Indian Creek to 0.36 t/ac/yr in Butler Creek (Table 7). For comparison, Clark et al. (2000) reported average yields of 0.77 lb/ac/yr nitrogen and 0.08 lb/ac/yr phosphorus in 40 undeveloped watersheds, while White et al. (2015) reported 1.13 lb/ac/yr nitrogen, 0.05 lb/ac/yr phosphorus, and 0.10 t/ac/yr sediment in undisturbed Ozark Highlands forests. Average background yields for the TRLW were 0.89 lb/ac/yr nitrogen, 0.29 lb/ac/yr phosphorus, and 0.21 t/ac/yr sediment. Overall, modeled background TP yields for the TRLW exceed the eutrophic threshold load, indicating that baseline conditions within the watershed already surpass the 0.075 mg/L eutrophic threshold, and suggesting that establishing a more attainable phosphorus reduction target may provide a more realistic foundation for management planning.

Present-Day Yields. STEPL modeling of present-day yields for the TRLW HUC-12s resulted in estimated TN ranging from 1.6 to 7.1 lb/ac/yr, TP from 0.5 to 1.4 lb/ac/yr, and S from 0.3 to 0.7 t/ac/yr (Table 8; Figure 15). The highest estimated yields for all three pollutants result from the Yocum Creek HUC-12, which has the smallest drainage area among the modeled HUC-12s and features significant agricultural land use, primarily poultry operations. As noted previously, approximately 4% (1,080 acres) of the total Yocum Creek watershed acreage lies within Missouri, with the remaining portion omitted from modeling. Owl Creek (5.1 lb/ac/yr TN; 1.20 lb/ac/yr TP; 0.72 t/ac/yr S) was estimated to contribute the second highest N, P, and S to yields the TRLW. By contrast, Cedar Creek (1.6 lb/ac/yr TN; 0.46 lb/ac/yr TP) and Rock Creek (1.7 lb/ac/yr TN; 0.47 lb/ac/yr TP) had the lowest TN and TP yields, while Big Creek (0.26 t/ac/yr), Cow Creek (0.27 t/ac/yr), and Little Indian Creek (0.27 t/ac/yr) produced the lowest S yields.

Land Use Contributions to N, P, and Sediment. Nitrogen, phosphorus, and sediment contributions to the TRLW are tabulated by land use within each HUC-12 and summarized in Table 9. These comparisons highlight which land uses exert the greatest influence on overall pollutant loads. Pastureland is the dominant source of TN, TP, and S across most HUC-12 subwatersheds, accounting for 46% of total N, 45% of total P, and 49% of total S in the TRLW. Urban land is the second-largest contributor of nitrogen (31%), while forested land contributes the next largest shares of phosphorus and sediment (33% and 45%, respectively). Cropland and septic systems contribute very little overall (<0.2%). This distribution highlights the land uses contributing disproportionate loads within the watershed, indicating that management strategies targeting nutrients in pastureland and urban areas, as well as sediment in forested areas, will likely have the greatest impact on reducing nutrient and sediment loads within the TRLW.

Comparison of Background and Present-Day Yields. In general, all subwatersheds show elevated nutrient and sediment yields relative to background levels, though the extent of change varies by watershed and pollutant (Table 8; Figure 15). Nitrogen exhibited the greatest departure from natural conditions, with present-day TN yields ranging from 1.3 to 11.6 times higher than modeled background levels. The highest TN ratios were observed in Yocum Creek (11.6), Owl Creek (5.9), Viney Creek (5.4), and Indian Creek (5.6), suggesting significant anthropogenic contributions from agriculture, development, or other land use changes. In contrast, Butler Creek, Cedar Creek, and Rock Creek had comparatively low TN ratios, ranging between 1.3 and 1.8, which indicates more modest increases in nitrogen loads. Phosphorus load ratios ranged from 1.1 to 7.9, with the highest increase from background conditions observed within Yocum Creek (7.9), followed by Owl Creek (4.4) and Indian Creek (4.0). Several subwatersheds, such as Butler, Cedar, and Rock Creek, had TP ratios close to 1.0, suggesting relatively minor increases in phosphorus compared to forested conditions. Sediment yield ratios ranged from 1.0 to 5.9. Yocum Creek had the most elevated sediment yield (5.9 times background), followed by Owl Creek (3.7) and Indian Creek (3.1). Notably, Cedar Creek had a sediment ratio of 1.0, indicating no measurable increase over natural background levels. This suggests limited land disturbance or effective sediment retention in that watershed.

Comparison with Adjacent and Regional Watersheds. Modeled nutrient and sediment yields for the TRLW are generally consistent with those reported for nearby and regional watersheds (Figure 16). Compared to the neighboring James River watershed (JRW) which lies upstream of the eastern TRLW HUC-12s and contributes runoff to the TRLW, TRLW yields for nitrogen (1.6–7.1 lb/ac/yr), phosphorus (0.4–1.4 lb/ac/yr), and sediment (0.26–0.73 t/ac/yr) fall within or near the lower end of JRW estimates (SMCOG, 2023; Zeiger, 2019). Relative to the downstream Lake Taneycomo watershed (LTW), TRLW yields are similar for nitrogen (4.3–6.0 lb/ac) and phosphorus (1.2–1.6 lb/ac), while sediment yields are somewhat lower (0.7–1.2 t/ac/yr) (Hess et al., 2024). Elevated sedimentation in the LTW is well documented and may explain these higher estimates compared to the TRLW. Overall, these comparisons indicate that nutrient and sediment yields modeled for TRLW align with regional trends, supporting the reliability of the estimates within the context of neighboring watersheds.

Summary. Overall, these results highlight a subset of subwatersheds, particularly Yocum, Owl, Indian, and Viney Creeks, that appear to be disproportionately affected by human land use change. The elevated present-day conditions modeled for Yocum Creek likely result from differences in land use, as present-day land use within Yocum Creek is predominantly (83%) pastureland, whereas the remaining TRLW subwatersheds are predominantly forested land use. These areas are likely to benefit the most from targeted load reduction strategies and

Table 8. Present-day and Background (all-forested) yields and yield ratios for HUC-12s within the TRLW.

	Present-Day			Background (All-Forested)			Ratio (P:B)		
HUC-12	**TN Yield (lb/ac/yr)**	**TP Yield (lb/ac/yr)**	**S Yield (t/ac/yr)**	**TN Yield (lb/ac/yr)**	**TP Yield (lb/ac/yr)**	**S Yield (t/ac/yr)**	**TN**	**TP**	**S**
Big Creek	2.7	0.55	0.26	0.66	0.19	0.13	4.2	2.9	1.9
Brush Creek	4.0	0.89	0.48	0.84	0.27	0.19	4.7	3.3	2.5
Butler Creek	2.5	0.64	0.41	1.41	0.48	0.36	1.8	1.3	1.1
Cedar Creek	1.6	0.46	0.32	1.22	0.41	0.30	1.3	1.1	1.0
Cow Creek	2.9	0.60	0.27	0.73	0.22	0.16	4.0	2.7	1.7
Cricket Creek	3.8	1.03	0.67	1.04	0.35	0.26	3.7	3.0	2.6
Haddock Creek	3.7	0.85	0.49	1.03	0.34	0.25	3.6	2.5	2.0
Indian Creek	3.1	0.64	0.33	0.56	0.16	0.11	5.6	4.0	3.1
Little Indian Creek	2.1	0.48	0.27	0.77	0.24	0.17	2.7	2.0	1.6
Owl Creek	5.1	1.20	0.72	0.86	0.27	0.20	5.9	4.4	3.7
Roaring River	2.4	0.58	0.36	1.06	0.36	0.27	2.3	1.6	1.3
Rock Creek	1.7	0.47	0.31	1.12	0.37	0.28	1.5	1.3	1.1
Sweetwater Creek	4.0	0.84	0.44	0.85	0.27	0.19	4.6	3.1	2.3
TRL Dam	3.6	0.76	0.36	0.79	0.25	0.17	4.6	3.1	2.1
Viney Creek	4.1	0.81	0.40	0.76	0.23	0.17	5.4	3.5	2.4
Yocum Creek	7.1	1.41	0.73	0.61	0.18	0.12	11.6	7.9	5.9

TN = Total Nitrogen; TP = Total Phosphorus; S = Sediment

Table 9. STEPL Land Use Contributions to Nutrient and Sediment Loads by HUC-12.

HUC-12	Pollutant	Urban	Cropland	Pastureland	Forest	Barren Land	Septic	Total
Big Creek	TN %	4.5	0.0	3.9	1.8	0.0	0.01	10.2
	TP %	3.1	0.0	3.7	2.4	0.0	0.03	9.1
	S %	0.8	0.0	3.8	3.0	0.0	0.00	7.6
Brush Creek	TN %	4.3	0.0	4.8	1.5	0.0	0.02	10.6
	TP%	2.9	0.0	5.4	2.1	0.0	0.01	10.5
	S %	0.8	0.0	6.5	2.8	0.0	0.00	10.1
Butler Creek	TN %	0.9	0.0	1.4	2.2	0.0	0.00	4.5
	TP %	0.6	0.0	1.3	3.3	0.0	0.00	5.2
	S %	0.2	0.0	1.3	4.5	0.0	0.00	6.0
Cedar Creek	TN %	0.1	0.0	0.2	0.7	0.0	0.00	0.9
	TP %	0.1	0.0	0.1	1.0	0.0	0.00	1.2
	S %	0.0	0.0	0.1	1.4	0.0	0.00	1.6
Cow Creek	TN %	5.0	0.0	1.9	1.6	0.0	0.03	8.6
	TP %	3.4	0.0	2.0	2.2	0.0	0.05	7.7
	S %	0.9	0.0	2.3	2.9	0.0	0.00	6.1
Cricket Creek	TN %	0.7	0.0	1.6	0.6	0.0	0.00	2.9
	TP %	0.5	0.0	2.0	0.9	0.0	0.00	3.4
	S %	0.1	0.0	2.6	1.2	0.0	0.00	3.9
Haddock Creek	TN %	0.8	0.0	1.8	0.6	0.0	0.00	3.2
	TP %	0.5	0.0	1.9	0.9	0.0	0.01	3.2
	S %	0.1	0.0	2.1	1.2	0.0	0.00	3.4
Indian Creek	TN %	1.1	0.0	3.2	0.6	0.0	0.00	5.0
	TP %	0.8	0.0	3.0	0.7	0.0	0.00	4.5
	S %	0.2	0.0	3.1	0.9	0.0	0.00	4.2
Little Indian Creek	TN %	1.1	0.0	1.2	1.1	0.0	0.00	3.4
	TP %	0.8	0.0	1.3	1.5	0.0	0.01	3.5
	S %	0.2	0.0	1.4	1.9	0.0	0.00	3.5
Owl Creek	TN %	0.9	0.0	3.4	0.4	0.0	0.00	4.7
	TP %	0.6	0.0	3.8	0.6	0.0	0.00	5.0
	S %	0.2	0.0	4.5	0.8	0.0	0.00	5.4
Roaring River	TN %	2.4	0.0	8.9	5.5	0.0	0.01	16.8
	TP %	1.6	0.0	8.1	8.2	0.0	0.01	17.9
	S %	0.4	0.0	8.1	11.4	0.0	0.00	19.9
Rock Creek	TN %	0.8	0.0	1.6	3.8	0.0	0.00	6.2
	TP %	0.5	0.0	1.5	5.7	0.0	0.00	7.7
	S %	0.1	0.0	1.6	7.7	0.0	0.00	9.4
Sweetwater Creek	TN %	2.1	0.0	5.2	1.1	0.0	0.00	8.4
	TP %	1.4	0.0	4.9	1.5	0.0	0.01	7.9
	S %	0.4	0.0	5.2	2.0	0.0	0.00	7.6
Table Rock Lake Dam	TN %	4.1	0.0	1.8	1.1	0.0	0.02	6.9
	TP %	2.8	0.0	2.0	1.5	0.0	0.03	6.3
	S %	0.8	0.0	2.5	1.9	0.0	0.00	5.1
Viney Creek	TN %	1.9	0.1	3.8	0.6	0.0	0.01	6.5
	TP %	1.3	0.1	3.3	0.9	0.0	0.01	5.7
	S %	0.4	0.1	3.3	1.2	0.0	0.00	4.9
Yocum Creek	TN %	0.2	0.0	1.0	0.0	0.0	0.00	1.2
	TP %	0.1	0.0	1.0	0.0	0.0	0.00	1.1
	S %	0.0	0.0	1.0	0.0	0.0	0.00	1.0
TRLW	*TN %*	*30.7*	*0.1*	*45.9*	*23.1*	*0.0*	*0.1*	*100.0*
	TP %	*21.1*	*0.1*	*45.3*	*33.3*	*0.0*	*0.2*	*100.0*
	S %	*5.7*	*0.1*	*49.4*	*44.7*	*0.0*	*0.0*	*100.0*

enhanced best management practice (BMP) implementation. Conversely, subwatersheds with near-background load conditions may require a more protective than restorative management approach, aiming to preserve current conditions and prevent future degradation.

ELEMENT 2: EXPECTED LOAD REDUCTIONS

Required Load Reductions

The runoff target load for TN ranged from a required 0 – 73% reduction in load and the TP load ranged from 73 – 87% reductions to meet the eutrophic threshold (Figure 17; Figure 18). The highest observed required load reduction in TN to meet the target load was within the Yocum Creek HUC-12, which is noted to typically have elevated TN concentrations due to agricultural operations on pastureland, as well as poultry and dairy operations within the watershed (Borchelt, 2007). Overall, the modeling resulted in 6 of the 16 HUC-12s (Big, Butler, Cedar, Cow, Little Indian, and Rock Creeks) with nitrogen loads below the eutrophic threshold for nitrogen, requiring no reduction in load to meet the eutrophic threshold for nitrogen at the time of modeling (Table 10; Table 11). Given these results, prioritizing management measures within HUC-12s that exceed the eutrophic threshold directs efforts toward watersheds with the greatest need for load reductions, while HUC-12s already below the threshold for nitrogen may benefit more from protective rather than restorative strategies, focusing on maintaining current conditions and preventing future degradation. However, it was estimated that all 16 HUC-12s would require a load reduction in phosphorus to meet the target eutrophic threshold, with an average required reduction of 79%.

While it may be difficult to reduce phosphorus loads to meet the eutrophic threshold, the modeled background 'all forested' loads outlined earlier in this document may offer a more practical target for load reductions. Achieving the eutrophic threshold would require an average 80% reduction in phosphorus, whereas meeting the all-forested background loads would require an average reduction of 57% (Figure 18 & Appendix Figure A3). Figure 7 presents the percentage phosphorus reduction required to achieve the eutrophic target versus the all-forested background. These background loads represent the lowest expected phosphorus levels under natural land cover conditions and are likely the most attainable benchmarks for phosphorus. As such, focusing management efforts on reaching background phosphorus load levels may present a more realistic and achievable path forward than aiming to reach the eutrophic threshold for phosphorus. Similarly, the Lake Taneycomo WMP sets a load reduction goal of reducing 50% of the load resulting from land use change from the all-forested background conditions (Hess et al., 2024). However, the eutrophic threshold remains a feasible target for nitrogen load reductions within the watershed.

Review of Neighboring Watersheds BMP and Load Reduction Goals

It is apparent that a phased BMP approach will be needed to improve water quality including goals to control nonpoint source loads from new and future developments. Major load reductions over a short term would be difficult or nearly impossible to achieve. However, other 319 watershed management plans were previously approved for both the downstream Lake Taneycomo, upstream James River, and nearby Spring River watersheds. Evaluating their approaches provided insight in developing a load reduction strategy for the TRLW. Both the James River and Spring River are HUC-8 watersheds containing several HUC-10 watersheds, whereas the LTW and TRLW are HUC-10 with smaller HUC-12 drainage areas. Both the James River and Spring River watersheds had listed impairments and/or TMDLs which set the nonpoint source target concentrations of pollutants and therefore provided the ability to determine the quantity of BMPs necessary to reach those targets. However, the TRLW has no currently approved TMDLs used for target determination, which led to the use of the EPA Eutrophic Threshold target as discussed in this plan.

Lake Taneycomo. The Lake Taneycomo WMP outlines BMP goals within the HUC-12 watersheds are to treat 25% of pastureland areas, 25% of urban areas, and 2,500 ft of eroding streambanks over a 20-year period (Hess et al., 2024). The selected BMPs focus on reducing runoff, which, in turn, reduces the pollutant and sediment loads transported within the watershed, including access control, alternative water, heavy use protection, forage and biomass planting, prescribed grazing, extended wet retention, and streambank stabilization (Hess et al., 2024). Achieving the annual goals of implementing BMPs on 441 acres of pastureland, 331 acres of urban land, and 125 feet of eroding streambanks within the Lake Taneycomo Watershed per year would reduce nitrogen and phosphorus by 10% and 8%, respectively. Long-term goals aim to achieve instream concentrations of 0.075 mg/L TP and 1.5 mg/L TN, in line with the eutrophic threshold targets (Hess et al., 2024).

James River. The James River Watershed Management Plan (WMP) outlines BMP goals within the six HUC10 subwatersheds to improve water quality over a 20-year period (SMCOG, 2023). Located north of the Table Rock Lake Watershed, the James River drains Springfield, Missouri, and surrounding areas before flowing into Table Rock Lake. The plan calls for implementing BMPs on 25% of pastureland areas, requiring phased annual treatment of 180 to 1,138 acres per HUC10, along with 25 to 125 feet of streambank stabilization each year (SMCOG, 2023). Additionally, urban stormwater basins are to be retrofitted annually for nutrient retention. Selected BMPs include vegetated stream buffers, prescribed grazing,

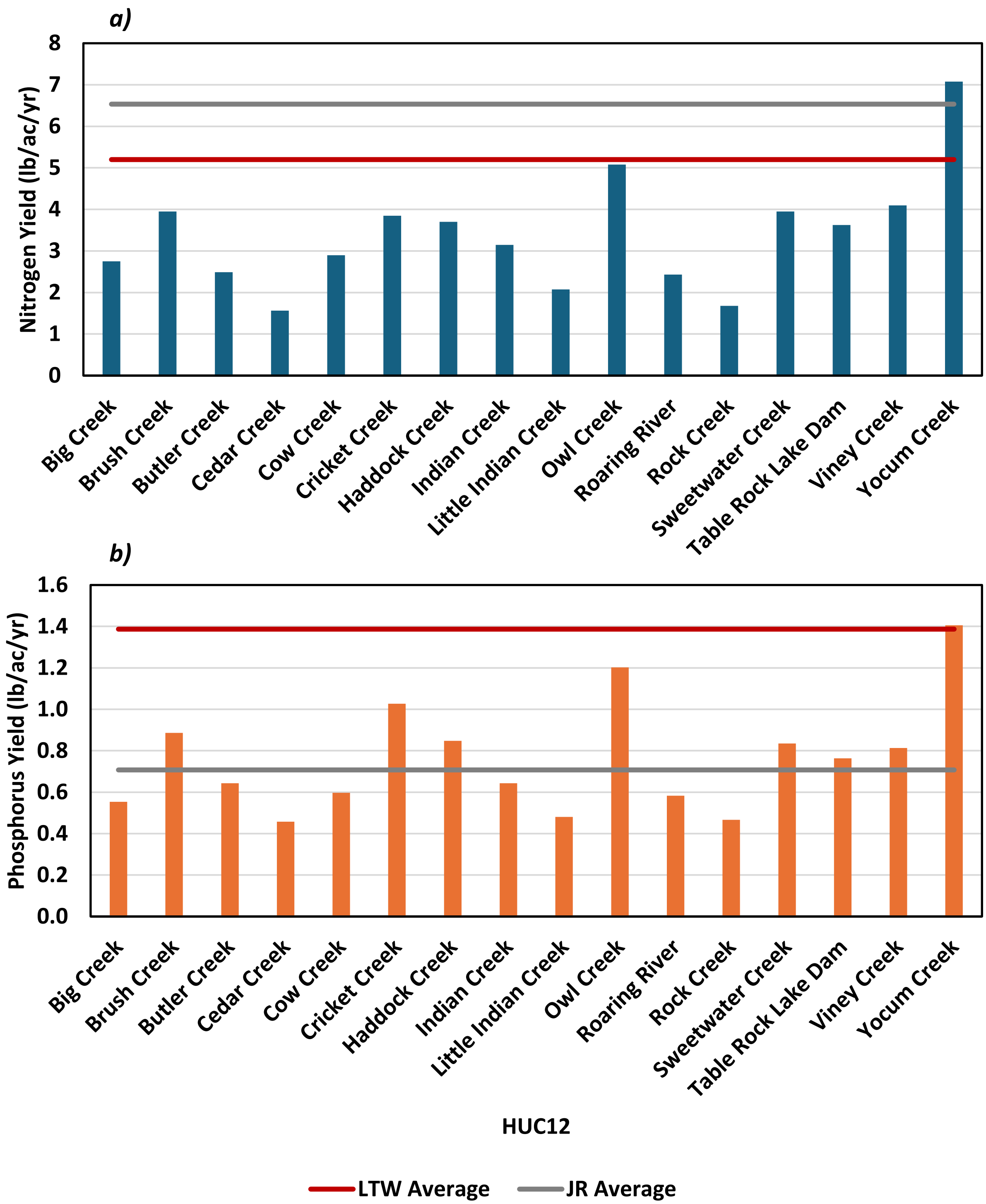

Figure 16. Modeled a) nitrogen and b) phosphorus yields (lb/ac/yr) by HUC-12 in the TRLW, compared with average reported yields for the James River (JR) and Lake Taneycomo (LTW) watersheds (Zeiger, 2019; Hess et al,. 2024).

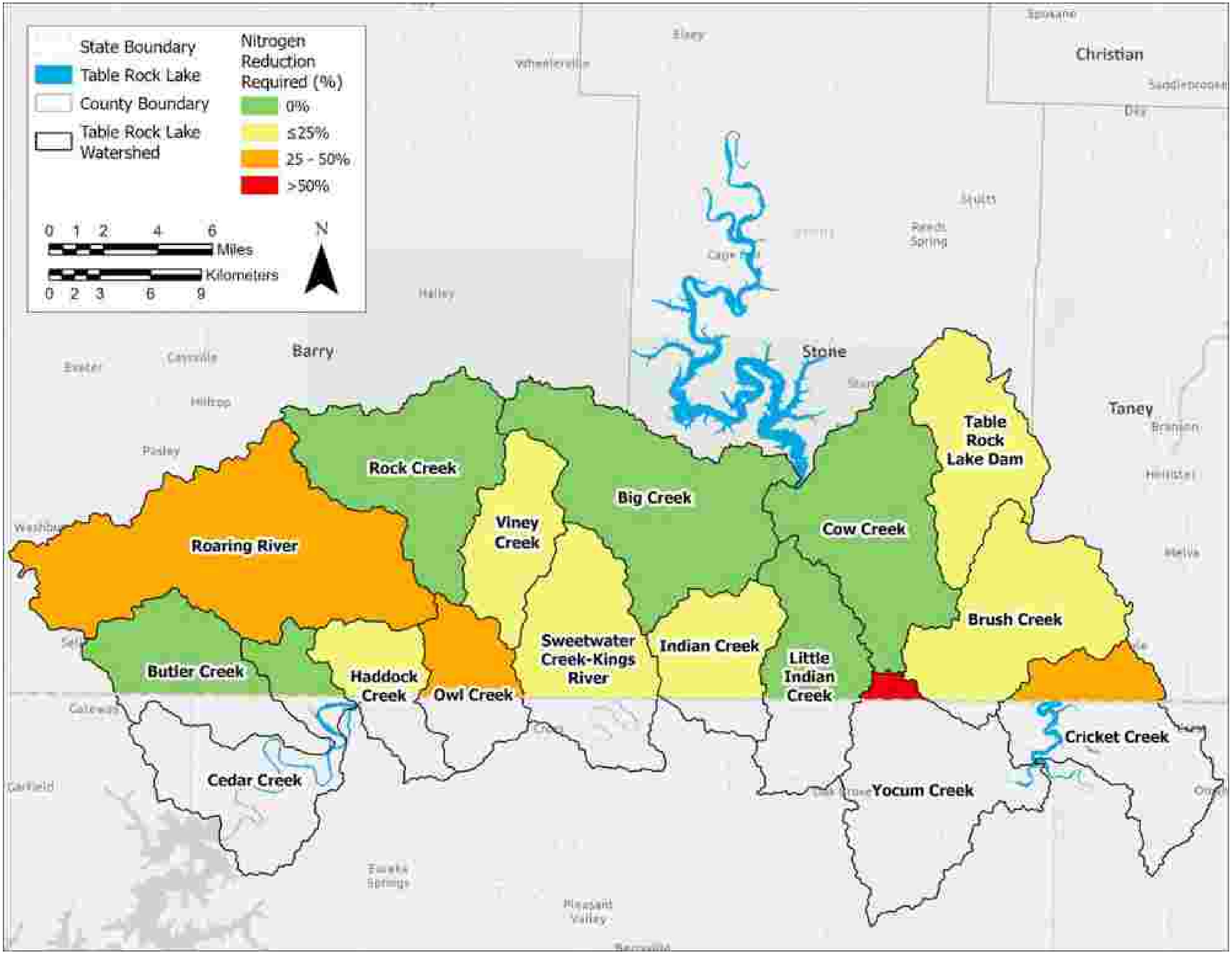

Figure 17. Required percent reductions in nitrogen by HUC-12 to meet eutrophic threshold (1.5 mg/L).

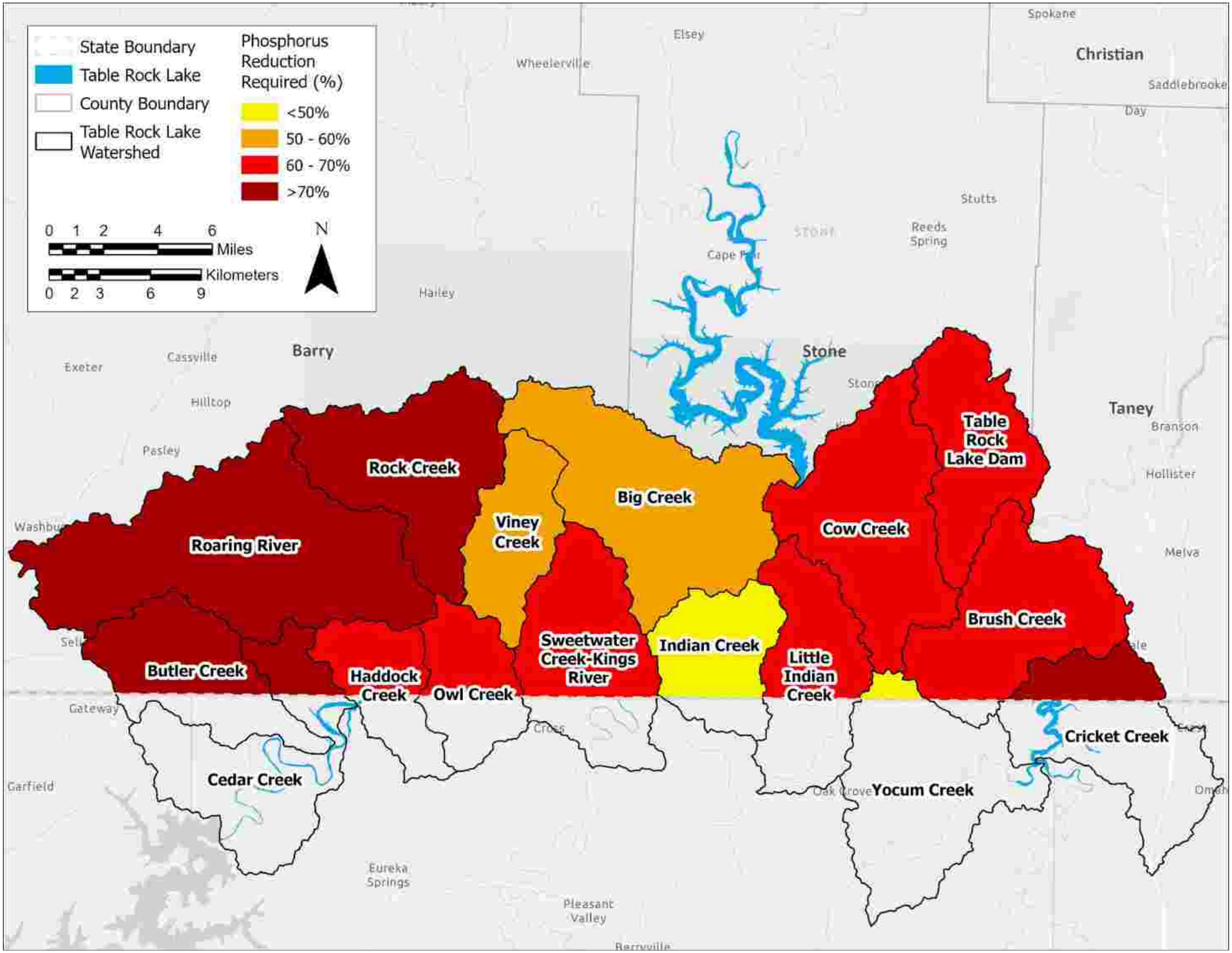

Figure 18. Required percent reductions in phosphorus by HUC-12 to meet the modeled all-forested background load.

Table 10. Baseflow, Runoff, Total, and Target Nitrogen Loads and Concentrations.

Total Nitrogen										
	Runoff		Baseflow		Total		Target			
HUC-12	Load (lb/yr)	Conc. (mg/L)	Load (lb/yr)	Est. Avg. Conc. (mg/L)	Load (lb/yr)	Conc. (mg/L)	Conc. (mg/L)	Total Load (lb/yr)	Runoff Load (lb/yr)	Runoff Load Reduction to Meet Target (%)
Yocum Creek	7,622	3.3	2,647	3.4	10,269	3.3	1.5	4,671	2,024	73
Roaring River	104,759	1.9	57,450	3.2	162,209	2.3	1.5	107,718	50,268	52
Owl Creek	29,307	2.8	4,397	1.2	33,703	2.4	1.5	21,204	16,808	43
Cricket Creek	18,819	2.4	3,012	1.2	21,831	2.1	1.5	15,466	12,454	34
Sweetwater Creek	52,284	2.2	9,815	1.2	62,099	1.9	1.5	48,491	38,676	26
Haddock Creek	19,946	2.1	3,746	1.2	23,692	1.9	1.5	18,774	15,029	25
Viney Creek	40,996	2.1	7,739	1.2	48,735	1.9	1.5	38,500	30,761	25
Brush Creek	67,148	2	12,603	1.1	79,752	1.8	1.5	67,214	54,610	19
Indian Creek	31,009	1.9	6,556	1.2	37,565	1.7	1.5	32,262	25,706	17
Table Rock Lake Dam	44,429	1.7	9,131	1.1	53,559	1.5	1.5	51,950	42,820	4
Big Creek	64,250	1.5	15,920	1.1	80,169	1.4	1.5	84,074	68,155	0
Butler Creek	27,842	1.6	6,865	1.2	34,707	1.5	1.5	35,140	28,276	0
Cedar Creek	5,873	1.2	1,938	1.2	7,811	1.2	1.5	9,904	7,966	0
Cow Creek	54,761	1.5	12,864	1.1	67,624	1.4	1.5	71,718	58,854	0
Little Indian Creek	21,301	1.4	5,805	1.2	27,107	1.3	1.5	30,156	24,351	0
Rock Creek	38,671	1.3	11,862	1.2	50,533	1.3	1.5	60,552	48,690	0

Table 11. Baseflow, Runoff, Total, and Target Phosphorus Loads and Concentrations.

Total Phosphorus										
HUC-12	Runoff		Baseflow		Total		Target			Runoff Load Reduction to Meet Target (%)
	Load (lb/yr)	Conc. (mg/L)	Load (lb/yr)	Est. Avg. Conc. (mg/L)	Load (lb/yr)	Conc. (mg/L)	Conc. (mg/L)	Total Load (lb/yr)	Runoff Load (lb/yr)	
Yocum Creek	1,515	0.65	39	0.05	1,554	0.5	0.075	212	193	87
Owl Creek	6,929	0.65	63	0.02	6,992	0.49	0.075	1,604	1,566	77
Indian Creek	6,337	0.39	176	0.03	6,512	0.3	0.075	1,689	1,571	75
Viney Creek	8,140	0.42	149	0.02	8,289	0.32	0.075	2,423	2,336	71
Brush Creek	15,068	0.45	499	0.04	15,567	0.35	0.075	4,815	4,531	70
Sweetwater Creek	11,053	0.46	221	0.03	11,274	0.35	0.075	3,699	3,561	68
Table Rock Lake Dam	9,368	0.36	474	0.05	9,842	0.28	0.075	3,274	3,026	68
Cricket Creek	5,029	0.65	121	0.05	5,150	0.5	0.075	1,774	1,693	66
Big Creek	12,945	0.31	716	0.05	13,662	0.24	0.075	5,001	4,542	65
Cow Creek	11,277	0.31	692	0.06	11,969	0.25	0.075	4,614	4,219	63
Haddock Creek	4,568	0.49	116	0.04	4,684	0.37	0.075	1,888	1,811	60
Little Indian Creek	4,930	0.33	297	0.06	5,227	0.26	0.075	2,684	2,462	50
Roaring River	25,093	0.47	539	0.03	25,631	0.36	0.075	15,829	15,414	39
Butler Creek	7,204	0.41	345	0.06	7,549	0.32	0.075	5,619	5,341	26
Rock Creek	10,747	0.35	661	0.07	11,408	0.28	0.075	9,142	8,549	20
Cedar Creek	1,714	0.35	112	0.07	1,827	0.28	0.075	1,628	1,523	11

stormwater detention, and septic maintenance, all targeting reductions in runoff, sediment, and nutrient loads. Long-term goals aim to achieve instream concentrations of 0.075 mg/L TP and 1.5 mg/L TN, in line with the James River TMDL for nutrient impairment (MODNR, 2004a).

Spring River. The Spring River Watershed Management Plan (WMP) outlines Best Management Practice (BMP) goals across its Missouri portion, which spans approximately 1,453,440 acres, over a 20-year period to address various water quality impairments, including sediment, bacteria, nutrients, and heavy metals (MODNR, 2023c). The plan aims to implement BMPs on 13% of pastureland and cropland, equating to treating 6,768 acres annually, totaling 135,460 acres over 20 years (MODNR, 2023c). Additionally, the plan targets the stabilization of 300 feet of streambank each year, for a total of 6,000 feet over the management period. These BMPs focus on reducing runoff, thereby decreasing pollutant and sediment loads transported within the watershed. Example BMPs include prescribed grazing, nutrient management, cover crops, exclusion fencing, and streambank stabilization (MODNR, 2023c). If all BMPs are implemented as planned, the required sediment load reduction of 2,737 tons could be achieved in 11 years, and the phosphorus load reduction of 230,758 pounds could be met within 20 years.

The review of these plans provided insight on setting load reduction goals for nonpoint source watershed management plans. Load reduction goals were set to reduce concentrations of pollutants to below thresholds of impairment based on TMDLs. However, while waterbodies in the TRLW are experiencing the effects of increased nutrients and sediment, nutrient and sediment impairments have not been established within the watershed. Therefore, in the absence of stream water quality criteria for nutrients and sediment, other methods were necessary for setting load reduction goals, including comparison to other WMPs.

Expected Load Reductions

Best management practice (BMP) goals for the TRLW were developed to represent realistic, long term implementation targets while maintaining flexibility for future project planning. Rather than prescribing specific projects or locations, BMP goals reflect partial implementation across key land uses to demonstrate potential watershed scale load reductions. A planning horizon of twenty years was used to align with funding cycles, stakeholder engagement timelines, and expected rates of voluntary BMP adoption. These goals are intended to support prioritization and grant development rather than mandate uniform implementation across the watershed.

Using the STEPL model, BMP implementation was evaluated assuming treatment of: (1) 25% of pastureland areas; (2) 25% of urban land uses; and (3) 2,500 ft of eroding streambanks. Under this planning scenario, pastureland BMP implementation would average approximately 450 acres per year, urban BMP implementation approximately 260 acres per year, and streambank stabilization approximately 125 feet per year over the 20-year planning horizon. This implementation level was selected to represent a meaningful but achievable level of adoption based on land availability, access considerations, and typical participation rates observed in similar watersheds.

To support practical application, modeled load reductions were summarized both as percent reductions at the watershed scale and as planning level reduction yields expressed on a per acre basis. Percent reductions demonstrate how partial BMP implementation could contribute toward overall nutrient and sediment reduction goals, while yield based values provide a scalable tool for estimating load reductions associated with specific project footprints. These yield values allow planners to approximate expected benefits based on actual acres treated, regardless of whether implementation occurs at the modeled 25 percent level. Together, these summaries support both strategic watershed planning and project specific decision making.

BMP goals and modeled reductions presented in this plan are intended to guide implementation planning and should be refined as site specific data become available. Actual load reductions will depend on BMP selection, design, maintenance, and placement, as well as participation by landowners and local partners. As projects are implemented, observed outcomes can be used to update and improve future planning assumptions. This adaptive approach allows the watershed strategy to remain responsive while continuing progress toward water quality goals.

While the BMP goals and modeled load reductions presented in this plan provide a structured framework for watershed scale planning, they do not represent the full suite of actions needed to improve water quality in the Table Rock watershed. Several practices were not directly modeled in STEPL but are expected to provide meaningful additional pollutant and nutrient load reductions. These additional practices, along with other management strategies that support water quality improvement, are described in greater detail in the Management Measures section of this plan. BMPs or management actions that emerge during the implementation period, whether or not explicitly identified in this plan, should also be considered for selection and funding provided they align with the overarching goals of reducing nutrient loads and improving water quality within the watershed.

ELEMENT 3: MANAGEMENT MEASURES AND TARGETED CRITICAL SOURCE AREAS

Identification of Critical Source Areas

Critical source areas (CSAs) are small watershed regions that disproportionately contribute pollutants or runoff, making targeted BMP implementation essential for reducing nonpoint source (NPS) loads (USEPA, 2008). Identifying CSAs within specific HUC-12s allows management efforts to be focused where they will have the greatest impact. This process considers both land use practices and natural susceptibility, since even poorly managed areas on less sensitive land may contribute less than well-managed areas on highly vulnerable soils or slopes (USEPA, 2008). Locating the highest-yielding areas where environmental factors and land use combine to generate the greatest pollutant loads is key for effective BMP implementation. Within this watershed, pastureland, urban areas, and streambanks have been identified as the most significant contributors to nutrient and sediment loading. While forested lands comprise the majority of the watershed, BMP implementation will focus on higher-yielding pastureland and urban areas. However, opportunities to enhance forested lands through restoration or management practices to reduce nutrient pollution should be considered, where feasible, during implementation.

At a land use scale, pastureland consistently contributes the largest portion of TN, TP, and sediment, while urban areas contribute substantially to nitrogen loads. Forested land also contributes notable amounts of sediment and phosphorus due to its extensive coverage. Input from stakeholders throughout the project have identified eroding streambanks as a critical source of NPS pollution within the watershed as well. At the subwatershed scale, Yocum Creek and Owl Creek exhibit the highest yields for all three pollutants, reflecting land use change and intensive agricultural activity, particularly poultry operations, while moderate yields are observed in Viney Creek and Indian Creek, and Cedar Creek. Rock Creek, Big Creek, Cow Creek, and Little Indian Creek have comparatively low yields. Based on these results, priority areas for management include pastureland within the highest-yielding subwatersheds, such as Yocum Creek and Owl Creek; pastureland in moderate-yielding subwatersheds, including Viney Creek and Indian Creek; and urban and forested lands in high-yielding subwatersheds. Focusing management efforts within these areas is expected to provide the greatest reductions in nutrient and sediment loads and improve overall watershed condition.

1) Pasturelands. Modeling results indicate that pastureland areas contributed the highest loads of TN, TP, and sediment across nearly all HUC-12s. The watersheds with the highest percentage of pastureland area (≥28%) were Yocum Creek (83%), Owl Creek (34%), and Viney Creek (28%). The watersheds with the lowest percentage of pastureland (≤5%) were Rock Creek (5%), Cow Creek (5%), and Cedar Creek (4%). Pastureland areas typically produced the highest TN, TP, and sediment yields in each HUC-12 with few exceptions (Table 9). The pastureland areas with the highest nonpoint source yields were in Cricket Creek (#1), Table Rock Dam (#2), and Brush Creek (#3) watersheds, producing a combined estimated annual 33.0 lbs/ac/yr TN, 8.7 lbs/ac/yr TP, and 5.9 t/ac/yr SS. Those three watersheds with the highest pastureland coverage contained between 822 and 2,919 acres of pastureland, making up 6% to 15% of their total area. Pastureland areas typically feature more erodible soils (higher soil k-factor), steeper slopes, and conditions that contribute to higher nonpoint source yields compared to other land uses (Goodnature, 2009).

2) Urban areas. Urban areas were modeled as a significant source of TN, particularly in HUC-12s with even modest levels of urban development (Table 9). The watersheds with the highest percentage of urban area were Table Rock Dam (16%), Cow Creek (13%), and Brush Creek (13%) (Table 15). The watersheds with the lowest percentage of urban area (<5%) were Roaring River (4%), Rock Creek (2%), and Cedar Creek (2%). Urban nonpoint source yields of TN, TP, and sediment were highest in Butler Creek (#1), Cedar Creek (#2), and Rock Creek (#3). These highest yield urban areas produced 29.9 lbs/ac/yr TN, 4.6 lbs/ac/yr TP, and 0.7 t/ac/yr S. The urban yields were highest in the HUC-12 watersheds with lowest percentages of urban areas overall, apart from the Roaring River watershed. New developments, particularly near Table Rock Lake, should be carefully monitored due to the area's vulnerable soil and slope conditions, which increase erosion and nonpoint source pollutant yields. As flatter areas have already been developed, expansion into steeper terrain further heightens the risk of erosion and nonpoint source pollution due to increased runoff velocity, reduced infiltration, and greater soil disturbance during construction (USDA-NRCS, 2007).

3) Streambanks. Actively eroding streambanks represent a potential critical source area for sediment and associated nutrient loading within the watershed. At present, no comprehensive data are available to document the location or extent of streambank erosion within the watershed, and a formal streambank erosion assessment has not yet been completed. However, stakeholder input has consistently identified streambank erosion as a concern throughout the watershed, indicating the need for further evaluation. Identification and stabilization of eroding streambanks should focus on priority locations identified through future assessments, landowner input, and other available information as implementation progresses. Conducting a streambank erosion assessment early in the project period would help quantify erosion severity, identify priority reaches, and support strategic placement of stabilization practices. While assessment efforts are underway, stabilization of streambanks identified through landowner concerns or project opportunities may proceed to address known problem areas and inform longer-term implementation strategies.

At a land use scale, pastureland consistently contributes the largest portion of TN, TP, and sediment, while urban areas contribute substantially to nitrogen loads. Forested land also contributes notable amounts of sediment and phosphorus due to its extensive coverage. At the subwatershed scale, Yocum Creek and Owl Creek exhibit the highest yields for all three pollutants, reflecting land use change and intensive agricultural activity, particularly poultry operations, while moderate yields are observed in Viney Creek and Indian Creek, and Cedar Creek. Rock Creek, Big Creek, Cow Creek, and Little Indian Creek have comparatively low yields. Based on these results, priority areas for management include pastureland within the highest-yielding subwatersheds, such as Yocum Creek and Owl Creek; pastureland in moderate-yielding subwatersheds, including Viney Creek and Indian Creek; and urban and forested lands in high-yielding subwatersheds. Focusing management efforts in these areas is expected to provide the greatest reductions in nutrient and sediment loads and improve overall watershed condition.

Priority Riparian Management Zone

To further refine BMP targeting within identified critical source areas, a Priority Riparian Management Zone was established, consisting of a 150-foot buffer surrounding streams throughout the watershed. This zone represents areas where pollutant delivery risk is highest due to the close proximity of land uses to surface waters and where implementation of BMPs is expected to provide the greatest water quality benefits per acre treated. The Priority Riparian Management Zone is not considered a separate land use or critical source area, rather, it serves as a spatial prioritization tool to guide BMP placement across pastureland, urban areas, and stream corridors. BMPs implemented within this zone are intended to contribute toward the overall pastureland and urban land implementation targets identified in this plan and will be prioritized during implementation due to their enhanced effectiveness in reducing nutrient and sediment transport, stabilizing streambanks, and protecting aquatic habitat. In practice, buffer implementation may include a mix of grassed and forested riparian vegetation depending on site conditions, landowner preferences, and program incentives.

Onsite Wastewater Treatment Systems

Failing onsite wastewater treatment systems (OWTS) contribute significantly to nutrient and pathogen loading within the watershed. Limited data on system numbers, age, and failure rates, combined with the karst topography of the area, highlight the importance of including OWTS management as a priority within the watershed management plan (WMP).Priority areas for OWTS management are informed by the OWTS Pollution Susceptibility Ranking described earlier, which identifies catchments with higher septic system density and soils with elevated potential for pollutant transport. Management goals include developing a comprehensive inventory of OWTS within the watershed, capturing system type, approximate age, functional status, and proximity to streams and groundwater where possible. Targeted *E. coli* monitoring in priority areas will help identify sites most in need of remediation, repair, or replacement, while microbial source tracking (MST) will confirm human fecal sources of contamination and associated nutrient contributions, ensuring remediation efforts focus on the most impactful sources. Systems identified as needing repair, replacement, or upgrades will be prioritized for improvement. Where funding allows, implementation of these actions will reduce pathogen and nutrient loading throughout the watershed. In locations where conventional OWTS are not feasible (such as areas with unsuitable soils, shallow bedrock, high groundwater tables, or documented water quality impacts), advanced or alternative treatment systems should be promoted and implemented to protect water quality.

OWTS Pollution Susceptibility Ranking. To support targeted OWTS management and prioritize implementation of best management practices (BMPs) within the watershed, a susceptibility analysis was conducted to identify catchments within each HUC-12 that are most at risk for potential OWTS-related pollution. This analysis helps focus resources and management actions on priority areas, including subwatersheds and smaller catchments, where septic system density, soil conditions, and hydrogeology suggest a higher likelihood of pollutant loading to surface water and groundwater. Two datasets were overlaid and ranked to assign susceptibility scores for each catchment. The primary dataset was the USGS Estimated Densities of Residential Septic Tanks across the Conterminous United States for HUC-12, NHDV2 Catchment, and Block Group Scales (USGS, 2025). This dataset models the number of septic systems per square kilometer, which was converted to systems per square mile before classification. Septic density within the TRLW was classified as Low (15 or fewer systems per square mile), Medium (15 to 75), or High (more than 75), and assigned scores of 1, 2, and 3 respectively (Figure 19). Higher septic density corresponds to greater susceptibility, as more systems increase the potential for pollutant loading.

Next, the USDA Gridded Soil Survey Hydrologic Soil Group data (USDA-NRCS, 2019) were used to rank soils based on their potential to transmit pollutants (Figure 2). Group D soils have very slow infiltration, high runoff potential, or shallow restrictive layers, and therefore received the highest susceptibility score (Table 2). Group A soils have very rapid infiltration, which increases the risk of groundwater contamination, and were assigned a high ranking. Group C soils have slower infiltration and were assigned a moderate ranking. Group B soils have moderate infiltration and were assigned the lowest susceptibility ranking. Composite groups were scored between these values. Final soil scores ranged from 1 to 6, with higher values indicating greater susceptibility. The septic density scores and soil group scores were overlaid in ArcGIS Pro and combined for each catchment. Total susceptibility scores ranged from 2 to 9. Scores of 3 or less indicate Low susceptibility, scores greater than 3 up to 4 indicate Moderate susceptibility, and

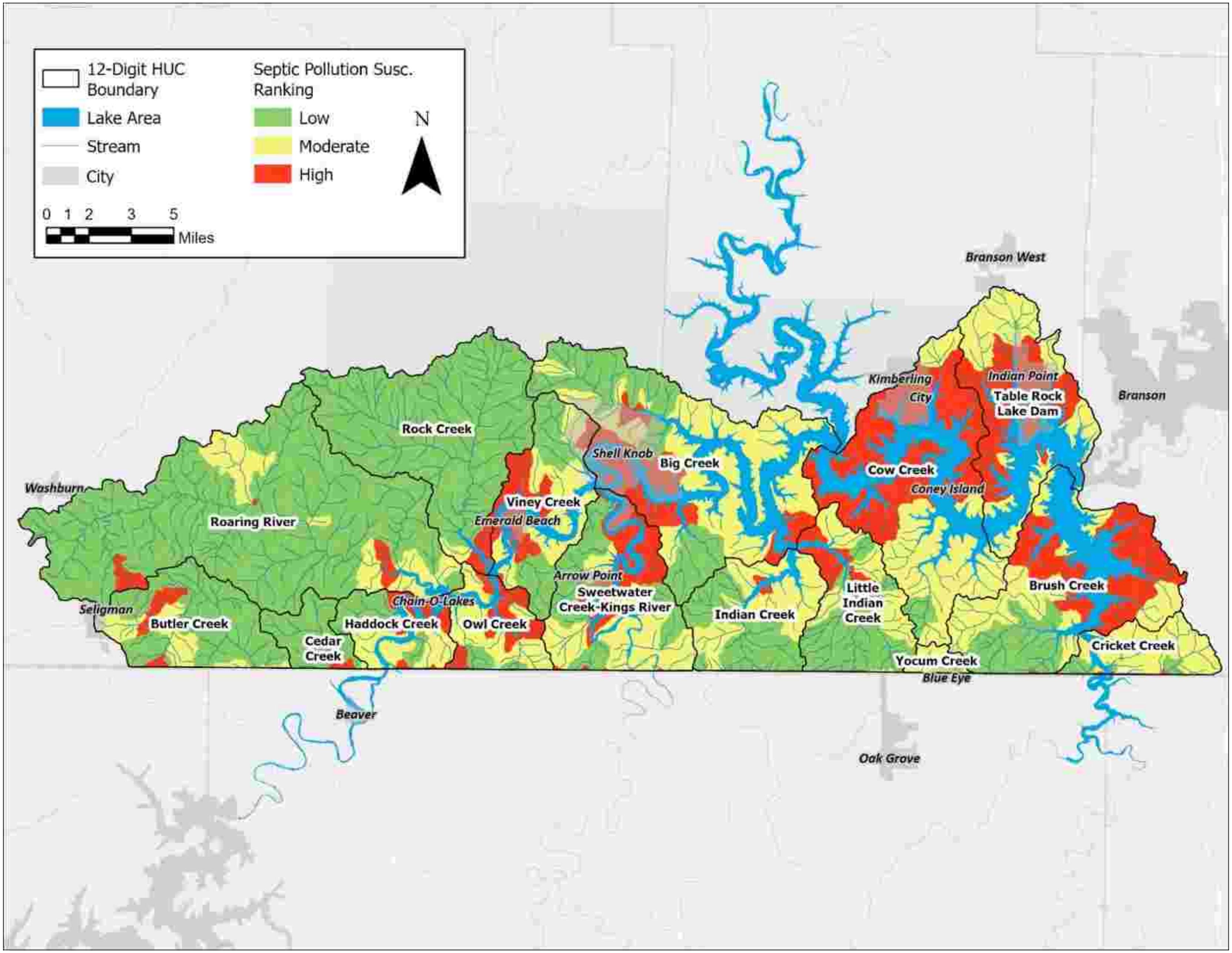

Figure 19. Map of OWTS Pollution Susceptibility Ranking based on hydrologic soil group and septic system densities by catchment for the Table Rock Lake Watershed.

scores greater than 4 to 9 indicate High susceptibility to potential OWTS system pollution (Figure 3).

Forested Land

Within the watershed, pastureland, urban areas, and streambanks have been identified as the most significant contributors to nutrient and sediment loading based on modeled pollutant yields and delivery risk. Forested lands comprise the majority of the watershed area and contribute background levels of nutrients and sediment. However, modeling indicates that even under an all-forested land use scenario, nutrient loads would still exceed eutrophic threshold targets. As a result, forest cover alone is insufficient to achieve water quality goals, and BMP implementation will prioritize higher-yielding pastureland and urban areas. Nevertheless, forest management and restoration practices remain important for long-term watershed resilience and water quality protection and will be considered during implementation where feasible and aligned with stakeholder priorities, such as stabilization of forest roads, forest management planning, establishment of native species, reduction of nonnative species, etc.

Best Management Practices

Best Management Practices (BMPs) refer to practices that help prevent or reduce pollutants from entering waterways and causing impairments to water quality. There are numerous BMPs available for implementation in pastureland, urban, and forested areas, as well as eroding streambanks. Several pastureland and urban land BMPs were identified and modeled within STEPL to examine potential load reductions for the watershed. The BMPs included in the STEPL models to reduce nonpoint source pollutant loads are described below. The default STEPL BMP efficiencies were used for all BMPs (Table 13). The BMPs presented below represent an implementation strategy designed to achieve meaningful nutrient and sediment reductions over the 20-year planning horizon. These practices are intended to serve as a guide for prioritization and modeling purposes and are not meant to preclude the implementation of other BMPs that provide equivalent or greater pollutant reduction benefits. Any BMPs or management measures identified during the implementation period but not explicitly addressed in this plan should be considered for implementation and funding if they are consistent with the water quality goals outlined in this plan. Some BMPs, such as stormwater pretreatment or sediment capture devices, are not directly dependent on acreage treated, and the per-acre load reductions are presented for planning and comparison purposes only, with actual reductions depending on site-specific design and drainage area. Additionally, some BMPs are not dependent on land use, and are appropriate for use on pastureland, urban, or forested areas, depending on site-conditions and available funding.

Table 12. STEPL reported efficiencies for BMPs on Pasture and Urban land.

Land Use	BMP	STEPL Efficiency		
		Nitrogen	Phosphorus	Sediment
Pastureland	Access Control [Livestock Exclusion Fencing]	0.203	0.304	0.620
	Alternative Water	0.133	0.115	0.187
	Prescribed Grazing	0.408	0.227	0.333
	Forage and Biomass Planting	0.181	0.150	ND
	Use Exclusion	0.390	0.040	0.589
	Grass Buffer	0.868	0.766	0.648
	Streambank Stabilization and Fencing	0.750	0.750	0.750
	Heavy Use Protection	0.183	0.193	0.333
Urban	Vegetated Filter Strip	0.400	0.453	0.730
	LID/Filter/Buffer Strip	0.300	0.300	0.600
	Wetland Detention	0.200	0.440	0.775
	Grass Swales	0.100	0.250	0.650
	Bioretention Facility	0.630	0.800	ND
	Extended Wet Detention	0.550	0.685	0.860
	Dry Detention	0.300	0.260	0.575
	Porous Pavement	0.850	0.650	0.900

Pastureland Best Management Practices

Pastureland pollutant loads are largely attributed to livestock-related waste and nutrient inputs from fertilizers and pesticides applied for forage management (USEPA, 2003). Therefore, agricultural BMPs aim to address these primary sources. Agricultural BMPs were modeled in STEPL as individual BMPs, though many BMPs are interdependent and function best when paired. For example, restricting livestock access to natural water sources through fencing often necessitates an alternative watering system, which may concentrate animal activity in a new location, therefore, requiring additional protection measures, such as a heavy use area treatment, to prevent localized soil degradation and nutrient runoff. Reducing the nutrient load within the TRLW will be more effective when BMPs are implemented together. The combined efficiency of multiple BMPs can be calculated within the BMP calculator of the STEPL model to determine load reductions from combined practices (Tetra Tech, 2018). Estimated load reductions assuming 25% pastureland treatment are reported in Table 13 and Table 14. Table 15 and Table 16 present estimated load reduction yields by HUC12 and BMP type, which can be multiplied by the total acres of BMPs implemented to estimate realistic nutrient and sediment load reductions and to support scenario based planning for BMP prioritization and implementation.

STEPL Pastureland Modeled BMPs

The following BMPs were explicitly modeled in STEPL, as they are incorporated within the model framework and include published pollutant removal efficiencies suitable for quantifying anticipated nutrient and sediment load reductions:

Access Control. Access control limits animals (livestock and wildlife) from entering waterways using fences or other means to prevent bank erosion and sediment from entering waterways and protecting aquatic habitats. Access control costs include materials, site preparation, installation, and maintenance. Costs associated with access control are low to moderate depending on fencing material (barbed wire, field fence, etc.) and the fenced length. Natural barriers (fallen trees/branches or dense thorny hedges) can also be used to prevent animal access to streams. However, these barriers may not be as effective and may require more upkeep/maintenance (Rawluk et al., 2014). Access control is typically used in combination with alternative water practices since animal access to a water source is limited.

Alternative Water. The alternative water source practice, also known as off-stream watering, supplies livestock with access to water away from streams, thereby reducing trampling, preventing streambank erosion, and minimizing sediment and nutrient inputs to nearby waterways. The effectiveness of preventing livestock from using a natural water source and using an alternative water source has been found to be largely influenced by the distance to the alternative water source and the presence of barriers to the natural source (Rawluk et al., 2014). Thus, access control and alternative water BMPs are commonly used together. Costs for alternative water practices include site preparation, installation, materials, and maintenance.

Forage and Biomass Planting. The planting of native or introduced plant species prevents nutrient transport and surface runoff from storm events. While effective for nitrogen and phosphorus reduction, this BMP does not directly reduce sediment loads. Plant species should be selected based on site-specific soil characteristics, as well as resistance to disease, pests, and environmental stressors. Heavily trafficked areas may require more durable species or reinforced planting methods. Costs for forage and biomass planting are relatively low and typically include site preparation, seed or plant material, and fertilizer.

Grass Buffer. Grass buffers consist of permanently vegetated strips of grasses established adjacent to streams, drainageways, or other sensitive areas to intercept runoff before it reaches surface waters. These buffers slow runoff velocity, promote infiltration, and trap sediment while also filtering nutrients bound to soil particles or dissolved in runoff. Grass buffers were modeled with a minimum width of 35 feet in STEPL.

Heavy Use Protection. Heavy use protection requires planting vegetation and/or the installation of erosion prevention materials to protect heavily trafficked areas (e.g., water/feeding troughs, hay rings). Heavy use protection reduces soil erosion and sediment/nutrient transport to waterways.

Costs for heavy use areas include site prep, installation, materials, and maintenance including the replacement of vegetation and/or other protective material covers over time.

Prescribed Grazing. The prescribed grazing practice uses grazing/browsing animals to harvest controlled amounts of vegetation. The STEPL BMP description for prescribed grazing states that on forest, pasture, or rangeland, grazing is limited to 50% of the annual growth of grazing species (Tetra Tech, 2018).

Use Exclusion. Use exclusion involves permanently or seasonally excluding livestock from sensitive areas such as riparian corridors, steep slopes, or highly erodible soils to prevent direct nutrient deposition, soil disturbance, and sediment delivery to waterways. Use exclusion practices are expected to be concentrated in areas with repeated livestock–stream interaction rather than uniformly distributed across pastureland.

Streambank and Shoreline Protection. Streambank and shoreline protection combines physical bank stabilization measures with livestock exclusion to reduce channel erosion, sediment loading, and nutrient transport, while protecting restored streambanks from future disturbance.

Additional Pastureland BMPs

In addition to the pastureland BMPs modeled in STEPL, several other conservation practices may provide meaningful water quality and watershed function benefits but were not explicitly assigned pollutant reduction efficiencies within the STEPL framework. These practices address site specific conditions, management objectives, and stakeholder priorities and may reduce nutrient and sediment delivery through mechanisms that are difficult to quantify at the watershed scale. The absence of modeled efficiencies does not imply reduced effectiveness. Many of these practices are well established conservation measures supported through state and federal programs and may be implemented alongside modeled BMPs to achieve broader watershed benefits. These practices should be considered for implementation and funding when appropriate and when consistent with the water quality goals of this plan.

Nutrient Management Plans. Developing nutrient management plans for fields where plant nutrients and soil amendments are applied, accounting for all sources of N and P, and using them in a manner that reduces nutrient loss to surface and groundwater. Not only does this reduce the risk of pollution to groundwater, but offers improved nutrient use efficiency and more efficient costs based on application under management plans. Although not explicitly represented in STEPL, nutrient management planning is expected to accompany grazing management and forage planting practices, further reducing nutrient inputs beyond modeled reductions.

Sustainable Ag Programs. Using programs, like UnderstandingAg, LLC., to educate and promote the use of sustainable, low-input ag practices that can increase profitability while utilizing regenerative agriculture practices to subsequently preserve water quality. In the past, workshops conducted by Understanding Ag LLC were partially funded by the USEPA Region 7 through the MODNR Clean Water Act Section 319 funding, with free admission and lunch to attendees (MODNR Communications Office, 2024). Stakeholders expressed that these are widely popular workshops, oftentimes filling up and that farmers in the area would benefit from additional opportunities to attend these workshops.

Urban Best Management Practices

Pollutants from urban areas enter waterways primarily through storm events that generate runoff. Oil, grease, heavy metals, and chemicals from vehicles and other urban sources are transported by runoff into streams, contributing to nutrient loading, water quality impairments, and nutrient-related effects such as algal blooms and eutrophication. Therefore, urban BMPs focus on stormwater detention, retention, and filtration to reduce pollutant delivery to streams. Urban BMPs were selected to represent a range of structural and nature-based stormwater practices applicable to both new development and retrofit opportunities. Modeled efficiencies were used to estimate planning-level load reductions rather than site-specific designs. As with pastureland BMPs, multiple complementary BMPs may be applied in combination to achieve higher overall nutrient and sediment reductions within a project area.

STEPL Modeled Urban BMPs.

The following BMPs were explicitly modeled in STEPL, as they are incorporated within the model framework and include published pollutant removal efficiencies suitable for quantifying anticipated nutrient and sediment load reductions. These efficiencies reflect planning-level reductions, with site-specific performance varying by basin design, soil type, and maintenance:

Extended Wet Detention. An extended wet detention basin is designed to retain stormwater over an extended period past the duration of the storm event so that there is typically a permanent pool of water in the basin. The basin is vegetated and releases water slowly into downstream waterways. The vegetation and slow release of water provides a filter for peak flows, sedimentation area for pollutants, and reduced erosion downstream due to the retention of stormwater (Tetra Tech, 2018).

Dry Detention. A dry detention basin retains stormwater for a brief period of time during and after a storm event. Dry detention basins regulate peak flows and erosion in downstream waterways (Tetra Tech, 2018).

Porous Pavement. Porous pavement is the use of porous media as an alternative to asphalt or other nonporous materials. These materials allow stormwater to infiltrate through the pavement structure and into the underlying soil, reducing surface runoff and associated pollutant transport (Tetra Tech, 2018). Stakeholders recommended implementing porous pavement primarily in lower-traffic areas, such as walking trails, urban parks, or eroding dirt paths, similar to the Eiserman Park demonstration project included in the Lake Taneycomo WMP (Hess et al., 2024). Previous installations in high-traffic areas, such as the Kimberling City Center parking lot, have experienced issues with settling and maintenance challenges. Project planning should include routine maintenance considerations to ensure long-term functionality and water quality benefits.

LID/Filter/Buffer Strip. Low Impact Development (LID) practices, including vegetated filter strips and bioretention areas, capture and treat runoff close to its source. These practices reduce flow velocity, promote infiltration, and filter nutrients and sediment before they reach downstream waterways (Tetra Tech, 2018).

Wetland Detention. Wetland detention areas store stormwater in constructed or restored wetlands, allowing sedimentation and nutrient uptake by vegetation and microbial processes. These systems reduce peak flows, stabilize downstream channels, and improve water quality through natural filtration (Tetra Tech, 2018).

Grass Swales. Grass swales are shallow, vegetated channels that convey stormwater while slowing flow and allowing infiltration. They reduce sediment transport, filter nutrients, and moderate peak flows (Tetra Tech, 2018). Swales are particularly effective along roadways, parking lots, and open areas where concentrated runoff occurs.

Additional Urban BMPs

In addition to the pastureland BMPs modeled in STEPL, several other conservation practices may provide meaningful water quality and watershed function benefits but were not explicitly assigned pollutant reduction efficiencies within the STEPL framework. These practices address site specific conditions, management objectives, and stakeholder priorities and may reduce nutrient and sediment delivery through mechanisms that are difficult to quantify at the watershed scale. The absence of modeled efficiencies does not imply reduced effectiveness. Many of these practices are well established conservation measures supported through state and federal programs and may be implemented alongside modeled BMPs to achieve broader watershed benefits. These practices should be considered for implementation and funding when appropriate and when consistent with the water quality goals of this plan.

Pollution Prevention Plans. Pollution prevention plans are educational and operational tools that identify routine activities that generate runoff pollutants (such as vehicle fluids, lawn chemicals, trash, and sediment) and specify actions to reduce those sources. Common elements include signage at storm drains and public access points, targeted outreach materials, business and resident workshops, and distribution of best practice guidance. By shifting behaviors/practices and increasing awareness of urban runoff pathways, pollution prevention plans help reduce nutrient, sediment, and chemical loads entering stormwater systems alongside structural BMPs.

Native Plant and Lawn Nutrient Educational Workshops. Native plant and lawn nutrient educational workshops provide information to residents, developers, and municipal staff on the water quality benefits of native vegetation, reduced turf coverage, and appropriate fertilizer use. These workshops promote practices such as replacing turf with native species, minimizing nutrient inputs, and improving soil health, which can reduce nutrient runoff and improve stormwater infiltration in urban areas.

Composition of Model Ordinance Guide. A model ordinance guide provides local governments with example language and technical considerations for ordinances that support improved stormwater management and water quality protection. Topics may include development and/or landscaping standards, fertilizer use restrictions, native vegetation requirements, and stormwater design criteria. Adoption or adaptation of model ordinances can help integrate water quality protection into local land use and development regulations.

Detention Basin Inventory and Retrofit Screening. A county-level inventory of existing detention and retention basins can be used to identify facilities with potential for water quality retrofits, particularly in areas where existing basins can be enhanced with native vegetation and redesigned to prioritize nutrient and sediment reduction. This process evaluates basin location, drainage area, design characteristics, and feasibility for improvements such as extended detention, native plant establishment, and sediment forebays. Identifying retrofit opportunities allows communities to prioritize cost-effective upgrades that improve the water quality function of existing stormwater infrastructure.

Urban Nutrient Management / Yard Programs. Urban nutrient management programs provide outreach and planning resources for homeowners and commercial property managers to reduce fertilizer, pesticide, and other nutrient applications. Additional related programs encouraging responsible yard care practices, such as composting, rainwater management, and native plantings, similar to Springfield, MO’s Yard Ethic initiative can be adapted for local communities to reduce nonpoint source pollution from urban landscapes, including lawn soil testing, nutrient management planning, rainwater harvesting rebates, etc.

Curbless Rain Gardens. Curbless rain gardens allow stormwater to sheet flow from impervious surfaces directly into vegetated depressions where infiltration and filtration occur. They reduce concentrated runoff, trap sediments, and capture nutrients from parking lots or other paved areas. Implementation is especially feasible in urban parks, walking paths, or redeveloped sites where curb infrastructure can be modified or does not exist, rather than high-traffic roadways.

Forest Best Management Practices

Although forested areas generally contribute lower nutrient yields compared to urban or agricultural lands, sediment from eroded soils can transport bound phosphorus and other pollutants into streams. While BMP implementation goals outlined in this plan prioritize higher-yielding pastureland and urban areas, forest management and restoration practices (e.g. native tree/shrub site preparation and establishment, forest trails and landings, and forest management plans) remain important for long-term watershed resilience and water quality protection and will be considered during implementation where feasible and aligned with stakeholder priorities. For this watershed, the prevalence of steep slopes can limit the effectiveness of some BMPs, necessitating careful site-specific management strategies to maximize erosion control and water quality benefits.

Additional BMPs

Floating Wetlands. The establishment of floating wetlands on or near to private docks, in coordination with the US Army Corps of Engineers to ensure permitted, could offer additional nutrient reductions from the lake waterbody. Floating wetlands have been installed by MDC and its partners at Fellows Lake, McDaniel Lake, Valley Water Mill Lake, several ponds at Dickerson Park Zoo, and Doling Park in the city of Springfield, MO, with individual islands ranging from 42 to 96 square feet and constructed using various buoyant materials that allow plants to adjust to seasonal water level fluctuations (MDC, 2025. These floating wetlands are planted with native species and are designed to improve water quality and enhance aquatic habitat across a range of waterbodies.

Onsite Wastewater Treatment Systems. Onsite wastewater treatment system management goals should emphasize routine pump-outs and inspections to extend system life and reduce failure risk, as well as targeted remediation or full replacement of systems that no longer meet performance standards. In areas where site conditions limit the effectiveness of conventional systems, the use of advanced or alternative wastewater treatment technologies should be encouraged to improve treatment efficiency and protect water quality. Focusing management efforts on maintenance, upgrades, and appropriate technology selection provides a practical pathway to reduce nonpoint source pollution while supporting long-term wastewater reliability in sensitive watershed settings.

ELEMENT 4: TECHNICAL AND FINANCIAL ASSISTANCE

Best Management Practice costs were gathered from several sources, including, the United States Department of Agriculture's (USDA) Natural Resource Conservation Service (NRCS) payment schedules (USDA-NRCS, 2023), an EPA Cost Analysis Report (USEPA, 2015), and stormwater estimates derived from the Lake Taneycomo WMP (Hess et al., 2024). The USDA

NRCS payment schedules are re-evaluated annually for the cost of material and labor for BMPs on agricultural areas and therefore, included values reflect BMP costs in FY2024-dollar amounts (NRCS, 2023). However, any BMPs or management measures identified during the project period that are not explicitly addressed in this plan should remain within consideration for implementation and funding if they are consistent with the reduction of nutrient loads as outlined in this plan.

The NRCS payment schedules provide detailed descriptions of BMPs and different scenarios for the same BMPs. As potential sites for BMPs can vary greatly even when implementing the same practice, the BMP cost was averaged over several of the NRCS scenarios. The NRCS practice and scenario number and their associated costs for several of the pastureland and streambank management practices are summarized in Table 18. In most instances, BMP cost could be easily applied by unit treated (ex: streambank stabilization cost per linear foot). However, the alternative water practice required a few BMPs to estimate cost– water well (depth in feet), pumping plant (each pump), watering facility (each tank), and livestock pipeline (sq. ft.). The typical cost for alternative water BMPs was estimated by averaging costs across modeled scenarios, including water wells and livestock pipelines. Each system was assumed to serve 30 animal units (AUs). To treat 25 percent of the estimated 28,394 AUs within the TRLW (355 AUs per year), approximately 12 alternative water systems would be installed annually. The total annual cost was calculated by multiplying the average cost per system by the number of systems installed per year. Heavy use protection area costs were estimated using the typical size reported by NRCS for that practice (3,900 sq. ft) converted to cost per acre, with the goal for Heavy Use Protection being 1 total acre implemented annually.

Planning level cost estimates for urban detention and retention basin retrofits in the Table Rock Lake Watershed were informed by the Lake Taneycomo Watershed Management Plan, which developed basin excavation costs using recent construction data from the City of Springfield, Missouri (Hess et al., 2024). That analysis estimated basin excavation costs on a per acre drained basis and provides a reasonable planning level reference for similar urban stormwater practices in the absence of site-specific design information. Applying a comparable approach in the TRLW allows urban detention and retention retrofits to be considered alongside other BMPs when evaluating long term implementation strategies. The cost estimates for the BMPs are shown in Table 19. Total costs estimate for the selected BMPs for treating 25% of urban areas and pastureland (including alternative water establishment for 12 systems / 355 animal units per year) and 2,500 ft of eroding streambanks in the TRLW are shown in Table 20.

Table 13. STEPL estimated nitrogen load reduction percentages based on 25% treatment goals for pasture and urban land.

Nitrogen % Reduction (based on 25% treatment)																
Pastureland										**Urban**						
HUC-12	***Acres Treated***	**Alternative Water**	**Critical Area Planting**	**Heavy Use Protection**	**Prescribed Grazing**	**Forage and Biomass Planting**	**Access Control / Livestock Exclusion Fencing**	**Use Exclusion**	**Streambank Stabilization & Fencing**	**Acres Treated**	**Vegetated Filter Strip**	**Dry Detention**	**Extended Wet Detention**	**LID/Filter/Buffer Strip**	**Porous Pavement**	**Bioretention Facility**
Big Creek	*779*	1.5	2.5	2.3	3.6	1.1	3.4	4.4	1.4	730	4.3	3.3	4.5	3.3	9.2	6.8
Brush Creek	*730*	1.8	3.4	2.9	4.1	0.9	4.7	5.5	1.7	690	4.0	3.0	4.1	3.0	8.4	6.2
Butler Creek	*264*	1.2	2.1	1.9	3.0	0.9	2.8	3.6	1.2	137	2.0	1.5	2.1	1.5	4.3	3.2
Cedar Creek	*34*	0.6	1.1	1.0	1.7	0.5	1.4	1.9	0.6	13	0.9	0.7	0.9	0.7	1.9	1.4
Cow Creek	*341*	0.9	1.6	1.4	2.0	0.5	2.2	2.7	0.8	851	5.7	4.3	5.9	4.3	12.1	9.0
Cricket Creek	*206*	2.2	4.4	3.7	4.8	0.9	6.3	6.9	2.0	114	2.2	1.7	2.3	1.7	4.7	3.5
Haddock Creek	*325*	2.2	4.1	3.6	5.3	1.4	5.5	6.8	2.1	126	2.4	1.8	2.5	1.8	5.1	3.8
Indian Creek	*678*	2.5	4.4	3.9	6.2	1.8	5.9	7.6	2.4	194	2.3	1.7	2.4	1.7	4.9	3.6
Little Indian Creek	*226*	1.4	2.6	2.3	3.4	0.9	3.5	4.3	1.4	182	3.2	2.4	3.3	2.4	6.8	5.0
Owl Creek	*544*	2.9	5.5	4.7	6.7	1.6	7.6	9.0	2.7	142	1.8	1.4	1.9	1.4	3.9	2.9
Roaring River	*2,243*	2.0	3.5	3.1	5.1	1.5	4.7	6.1	2.0	485	1.4	1.1	1.5	1.1	3.0	2.2
Rock Creek	*309*	1.0	1.7	1.6	2.4	0.7	2.3	3.0	1.0	121	1.2	0.9	1.3	0.9	2.6	1.9
Sweetwater Creek	*1,017*	2.4	4.2	3.7	5.9	1.7	5.7	7.2	2.3	345	2.5	1.9	2.6	1.9	5.3	3.9
Table Rock Lake Dam	*262*	1.0	1.9	1.6	2.3	0.5	2.7	3.1	0.9	675	5.7	4.3	5.9	4.3	12.1	9.0
Viney Creek	*826*	2.2	3.7	3.4	5.5	1.7	5.0	6.6	2.2	320	2.9	2.2	3.0	2.2	6.2	4.6
Yocum Creek	*221*	3.3	5.7	5.1	8.1	2.4	7.6	9.9	3.2	29	1.4	1.1	1.5	1.1	3.0	2.2
TRLW TOTAL	***9,007***	**1.8**	**3.2**	**2.8**	**4.3**	**1.2**	**4.3**	**5.4**	**1.7**	**5,153**	**3.0**	**2.3**	**3.2**	**2.3**	**6.5**	**4.8**

Table 14. STEPL estimated phosphorus load reduction percentages based on 25% treatment goals for pasture and urban land.

Phosphorus % Reduction (based on 25% treatment)																	
	Pastureland									Urban							
HUC-12	***Acres Treated***	**Alternative Water**	**Critical Area Planting**	**Heavy Use Protection**	**Prescribed Grazing**	**Forage and Biomass Planting**	**Access Control / Livestock Exclusion Fencing**	**Use Exclusion**	**Streambank Stabilization & Fencing**	***Acres Treated***	**Vegetated Filter Strip**	**Dry Detention**	**Extended Wet Detention**	**LID/Filter/Buffer Strip**	**Porous Pavement**	**Bioretention Facility**	
Big Creek	*779*	1.6	3.5	2.9	3.0	0.4	5.2	4.2	1.5	*730*	3.7	2.1	2.8	2.5	5.4	6.6	
Brush Creek	*730*	2.2	4.7	3.8	3.9	0.3	7.0	6.1	1.9	*690*	3.1	1.8	2.3	2.0	4.4	5.4	
Butler Creek	*264*	1.0	2.2	1.8	1.8	0.3	3.2	2.6	0.9	*137*	1.4	0.8	1.0	0.9	1.9	2.4	
Cedar Creek	*34*	0.4	0.9	0.8	0.8	0.2	1.4	1.1	0.4	*13*	0.5	0.3	0.4	0.3	0.7	0.9	
Cow Creek	*341*	1.1	2.3	1.9	1.9	0.2	3.5	2.9	0.9	*851*	4.8	2.8	3.6	3.2	6.9	8.5	
Cricket Creek	*206*	2.5	5.5	4.4	4.5	0.3	8.2	7.3	2.1	*114*	1.4	0.8	1.1	1.0	2.1	2.5	
Haddock Creek	*325*	2.4	5.2	4.2	4.3	0.5	7.7	6.4	2.1	*126*	1.8	1.0	1.4	1.2	2.6	3.2	
Indian Creek	*678*	2.7	5.8	4.8	5.0	0.7	8.7	7.0	2.5	*194*	2.0	1.1	1.5	1.3	2.8	3.5	
Little Indian Creek	*226*	1.5	3.3	2.7	2.7	0.3	4.8	4.0	1.3	*182*	2.4	1.4	1.8	1.6	3.4	4.2	
Owl Creek	*544*	3.3	7.2	5.8	5.9	0.6	10.6	9.1	2.9	*142*	1.3	0.8	1.0	0.9	1.9	2.4	
Roaring River	*2,243*	1.8	3.9	3.2	3.3	0.5	5.8	4.6	1.7	*485*	1.0	0.6	0.8	0.7	1.5	1.8	
Rock Creek	*309*	0.8	1.7	1.4	1.5	0.2	2.6	2.1	0.7	*121*	0.8	0.4	0.6	0.5	1.1	1.3	
Sweetwater Creek	*1,017*	2.6	5.6	4.6	4.7	0.7	8.2	6.7	2.3	*345*	2.1	1.2	1.5	1.4	3.0	3.6	
Table Rock Lake Dam	*262*	1.3	2.9	2.3	2.4	0.2	4.3	3.7	1.1	*675*	4.7	2.7	3.5	3.1	6.7	8.3	
Viney Creek	*826*	2.3	4.9	4.1	4.2	0.7	7.3	5.8	2.1	*320*	2.6	1.5	1.9	1.7	3.7	4.5	
Yocum Creek	*221*	3.6	7.8	6.4	6.6	1.0	11.5	9.3	3.3	*29*	1.2	0.7	0.9	0.8	1.8	2.2	
TRLW TOTAL	***9,007***	**1.9**	**4.0**	**3.3**	**3.4**	**0.4**	**6.0**	**4.9**	**1.7**	***5,153***	**2.3**	**1.3**	**1.7**	**1.5**	**3.4**	**4.1**	

Table 15. Planning Level Nitrogen Load Reduction Yields by HUC12 and BMP Type (lb per acre per year).

Planning-Level Nitrogen Reduction Yields (lb/ac/yr)														
	Pasture								Urban					
HUC-12	Alternative Water	Critical Area Planting	Heavy Use Protection	Prescribed Grazing	Forage and Biomass Planting	Access Control / Livestock Exclusion Fencing	Use Exclusion	Streambank Stabilization & Fencing	Vegetated Filter Strip	Dry Detention	Extended Wet Detention	LID/Filter/Buffer Strip	Porous Pavement	Bioretention Facility
Big Creek	0.3	0.5	0.5	0.7	0.2	0.7	0.9	0.3	1.0	0.7	1.3	0.7	2.0	1.5
Brush Creek	0.4	0.8	0.7	0.9	0.2	1.1	1.3	0.4	1.0	0.7	1.3	0.7	2.0	1.5
Butler Creek	0.3	0.5	0.5	0.8	0.2	0.7	1.0	0.3	1.0	0.8	1.4	0.8	2.2	1.6
Cedar Creek	0.3	0.5	0.4	0.7	0.2	0.6	0.8	0.3	1.0	0.7	1.4	0.7	2.1	1.6
Cow Creek	0.3	0.6	0.6	0.8	0.2	0.9	1.1	0.3	0.9	0.7	1.3	0.7	2.0	1.4
Cricket Creek	0.5	1.0	0.9	1.1	0.2	1.4	1.6	0.5	0.9	0.7	1.3	0.7	1.9	1.4
Haddock Creek	0.3	0.6	0.5	0.8	0.2	0.9	1.0	0.3	1.0	0.7	1.3	0.7	2.0	1.5
Indian Creek	0.3	0.5	0.4	0.7	0.2	0.7	0.9	0.3	0.9	0.7	1.3	0.7	2.0	1.4
Little Indian Creek	0.3	0.6	0.5	0.8	0.2	0.8	1.0	0.3	0.9	0.7	1.3	0.7	2.0	1.5
Owl Creek	0.4	0.7	0.6	0.9	0.2	1.0	1.2	0.4	0.9	0.7	1.3	0.7	2.0	1.5
Roaring River	0.2	0.4	0.4	0.6	0.2	0.5	0.7	0.2	0.8	0.6	1.0	0.6	1.6	1.2
Rock Creek	0.3	0.5	0.5	0.8	0.2	0.7	0.9	0.3	1.0	0.7	1.3	0.7	2.1	1.5
Sweetwater Creek	0.3	0.5	0.5	0.8	0.2	0.7	0.9	0.3	1.0	0.7	1.3	0.7	2.0	1.5
Table Rock Lake Dam	0.4	0.8	0.7	1.0	0.2	1.1	1.3	0.4	0.9	0.7	1.3	0.7	2.0	1.5
Viney Creek	0.3	0.5	0.4	0.7	0.2	0.6	0.8	0.3	0.9	0.7	1.3	0.7	2.0	1.5
Yocum Creek	0.3	0.5	0.4	0.7	0.2	0.7	0.9	0.3	0.9	0.7	1.3	0.7	2.0	1.5

**The table presents estimated load reduction yields by HUC12 and BMP type, which can be multiplied by the total acres of BMPs implemented during the project period to estimate realistic nutrient and sediment load reductions and to support scenario-based planning for BMP prioritization and implementation.*

Table 16. Planning Level Phosphorus Load Reduction Yields by HUC12 and BMP Type (lb per acre per year).

Planning-Level Phosphorus Reduction Yields (lb/ac/yr)														
	Pasture								Urban					
HUC-12	**Alternative Water**	**Critical Area Planting**	**Heavy Use Protection**	**Prescribed Grazing**	**Forage and Biomass Planting**	**Access Control / Livestock Exclusion Fencing**	**Use Exclusion**	**Streambank Stabilization & Fencing**	**Vegetated Filter Strip**	**Dry Detention**	**Extended Wet Detention**	**LID/Filter/Buffer Strip**	**Porous Pavement**	**Bioretention Facility**
Big Creek	0.1	0.1	0.1	0.1	0.02	0.2	0.2	0.1	0.2	4.3	0.3	0.1	0.2	0.3
Brush Creek	0.1	0.2	0.2	0.2	0.02	0.4	0.3	0.1	0.2	5.4	0.3	0.1	0.2	0.3
Butler Creek	0.1	0.1	0.1	0.1	0.02	0.2	0.2	0.1	0.2	13.1	0.3	0.1	0.3	0.3
Cedar Creek	0.1	0.1	0.1	0.1	0.02	0.2	0.1	0.1	0.2	33.1	0.3	0.1	0.2	0.3
Cow Creek	0.1	0.2	0.2	0.2	0.02	0.3	0.2	0.1	0.2	3.2	0.2	0.1	0.2	0.3
Cricket Creek	0.2	0.3	0.3	0.3	0.02	0.5	0.4	0.1	0.2	10.9	0.2	0.1	0.2	0.3
Haddock Creek	0.1	0.2	0.1	0.2	0.02	0.3	0.2	0.1	0.2	9.0	0.2	0.1	0.2	0.3
Indian Creek	0.1	0.1	0.1	0.1	0.02	0.2	0.2	0.1	0.2	8.1	0.2	0.1	0.2	0.3
Little Indian Creek	0.1	0.2	0.1	0.1	0.02	0.3	0.2	0.1	0.2	6.7	0.2	0.1	0.2	0.3
Owl Creek	0.1	0.2	0.2	0.2	0.02	0.3	0.3	0.1	0.2	12.1	0.2	0.1	0.2	0.3
Roaring River	0.1	0.1	0.1	0.1	0.01	0.2	0.1	0.0	0.1	12.9	0.2	0.1	0.2	0.2
Rock Creek	0.1	0.2	0.1	0.1	0.02	0.2	0.2	0.1	0.2	22.1	0.3	0.1	0.2	0.3
Sweetwater Creek	0.1	0.2	0.1	0.1	0.02	0.2	0.2	0.1	0.2	7.9	0.3	0.1	0.2	0.3
Table Rock Lake Dam	0.1	0.3	0.2	0.2	0.02	0.4	0.3	0.1	0.2	3.4	0.2	0.1	0.2	0.3
Viney Creek	0.1	0.1	0.1	0.1	0.02	0.2	0.1	0.1	0.2	6.3	0.2	0.1	0.2	0.3
Yocum Creek	0.1	0.1	0.1	0.1	0.02	0.2	0.2	0.1	0.2	12.9	0.2	0.1	0.2	0.3

**The table presents estimated load reduction yields by HUC12 and BMP type, which can be multiplied by the total acres of BMPs implemented during the project period to estimate realistic nutrient and sediment load reductions and to support scenario-based planning for BMP prioritization and implementation.*

Table 17. NRCS BMP Scenarios and their associated cost per unit and per typical project (USDA-NRCS, 2023).

NRCS Practice		Scenario				
Name	**#**	**#**	**Description**	**Unit**	**Cost / Unit ($)**	**Typical Total Cost ($)**
Pastureland						
Access Control	472	2	Animal exclusion from sensitive areas	Acres	53.31	533.08
Forage and Biomass Planting	E512B	1	Forage and biomass planting to reduce soil erosion	Acres	27.95	2,794.56
Prescribed Grazing	528	1	Low Intensity, > 7 Day Rotation Frequency	Acres	34.20	2,736.19
		2	Medium Intensity, 7-3 Days Rotation Frequency	Acres	50.24	4,018.90
		3	High Intensity, <=2 Day Rotation Frequency	Acres	72.09	5,767.17
		4	Enhanced - Strip Grazing	Acres	84.57	6,765.77
	E528J	1	Prescribed grazing on pastureland that improves riparian and watershed function	Acres	16.82	1,682.19
	E528L	1	Prescribed grazing that improves or maintains riparian and watershed function-erosion	Acres	10.99	1,098.71
	E528M	1	Grazing management that protects sensitive areas from gully erosion	Acres	1.80	1,797.72
Heavy Use Area Protection	561	1	Concrete HUA	Sq. Ft.	7.42	28,923.85
		5	Winter Feeding Station with Gravel	Sq. Ft.	7.75	33,513.85
		6	Winter Feeding Station	Sq. Ft.	12.16	31,896.97
		7	Gravel with Geotextile, Thick	Sq. Ft.	1.68	6,568.74
		8	Gravel without Geotextile, Thick	Sq. Ft.	1.56	6,101.10
		9	Gravel with Geotextile, Regular Thickness	Sq. Ft.	1.28	4,975.14
		34	Reinforced Concrete with Sand or Gravel Foundation	Sq. Ft.	7.33	4,620.89
		35	Rock/Gravel on Geotextile	Sq. Ft.	1.99	1,254.33
Water Well (Alternative Water)	642	2	Shallow Drilled Well, <= 100 feet, <= 6in Dia	Ft. (Depth)	67.65	6,764.52
		3	Shallow Drilled Well, <= 100 feet, > 6in Dia.	Ft. (Depth)	85.59	8,558.88
		4	Deep Drilled Well, > 100 Feet	Ft. (Depth)	35.49	10,648.26
Pumping Plant (Alternative Water)	533	8	Solar Pump for Shallow Well or Spring Development	Each	3,659.89	3,659.89
		10	Shallow Well Pump (<= 25 ft deep)	Each	2,623.77	2,623.77
		11	Shallow Well Pump (<= 25ft deep) with Above Ground Pump House	Each	3,838.75	3,838.75
		13	Deep Well Pump (>25 ft deep)	Each	3,004.65	3,004.65
		14	Deep Well Pump (> 25ft deep) with Above Ground Pump House	Each	4,219.63	4,219.63
Watering Facility (Alternative Water)	614	2	Portable Tank	Each	244.24	244.24
		3	Tire Tank	Each	1,548.45	7,742.26
		5	Above Ground Storage, 1,000 - 3,000 gallons	Each	4,520.41	4,520.41
		6	Above Ground Storage, >3,000 gallons	Each	7,205.57	7,205.57
		7	Underground Storage Tank	Each	5,542.34	5,542.34
		8	Frost Free Waterer	Each	1,818.58	9,092.90
Livestock Pipeline (Alternative Water)	516	1	Above Ground Pipeline	Sq. Ft.	1.92	3,831.94
		2	Buried Pipeline, < 2in Plastic	Sq. Ft.	3.02	12,574.21
		3	Buried Pipeline, 2in - 3in Plastic	Sq. Ft.	4.48	14,798.39
		4	Buried Pipeline, >3in	Sq. Ft.	8.39	6,713.84
Critical Area Planting	342	1	Native or Introduced Vegetation - Normal Tillage	Acres	322.72	322.72

		4	Native or Introduced Vegetation - Moderate Grading	Acres	850.59	850.59
		22	Small Area Disturbance	1,000 Sq. Ft.	8.75	8.75
Grazing Management Plan	110	85	Conservation Plan for Grazed Lands <100 Acres	Each	2,508.96	2,508.96
		69	Conservation Plan for Grazed Lands 101 to 500 Acres	Each	3,136.20	3,136.20
		101	Conservation Plan for Grazed Lands 501 to 1,500 Acres	Each	3,763.44	3,763.44
		117	Conservation Plan for Grazed Lands 1,501 to 5,000 Acres	Each	4,390.68	4,390.68
Edge-of-Field Water Quality Monitoring-Data Collection and Evaluation	201	56	Data Collect Surface Year 1-QAPP	Each	31,115.24	31,115.24
		57	Data Collect Surface Year 1- NO QAPP	Each	23,601.70	23,601.70
		213	Data Collect - Discrete Sampling, Year 1, Single Parameter	Each	7,336.56	7,336.56
		229	Data Collect - Discrete Sampling, Single Parameter, Additional Year	Each	6,115.08	6,115.08
		59	Data Collect Surface Last Year	Each	27,450.80	27,450.80
		64	Data Collect Surface Year 1-QAPP with two treatment Sites	Each	43,024.02	43,024.02
		67	Data Collect Surface Last Year with two treatment sites	Each	39,563.16	39,563.16
Edge-of-Field Water Quality Monitoring-System Installation	202	38	System Installation-Surface	Each	28,164.54	28,164.54
		44	System Installation-Retrofit 1	Each	3,311.04	3,311.04
Water Harvesting Catchment	636	34	Plastic tank, less than or equal to 1,000 gallons	Gallon	2.54	2,544.61
Pastureland / Urban / Forest						
Filter Strip	393	5	Filter Strip, Native species	Acres	289.81	289.81
Stream Crossing	578	1	Gravel Crossing	Sq. Ft.	2.05	1,673.66
		4	Concrete Crossing	Sq. Ft.	11.19	11,185.05
		6	Culvert Installation	In. Ft. Diameter	5.07	6,087.76
		8	Stream Crossing Repair	Sq. Ft.	3.86	2,314.19
Water and Sediment Control Basin	638	1	Base	Cubic Yds.	3.85	2,696.12
		2	Topsoil	Cubic Yds.	4.14	2,898.62
		3	Narrow Base	Feet	2.86	5,154.10
		4	Farmable	Feet	6.57	11,817.18
Stormwater Runoff Control	570	1	Stormwater Runoff Control	Acres	1,385.10	1,385.10
		13	Rain Garden, greater than 750 sq ft	Sq Ft	1.28	1,379.74
		14	Combination, Most common BMPs	Acres	1,242.95	1,242.95
		31	Rain Garden, 750 sq ft. or less	Sq Ft	1.98	1,187.31
Streambank and Shoreline Protection	580	1	Bank shaping	Linear Feet	12.01	12,008.40
		2	Bioengineered	Linear Feet	27.02	27,016.92
		4	Stream Barb/LPSTP-Longitudinal Peaked Stone Toe Protection-small Streams	Linear Feet	58.24	16,016.15
		5	Stone Toe protection with vegetation	Linear Feet	61.62	15,405.14
Stream Corridor Bank Stability Improvement	E580A	1	Stream corridor bank stability improvement	Acres	2,301.39	4,602.78
Stream Corridor Bank Vegetation Improvement	E580B	1	Stream corridor bank vegetation improvement	Acres	2,301.39	4,602.78
Fencing	382	2	Permanent Barbed Wire Multi Strand	Linear Feet	3.22	4,251.24
		8	Temporary/Portable Fence	Linear Feet	0.54	706.71
		10	Temporary - Portable for Small Livestock	Linear Feet	2.09	2,755.23
		97	Multi Strand Barbed/Smooth Wire	Linear Feet	2.91	3,843.70

Riparian Forest Buffer	391	1	Direct seeding	Acres	1,464.49	7,322.45
		2	Bareroot trees and shrubs	Acres	1,474.19	7,370.93
		3	Bareroot trees	Each	2.93	6,395.35
		4	Bareroot shrubs	Each	2.32	2,802.51
		5	Container Trees and Shrubs 2 gallon and larger	Each	28.78	28.78
		22	Container Trees and Shrubs, less than 2 gallon	Each	18.42	1,842.05
Stream Habitat Improvement and Management	395	1	Riparian Zone Improvement, Forested	Acres	4,838.06	9,676.12
Streambank and Shoreline Protection	580	1	Bank shaping	Linear Feet	12.01	12,008.40

Table 18. BMP costs per unit in FY24 dollars for pasture and urban land.

BMP Cost/Unit/Year (Year 1 = FY24 dollars; then 3% inflation each year following)															
Year	Pastureland									Urban					
	Alternative Water (Each)	Forage and Biomass Planting (ac)	Access Control (ac)	Prescribed Grazing (ac)	Heavy Use Protection (SQ. Ft.)	Streambank and Shoreline protection (linear ft)	Fencing (ft)	Critical Area Planting ac)	Use Exclusion (linear Feet)	Vegetated Filter Strip	Extended Wet Detention (cubic yds)	LID/Filter/Buffer Strip (ac)	Rain Garden (sq. ft.)	Porous Pavement (sq. ft.)	Bioretention Facility (sq. ft.)
1	5,673.13	27.95	518.44	62.17	5.15	45.29	3.87	518.14	2.19	289.81	4.00	1,314	1.63	11.70	27.95
2	5,843.32	28.79	533.99	64.03	5.30	46.65	3.99	533.68	2.26	298.50	4.12	1,353	1.68	12.05	28.79
3	6,018.62	29.65	550.01	65.95	5.46	48.05	4.11	549.69	2.32	307.46	4.24	1,394	1.73	12.41	29.65
4	6,199.18	30.54	566.51	67.93	5.62	49.49	4.23	566.18	2.39	316.68	4.37	1,436	1.78	12.78	30.54
5	6,385.16	31.46	583.51	69.97	5.79	50.98	4.36	583.17	2.46	326.18	4.50	1,479	1.83	13.17	31.46
6	6,576.71	32.40	601.01	72.07	5.97	52.51	4.49	600.66	2.54	335.97	4.64	1,523	1.89	13.56	32.40
7	6,774.01	33.37	619.04	74.23	6.14	54.08	4.62	618.68	2.61	346.05	4.78	1,569	1.95	13.97	33.37
8	6,977.23	34.37	637.62	76.46	6.33	55.70	4.76	637.24	2.69	356.43	4.92	1,616	2.00	14.39	34.37
9	7,186.55	35.41	656.74	78.75	6.52	57.37	4.90	656.36	2.77	367.12	5.07	1,665	2.06	14.82	35.41
10	7,402.15	36.47	676.45	81.11	6.71	59.10	5.05	676.05	2.86	378.14	5.22	1,715	2.13	15.27	36.47
11	7,624.21	37.56	696.74	83.55	6.92	60.87	5.20	696.33	2.94	389.48	5.38	1,766	2.19	15.72	37.56
12	7,852.94	38.69	717.64	86.05	7.12	62.69	5.36	717.22	3.03	401.16	5.54	1,819	2.26	16.20	38.69
13	8,088.53	39.85	739.17	88.63	7.34	64.57	5.52	738.74	3.12	413.20	5.70	1,873	2.32	16.68	39.85
14	8,331.18	41.05	761.35	91.29	7.56	66.51	5.69	760.90	3.22	425.60	5.87	1,930	2.39	17.18	41.05
15	8,581.12	42.28	784.19	94.03	7.78	68.51	5.86	783.73	3.31	438.36	6.05	1,988	2.47	17.70	42.28
16	8,838.55	43.55	807.71	96.85	8.02	70.56	6.03	807.24	3.41	451.51	6.23	2,047	2.54	18.23	43.55
17	9,103.71	44.85	831.94	99.76	8.26	72.68	6.21	831.46	3.51	465.06	6.42	2,109	2.62	18.78	44.85
18	9,376.82	46.20	856.90	102.75	8.51	74.86	6.40	856.40	3.62	479.01	6.61	2,172	2.69	19.34	46.20
19	9,658.12	47.58	882.61	105.83	8.76	77.11	6.59	882.09	3.73	493.38	6.81	2,237	2.77	19.92	47.58
20	9,947.87	49.01	909.09	109.01	9.02	79.42	6.79	908.55	3.84	508.18	7.01	2,304	2.86	20.52	49.01

Table 19. Estimated Costs for BMP implementation to reach project goals over 20-year period.

	Pastureland Practices Estimated Total Costs for TRLW								Urban Practices Estimated Total Costs for TRLW			
Year	**Alternative Water ($)**	**Critical Area Planting ($)**	**Heavy Use Protection (1 acre total / year) ($)**	**Prescribed Grazing ($)**	**Forage and Biomass Planting (ac) ($)**	**Access Control ($)**	**Use Exclusion Fencing ($)**	**Streambank and Shoreline Protection ($)**	**Vegetated Filter Strip (ac)**	**LID/Filter/Buffer Strip (ac)**	**Porous Pavement (sq. ft.)**	**Bioretention Facility (sq. ft.)**
1	68,078	233,161	224,171	27,975	12,578	233,298	274	5,661	74,771	339,018	509,652	1,217,502
2	70,120	240,156	230,896	28,814	12,955	240,297	282	5,831	77,014	349,189	524,942	1,254,027
3	72,223	247,361	237,823	29,678	13,343	247,506	290	6,006	79,325	359,665	540,690	1,291,648
4	74,390	254,781	244,957	30,569	13,744	254,931	299	6,186	81,704	370,455	556,911	1,330,397
5	76,622	262,425	252,306	31,486	14,156	262,579	308	6,372	84,155	381,568	573,618	1,370,309
6	78,921	270,298	259,875	32,430	14,581	270,456	317	6,563	86,680	393,015	590,826	1,411,419
7	81,288	278,407	267,671	33,403	15,018	278,570	327	6,760	89,280	404,806	608,551	1,453,761
8	83,727	286,759	275,702	34,405	15,469	286,927	337	6,963	91,959	416,950	626,808	1,497,374
9	86,239	295,362	283,973	35,438	15,933	295,535	347	7,172	94,718	429,458	645,612	1,542,295
10	88,826	304,222	292,492	36,501	16,411	304,401	357	7,387	97,559	442,342	664,980	1,588,564
11	91,491	313,349	301,267	37,596	16,903	313,533	368	7,608	100,486	455,612	684,930	1,636,221
12	94,235	322,750	310,305	38,724	17,410	322,939	379	7,837	103,501	469,281	705,478	1,685,308
13	97,062	332,432	319,614	39,885	17,933	332,627	390	8,072	106,606	483,359	726,642	1,735,867
14	99,974	342,405	329,202	41,082	18,470	342,606	402	8,314	109,804	497,860	748,441	1,787,943
15	102,973	352,677	339,078	42,314	19,025	352,884	414	8,563	113,098	512,796	770,894	1,841,581
16	106,063	363,257	349,251	43,584	19,595	363,471	426	8,820	116,491	528,180	794,021	1,896,828
17	109,244	374,155	359,728	44,891	20,183	374,375	439	9,085	119,985	544,025	817,842	1,953,733
18	112,522	385,380	370,520	46,238	20,789	385,606	452	9,357	123,585	560,346	842,377	2,012,345
19	115,897	396,941	381,636	47,625	21,412	397,174	466	9,638	127,293	577,156	867,648	2,072,716
20	119,374	408,849	393,085	49,054	22,055	409,089	480	9,927	131,111	594,471	893,678	2,134,897
Total	***$1,829,269***	**$6,265,127**	**$6,023,549**	**$751,694**	**$337,962**	**$6,268,805**	**$7,356**	**$152,125**	**$2,009,124**	**$9,109,553**	**$13,694,540**	**$32,714,735**

** With 450 pastureland acres/year, 12 Alternative Water systems per year, 258 urban acres per year, and 125 ft of streambank per year*

Over the course of the 20-year WMP, the total cost for pastureland BMPs is estimated to range between $337,962 and 6 million dollars, depending on the BMPs selected for implementation (Table 20). Streambank BMPs for the 20-year project period are estimated to cost over $152,000 total, and urban stormwater detention retrofit costs are estimated to exceed 43 million dollars, depending on design and site conditions. Additionally, where feasible, maintenance costs associated with the upkeep of certain BMPs should be evaluated, and responsible parties should be established during the design phase prior to implementation.

Technical and Financial Assistance Sources

Sources of both technical and financial assistance will be necessary for implementation of water quality monitoring projects, educational and informational tasks, as well as BMP projects. Possible sources of financial or technical assistance are discussed in detail below, though any relevant funding sources identified throughout the project period should be utilized, when possible, as sources may shift throughout the period:

Missouri Department of Natural Resources (MODNR)

319 Nonpoint Source Project Grants. Under Section 319(h) of the Clean Water Act, the MODNR offers subgrants intended to help restore and protect waters that have been impaired or threatened by nonpoint source pollution. The purpose of the funding is to support planning for and implementing on-the-ground practices that control, reduce or manage nonpoint source pollution as described in the Missouri Nonpoint Source Management Plan. The funding is available to help organizations with watershed planning or implementing activities as described in a department and USEPA accepted 9-element watershed based plan or alternative plan under certain specific conditions.

6***04(b) Water Quality Management Planning Grants.*** Grants to assist regional public comprehensive planning organizations and interstate organizations to carry out water quality management planning. Planning activities include determining the nature, extent and causes of point and nonpoint source water pollution problems and developing plans to resolve these problems.

Soil And Water Conservation Cost-share Program. A portion of the Parks, Soils and Water Sales Tax is used for Missouri landowners to install soil and water conservation practices through the state cost-share program. These practices conserve soil, which consequently improves water quality by reducing sedimentation in rivers and streams.

Abandoned Well Plugging Grants. Part of the Missouri Drinking Water State Revolving Fund to promote wellhead protection awareness, education and implementation. Through this grant program, the department provides financial assistance to groundwater-based community and not-for-profit noncommunity public water systems to identify and properly plug abandoned drinking water wells according to state and federal regulations and requirements. Funding is offered through a competitive, annual funding cycle. Projects must focus on proper plugging of abandoned drinking water wells that, if left unplugged, may present a contamination risk to groundwater resources used by a regulated public water system. Certified well drilling or pump installation contractors licensed to operate in Missouri must perform actual well plugging activities for proposed projects to qualify for funding.

United States Environmental Protection Agency (USEPA)

Clean Water State Revolving Funds. Provides low-cost financing to communities for a wide range of water quality infrastructure projects, including municipal wastewater facilities, nonpoint source pollution control, decentralized wastewater treatment systems, stormwater runoff mitigation, green infrastructure, estuary protection, and water reuse.

Water Finance Clearinghouse. The Water Finance Clearinghouse is an easily navigable web-based portal to help communities locate information and resources that will assist them in making informed decisions for their drinking water, wastewater, and stormwater infrastructure needs. The Water Finance Clearinghouse includes two searchable databases: one contains available funding sources for water infrastructure and the second contains resources, such as reports, weblinks, webinars etc. on financing mechanisms and approaches that can help communities access capital to meet their water infrastructure needs.

Wetland Program Development Grants. WPDGs provide eligible applicants an opportunity to conduct projects that promote the coordination and acceleration of research, investigations, experiments, training, demonstrations, surveys and studies relating to the causes, effects, extent, prevention, reduction and elimination of water pollution. WPDGs assist state, tribal, local government (S/T/LG) agencies and interstate/intertribal entities in building programs to protect, manage and restore wetlands. States, tribes, local governments, interstate associations, and intertribal consortia are eligible to apply for the Regional WPDG Request for Proposals (RFPs). Nonprofits, interstate associations and intertribal consortia are eligible to apply for the National WPDG RFPs.

Healthy Watersheds Consortium Grants. The EPA established the Healthy Watersheds Consortium (HWC) Grant Program to accelerate and expand the strategic protection of healthy watersheds, including freshwater, estuarine, and marine ecosystems, across the United States. The EPA launched the HWC Grant Program in 2015 through a cooperative agreement with the US Endowment for Forestry & Communities and funding support from the US Department of Agriculture's Natural Resources Conservation Service. The HWC Grant Program previously awarded approximately $11 million to a total of 56 subawards across approximately 25 states and 9 EPA regions. These projects demonstrated an array of protection techniques and approaches, including implementing watershed protection plans, building organizational and social infrastructure needed for long-term protection efforts, and employing innovative, new strategies for achieving watershed protection goals. In total, these projects supported by the HWC Grant Program contributed to the protection of more than 1 million land acres and more than 5,100 stream miles, primarily via land conservation and enhanced regulatory protections.

Environmental Justice Small Grants Program. The Environmental Justice Small Grants Program supports and empowers communities working on solutions to local environmental and public health issues. The program is designed to help communities understand and address exposure to multiple environmental harms and risks. Environmental Justice Small Grants fund projects up to $100,000, depending on the availability of funds in a given year. All projects are associated with at least one qualified environmental statute.

Source Reduction Assistance (SRA) Grant Program. The Source Reduction Assistance (SRA) grants support research, investigation, experiments, surveys, study, demonstration, education, and training using source reduction approaches (P2 or pollution prevention). EPA is particularly interested in projects that promote practical source reduction practices, tools, and training on P2 approaches to measurably improve human and environmental health by reducing the use of hazardous substances, reducing toxic pollutants, reducing resource use (e.g., water and energy) and reducing expenditures and liability costs to businesses, non-profit organizations and/or communities.

Gulf Hypoxia Program. Through the Gulf Hypoxia Program, Task Force member states, Tribes, sub-basin committees, and Land Grant Universities will have the resources to make significant progress toward reducing nutrient loads. These efforts will improve water quality in the Gulf and throughout the Mississippi River/Atchafalaya River Basin and track the results. Through improved water quality, communities across the basin will benefit from safer drinking water, protected fisheries, and a more stable economy.

Mississippi River Basin Healthy Watersheds Initiative. The Mississippi River Basin Healthy Watershed Initiative (MRBI) is accelerating voluntary, on-farm conservation investments and focused water quality monitoring and assessment resources in the Mississippi River watershed. The overall goals of MRBI are to improve water quality, restore wetlands and enhance wildlife habitat while ensuring economic viability of agricultural lands.

United States Department of Agriculture (USDA)

Conservation Reserve Program. The Conservation Reserve Program (CRP), administered by the Farm Service Agency (FSA), is a voluntary program that encourages agricultural producers and landowners to convert highly erodible and other environmentally sensitive acreage to vegetative cover, such as native grasses, trees, and riparian buffers. By enrolling in CRP, participants receive annual rental payments and cost-share assistance to establish long-term, resource-conserving vegetative covers. The program helps to improve water quality, control soil erosion, and enhance wildlife habitat, contributing to overall environmental health and sustainability.

Agricultural Conservation Easement Program. The Agricultural Conservation Easement Program (ACEP) protects the agricultural viability and related conservation values of eligible land by limiting nonagricultural uses which negatively affect agricultural uses and conservation values, protect grazing uses and related conservation values by restoring or conserving eligible grazing land, and protecting and restoring and enhancing wetlands on eligible land. ACEP has two components: Agricultural Land Easements (ALE) help private and tribal landowners, land trusts, and other entities such as state and local governments protect croplands and grasslands on working farms and ranches by limiting non-agricultural uses of the land through conservation easements. Wetland Reserve Easements (WRE) help private and tribal landowners protect, restore and enhance wetlands which have been previously degraded due to agricultural uses. Additionally, through ACEP, USDA offers the Wetland Reserve Enhancement Partnership (WREP), a voluntary program through which NRCS enters into agreements with eligible partners to leverage resources to carry out high priority wetland protection, restoration, and enhancement and to improve wildlife habitat.

Environmental Quality Incentives Program (EQIP). EQIP provides technical and financial assistance to agricultural producers and forest landowners to address natural resource concerns, such as: Improved water and air quality; Conserved ground and surface water; Increased soil health ; Reduced soil erosion and sedimentation; Improved or created wildlife habitat; and Mitigation against drought and increasing weather volatility.

Conservation Stewardship Program (CSP). NRCS works one-on-one with producers to develop a conservation plan that outlines and enhances existing efforts, using new conservation practices or activities, based on management objectives for your operation. Producers implement practices and activities in their conservation plan that expands on the benefits of cleaner water and air, healthier soil and better wildlife habitat, all while improving their agricultural operations.

Missouri Rural Decentralized Water Systems Grant. This program provides grant funding to qualified nonprofits, including tribally owned nonprofits, to create a revolving loan fund or to award sub-grants to homeowners for supporting access to individually owned water and wastewater services in eligible rural areas. The fund may be used to construct, refurbish, or service individually owned household water well and decentralized wastewater systems.

Missouri Department of Conservation (MDC)

Community Conservation Cost-Share. MDC's Community Conservation Cost-Share Program promotes sustainable development practices and the establishment of natural resource conservation practices in municipal and developing areas. Cost-share is authorized for activities such as native grass and pollinator plantings, forest and woodland management, invasive species control, and aquatic resource management. In addition, other practices eligible for cost-share include urban green space planning, engineered drawings, and training of staff on conservation-related programs.

Community Forestry Cost-Share. Community Forestry Cost-Share is designed to assist Missouri communities with improving their community forest. This cost-share program encourages communities to have a sustainable, balanced, and comprehensive community forestry program based on a current tree inventory and managed with the guidance of a community forestry professional. Lastly, Community Forestry Cost-Share is designed to promote community forest benefits through the proper management and care of trees. Cost-share opportunities available under the Community Forestry Cost-Share include municipal tree ordinance development, development of a written community tree management plan, or community readiness plan for addressing exotic insect disease outbreaks, community tree inventories, management of ash (Fraxinus sp.) trees, training of city employees and volunteers to improve community forestry, purchase of tree-care education materials, development and/or distribution of tree-care-related educational materials, removal of critical-risk trees, pruning, tree planting, and other opportunities to further community forestry.

Landowner and Community Assistance Program. Our Landowner and Community Assistance Program (LCAP) is designed to financially support private landowners, communities or towns, government entities, and others in implementing conservation practices on their land. MDC assistance focuses on improving wildlife habitat, managing forests, restoring native ecosystems, and enhancing land stewardship.

U. S. Fish and Wildlife Service

Cooperative Endangered Species Conservation Fund. Section 6 of the Endangered Species Act allows the U.S. Fish and Wildlife Service to provide competitive grants through the Cooperative Endangered Species Conservation Fund, supporting state programs that conserve listed, candidate, and at-risk species on non-federal lands, with about $51.8 million awarded annually.

Partners for Fish and Wildlife. The Partners for Fish and Wildlife Program provides voluntary technical and financial assistance to private landowners to restore, enhance, and manage habitats, such as wetlands, streams, and forests, for the benefit of fish, wildlife, and federally or state listed species, while landowners retain full ownership and control. Projects prioritize areas supporting rare, threatened, and endangered species and can help address water quality and habitat goals relevant to nonpoint source pollution reduction in a watershed.

National Fish and Wildlife Foundation (NFWF)

Five Star and Urban Waters Restoration Grant Program. Grants seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development.

Conservation Partners Program. The Conservation Partners Program will finance projects that offer technical assistance to agricultural producers interested in voluntarily adopting regenerative agriculture systems and conservation practices. Grant recipients will employ field conservation professionals to aid producers in developing and implementing economically viable management practices that lead to positive environmental results. Grant funds cannot be used to provide direct financial assistance to farmers and ranchers, although projects may leverage additional funding for this purpose. Additionally, grant funds cannot directly support projects that already have USDA-funded technical assistance, such as those under the Regional Conservation Partnership Program and the Partnerships for Climate-Smart Commodities program.

Missouri Department of Transportation (MODOT)

Governor's Rural Routes Program. The Governor's Rural Routes Program provides funding to improve the condition and safety of low volume rural roads, supporting upgrades such as surface improvements, drainage enhancements, and erosion control that can also reduce sediment and pollutant runoff to nearby streams.

Soil and Water Conservation Districts (SWCD)

Landowner Cost-Share. Soil and water conservation practices installed on agricultural land save soil from eroding and reduce nutrients and pesticides from entering Missouri's waterways. The Parks, Soils and Water Sales Tax provides financial incentives and share the cost between the farmer and the state for implementing soil and water conservation practices that prevent or control soil erosion and protect water quality. Certain counties offer: Sheet/Rill and Gully Erosion, Grazing Management, Irrigation Management, Animal Waste Management, Nutrient and Pest Management, Sensitive Areas, Woodland Erosion.

Friends of Reservoirs

Friends of Reservoirs Small and Large Project Grants. The Reservoir Fisheries Habitat Partnership provides seed funding and coordination for collaborative, science based efforts to protect, restore, and enhance fish habitat in reservoir systems, while advancing best management practices, supporting long term conservation funding and partnerships, and promoting public awareness of healthy reservoir ecosystems.

Forest ReLeaf of Missouri

CommuniTree. Forest ReLeaf plants and sustains resilient, ecologically appropriate tree canopy across Missouri through community partnerships, education, and strategic planning, to support healthy people, habitats, and ecosystems. Through the Project CommuniTree program, Forest ReLeaf provides access to tree canopy by providing free nursery grown trees to public and nonprofit partners, supporting community-based planting efforts that also offer opportunities to advance watershed BMP implementation.

ELEMENT 5: INFORMATION AND EDUCATION

Information and Education

Public education and stakeholder engagement are essential to reducing nonpoint source pollution and supporting successful implementation of this Watershed Management Plan. Many nutrient and sediment inputs within the watershed are influenced by individual and community level behaviors, land management decisions, and routine maintenance practices. Disseminating clear, accessible information about watershed conditions, plan goals, and voluntary best management practices helps build awareness, encourage participation, and foster long term stewardship among residents, landowners, producers, and recreational users.

Information and education efforts will focus on reaching diverse audiences throughout the watershed using multiple delivery methods to ensure information is widely accessible. Outreach activities are intended to complement structural and management based BMPs by increasing understanding of how everyday actions contribute to nutrient loading and how targeted practices can reduce nonpoint source pollution. Potential education and outreach approaches may include, but are not limited to, the following examples.

Urban and Residential Audiences

- Pollution prevention messaging such as storm drain stenciling, signage, and educational materials
- Promotion of green stormwater infrastructure and native plantings through partnerships with MDC and Grow Native!
- Lawn nutrient management education and Grow Native workshops
- Use of EPA Stormwater Smart outreach tools and materials
- Community events incorporating pet waste education and responsible disposal messaging
- Adoption of outreach approaches modeled after existing programs such as the City of Springfield’s Yard Ethic Program
- Outreach focused on land stewardship practices that reduce erosion, nutrient runoff, and streambank impacts

Agricultural and Pastureland Audiences

- Education related to nutrient management planning for pasture and hay operations

- Promotion of sustainable grazing and soil health practices through programs such as Understanding Ag
- Outreach highlighting the water quality benefits of pasture management BMPs

Septic System Owners

- Education on proper septic system operation and maintenance
- Promotion of workshops such as the Missouri Smallflows Septic System Program

Recreational Users

- Education on best boating practices and pollution prevention measures for lakes and streams

Policy Makers and Local Officials

- Engagement of county commissioners and local officials through nonpoint source pollution workshops
- Field days or informational events to increase understanding of watershed conditions, plan goals, and implementation progress

Community and Volunteer Engagement

- Encouragement of student participation in water quality monitoring and watershed education through K 12 schools, colleges, and universities
- Promotion of volunteer involvement from residents and recreational users within the watershed
- Watershed focused education events such as a "Love Your Watershed" day

ELEMENT 6: PROJECT SCHEDULE

A project schedule was developed to guide implementation of the load reduction and BMP goals outlined in this Watershed Management Plan (Table 20). Implementation is organized into three phases based on timing and capacity building needs: short-term actions within the first five years, medium-term actions between years five and ten, and long-term actions between years ten and twenty. This phased approach reflects the need to establish baseline data, partnerships, and prioritization frameworks early in the process, while allowing sufficient time for BMP implementation, evaluation, and adaptive management. Phase 1 activities focus on developing the foundational information needed to support effective BMP placement and long-term nutrient reduction. These efforts include inventories of streambank erosion and onsite wastewater treatment systems, *E. coli* screening to identify areas appropriate for microbial source tracking, and establishment of the entities responsible for implementing the information and education, monitoring, and coordination components of the plan. Data and insights gained during the short-term phase will inform targeted BMP implementation in the medium- and long-term phases, including streambank stabilization, nutrient reduction practices, and OWTS improvements in priority areas. By the end of the twenty-year implementation period, the load reduction and BMP goals described in this WMP are expected to be achieved, assuming no new unmanaged sources are introduced.

ELEMENT 7: INTERIM, MEASURABLE MILESTONES

Short-, medium-, and long-term milestones for BMP implementation and associated pollutant load reductions are summarized in Table 23 and reflect incremental progress toward achieving the watershed's nutrient and sediment reduction goals over a twenty-year planning horizon. By the end of the five-year short-term milestone, BMPs are anticipated to be implemented on approximately 2,252 acres of pastureland, 1,288 acres of urban land, and 625 linear feet of eroding streambanks. Achievement of these early implementation targets is expected to reduce pollutant loading to watershed waterways by approximately 21,295 pounds of nitrogen, 4,174 pounds of phosphorus, and 2,301 tons of sediment. Continued BMP implementation through the 10-year medium-term milestone is projected to result in cumulative reductions of 42,591 pounds of nitrogen (7%), 8,348 pounds of phosphorus (6%), and 4,602 tons of sediment (5%) entering Table Rock Lake Watershed waterways. The long-term milestone represents attainment of the BMP implementation targets established in this plan, including treatment of 25% of pastureland and urban areas and stabilization of 2,500 linear feet of eroding streambanks. By Year 20, implementation of BMPs across approximately 9,007 acres of pastureland, 5,153 acres of urban land, and 2,500 feet of streambank is projected to result in cumulative reductions of 85,181 pounds of nitrogen, 16,697 pounds of phosphorus, and 9,205 tons of sediment. These reductions correspond to decreases of approximately 14% of TN, 12% of TP, and 10% of total sediment loads within the TRLW (Table 20). Predicted runoff concentrations for TN and TP associated with the short-, medium-, and long-term milestones are presented in Table 24. In addition to structural BMP implementation, informational and educational activities will be conducted on an ongoing basis throughout the planning period using the outreach and education strategies identified in this plan. At a minimum, at least one informational or educational activity will be implemented annually, resulting in no fewer than five activities by the short-term milestone, ten by the medium-term milestone, and twenty by the long-term milestone. These activities may include workshops, stakeholder meetings, public outreach events, or other education efforts identified in the plan, and may be adjusted over time based on stakeholder needs and implementation priorities.

Table 20. Twenty-year BMP implementation plan to achieve target load reductions.

Milestone	Year	Pastureland				Urban				Streambank			
		Acres Treated	% Reduction			Acres Treated	% Reduction			Feet Treated	% Reduction		
			N	P	S		N	P	S		N	P	S
Short-Term	**1**	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	2	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	3	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	4	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	5	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	TOTAL	**2,252**	**1.4**	**1.5**	**1.8**	**1,288**	**1.6**	**1.0**	**0.3**	**625**	**0.4**	**0.4**	**0.5**
	lb/ac/yr Reduction		**8,470**	**2,117**	**1,464**	**lb/ac/yr Reduction**	**10,146**	**1,466**	**246**	**lb/ac/yr Reduction**	**2,679**	**591**	**591**
Medium-Term	**6**	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	7	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	8	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	9	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	10	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	TOTAL	**4,504**	**2.7**	**3.0**	**3.6**	**2,577**	**3.3**	**2.1**	**0.7**	**1,250**	**0.9**	**0.9**	**0.9**
	lb/ac/yr Reduction		**16,940**	**4,234**	**2,928**	**lb/ac/yr Reduction**	**20,292**	**2,933**	**493**	**lb/ac/yr Reduction**	**5,359**	**1,182**	**1,182**
Long-Term	**11**	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	12	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	13	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	14	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	15	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	16	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	17	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	18	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	19	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	20	450	0.3	0.3	0.4	258	0.3	0.2	0.1	125	0.1	0.1	0.1
	TOTAL	**9,007**	**5.4**	**6.0**	**7.1**	**5,153**	**6.5**	**4.1**	**1.3**	**2,500**	**1.7**	**1.7**	**1.8**
	lb/ac/yr Reduction		**33,880**	**8,468**	**5,856**	**lb/ac/yr Reduction**	**40,584**	**5,865**	**985**	**lb/ac/yr Reduction**	**10,717**	**2,364**	**2,364**

ELEMENT 8: INDICATORS TO MEASURE PROGRESS

Progress toward achieving the management objectives and water quality goals of this Watershed Management Plan will be evaluated using both implementation based and water quality based indicators. Implementation progress will be measured by tracking the extent of land treated with BMPs, including acres of pastureland and urban land treated and linear feet of streambank stabilized, as well as any additional BMPs implemented on forested land. The amount of land treated provides a direct indicator of progress toward achieving pollutant load reduction goals, with estimated reductions calculated using the BMP load reduction yields summarized in Table 15 and Table 16. Tracking BMP implementation over time allows comparison of actual progress against the short-, medium-, and long-term milestones established in this plan. Water quality indicators will be used to evaluate watershed response to BMP implementation. Progress will be assessed through monitoring of TN and TP concentrations during both runoff and baseflow conditions.

Over the 20-year planning horizon, modeled results indicate that average nutrient concentrations in runoff are expected to decrease by approximately 14% for TN and 12% for TP (Table 21). Collection of runoff samples is particularly important, as no storm event water quality data currently exist for the Table Rock Lake Watershed. These initial data will establish baseline conditions and allow future comparison between observed water quality trends and modeled expectations. As nutrient inputs are reduced, secondary indicators such as chlorophyll a concentrations are also expected to decline over time. BMP implementation progress and water quality trends will be reviewed annually to evaluate plan effectiveness. If implementation targets are not being met or expected water quality improvements are not observed, management strategies and milestones may be adjusted to ensure continued progress toward watershed goals.

ELEMENT 9: WATER QUALITY MONITORING

Estimated load reductions associated with BMP implementation can be evaluated using planning-level modeling tools such as STEPL or PLET, which provide a framework for estimating anticipated nutrient and sediment reductions at the watershed scale. However, modeled results alone cannot confirm whether water quality conditions are improving or whether water quality goals are being met. Direct collection of water quality data is essential for evaluating the effectiveness of implemented practices, validating modeled assumptions, and guiding adaptive management. Monitoring within the Table Rock Lake Watershed will rely on a combination of

Table 21. Concentrations of TN and TP estimated over the 20-year project period to serve as an indicator of project progress.

HUC-12	Predicted TN Concentration in Runoff (mg/L)				Predicted TP Concentration in Runoff (mg/L)			
	Initial	5-Year	10-Year	20-Year	Initial	5-Year	10-Year	20-Year
Big Creek	1.4	1.4	1.3	1.2	0.24	0.24	0.23	0.21
Brush Creek	1.8	1.7	1.7	1.5	0.35	0.34	0.33	0.31
Butler Creek	1.5	1.4	1.4	1.3	0.32	0.31	0.30	0.28
Cedar Creek	1.2	1.1	1.1	1.0	0.28	0.27	0.26	0.24
Cow Creek	1.4	1.4	1.3	1.2	0.25	0.24	0.24	0.22
Cricket Creek	2.1	2.0	2.0	1.8	0.50	0.48	0.47	0.44
Haddock Creek	1.9	1.8	1.8	1.6	0.37	0.36	0.35	0.33
Indian Creek	1.7	1.7	1.6	1.5	0.30	0.29	0.28	0.27
Little Indian Creek	1.3	1.3	1.3	1.2	0.26	0.25	0.24	0.23
Owl Creek	2.4	2.3	2.2	2.1	0.49	0.48	0.47	0.44
Roaring River	2.3	2.2	2.1	1.9	0.36	0.35	0.34	0.31
Rock Creek	1.3	1.2	1.2	1.1	0.28	0.27	0.27	0.25
Sweetwater Creek-Kings River	1.9	1.9	1.8	1.7	0.35	0.34	0.33	0.31
Table Rock Lake Dam	1.5	1.5	1.4	1.3	0.28	0.28	0.27	0.25
Viney Creek	1.9	1.8	1.8	1.6	0.32	0.31	0.30	0.28
Yocum Creek	3.3	3.2	3.1	2.8	0.50	0.48	0.47	0.44

existing programs and targeted future efforts designed to assess both short-term responses to BMP implementation and long-term watershed trends. Consistent monitoring should include both tributary streams and Table Rock Lake, with lake sampling conducted at multiple locations such as the main dam, arms, and inlet streams to capture spatial variability in nutrient concentrations, as recommended in the MODNR water quality monitoring strategy. (MODNR-WPCB, n.d.)

Long-Term Monitoring

Tributary Streams: Long-term water quality monitoring within watershed is currently limited and relies on a small number of programs. Nutrient concentration data are collected at a single USGS gaging station within the watershed (USGS Gage No. 07050150, Roaring River at Roaring River State Park), although the record is intermittent and includes multi-year gaps. This sampling site alone is not sufficient to characterize long-term nutrient trends across the watershed or within Table Rock Lake. Long-term monitoring should occur near the downstream outlets of major tributaries to capture integrated upstream conditions and evaluate cumulative responses to BMP implementation. Expanding monitoring across HUC-12s can identify new upstream sources of impairment, such as urban or agricultural inputs, guiding further management actions. Sampling is recommended at least once per season (Geosyntec Consultants, 2013). The MODNR will also conduct follow-up monitoring in impaired waters or those with approved TMDLs, in accordance with state water quality strategy (MODNR-WPCB, n.d.).

Table Rock Lake: Long-term monitoring of in-lake conditions is essential for evaluating watershed-scale responses to BMP implementation, documenting progress toward water quality goals, and supporting 303(d) listing evaluations. The Lakes of Missouri Volunteer Program has provided critical long-term lake monitoring data for Table Rock Lake since 1992 and represents the most comprehensive and consistent source of in-lake water quality information for the watershed. Monitoring has occurred at a total of 32 lake sites over the course of the program, with the number and location of active sites varying over the years. The LMVP dataset is uniquely valuable for evaluating long-term trends, seasonal patterns, and gradual changes in lake water quality that are not captured through short-term or project-based monitoring efforts. Continued support for LMVP is strongly encouraged, and if program capacity is reduced, additional monitoring should be developed through local, volunteer, or agency partnerships to maintain lake water quality assessment. Lake monitoring will complement the potential tributary stream data collected by the USGS, LMVP, and MODNR within the TRLW.

Short-Term Monitoring

Short-term monitoring will evaluate BMP effectiveness under runoff-driven, nonpoint source conditions. Paired upstream and downstream sampling locations should be established at representative implementation sites, including streambank restoration, pastureland BMP clusters, urban stormwater retrofits, and septic system improvements. For septic BMPs, microbial indicators such as E. coli should be included to assess reductions in pathogen transport to surface waters, as well as microbial source tracking to determine fecal pollutant sources. Sampling should target precipitation events sufficient to generate runoff, following established guidance: a *minimum* of 0.25 inches in 24 hours, preceded by at least 72 hours of dry conditions, and at least three storm events per year (Geosyntec Consultants, 2013). Short-term monitoring will provide early indicators of BMP performance, inform adaptive management, help identify previously unrecognized sources of nutrient or sediment loading, and complement long-term tributary and in-lake monitoring efforts, with multiple storm events per year capturing seasonal variability in runoff-driven pollutant transport. While primary short-term monitoring focuses on tributaries, targeted lake monitoring may be considered if additional resources or funding become available, especially at nearshore sites influenced by BMP-contributing watersheds.

<u>The following water quality parameters should be monitored at the proposed monitoring sites:</u>

- **Nutrients** -Nitrogen and phosphorus, though necessary for plant and animal growth (USGS, b), are primary drivers of eutrophication and are key pollutants of concern within the watershed, where nutrient and chlorophyll-a impairments have been identified. Monitoring both *total and dissolved* forms of nitrogen and phosphorus supports evaluation of nutrient load reductions from BMP implementation, assessment of algal response in receiving waters, and progress toward addressing nutrient related water quality impairments. Nutrients are commonly transported to surface waters through agricultural runoff, urban stormwater, and failing septic systems.

- **Total Suspended Solids (TSS)** is the measured weight of all the solids in water that can be trapped by a filter (US EPA, f). TSS is an indicator of sediment transport associated with surface runoff, streambank erosion, and land disturbance (US EPA, 2006). Elevated TSS can degrade aquatic habitat and serve as a transport mechanism for attached nutrients and other pollutants, including phosphorus, which is often transported in sediment bound forms in nonpoint source dominated watersheds (Sharpley et al., 1994; US EPA, 2000).

- **Dissolved Oxygen (DO)** is a measure of how much oxygen is dissolved in the water and is directly related to how much oxygen is available for living aquatic organisms (USGS, 2018a). In nutrient enriched systems, increased nitrogen loading can promote algal growth reflected by elevated chlorophyll a concentrations, which can reduce DO through increased biological oxygen demand, particularly during nighttime respiration and algal decay.is a measure of how much oxygen is dissolved in the water and is directly related to how much oxygen is available for living aquatic organisms (USGS, 2018a).

- **Chloride** is a major component of dissolved solids in water (USGS, 2019a). Chloride can be introduced into aquatic systems naturally and through anthropogenic influences. Increased urban growth in the project area may lead to elevated chloride concentrations in the water. Elevated concentrations of chloride in streams increase the potential for water to be corrosive, impacts drinking water quality, and can be toxic to aquatic life (USGS, 2019a).

- **Total Coliform and *Escherichia coli* (*E. coli*)** are bacteria used as microbial indicators used to assess fecal contamination (USGS, 2018b). Elevated *E. coli* levels indicate fecal pollution, which poses public health risks and can contribute nutrients to surface waters. High concentrations are commonly associated with failing septic systems, livestock access, and runoff from developed areas. Monitoring upstream and downstream of septic improvements and other BMPs supports evaluation of pathogen reduction and protection of designated recreational uses. When elevated *E. coli* concentrations are detected, microbial source tracking can identify whether elevated *E. coli* originates from humans, livestock, or wildlife, guiding targeted BMP implementation.

- **pH** is a measurement of how acidic or basic water is (on a scale of 0 – 14, <7 indicates acidic, 7 indicates neutral, and >7 indicates basic) (USGS, 2019b). pH influences nutrient availability, metal solubility, and biological processes in aquatic systems. Waters in the project area are typically near neutral. However, runoff, land use changes, and wastewater inputs can alter pH conditions. Monitoring pH helps ensure compliance with water quality standards and supports interpretation of other chemical and biological parameters.

- **Temperature** influences water chemistry, water quality measurements, and governs which organisms can live or grow in rivers and lakes (USGS, 2018c). Temperatures of spring waters in the project area are typical of karst systems and tend to be lower than surface water temperatures in summer months.

- **Specific Conductance** is the measurement of ionic compounds within a water solution, where large amounts of solutes and ions present cause water to become an efficient conductor of electricity (USGS, 2018d). Surface water runoff during rainfall events is a major contributor to high conductivity levels in water.

Any additional water quality parameters that become pertinent to the goals of the plan throughout the goal period should be considered as well.

SUMMARY AND CONCLUSIONS

This Watershed Management Plan satisfies the United States Environmental Protection Agency's nine minimum elements for a watershed-based management plan and provides a comprehensive framework for addressing nonpoint source pollution within the Table Rock Lake Watershed. Main conclusions are summarized below:

1. **The causes and sources of pollution were identified within the Table Rock Lake Watershed as areas generating elevated nutrient and sediment loads.** Pastureland was the dominant contributor of TN, TP, and sediment across the majority of HUC 12 subwatersheds, accounting for approximately 46 percent of nitrogen, 45 percent of phosphorus, and 49 percent of sediment loads. Urban land uses were the second largest contributor of nitrogen and represented a growing source of nutrient inputs in eastern subwatersheds near Table Rock Lake Dam. Forested land contributed notable portions of sediment and phosphorus loads in several subwatersheds. Streambank erosion was

also identified as a contributing nonpoint source concern within the watershed, particularly in areas experiencing land disturbance and development.

2. **Nonpoint source nutrient and sediment loads and expected load reductions were estimated using the United States Environmental Protection Agency's Spreadsheet Tool for Estimating Pollutant Loads (STEPL).** Modeling results indicate that nonpoint sources are the primary contributors of nutrient and sediment loads delivered to Table Rock Lake. While six of the sixteen modeled HUC 12 subwatersheds met nitrogen eutrophic thresholds at the time of modeling, all subwatersheds require phosphorus load reductions to achieve water quality goals. Achieving nitrogen reductions consistent with the eutrophic threshold will require an overall average reduction of 20%. Achieving phosphorus reductions consistent with all forested background conditions will require an average reduction of approximately 57 percent across the watershed.

3. **Nonpoint source load reductions were addressed through targeted best management practices and prioritized critical source areas.** Critical source areas include pastureland, urban land uses, and riparian corridors experiencing streambank erosion. Pastureland areas produce the highest nutrient and sediment yields and represent the greatest opportunity for load reduction through agricultural best management practices. Urban areas contribute substantial nitrogen loads and are expected to continue expanding. Streambank erosion contributes sediment and associated nutrient loading and warrants targeted stabilization efforts. Implementation goals were established assuming treatment of 25 percent of pastureland areas, 25 percent of urban land uses, and 2,500 feet of eroding streambanks over the planning horizon.

4. **Technical, financial, and regulatory assistance needs were identified to support implementation of best management practices.** Cost estimates for pastureland, urban, and streambank practices were developed using typical costs from established state and federal sources and applied across the twenty-year lifespan of the plan. Potential funding sources include programs administered by the Missouri Department of Natural Resources, United States Environmental Protection Agency Section 319 program, Natural Resources Conservation Service, United States Fish and Wildlife Service, and other state and federal conservation programs.

5. **Information and education activities were identified as critical components of successful implementation.** Stakeholder engagement conducted during plan development highlighted concerns related to nutrient pollution, algae growth, and streambank erosion. Continued outreach, education, and demonstration efforts are

recommended to promote best management practice adoption, increase awareness of nonpoint source pollution, and maintain stakeholder involvement throughout implementation.

6. **An implementation schedule was developed to guide best management practice installation over the twenty-year planning horizon.** Under the modeled implementation scenario, pastureland practices would be applied to an average of approximately 450 acres per year, urban practices to approximately 260 acres per year, and streambank stabilization to approximately 125 feet per year. This phased approach provides a realistic and achievable framework for long-term water quality improvement.

7. **Measurable milestones were established to track progress toward water quality goals.** Short term, medium term, and long-term milestones were defined based on the number of acres treated with best management practices and the length of streambank stabilized. Milestones also include continued stakeholder engagement and education activities to support implementation.

8. **Indicators to measure progress were identified as the extent of best management practice implementation and changes in water quality conditions.** As best management practices are installed and maintained, reductions in nutrient and sediment loads are expected to occur, contributing to improved water clarity, reduced chlorophyll-a concentrations, and progress toward meeting aquatic life use criteria in Table Rock Lake.

9. **A monitoring component was outlined to evaluate future improvements and trends in water quality throughout the watershed.** Existing lake and tributary monitoring conducted by state agencies and volunteer programs will provide critical data to assess progress, refine implementation priorities, and support adaptive management. Continued monitoring will be essential to document water quality responses to best management practice implementation and guide future watershed restoration efforts.

REFERENCES

Alewell, C., P. Borrelli, K. Meusburger, and P. Panagos (2019) Using the USLE: Chance, Challenges and Limitations of Soil Erosion Modeling. International Soil and Water Conservation Research. Vol. 7:203-225.

ARDEQ (2024). Arkansas GIS Office: Environmental Permitted Sites (point) Layer File. Arkansas Department of Environmental Quality.

Baker, L. (1992). Introduction to nonpoint source pollution in the United States and prospects for wetland use. Ecological Engineering, 1, 1–26. https://www.sciencedirect.com/science/article/abs/pii/092585749290023U?via%3Dihub

BCP (2012). *Branson Community Plan 2030.* https://www.bransonmo.gov/DocumentCenter/View/370/Community-Plan-2030-PDF

BCHD (2008). *Barry County Wastewater Treatment Systems Ordinance.* Barry County Health Department. Effective May 15, 2008. https://www.barrycountyhealth.com/_files/ugd/d9f579_553806a2872e477ab899bfacf1932113.pdf

Borchelt, G. G. (2007). *Nutrient concentrations at baseflow conditions in the Upper White River Basin, southwest Missouri and northwest Arkansas.* Missouri State University Graduate Theses and Dissertations, 2137. https://bearworks.missouristate.edu/theses/2137

Casaletto, D., Wallace, T., & Miles, R. (2007). *Overcoming tough site conditions at Table Rock Lake using drip dispersal in imported soil.* Paper VI-IS-07-14. https://www.nowra.org/Customer-Content/www/CMS/files/CasalettoWallaceMiles2007NOWRA_Drip_in_Imported_Soil.pdf

CEQ. (n.d.). Explore the Map. Screeningtool.geoplatform.gov. Council on Environmental Quality. https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5 [*currently inaccessible*]

Chapman, S., Omernik, J., Griffith, G., Schroeder, W., Nigh, T., & Wilton, T. (2002). *Ecoregions of Iowa and Missouri* (map scale 1:1,800,000). U.S. Geological Survey, Reston, Virginia. https://dmap-prod-oms-edc.s3.us-east-1.amazonaws.com/ORD/Ecoregions/mo/moia_front.pdf

Clark, G. M., Mueller, D. K., & Mast, M. A. (2000). Nutrient concentrations and yields in undeveloped stream basins of the United States. Journal of the American Water Resources Association, 36(4), 849–860. https://doi.org/10.1111/j.1752-1688.2000.tb04311.x

Geosyntec Consultants. (2013). Water Quality Monitoring Plan for Newhall Ranch Specific Plan Conditions of Approval and Clean Water Act Section 401 Water Quality Certification and Water Discharge Requirements.

Goodnature, M. J. (2009). A GIS Developed Mapping Protocol to Determine Optimal Areas for Shoreline Restoration. Saint Mary's University of Minnesota University Central Services Press, Winona. https://gis.smumn.edu/research-atsmu/grad-papers.shtml.

Heimann, D. C., Holmes, R. R., & Harris, T. E. (2018). *Flooding in the southern Midwestern United States, April–May 2017.* U.S. Geological Survey Open File Report 2018-1004. https://doi.org/10.3133/ofr20181004

Hess, J. W., Pavlowsky, R. T., & Owen, M. (2024). *Lake Taneycomo Nine Element Nonpoint Source Watershed Management Plan.* Missouri Department of Natural Resources, Section 319 Nonpoint Source Unit. Project Number G19-NPS-13. https://oewri.missouristate.edu/_Files/LakeTaneycomo_Accepted_WMP_2024.pdf

Troutman, Kyle. (2022). *Upgrades coming to Roaring River.* Cassville Democrat News. Published July 26, 2022. https://www.cassville-democrat.com/2022/07/26/upgrades-coming-to-roaring-river/

LMVP (2023). *2022 Lake Report.* Lakes of Missouri Volunteer Program. https://static1.squarespace.com/static/65368bda2c38623ad62dd9c9/t/6537e17eb09a7308a8df17aa/1698161025016/LMVP+2022+WEB.pdf

LMVP (2024). *2023 Lake Report.* Lakes of Missouri Volunteer Program. https://static1.squarespace.com/static/65368bda2c38623ad62dd9c9/t/665f2fbfc7f7ab535dcc4176/1717514176744/LMVP_2023_summary_web.pdf

MDC (n.d.). *Missouri Natural Heritage Program – Heritage Review search by county.* Missouri Department of Conservation, Science Branch.

MDC. (2022). *White River Watershed and Inventory Assessment.* Missouri Department of Conservation. https://mdc.mo.gov/sites/default/files/2022-07/390_2022_WhiteRiver.pdf

MDC. (2025). *MDC recognizes partners for floating wetlands work in southwest Missouri.* Article by Francis Skalicky. Missouri Department of Conservation.

MODNR-WPCB (n.d.). *Water Quality Monitoring Strategy for Missouri Federal Fiscal Years 2021–2026.* https://dnr.mo.gov/document/water-quality-monitoring-strategy-missouri-federal-fiscal-year-2021-2026

MODNR. (1995). *Missouri Water Quality Basin Plans.* Basin Plans 55, 56, and 57. Missouri Department of Natural Resources.

MODNR (2004a). *Water Pollution Control Program update for the James River Total Maximum Daily Load.* Missouri Department of Natural Resources. https://dnr.mo.gov/document-search/james-river-nutrient-total-maximum-daily-load-december-2004

MODNR (2004b). *Missouri 2002 Section 303(d) Listed Waters.* Missouri Department of Natural Resources.

MODNR (2005). *Effluent limits and water quality based effluent limits for specific waters Table Rock Lake.* Missouri Department of Natural Resources.

MODNR (2010). *Total Maximum Daily Load for Lake Taneycomo in Taney County, Missouri.* Approved December 30, 2010. https://dnr.mo.gov/document-search/lake-taneycomo-dissolved-oxygen-total-maximum-daily-load

MODNR (2020). *Water wells GIS dataset.* Missouri Department of Natural Resources, Office of Geospatial Information. Updated April 2024. https://gis-modnr.opendata.arcgis.com/search?collection=Dataset&q=Water+Wells

MODNR (2021). *Groundwater Provinces of Missouri: Springfield Plateau Groundwater Province Fact Sheet (PUB3002).* Accessed August 19, 2024. https://dnr.mo.gov/print/document-search/pub3002

MODNR (2021a). *2020 Section 303(d) Listed Waters.* EPA approved September 13, 2021.

MODNR (2021b). *Missouri Nonpoint Source Management Plan Update 2020–2025.* Last revised December 15, 2021.

MODNR (2023a). *Missouri's regulated municipal separate storm sewer systems.* Revised November 2023.

MODNR (2023b). *Code of State Regulations 10 CSR § 20-7.031 (5)(N).* Rules of Department of Natural Resources, Division 20 Clean Water Commission, Chapter 7 Water Quality.

MODNR (2023c). *Spring River Watershed Management Plan summary (PUB3065).* Published October 26, 2023.

MODNR (2024a). *NPDES wastewater outfalls GIS dataset.* Missouri Department of Natural Resources. Updated April 24, 2024. https://gis-modnr.opendata.arcgis.com/datasets/modnr::npdes-waste-water-outfalls/

MODNR (2024b). *NPDES Animal Feeding Operations GIS Dataset*. Missouri Department of Natural Resources. https://gis-modnr.opendata.arcgis.com/datasets/modnr::npdes-animal-feeding-operations

MODNR (2024c). *Lake classifications and use designations water quality standards map viewer.* Accessed July 15, 2024.

MODNR Communications Office. (2024). *Department of Natural Resources offers free workshops on regenerative agriculture practices.* Published February 12, 2024. https://dnr.mo.gov/communications/news/department-natural-resources-offers-free-workshops-regenerative-agriculture-practices

MODOT (2023). *Environmental studies stormwater and water quality.* Missouri Department of Transportation. https://www.modot.org/stormwater

MRCC (n.d.). *cli-MATE climate data.* Midwest Regional Climate Center, NCEI and Purdue University. https://mrcc.purdue.edu/CLIMATE/

Nigh, T. A., & Schroeder, W. A. (2002). *Atlas of Missouri ecoregions.* Missouri Department of Conservation.

NLCD (1992). 1992 *National Land Cover Database.* United States Geological Survey, MRLC Consortium.

NLCD (2023). 2021 *National Land Cover Database.* United States Geological Survey, MRLC Consortium.

Obrecht, D. V., Milanick, M., Perkins, B. D., Ready, D., & Jones, J. R. (2009). *Evaluation of data generated from lake samples collected by volunteers*. Journal of Lake and Reservoir

Management, 14(1), 21–27. https://www.tandfonline.com/doi/abs/10.1080/07438149809354106

OEWRI (2024). *Quality Assurance Project Plan for STEPL modeling in the Table Rock Lake Watershed.* OEWRI QAPP-24-004.

OEWRI (2025). *Table Rock Lake White River Watershed Planning Project nonpoint source load modeling report.* OEWRI EDR-25-017.

OWW (2014). *Status of the Watershed 2014: The White River in Arkansas and Missouri.* Ozarks Water Watch.

Owen, M. R., Borchelt, G., & Pavlowsky, R. T. (2006). *Environmental data report for geospatial database and water quality baseline development for the Upper White River Basin.* USEPA Region 7 Assistance ID WS-98744001-0. https://oewri.missouristate.edu/_Files/Final_Report_2006_UWRB_GeospatialData.pdf

Rawluk A.A., Crow G., Legesse G., Veira D.M., Bullock, P.R., González, L.A., Dubois, M., Ominski, K.H. (2014). Off-Stream Watering Systems and Partial Barriers as a Strategy to Maximize Cattle Production and Minimize Time Spent in the Riparian Area. Animals (Basel) 4(4):670-92. doi:10.3390/ani4040670.

Robertson, D.M. and D.A. Saad (2019). Spatially Referenced Models of Streamflow and Nitrogen, Phosphorus, and Suspended Sediment Loads in Streams of the Midwestern United States.

SCPC (2013). *Stone County Comprehensive Plan.* Stone County Planning Commission.

SCHD (2009). *Stone County Health Code onsite wastewater treatment systems ordinance.* Stone County Health Department. https://stonecountyhealthdepartment.com/wp-content/uploads/2016/11/onsite-wastewater-ordinance-sept-2009-wd.pdf

SCHD (2024). *Stone County Health Department septic system permit search.* https://stonecountyhealthdepartment.com/septic-system-search/

Sharpley, A., Chapra, S., Wedepohl, R., Sims, J., Daniel, T., Reddy, K. (1994). *Managing agricultural phosphorus for protection of surface waters.* Journal of Environmental Quality. https://acsess.onlinelibrary.wiley.com/doi/10.2134/jeq1994.00472425002300030006x?utm_medium=article&utm_source=researchgate.net

SMCOG. (2023). *James River Watershed Management Plan.* Southwest Missouri Council of Governments. https://static1.squarespace.com/static/590e3cede3df2845837660df/t/60b1355feb57de385026532e/1622226283586/WMP+%28Includes+Exec.+Summary+%26+WMP%29.pdf

TCES (n.d.). *Taney County Environmental Services webpage.* Accessed June 20, 2025. https://www.taneycounty.org/index.php?section=departments&department=28

Tetra Tech (2018). *User's guide: Spreadsheet Tool for the Estimation of Pollutant Load (STEPL), version 4.4.* U.S. Environmental Protection Agency. https://19january2021snapshot.epa.gov/sites/static/files/2021-01/documents/steplguide404.pdf

Tetra Tech, Inc. (2022). *User's guide: Pollutant Load Estimation Tool (PLET), version 1.0.* U.S. Environmental Protection Agency. https://www.epa.gov/system/files/documents/2022-04/user-guide-final-04-18-22_508.pdf

TRLCC (2023). *Stone County Economic Development Plan.* Table Rock Lake Chamber of Commerce.

TRLWQI. (2007). *Table Rock Lake Water Quality Decentralized Wastewater Demonstration Project final technical report.* USEPA Cooperative Agreement XP8309301. https://www.epa.gov/sites/default/files/2015-06/documents/tablerock_report_0.pdf

USACE (2010). *Characterization of park visitors, visitation levels, and economic impacts of recreation at Table Rock Lake.* U.S. Army Corps of Engineers. https://erdc-library.erdc.dren.mil/jspui/bitstream/11681/6943/1/EL-TR-10-18.pdf

USACE (2014). *White River Watershed Arkansas and Missouri Table Rock Lake master plan.* Revised final February 2014. https://cdm16021.contentdm.oclc.org/utils/getfile/collection/p16021coll7/id/4048

USACE (2020). *Shoreline Management Plan Table Rock Lake.* U.S. Army Corps of Engineers. https://www.swl.usace.army.mil/Portals/50/docs/tablerocklake/Shoreline/trl-smp-2020/2020-Table-Rock-Lake-SMP.pdf

USCB. (2022). *2020 United States Census Bureau Data.*

USDA NRCS (2007). *National Engineering Handbook Part 630 Hydrology.*

USDA-NRCS (2019). *Gridded Soil Survey Geographic Database.* https://www.nrcs.usda.gov/resources/data-and-reports/gridded-soil-survey-geographic-gssurgo-database

USDA-NRCS (2023). *Missouri practice scenarios fiscal year 2024.* https://www.nrcs.usda.gov/sites/default/files/2023-12/fy24-missouri-scenarios.pdf

USDA FS (n.d.). *Ranger District Series Map.* https://experience.arcgis.com/experience/9ab8d03e2bec4d7fbfc27ba836e70aed/page/Ranger-District-Series

USEPA. (n.d.). *Basic Information about Nonpoint Source (NPS) Pollution*. United States Environmental Protection Agency. https://www.epa.gov/nps/basic-information-about-nonpoint-source-nps-pollution

USEPA (2000). *Nutrient Criteria Technical Guidance Manual Rivers and Streams.* EPA 822-B-00-002. https://www.epa.gov/sites/default/files/2018-10/documents/nutrient-criteria-manual-rivers-streams.pdf

USEPA (2002). *Onsite Wastewater Treatment Systems Manual.* EPA 625-R-00-008. https://www.epa.gov/sites/default/files/2015-06/documents/2004_07_07_septics_septic_2002_osdm_all.pdf

USEPA (2003). *National management measures to control nonpoint source pollution from agriculture.* EPA 841-B-03-004. https://www.epa.gov/sites/default/files/2015-10/documents/chap2_0.pdf

USEPA (2006). *Volunteer stream monitoring a methods manual.*

USEPA (2008). Handbook for Developing Watershed Plans to Restore and Protect Our Waters. United States Environmental Protection Agency, Office of Water, Nonpoint Source Control *Branch*.

USEPA (2011). *EPA decision on Missouri's list of impaired waters.* Approved April 29, 2011.

USEPA (2015). *Low impact development stormwater control cost estimation analysis.* https://pasteur.epa.gov/uploads/10.23719/1510483/documents/LID%20Cost%20Analysis_Report_National%20SWC_2015.pdf

USEPA (2016). *Nutrient reference condition identification and ambient benchmark development process Region 7.*

USEPA (2020). *NPDES permit basics.* Retrieved July 15, 2024. https://www.epa.gov/npdes/npdes-permit-basics

USEPA (2024a). *Nonpoint Source Program and Grants Guidelines for States and Territories.* EPA 841-R-24-009.

USEPA (2024b). *National Aquatic Resource Surveys indicators water quality.* https://www.epa.gov/national-aquatic-resource-surveys/indicators-water-clarity

USGS (2009). *Table Rock Lake water clarity assessment using Landsat data.* Scientific Investigations Report 2009-5162. https://pubs.usgs.gov/sir/2009/5162/pdf/SIR2009-5162.pdf

USGS (2018a). Water Science School. Dissolved Oxygen and Water. https://www.usgs.gov/specialtopic/water-science-school/science/dissolved-oxygen-and-water?qtscience_center_objects=0#qt-science_center_objects

USGS (2018b). Water Science School. Bacteria and E. Coli in Water. https://www.usgs.gov/specialtopic/water-science-school/science/bacteria-and-e-coli-water?qtscience_center_objects=0#qt-science_center_objects

USGS (2018c). Water Science School. Temperature and Water. https://www.usgs.gov/specialtopic/water-science-school/science/temperature-and-water?qtscience_center_objects=0#qt-science_center_objects

USGS. (2018d). Water Science School. Conductivity (Electrical Conductance) and Water. https://www.usgs.gov/special-topic/water-science-school/science/conductivity-electricalconductance-and-water?qt-science_center_objects=0#qt-science_center_objects

USGS. (2019a). Water Science School. Chloride, Salinity, and Dissolved Solids. https://www.usgs.gov/mission-areas/water-resources/science/chloride-salinity-anddissolved-solids?qt-science_center_objects=0#qt-science_center_objects

USGS. (2019b). Water Science School. pH and Water. https://www.usgs.gov/special-topic/waterscience-school/science/ph-and-water?qt-science_center_objects=0#qtscience_center_objects

USGS (2025). *Estimated densities of residential septic tanks across the conterminous United States.* https://data.usgs.gov/datacatalog/data/USGS:6734c572d34e6fbce7b5c09a

USGS (n.d.). *Hydrologic Unit Maps.* https://water.usgs.gov/GIS/huc.html

USLE (2012). *Ontario Ministry of Agriculture, Food and Rural Affairs. Universal Soil Loss Equation. (USLE).* https://www.ontario.ca/page/universal-soil-loss-equation

White, M., Harmel, D., Yen, H., Arnold, J., Gambone, M., & Haney, R. (2015). Development of sediment and nutrient export coefficients for U.S. ecoregions. JAWRA Journal of the *American* Water Resources Association, 51(3), 758–775. https://doi.org/10.1111/jawr.12270

Zeiger, S.J. (2019). Soil and Water Assessment Tool (SWAT) simulated sediment and nutrient yields in James River Basin. OEWRI-EDR-18-006. James River Watershed Management Plan: Appendix D. https://dnr.mo.gov/media/pdf/james-river-watershed-management-plan-appendix-d

APPENDIX

APPENDIX A. APPENDIX FIGURES

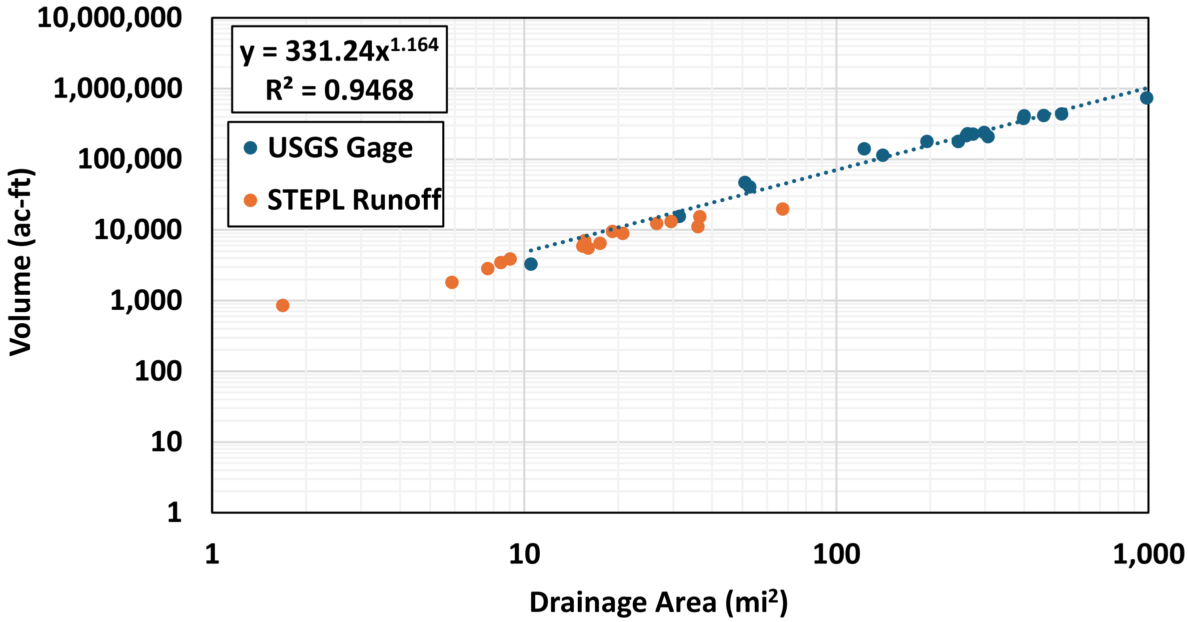

Figure A1. USGS Gaged Runoff Volumes Compared to STEPL Runoff Volume.

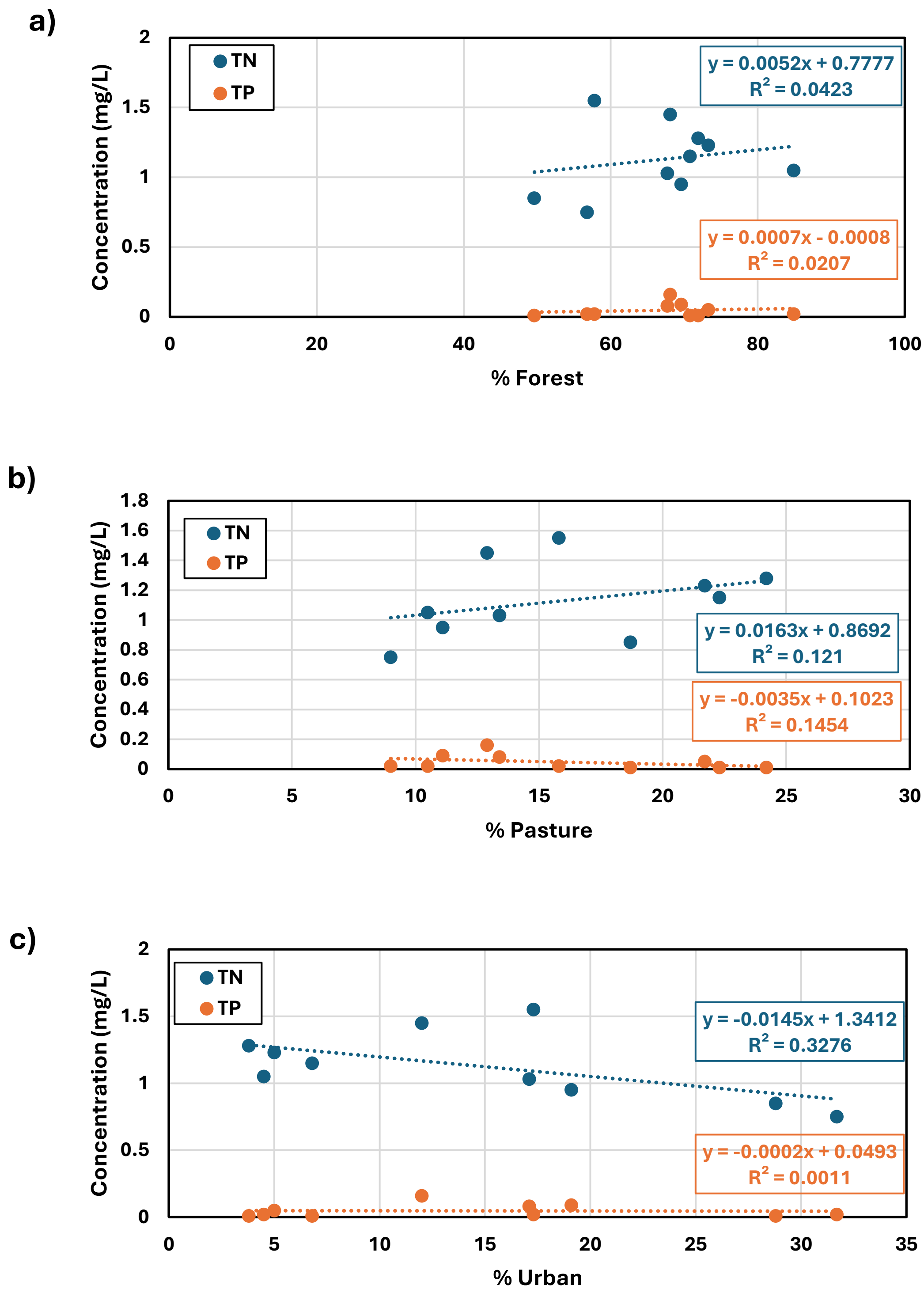

Figure A2. Regression plots of Lake Taneycomo Watershed (LTW) baseflow total nitrogen (TN) and total phosphorus (TP) concentrations by percentage of land use: a) forest, b) pasture, and c) urban. These relationships were used to estimate baseflow concentrations for Table Rock Lake Watershed (TRLW) HUC-12s.

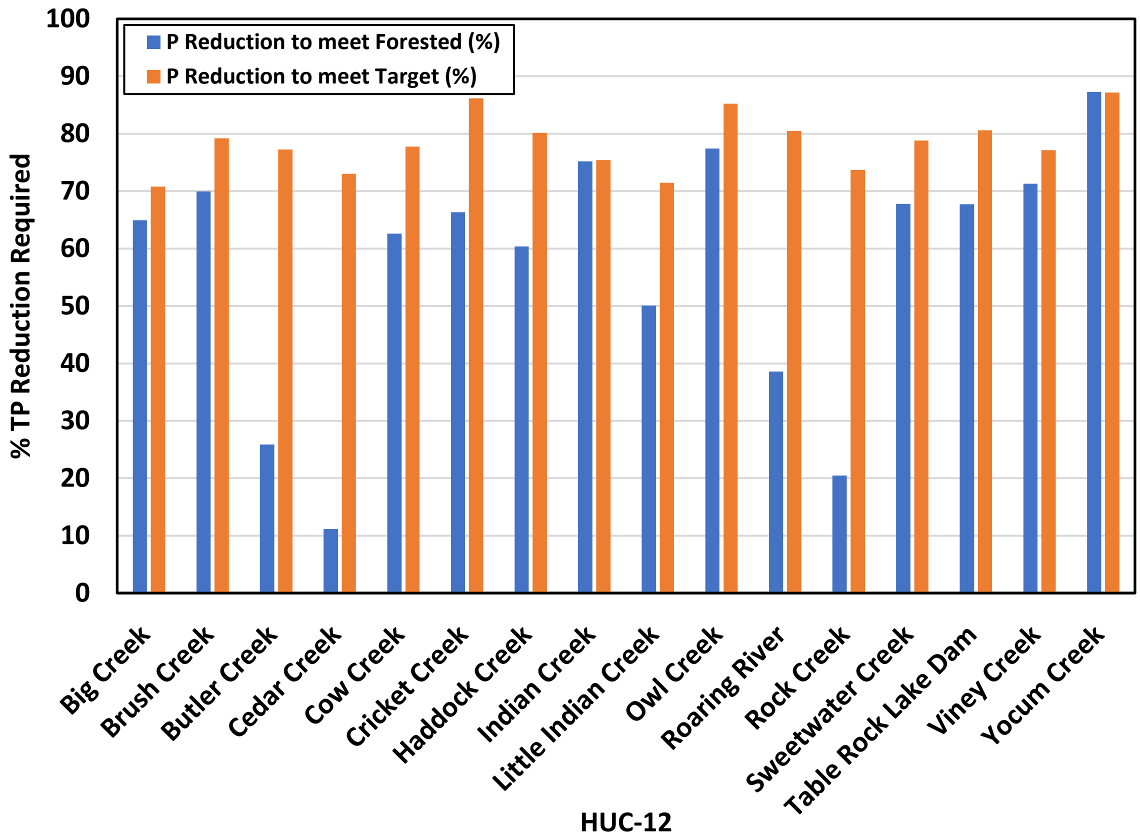

Figure A3. Percent phosphorus reductions required to meet the eutrophic target threshold compared to the all-forested background target.

APPENDIX A. APPENDIX TABLES

Table A1. STEPL HUC-12 Land Use Acreage.

HUC-12	MO Area (ac)	Urban (ac)	Cropland (ac)	Pasture (ac)	Forest (ac)	Water (ac)	Barren Land (ac)
Big Cr	30,657	2,919	-	3,100	17,256	7,309	72
Brush Cr	21,890	2,760	-	2,903	11,194	4,919	115
Butler Cr	11,112	559	-	1,045	9,505	-	3
Cedar Cr	3,755	64	-	139	3,553	-	
Cow Cr	26,020	3,379	-	1,355	13,963	7,148	174
Cricket Cr	5,348	481	-	823	3,533	458	54
Haddock Cr	6,291	510	-	1,302	3,556	915	10
Indian Cr	10,446	767	-	2,690	6,315	658	16
Little Indian Cr	10,582	742	-	882	8,544	385	30
Owl Cr	6,359	558	-	2,169	2,996	624	12
Roaring River	43,364	1,903	-	8,973	32,051	365	72
Rock Cr	23,251	482	-	1,228	21,302	235	3
Sweetwater Cr	15,249	1,390	-	4,038	7,730	2,071	21
Table Rock Dam	17,197	2,691	-	1,048	8,373	4,951	135
Viney Cr	11,855	1,291	35	3,294	5,332	1,849	54
Yocum Cr	1,080	113	-	893	75	0	0
TOTAL	244,456	20,608	35	35,882	155,277	31,885	769

Table A2. STEPL Septic Inputs.

Watershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %
Big Creek	912	2	0.39
Brush Creek	949	2	0.39
Butler Creek	93	2	0.37
Cedar Creek	57	2	0.30
Cow Creek	1773	2	0.39
Cricket Creek	119	2	0.31
Haddock Creek	239	2	0.33
Indian Creek	169	2	0.39
Little Indian Creek	190	2	0.38
Owl Creek	117	2	0.37
Roaring River	526	2	0.39
Rock Creek	130	2	0.39
Sweetwater Creek	294	2	0.38
Table Rock Dam	1099	2	0.39
Viney Creek	321	2	0.39
Yocum Creek	10	2	0.32

Table A3. STEPL Livestock Inputs.

Watershed	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck
Big Creek	1,005	42	3	14	30	-	-	2
Brush Creek	823	30	7	11	26	46,996	7,254	2
Butler Creek	621	14	2	9	14	103,003	7,260	1
Cedar Creek	133	1	0	2	3	-	-	0
Cow Creek	321	16	1	4	11	-	-	1
Cricket Creek	275	1	3	5	10	20,222	5,845	0
Haddock Creek	334	10	1	5	8	-	-	0
Indian Creek	987	31	2	14	27	75,075	10,963	2
Little Indian Creek	1,360	13	5	22	26	163,333	21,555	1
Owl Creek	1,007	18	3	15	20	-	-	1
Roaring River	3,275	115	12	46	84	619,743	31,399	3
Rock Creek	537	19	2	8	14	-	-	1
Sweetwater Creek	2,124	40	7	33	45	304,628	28,863	1
Table Rock Dam	248	12	1	3	9	-	-	1
Viney Creek	1,160	41	4	16	30	-	-	1
Yocum Creek	359	2	1	6	6	45,665	5,964	0
Total	14,570	405	56	212	362	1,378,666	119,102	16

Table A4. STEPL Soil Inputs.

		Cropland		Pastureland		Forest		User Defined	
HUC-12	HSG	K	LS	K	LS	K	LS	K	LS
Big Creek	C	0.319	1.688	0.466	1.924	0.455	3.756	0.451	2.555
Brush Creek	C	0.319	1.688	0.412	3.674	0.424	5.335	0.407	3.601
Butler Creek	C	0.319	1.688	0.421	1.762	0.417	9.221	0.240	0.144
Cedar Creek	C	0.319	1.688	0.389	1.116	0.447	5.617	0.319	1.688
Cow Creek	C	0.319	1.688	0.409	2.928	0.427	4.442	0.425	2.608
Cricket Creek	C	0.319	1.688	0.473	3.381	0.427	5.304	0.454	3.587
Haddock Creek	C	0.319	1.688	0.506	1.621	0.483	4.600	0.498	2.723
Indian Creek	C	0.319	1.688	0.434	1.562	0.411	2.674	0.476	1.665
Little Indian Creek	C	0.319	1.688	0.421	2.201	0.422	4.237	0.414	2.023
Owl Creek	C	0.319	1.688	0.511	2.108	0.513	3.485	0.549	1.243
Roaring River	C	0.319	1.688	0.433	1.822	0.456	9.034	0.313	2.293
Rock Creek	C	0.319	1.688	0.459	2.025	0.512	6.922	0.504	5.817
Sweetwater Creek	C	0.319	1.688	0.518	1.572	0.515	4.185	0.513	2.312
Table Rock Dam	C	0.319	1.688	0.418	3.514	0.432	4.402	0.401	3.642
Viney Creek	C	0.511	0.905	0.485	1.207	0.501	3.425	0.505	2.839
Yocum Creek	C	0.319	1.688	0.461	0.878	0.449	1.736	0.490	0.828

Table A5. USGS Gages used for analysis of runoff volume.

Gage Name	USGS Gage #	Drainage Area (mi^2)
War Eagle Creek Near Hindsville, AR	07049000	263
Kings River Near Berryville, AR	07050500	527
Yocum Creek Near Oak Grove, AR	07053250	52
White River Near Fayetteville, AR	07048600	400
West Fork White River East Of Fayetteville, AR	07048550	123
Flat Creek Below Jenkins, MO	07052820	274
James River At Galena, MO	07052500	987
Big Sugar Creek Near Powell, MO	07188653	141
Beaver Creek At Bradleyville, MO	07054080	298
Crooked Creek At Kelly Crossing At Yellville, AR	07055607	398
Little Sugar Creek Near Pineville, MO	07188838	195
Spring River At La Russell, MO	07185700	306
Finley Creek Below Riverdale, MO	07052345	261
James River Near Springfield, MO	07050700	246
James River Near Boaz, MO	07052250	462
Wilson Creek Near Brookline, MO	07052125	51
South Creek Near Springfield, MO	07052120	10
Wilson Creek Near Springfield, MO	07052100	31
James River Near Springfield, MO	07050700	246

Table A6. Nutrient (lb/ac/yr) and sediment (t/ac/yr) yields for TRLW HUC-12s by land use, with the range of EC values described in White et al (2015) noted.

HUC-12	**Urban**			**Cropland**			**Pasture**			**Forest**		
	TN	**TP**	**S**	**TN**	**TP**	**S**	**TN**	**TP**	**S**	**TN**	**TP**	**S**
Big Creek	9.5	1.5	0.2	0	0	0	7.8	1.6	0.9	0.7	0.2	0.1
Brush Creek	9.6	1.5	0.2	0	0	0	10.3	2.6	1.7	0.8	0.3	0.2
Butler Creek	10.3	1.6	0.2	0	0	0	8.3	1.7	0.9	1.4	0.5	0.4
Cedar Creek	10.0	1.5	0.2	0	0	0	7.4	1.4	0.7	1.2	0.4	0.3
Cow Creek	9.2	1.4	0.2	0	0	0	8.8	2.1	1.3	0.7	0.2	0.2
Cricket Creek	9.1	1.4	0.2	0	0	0	12.3	3.5	2.4	1.0	0.3	0.3
Haddock Creek	9.5	1.5	0.2	0	0	0	8.7	2.0	1.2	1.0	0.3	0.2
Indian Creek	9.2	1.4	0.2	0	0	0	7.4	1.5	0.9	0.6	0.2	0.1
L. Indian Creek	9.4	1.4	0.2	0	0	0	8.5	1.9	1.2	0.8	0.2	0.2
Owl Creek	9.4	1.4	0.2	0	0	0	9.8	2.4	1.6	0.9	0.3	0.2
Roaring River	7.6	1.2	0.2	0	0	0	6.2	1.3	0.7	1.1	0.4	0.3
Rock Creek	9.7	1.5	0.2	0	0	0	8.1	1.7	1.0	1.1	0.4	0.3
Sweetwater Creek	9.5	1.5	0.2	0	0	0	8.0	1.7	1.0	0.9	0.3	0.2
Table Rock Lake Dam	9.4	1.4	0.2	0	0	0	10.5	2.7	1.8	0.8	0.2	0.2
Viney Creek	9.4	1.4	0.2	21.6	5	3.0	7.1	1.4	0.8	0.8	0.2	0.2
Yocum Creek	9.2	1.4	0.2	0	0	0	7.3	1.5	0.8	0.6	0.2	0.1
(White et al., 2015) ECs	*4.3-27.0*	*0.3-1.9*	*0.2-1.2*	*7.4-43.1*	*0.5-4.5*	*0.4-5.2*	*0.4-4.9*	*0.1-1.2*	*0.0-0.2*	*0.5-2.7*	*0.0-0.1*	*0-0.005*

TN = Total Nitrogen; TP = Total Phosphorus; S = Sediment

Table A7. Baseflow water quality and flow data (1993 – 2018) derived from the USGS Gage at Yocum Creek near Oak Grove, Arkansas (Gage 07053250) used to estimate the baseflow concentration of total nitrogen (N) for the Yocum Creek HUC-12 (average = 3.4 mg/L).

Date	**Total N (mg/L)**	**Flow (cfs)**	**Flow Exceedance (%)**
6/21/2007	3.72	1.3	100%
6/6/2007	3.21	2.26	100%
1/5/2006	2.75	2.92	99%
8/21/2007	2.45	2.99	99%
6/15/2005	3.75	3.08	99%
7/7/2005	3.46	4.57	96%
9/20/2012	2.77	4.61	96%
8/28/2007	2.25	4.99	96%
9/13/2017	3.61	5.07	95%
9/19/2007	2.5	6.05	94%
11/6/2012	4.98	6.55	92%
10/30/2007	2.94	6.67	92%
11/9/2005	2.62	6.71	92%
8/18/2005	2.46	7.47	90%
7/25/2006	2.02	7.55	90%
7/24/2007	3.29	7.8	89%
12/14/2016	4.2	8.55	86%
9/6/2006	1.44	8.64	86%
12/3/2008	4.92	8.95	85%
8/25/2004	3.29	9.1	84%
1/10/2013	4.37	9.27	83%
6/27/2006	2.72	9.28	83%
1/14/2004	4.99	9.4	83%
1/13/2011	4.19	9.65	81%
11/2/2017	4.23	9.88	80%
8/17/2010	4.05	9.94	80%
6/30/2009	4.59	10.5	78%
8/31/2011	3.25	10.7	78%
10/13/2004	3.39	10.8	77%
12/9/2010	4.54	10.8	77%
7/10/2012	3.05	10.9	77%

Appendix Table A8. Baseflow water quality data (1994 – 2017) derived from the USGS Gage at Yocum Creek near Oak Grove, Arkansas (Gage 07053250) used to estimate the baseflow concentration of total phosphorus (P) for the Yocum Creek HUC-12 (average = 0.05 mg/L).

Date	Total P (mg/L)	Flow (cfs)	Flow Exceedance
8/16/1994	0.04	10	80%
9/13/1994	0.02	8.4	87%
10/18/1994	0.05	7.6	89%
8/22/1996	0.04	6.8	92%
9/19/1996	0.04	8.6	86%
2/10/1998	0.05	3	99%
9/10/1998	0.03	7.8	89%
10/21/1998	0.04	9.7	81%
11/19/1998	0.04	10	80%
9/7/1999	0.051	9.2	84%
10/21/1999	0.041	7.7	89%
11/17/1999	0.039	5.9	94%
12/21/1999	0.035	10	80%
10/11/2000	0.047	8	88%
6/26/2001	0.042	6.9	91%
7/17/2001	0.043	9.8	81%
8/16/2001	0.05	6.1	93%
11/20/2001	0.035	9.36	83%
9/10/2002	0.061	9.22	83%
11/26/2002	0.046	9.04	84%
7/8/2003	0.06	6.46	93%
9/3/2003	0.054	10.1	79%
1/14/2004	0.03	9.4	83%
8/25/2004	0.045	9.1	84%
10/13/2004	0.046	10.8	77%
6/15/2005	0.061	3.08	99%
7/7/2005	0.058	4.57	96%
8/18/2005	0.05	7.47	90%
11/9/2005	0.04	6.71	92%
1/5/2006	0.028	2.92	99%
6/27/2006	0.05	9.28	83%
7/25/2006	0.044	7.55	90%
9/6/2006	0.038	8.64	86%
6/6/2007	0.043	2.26	100%
6/21/2007	0.063	1.3	100%
7/24/2007	0.049	7.8	89%

Date	Total P (mg/L)	Flow (cfs)	Flow Exceedance
8/21/2007	0.047	2.99	99%
8/28/2007	0.044	4.99	96%
9/19/2007	0.04	6.05	94%
10/30/2007	0.042	6.67	92%
12/3/2008	0.055	8.95	85%
6/30/2009	0.092	10.5	78%
8/17/2010	0.073	9.94	80%
12/9/2010	0.051	10.8	77%
1/13/2011	0.038	9.65	81%
8/31/2011	0.079	10.7	78%
7/10/2012	0.067	10.9	77%
9/20/2012	0.051	4.61	96%
11/6/2012	0.047	6.55	92%
1/10/2013	0.037	9.27	83%
12/14/2016	0.058	8.55	86%
9/13/2017	0.083	5.07	95%
11/2/2017	0.078	9.88	80%

Appendix Table A9. Water quality data collected between 1996 and 2018, which were derived from the MODNR Water Quality Database (Station ID: MDNR-2416/6.5/0.5) and used to estimate the baseflow concentrations of total nitrogen (N) and total phosphorus (P) for the Roaring River HUC-12 (Average N = 3.2 mg/L; P = 0.03 mg/L).

Date	Flow (cfs)	TN (mg/L)	TP (mg/L)
8/5/1996	13.0	2.90	0.01
1/27/2003	15.0	3.18	0.02
7/29/2003	13.0	3.00	0.03
9/15/2003	13.0	2.90	0.02
9/7/2004	14.0	3.28	0.02
11/8/2005	13.0	3.23	0.02
1/18/2006	7.2	3.21	0.02
3/13/2006	11.0	2.98	0.02
9/11/2006	7.2	3.51	0.02
10/24/2006	13.0	3.38	0.04
11/14/2006	8.0	3.19	0.03
12/11/2006	12.0	3.11	0.04
5/30/2007	13.0	3.19	0.03
7/23/2007	12.0	3.32	0.04
8/8/2007	9.3	3.36	0.04
11/26/2007	13.0	4.13	0.03
1/24/2011	13.0	3.60	0.05
9/12/2012	11.0	3.80	0.03
1/14/2013	14.0	1.75	0.03
9/12/2016	14.0	4.00	0.03
10/15/2018	8.0	1.95	0.01

Appendix Table A10. Estimated baseflow concentrations of total nitrogen (N) and phosphorus (P) for each Table Rock Lake HUC-12, calculated from Lake Taneycomo WMP baseflow data using land use regressions (% forest, % urban, % pasture) with equations shown below. Roaring River and Yocum Creek HUC-12s were excluded due to available local baseflow data. Underlined values indicate averages used for load reduction calculations.

	Estimated TN (mg/L)				**Estimated TP (mg/L)**			
Watershed	**Urban**	**Pasture**	**Forest**	***Average***	**Urban**	**Pasture**	**Forest**	***Average***
Big Creek	1.16	1.09	1.16	*1.14*	0.05	0.06	0.05	*0.05*
Brush Creek	1.11	1.15	1.12	*1.13*	0.05	0.04	0.05	*0.04*
Butler Creek	1.27	1.02	1.22	*1.17*	0.05	0.07	0.06	*0.06*
Cedar Creek	1.32	0.93	1.27	*1.17*	0.05	0.09	0.07	*0.07*
Cow Creek	1.08	0.99	1.16	*1.08*	0.05	0.08	0.05	*0.06*
Cricket Creek	1.21	1.14	1.16	*1.17*	0.05	0.04	0.05	*0.05*
Haddock Creek	1.21	1.26	1.12	*1.20*	0.05	0.02	0.05	*0.04*
Indian Creek	1.23	1.32	1.11	*1.22*	0.05	0.01	0.04	*0.03*
Little Indian Creek	1.24	1.01	1.21	*1.16*	0.05	0.07	0.06	*0.06*
Owl Creek	1.20	1.48	1.05	*1.24*	0.05	-0.03	0.04	*0.02*
Rock Creek	1.31	0.96	1.26	*1.18*	0.05	0.08	0.06	*0.07*
Sweetwater Creek	1.19	1.37	1.08	*1.21*	0.05	-0.01	0.04	*0.03*
Table Rock Dam	1.02	1.01	1.13	*1.05*	0.04	0.07	0.05	*0.05*
Viney Creek	1.16	1.41	1.05	*1.21*	0.05	-0.01	0.04	*0.02*
Regression Equation	*y = -0.0145x + 1.3412*	*y = 0.0163x + 0.8692*	*y = 0.0052x + 0.7777*	-	*y = -0.0002x + 0.0493*	*y = -0.0035x + 0.1023*	*y = 0.0007x - 0.0008*	-