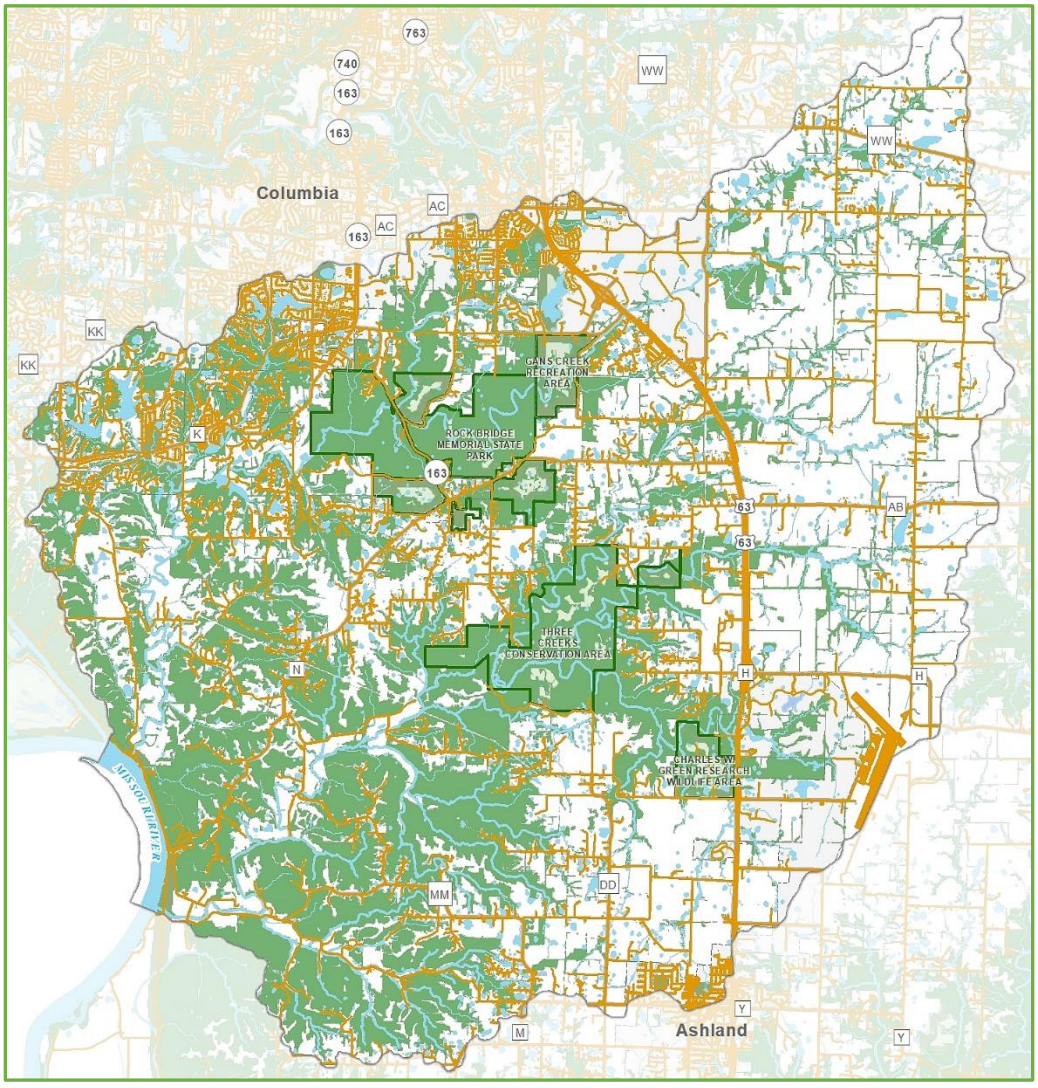
GREATER BONNE FEMME WATERSHED-BASED PLAN

June 12, 2023



To address impairments in:
Bass Creek, Bonne Femme Creek and Turkey Creek – HUC: 10300102-0902
Gans Creek and Little Bonne Femme Creek – HUC: 10300102-0903

Prepared by Boone County Resource Management and Project Partners

Acknowledgements

USDA / ARS, and specifically Dr. Robert Lerch, for supporting this project from the beginning. Dr. Lerch was involved with the Greater Bonne Femme Watershed (GBFW) for many years. He conducted water quality monitoring at 10 sites in the GBFW over an extended period of time, giving us a baseline for levels of various constituents as discussed in this watershed-based plan (WBP). Bob was also instrumental in developing the water quality QAPP for this project. The project partners are grateful for his contributions and insight.

Roxie Campbell, Park Naturalist for Rock Bridge Memorial State Park, who has been involved with stewardship of this watershed for decades.

Boone County Regional Sewer District for the use of their laboratory for *E. coli* analysis.

The Technical Advisory Team, comprised of local, state and federal government and agency partners, as well as local landowners and non-governmental organizations, was instrumental in assisting project partners with evaluating the impaired waters in the GBFW and determining the path forward for drafting and implementation of the watershed-based plan. The Steering Committee consists of local government partners who have and will continue to provide policy support to facilitate implementation of the WBP. Members of the Technical Advisory Team and Steering Committees are listed below:

Amelia Cottle, landowner
Bryan Mayhan, University of Missouri and private soil scientist
Boone County Commission
Boone County Regional Sewer District
Boone County Soil and Water Conservation District
City of Ashland, Missouri
City of Columbia, Missouri
Columbia / Boone County Health Department
Emily Wright, local producer and Board Member of Greenbelt Land Trust
Greenbelt Land Trust
Missouri Department of Conservation
Missouri Department of Natural Resources / Section 319 and TMDL Teams
Missouri Stream Teams
Fred Parry, former Boone County Southern District Commissioner
Rock Bridge Memorial State Park
University of Missouri Extension
United States Department of Agriculture / Agricultural Research Service
United States Geological Survey / Columbia Education and Research Facility
University of Missouri-Columbia

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Vision Statement

The 2007 Bonne Femme Watershed Plan included a vision statement for the watershed:

> In the year 2030, we envision a watershed where quality of life and economic vitality are fostered by maintaining or improving the current conditions of the water resources, having a mix of land uses and development types, and maintaining thriving agricultural activities.

As we move forward, with an updated 9-element plan framework, it is important to note that our efforts remain true to this vision.

Executive Summary

Introduction

Boone County and project partners, including local government, state and federal agency, non-governmental organization, and local landowner partners, initiated the current Greater Bonne Femme Watershed (GBFW) Project to develop a watershed-based plan that contains EPA's nine critical planning elements for Bonne Femme and Little Bonne Femme subwatersheds (Hydrologic Unit Code #s 103001020902 and 103001020903). The plan was developed to help improve and protect water quality in the watershed by identifying pollutant sources, identifying better management practices to be implemented, setting reachable goals and a timeline for implementation projects, and establishing an evaluation and monitoring program. The project also implemented a best management practice (BMP) demonstration project to inform the public about practices that can be installed to address the streams' bacteria impairment.

Background

The Greater Bonne Femme Watershed (GBFW), which includes the Bonne Femme and Little Bonne Femme subwatersheds, along with their tributaries, is the focus of this project. The GBFW lies in southern Boone County, between the cities of Columbia and Ashland. GBFW tributaries include Bass Creek, Turkey Creek, Fox Hollow Branch, Smith Branch, Devil's Icebox Branch, Gans Creek, Clear Creek, and Mayhan Creek (Figure ES-1). The geographic area of the GBFW comprises 92.4 square miles. Major land uses include row cropping, livestock grazing, residential development, and recreation. Threats to stream and water quality include the collapse of stream banks; deforestation of riparian areas; microbial contamination from on-site sewage systems; sediments, nutrients and pesticides in stormwater runoff from residential, commercial, and industrial sites; animal wastes in stormwater runoff from pastures; and sediments, nutrients, and pesticides in stormwater runoff from row crops. Streams within the watershed have been shown to have fecal coliform levels in excess of current whole body contact Water Quality Standard criteria. Currently, there are five (5) streams in the Greater Bonne Femme Watershed (GBFW) that are on the Clean Water Act Section 303(d) list of impaired waters for exceeding the *E. coli* bacteria water quality standard criteria (Table ES-1).

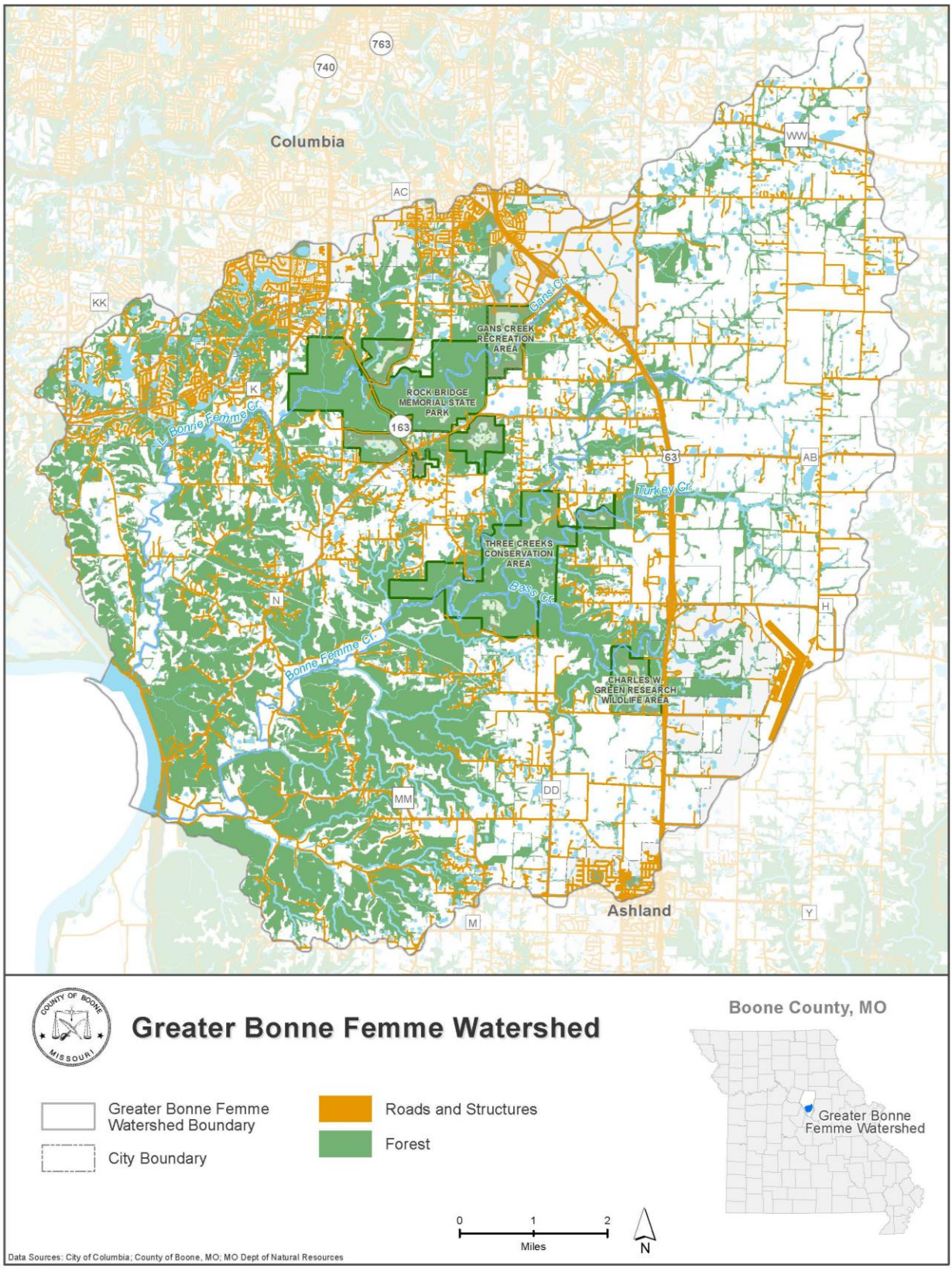

Figure ES-1. The Greater Bonne Femme Watershed in Boone County, Missouri.

Table ES-1. Impaired waterbody information for the Greater Bonne Femme Watershed.

Waterbody	WBID	Year First Listed	Class*	Impaired Use	WBID Size (miles)	HUC 12
Bonne Femme Creek (lower)	750	2006	P	WBC A	7.8	10300102-0902
Turkey Creek	751	2012	C	WBC A	6.3	10300102-0902
Bass Creek	752	2012	C	WBC A	4.4	10300102-0902
Bonne Femme Creek (upper)	753	2012	C	WBC B	7.0	10300102-0902
Little Bonne Femme Creek	1003	2012	P	WBC B	9.0	10300102-0903
Gans Creek	1004	2012	C	WBC A	5.5	10300102-0903

Land use / land cover is mixed in the GBFW but is predominantly in agricultural use (Table ES-2). Recent trends show rapid development in the cities of Ashland (south) and Columbia (north), Missouri, where population growth has increased by 40 percent over the last 10 years. Building density and overall impervious surface area has increased in the watershed over time. Recently, several large tracts of land that were formerly in agricultural production have been converted to planned residential developments or single-family dwellings on 2.5 to 10-acre lots. Boone County and project partners wanted to consider the potential impact of these new and future developments on natural communities and ecosystems in the GBFW and strive to foster watershed management that invests in the environment which will allow communities and their economies to grow and thrive.

Table ES-2. Existing land cover breakdown for the Greater Bonne Femme Watershed.

Land Use	Percent Land Use (%)
Urban	9
Cultivated Crops	13
Pasture/Hay	33
Forest	43
Other	2

Goals of the Watershed-based Plan

Boone County and project partners worked to develop the watershed-based plan with the following goals:

1) Restoration, Protection, and Adaptive Management

   The two themes of the WBP, restoration and protection, will be achieved using adaptive management methods. Interdisciplinary approaches incorporating science (physical, biological, chemical, economic, and social) and policy will be used in an adaptive manner to address the unique challenges and opportunities presented by restoration and protection strategies and changing conditions over time.

2) Integration of the WBP implementation with the Municipal Separate Storm Sewer System (MS4) permit held jointly by Boone County, the City of Columbia, and the University of Missouri; any future Section 319 grant funded projects will be above and beyond all MS4 permit requirements.

3) Ratification of the WBP by the City of Columbia, the City of Ashland, and the University of Missouri, with a dual objective of promoting increased uniformity of stormwater and building regulations, and improving coordination with state and federal agencies to restore and protect water quality throughout incorporated and unincorporated areas of Boone County.

4) Identification and engagement of stakeholders in future conversations about the GBFW and land management impacts at multiple geographic scales through the information and outreach approaches discussed in the WBP. The appeal to stakeholders will be made across the spectrum of value systems, economic circumstances, and political beliefs. It is hoped that a culture of watershed management will be developed and adopted within the GBF, and in other areas of Boone County and beyond.

Approach

Due to the highly interspersed land use types in the GBFW, particularly in portion of the watershed east of Highway 63, a decision was made early on to break the watershed down into smaller subwatersheds to be used in modeling and analysis of loading of *E. coli* and other pollutants of concern (Figure ES-2). After the subwatersheds were delineated, the modeling consultant used a combination of models and various types of available data (land use/land cover, water quality analysis results, location of livestock on the landscape, among others) to calculate estimated pollutant loading in each of the subwatersheds. With this information, the consultant could then assist Boone County and project partners in putting together the watershed-based plan to address the nine elements outlined by the United States Environmental Protection Agency.

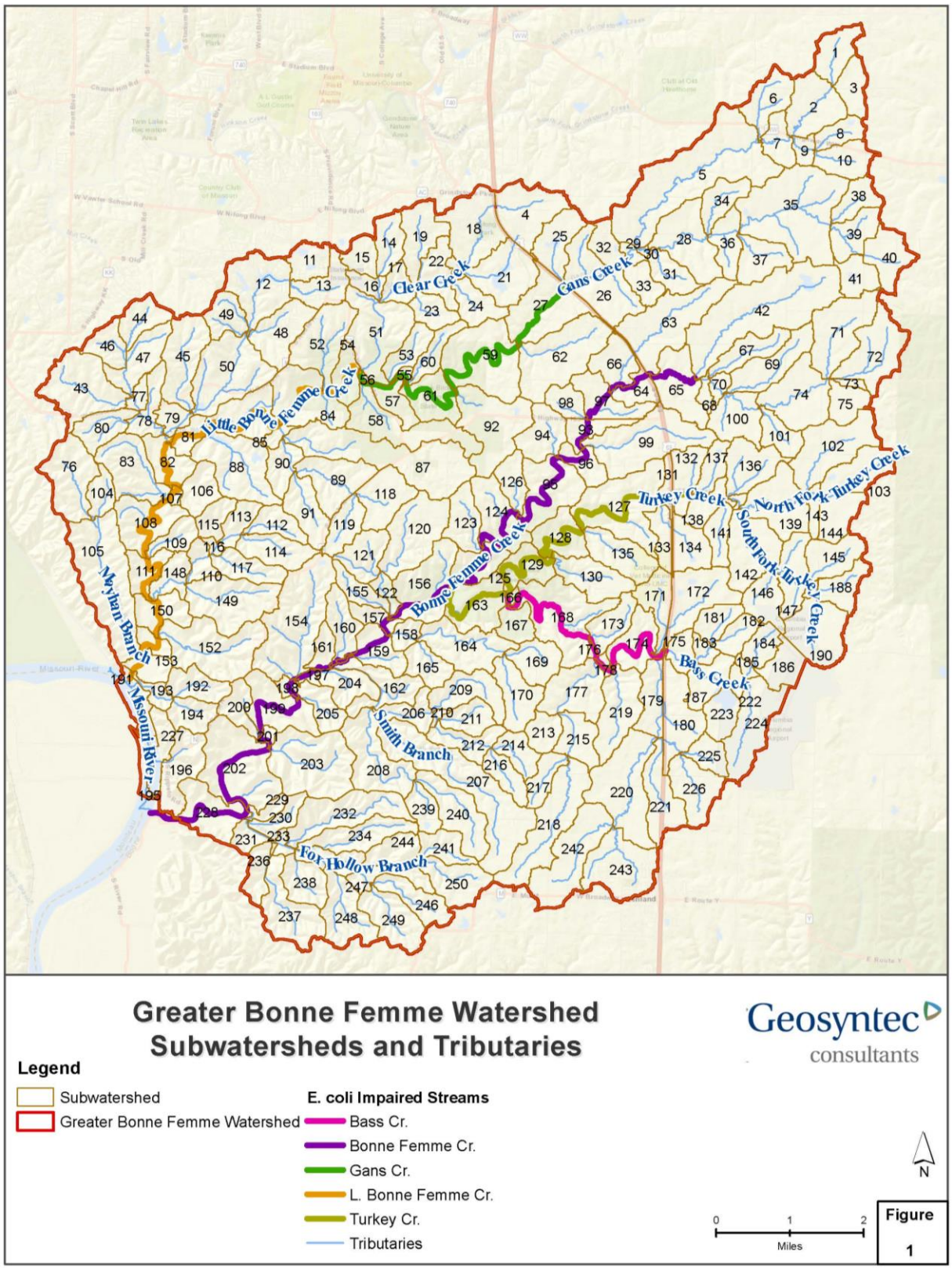

Figure ES-2. The Greater Bonne Femme Watershed subwatershed delineation, with impaired stream segments shown.

The Nine Elements

The United States Environmental Protection Agency has created a list of nine critical elements that need to be addressed in a watershed-based plan.

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

Analysis of available data indicated that various potential non-point sources of *E. coli* were present in the GBFW, including human waste from on-site wastewater systems, animal waste (pet waste, deer, coyote, etc.) and livestock waste (cows in particular). Modeling determined that over 98% of the *E. coli* loading in the GBFW comes from cattle.

Element 2: *Pollutant load reductions expected from the application of management measures in critical areas.*
Element 3: *Description of the management measures that will need to be implemented in the GBFW to achieve the desired reduction in pollutants.*

The modeling consultant used all the available information and modeling results to create a catchment priority index and generate a list of priority subwatersheds in the GBFW. These priority watersheds represent critical areas identified to have the highest pollutant loading which makes them the most significant locations for implementation of best management practices in order to achieve the water quality standard criteria for *E. coli* (Figure ES-3). Additional modeling work was then performed to determine which best management practices would be most effective at load reduction (Table ES-3) and to calculate expected pollutant load reductions from the implementation of best management practices in the critical areas (Table ES-4). Based on comparison shown in Table ES-4 of the estimated load reductions with the estimated load reduction needed to meet the plan's restoration goal of attainment of Water Quality Standards criteria for *E. coli*, it is estimated that 90% implementation of recommended BMPs over the modeled 21-year time frame will provide sufficient *E. coli* load reductions to allow GBFW streams to meet those water quality criteria.

Boone County and project partners will work to engage landowners and other stakeholders to encourage voluntary implementation of the recommended best management practices on privately owned land. Funding to help producers and other stakeholders implement these practices is available through state and federal cost-share programs and grant funding.

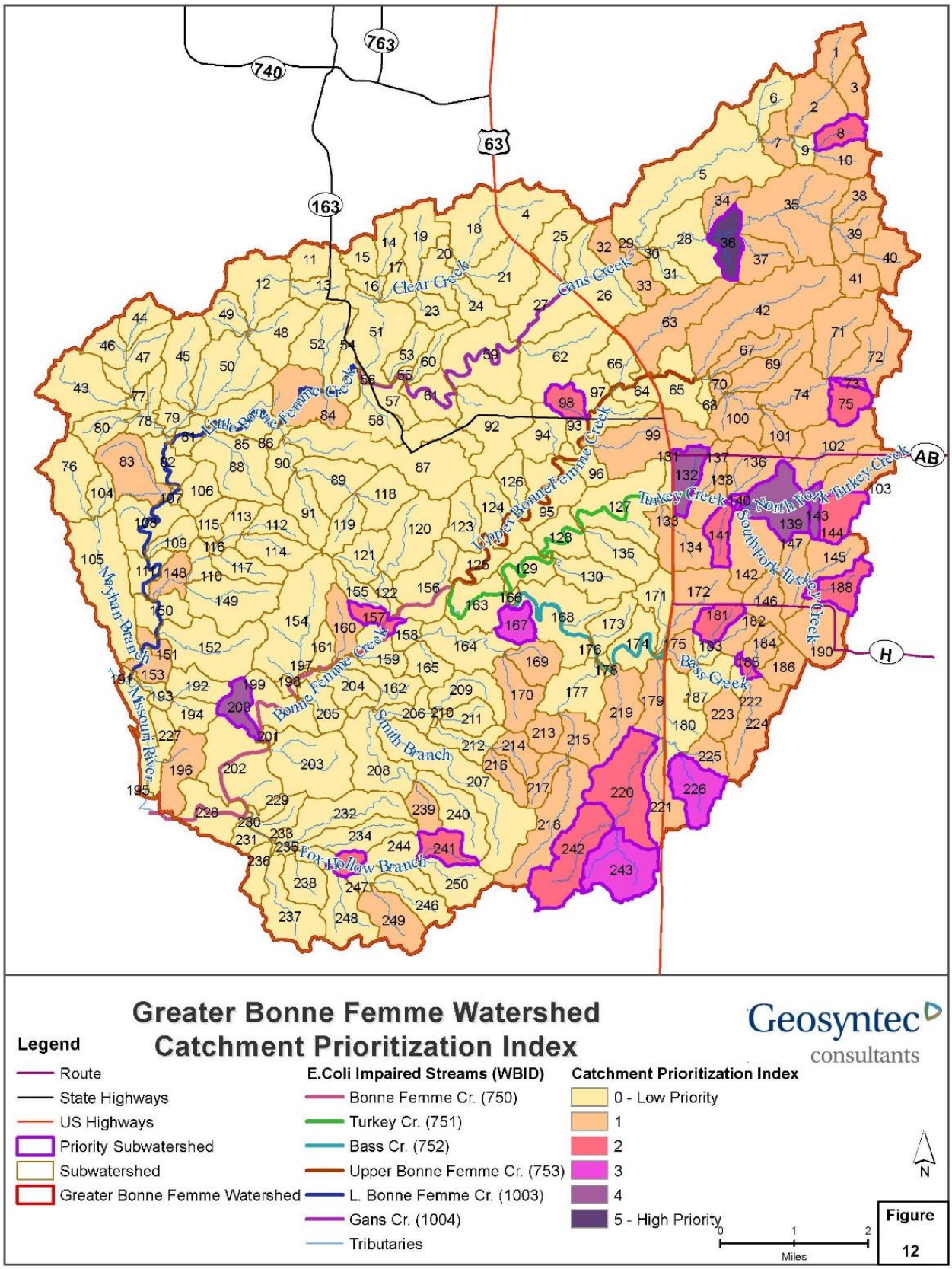

Figure ES-3. Greater Bonne Femme Watershed Catchment Prioritization Index.

Table ES-3. Watershed-wide best management practice recommendations for the Greater Bonne Femme Watershed.

Targeted Subwatershed ID	Area (ac)	CPI Score	Primary Watershed-Wide BMP (Applicable location in subwatershed[1])	Alternative Watershed-Wide BMP (Applicable location in subwatershed[1])
8[2]	114	2	Livestock exclusion/ Alternative source of water (P)	Vegetated Buffer with Trees (S)
36[2]	185	5	Fencing (P)	Grazing Management (P)
73	25	2	Vegetated Buffer (C, S)	Streambank buffer[3] (S)
75	156	2	Streambank buffer[3] (S)	Vegetated buffer (C, S)
98	124	2	Streambank buffer[3] (S)	Vegetated buffer (S)
132	189	4	Grazing management (P)	Fencing (P)
139	356	4	Fencing (P)	Grazing Management (P)
140[2]	20	2	Vegetated Buffer (C)	Retention pond (C)
141[2]	143	2	Vegetated Buffer with Trees (S)	Streambank buffer[3] (S)
143	70	4	Grazing management (P)	Fencing (P)
144[2]	202	2	Livestock exclusion/ Alternative source of water (P)	Vegetated Buffer with Trees (S)
157	97	2	Grazing management (P)	Fencing (P)
167	135	3	Grazing management (P)	Fencing (P)
181	145	2	Vegetated Buffer (C)	Maintain existing BMPs in accordance with the SWPP (U)
185[2]	37	2	Vegetated Buffer (C)	Retention pond (C)
188[2]	177	2	Vegetated Buffer (C)	Retention pond (C)
189[2]	23	2	Vegetated Buffer (C)	Retention pond (C)
200	144	4	Grazing management (P)	Fencing (P)
220	560	2	Vegetative filter strip (P)	Livestock exclusion/ Alternative source of water (P, S)
226	288	3	Vegetative filter strip (P)	Livestock exclusion/ Alternative source of water (P, S)
241	159	2	Grazing management (P)	Fencing (P)
242	487	2	Vegetative filter strip (P)	Livestock exclusion/ Alternative source of water (P)
243	429	3	Bioretention Basin (U)	Detention Pond (U)
245	75	2	Grazing Management (P)	Fencing (P)

[1] Applicable location in subwatershed: P – Pasture, C – Cropland, S – Stream bank, U – Urban

[2] Several subwatersheds have been identified as appropriate for additional BMPs to focus on the protection goal of the WBP. Additional BMPs to be considered in cropland areas of these subwatersheds include Conservation Agriculture practices, i.e. those that focus on reducing NPS pollutant loading in general, and soil health, regenerative agriculture, and agroforestry in particular.

[3] This may be a riparian buffer, vegetative buffer or reinforcing the existing tree line in the vicinity of stream bank.

Table ES-4. Results of BMP Implementation: Comparison of estimated post-implementation E. coli concentrations to WQS criteria, and comparison of Target Load Reductions needed for E.coli WQS attainment (as determined by Load Duration Curve Analysis), with Estimated Load Reduction for E. coli through the implementation of Primary and Alternative BMPs recommended in the Greater Bonne Femme Watershed-Based Plan; relevant values are highlighted to facilitate comparison of estimated load reductions with the most conservative target load reduction for each impaired stream. See Appendix I Load Duration Curves and Pollutant Reduction Estimates for Six Impaired Streams in Boone County, Missouri for current existing E. coli loads.

WBID	Water Body Name	WQS (cfu/100ml)	Target Load Reduction Range (cfu/day)	Implementation Phase	Estimated Load Reduction for Primary BMPs (cfu/day)	Estimated E. coli Concentration at End of Primary BMP Implementation Phase (cfu/100ml)	Estimated Load Reduction for Alternative BMPs (cfu/day)	Estimated E. coli Concentration at End of Alternative BMP Implementation Phase (cfu/100ml)
750	Bonne Femme Cr.	126	1.15E+09 to 1.45E+13	30% of BMP Implementation	8.48E+12	2164.73	6.81E+12	2727.82
				60% of BMP Implementation	1.70E+13	0	1.36E+13	438.34
				90% of BMP Implementation	2.54E+13	0	2.04E+13	0
751	Turkey Cr.	126	1.21E+09 to 2.71E+12	30% of BMP Implementation	7.23E+12	0	5.35E+12	0
				60% of BMP Implementation	1.45E+13	0	1.07E+13	0
				90% of BMP Implementation	2.17E+13	0	1.60E+13	0
752	Bass Cr.	126	0 to 1.96E+12	30% of BMP Implementation	5.52E+12	0	3.66E+12	0
				60% of BMP Implementation	1.10E+13	0	7.32E+12	0
				90% of BMP Implementation	1.66E+13	0	1.10E+13	0
1003	Little Bonne Femme Cr.	206	0 to 1.31E+12	30% of BMP Implementation	7.69E+11	420.17	6.59E+11	464.14
				60% of BMP Implementation	1.54E+12	111.94	1.32E+12	199.89
				90% of BMP Implementation	2.31E+12	0	1.98E+12	0
1004	Gans Cr.	126	2.77E+08 to 4.07E+11	30% of BMP Implementation	7.69E+11	0	6.59E+11	0
				60% of BMP Implementation	1.54E+12	0	1.32E+12	0
				90% of BMP Implementation	2.31E+12	0	1.98E+12	0
753	Bonne Femme Cr. (Upper)	206	0 to 4.11E+07	30% of BMP Implementation	1.57E+09	98.01	1.33E+09	101.46
				60% of BMP Implementation	3.15E+09	75.27	2.65E+09	82.47
				90% of BMP Implementation	4.72E+09	52.68	3.98E+09	63.33

Element 4: *Technical and financial assistance that will be needed to implement practices over 21 years.*

Once the best management practices were identified, Boone County worked with project partners to calculate the cost of implementing the best management practices in the GBFW (Table ES-5). Specifically, Boone County worked closely with the Boone County Soil and Water Conservation District to develop the cost estimate and most of the practices recommended will be for land that is in agricultural production. Additional costs of implementation were also calculated and the total cost of watershed-based plan implementation is shown in Table ES-6.

Table ES-5. Cost of BMP implementation in Greater Bonne Femme Watershed over 21-year implementation timeline.

Implementation Cost Category	Phase 1 Years 1-7 (30% implementation)	Phase 2 Years 8-14 (60% implementation)	Phase 3 Years 15-21 (90% implementation)	Total Estimated Cost
Watershed-wide BMP Installation	$135,018.93	$135,018.93	$135,018.93	$405,056.79

Table ES-6. Total cost of watershed-based plan implementation in Greater Bonne Femme Watershed over 21-year implementation time.

Implementation Cost Category	**Phase 1 Years 1-7 (30% implementation)**	**Phase 2 Years 8-14 (60% implementation)**	**Phase 3 Years 15-21 (90% implementation)**	**Total Estimated Cost**
Watershed-wide BMP Installation*	**$135,018.93**	**$135,018.93**	**$135,018.93**	**$405,056.79**
Cover Crops Pilot, Subwatershed 42**	**$14,700.00**	**$29,400.00**	**$44,100.00**	**$88,200.00**
Demonstration Project	**$30,000.00**			**$30,000.00**
Information and Outreach	**$119,950.00**	**$204,950.00**	**$89,950.00**	**$414,850.00**
Septic Pump-out Program	**$6,000.00**	**$6,000.00**	**$6,000.00**	**$18,000.00**
Monitoring	**$68,296.20**	**$68,296.20**	**$68,296.20**	**$204,888.60**
Administrative	**$28,000.00**	**$28,000.00**	**$28,000.00**	**$84,000.00**
Total Estimated Cost	**$401,965.13**	**$471,665.13**	**$371,365.13**	**$1,244,995.39**

*For the most conservative cost estimate, the Watershed-wide BMP Installation estimate is the most costly of the ranges of Primary and Alternative BMP options; BMP cost estimation details are found in Appendix J.
**Max assumes all 70 new cover crop acres installed in first year and existing and new cover crop acres are kept in cover crops throughout each 7-year milestone period. Also assume that $20,000 lifetime cost-share maximum for cover crops per landowner is not met during the 21-year milestone period.

Element 5: *Information and education programs that will lead to enhanced public understanding of water quality problems and solutions, and that will engage interest and participation in implementing BMPs.*

The information and outreach strategy of the watershed-based plan identifies three foundational goals:

1) Increase awareness about water quality and watersheds
2) Strengthen understanding among stakeholders of how land use activities are connected to water quality and flooding
3) Encourage BMP implementation for the protection and improvement of water quality

In order to achieve these goals, Boone County and project partners plan to host and promote a variety of information and outreach events and opportunities on an annual basis. These are as follows:

- Water quality Monitoring Blitz at six sites in and around Rock Bridge Memorial State Park (Spring and Fall of each year)
- Greater Bonne Femme Watershed Festival
- Land Management Workshops
- Promote and offer scholarships for agricultural producer attendance at technical workshops
- Farm tour/consultation with Understanding Ag or similar consultant
- Farm tours of demonstration project and pilot project sites
- Septic Pump-out and Awareness Program
- Maintenance of watershed signs on major roadways in the GBFW
- Promote volunteer water quality monitoring and stream adoption through Missouri Stream Team
- Watershed clean-ups
- Storm drain marking in the GBFW
- Presentations to school and other student groups
- Stormwater Champions program awards presentation
- Frequent update of information on the website

Element 6: *Schedule for implementation of the watershed-based plan.*

Element 7: *Description of the interim milestones for completion of the goals and recommendations of the watershed-based plan.*

Boone County and project partners have developed a schedule for implementation of the watershed-based plan over a 21-year timeline. A summary of the implementation milestones is presented in Table ES-7.

Table ES-7. Greater Bonne Femme WBP Implementation Schedule of Milestones

Implementation Category	**Phase 1 Years 1-7 (30% implementation)**
Watershed-wide BMP Installation	Implementation of 30% of critical area land use area or stream length identified or as close as practicable
Cover Crop Pilot, Subwatershed 42	70 acres of the cropland acres in watershed
Monitoring	7 sites in GBFW, monitored quarterly
Information and Outreach	See list of annual events; Social marketing training and technical assistance
Septic Pump-out and Awareness Program	30 septic pump-outs and/or inspections
Demonstration Project	Installation of demonstration project on Gans Creek at South Farm, University of Missouri
WBP Update	WBP will be reviewed and updated at year 5 of Phase 1
Implementation Category	**Phase 2 Years 8-14 (60% implementation)**
Watershed-wide BMP Installation	Implementation of additional 30% of critical area land use area or stream length identified or as close as practicable
Cover Crops Pilot, Subwatershed 42	70 cropland acres in subwatershed 42 continue in cover crops; 70 additional cropland acres put in cover crops
Monitoring	7 sites in GBFW, monitored quarterly
Information and Outreach	See list of annual events; Return on Environment Study completion
Septic Pump-out and Awareness Program	30 septic pump-outs and/or inspections
Demonstration Project	Ongoing use of demonstration project site for research and education
WBP Update	WBP will be reviewed and updated at year 5 of Phase 2
Implementation Category	**Phase 3 Years 15-21 (90% implementation)**
Watershed-wide BMP Installation	Implementation of additional 30% of critical area land use area or stream length identified or as close as practicable
Cover Crops Pilot, Subwatershed 42	140 cropland acres in subwatershed 42 continue in cover crops; 70 additional acres put in cover crops
Monitoring	7 sites in GBFW, monitored quarterly
Information and Outreach	See list of annual events
Septic Pump-out and Awareness Program	30 septic pump-outs and/or inspections
Demonstration Project	Ongoing use of demonstration project site for research and education
WBP update	WBP implementation success will be assessed at year 5 of Phase 3

Element 8: *Criteria for determining progress in meeting the goals of the watershed-based plan.*

Element 9: *Clearly defined monitoring plan.*

In order to determine the level of progress being made in meeting the goals of the watershed-based plan, particularly progress being made towards attainment of *E. coli* Water Quality Standards criteria, a water quality monitoring program will be put in place during the 21-year implementation timeline.

Stream monitoring will continue at seven sites in the GBFW (one on each of the impaired stream segments, plus a site on the Devil's Icebox Spring Branch, Figure ES-4) quarterly for four weeks per quarter. Water quality samples will be analyzed for *E. coli*, TN, TP and TSS, at a minimum. This monitoring schedule ensures that at least 5 *E. coli* samples will be collected during the recreational season (April 1-October 31) which is important for assessment for CWA Section 303(d) assessment for impairment. If funding permits, storm water samples may be collected during the recreational season. Additionally, with landowner consent, pre- and post-installation edge-of-field monitoring where BMPs are installed will be considered. Where edge-of-field monitoring is not feasible, project partners will rely on monitoring at the seven sites described above to determine BMP effectiveness. Boone County Resource Management will be responsible for monitoring and sample collection, but partnerships, memoranda of understanding, and contracts with vendors for sample analysis are anticipated.

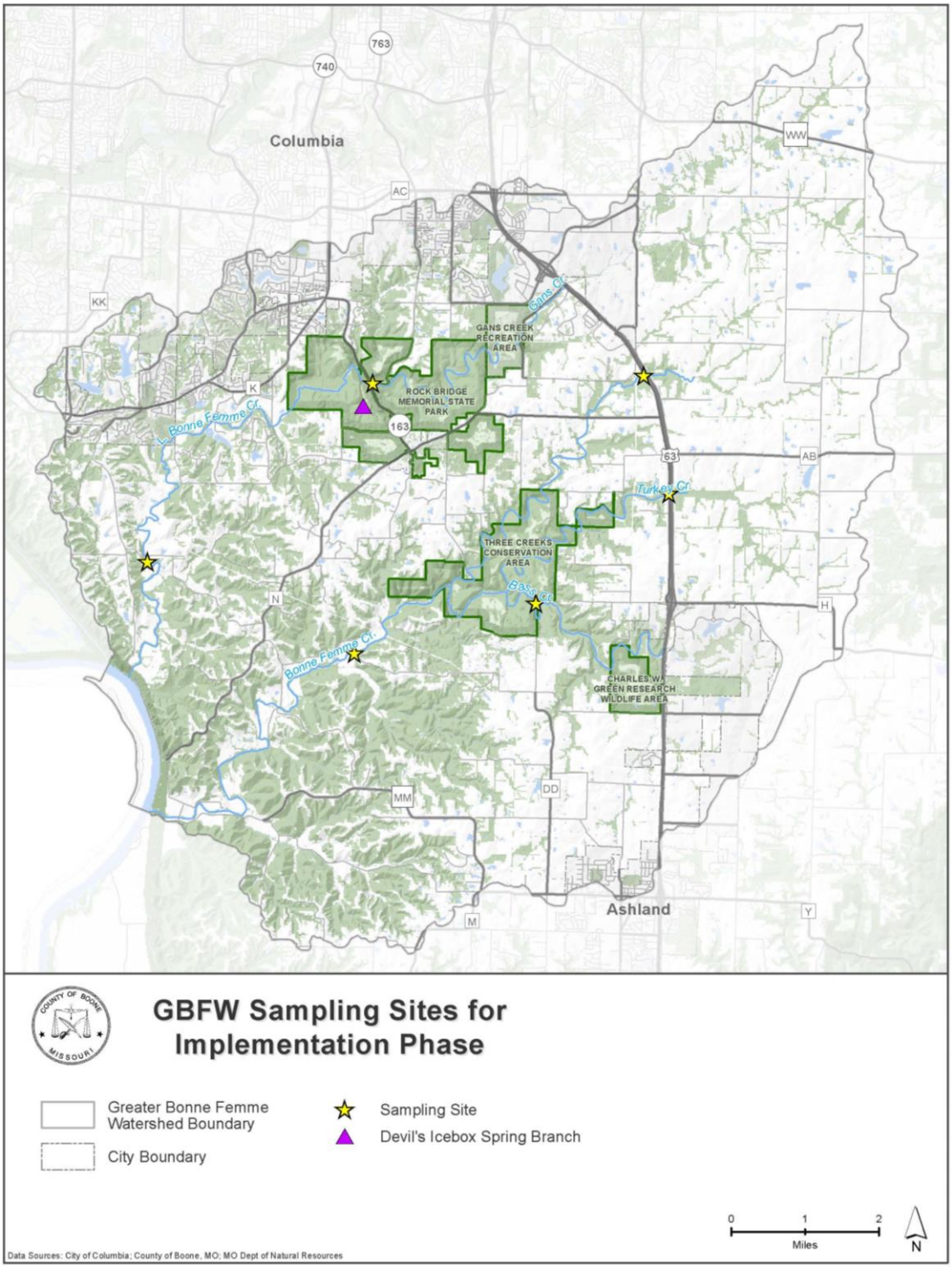

Figure ES-4. Water quality monitoring sites in the Greater Bonne Femme Watershed during the 21-year milestone period.

Boone County Resource Management intends to work with our project partners during the 21-year milestone period to expand existing knowledge about the efficacy of agricultural conservation practices at reducing POC loading. Research connected with the Greater Bonne

Femme Watershed Project and this WBP may be coordinated through a Soil Health Working Group made up of members of the Technical Advisory Team, local producers, and research scientists from the local universities.

Effectiveness of BMPs over time, primarily based upon quantitative results from water quality monitoring with consideration of qualitative input from stakeholders, will be reviewed at three-year (renewal of implementation phase funding), five-year (WBP update and revision), and seven-year (milestones) intervals. The review process will allow for incorporation of adaptive management strategies so that project partners incorporate ever-changing information about the effectiveness of BMPs, particularly given the potential for increased climate variability, moving forward. Any updated watershed-based plan will include analysis of available flow data collected at gauging stations maintained by Boone County on Turkey, Bonne Femme and Little Bonne Femme Creeks.

Table of Contents

Figures

Tables

Glossary

303(d) list – a list of impaired waters generated by the State of Missouri and approved by the U.S. Environmental Protection Agency (EPA)

Acetochlor – an herbicide used in agricultural production

Adaptive Management – a method of management where goals and strategies are periodically adjusted based upon success or failure of previous goals and strategies

Alachlor – an herbicide used in agricultural production

Atrazine – an herbicide used in agricultural production, particularly used on corn within the watershed. It has been demonstrated to be an endocrine disruptor in fish and mammals.

BMP – best management practice; best management practices are methods that have been determined to be the most effective and practical means of preventing or reducing nonpoint source pollution to help achieve water quality goals

Continuous Living Cover Practices – BMPs that promote maintaining living vegetative cover on the landscape for as much of the year as possible

Deethyl-atrazine (DEA) – a breakdown product of atrazine

Deisopropyl-atrazine (DIA) – a breakdown product of atrazine

GBFW – Greater Bonne Femme Watershed, a combination of the Little Bonne Femme Watershed and the Bonne Femme Watershed in Boone County, Missouri.

Impervious – materials that prevent water from flowing through and infiltrating into the soil (concrete and asphalt are typical examples) or compaction of the soil itself

LID – low impact development. LID is governed by the concept that development can have less of an impact on the natural world.

Metolachlor – an herbicide used in agricultural production

Metribuzin – an herbicide used in agricultural production

Pervious – allowing water to flow through and infiltrate into the soil

POC – pollutants of concern

Simazine – an herbicide used in agricultural production; the compound is similar to that of atrazine

TAT – the Technical Advisory Team for the Greater Bonne Femme Watershed Project

TMDL – Total Maximum Daily Load. A document required under the Clean Water Act for all waters identified on a state's 303(d) list of impaired waters. In addition to calculating the maximum amount of a pollutant that a water body can assimilate and still meet water quality standards, it also allocates a portion of that calculated load to point and nonpoint sources. Those allocations become the goals for restoring water quality. Nonpoint sources remain unregulated by the federal or state government with or without a TMDL. For point sources, discharge permits must contain effluent limits or conditions that are consistent with the assumptions and requirements of the TMDL wasteload allocation.

TN – water quality parameter representing the total of all types of nitrogen (nitrate, ammonia, organic nitrogen, etc.)

TP – water quality parameter representing the total of all types of phosphorus

QAPP – Quality Assurance Project Plan. A document entered into with a regulatory agency governing methods of data collection and application.

WBC – Whole Body Contact Recreation. Water Quality Standards designated use for water bodies expected to have activities involving direct human contact with waters of the state to the point of complete body submergence. The water may be ingested accidentally and certain sensitive body organs, such as the eyes, ears, and the nose, will be exposed to the water. Although the water may be ingested accidentally, it is not intended to be used as a potable supply unless acceptable treatment is applied. Waters so designated are intended to be used for swimming, water skiing, or skin diving.

WBC-A – Whole Body Contact Recreation Category A. This Water Quality Standards designated use category applies to waters that have been established by the property owner as public swimming areas welcoming access by the public for swimming purposes and waters with documented existing whole body contact recreational use(s) by the public. Examples of this category include but are not limited to: public swimming beaches and property where whole body contact recreational activity is open to and accessible by the public through law or written permission of the landowner. (upper limit criteria for *E. coli* concentration is defined as a geometric mean of 126 CFU / 100 ml during the recreational season)

WBC-B – Whole Body Contact Recreation Category B. This Water Quality Standards designated use category applies to waters designated for whole body contact recreation. This category includes the same activities as WBC A, but the waters are

not necessarily identified as public swimming areas - land owners may still use them for swimming. (upper limit criteria for *E. coli* concentration is defined as a geometric mean of 206 CFU / 100 ml during the recreational season)

WBP – Watershed-based Plan. A plan that describes how various aspects of a watershed will be managed by stakeholders, including restoration and/or improvement of water quality.

WQS – Water Quality Standards. Water quality standards include criteria codified in state regulations that describe limits for pollutants of concern. They may be upper or lower limits depending upon the standard. WQS include designated uses, water quality criteria, and the state's antidegradation policy. The criteria themselves are not the standards but are the part of the standards meant to protect designated uses.

1.0 Introduction

1.1 Watershed at a Glance

The Greater Bonne Femme Watershed (GBFW) lies in southwest Boone County, Missouri (Figure 1). The greater watershed consists of the Little Bonne Femme Creek Watershed to the north, and the Bonne Femme Creek Watershed to the south and west. Both streams flow directly into the Missouri River near Easley, Missouri. The total watershed land area is approximately 92.4 square miles. Losing streams, sinkholes and other pathways in the GBFW connect surface flow with groundwater and also connect the hydrology of the two watersheds. The recharge areas for the Devil's Icebox Cave and Hunter's Cave are delineated in Figure 6. These recharge areas are locations where there is a clear connection between what happens to the water quality on the surface of the land and the condition of water quality in the respective cave systems.

Land use in the watershed is mixed and includes row cropping, livestock pasture, residential development, forest, and recreation. Row cropping and pasturing of livestock occurs primarily on the east side of Highway 63. Prior to development as agricultural land, this area was considered young prairie with loess soils rich in nutrients. The west side of Highway 63 is largely forested and dominated by limestone / karst formations including many sinkholes and the Devil's Icebox Cave System. This area has steep slopes and rolling hills moving down toward the Missouri River. A detailed analysis of landscape features was performed for the Watershed Plan completed in 2007. The plan may be found in its entirety at www.cavewatershed.org.

Precipitation in the watershed, measured by the climate station located at the University of Missouri's South Farm, averaged 38.03 inches annually from January 1, 2015 through December 31, 2019. The greatest amount of precipitation fell in 2015 with a total of 44.99 inches, while the least amount fell in 2018 with 33.71 inches.

Residential and commercial development continue to put pressure on natural resources in the GBFW. Particularly as agricultural land ownership is transferred as part of estate settlements, parcels of land are opened up for potential rezoning for use as residential neighborhoods or estate homes. Although some land disturbance protections are in place in the form of state, city and county regulations (see Existing Regulatory Protections in Section 1.2), pollutants, primarily sediment, are frequently delivered to streams during storm events while construction is ongoing. Commercial development is expanding along the Highway 63 corridor, desirable due to ease of access.

Recreational land use in the GBFW is a big part of the natural heritage of Boone County. Rock Bridge Memorial State Park lies in the Little Bonne Femme Watershed, and a long reach of Little Bonne Femme Creek runs through the park as it makes its way to the Missouri River. Numbers of Park visitors are increasing of late, with 449,968 visitors in 2019, 709,170 visitors in 2020, and 909,022 visitors in 2021 (more than double the number of visitors in 2019). The Park is home to beautiful karst features and an endemic species, the pink planarian that lives only in

the Devil's Icebox Cave System. The Devil's Icebox Cave is 6.5 miles long. Groundwater quality for the pink planarian and other wildlife that live in the cave system is influenced by surface water quality in the recharge areas in the watershed (Figure 6). Several species of bats, some endangered, also use the cave system. Maintaining water quality is key to the survival of these species. Three Creeks Conservation Area lies in the Bonne Femme Watershed and is the aptly named home to the confluence of Bass, Turkey, and Bonne Femme Creeks. Three Creeks has spectacular karst features of its own including karst windows and the 1.6-mile-long Hunter's Cave.

Sections of several streams in the GBFW are classified as Missouri Outstanding State Resource Waters. This classification is awarded to streams that are high quality waters with a significant aesthetic, recreational, or scientific value as natural resources of the State. These streams are: Bass Creek (1.0 mile in Three Creeks CA), Bonne Femme Creek (2.0 miles in Three Creeks CA), Turkey Creek (4.6 miles in Three Creeks CA), Gans Creek (3 miles in Rock Bridge Memorial State Park), and the Devil's Icebox Cave Branch (1.5 miles in Rock Bridge Memorial State Park), where the pink planarian is found.

The watershed contains sensitive karst habitats, Outstanding State Resource Waters, and losing stream hydrology that are vulnerable to water quality degradation. Consequently, land-use and land management practices have significant impacts on these unique ecosystems. Threats include riparian area deforestation; nutrients, pesticides, and animal waste from agricultural production and residential sites; sediment in stormwater runoff from commercial, agricultural and residential sites; and failing on-site wastewater systems.

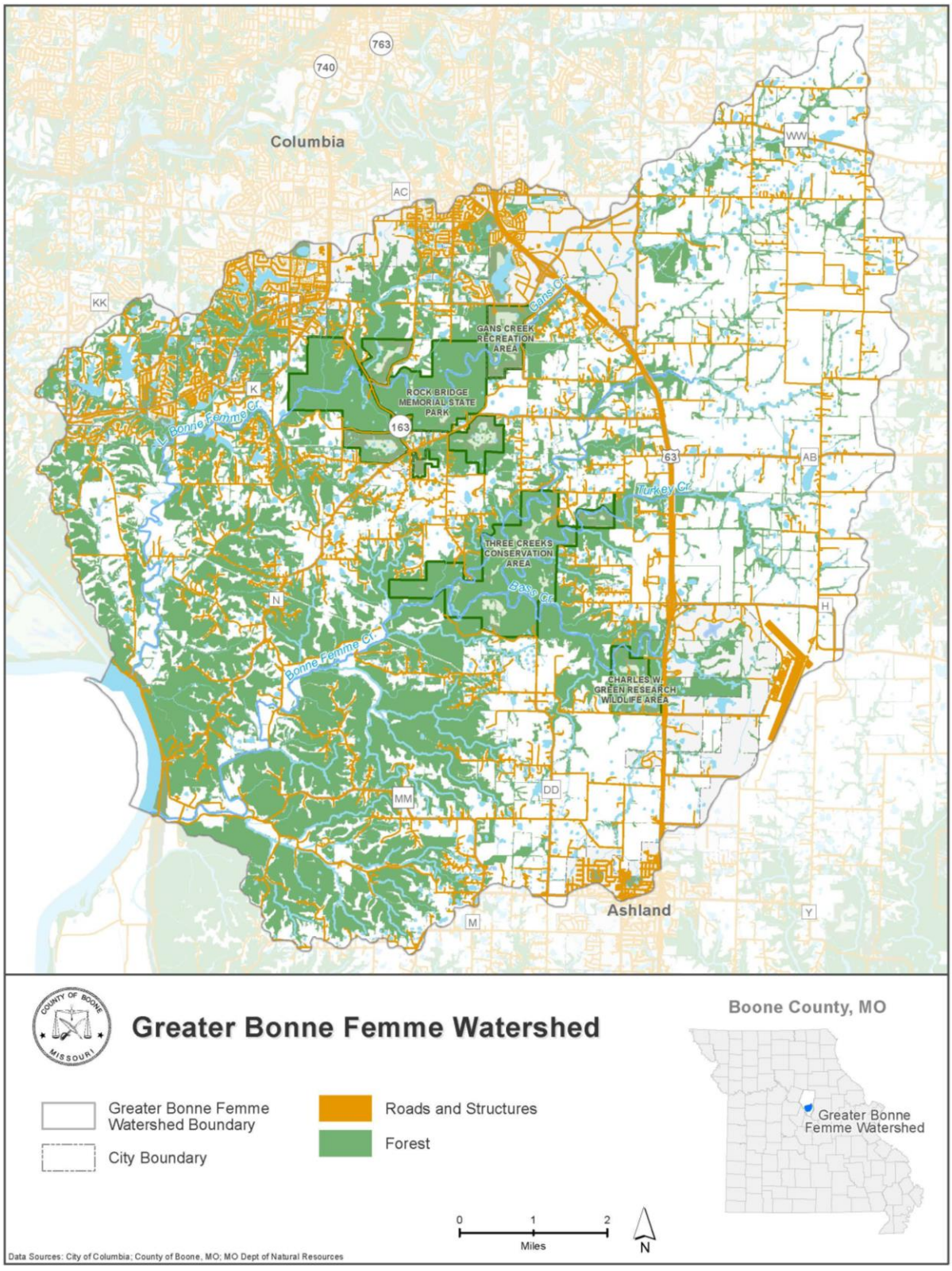

Figure 1. The Greater Bonne Femme Watershed in Boone County, Missouri.

Water quality parameters of concern in the GBFW streams include Escherichia coli (*E. coli*), nutrients (particularly nitrogen and phosphorus), and total suspended solids (TSS – including sediment). A summary of the water quality challenges in the GBFW is below:

- *E. coli* bacteria are used as an indicator of the presence of pathogenic organisms that are a threat to human health. Streams in the GBFW have elevated levels of microbial contamination as measured by *E. coli* bacteria, with levels that have exceeded the recreational season (April 1 through October 31) geometric mean Missouri Water Quality Standards (WQS) criterion for whole body contact "A" (126 colony forming units per 100 milliliters, cfu/100 mL) and whole body contact "B" (206 cfu/100 mL). The Missouri Department of Natural Resources (MDNR) has listed six stream segments in the GBFW as being impaired for *E. coli* on the state's 303(d) List of Impaired Waters. These include Little Bonne Femme Creek - Water Body Identification number [WBID] 1003 and Gans Creek - WBID 1004 in HUC 12 103001020903, and Bonne Femme Creek - WBIDs 750 and 753, Turkey Creek - WBID 751 and Bass Creek WBID 752 in HUC 12 103001020902. The locations of the impaired stream segments are shown in Figure 2. Total maximum daily loads (TMDLs) have not been developed for these WBIDs. The restoration goal of this watershed-based plan (WBP) is to bring all six of the impaired stream segments into compliance with WQS.

- Excessive nutrient concentrations, particularly those for nitrogen and phosphorus, can affect stream ecology in a variety of ways, including increasing the likelihood of algal blooms which can harm water quality, food resources and habitats, and decrease the oxygen that fish and other aquatic life need to survive. A previous watershed plan indicated several sites in the watershed had some level of nuisance algal growth associated with nutrient pollution (see Figure 3 for a recent algal bloom in the GBFW).

  Water quality monitoring data from 2001 to 2006 collected as part of the previous watershed-based plan, and more recent data collection as part of this WBP development, show that reported total nitrogen (TN) and nitrate concentrations in several sub-watersheds could potentially exceed future WQS. Elevated levels of phosphorus (TP) have also been reported in upper Bonne Femme Creek, Little Bonne Femme Creek, and Fox Hollow Branch over the last decade by the United States Department of Agriculture (USDA), Agricultural Research Service (ARS). Although Missouri has not yet adopted in-stream criteria for TN or TP, U.S. Environmental Protection Agency (US EPA) Region 7's Regional Technical Assistance Group (RTAG) has recommended benchmarks of 0.9 mg/L for TN and 0.075 mg/L for TP for Missouri, Kansas, Nebraska, and Iowa. These benchmarks are surrogate criteria designed to protect aquatic life against nutrient concentrations beyond natural levels. The targets are not water quality standards but EPA has stated that, in lieu of WQS, they may be used as numeric translators of narrative criteria for purposes where numeric values are typically used.

- Sediment can affect stream water quality by smothering critical benthic habitat and food sources or making it more difficult for sight-feeding fish to locate prey, and acting as a

vector for transport of other pollutants into the stream. High turbidity levels have been reported in GBFW streams during wet weather, indicating sediment loss from land (BFSC, 2007). Sedimentation in the Devil's Icebox Cave system was previously correlated to a decreased abundance of endemic pink planarians in the cave. Fate and transport of sediment is therefore of particular concern in the Devil's Icebox Recharge Area (Figure 6).

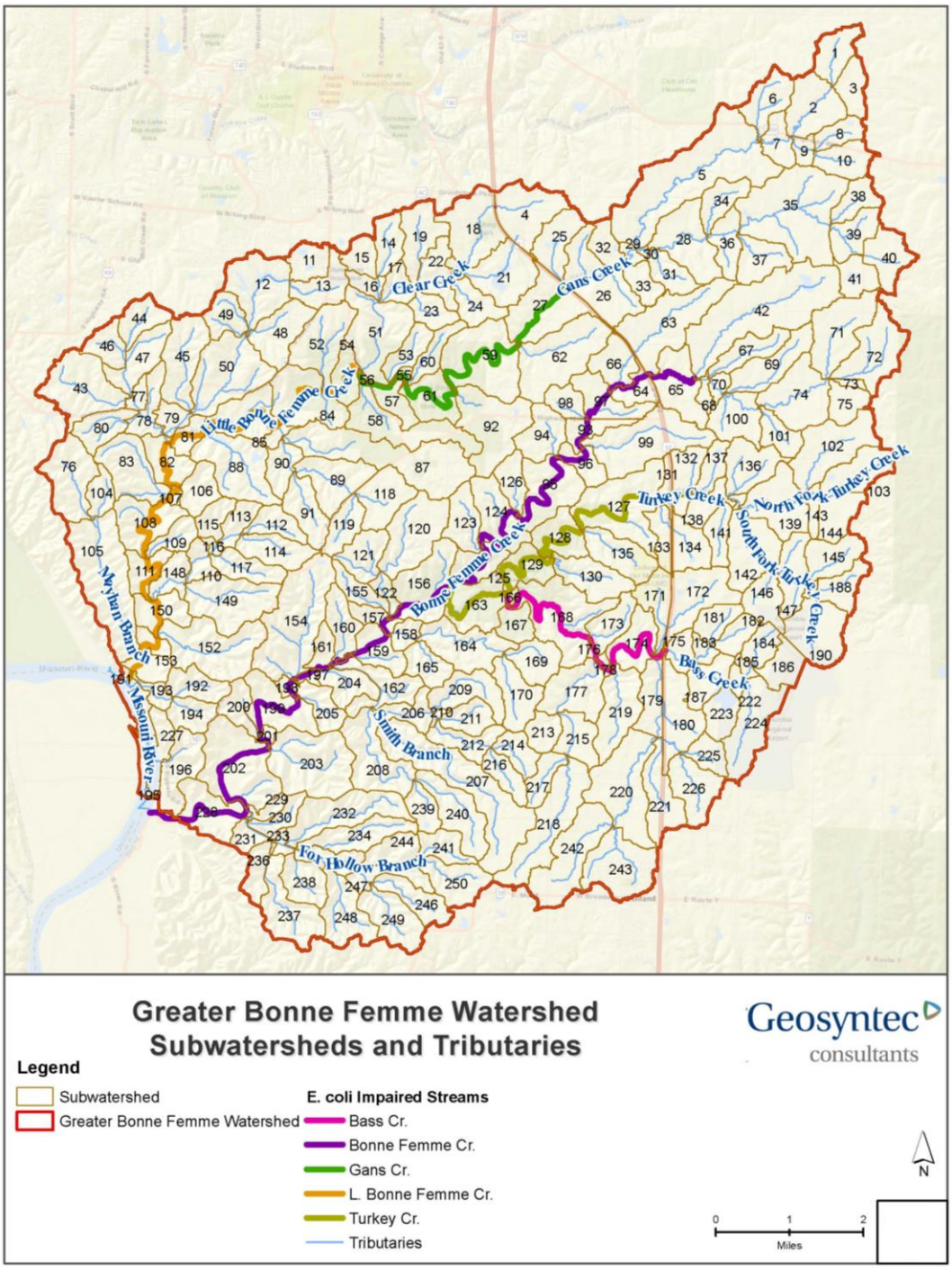

Figure 2. Impaired stream segments in the Greater Bonne Femme Watershed

1.2 Existing Regulatory Protections

Regulations are in place in Boone County to help protect streams from nonpoint source pollution caused by development. Boone County regulations apply to unincorporated areas of the County, while incorporated areas have their own regulatory authority.

Boone County's regulations apply to all land development, regardless of new or redevelopment, that meets one or more of the following: land development that disturbs one acre or more, redevelopment that creates or adds 3,000 square feet or more of impervious cover, land development in or near an ecologically/environmentally sensitive area that disturbs more than 3,000 square feet, and land development activities that are less than one acre but are part of a common plan of development or sale. Boone County exempts projects that are exclusively for agricultural or silvicultural use, maintenance and repair to any stormwater best management practice (BMP) deemed necessary by Boone County Road and Bridge, any emergency project immediately necessary for the protection of life, property, or natural resources, and linear construction projects disturbing less than one acre. To view the ordinance in its entirety, visit www.showmeboone.com/resource-management/regulations/.

The City of Columbia's stormwater ordinance applies to all land disturbances equal to or greater than one acre, or less than one acre that is part of a common plan of development or sale. Exceptions to the ordinance are attached and detached single-family residences, and farmland and domestic gardens. Redevelopment on a site of one acre or more, or that is a highly impervious surface site, could be eligible for partial exceptions from the ordinance, as set out in the stormwater manual, if the site meets several criteria. To view the ordinance in its entirety, visit https://library.municode.com/mo/columbia/codes/code_of_ordinances?nodeId=PTIICOOR_CH12ALAPR.

While Boone County and the City of Columbia have regulations in place to minimize the impacts from large-scale development, a plan is still needed to address water quality concerns from non-regulated activities. Almost half of the watershed's land use is some form of agriculture. By having a plan in place to promote the principles of Conservation Agriculture that focus on improving and maintaining soil health, we can partner with interested landowners and local agencies such as the Boone County Soil Conservation District and Missouri Department of Conservation to install BMPs that will support soil health, improve water quality, and support producer profitability.

The other half of the watershed is largely forest and karst features. By having a plan that outlines how we would like to assimilate use of information and outreach materials and activities in partner efforts, we can reach residents that live in, and visitors that recreate in the watershed to provide them with tools to help improve water quality, e.g., maintaining/upgrading on-site wastewater systems, picking up after pets, composting, and volunteer opportunities.

A summary table of existing regulations is below (Table 1). A thorough discussion of the existing regulations may be found in Appendix A.

Table 1. Existing regulatory framework for environmental protections from development activities in incorporated and unincorporated areas of Boone County.

Existing Environmental Protections in the Greater Bonne Femme Watershed						
	City of Columbia*	Boone County	University of Missouri	City of Ashland**	MO Dept. of Natural Resources	Army Corps of Engineers
Stormwater Ordinance	X	X		X		
Wastewater Ordinance	X	X		X		
Stream Buffer Ordinance	X	X				
Stormwater Design Manual	X	X	X	X		
Landscaping, Screening, and Tree Preservation Ordinance	X					
Stormwater Master Plan	X		X			
Misc. Stormwater and Water-related Permits					X	X

*City of Columbia has an Integrated Management Plan for Wastewater and Stormwater.

**The City of Ashland is currently working to revise their stormwater ordinance and stormwater design manual.

1.3 History of the Watershed Planning Process

There have been ongoing efforts to restore and protect the GBFW for decades. This is, in large part, due to the bounty of natural resources found here, and in particular the Devil's Icebox Cave System. Roxie Campbell, Park Naturalist for Rock Bridge Memorial State Park, has shared a history of water quality concerns and projects in the watershed that may be found in Appendix B.

A formal watershed plan was developed by a team of stakeholders and a policy committee from 2003 to 2007 with financial assistance from a Missouri Section 319 Nonpoint Source grant. The Bonne Femme Watershed Plan was ratified by Boone County, the City of Columbia, and the City of Ashland. The Executive Summary of the watershed plan lays out a table of Goals, Strategies, and Recommendations for the watershed that are still being used by Boone County Planners (see Appendix E for a description of the 2007 plan goals).

In addition to the watershed plan, a number of deliverables came out of the Section 319 project from 2003 to 2007, laying the groundwork for the current project. A partial list of deliverables follows:

Public Education:

- Public Policy Debates: Two policy debates were held where experts and community leaders were able to provide insight into differing perspectives on local watershed concerns.
- Low Impact Development (LID) Workshops: Workshops were held for a diverse audience that included all members of the community but were specifically targeted toward the local development community. The first LID workshop focused on LID techniques. The second focused on the economics of LID and included examples of successful LID projects in the Midwest.
- Technical Workshops/BMP Tours: These included instruction about on-site wastewater systems using conventional and new technology and stormwater BMPs that have been installed in the Columbia area.
- Annual Newsletter
- Annual Public Meetings

Cost-Share: $121,200 in cost-share money was dispersed to finance construction of BMPs within the watershed, such as a streambank stabilization project, several rain gardens, a pervious parking lot, and a wetland restoration project. Cost-share projects also included several on-site waste water systems demonstration projects and a septic tank pump-out rebate program.

Advanced Understanding of Watershed Hydrology:

- Quarterly water quality monitoring by Dr. Robert Lerch, USDA/ARS
- Development of watershed sensitivity analysis
- Better understanding of fate and transport of pollutants based upon dye-tracing studies conducted in 2003 and 2004.

The previous watershed plan did not move forward with an implementation phase, and the watershed planning process for GBFW was largely dormant until late 2015. Recognizing the need to move forward with implementation, the County initiated formation of the Technical Advisory Team (TAT) for the current project. Quarterly water quality monitoring at the ten sites historically monitored by Dr. Robert Lerch from USDA/ARS started up again in fourth quarter of 2016 and continued through 2019. Additionally, some *E. coli* data were collected in the watershed in 2020. More information about this water quality monitoring will be presented in the Water Quality Summary section of this document and Appendix C.

The TAT is made up of local government, state and federal agency, non-governmental organization, and local landowner partners. Regular meetings of the TAT started in March of 2016 and have continued through the date of this WBP. It was clear to the members of the TAT that in order to restore and protect the streams of the GBFW, a new 9-element plan was needed.

Boone County applied for a Section 319 subgrant to finance development of this 9-element WBP. The utility of the plan is twofold – it will serve as a guide for stakeholders as we move forward to restore and protect the streams in the watershed, and the plan can be used as a foundation for 5-alt subcategorization designation for the impaired streams with the US EPA, reducing the priority for development of TMDL documents. The ultimate goal of this WBP is for the impaired streams to meet water quality standards, which will ultimately eliminate the need to develop TMDLs. The 5-alt subcategorization designation will be discussed more fully in its own section near the end of this document.

1.4 Watershed-based Plan Themes

As a non-regulatory document, the overall purpose of this WBP is to guide voluntary watershed management for the next 21 years with a primary focus on reducing *E. coli* loading into impaired streams, moving toward compliance with WQS, while simultaneously protecting the streams in the watershed from degradation due to other pollutants of concern described below. US EPA has created a checklist of 9 essential elements that a WBP needs to address in order to assure attainment of the necessary pollutant load reductions to meet WQS. This WBP incorporates these elements while addressing two core themes of the project that have been expressed over the years. The primary theme and goal of the WBP is one of restoration. Effective strategies are needed to bring the streams in the watershed that are impaired by *E. coli* into compliance with WQS. The second WBP theme and goal, equally important due to the nature and value of the natural resources in the GBFW, is protection. Although WQS are not yet in place for nutrients (particularly nitrogen and phosphorus) in flowing waters in Missouri, data collected in the watershed suggest that nutrient levels may exceed standards when written into state regulations. Additionally, data collected over the years suggest that agricultural chemicals, specifically herbicides and their breakdown products, are present in streams of the GBFW. Project partners want to protect the Outstanding State Resource Waters, vulnerable karst features, and other streams from excessive nutrient concentrations and algal blooms, as well as any harmful effects from agricultural chemicals (see Figure 3 for an image of a 2018 algal bloom in the GBFW). Additionally, project partners want to ensure that sediment concentrations, measured as total suspended sediment (TSS), do not damage habitat for pink planarians or other wildlife in the GBFW. Restoration and protection measures will increase the likelihood that the natural communities and ecosystems in the GBFW are resilient in times of climate variability.

Boone County worked with partners and a modeling consultant to develop a plan for implementation of best management practices (BMPs) to be installed in the watershed to address the plan's two themes. The development of the list of recommended BMPs and a strategy for Proposed Management Measures for the Greater Bonne Femme Watershed are fully described in later sections of this WBP. Installation of the recommended BMPs will reduce *E. coli*, nutrient, and sediment loading to the impaired streams and bring the bacteria levels into compliance with WQS over the 21-year plan period discussed in the implementation sections later in this WBP. The primary focus of the recommended BMPs is reduction of *E. coli* loading.

Figure 3. Algal bloom on Gans Creek in 2018

1.5 Watershed Goals

The planning partners anticipate that the overarching goals for the GBFW of achieving restoration of impaired streams and protection of Outstanding State Resource Waters and sensitive karst features from degradation will be achieved through development and implementation of this WBP. Consequently, the following objectives for the planning process and subsequent WBP were set to help ensure realization of those watershed goals through implementation of the resulting WBP.

1) Restoration, Protection, and Adaptive Management

2) The two themes of the WBP, restoration and protection, will be achieved using adaptive management methods. Interdisciplinary approaches incorporating science (physical, biological, chemical, economic, and social) and policy will be used in an adaptive manner to address the unique challenges and opportunities presented by restoration and protection strategies and changing conditions over time.

3) Integration of the WBP implementation with the Municipal Separate Storm Sewer System (MS4) permit held jointly by Boone County, the City of Columbia, and the University of Missouri; any future Section 319 grant funded projects will be above and beyond all MS4 permit requirements.

   See Appendix F for a thorough discussion of this objective of the WBP.

4) Ratification of the WBP by the City of Columbia, the City of Ashland, and the University of Missouri, with a dual objective of promoting increased uniformity of residential and commercial stormwater and building regulations, and improving coordination with state and federal agencies to restore and protect water quality throughout incorporated and unincorporated areas of Boone County.

5) Identification and engagement of stakeholders in future conversations about the GBFW and land management impacts at multiple geographic scales through the information and outreach approaches discussed in the WBP. The appeal to stakeholders will be made across the spectrum of value systems, economic circumstances, and political beliefs. It is hoped that a culture of watershed management will be developed and adopted within the GBFW, and in other areas of Boone County and beyond.

In order to address these watershed goals, this WBP incorporates 9 elements as prescribed by US EPA for the development and implementation of watershed-based plans. The elements are listed here and will be addressed in detail in the following pages.

A) Causes and Sources of Pollution
B) Expected Load Reductions
C) Proposed Management Measures
D) Technical, Financial, and Regulatory Assistance Needs

E) Information and Education
F) Implementation Schedule
G) Measurable Milestones and Project Outcomes
H) Evaluation Criteria
I) Monitoring

2.0 Causes and Sources of Pollution (Element A)

2.1 Water Body Impairment in the Watershed (Element A, Criteria 1, 2, and 3)

The following table lists the impaired stream segments in the GBFW, including the year of the 303(d) listing and additional information (Table 2). All stream segments are impaired by exceedance of the applicable Missouri Water Quality Standards criteria for *E. coli* bacteria:

Table 2. Impaired waterbody information for the Greater Bonne Femme Watershed.

Waterbody	WBID	Year First Listed	Class*	Impaired Use	WBID Size (miles)	HUC 12
Bonne Femme Creek (lower)	750	2006	P	WBC A	7.8	10300102-0902
Turkey Creek	751	2012	C	WBC A	6.3	10300102-0902
Bass Creek	752	2012	C	WBC A	4.4	10300102-0902
Bonne Femme Creek (upper)	753	2012	C	WBC B	7.0	10300102-0902
Little Bonne Femme Creek	1003	2012	P	WBC B	9.0	10300102-0903
Gans Creek	1004	2012	C	WBC A	5.5	10300102-0903

** Per 10 CSR 20-7.031(1)(F), Classes are defined as follows:*
P: Streams that maintain permanent flow even in drought periods.
C: Streams that may cease flow in dry periods but maintain permanent pools which support aquatic life.

The source of the impairment listed for Bass, Bonne Femme and Gans Creeks is rural nonpoint source. The source of the impairment listed for Little Bonne Femme and Turkey Creeks is shown as source unknown (Element A, Criterion 2). Additional source information obtained from the use of microbial source tracking (MST) analysis of water samples from the GBFW will be discussed in more detail in a later section of the WBP.

The impaired streams are designated as either Whole Body Contact Recreation (WBC) A or B as defined in the Missouri Code of State Regulations, 10 CSR 20-7.031 (2), Water Quality Standards. The impaired streams all share the following additional designated uses:

AQL - Protection of Aquatic Life
IRR - Irrigation
LWW - Livestock and Wildlife Watering
SCR - Secondary Contact Recreation
GEN - General Criteria
HHP - Human-Health Protection (Fish Consumption)

TMDLs have not been developed for any of the WBIDs listed above (Element A, Criterion 3).

2.2 Point Source Identification and Potential Impact (Element A, Criterion 5)

Facilities with National Pollutant Discharge Elimination System (NPDES) permits for discharge into waterways in the GBFW are identified on the map in Figure 4. The permittees may be categorized as follows:

Missouri State Operating Site-Specific Permits. Four of the NPDES permits are for wastewater treatment. Three of the four are wastewater treatment plants owned by Boone County Regional Sewer District (BCRSD). All the wastewater treatment plants owned by BCRSD are operating below design flow and are in compliance with the Missouri Department of Natural Resources. These permits require the permittee to submit an annual report to MDNR for the previous calendar year providing a summary of efforts taken to locate and eliminate sources of excess inflow and infiltration, general maintenance and repairs to the collection system, and any planned repairs to the collection system for the upcoming calendar year. Discharges are regularly analyzed for various constituents under the terms of the issued state operating permits, including *E. coli*. Two of the BCRSD permits have required schedules of compliance included in their permits to attain final effluent limitations for *E. coli*. Microbial source tracking conducted on these streams indicates it is unlikely that *E. coli* contamination is coming from these plants, however, it is possible that excessive nutrients, not regulated by the wastewater discharge permits, are entering the streams below the plants. The fourth permit is held by the City of Columbia, Missouri for land application of wastewater at the Columbia Regional Airport. The general wastewater system for the City of Columbia is managed under a separate permitting system.

Magellan Midstream Partners, L.P. is a permit holder for a petroleum terminal with storage and transportation of refined petroleum products on Tom Bass Road. There has been at least one chemical spill at this facility in the past. Permit limits allow for the discharge of small amounts of hydrocarbons into a tributary of Gans Creek.

Missouri State General Permit for Sewer Extension Construction. Two residential development projects within the watershed currently hold general permits for sewer extension construction. The sewer extension at the Martha's Grove site extends to a facility owned by BCRSD. The sewer extension at Oak Hill Estates also extends to a facility owned by BCRSD. By tying into the BCRSD system, the homes in these neighborhoods will have access to central sewer systems, negating the need for on-site systems that can fail without proper maintenance. During the construction process, erosion and sediment controls will be used to minimize impacts to the watershed. The Martha's Grove permit expires in 2022 and Oak Hill Estates expires in 2023.

Missouri State General Permit for Limestone Quarries. Two companies hold general permits for limestone quarries with sites located within the watershed. These permits

allow stormwater and other specified discharges from limestone and other rock quarries, concrete, glass and asphalt industries. Both permits expire in 2022.

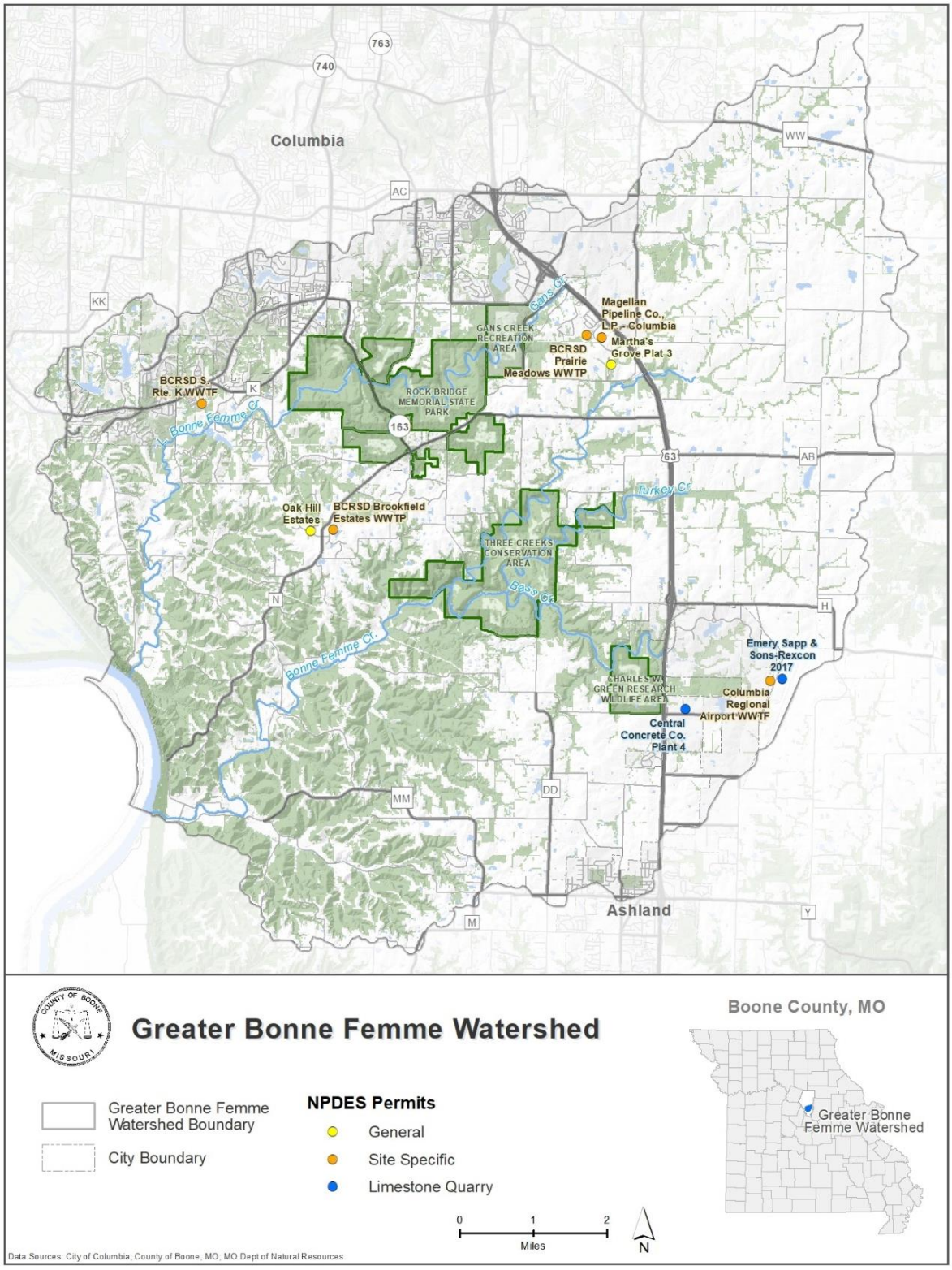

Figure 4. NPDES permitted facilities in the Greater Bonne Femme Watershed.

2.3 Specific Nonpoint Sources of Impairment (Element A, Criterion 4)

2.3.1 Land Use/Land Cover

The land use/land cover data were downloaded from the National Land Cover Database (NLCD, 2016). Table 3 shows the breakdown of the land use in the GBFW. Review of the land cover data shows that much of the watershed is rural and forested with scattered residential use, with most new development occurring close to the cities of Ashland (south) and Columbia (north), Missouri, and some along the Highway 63 corridor (Figure 5). About 13% of the watershed is cropland, primarily east of Highway 63, where there is flatter land and deeper soils. Pasture is about 33% of the total watershed area, interspersed throughout the watershed. Various forest types cover an additional 44%, most of it occurring west of Highway 63 in the areas with steeper terrain. Suburban and commercial development cover about 9% of the total watershed area. Other land use (open water, wetlands, shrub, grassland, and barren land) covers about 2% of the total watershed area.

Land use/land cover for the GBFW, presented in Table 3, was categorized as urban, cultivated crops, pasture/hay, forest and other based on land use categories defined in the STEPL watershed model described later in the plan. Other land use includes all land uses that do not fit into urban, cultivated crops, pasture/hay or forest. The acreage for open water was not included in the watershed model, as it was assumed to not contribute to pollutant loading.

Certain types of nonpoint source (NPS) pollution are associated with certain land use types. For example, *E. coli* would be associated with pasture due to the presence of grazing animals and their waste products. *E. coli* can also be associated with failing on-site wastewater systems in rural areas, or pet waste in urban or suburban areas. Nutrients, such as nitrogen and phosphorus, could be associated with either cultivated crop land (agricultural fertilizer application), pasture (animal waste), or, to a lesser extent, urban residential areas (lawn fertilizer application, pet waste) or failing on-site wastewater systems. Sediment has more universal sources and can enter streams from virtually anywhere on the landscape, including cultivated crop land, overgrazed pastures, construction sites and streambank erosion. For the purposes of this plan, pesticides of concern are those that are applied in the agricultural row crop setting. Based upon these relationships, land use/land cover types are a starting point in determining locations for best management practices in the GBFW.

Table 3. Existing land cover breakdown for the Greater Bonne Femme Watershed.

Land Use	Percent Land Use (%)
Urban	9
Cultivated Crops	13
Pasture/Hay	33
Forest	43
Other	2

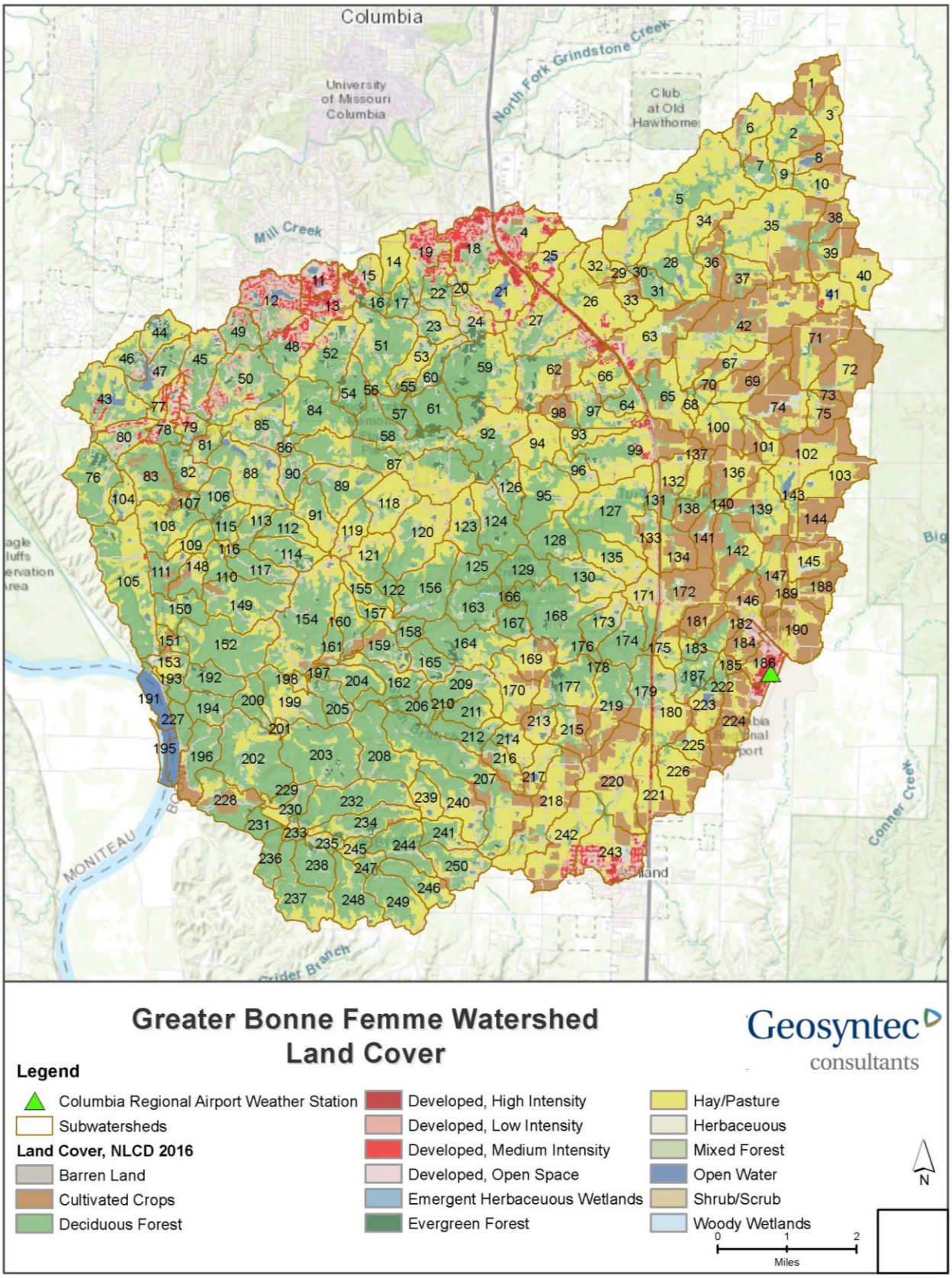

Figure 5. Greater Bonne Femme Watershed land cover.

2.3.2 Microbial Source Tracking

Microbial Source Tracking (MST) is a technique that is used to help determine the animal source of *E. coli*. The way that Boone County used MST to assist with this project is described below:

- Water samples were collected from collection sites previously monitored by Dr. Robert Lerch (Figure 6). The recharge areas for the Devil's Icebox Cave and Hunter's Cave are also shown on this map to illustrate areas where surface water in the karst system directly impacts groundwater quality, i.e. where *E. coli* from the land surface could be transported directly or indirectly into groundwater.
- Water samples were filtered using a special filtration process and a very fine filter in order to capture any solids from the stream water. These solids include bacteria such as *E. coli*.
- The filters were processed by a company in Florida that specializes in MST. The process that was used was a type of qPCR to amplify DNA from *E. coli* that were found in the filter.
- The amplified DNA were compared to DNA markers identified for certain mammal host species (*E. coli* live in the gut of mammals and are excreted when the animal defecates). The markers are specific sequences of DNA that are only found in the *E. coli* of animals from specific host species. The list of species available for comparison was somewhat limited as this technology is emerging. One of the mammals that was not available for MST that would have greatly informed our research was bat.
- Each test run is host animal specific, and the research company charged accordingly. Boone County had to specify which animal test would be run for each sample. The testing was expensive, so analysis was limited to tests that would be useful.
- The list of species markers used for analysis of the Boone County samples is as follows:
    - Human
    - Ruminant – a general category for any animals that are ruminants, including deer, cows, alpaca, goats and sheep. Separate tests were not available specifically for deer at the time of our testing. While certain areas of the GBFW have high concentrations of goats, these areas are generally lower in the watershed, downstream of the areas where samples were collected. Alpaca are present in the watershed, but not in numbers anywhere approaching those of cows.
    - Cow – this DNA marker is different than the marker for ruminant and is specific to just cows. The percentage of cow versus other ruminants cannot be separated out from the ruminant sample and the objective was to determine whether there was just cow DNA in our stream water samples as there were and are many cows on the landscape in the GBFW. A map showing generalized locations of livestock in the GBFW has been assembled using Boone County Assessor data from 2017 and 2018 (Figure 9). The MST research company had the only EPA-approved *E. coli* testing for cows at the time of our sampling.
    - Goose – a sample for goose was only run once during the MST work. Geese typically congregate on lakes rather than flowing stream waters, so, as expected, goose DNA was not found in the sample tested.

    - Dog – samples for dog were only run once during the MST work. The company that did the analysis could not confirm whether *E. coli* from coyotes would trigger the dog response from the MST testing. It is known that there are coyotes on the landscape, particularly along stream corridors in Boone County, but dogs are ubiquitous, and the presence of dog DNA among the *E. coli* samples was expected. Boone County works with the City of Columbia and the University of Missouri to educate citizens about picking up after their dogs, and this work is ongoing and outside the scope of the GBFW watershed-based plan.
    - Horse – there are several large horse farms in the GBFW. However, at the outset of our MST work, the MST research company indicated that horse DNA is incredibly hard to pick up using the qPCR methods and running the horse testing would not be very useful. One sample for horse was run during the MST work, after a heavy rain, with a sample in a stream segment downstream of a large horse farm and did not pick up a horse signal in the *E. coli*.
- When results came in from the MST research company, they were rated as either low, medium or high for the *E. coli* from the animal (or group of animals in the case of ruminant) found during the testing. A specific concentration of *E. coli* was not given – only a range for low, medium or high.
- The MST results cannot be used to extrapolate to the water flowing in an entire stream. *E. coli* may or may not be distributed evenly throughout stream water, so each sample is a snapshot of the amount of *E. coli* from a specific animal in that specific sample at that moment in time. The samples from a specific site could, however, be compared to each other over time to help inform what type of animal *E. coli* was in a specific stream segment.
- Because the testing uses DNA as the basis of animal host identification, the presence of dead *E. coli* would also trigger a positive result. Dead *E. coli* are not a threat to human health or safety. This was relevant for a couple of the sampling sites that are downstream from wastewater treatment plants in the GBFW. The wastewater treatment plants are set up with ultra-violet light treatment technology. The final stage of wastewater treatment is exposure to ultra-violet light to kill any remaining *E. coli* before the treated wastewater is returned to streams. Initially there was some concern that there would be higher results for human *E. coli* through the testing, but this turned out not to be an issue.

High percentages of human *E. coli* were expected to be found in the streams due to many residential on-site wastewater systems in the watershed (Figure 10). However, the human component of the *E. coli* in the streams was relatively low at all the sites sampled.

While there was a human component in the *E. coli* found in the GBFW, the MST results showed that the animal hosts contributing most of the *E. coli* were cow and ruminant. At various times, samples were analyzed for cow and ruminant separately, or simultaneously, to understand the relative presence of cow *E. coli* as compared to other ruminants. Deer, another member of the ruminant community, are certainly contributing to the *E. coli* levels in the impaired streams, as a

large percentage of the GBFW is forested and provides perfect habitat for deer (Element A, Criterion 2).

Maps delineating specific NPS sources of impairment, including livestock, wildlife, and failing on-site wastewater systems, are found in Figures 9 and 10 (Element A, Criterion 4).

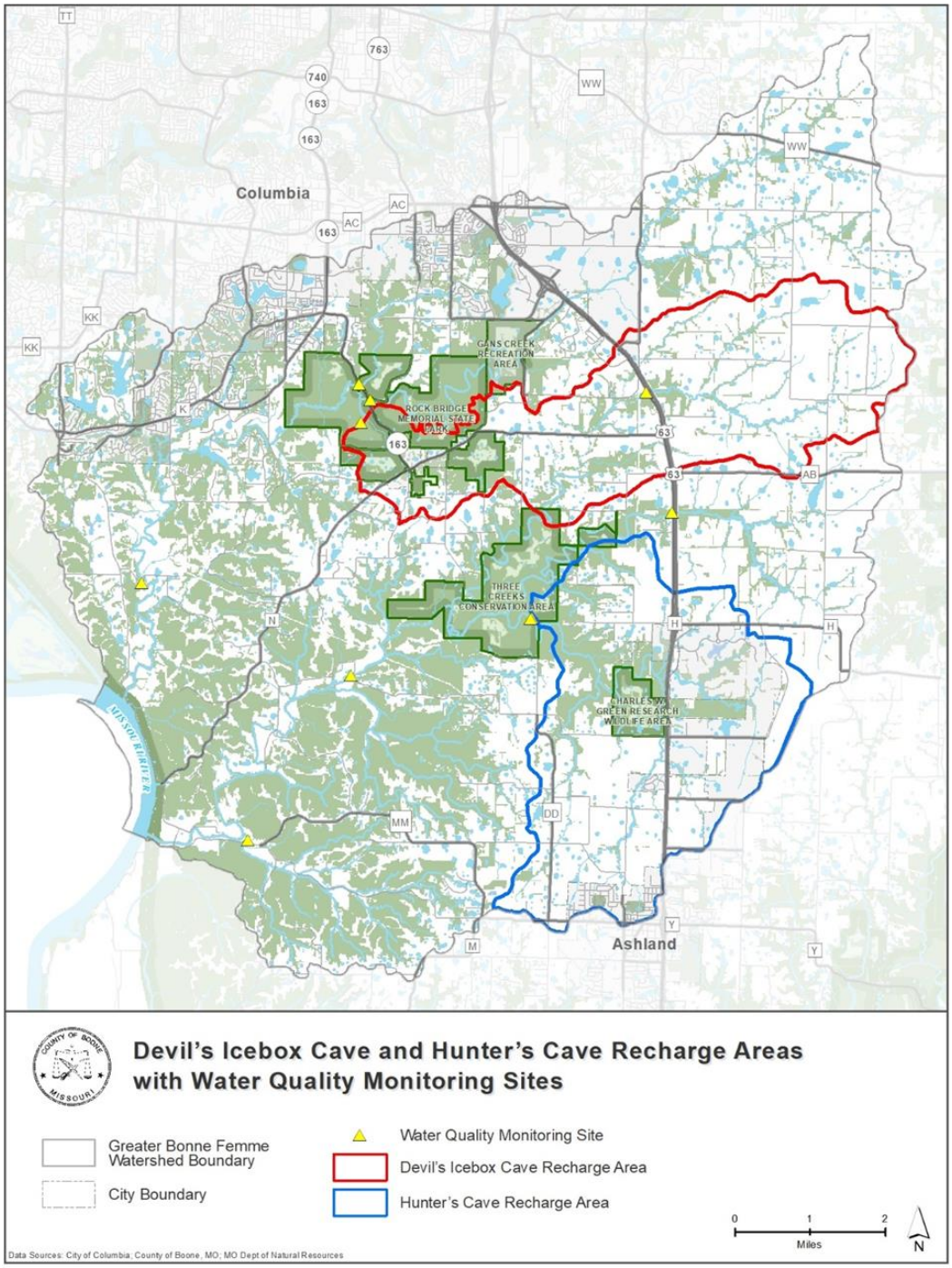

Figure 6. Historical monitoring sites in the GBFW and location of recharge areas for the Devil's Icebox Cave and Hunter's Cave.

2.3.3 Agricultural Land Use in Boone County, Missouri

According to a census conducted in 2016, roughly half of the land in Boone County is in agricultural use (USDA NASS, 2017; and Appendix D). This ratio holds true in the GBFW as 46 percent of the total acreage is in cultivated crops or pasture/hay (Table 3). Project partners have worked throughout the project to promote principles of Conservation Agriculture with implementation of cropland and pastureland BMPs as a way forward to simultaneously improve water quality and improve soil health with its concomitant benefits of improved biodiversity, micronutrients, and water infiltration and storage – which in turn helps improve farm profitability and resiliency. Application of these practices on the landscape can have far-reaching effects, including restoration of local water balances, carbon storage, and reduced pesticide and fertilizer use. These concepts will be explored more fully in later sections of the WBP.

2.3.4 Population Expansion in Urban Centers

The GBFW is located between the rapidly developing cities of Ashland (south) and Columbia (north), Missouri, where population growth has increased by 40 percent over the last 10 years. Building density and overall impervious surface area has increased in the watershed over time (Figure 7). Recently, several large tracts of land that were formerly in agricultural production have been converted to planned residential developments or single-family dwellings on 2.5 to 10-acre lots. It is important to consider the potential impact of these new and future developments on natural communities and ecosystems in the GBFW and strive to foster watershed management that invests in the environment which will allow communities and their economies to grow and thrive.

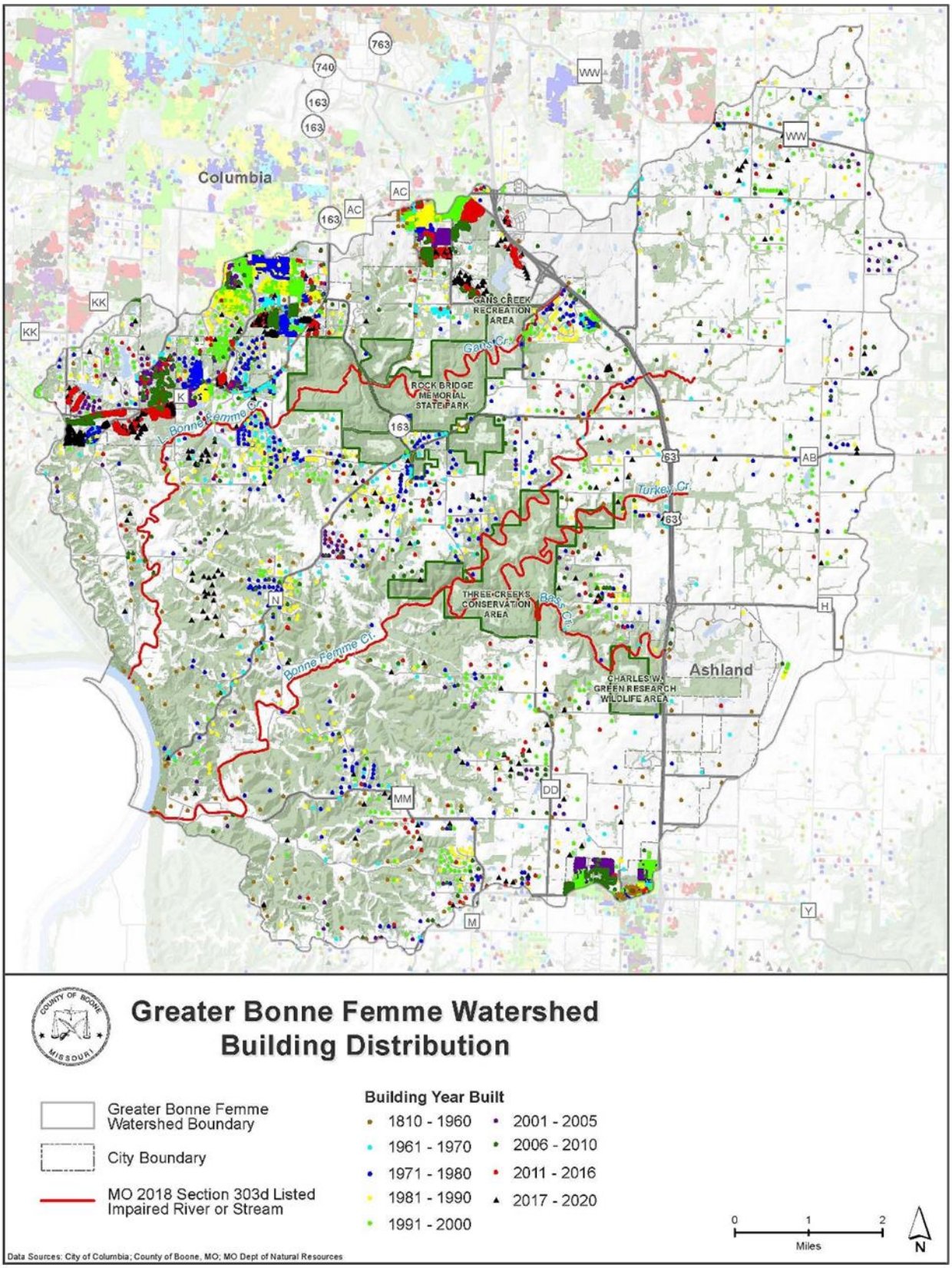

Figure 7. Building distribution in the Greater Bonne Femme Watershed.

2.4 Water Quality Summary

Dr. Robert Lerch, a soil scientist with USDA/ARS, prepared a water quality summary for the GBFW. Dr. Lerch's full report is presented in Appendix C. Some of the data discussed in the report were collected and processed in accordance with a Quality Assurance Project Plan (QAPP) entered into with MDNR – the rest of the data pre-date the QAPP.

2.5 Apportionment / Quantification of Pollutant Loading to Nonpoint Sources (Element A, Criterion 6)

In order to meet US EPA's 9 required elements for a WBP, Boone County engaged the services of an environmental modeling consultant (Geosyntec Consultants) to identify causes and sources of pollution, develop current pollutant loading, determine critical areas for BMP implementation to address WBP goals, and identify specific BMPs and an implementation schedule to optimize pollutant load reduction to result in eventual attainment of WQS and other water quality goals. This section and the sections following draw heavily from the Greater Bonne Femme Watershed Modeling Report (Report) prepared by Geosyntec Consultants (Geosyntec). The modeling work was conducted in accordance with a QAPP developed by Geosyntec and approved by MDNR. The Report is available in its entirety in Appendix G.

The GBFW was delineated into subwatersheds based on a USGS Digital Elevation Model (DEM) using the Arc Hydro Tool in ArcGIS. The delineation for the watershed into 250 subwatersheds is shown in Figure 8. Subwatersheds with areas less than 10 acres were merged with adjoining subwatersheds based on drainage patterns to avoid very small subwatersheds. This is a minor deviation from the MDNR approved QAPP (Geosyntec, 2020) and was done to ensure that subwatersheds do not show up as critical hotspots for load per acre because of their size. The area of the delineated subwatersheds ranges from 11 acres to 1,097 acres. The average subwatershed area is 240 acres. The estimation of pollutant load at the fine resolution subwatershed level allowed better identification of critical areas with the greatest load generating potential.

Geosyntec developed watershed models to estimate the existing loads for *E. coli*, nutrients, and TSS (Element A, Criterion 6). Modeling platforms, like STEPL and SELECT used for this project, can be used to simulate natural and human-altered processes and provide quantification of their results – including the flow of water and associated transport of sediment, chemicals, nutrients, and microbial organisms within a watershed – which can help guide decision making on best practices to improve water quality. Pollutant loads were estimated for each of the subwatersheds shown in Figure 8. Nutrient and TSS loads were estimated using US EPA's STEPL framework version 4.4 (TetraTech, 2018) (see https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl for information about the STEPL model). *E. coli* loads were simulated using the methodology of SELECT, a separate modeling framework. SELECT simulates the annualized loading of *E. coli* from various sources within a mixed land use watershed based on spatial inputs such as animal population density and septic systems. A more

detailed discussion of the SELECT model inputs and analysis used by Geosyntec may be found in Section 2 of the Modeling Report and Section 2.1 of the Modeling QAPP (available upon request). Additional details about the use of STEPL and SELECT are provided below.

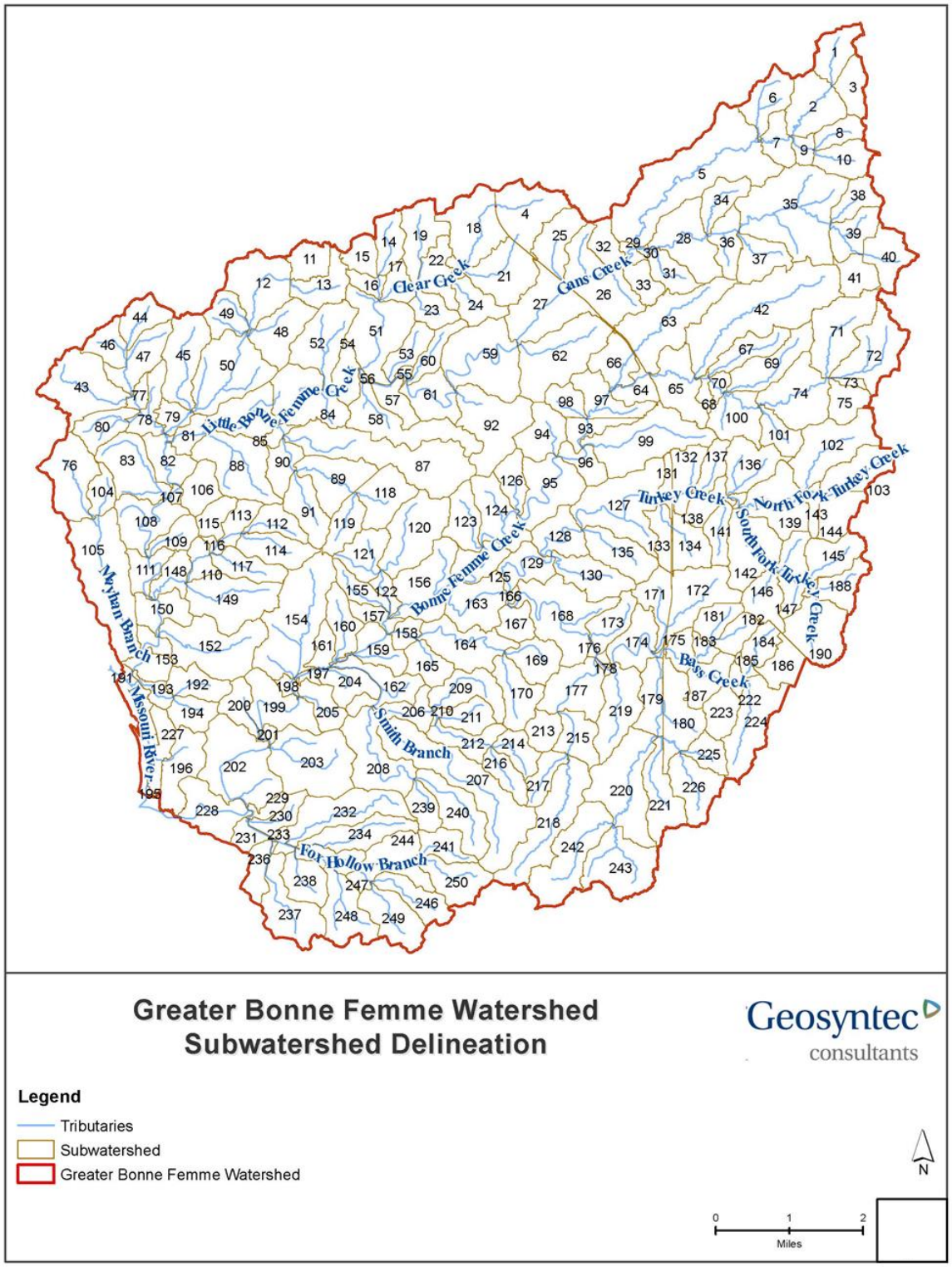

Figure 8. Subwatershed Delineation for the Greater Bonne Femme Watershed.

2.5.1 *E. coli*

Geosyntec simulated *E. coli* loads using the methodology of the Spatially Explicit Load Enrichment Calculation Tool (SELECT) developed by the Spatial Sciences Laboratory and the Biological and Agricultural Engineering Department at Texas A&M University (Teague et. al, 2009). SELECT has been applied to assess sources of bacterial contamination for WBPs and TMDL projects (Riebschleager et al., 2012; Borel et al., 2012; Borel et al., 2015; Roberts et. al, 2015; NTMWD et al., 2017; Glen et al., 2017). The methodology is consistent with the guidance provided by US EPA to estimate *E. coli* loading from NPS (US EPA, 2001). This methodology was selected for application in the GBFW since it is less data intensive and requires less effort as compared to complex mechanistic models such as HSPF and SWAT, but still provides information suitable for watershed planning purposes, similar to STEPL. A description of SELECT's methodology is provided below.

The potential sources of *E. coli* load in the GBFW include livestock, wildlife and pets, and failing on-site wastewater systems (Figures 9 and 10) (Element A, Criterion 4). The generalized location of subwatersheds with reported livestock are shown in Figure 9. These subwatersheds are generalized because livestock are often set out to graze in rotational patterns between paddocks and their precise location cannot be identified. Wildlife are also represented on Figure 9 as they are free roaming across the watershed. Although failing on-site wastewater systems were not found through MST analyses to be a major contributor to the *E. coli* loading in streams of the GBFW, in order to represent all potential sources of loading, non-sewered areas are shown in Figure 10.

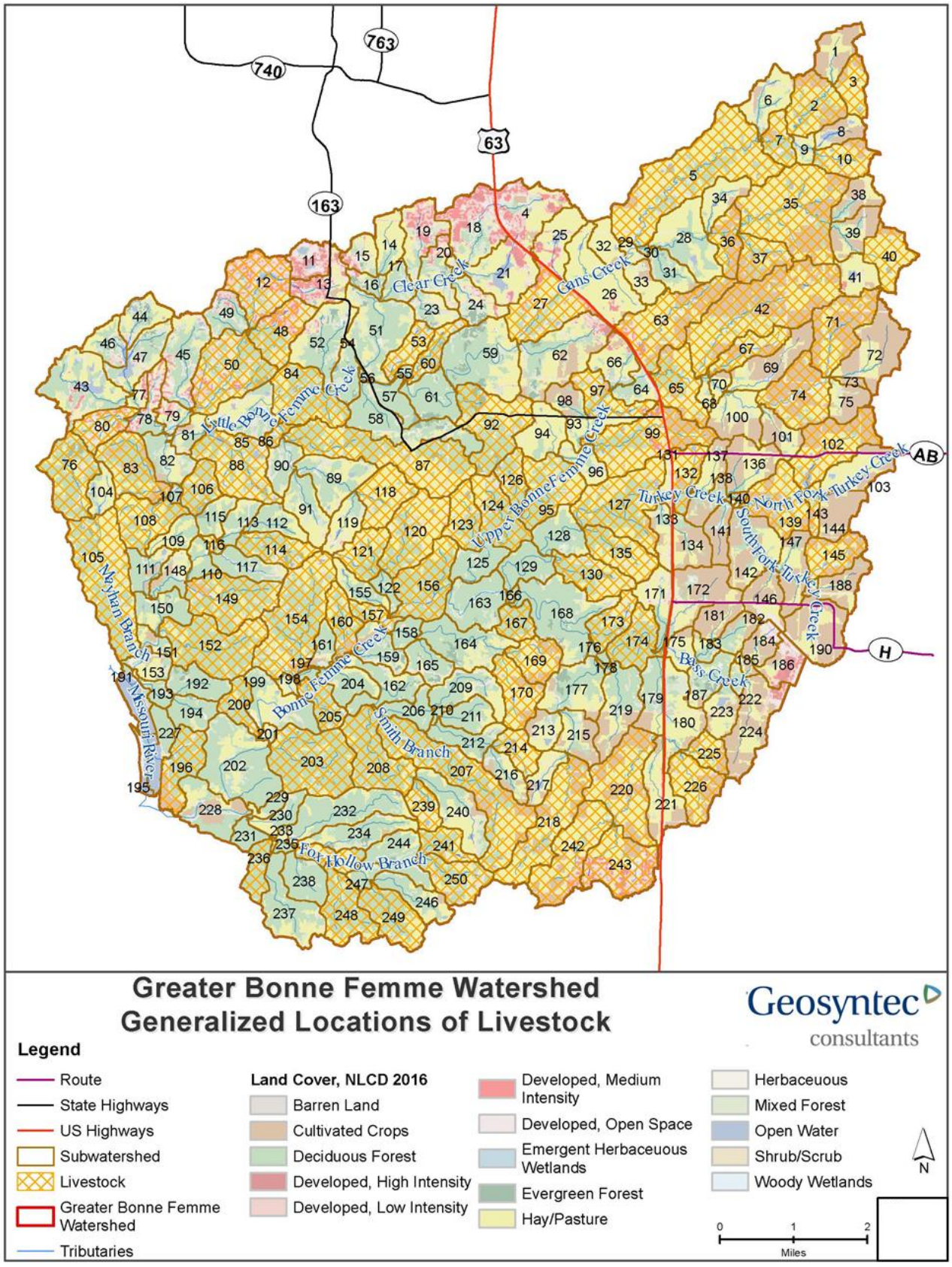

Figure 9. Greater Bonne Femme Watershed Generalized Locations of Livestock.

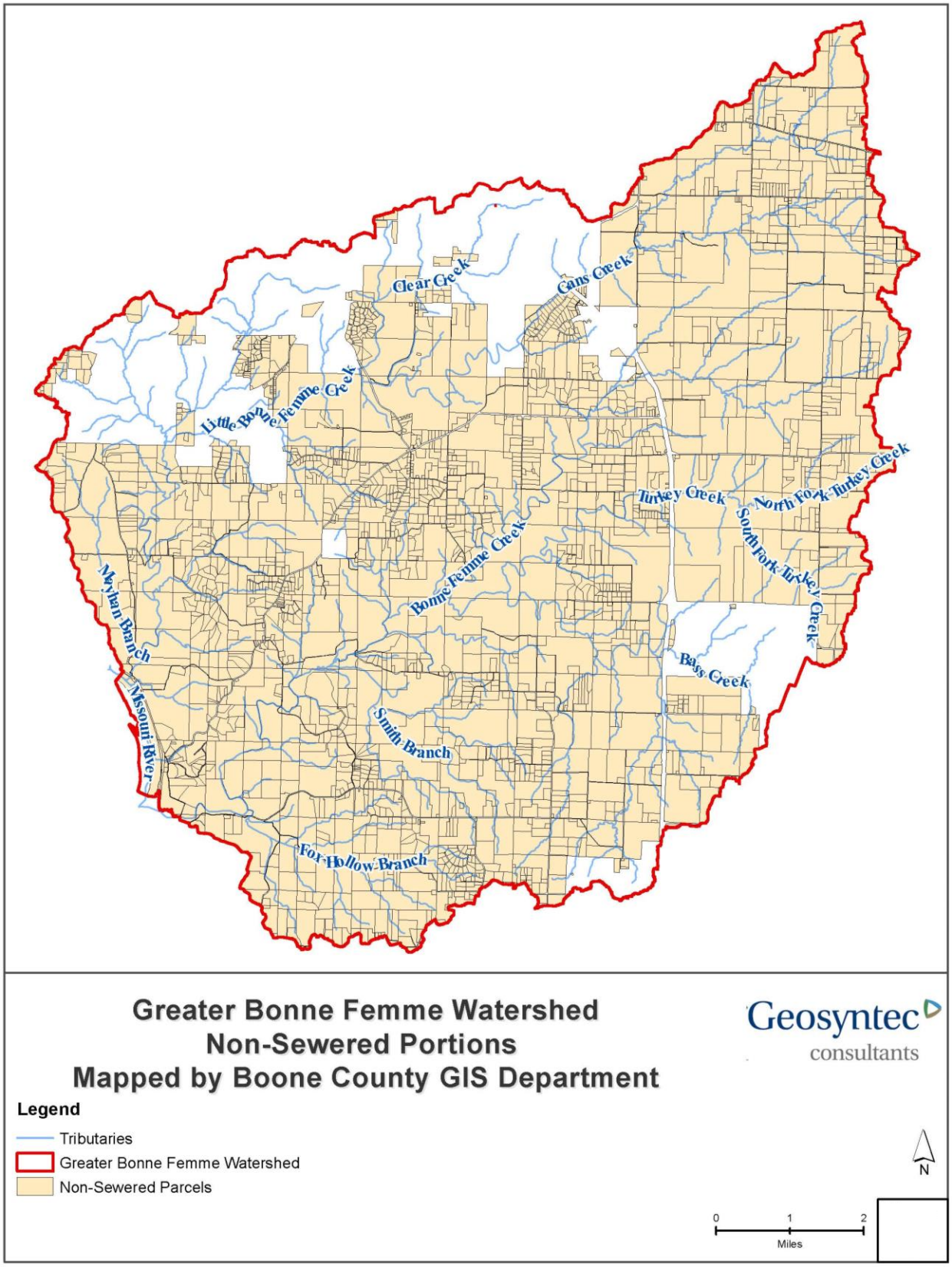

Figure 10. Non-Sewered Portions of Greater Bonne Femme Watershed Mapped by Boone County GIS Department.

Daily *E. coli* loading from potential *E. coli* sources were estimated for each subwatershed using the equations in Table 4. *E. coli* production rates are based on literature reported values from US EPA for fecal coliform (US EPA, 2001). A conversion factor was applied to convert the fecal coliform loading rate to an *E. coli* loading rate. *E. coli* water quality data from the GBFW were also used in the estimation of the *E. coli* loading rate. This methodology did not account for die-off of *E. coli* in the environment, and hence provides a conservative estimate of loading (i.e., if die-off were factored in, the estimated *E. coli* loading rates would be lower).

Table 4. Equations for estimating E. coli load from different potential sources.

Source	***E. coli* Load (colony forming units per day or cfu/day)**
Cattle	(#Cattle) * (10^{11} cfu/day/Cattle) * f^1
Goats	(#Goats) * ($1.2*10^{10}$ cfu/day/Goat) * f^1
Sheep	(#Sheep) * ($1.2*10^{10}$ cfu/day/Sheep) * f^1
Deer	(#Deer) * ($3.5*10^{8}$ cfu/day/Deer) * f^1
On-site wastewater systems	(#Households) * Malfunction Rate * (#Average people/household) * (Volume generated/person/day) * (10^4cfu/100mL) * (3758.2mL/gallon) * f^1

f^1- conversion factor to convert fecal coliform loading rate to *E. coli*

The methodology described above was implemented in a single Excel spreadsheet for 250 subwatersheds to calculate the *E. coli* daily loading for each subwatershed.

Loading by source for *E. coli* in the GBFW as determined by the SELECT modeling is shown in Table 5. With livestock (especially cattle) comprising 98.4% of the total estimated *E. coli* load in the watershed, the land use source for *E. coli* loading is likely almost completely coming from pasture land use. Daily *E. coli* unit loads simulated using the SELECT modeling approach are represented in Figure 11 for each subwatershed. The daily *E. coli* unit loads range from 0 to 4.91 x 1010 cfu/acre/day. Loading from livestock constitutes the largest proportion of simulated loads – with cattle accounting for over 98% of total estimated *E. coli* loading in the GBFW. Failing on-site wastewater and wildlife contribute a very small portion of the simulated *E. coli* unit loads. These results are in agreement with the results of MST conducted by Boone County.

Table 5. Estimated E. coli loading by source in the GBFW.

Source	Total E.coli Load (cfu/day)	% of Total Load
Cattle	8.7216E+13	98.0260%
Goats	1.2144E+11	0.2606%
Sheep	2.3184E+11	0.1365%
Deer	4.7076E+11	0.5291%
On-site Systems	9.32292E+11	1.0478%
GRAND TOTAL	**8.89723E+13**	**100.0000%**

2.5.2 Additional POCs

The *E. coli* modeling work was done to address the restoration theme of the WBP. Geosyntec Consultants also conducted modeling work for nutrients (TN and TP) and sediment (TSS) to address the protection theme of the WBP. Geosyntec developed the watershed model for nutrients and TSS using STEPL – a modeling application developed by US EPA (see https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl for information about the STEPL model). STEPL simulates annualized estimates of total runoff volume and nutrient and TSS loads based on the Universal Soil Loss Equation (USLE), watershed characteristics (both default and user-specified), BMP implementation, and meteorology. STEPL has been used by MDNR to estimate NPS pollutant loads for several WBPs.

2.5.3 Total Nitrogen (TN)

Total Nitrogen (TN) is commonly found in surface waters and serves as a primary nutrient for aquatic species. Major sources that deliver TN to streams within GBFW include runoff from cropland (48.2% of the total load), hay/pasture lands (40.8%), and urban areas (6%).

Loading by source for TN in the GBFW as determined by the STEPL modeling is shown in Table 6. Yearly TN unit loads were simulated using the STEPL model and are mapped in Figure 12. The TN unit loads by subwatershed in the GBFW range from 0.7 to 47.4 lb/acre/year. The subwatersheds with maximum loading for TN have pastureland and cropland as their dominant land uses. Hence, the greatest reduction in TN nutrient loading would be achieved by implementing BMPs in subwatersheds with a majority of pastureland and cropland.

2.5.4 Total Phosphorus (TP)

Similar to TN, Total Phosphorus (TP) serves as primary nutrient for aquatic species. Major sources that deliver TP to streams within the GBFW include runoff from cropland (58.3% of the total load), hay/pasture lands (28.4%), urban areas (5.4%), and forest lands (5.3%).

Loading by source for TP in the GBFW as determined by the STEPL modeling is shown in Table 6. Yearly TP unit loads simulated using the STEPL model are mapped in Figure 13. The TP unit loads by subwatershed range from 0.2 to 10.1 lb/acre/year. Similar to TN, the subwatersheds with maximum loading for TP have pastureland and cropland as their dominant land uses.

2.5.5 Total Suspended Solids (TSS)

Major sources that deliver TSS to streams within GBFW include runoff from cropland (60.2% of the total load), hay/pasture lands (30.4%), “other” land uses (4.7%), and forest lands (3%). Streambank erosion also contributes to TSS. The construction phase of building projects can also contribute additional TSS loading to streams.

Loading by source for TSS in the GBFW as determined by the STEPL modeling is shown in Table 6. Yearly TSS unit loads simulated using the STEPL model are mapped in Figure 14. The TSS unit loads by subwatershed range from 0.1 to 5.8 tons/acre/year (note that STEPL does not

consider streambank erosion in modeling for TSS loads). The figure suggests that the greatest reduction in TSS loss would be achieved by implementing BMPs in watersheds with majority cultivated crop and transportation land use.

Table 6. Estimated loading by source for TN, TP, and TSS in the GBFW.

Source	Percent of GBFW's Total Acres	TN		TP		TSS	
		lbs/yr	% of loading	lbs/yr	% of loading	tons/yr	% of loading
Cropland	13	277,961	48.20	60,721	58.27	59,397,870	60.21
Hay/Pasture	33	235,420	40.83	29,578	28.38	29,962,052	30.37
Forest	43	16,004	2.78	5,514	5.29	2,991,291	3.03
Urban	9	34,491	5.98	5,627	5.40	1,643,648	1.67
Other*	2	12,695	2.20	2,744	2.63	4,662,764	4.73
Septic	-	57	0.01	23	0.02	0	0.00
Totals:	100	576,629	100	104,205	100	98,657,626	100

*Other land use includes shrubland, barren, sparsely vegetated, wetland, etc.

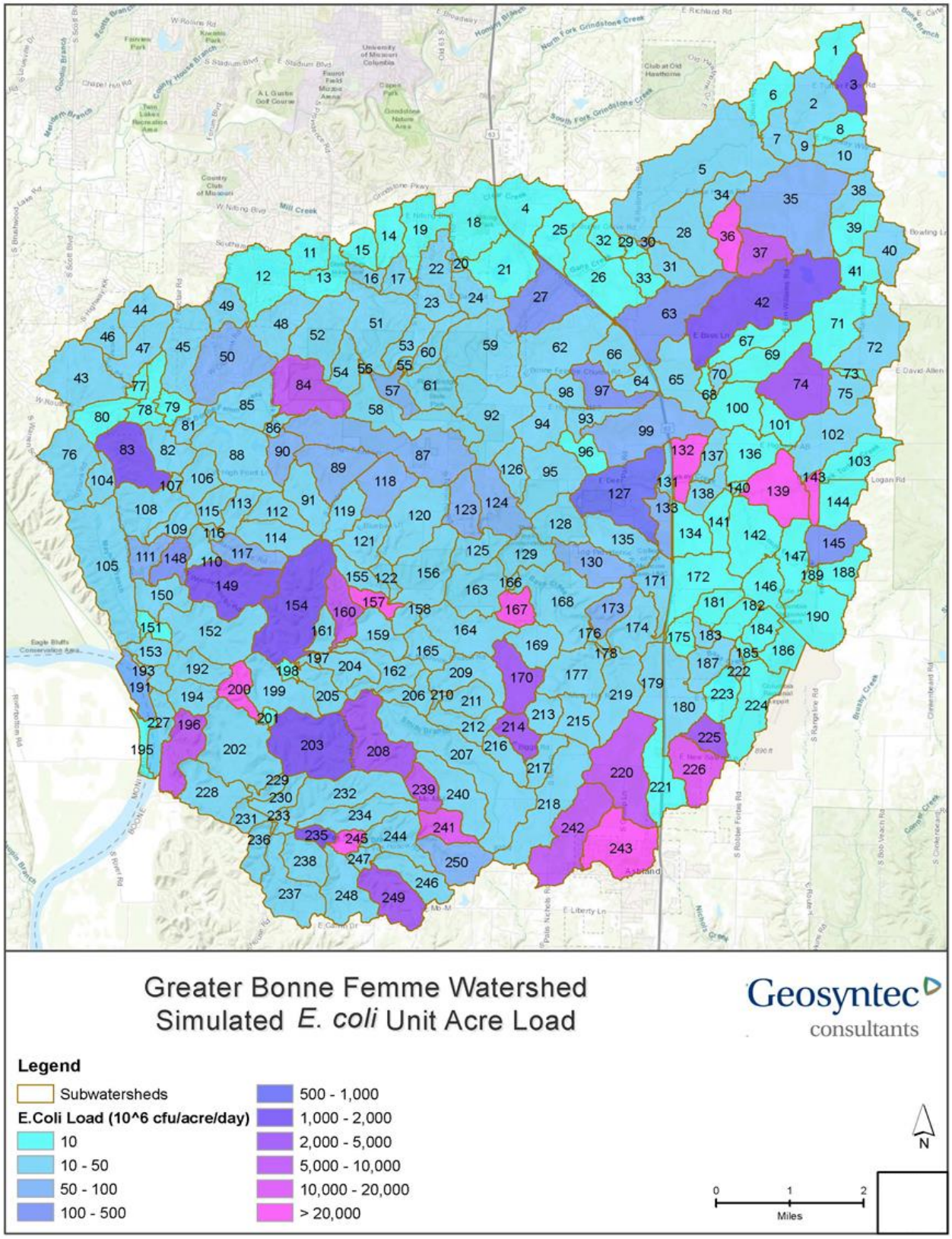

Figure 11. Simulated E. Coli Unit Area Load for the Greater Bonne Femme Watershed.

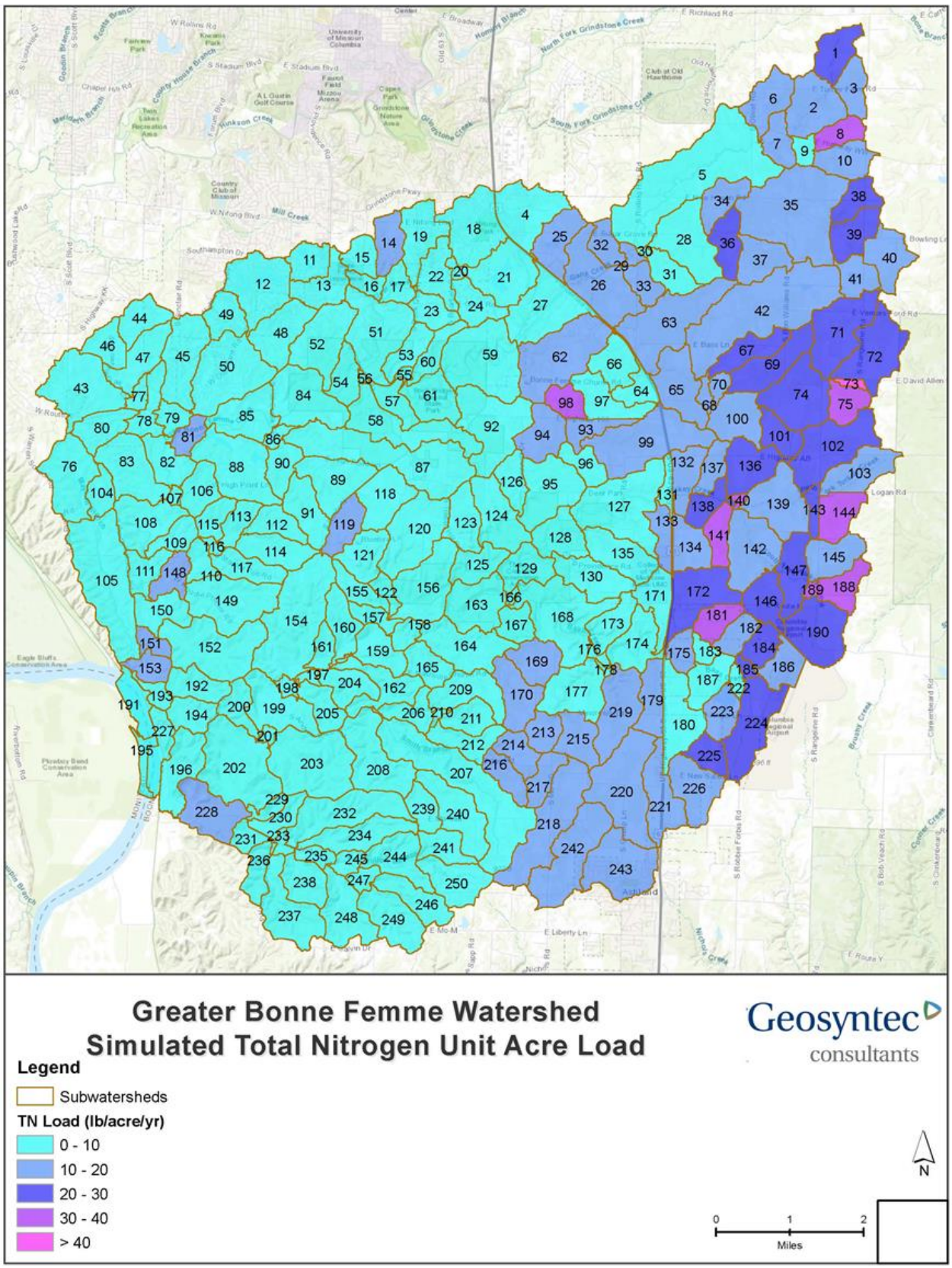

Figure 12. Simulated Total Nitrogen Unit Acre Load for the Greater Bonne Femme Watershed.

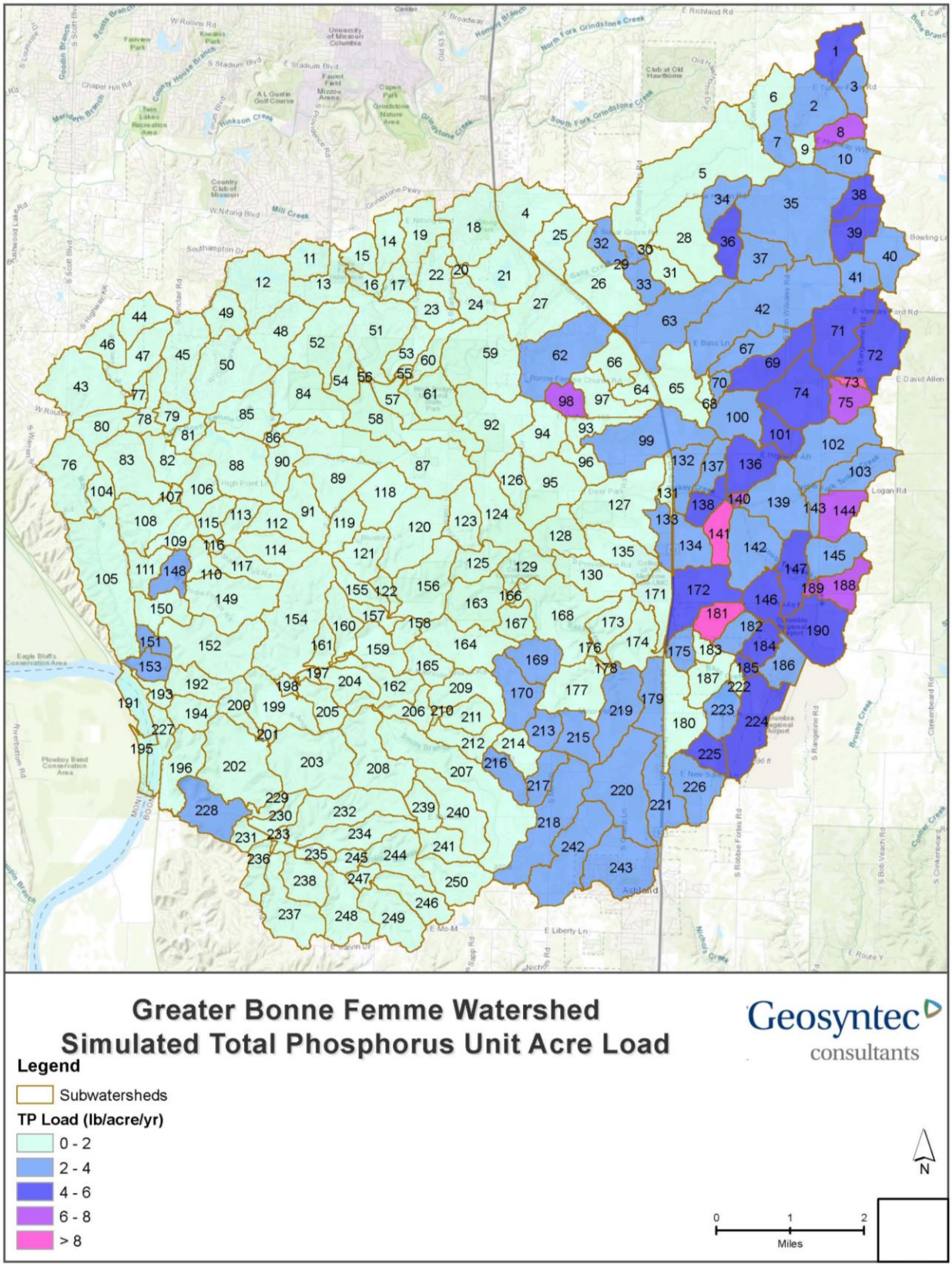

Figure 13. Simulated Total Phosphorus Unit Acre Load for the Greater Bonne Femme Watershed.

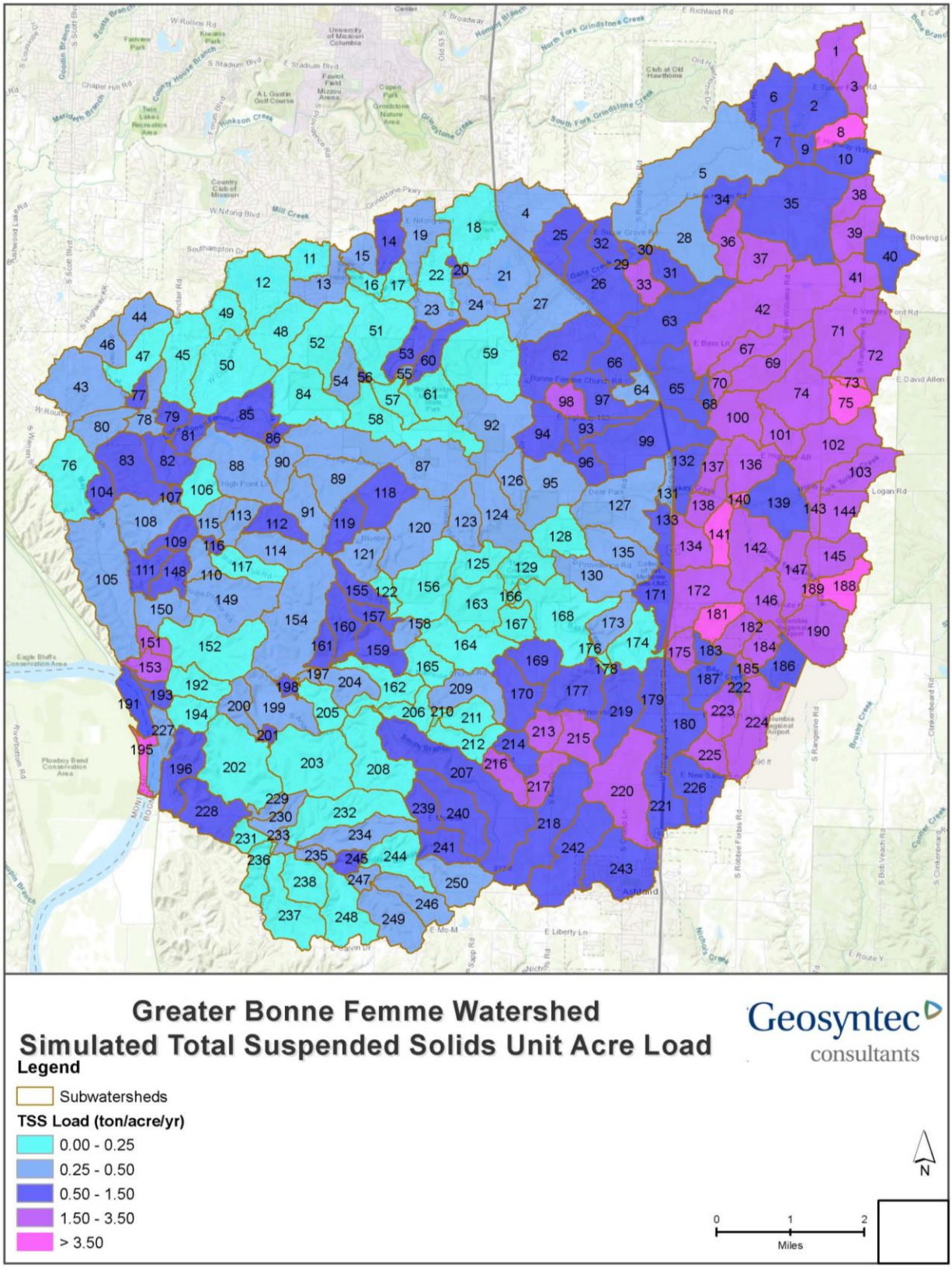

Figure 14. Simulated Total Suspended Solids Unit Acre Load for the Greater Bonne Femme Watershed.

3.0 Critical Areas / Targeted Areas (Element A, Criterion 7) (Element C, Criterion 1)

3.1 Critical Area Identification (Element A, Criterion 7; Element C, Criterion 1)

Although this section describes the process used for identifying those areas in the watershed where the greatest load reduction could be achieved by installation of BMPs, and which therefore should be prioritized for implementation if possible, because the entire GBFW comprises source area for the watershed's impaired streams, project partners consider the entire watershed to be a critical area.

In order to identify the most critical areas for BMP implementation, Geosyntec applied a Catchment Prioritization Index (CPI) that was developed for watershed planning. The CPI prioritizes BMPs when addressing multiple pollutants (Geosyntec, 2006) to identify critical areas for BMP implementation. A CPI was calculated for the subwatersheds shown in Figure 15 based on pollutants of concern, pollutant loading, and impairments. A higher CPI score would indicate higher priority of a subwatershed for BMP implementation. (Element C, Criterion 1)

The CPI was calculated for each subwatershed using the methodology described in Section 3.5 of the Greater Bonne Femme Watershed Modeling Report and also inserted below. The calculated CPIs are shown in Figure 15. The CPI scores range from 1 to 5. The subwatershed (subwatershed 36) with the largest CPI score drains to Gans Creek. Twenty-four subwatersheds had CPIs equal to or greater than 2. These were identified as critical areas for BMP implementation in the GBFW. All twenty-four subwatersheds are also identified as target areas for implementation. The pollutants of concern for each of the identified critical subwatersheds and the downstream impaired stream are shown in Table 7.

The steps for calculating the CPI are:

1) For each pollutant of concern (POC), i.e., *E. coli*, TN, TP, and TSS, the pollutant catchment prioritization index ($PCPI^i_s$) was calculated using the following equation:

$$PCPI_s^i = \frac{L_s^i}{Max(L_s^i)}$$

Where, L^i_s is the estimated unit acre load for subwatershed "s" and pollutant of concern "i".

2) PCPIs were weighted by a weighting factor for each POC and summed to calculate the Total PCPI for each subwatershed. Weighting factors used for different POCs are provided in Table 7 below. The use of the selected weighting factors in Table 7 puts the

strongest emphasis on addressing the *E. coli* impairments, with a secondary emphasis on optimizing TSS and nutrient load reductions.

$$Total\ PCPI_s = \sum_{i}^{N} (PCPI_s^i \times F)$$

Table 7. Weighting Factors for Pollutants of Concern.

Pollutant of Concern	Weighting Factor (F)
E. coli	**10**
Total Nitrogen	**3**
Total Phosphorus	**1**
TSS	**1**

3) For subwatersheds with downstream impairments, the Total PCPI are multiplied by a factor for each downstream impairment. A sensitivity analysis was conducted to assess the impact of magnitude of downstream impairment factor and location of downstream impairment on the prioritization of subwatersheds. A factor of 1.1 was deemed appropriate for the GBFW after consultation with MDNR and Boone County. This is a minor deviation from the approved QAPP, which included using a factor of 2 for each downstream impairment. The change was necessitated because using a factor of 2 was resulting in higher weighting of subwatersheds with low simulated loads but located upstream of multiple impaired streams. The use of a factor of 1.1 prioritized subwatersheds with higher simulated pollutant loading located downstream of the impaired streams. This change improved the identification and prioritization of subwatersheds for BMP implementation.

4) The CPI for each subwatershed is calculated by normalizing the Total PCPI, scaling by five (5), and rounding to nearest integer:

$$CPI_s = \text{Round}\left(\frac{Total\ PCPI_s}{Max(Total\ PCPI_s)} \times 5\right)$$

The normalization and scaling of CPI results in binning of subwatersheds with CPI scores in the range of 1 to 5. This approach provides the stakeholders with more options for BMP implementation in the critical areas corresponding to higher CPI bins. Twenty-four subwatersheds with CPIs of 2 or greater were identified as target areas for BMP implementation (Figure 15 and Table 12). The use of the CPI scoring approach allowed subwatershed prioritization for implementation of BMPs.

Other critical areas in the watershed include areas that are particularly sensitive to runoff and erosion. These areas were identified using the sensitivity analysis conducted as part of the previous watershed planning process (BFSC, 2007). The critical subwatersheds identified using the CPI methodology were overlaid over the sensitive areas from the

2007 analysis, and several of the identified critical subwatersheds were found to be fall within the sensitive areas.

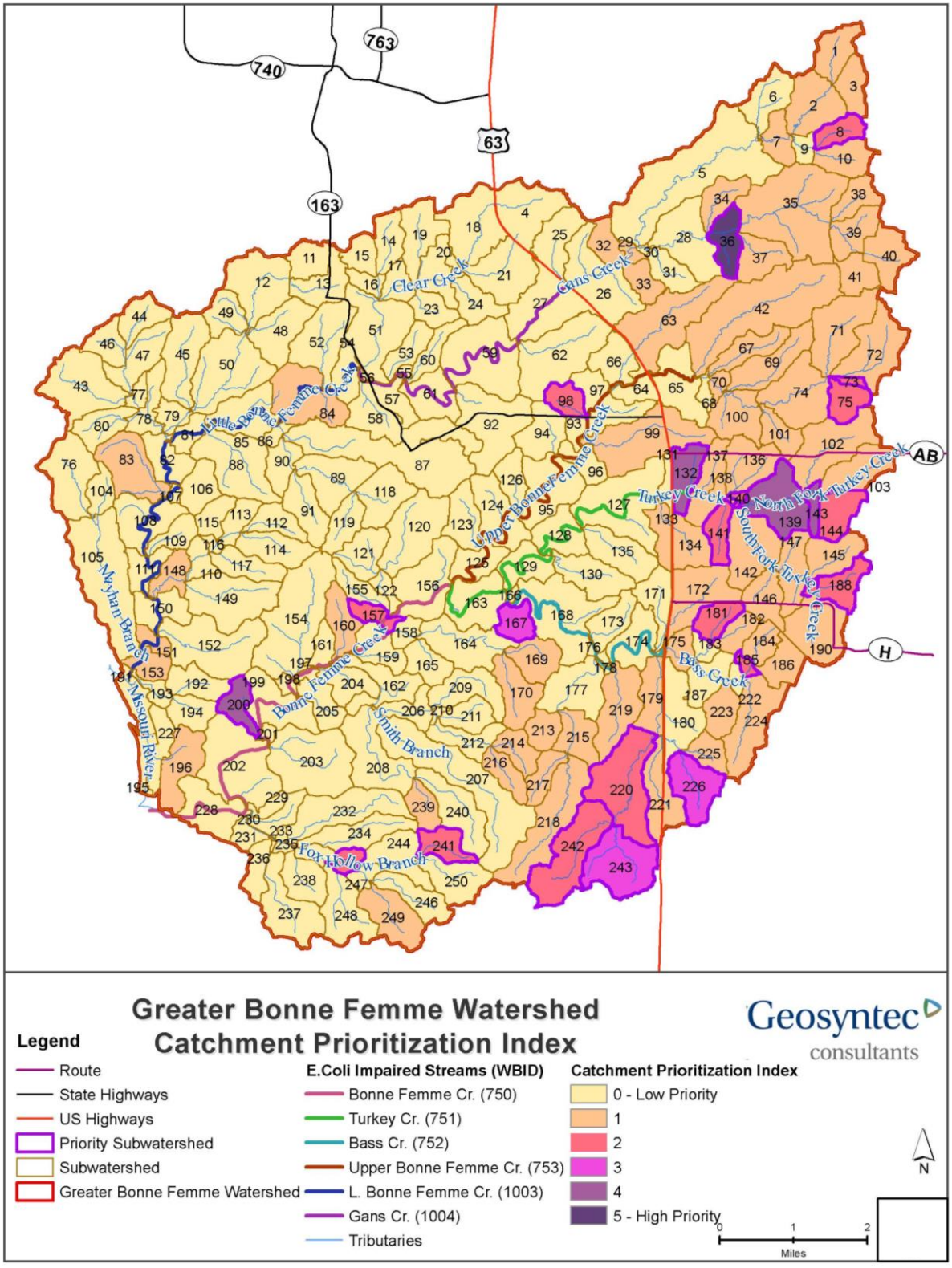

Figure 15. Catchment Prioritization Index for the Greater Bonne Femme Watershed.

Table 8. Critical areas for BMP implementation with their CPI scores, downstream impaired streams, and pollutants of concern in critical areas.

Subwatershed ID	Area (ac)	CPI** Score	Downstream Impaired Stream(s)	Pollutant*			
				TN	TP	TSS	*E. coli*
8	114	2	Gans Cr. & L. Bonne Femme Cr.	x	x	x	x
36	185	5	Gans Cr. & L. Bonne Femme Cr.	x	x	x	x
73	25	2	Bonne Femme Cr.	x	x	x	
75	156	2	Bonne Femme Cr.	x	x	x	x
98	124	2	Bonne Femme Cr.	x	x	x	x
132	189	4	Turkey Cr. & Bonne Femme Cr.	x	x	x	x
139	356	4	Turkey Cr. & Bonne Femme Cr.	x	x	x	x
140	20	2	Turkey Cr. & Bonne Femme Cr.	x	x	x	
141	143	2	Turkey Cr. & Bonne Femme Cr.	x	x	x	x
143	70	4	Turkey Cr. & Bonne Femme Cr.	x	x	x	x
144	202	2	Turkey Cr. & Bonne Femme Cr.	x	x	x	x
157	97	2	Bonne Femme Cr.	x	x	x	x
167	135	3	Bass Cr., Turkey Cr. & Bonne Femme Cr.	x	x	x	x
181	145	2	Bass Cr., Turkey Cr. & Bonne Femme Cr.	x	x	x	
185	37	2	Bass Cr., Turkey Cr. & Bonne Femme Cr.	x	x	x	
188	177	2	Turkey Cr. & Bonne Femme Cr.	x	x	x	
189	23	2	Turkey Cr. & Bonne Femme Cr.	x	x	x	
200	144	4	Bonne Femme Cr.	x	x	x	x
220	560	2	Bass Cr., Turkey Cr. & Bonne Femme Cr.	x	x	x	x
226	288	3	Bass Cr., Turkey Cr. & Bonne Femme Cr.	x	x	x	x
241	159	2	Bonne Femme Cr.	x	x	x	x
242	487	2	Bass Cr., Turkey Cr. & Bonne Femme Cr.	x	x	x	x
243	429	3	Bass Cr., Turkey Cr. & Bonne Femme Cr.	x	x	x	x
245	75	2	Bonne Femme Cr.	x	x	x	x

* TN = total nitrogen; TP = total phosphorus; *E. coli* = *Escherichia coli*; TSS = total suspended solids.
** CPI = Catchment Prioritization Index (ranges from 1-5)

3.2 Additional Targeted Area (Element A, Criterion 7; Element C, Criterion 1)

Modeling of POC loading did not identify subwatershed 42 as a priority watershed for watershed-wide BMP implementation based on CPI score. However, subwatershed 42 is in the upper reaches of Bonne Femme Creek and is a critical area with respect to inputs (surface water and infiltrated groundwater) into the vulnerable Devil's Icebox Cave System. Modeling showed

this subwatershed to have low to moderate levels of estimated TN and TP loading, and high level of sediment loading, and has the 16th highest estimated *E. coli* loading and number of cows out of 250 subwatersheds. In order to address the protection goals of the WBP, subwatershed 42 has been chosen as a pilot subwatershed to, in addition to addressing the *E. coli* impairment, address nutrient and sediment pollutant loading to sensitive karst features and Outstanding State Resource Waters.

4.0 Best Management Practices (Element C, Criteria 1, 2, and 3)

4.1 Selection of Best Management Practices (BMPs) for Use in the GBFW (Element C, Criteria 1, 2, and 3)

A BMP is defined as an environmental protection practice used to control pollutants. For the target areas identified using the methodology described above, the feasibility and effectiveness of pastureland, cropland, forestry, streambank, on-site wastewater systems, and urban BMPs were assessed. Stormwater BMPs control pollutants several of ways. Practices that slow the movement of runoff reduce its erosive capacity and ability to pick up and move pollutants from the landscape to nearby waterways while also allowing greater infiltration of runoff. Those that maintain vegetative cover on the landscape help slow runoff, increase infiltration and soil moisture storage, reduce pollutant movement to streams, and provide a natural filter for some pollutants as they move through the soil and are taken up by plant roots. Practices that keep the soil covered with plants (particularly practices that provide continuous living cover as discussed in this WBP) or increase the infiltration of runoff near its source are a boon to NPS pollutant reduction. Practices that provide management to reduce the introduction of pollutants to the landscape and streams (e.g., animal or human waste products; excess fertilizers from fields or yards; sediment from development, cultivated fields, roadways, or streambanks; road salt and other substances toxic to aquatic life or harmful to human health) are also extremely beneficial.

While this WBP's focus is on implementation of BMPs to improve water quality, and the focus is primarily on agricultural BMPs to address the GBFW's *E. coli* impairments, these BMPs also provide significant benefits to agricultural producers by reducing soil erosion, improving soil health, and increasing profitability. Funding to help producers implement these practices is available through state and federal cost-share programs.

The POCs in the GBFW include *E. coli*, TN, TP, and TSS. Although the primary focus in BMP selection was reduction of *E. coli* loading, many BMPs have a positive effect on reducing the load of multiple POCs simultaneously. The ability of the assessed BMPs to reduce POC loading is one part of the rationalization for their selection (Element C, Criterion 2). A brief description of each BMP assessed for implementation in the GBFW is provided below.

4.1.1 Cropland BMPs

Cropland BMPs control the runoff from agriculture fields resulting in reduced sediment and nutrient loading. Given the proximity of some of the cropland to pastureland in the GBFW, the use of cropland BMPs would also manage any runoff from adjacent land use types – including pastureland. This would result in reduced loading of other POCs which could include *E. coli*. Seven types of BMPs were assessed for implementation in the cropland areas of the GBFW:

- **Cover Crops** are short-term crops grown after the main cropping season and are used primarily to slow erosion, improve soil health, enhance water availability, smother weeds, help control pests and diseases, increase biodiversity, and to reduce POC loading from the farm fields or adjacent areas.
- **Nutrient Management** helps the producer maximize profits by balancing crop yields and nutrient inputs. Using a nutrient management plan, producers can optimize the economic returns from nutrients used in production, minimize nutrient loss and improve water quality at the same time.
- **Conservation Tillage** involves the planting, growing, and harvesting of crops with minimal disturbance to the soil. This practice uses seeders and techniques that are more precise and require fewer passes, reducing the amount of fuel used for farm equipment in addition to reducing POC loading.
- **Terraces** are earth embankments and/or channels constructed across the slope of the field to intercept runoff, reduce erosion, and trap POCs contained in runoff.
- **Vegetated Buffers** are areas of crop fields maintained in permanent vegetation intended to intercept and slow runoff thereby reducing erosion and helping reduce POC loading from the farm fields or adjacent areas.
- **Retention Ponds** trap POCs from runoff and provide habitat for wildlife.
- **Conservation Agriculture** is a holistic approach for agriculture that focuses on practices that involve minimizing soil disturbance, keeping soil covered, increased plant diversity, keeping living roots in the soil as much as possible and integrating animals into the farm. Examples of conservation agriculture practices include diverse crop rotation, multi species cover crop, continuous living cover, no-till and low till farming, soil management, riparian corridor enhancement, prairie strips and rotational grazing. Examples of agroforestry practices include riparian forest buffers and other practices that can provide economic opportunities as well as add to plant diversity and habitat on the farm, such as alley cropping, silvopasture, and forest farming.

4.1.2 Pastureland BMPs

Six types of pastureland BMPs were assessed for implementation in the pasture areas of the GBFW. Some of these BMPs limit the source of POC from feeding operations and others reduce the pathways for the POC to enter the adjacent waterbodies.

- **Manure Management** or animal waste management systems involve manure storage, transportation off-site, and improvements in manure recoverability. This practice reduces the source of nutrients and bacteria in the runoff.
- **Grazing Management** involves controlling the movement of animals on the field. Grazing, movement and manure deposition by the animals encourages growth of pasture vegetation. However, animals can overgraze a pasture if they are not moved to a fresh area frequently enough. By rotating animals to other areas or pastures, the recently grazed

vegetation has an opportunity to regrow, which impedes flow of runoff across the pasture and improves the soil nutrient content. The improved soil nutrient content reduces the need for fertilizer application in the field and reduces nutrient loading

- **Fencing** of streams and other waterbodies is designed to prevent livestock from entering the waterbody. This prevents livestock from depositing manure directly into the waterway and from damaging streambanks.
- **Vegetative Filter Strips** are vegetated areas that receive stormwater runoff from a pastureland with animal feeding operations.
- **Livestock Exclusion / Alternative Sources of Water** involves fencing of streams and other waterbodies to prevent livestock from entering the waterbody, coupled with providing alternative sources of water.
- **Wetland restoration or creation** projects on pastureland provides numerous crucial environmental functions such as wildlife habitat, flood protection, and water quality improvements.

4.1.3. Streambank BMPs

Streambank BMPs are installed along the banks of streams to reduce POC loadings into the receiving streams, improve water quality, and improve the biological condition along the stream bank. Two types of streambank BMPs were considered for implementation in the GBFW:

- **Streambank Stabilization** is an engineered vegetative, structural or combination practice for eroding streambanks designed to stabilize the stream, reduce further erosion and provide a stable area to establish grasses or other vegetation to protect the soil and water resource from erosion losses and contamination. Soils lost from eroding streambanks flush into river and stream systems, carrying excessive nutrients, damaging recreational assets, placing increased stress on downstream infrastructure, and diminishing the aquatic habitat that many freshwater species rely upon. These approaches are carefully designed interventions to improve the hydrologic, hydraulic, geomorphic, water quality, and biological condition of degraded streams.
- **Streambank Buffers** includes riparian buffer, vegetative buffer or reinforcing the existing tree line in the vicinity of stream bank (riparian corridor enhancement), sometimes implemented with stream exclusion fencing to restrict animal access to the stream, to reduce streambank erosion and improve the biological condition of the streambank.

4.1.4 On-site Wastewater System BMPs

On-site wastewater system BMPs address the POC loading from failing on-site wastewater systems that leak bacteria or nutrients into surface water and groundwater. This practice involves replacing old systems with more reliable systems and/or repairing malfunctioning treatment systems, failing drain fields, or waste lagoon systems. For the purposes of this WBP, a very low cost septic pump-out and awareness program will be part of the plan's Information and Outreach

program. This program will likely garner some *E. coli* and nutrient load reductions, but its main objective is to positively impact awareness of NPS water quality concerns in the watershed by participants who are required to attend a NPS workshop to be eligible for a pump-out rebate.

4.1.5 Urban BMPs

Urban BMPs are designed to reduce the quantity and improve the quality of stormwater runoff from impervious surfaces in urban areas. The selection and implementation of urban BMPs are subject to site-specific constraints such as local hydrology, soil infiltration feasibility, and space restrictions. Four commonly used urban BMPs assessed for implementation in GBFW include:

- **Bioretention systems** consist of a soil bed planted with suitable native vegetation. Stormwater runoff entering the bioretention system is filtered through the soil planting bed before being discharged downstream.
- **Grass swales**, or ditches, can be placed in residential areas or along major roadways to help reduce peak runoff through infiltration and storage.
- **Wetland basins** are man-made systems engineered to approximate the water-cleansing process of natural wetlands. They are used to filter runoff from urban impervious areas and provide habitat for wildlife.
- **Detention ponds** hold stormwater runoff until pollutants settle to the bottom. The water is then released slowly into the stream, reducing flooding and POCs in the discharge.

In addition to recommending the installation of new BMPs where applicable, Table 12 also lists maintenance of existing BMPs under a stormwater management plan for a commercial area in the GBFW (subwatershed 181).

4.2 Load Reduction Effectiveness of Assessed BMPs (Element B, Criterion 2)

4.2.1 BMP Pollutant Load Reduction Effectiveness

Percent load reduction efficiency data was extracted from a literature review to estimate the load reduction of the selected BMPs for the GBFW. The literature review includes a summary of paired watershed case studies, watershed plans for similar watersheds and agricultural BMP reference guides. Percent load reduction was extracted for each BMP to reduce the load for each POC in the GBFW.

4.2.2 Literature Review

A literature review was conducted to estimate the BMP percent removal efficiencies for the four POCs in the GBFW. Due to the limited performance data available for *E. coli* treatment and agricultural BMPs in general, no single source of data covers the performance of all types of

BMPs considered for use in the GBFW. Six sources of data were analyzed, from which BMP performance data are extracted:

a. **Spring River Nonpoint Source Watershed Plan**
   The WBP was written for the Spring River Watershed to address impairments caused by nutrients and sediment (MDNR, 2015). The list of considered BMPs in the Spring River Watershed study is similar to the list considered for use in the GBFW, including urban, agricultural, streambank and on-site wastewater system BMPs. The BMP removal efficiency data for nutrients and sediment from this WBP were utilized for this project, where applicable.

b. **International Stormwater BMP Database 2016 Summary Statistics**
   The International Stormwater BMP Database (the Database) is a publicly accessible repository for BMP performance, design, and cost information. Since the initial development of the BMP Database in 1996, a portfolio of more than $200 million in water quality research is represented in the Database. The 2016 summary statistics of the Database include treatment performance of urban BMPs for TN, TP, and TSS (Clary. J. et al. 2017). The median removal percentage for each BMP-POC pairing for all case studies in the Database was extracted from the report and used in this evaluation to estimate load reductions.

c. **Effectiveness of BMPs for Bacteria Removal Developed for the Upper Mississippi River Bacteria TMDL**
   A literature review was conducted to inform the selection of the most practical and effective implementation strategies to improve water quality in the Upper Mississippi River Bacteria TMDL project area in the state of Minnesota (Tilman, L. et al., 2011). This literature review evaluated research findings regarding the effectiveness of various BMPs to reduce bacteria loading to surface waters. Only a limited number of BMPs were reviewed in this data source, but multiple studies were analyzed for each type of BMP. The median load reduction performance for indicator bacteria from all studies included in the data source for each type of BMP was extracted and used in this project for calculating *E. coli* load reduction.

d. **The Agricultural BMP Handbook for Minnesota**
   This literature review, published by the Minnesota Department of Agriculture (MDA), included empirical research on the effectiveness of 30 conservation practices, i.e., agricultural BMPs (MDA, 2012). Nutrient, sediment, and limited bacteria removal performance data for the 30 BMPs are available in this data source.

e. **Chesapeake Bay Quick Reference Guide for BMPs**
   The Chesapeake Bay Program (CBP) is a regional partnership that leads and directs Chesapeake Bay restoration and protection. This reference guide provides summarized profiles for each CBP-approved BMP, including the effectiveness in pollutant load removal, cost and feasibility of implementation (CBP, 2018). In this data source, BMP load reduction percentages are often summarized for specific land use, crop types, or sub-

type of the BMP. For the purpose of this project, the median value of the load reduction for each BMP-POC pairing was extracted from this reference guide.
Table 9 summarizes the load reduction percentage of each BMP listed above for *E. coli*, TN, TP, and TSS and the corresponding source of data from the five sources listed in the preceding section.

4.2.3 Pollutants of Concern Load Reduction Effectiveness (Element B, Criteria 1, 2 and 3) (Element C, Criteria 2 and 3)

Table 9 summarizes the load reduction percentage of each BMP listed above for *E. coli*, TN, TP, and TSS and the corresponding source of data from the five sources listed in the preceding section.

Table 9. BMP Pollutant Load Reduction Efficiencies Used for Calculating Load Reductions through BMPs.

BMP Type	BMP	*E. coli*	TN	TP	TSS
Cropland	Cover Crops	0 [e]	0.23 [e]	0.07 [e]	0.1 [e]
	Nutrient Management	0 [e]	0.05 [e]	0.05 [e]	0.25 [a]
	Conservation Tillage	0 [e]	0.08 [e]	0.35 [e]	0.47 [e]
	Terrace	0 [e]	0.38 [a]	0.3 [a]	0.36 [a]
	Vegetated Buffer	0.59 [d]	0.36 [a]	0.5 [a]	0.5 [a]
	Retention Pond	0.7 [c]	0.5 [a]	0.5 [a]	0.5 [a]
Pastureland	Manure Management	TP, TN and *E. coli* removal based on percent of manure removed from the barnlot.			
	Grazing Management	0.3 [d]	0.09 [d]	0.24 [d]	0.3 [d]
	Fencing	0.35 [c]	0.34 [e]	0.42 [e]	0.56 [e]
	Vegetative Filter Strip	0.7 [c]	0.32 [e]	0.5 [a]	0.56 [e]
	Livestock Exclusion/Alternative sources of water	0.35 [c]	0.34 [e]	0.42 [e]	0.56 [e]
	Wetland	0.78 [c]	0.42 [e]	0.4 [e]	0.31 [e]
Streambank	Streambank Stabilization	0 [e]	0.075 lbs/ft/yr [e]	0.068 lbs/ft/yr [e]	248 lbs/ft/yr [e]
	Streambank Buffer	0.7 [c]	0.34 [e]	0.42 [e]	0.56 [e]
	Vegetated Buffer with Trees	0.7 [c]	0.34 [e]	0.42 [e]	0.56 [e]
Urban	Bioretention	0.8 [b]	0.16 [b]	0 [b]	0.75 [b]
	Grass Swale	0 [b]	0 [b]	0 [b]	0.16 [b]
	Wetland Basin	0.64 [b]	0.04 [b]	0.25 [b]	0.55 [b]
	Detention Pond	0.64 [b]	0 [b]	0.17 [b]	0.64 [b]
	Maintain existing BMPs in accordance with the SWPP (Retention Pond)	0.7 [c]	0.5 [a]	0.5 [a]	0.5 [a]

On-site Wastewater	**Repair/Replace program**	**TN, TP and TSS removal based on percent of on-site wastewater system repaired/replaced**

The data source for the load reduction rate for each BMP-POC pairing is from one of the six data sources listed in Section 3.8.1.1:
a – Spring River Nonpoint Source Watershed Plan;
b – International Stormwater BMP Database 2016 Summary Statistics;
c – Effectiveness of BMP for Bacteria Removal Developed for the Upper Mississippi River Bacteria TMDL;
d – The Agricultural BMP Handbook for Minnesota;
e – Chesapeake Bay Quick Reference Guide for BMP.

As shown in Table 9, load reduction percentages of all BMPs assessed for implementation for each of the four POCs were extracted from the literature review, except those for manure management, streambank stabilization, and on-site wastewater system BMPs. The load reduction resulting from manure management depends on the amount of manure collected, stored, transferred, or removed from the barnlot. The load reduction resulting from streambank stabilization is a function of the length of streambank stabilized. The load reduction resulting from on-site wastewater system BMPs is a function of the percentage of on-site wastewater systems repaired or replaced. As a result, the load reduction of these three types of BMPs cannot be represented as percent of load removal from the BMPs' tributary areas.

4.3 BMP Implementation Feasibility Assessment (Element C, Criterion 2)

The other rationalization for selecting the BMPs assessed and discussed in this plan, in addition to the ability of the BMP to reduce POC loading, is the feasibility of implementation for each type of BMP. The feasibility of implementing a certain type of BMP in a subwatershed was assessed based on factors including the land use, space constraint, slope and vegetation of the subwatershed, proximity of the source of POC to the stream, cost-effectiveness and stakeholder involvement. The feasibility assessments for each BMP are summarized below:

4.3.1 Cropland BMP Feasibility

Cropland BMPs are feasible for locations with a larger proportion of cropland land use. Cover crops, nutrient management, conservation tillage, conservation agriculture and agroforestry can generally be implemented in cropland areas of the watershed without space constraints since these BMPs do not reduce the existing footprint of the cropland. However, there are currently not data available to quantify *E. coli* load reduction from implementation of these practices. Terraces, vegetated buffers, and retention ponds require extra space to implement but can result in reduction of *E. coli* load. In addition, terraces are typically implemented in cropland areas with moderate to high slopes which may already be difficult to farm.

4.3.2 Pastureland BMP Feasibility

Pastureland BMPs are suitable for locations with dominant pasture/hay land use. Manure management requires construction of structures designed for collection, transfer, and storage of manures and associated wastes. As a result, the practice requires space for the facility, including operation and maintenance. Grazing management involves rotating paddocks which requires

sufficient pastureland area relative to the animal population in the subwatershed, along with fencing and water sources for each paddock. Vegetative filter strips and wetlands also require extra space to be installed adjacent to the pastureland, while livestock exclusion fencing requires a limited amount of space for implementation, but often requires infrastructure to provide alternative water sources.

4.3.3 Streambank BMP Feasibility

Streambank stabilization projects are feasible for stream segments that are severely eroded or composed with karst formation in the streambed. Streambank stabilization usually requires the services of an engineer, which can make this type of BMP more expensive for landowners. The Subwatershed Sensitivity Analysis done as part of the previous WBP (BFSC, 2007) was used to identify areas that are suitable for streambank stabilization projects, which include:

- Clear Creek
- Upper Little Bonne Femme Creek before confluence with Clear Creek
- Mayhan Branch
- Bonne Femme Creek between U.S. Route 63 and confluence with Turkey Creek
- Turkey Creek
- Lower Bass Creek between U.S. Route 63 and confluence with Turkey Creek
- Fox Hollow Branch

The feasibility of implementing streambank buffers in a subwatershed depends on the distance from the source of pollutants (e.g., animals) to the waterbody and whether vegetation already exists adjacent to the waterbody which can be enhanced for implementation of the practice.

4.3.4 On-site Wastewater System BMP Feasibility

On-site wastewater system BMPs are suitable for areas with existing on-site wastewater systems with indications of failure. Although modeling only attributes a small amount of *E. coli* loading to failing on-site wastewater systems, and human sources identified in the microbial source tracking were low, they still present a potential source of *E. coli* in the impaired streams and should be addressed. A low-cost septic pump-out and awareness program with a strong education component would allow a proactive approach to address potential on-site issues, hopefully before failure occurs.

4.3.5 Urban BMP Feasibility

Urban BMPs are feasible for subwatersheds with a significant amount of stormwater runoff from impervious surfaces. Space, soil infiltration capacity, local hydrology, and stormwater regulatory requirements are some of the major factors that affect the feasibility and design of urban BMPs. Urban areas in the GBFW watershed include the southern part of the City of Columbia, the northern part of the City of Ashland, the Columbia Regional Airport, and the Community of Deer Park along U.S. Route 63. Boone County has regulatory authority over unincorporated areas in the County.

4.4 Endorsement of Conservation Agriculture and Other Practices that Promote Continuous Living Cover for Use in the GBFW

The protection theme of the WBP addresses the need to protect vulnerable karst features and Outstanding State Resource Waters and other streams in the GBFW from degradation from nutrient and sediment pollution. Protection of waters from nutrient pollution in particular has become a priority nationwide and was the subject of EPA's Memorandum of April 5, 2022 concerning "Accelerating Nutrient Pollution Reductions in the Nation's Waters" (USEPA, 2022). This memo states that a key area of focus for EPA's Office of Water is to accelerate progress in controlling excess nutrients entering our nation's waters by scaling up existing approaches and more broadly deploying new data assessments, tools, financing approaches, and implementation strategies. Two of the strategies expounded in the memo to address this pressing concern relate directly to the protection theme of this WBP:

- Deepen collaborative partnerships with agriculture.
- Redouble efforts to support states to achieve nutrient pollution reductions from all sources.

The pastureland and cropland BMPs discussed earlier in this section universally address reduction of nutrient and sediment pollution. Some also address *E. coli* loading. See Appendix H for a list of agricultural BMPs with their mode of action and the pollutants they address. Research and development with the goal of understanding and improving the efficacy of conservation agriculture practices has evolved and progressed over time with the realization of the severity of the environmental consequences that nutrients present for the nation's waterways. Boone County stormwater staff have been investigating existing and developing options for improved nutrient and sediment removal through conservation agriculture practices. One of the more promising approaches to address nutrient and sediment pollution, while also improving the profitability of agricultural production, is that of continuous living cover practices. Over the last several years, Boone County stormwater staff have engaged extensively with continuous living cover practices including conservation agriculture practices such as regenerative agriculture, soil health and agroforestry. During this time, Boone County stormwater staff have been immersed in learning about row crop and livestock production practices by attending workshops, webinars, and hosting land management workshops to promote soil health practices locally.

Continuous Living Cover (CLC) refers to land-use practices in which there are living plants and roots in the ground throughout the entire year. The core of the CLC approach is on the ground implementation that can translate to landscape-scale transformation on a broad scale: moving away from months of bare soil and wasted solar energy and water to continuous soil coverage and longer periods of growth and crop production. It addresses a suite of environmental challenges, notably surface and groundwater quality, water use efficiency, hypoxia, and soil health, and may result in socioeconomic benefits such as improved financial stability for producers, long-term farm sustainability and community and producer resiliency. CLC practices can take many forms including planting native plants, shrubs and trees in urban or residential

areas, reduced tillage during agricultural planting (allows for development of mycorrhizal fungi and other soil biota), cover crops (on home gardens or agricultural fields), perennial forage and grazing in pasturelands, and agroforestry. The CLC practices that focus on soil health in the agricultural setting, which are the focus of the following discussion, are particularly beneficial for the type of large-scale pollutant load reduction that would be beneficial in the GBFW.

GBFW project partners are interested in pursuing and promoting these practices in the watershed to allow landowners to work with the land – not against it – to reduce erosion, maximize water infiltration and soil moisture storage, improve nutrient cycling, save money on inputs, and ultimately improve the resiliency of their land. Whether managing residential property, growing row crops or raising livestock, building soil health can help improve water quality and for producers, strengthen farming operations at the same time.

Cover Crops and Prairie Strips:
Load reduction efficiencies have not been developed for practices such as cover crops or prairie strips, so these practices have not been included as BMPs for *E. coli* load reduction in the WBP.

While use of cover crops is not a new agricultural practice, there is a trend of increasing promotion and adoption of cover crops and prairie strips at the national and state levels:

- Cover crops are one of the practices recognized by the USDA Partnerships for Climate-Smart Commodities program, as they are beneficial in remediating damaged and eroding soils and increase resilience of farmland in weather patterns of drought and flooding. The cycle between these two weather extremes has been observed by producers in Missouri over the last few years. The USDA's risk management agency offered a reduction in the cost of crop insurance in 2021 and 2022 for producers who use cover crops.
- The USDA/ARS is now deploying drones to monitor soil health and the level of green cover on agricultural lands to further research on land cover practices to improve production.
- The Missouri Department of Conservation has initiated a new program to benefit soil health on lands that they lease to agricultural producers. Neonicotinoid pesticides cannot be used on MDC lands after 2022. Cover crops are being required in new MDC agricultural contracts, and the Department has a goal of having 75% of their leased agricultural acreage in cover crops within five years.
- The Missouri Department of Natural Resources has been working internally and with other states to develop a nutrient reduction strategy and a nutrient trading program to help reduce nutrient loading into streams, rivers, and ultimately the Gulf of Mexico. The Missouri Nutrient Loss Reduction Strategy 2020 Update noted that, through the state's SWCP cost-share program, Missouri landowners covered 286,685 acres in cover crops in 2019.
- Cost-share practices for cover crops are available through GBFW project partners.

Prairie strips are also increasing in popularity as an agricultural practice. The potential benefits of prairie strips for nutrient reduction and habitat creation on agricultural land are being extensively studied at the University of Iowa and other states in the North Central region of the United States. Organizations such as Women for the Land, Missouri Prairie Foundation, and the Sand County Foundation are promoting the use of prairie strips throughout the midwestern states. Cost-share for prairie strips is available for landowners through the Farm Service Agency's CRP program.

Although there are not load reduction efficiencies for some of the continuous living cover practices mentioned in this WBP, the close proximity and interconnectedness of row crop and pasture lands in the watershed make it seem likely that, in addition to reducing nutrient and sediment loading, those practices will reduce *E. coli* loading in the GBFW streams. For ease of identification of priority areas with high *E. coli*, nutrient and sediment loading and consequent BMP installation, the GBFW was divided into 250 subwatersheds. Figure 5 was presented earlier in this WBP to illustrate land use / land cover patterns in the GBFW by subwatershed. A quick glance at the figure shows that in the areas east of Highway 63, pastureland and row crop production areas are interspersed, often within the same subwatershed. Due to the small size of the subwatersheds and the interconnected nature of the pasture and row crop fields, continuous living cover practices on row crop fields could potentially reduce *E. coli* loading into streams of the GBFW from manure from pastureland runoff.

The following is a very basic summary of the current state of knowledge about the effects of continuous living cover in remediating agricultural soils and how this remediation would ultimately reduce *E. coli* loading:

- Cover crops are planted after cash crops are harvested and protect soils that might otherwise be bare throughout the winter months. Agroforestry practices such as planting fruit or nut trees or shrubs can enhance the riparian corridor and its associated water quality benefits without reducing the number of acres available for row crop or animal production.
- In addition to reducing erosion, continuous vegetative cover on the soils will slow down runoff as it travels across row crop fields.
- As the runoff is slowed down, there is additional time for soils to absorb the runoff.
- Continuous living cover, when managed correctly (factors for consideration include pairing with no- or low-till management, method of termination / management, whether livestock are allowed to graze the vegetation), increases the health of the soil by, including but not limited to, increasing soil organic matter, increasing pore space, increasing soil water holding capacity, and increasing activity of the soil food web (bacteria, fungi [mycorrhizal fungi in particular], protozoa, other beneficial biota).
- Increased pore space and the presence of beneficial bacteria and other organisms directly contribute to infiltration of runoff and the breaking down of *E. coli* in the soil. Certain bacteria present in healthy soil can inactivate or kill *E. coli* bacteria. The presence of the

bacteria in the soil to inactivate *E. coli* is part of the theory behind using drip irrigation as a method of wastewater disposal. Drip irrigation systems for wastewater are becoming more popular in residential construction in Boone County.

- Over time, increased soil health decreases the need for inputs such as nutrients and pesticides, reducing costs of farm operation for producers. Beneficial insects and other organisms attracted by continuous living cover also help to make plants more resistant to disease and predation.
- Continuous living cover on the landscape improves the functioning of the local water cycle (microclimate).

Prairie strips, particularly when used in areas of row crop fields that are not productive (too wet, tight slopes, etc.), potentially offer benefits in addition to *E. coli* load reduction. Vegetation stays on the landscape for longer, providing potential interception and infiltration of runoff, helping to remediate bacteria and excess nutrients or sediment. As a bonus, prairie strips provide habitat for insects, including pollinators, other beneficial insects, birds, and other wildlife.

Although the WBP does not exclusively recommend cover crops, prairie strips or agroforestry practices as BMPs for *E. coli* reduction in the GBFW, Boone County and project partners would like to see these practices used throughout the watershed and Boone County. Given the underlying karst bedrock in the GBFW and other areas of the County, and the related hydrology with gaining and losing streams, the reduction and potential treatment of runoff would be beneficial for both surface waters, currently impaired or otherwise, and groundwater. This WBP recommends a pilot program for implementing cover crops on row crop production areas, specifically in subwatershed 42. Subwatershed 42 is not identified as a priority subwatershed in the Catchment Prioritization Index, but its location in the recharge area for the Devils Icebox Cave System elevates its priority for groundwater quality in the GBFW as we move forward with the WBP.

5.0 Proposed Management Measures for the Greater Bonne Femme Watershed (Element B, Criterion 1, and Element C, Criterion 1 & 2)

5.1 Water Quality Goals, Current Loading, and Needed Load Reductions

In order to develop an effective BMP implementation strategy for the GBFW, the process must begin with understanding what the goal of the strategy is, what current conditions are, and how it will be determined if the strategy will be successful – i.e. what WQ targets is the strategy shooting for and what pollutant load reductions will be needed to achieve them.

5.1.1 Water Quality Goals

The WBP has two types of water quality goals – one for restoration of *E. coli* impaired waters, and one for protection of the GBFW's Outstanding State Resource Waters and vulnerable karst features from excessive nutrient and sediment loading.

The restoration water quality goal for WBP implementation is for enough improvement to occur in watershed streams that are currently listed as impaired due to exceedances of the state's *E. coli* water quality criteria that they will meet the WQS criteria for *E. coli* and be delisted. The specific criteria for achieving WQS in local streams depends on the designated use the stream segment is impaired for. Table 10, below, lists the *E. coli* impaired creeks in the GBFW, their impaired use, and the Missouri WQS criteria that must be attained for delisting. These criteria are the targets for developing load reductions from the plan's recommended BMP implementation to achieve the plan's restoration goal of delisting GBFW impaired streams. Restoring the GBFW's *E. coli* impaired streams is the primary goal of the WBP.

Table 10. E. coli water quality targets for WBP implementation.

Creek Name (WBID)	Impaired Designated Use	MO WQS Criteria*
Bonne Femme (WBID 750) - lower	Whole Body Contact Recreation Category A	126 counts/100 mL
Gans (WBID 1004)		
Turkey (WBID 751)		
Bass (WBID 752)		
Bonne Femme (WBID 753) - upper	Whole Body Contact Recreation Category B	206 counts/100 mL
Little Bonne Femme (WBID 1003)		

* MO WQS criteria is expressed as a geometric mean during the recreational season.

The protection water quality goal for WBP implementation is to help maintain GBFW waters that are in excellent condition with regards to nutrient and sediment loading, and to reduce loading for these pollutants that impact water quality. Missouri does not yet have specific

numeric WQS criteria for nutrients in streams, therefore load reductions are based on the implementation of BMPs to address *E. coli* loading which may also reduce nutrient and sediment loading in the GBFW. Geosyntec recommended to Boone County that a baseline for nutrient and sediment loading be established so that any issues with nutrients and sediment can be addressed, if necessary, in the future. The monitoring section of the WBP includes this baseline sampling for TN, TP and TSS along with *E. coli* sampling during the implementation phase.

5.1.2 Current Pollutant Loading and Needed Load Reductions

Geosyntec's modeling analysis estimated current loading for different pollutants of concern by catchment sized subwatersheds in the GBFW in order to direct types and locations of BMP implementation to best achieve the plan's water quality goals. Load duration curves for the GBFW POCs were created by MDNR in order to provide estimates of existing pollutant loading for the six impaired streams in the GBFW using currently available water quality data, and to identify load reduction targets based on the water quality criteria and benchmarks noted above, which BMP implementation will seek to achieve. See Appendix I for the full load duration curve report.

In addition to providing load duration curves for the *E. coli* impairments, additional nutrient (nitrogen and phosphorus) and sediment (total suspended solids) load duration curves were provided to assist watershed planning efforts. Best management practices implemented to address bacteria impairments typically reduce stormwater runoff and erosion and will often address these other pollutants as well as *E. coli*.

The flow conditions presented in the load duration curves were based on EPA guidance for TMDL development (USEPA 2007b). This WBP is not a TMDL, but these descriptions are useful for illustrating the general base-flow and surface-runoff conditions in GBFW streams, which can help inform BMP implementation – e.g. higher pollutant loading at mid-range to high flows would indicate surface runoff as an important source of pollutant loading, which can be addressed by BMP implementation.

The pollutant loads and reductions provided for *E. coli* are calculated to result in attainment of water quality standards. For this reason, incorporation of these loading targets into an EPA-accepted nine element watershed-based plan along with its implementation may serve as a Category 5 – alternative restoration approach (5-alt plan). Waters that are subcategorized as Category 5-alt remain on the 303(d) list but are considered low priority for TMDL development because other actions and efforts in the watershed may be more immediately beneficial or practicable for achieving water quality standards.

Load duration curves were calculated for each of the impaired streams for *E. coli* – the impairment pollutant, and for the mainstem streams for each of the GBFW HUC-12s for nutrients and sediment. The targets used for load duration curve analysis for *E. coli* are found in Table 10 above.

The table below (Table 11) provides a summary of loading and needed load reductions for *E. coli* for GBFW streams as calculated in load duration curve development. The needed load reductions provide the target load reductions for BMP implementation to meet the *E. coli* water quality goal of the WBP, and WBP and provide values to assess if the BMP implementation recommended in the WBP will be sufficient to achieve the plan's water quality goals.

Table 11. Summary of E. coli loading and needed reductions at various flows for GBFW impaired streams.

Flow Condition	% of Time Flow is Equaled or Exceeded	Flow (cfs)	Existing Load (counts/ day)	TMDL (counts/ day)	Needed Reduction (counts/ day)	Needed Reduction (%)	Existing Concentration (count/100mL)
Bonne Femme Creek - lower (WBID 750) - HUC-12 103001020902							
Low Flows	95	0.03	No data	2.22E+08	No data	No data	No data
Dry Conditions	72	1.12	5.29E+09	4.14E+09	1.15E+09	22%	192
Mid-Range	55	4.32	2.08E+10	1.42E+10	6.62E+09	32%	197
Moist Conditions	34	13.19	2.57E+11	4.24E+10	2.15E+11	84%	798
High Flows	9	121.22	1.49E+13	3.65E+11	1.45E+13	98%	5,016
Bonne Femme Creek - upper (WBID 753) - HUC-12 103001020902							
Low Flows	95	0.01	No data	3.13E+07	No data	No data	No data
Dry Conditions	75	0.19	9.89E+08	9.59E+08	2.94E+07	3%	212
Mid-Range	52	1.10	5.60E+09	5.56E+09	4.11E+07	1%	208
Moist Conditions	34	2.84	8.38E+09	1.43E+10	0.00E+00	0%	120
High Flows	5	52.28	No data	2.64E+11	No data	No data	No data
Turkey Creek (WBID 751) - HUC-12 103001020902							
Low Flows	95	0.01	No data	0.00E+00	No data	No data	No data
Dry Conditions	79	0.25	1.84E+09	6.35E+08	1.21E+09	65%	301
Mid-Range	57	1.57	6.66E+09	4.61E+09	2.05E+09	31%	173
Moist Conditions	25	9.53	No data	2.89E+10	No data	No data	No data
High Flows	5	99.98	3.03E+12	3.12E+11	2.71E+12	90%	1,237
Bass Creek (WBID 752) - HUC-12 103001020902							
Low Flows	95	0.01	No data	5.17E+07	No data	No data	No data
Dry Conditions	78	0.16	4.85E+08	6.04E+08	0.00E+00	0%	126
Mid-Range	46	1.60	9.58E+09	5.24E+09	4.34E+09	45%	244
Moist Conditions	37	2.62	2.08E+10	8.47E+09	1.23E+10	59%	323
High Flows	8	32.87	2.06E+12	9.90E+10	1.96E+12	95%	2,561
Little Bonne Femme Creek (WBID 1003) - HUC-12 103001020903							
Low Flows	93	0.09	2.94E+07	4.29E+08	0.00E+00	0%	14
Dry Conditions	72	1.00	1.15E+09	5.02E+09	0.00E+00	0%	47
Mid-Range	48	4.85	9.58E+09	2.45E+10	0.00E+00	0%	81
Moist Conditions	24	18.80	2.29E+11	9.48E+10	1.34E+11	59%	497
High Flows	8	102.24	1.82E+12	5.15E+11	1.31E+12	72%	729
Gans Creek (WBID 1004) - HUC-12 103001020903							
Low Flows	95	0.01	5.04E+08	6.11E+07	4.43E+08	88%	2602
Dry Conditions	86	0.07	5.76E+08	2.99E+08	2.77E+08	48%	359
Mid-Range	51	1.48	1.96E+10	4.84E+09	1.48E+10	75%	542
Moist Conditions	39	2.81	4.16E+11	9.08E+09	4.07E+11	98%	6,062
High Flows	5	66.79	No data	2.02E+11	No data	No data	No data

Additional monitoring is needed to assess the need for future implementation of TN, TP and TSS load reductions to address these POCs, which can then be addressed in future WBP updates. The Information and Outreach strategy is also intended to raise awareness in the GBFW about ways to protect watershed resources from other POCs in addition to addressing the watershed's *E. coli* impairments.

5.2 Watershed-Wide BMP Implementation

Because restoration of the GBFW's *E. coli* impaired streams is the primary goal of the WBP, Geosyntec did the necessary modeling analysis and recommended watershed-wide BMPs for critical areas in the GBFW to reduce *E. coli* loading to the watershed's impaired streams. Watershed-wide BMPs (Table 12) are recommended for implementation in suitable locations in the prioritized subwatersheds (Figure 15) by watershed stakeholders. Geosyntec proposed a primary and alternative BMP type for each of the 24 subwatersheds in GBFW identified as target areas from the loading analysis. The BMP types were selected based on the MST results, land use distribution and other factors in each subwatershed.

Watershed modeling provided a prioritization of the entire GBFW by subwatershed for BMP implementation based on the relative unit area loading and weighting factor for *E. coli* (primary), nutrient, and sediment pollution of the GBFW's streams. Figure 15 shows this prioritization; subwatersheds with CPI scores 2 or greater are identified as targets for the prescribed watershed-wide BMP implementation, however, the entire GBFW is prioritized for implementation because all areas are potential pollutant sources for the watershed's impaired streams.

Modeling was used to identify options for BMP placement in the prioritized subwatersheds that would result in the most effective *E. coli* load reduction (Table 12) to allow for *E. coli* WQS criteria attainment in GBFW impaired streams by the end of the 21-year WBP implementation period, with a goal of 30% and 60% of needed load reductions by the end of the first and second 7-year WBP milestone periods respectively.

Table 12. Watershed-Wide BMP Recommendations for the Greater Bonne Femme Watershed.

Targeted Subwatershed ID	Area (ac)	CPI Score	Primary Watershed-Wide BMP	Alternative Watershed-Wide BMP
			(Applicable location in subwatershed[1])	
8[2]	114	2	Livestock exclusion/ Alternative source of water (P)	Vegetated Buffer with Trees (S)
36[2]	185	5	Fencing (P)	Grazing Management (P)
73	25	2	Vegetated Buffer (C, S)	Streambank buffer[3] (S)
75	156	2	Streambank buffer[3] (S)	Vegetated buffer (C, S)
98	124	2	Streambank buffer[3] (S)	Vegetated buffer (S)
132	189	4	Grazing management (P)	Fencing (P)
139	356	4	Fencing (P)	Grazing Management (P)
140[2]	20	2	Vegetated Buffer (C)	Retention pond (C)
141[2]	143	2	Vegetated Buffer with Trees (S)	Streambank buffer[3] (S)
143	70	4	Grazing management (P)	Fencing (P)
144[2]	202	2	Livestock exclusion/ Alternative source of water (P)	Vegetated Buffer with Trees (S)
157	97	2	Grazing management (P)	Fencing (P)
167	135	3	Grazing management (P)	Fencing (P)
181	145	2	Vegetated Buffer (C)	Maintain existing BMPs in accordance with the SWPP (U)
185[2]	37	2	Vegetated Buffer (C)	Retention pond (C)
188[2]	177	2	Vegetated Buffer (C)	Retention pond (C)
189[2]	23	2	Vegetated Buffer (C)	Retention pond (C)
200	144	4	Grazing management (P)	Fencing (P)
220	560	2	Vegetative filter strip (P)	Livestock exclusion/ Alternative source of water (P, S)
226	288	3	Vegetative filter strip (P)	Livestock exclusion/ Alternative source of water (P, S)
241	159	2	Grazing management (P)	Fencing (P)
242	487	2	Vegetative filter strip (P)	Livestock exclusion/ Alternative source of water (P)
243	429	3	Bioretention Basin (U)	Detention Pond (U)
245	75	2	Grazing Management (P)	Fencing (P)

[1] Applicable location in subwatershed: P – Pasture, C – Cropland, S – Stream bank, U – Urban

[2] Several subwatersheds have been identified as appropriate for additional BMPs to focus on the protection goal of the WBP. Additional BMPs to be considered in cropland areas of these subwatersheds include Conservation Agriculture practices, i.e. those that focus on reducing NPS pollutant loading in general, and soil health, regenerative agriculture, and agroforestry in particular.

[3] This may be a riparian buffer, vegetative buffer or reinforcing the existing tree line in the vicinity of stream bank.

While the primary focus for BMP implementation is *E. coli* reduction with a goal of achieving *E. coli* WQS criteria in watershed streams, the recommended watershed-wide BMPs will have the added benefit of addressing the protection goal for the WBP of reducing nutrient and sediment loading in local waterways. Beyond the recommended watershed-wide BMPs, the added emphasis on encouraging conservation agriculture practices throughout the watershed will also have the result of reducing nutrient and sediment loading in GBFW streams.

5.3 Other BMP Implementation

- Cover Crops Pilot: In order to address the protection goals of the WBP, subwatershed 42 has been chosen as a pilot subwatershed to, in addition to addressing the *E. coli* impairment, address nutrient and sediment pollutant loading to sensitive karst features and Outstanding State Resource Waters in the GBFW, with a particular goal of protecting the sensitive Devil's Icebox Cave system from pollutants. A cover crops installation program will be developed to encourage landowners in the GBFW to implement conservation agriculture practices. The plan is to increase the number of acres in the subwatershed in cover crops with a total goal of 210 acres over the 21-year WBP milestone period, which represents about half of the acreage currently in row crop production.

- Demonstration Project: A BMP demonstration project is planned for the first phase of WBP implementation and is planned to be a riparian corridor enhancement BMP adjacent to pastureland on South Farm, a cattle research facility owned by the University of Missouri. The BMP will incorporate agroforestry practices of riparian corridor enhancement inside of an existing pastureland buffer (fenced for cattle exclusion) along a reach of Gans Creek that runs through the University property. This demonstration project is ideal for several reasons. Gans Creek, while impaired for *E. coli*, is one of the Outstanding State Resource Waters in the GBFW. The status of the University of Missouri as a research institution allows for the potential involvement of interdisciplinary faculty, staff and/or graduate students to engage in planning the BMP and monitoring the effectiveness of the enhanced riparian corridor in reducing *E. coli* and other pollutant loading into Gans Creek. Additionally, the University will allow farm visits by project stakeholders and other interested parties to view the BMP installation. The involvement of the University in this project should be very beneficial in communicating with and engaging other producers and producer organizations in the GBFW and beyond. The University is also interested in exploring the financial and water quality benefits of producers using practices like the enhanced riparian corridor to diversity their production base. Project partners anticipate that this project will be the first of many collaborations with the University Farms moving forward.

5.4 Expected Load Reductions – Ability to Achieve Water Quality Goals (Element B, Criteria 1 and 3; Element H, Criterion 1)

In order to ascertain if the recommended BMP implementation would achieve the WBP's restoration water quality goals over the course of WBP implementation, Geosyntec estimated load reductions resulting from the implementation of proposed watershed-wide BMPs for three implementation milestones measured at 30%, 60% and 90% of recommended watershed-wide BMP implementation. See Tables 13-16 below for summaries of estimated load reductions for all POCs for Primary Watershed-Wide BMP implementation at 30%, 60%, and 90% implementation, and Alternative Watershed-Wide BMP at 90% implementation, which show estimated POC load reductions by subwatershed, specific BMP type and its associated land use type, and the size of BMP implementation. (Element H, Criteria 2)

Table 13. Primary Watershed-Wide BMPs Load Reduction Summary for the 30% Implementation Scenario (7-Year Implementation Milestone)

Subwatershed	Watershed-Wide BMP Recommendation (Applicable location in subwatershed[2])	*E. coli*		TN		TP		TSS	
		Load Reduction (cfu/day)	Percent Reduction	Load Reduction (lb/yr)	Percent Reduction	Load Reduction (lb/yr)	Percent Reduction	Load Reduction (lb/yr)	Percent Reduction
8	Livestock exclusion/Alternative source of water (P)	6.53E+07	11%	56	2%	9	1%	13,482	2%
36	Fencing (P)	7.69E+11	11%	74	2%	13	1%	19,883	2%
73	Vegetated Buffer (C, S)	0.00E+00[1]	0%	128	11%	38	15%	43,357	15%
75	Streambank buffer (S)	4.60E+08	21%	522	10%	135	13%	191,533	17%
98	Streambank buffer (S)	1.11E+09	21%	395	10%	102	13%	146,201	17%
132	Grazing management (P)	5.47E+11	9%	27	1%	11	2%	17,610	3%
139	Fencing (P)	9.66E+11	11%	208	4%	30	3%	37,028	4%
140	Vegetated Buffer (C)	0.00E+00	0%	59	9%	18	13%	20,680	12%
141	Vegetated Buffer with Trees (S)	6.76E+07	21%	539	10%	144	13%	226,133	17%
143	Grazing management (P)	1.91E+11	9%	13	1%	5	2%	6,435	2%
144	Livestock exclusion/Alternative source of water (P)	1.96E+08	11%	29	0%	4	0%	5,625	0%
157	Grazing management (P)	2.15E+11	9%	16	2%	6	5%	7,688	6%
167	Grazing management (P)	3.31E+11	9%	3	1%	1	2%	1,619	4%
181	Vegetated Buffer (C)	0.00E+00[1]	0%	553	10%	168	14%	179,110	14%
185	Vegetated Buffer (C)	0.00E+00[1]	0%	91	9%	27	13%	30,902	13%
188	Vegetated Buffer (C)	0.00E+00[1]	0%	557	10%	168	14%	192,582	14%
189	Vegetated Buffer (C)	0.00E+00[1]	0%	80	9%	24	13%	27,859	13%
200	Grazing management (P)	6.38E+11	9%	7	1%	2	3%	3,127	4%
220	Vegetative filter strip (P)	8.71E+11	21%	266	3%	51	3%	56,212	3%
226	Vegetative filter strip (P)	1.20E+12	21%	191	4%	38	5%	43,863	5%
241	Grazing management (P)	2.33E+11	9%	23	2%	8	5%	10,692	7%
242	Vegetative filter strip (P)	8.71E+11	21%	282	4%	55	5%	60,794	6%
243	Bioretention Basin (U)	2.25E+12	24%	88	2%	0	0%	19,312	4%
245	Grazing Management (P)	1.66E+11	9%	9	2%	4	6%	6,057	8%

[1] Estimated load reduction is zero since the estimated *E. coli* loading for the subwatershed is 0

[2] Applicable location in subwatershed: P – Pasture, C – Cropland, S – Stream bank, U – Urban

Table 14. Primary Watershed-Wide BMPs Load Reduction Summary for the 60% Implementation Scenario (14-Year Implementation Milestone)

Subwatershed	Watershed-Wide BMP Recommendation (Applicable location in subwatershed[2])	*E. coli*		TN		TP		TSS	
		Load Reduction (cfu/day)	Percent Reduction	Load Reduction (lb/yr)	Percent Reduction	Load Reduction (lb/yr)	Percent Reduction	Load Reduction (lb/yr)	Percent Reduction
8	Livestock exclusion/Alternative source of water (P)	1.31E+08	21%	112	3%	18	2%	26,964	3%
36	Fencing (P)	1.54E+12	21%	149	3%	26	3%	39,765	4%
73	Vegetated Buffer (C, S)	0.00E+00[1]	0%	255	22%	76	30%	86,713	30%
75	Streambank buffer (S)	9.19E+08	42%	1,044	20%	270	25%	383,066	34%
98	Streambank buffer (S)	2.23E+09	42%	790	20%	205	25%	292,402	34%
132	Grazing management (P)	1.09E+12	18%	53	2%	22	5%	35,219	7%
139	Fencing (P)	1.93E+12	21%	416	7%	61	6%	74,056	7%
140	Vegetated Buffer (C)	0.00E+00[1]	0%	119	18%	36	25%	41,360	24%
141	Vegetated Buffer with Trees (S)	1.35E+08	42%	1,078	20%	289	25%	452,266	34%
143	Grazing management (P)	3.82E+11	18%	26	2%	9	3%	12,869	5%
144	Livestock exclusion/Alternative source of water (P)	3.92E+08	21%	59	1%	9	1%	11,250	1%
157	Grazing management (P)	4.31E+11	18%	31	4%	11	10%	15,376	12%
167	Grazing management (P)	6.63E+11	18%	7	3%	2	4%	3,239	8%
181	Vegetated Buffer (C)	0.00E+00[1]	0%	1,107	20%	335	29%	358,220	29%
185	Vegetated Buffer (C)	0.00E+00[1]	0%	181	17%	55	26%	61,804	26%
188	Vegetated Buffer (C)	0.00E+00[1]	0%	1,114	20%	336	28%	385,164	28%
189	Vegetated Buffer (C)	0.00E+00[1]	0%	161	18%	49	27%	55,717	27%
200	Grazing management (P)	1.28E+12	18%	13	3%	5	5%	6,254	8%
220	Vegetative filter strip (P)	1.74E+12	42%	531	6%	102	6%	112,424	7%
226	Vegetative filter strip (P)	2.40E+12	42%	383	8%	76	9%	87,726	10%
241	Grazing management (P)	4.66E+11	18%	45	4%	16	10%	21,384	13%
242	Vegetative filter strip (P)	1.74E+12	42%	565	9%	109	10%	121,588	12%
243	Bioretention Basin (U)	4.51E+12	48%	175	3%	0	0%	38,624	7%
245	Grazing Management (P)	3.31E+11	18%	17	5%	7	12%	12,113	16%

[1] Estimated load reduction is zero since the estimated *E. coli* loading for the subwatershed is 0

[2] Applicable location in subwatershed: P – Pasture, C – Cropland, S – Stream bank, U – Urban

Table 15. Primary Watershed-Wide BMPs Load Reduction Summary for the 90% Implementation Scenario (21-Year Implementation Milestone)

Subwatershed	Watershed-Wide BMP Recommendation (Applicable location in subwatershed[2])	*E. coli*		TN		TP		TSS	
		Load Reduction (cfu/day)	Percent Reduction	Load Reduction (lb/yr)	Percent Reduction	Load Reduction (lb/yr)	Percent Reduction	Load Reduction (lb/yr)	Percent Reduction
8	Livestock exclusion/Alternative source of water (P)	1.96E+08	32%	169	5%	28	4%	40,446	5%
36	Fencing (P)	2.31E+12	32%	223	5%	39	4%	59,648	6%
73	Vegetated Buffer (C, S)	0.00E+00[1]	0%	383	32%	114	45%	130,070	45%
75	Streambank buffer (S)	1.38E+09	63%	1,566	31%	405	38%	574,598	50%
98	Streambank buffer (S)	3.34E+09	63%	1,184	31%	307	38%	438,603	50%
132	Grazing management (P)	1.64E+12	27%	80	3%	33	7%	52,829	10%
139	Fencing (P)	2.90E+12	32%	624	11%	91	8%	111,084	11%
140	Vegetated Buffer (C)	0.00E+00[1]	0%	178	28%	54	38%	62,040	37%
141	Vegetated Buffer with Trees (S)	2.03E+08	63%	1,617	31%	433	38%	678,399	50%
143	Grazing management (P)	5.72E+11	27%	38	3%	14	5%	19,304	7%
144	Livestock exclusion/Alternative source of water (P)	5.88E+08	32%	88	1%	13	1%	16,875	1%
157	Grazing management (P)	6.46E+11	27%	47	7%	17	15%	23,064	19%
167	Grazing management (P)	9.94E+11	27%	10	4%	4	7%	4,858	12%
181	Vegetated Buffer (C)	0.00E+00[1]	0%	1,660	30%	503	43%	537,331	43%
185	Vegetated Buffer (C)	0.00E+00[1]	0%	272	26%	82	39%	92,706	39%
188	Vegetated Buffer (C)	0.00E+00[1]	0%	1,672	30%	505	42%	577,746	43%
189	Vegetated Buffer (C)	0.00E+00[1]	0%	241	27%	73	40%	83,576	40%
200	Grazing management (P)	1.91E+12	27%	20	4%	7	8%	9,381	12%
220	Vegetative filter strip (P)	2.61E+12	63%	797	9%	153	9%	168,635	10%
226	Vegetative filter strip (P)	3.59E+12	63%	574	12%	114	14%	131,590	16%
241	Grazing management (P)	6.99E+11	27%	68	7%	24	15%	32,075	20%
242	Vegetative filter strip (P)	2.61E+12	63%	847	13%	164	15%	182,381	18%
243	Bioretention Basin (U)	6.76E+12	72%	263	5%	0	0%	57,936	11%
245	Grazing Management (P)	4.97E+11	27%	26	7%	11	18%	18,170	24%

[1] Estimated load reduction is zero since the estimated *E. coli* loading for the subwatershed is 0

[2] Applicable location in subwatershed: P – Pasture, C – Cropland, S – Stream bank, U – Urban

Table 16. Alternative Watershed-Wide BMPs Load Reduction Summary for the 90% Implementation Scenario (21-Year Implementation Milestone)

Subwatershed	Watershed-Wide BMP Recommendation (Applicable location in subwatershed[2])	*E. coli*		TN		TP		TSS	
		Load Reduction (cfu/day)	Percent Reduction	Load Reduction (lb/yr)	Percent Reduction	Load Reduction (lb/yr)	Percent Reduction	Load Reduction (lb/yr)	Percent Reduction
8	Vegetated Buffer with Trees (S)	3.92E+08	63%	169	5%	28	4%	40,446	5%
36	Grazing Management (P)	1.98E+12	27%	59	1%	22	2%	31,954	3%
73	Streambank buffer (S)	0.00E+00[1]	0%	361	31%	95	38%	145,678	50%
75	Vegetated buffer (C, S)	1.16E+09	53%	1,658	32%	482	45%	513,034	45%
98	Vegetated buffer (S)	2.81E+09	53%	1,254	32%	366	45%	391,610	45%
132	Fencing (P)	1.91E+12	32%	300	12%	57	12%	98,613	19%
139	Grazing Management (P)	2.49E+12	27%	165	3%	52	5%	59,509	6%
140	Retention pond (C)	0.00E+00[1]	0%	247	38%	54	38%	62,040	37%
141	Streambank buffer (S)	2.03E+08	63%	1,617	31%	433	38%	678,399	50%
143	Fencing (P)	6.68E+11	32%	145	10%	24	9%	36,034	14%
144	Vegetated Buffer with Trees (S)	1.18E+09	63%	1,977	31%	523	38%	651,694	50%
157	Fencing (P)	7.54E+11	32%	177	25%	29	26%	43,052	35%
167	Fencing (P)	1.16E+12	32%	38	14%	6	11%	9,068	23%
181	Maintain existing BMPs in accordance with the SWPP (U)	0.00E+00[1]	0%	2,306	42%	503	43%	537,331	43%
185	Retention pond (C)	0.00E+00[1]	0%	378	36%	82	39%	92,706	39%
188	Retention pond (C)	0.00E+00[1]	0%	2,322	41%	505	42%	577,746	43%
189	Retention pond (C)	0.00E+00[1]	0%	335	37%	73	40%	83,576	40%
200	Fencing (P)	2.23E+12	32%	74	16%	12	14%	17,512	22%
220	Livestock exclusion/Alternative source of water (P, S)	1.31E+12	32%	847	9%	129	7%	168,635	10%
226	Livestock exclusion/Alternative source of water (P, S)	1.80E+12	32%	610	13%	96	11%	131,590	16%
241	Fencing (P)	8.15E+11	32%	256	25%	42	26%	59,874	38%
242	Livestock exclusion/Alternative source of water (P)	1.31E+12	32%	900	14%	138	13%	182,381	18%
243	Detention Pond (U)	5.41E+12	58%	0	0%	49	6%	49,399	9%
245	Fencing (P)	5.80E+11	32%	99	27%	19	31%	33,917	45%

[1] Estimated load reduction is zero since the estimated *E. coli* loading for the subwatershed is 0

[2] Applicable location in subwatershed: P – Pasture, C – Cropland, S – Stream bank, U – Urban

Based on comparison of the estimated load reductions shown above with the estimated load reduction needed to meet the plan's restoration goal as determined by the load duration curves, it is estimated that 90% implementation of watershed-wide BMPs over the modeled 21-year time frame will provide sufficient *E. coli* load reductions to allow GBFW streams to meet WQS (Tables 15 and 16).

A comparison of target load reduction from MDNR load duration curves with estimated load reduction from implementation of watershed-wide BMPs for each of the impaired WBIDs was made to demonstrate compliance with WQS through the implementation of proposed BMPs in the GBFW. The range of target load reductions provided by the load duration curves for different flow conditions was compared to the estimated load reductions gained by recommended BMP implementation. This approach was discussed with MDNR and subsequently approved (per Boone County's email correspondence with Mike Kruse, MDNR TMDL Unit Chief on September 11, 2020). At full 21-year plan implementation (implementation of 90% of the prescribed watershed-wide BMPs), the estimated load reduction from implementation of the recommended BMPs exceeds the highest load reduction requirement necessary for *E. coli* WQS attainment indicated by the load duration curve analysis. This is a very conservative estimate as the highest load reduction required is that for high flow conditions which only occur roughly 5 % of time. This analysis shows that WQS for *E. coli* will likely be met over the 21-year plan period through the implementation of recommended BMPs in the GBFW, as shown in Table 17. Since the WQS criteria is expressed as a geometric mean, reductions in the magnitude and frequency of exceedances that will occur during other than high flow conditions will provide additional certainty that water quality standards will be attained, i.e. comparison by using the highest, most conservative load reduction target, it ensures the plan's implementation will result in the necessary *E. coli* reductions. Since this is the most conservative target, attainment of WQS might happen even sooner than the end of the 21-year plan period. Table 17 shows the target load reduction range at different flow conditions needed to meet WQS as determined by the load duration curve analysis for each of the *E. coli* impaired streams in the GBFW, along with the estimated *E. coli* load reductions to be achieved with implementation of the Primary or Alternative BMPs at 30%, 60% and 90% implementation levels. The most conservative target load reduction value and estimated load reductions at 90% implementation are highlighted for ease of comparison – comparison of these highlighted values indicates that WQS should be attained for all impaired streams at full implementation for either Primary or Alternative BMP implementation.

Applying a conversion equation to the net E. coli load after subtracting the load reduction from current existing load for each water body at each implementation phase (see Appendix I Load Duration Curves and Pollutant Reduction Estimates for Six Impaired Streams in Boone County, Missouri for current existing load), the E. coli concentration resulting from implementation can be estimated. Table 17 includes those estimated future E. coli concentrations at each implementation phase for each impaired stream, as well as the relevant Water Quality Standard E. coli criteria for each stream for comparison. The modeling results support the conclusion that following either the Primary or Alternative BMP recommendations in the identified critical

subwatersheds will result in attainment of WQS in all GBFW streams by the end of the 21-year plan period. The results are so positive that, even if the exact BMP prescription cannot be followed due to the voluntary nature of implementation and the uncertainty of landowner engagement, it seems likely that any reasonable substitutions of implementation locations or BMPs will still result in WQS attainment in GBFW streams. (Element H, Criteria 2 & 3)

Table 17. Results of BMP Implementation: Comparison of estimated post-implementation E. coli concentrations to WQS criteria, and comparison of Target Load Reductions needed for E.coli WQS attainment (as determined by Load Duration Curve Analysis), with Estimated Load Reduction for E. coli through the implementation of Primary and Alternative BMPs recommended in the Greater Bonne Femme Watershed-Based Plan; relevant values are highlighted to facilitate comparison of estimated load reductions with the most conservative target load reduction for each impaired stream. See Appendix I Load Duration Curves and Pollutant Reduction Estimates for Six Impaired Streams in Boone County, Missouri for current existing E. coli loads.

WBID	Water Body Name	WQS (cfu/100ml)	Target Load Reduction Range (cfu/day)	Implementation Phase	Estimated Load Reduction for Primary BMPs (cfu/day)	Estimated E. coli Concentration at End of Primary BMP Implementation Phase (cfu/100ml)	Estimated Load Reduction for Alternative BMPs (cfu/day)	Estimated E. coli Concentration at End of Alternative BMP Implementation Phase (cfu/100ml)
750	Bonne Femme Cr.	126	1.15E+09 to 1.45E+13	30% of BMP Implementation	8.48E+12	2164.73	6.81E+12	2727.82
				60% of BMP Implementation	1.70E+13	0	1.36E+13	438.34
				90% of BMP Implementation	2.54E+13	0	2.04E+13	0
751	Turkey Cr.	126	1.21E+09 to 2.71E+12	30% of BMP Implementation	7.23E+12	0	5.35E+12	0
				60% of BMP Implementation	1.45E+13	0	1.07E+13	0
				90% of BMP Implementation	2.17E+13	0	1.60E+13	0
752	Bass Cr.	126	0 to 1.96E+12	30% of BMP Implementation	5.52E+12	0	3.66E+12	0
				60% of BMP Implementation	1.10E+13	0	7.32E+12	0
				90% of BMP Implementation	1.66E+13	0	1.10E+13	0
1003	Little Bonne Femme Cr.	206	0 to 1.31E+12	30% of BMP Implementation	7.69E+11	420.17	6.59E+11	464.14
				60% of BMP Implementation	1.54E+12	111.94	1.32E+12	199.89
				90% of BMP Implementation	2.31E+12	0	1.98E+12	0
1004	Gans Cr.	126	2.77E+08 to 4.07E+11	30% of BMP Implementation	7.69E+11	0	6.59E+11	0
				60% of BMP Implementation	1.54E+12	0	1.32E+12	0
				90% of BMP Implementation	2.31E+12	0	1.98E+12	0
753	Bonne Femme Cr. (Upper)	206	0 to 4.11E+07	30% of BMP Implementation	1.57E+09	98.01	1.33E+09	101.46
				60% of BMP Implementation	3.15E+09	75.27	2.65E+09	82.47
				90% of BMP Implementation	4.72E+09	52.68	3.98E+09	63.33

In addition to achieving WQS for *E. coli*, full plan implementation will also result in load reductions for the additional pollutants of concern for the watershed: Total Nitrogen (TN), Total Phosphorus (TP), and Sediment (TSS). Tables 15 and 16 show summaries of estimated load reductions for TN, TP, and TSS (in addition to *E. coli*) for Primary and Alternative Watershed-Wide BMP implementation at 90% implementation. These tables show that implementation of the recommended watershed-wide BMPs will result in marked annual load reductions for TN, TP, and TSS, which will accomplish the protection goal of the WBP of helping to maintain GBFW waters that are in excellent condition with regards to nutrient and sediment loading, and helping improve those with loading for those pollutants that may exceed future WQS criteria. Additionally, nutrient and sediment load reductions are to be expected with implementation of the Cover Crops Pilot program and Demonstration Project that will help achieve the plan's protection water quality goal.

6.0 Information and Outreach (Element E)

6.1 Overall strategy (Element E, Criterion 1)

The success of addressing conservation challenges depends on inclusive efforts that incorporate diverse community members with multiple views of valuing and practicing conservation. Diversity and inclusion must occur in a manner where people feel comfortable, valued, and respected in decision-making processes and all education, outreach, and information activities.

A watershed restoration and protection plan's success relies heavily on citizen support and voluntary participation through BMP implementation, and awareness that as watershed stakeholders, we all have a chance to play a part in watershed improvement. This watershed-based plan provides recommendations for actions that can be taken on a voluntary basis to improve GBFW waters. Voluntary participation in implementation of this WBP is critical because most priority areas for BMP implementation in the GBFW are on private land. The voluntary adoption of BMPs by private landowners is frequently driven by their desire to protect and improve their land for current and future generations, and/or an economic benefit derived from BMP adoption. The information and outreach program will address these realities in order to improve the potential for successful achievement of the WBP's goals.

The Information and Outreach Program aspires to increase community awareness and involvement in caring for the GBFW through communication of the long-term social, financial, and environmental benefits gained by sustainable resource stewardship and adoption of conservation BMPs. The goal of the Information and Outreach Program is to garner citizen support and participation in watershed stewardship activities that will result in reducing nonpoint source pollution in the GBFW. The approach used will respect current belief systems and land management practices and encourage citizen participation by illustrating the benefits of BMP adoption for people and the environment while acknowledging and mitigating understanding of the economic realities of adopting new land management practices.

Multiple driving forces will shape the developed outreach program objectives. These driving forces include, but are not limited to, agricultural practices that can negatively impact soil health and lead to NPS pollution, streams not meeting WQS, land development, and the need to increase understanding of watershed function and water quality value.

6.1.1 Information and Outreach Subcommittee

The existing Information and Outreach Subcommittee of the Technical Advisory Team will be expanded to address these driving forces and effectively engage stakeholders. This subcommittee will be made up of a diverse group of educators, government officials, agricultural producers, organizations, and other local community members. The subcommittee will encourage sustainable management of the resources in the GBFW by connecting people to the watershed and by engaging with landowners/managers about land management principles that will improve watershed health.

The Information and Outreach Subcommittee will aid in networking, creating information resources, evaluating program effectiveness, and coordinating technical aid for programming and BMP implementation. This subcommittee will also help develop and revise the project's information and outreach goals and strategies (Appendix K) using adaptive management techniques. Evaluations and revisions will be completed every two years based on the increased knowledge of the community and BMP adoption.

6.1.2 Information and Outreach Program Goals

In order to facilitate implementation of the Watershed Based Plan and its recommended BMPs, the first task of the Information and Outreach Program is to help establish a strong foundational knowledge of the watershed and its concerns among GBFW stakeholders. These goals reflect and evolved from the goals in the 2007 Bonne Femme Watershed Plan, which can be found in Appendix E This knowledge is crucial for implementing the WBP and to connect community members with local resources. The subcommittee will periodically evaluate and modify foundational goals to maintain relevance as the program progresses. This WBP establishes the following three foundational goals of the Information and Outreach program:

1) Increase awareness about water quality and watersheds
2) Strengthen understanding among stakeholders of how land use activities are connected to water quality and flooding
3) Encourage BMP implementation for the protection and improvement of water quality

6.1.3 Understanding the Audience

The cornerstone of making outreach meaningful is understanding people who live in and visit the watershed: their value systems and beliefs about how land and water resources should be managed as well as the economic realities that impact their behaviors related to land and water resource management. Surveys and targeted public engagements will continue to be used to gain a holistic understanding of stakeholders' relationship to the environment, what is important to them in terms of land management, and their understanding of how actions can alter local streams and water quality. Responses will be used to gain a better understanding of population opinions and direct information and outreach programs over time. Surveys will help reach outreach goals, create a return on environment study, and build an effective marketing campaign.

Marketing campaigns will help engage community participation in watershed stewardship actions and promote land management practices through different media types such as television, radio, print, and online platforms. Campaigns could include workshops, BMP demonstrations, video conferencing, and other interactive techniques. Additional campaign strategies include watershed and stream signage, a demonstration site, a GBFW webpage, information resources, and contests. Funding and assistance for the creation, instruction, and implementation of these campaigns will increase the success of outreach efforts.

Social and digital marketing is a complex endeavor and critical tool needed to facilitate WBP implementation. When appropriately used, social and digital marketing for the GBFW allows

material to reach a wider audience, creates a community understanding of BMPs, and supports local partners adopting BMPs in the landscape. Training for project partners focusing on social and digital marketing methodologies and successful tactics would greatly benefit the success of the plan. Training design would explain marketing tools, strategies, and assist partners in implementing social and digital media marketing, with the goal of promoting information about the plan and BMPs targeted to people in and around the watershed. Another benefit of training would be assistance in developing a cohesive brand for partners to use for the GBFW.

6.1.4 Return on Environment Study (ROE)

Fields, forests, streams, and other green spaces supply numerous benefits to the community, including clean air, water purification, wildlife habitat, timber, food, nutrient cycling, and recreation for the Greater Bonne Femme Watershed. These benefits are supplied freely by nature, so they are not traditionally accounted for in the economic analysis. To complete a Return on Environment Study (ROE) for the Greater Bonne Femme Watershed, the benefit information will be used along with the economic values of property, tax revenues, and the avoided replacement of services costs. Survey responses from landowners and visitors of the Greater Bonne Femme Watershed will help inform understanding of the importance of and the community's thoughts on these green spaces.

A ROE analyzes the benefits of natural resources, ecosystem services, and community values through an economic lens, translating these functions into dollar amounts. The ROE will measure economic value by measuring avoided costs associated with natural systems services, avoided costs associated with air and water pollution, value related to recreation, avoided healthcare costs, and impact of open spaces and water on property value. The ROE does not replace the intrinsic values held by many people. Providing monetary values to these natural system services gives a universal language more people can understand and communicate. The ROE is used when making decisions concerning land use, economic development, safety, utility costs, and the preventive costs of replacing them, or artificially reproducing their functions.

A ROE explains conservation in a language that is easy to understand and can immediately be used in decision-making by developers, landowners, and officials. It also connects nature to a community's quality of life and welfare while quantifying nature's significant benefits. The ROE would help businesses, policymakers and residents make informed decisions on land use, infrastructure, economic development, recreation, and tourism. To ensure responsible stewardship of the environment, the ROE is integral in every resource-based decision process. The ROE will help to ensure that the value of environmental services is part of the conversation when the cities of Columbia and Ashland consider development in the GBFW.

Completing a ROE in upcoming years will give government officials, businesses, and residents a perspective about the unseen values and services that green spaces offer and help inform their decisions by giving the full economic picture of the GBFW. Funding for the survey mailing and marketing would help gain more responses to the surveys and represent the population better. Additional funding may be needed to help craft the Return on Environment Study beyond the

surveys. Project partners hope to hire a consultant to carry out the ROE and provide the necessary products to help guide decision making during the second 7-year implementation phase of the WBP.

6.2 Methods of Information and Outreach (Element E, Criterion 2)

Information and outreach approaches are dependent on the characteristics of the audience. There is a wide range of knowledge, tradition, interest, and requirements in the watershed. Messaging must be meaningful and useful for behavior changes to occur and the WBP goals to be met. Outreach implementation and strategies will be executed using the following steps:

1) Find and analyze target audiences
2) Create messages for each audience
3) Package the message for the various audiences
4) Distribute the messages
5) Evaluate the information/outreach program
6) Grow and improve programs (adaptive management)

Enhancing understanding of complex environmental problems such as watershed protection and rehabilitation requires an interdisciplinary approach using ecological, social and economic science and resources. The information and outreach methods used by the Information and Outreach Subcommittee are modeled after the Jane Goodall Institute's Roots and Shoots Program putting local communities at the heart of conservation, by improving the lives of people, animals, and the environment. The development of deep-rooted, strong outreach programs is focused on development of community involvement, values, and sense of ownership of the resources to aid in program success and longevity. Following the principles of adaptive management, a well-established outreach program should be periodically evaluated and adjusted, starting small and building upon successful programs and campaigns. The proven programs (the "roots") grow "shoots", or additional applications, forming a network of strategies and connections that are tailored in each setting, but grown from the same source toward improving the watershed and water quality. The multifaceted systems of roots and shoots engage a wide variety of populations through different programs while remaining a unified, connected program of ideas, actions, and people.

There are a wide range of interests and knowledge among watershed landowners. Many GBFW landowners are involved in food production for their livelihood through farming – and everyone has to eat. So, integrating sustainable food production, foraging, hunting, and fishing into watershed management will act as a gateway for meeting people and understanding where their knowledge and interests lie. Food production outreach should happen on multiple levels ranging from large-scale production to personal gardens, broadening the audience and opening a connection between producers, neighbors, and consumers. The Greater Bonne Femme Watershed and surrounding community are rich in food production resources and organizations. These resources include agriculture research, universities, cooperative associations, producers, and consumers. Working in partnership with these entities encourages a strong network,

increasing the outreach capacity of the program. Threading a food production theme throughout the Information and Outreach Program will promote achievable improvements to the watershed that will benefit all.

Information and outreach methods will include, but not be limited to, the use of various media, public meetings (virtual and in-person), watershed events (water quality monitoring, cleanups, festivals, BMP demonstration and other field days, workshops, etc.), a septic pump-out and awareness program, multimedia campaigns, news articles, website development and update, and signage in high visibility areas (watershed delineation signs, BMP demonstration project signage, etc.).

6.2.1 Missouri Stream Team Program and the Rock Bridge Monitoring Blitz

The Information and Outreach Program will advocate and encourage citizens to adopt stream segments and become volunteers for Missouri Stream Team. The program will develop a network of Stream Team Volunteers who will adopt segments of the GBFW streams. Engagement with the Stream Team Program means creating a community, coordinating monitoring and stream cleanup events, encouraging citizen engagement and stewardship while providing information on how streams change over the years. Serving as a method of connecting community members to our watershed and provide a gauge on the stream's health is the volunteer stream monitoring program. The Missouri Stream Team Volunteer Water Quality Monitoring (VWQM) program trains volunteers to monitor streams and collect biological, physical, and chemical data. There are four training levels, with Levels 2 and 3 considered Quality Assurance levels. An important component of the Information and Outreach Program is the Monitoring Blitz at Rock Bridge Memorial State Park. This monitoring event is held each spring and fall, where local citizens can learn about stream life and water quality by assisting with VWQM data collection at 6 established sites in and around Rock Bridge Memorial State Park, with a Level 2 or 3 site leader ensuring data quality at each site. Volunteer data will be used to inform and educate GBFW citizens about water quality in the watershed, establish baseline data on sampled streams, screen for potential emerging water quality problems and help identify long-term trends in stream conditions.

Figure 16. Water quality monitoring sites for the Rock Bridge Monitoring Blitz; sites monitored may vary and sites may change as needed due to stream conditions and volunteer participation

6.2.2 Greater Bonne Femme Watershed Festival

The water festival is a community event that connects people to water resources and organizations that protect, educate about, and utilize water in the watershed. The Rock Bridge Memorial State Park Water Festival is an established community event within the watershed. This event targets families but is limited in size due to location and limited parking constraints. By merging the Park's Water Festival with a Greater Bonne Femme Watershed Festival, we hope to provide a festival for all ages, highlighting activities in the watershed that are beneficial to water quality and quantity. The event would serve as a celebration for the watershed and community. Additionally, the festival would provide an opportunity to reach people interested in adopting best management practices on their property, providing community members with opportunities to better understand what is needed to implement them and the benefits they provide the watershed, and establish a community centered around the watershed.

The event would grow into a community celebration of the watershed, strengthening people's connection to the landscape and the community while still highlighting public open places and connecting children to our water. The event will utilize an interdisciplinary approach that emphasizes stormwater champions living in the watershed, as well as organizations, businesses, and farms that are stewards of the land.

6.2.3 Land Management Workshops and Producer Outreach Activities

Changes in the way land is managed in the GBFW need to occur in order to meet water quality standards and program goals. Conservation and restoration practices, including soils health improvement practices, agroforestry, conservation agriculture, and various landscaping techniques, are practical methods that could be used to improve land use management and water quality in the watershed. These practices emphasize utilizing ecosystem functions and the

environment to enhance the watershed and streams. Conservation agriculture practices improve soil health, biodiversity, soil moisture capture and storage capacity, and nutrient cycling, and reduce runoff from rainfall events that can transport pollutants to waterways. Outreach program elements that promote the adoption of conservation and restoration practices will endeavor to positively impact water quality and quantity in GBFW streams and groundwater. These practices include, but are not limited to, managed rotational grazing, livestock exclusion from streams, riparian buffer improvement, conservation tillage, cover crops, agroforestry, and holistic management, in addition to rain barrels, rain gardens, and proper hazardous waste disposal. Conservation and restoration practices offer a mutually beneficial relationship for landowners and environment through principles and practices seeking to rehabilitate and enhance natural communities and ecosystems while increasing agricultural profitability and building resilience to climate variability.

The Information and Outreach Program will co-host an annual Land Management Workshop with an agricultural organization to promote the adoption of conservation agriculture practices by agricultural producers in the GBFW. Workshops are planned to offer a program to benefit producers and facilitate conservation agriculture practice adoption that will include presentations from an organization like Understanding Ag, Boone County Soil and Water Conservation District, University of Missouri researchers, and others – and will include a field day component if possible.

Training and landowner coaching on the adoption of conservation and restoration practices throughout the area is a crucial element in supporting the success of these practices and the implementation of the plan. Many programs focus on these practices, including programs provided by government agencies, universities, local farmers, and consulting organizations. These programs can be costly to attend. The GBFW project will offer an annual scholarship program to pay for partners and land stewards to attend these trainings, increasing the likelihood of people engaging in promoted practices that fit the needs of their property.

A second annual landowner scholarship will be offered for BMP coaching from an organization like Understanding Ag. This program will be coupled with a field day. A landowner would apply to have a landscape coach or expert come to their property and discuss the current state of the property and their future goals. From this, the coach will help the landowner develop a plan to move forward using BMPs to improve the functionality of the property and water quality leaving their landscape. As part of this scholarship program, the landowner would have to allow community members to attend a field day on the property during the evaluation visit from the coach or expert, so that all in attendance can learn from the experience.

6.2.4 A Septic Pump-out and Awareness Program

Many homes and buildings in the watershed have on-site sewage treatment, including septic and lateral field systems. Untreated sewage can enter surface waters and groundwater, contributing to

E. coli and nutrient pollution when septic tanks and lateral fields are not properly maintained and reach a point of failure or damage. Although human *E. coli* sources identified in the microbial source tracking were low, they indicate that septic system failure is occurring in the GBFW and should be addressed. Regular maintenance is essential to ensure the system is working correctly and that there is no damage to the system that would allow untreated water to enter the watershed. This program will serve as a method to reduce pollution sources and as a form of information and outreach. This program will supply a pathway to help the community learn about the watershed, fund low-cost BMPs on the landscape, and develop connections between personal actions and water quality.

The Septic Pump-out and Awareness Program is an Information and Outreach method to help limit untreated wastewater entering the waterway and reduce *E. coli* loading in GBFW streams. On-site systems are often out of sight and out of mind for many people. Cost can be a barrier to septic system maintenance. Outreach efforts explaining and funding regular maintenance will improve the function of private on-site systems. The program would provide a rebate for community members who have inspections and/or pump-outs for on-site sewage systems. Community members will be able to apply for these rebates on a biannual basis if they meet the following requirements:

1) The onsite treatment must be in the watershed
2) The applicant must attend an approved education program
3) They must use an approved professional

6.2.5 Informational Signage

The Information and Outreach Program will include signage to help raise awareness in GBFW stakeholders about their watershed, what is happening there to improve water quality, and things they can do to help. Existing watershed-boundary signs will be maintained over time, and signage will be installed at demonstration and field day sites.

6.2.6 Stakeholder Engagement

The Information Outreach Committee and project partners will undertake a variety of activities to engage local stakeholders and promote programs that will help facilitate WBP implementation.

Programs that are planned include:

- Stormwater Champion program: Hosting the Stormwater Champion recognition and awarding program is a method to reinforce beneficial actions and create a community presence among landowners, organizations, businesses, and farms that are stewards of the land and implementing BMPs. Awardees will be recognized and given a sign they can display on their property or business.
- Presentations: Presentation to school and other student groups is a key method of engaging community members and future landowners to highlight the watershed and

BMPs. Encouraging students to participate in community activities that strengthen their connection to water quality through stream monitoring, native plant installation, and litter clean-ups. They can also share their gained knowledge and experiences with others in their community.

- Storm drain marking: Students and local community members can positively impact the community through storm drain marking. Storm drains directly affect our waterways, making it crucial that people understand how the storm drainage system functions and that only rain should go down the storm drain. The committee facilitation of a storm drain marking program provides an action step that people can do no matter their age or ownership of property.

Additional activities may include, but are not limited to: stakeholder surveys, news articles in local media highlighting watershed events and training opportunities, annual or semi-annual website update, brand development, etc.

6.3 Evaluation of Information and Outreach Activities and WBP Effectiveness (Element E, Criterion 3)

6.3.1 Information and Outreach Program Evaluation

Reaching the three foundational goals of the information and outreach program will require engagement strategies and evaluations. A minimum of one strategy for each goal must be completed each year. Examples of information strategies include informational signs, public speaking events, multimedia campaigns, online and virtual resources, monitoring events, demonstration projects, tours, wet feet activities, recognition programs, field guides, conservation agriculture and agroforestry practices, etc. Examples of the information and outreach programs' evaluation will include follow-up conversations with event attendees and program participants, watershed surveys, attendee/participant evaluation surveys, assessment of county website traffic (i.e. numbers of hits before and after the Information and Outreach Program activities), assessment of changes in behavior over time, etc. A complete list of the Strategies, Examples, and Evaluation can be found in Appendix K.

6.3.2 Information and Outreach Program and WBP Effectiveness

The voluntary adoption of BMPs and the improvement of water quality are the best way to quantify effectiveness of both the information and outreach program and the WBP itself. The following strategies will seek to evaluate those metrics and the overall effectiveness the Information and Outreach Program and the WBP:

- Gauging the level of voluntary adoption of agricultural BMPs is difficult because there is no way to track self-funded BMP implementation, and because of privacy concerns inherent in NRCS and SWCD cost-share program reporting, but a higher level

assessment of those programs' reports for the county can provide valuable data about BMP adoption in the area.

- Surveying general watershed/water quality knowledge of GBFW citizens will help gauge if outreach strategies are successful.
- Monitoring water quality of GBFW streams will provide data for assessment of relative improvement as a result of BMP adoption, and WBP effectiveness in making progress towards the goals of restoration of impaired waters and protection of all waters in the watershed.
- Utilizing the National Institute of Food and Agriculture report for the county to see the use of conservation and restoration practices in the watershed. Analyzing this data will indicate the success of the information and outreach program.

7.0 Monitoring (Element I), Research and Adaptive Management

7.1 Monitoring

The effectiveness of BMP implementation and progress being made towards achievement of WQS in the GBFW's impaired streams will be evaluated through regular water quality monitoring.

Stream monitoring will continue at seven of the original ten sites monitored by Dr. Robert Lerch (one on each of the impaired stream segments, plus a site on the Devil's Icebox Spring Branch) quarterly for four weeks per quarter (Element I, Criterion 1c). Water quality samples will be analyzed for *E. coli*, TN, TP and TSS, at a minimum. This monitoring schedule ensures that at least five *E. coli* samples will be collected during the recreational season (April 1-October 31) which is important for assessment for CWA Section 303(d) assessment for impairment. If funding permits, storm water samples may be collected during the recreational season as recommended by Dr. Robert Lerch in his Water Quality Summary report (see Appendix C). Additionally, with landowner consent, pre- and post-installation edge-of-field monitoring where BMPs are installed will be considered. Where edge-of-field monitoring is not feasible, project partners will rely on monitoring at the seven sites described above to determine BMP effectiveness. Boone County Resource Management will be responsible for monitoring and sample collection, but partnerships, memoranda of understanding, and contracts with vendors for sample analysis are anticipated.

At this time, project partners do not plan to analyze water quality samples for the presence of agricultural herbicides, pesticides or their breakdown products. However, as new agricultural products become available in the local market and are being applied to agricultural lands in the GBFW and/or new methods of analysis become available during the implementation period of the WBP, project partners may determine that water quality analysis for the presence of these chemicals or their breakdown products should resume and proceed accordingly.

E. coli data collected in the GBFW under the WBP will be evaluated against the WQS promulgated by the Missouri State Legislature and codified in the Missouri Code of State Regulations.

7.2 Research

Boone County Resource Management intends to work with our project partners during the 21-year milestone period to expand existing knowledge about the efficacy of agricultural conservation practices at reducing POC loading. Research connected with the Greater Bonne Femme Watershed Project and this WBP may be coordinated through a Soil Health Working

Group made up of members of the Technical Advisory Team, local producers, and research scientists from local universities.

7.3 Adaptive Management

Effectiveness of BMPs over time, primarily based upon quantitative results from water quality monitoring with consideration of qualitative input from stakeholders, will be reviewed at three-year (renewal of implementation phase funding), five-year (WBP update and revision), and seven-year (milestones) intervals (Element I, Criteria 2). The review process will allow for incorporation of adaptive management strategies so that project partners incorporate ever-changing information about the effectiveness of BMPs, particularly given the potential for increased climate variability, moving forward (Element H, Criteria 4). The review process will be coordinated through the Soil Health Working Group discussed in the Research section above. Any updated WBP will include analysis of available flow data collected at gauging stations maintained by Boone County on Turkey, Bonne Femme and Little Bonne Femme Creeks.

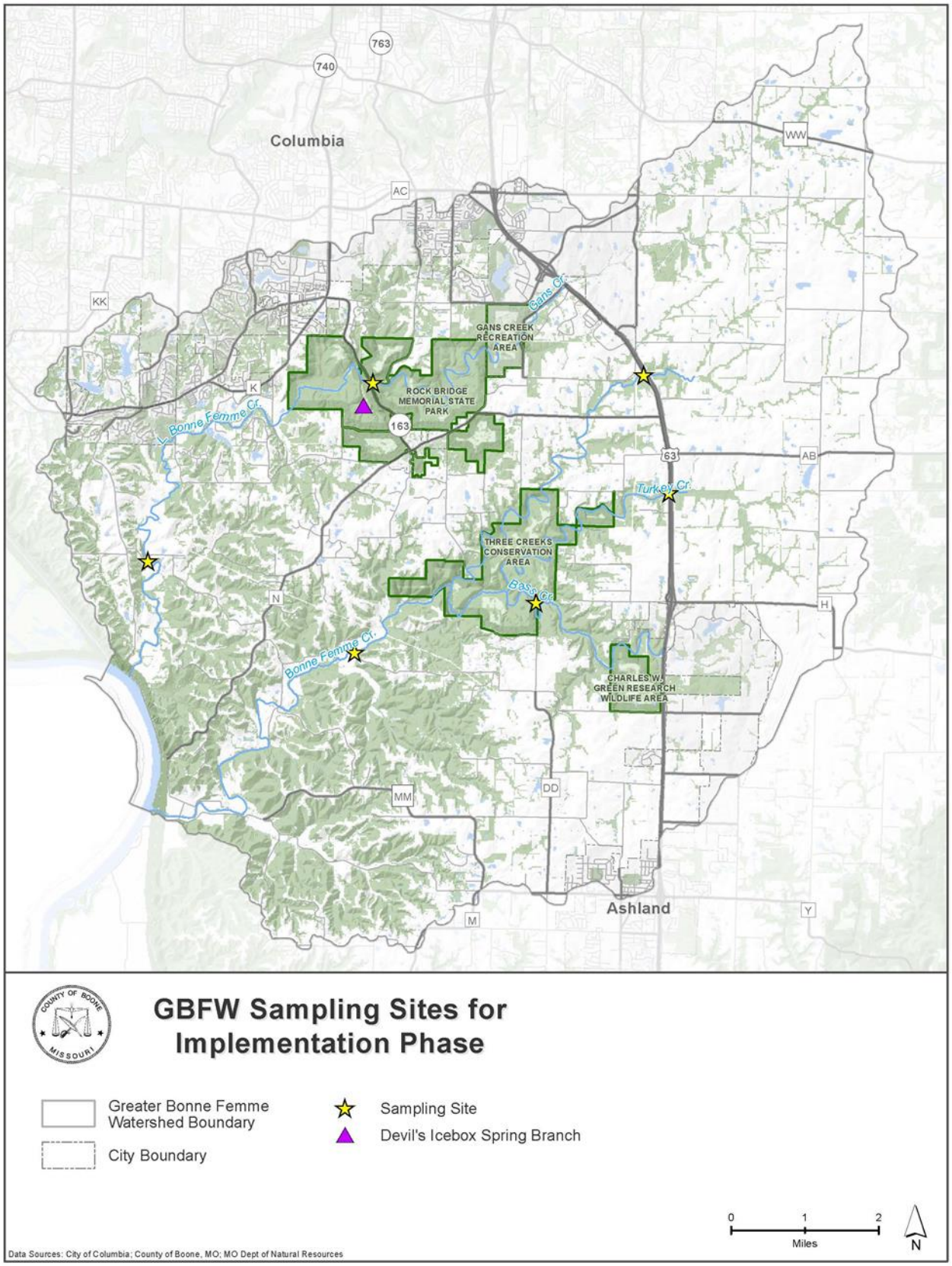

Figure 17. Water quality monitoring sites for the WBP.

8.0 Cost of Plan Implementation and Sources of Technical and Financial Assistance (Element D, Criteria 1-6)

8.1 Overall Plan Implementation Costs

Plan implementation will incur costs for BMP implementation, outreach strategies, monitoring activities, and administrative duties. A summary of estimated costs for implementation of the Greater Bonne Femme Watershed-based Plan is provided in Table 18. Appendix J includes details of cost estimate calculations for all expected WBP implementation costs.

8.1.1 BMP Implementation Costs

- Watershed-wide BMPs: Implementation of the recommended watershed-wide BMPs comprises the greatest portion of estimated costs in implementing the WBP. There are several difficulties with establishing a precise cost estimate for implementing these BMPs. The majority of the watershed-wide BMPs recommended for implementation in the GBFW are prescribed for use on agricultural land. The areas suitable for agricultural BMPs are primarily on private land, so successful implementation of this WBP will hinge on private landowners taking voluntary action to implement its guidelines. While estimated costs are based on the modeled priority subwatersheds, since the exact locations where landowner interest for BMP placement will be engaged is not known, the cost estimate for BMP implementation is not precise. One of the benefits of the detailed subwatershed delineation calculated for this project (Figure 8) is that if project partners are unable to obtain landowner participation in a targeted subwatershed, similar results can be achieved with another landowner in a nearby subwatershed. Additionally, Geosyntec Consultants provided Primary and Alternative sets of BMPs to obtain the load reductions needed to achieve water quality goals, allowing more flexibility in working with landowners in the GBFW – but adding greater uncertainty in estimating implementation costs.

  Details for estimated costs for agricultural (cropland and pastureland) BMP planning and implementation is included in Appendix J for Primary BMPs and Alternative BMPs. Cost estimates were made using the BMP types and acreages / linear feet provided by Geosyntec Consultants, and with unit costs extracted from recent projects conducted by the Boone County Soil and Water Conservation District and the Natural Resource Conservation Service (details found in Appendix J). Cost estimates for the watershed-wide urban BMPs will be discussed below and are not included in Table 18.

  Costs provided in Table 18 for Watershed-wide BMP Installation represent the high end of a possible range of estimated costs. The range depends on a number of factors, including varying costs between selection of Primary or Alternative BMPs, and certain BMPs whose costs vary depending on the animal species involved in the practice.

- Cover Crops Pilot: As discussed in the Proposed Management Measures in Section V, in order to address the protection goals of the WBP, subwatershed 42 has been chosen as a pilot subwatershed for a cover crops installation program to encourage landowners in the GBFW to implement conservation agriculture, soil health and agroforestry practices. The Cover Crops Pilot program costs are based on unit costs extracted from projects conducted by the Boone County Soil and Water Conservation District and are detailed in Appendix J.
- Demonstration Project: As the exact details of the project are unknown at this time, but are expected to include BMP implementation and monitoring, a broad cost estimate was used for the demonstration project at the University of Missouri's farm property along Gans Creek to the east of Highway 63 that is planned for Phase 1 of plan implementation.

8.1.2 Outreach Costs

- Information and Outreach Program: Since voluntary adoption of the recommended BMPs by GBFW producers is critical to WBP implementation, a major focus of the WBP implementation strategy will be Information and Outreach. Cost estimates for this part of the implementation process are also summarized in Table 18 with accounting details for individual outreach components included in Appendix J. Costs were based on known costs from events and engagement activities held the last several years, and on current prices researched for planned cost items such as replacement watershed signs, demonstration and field day signage, and Understanding Ag services.
- Septic Pump-Out and Awareness Program: Since the Septic Pump-out Program is a component of the Information and Outreach strategy, but has a BMP component, the cost is listed separately in Table 18, with details in Appendix J. The estimated program cost is based on a previous pump-out program and current pump-out prices, and accounts for $200 septic pump-out rebates for up to 30 eligible program participants (or $100 rebates for up to 60 participants) for each 7-year WBP implementation phase.

8.1.3 Monitoring Costs

- For the plan's monitoring program, while *E. coli* sample analysis costs are based on costs from current ongoing monitoring, there was a range of potential cost estimates for sample processing for other parameters depending on the lab used – either the University of Missouri Limnology Lab or WRO at Lincoln University. Details of the cost calculations are available in Appendix J. Costs for monitoring in Table 18 represent the high end of the range of cost estimates.

8.1.4 Administration Costs

- Estimated costs for administration of the plan have also been incorporated into the cost projection and are included in Table 18. These costs are based on known costs from the planning process and extrapolated to future project implementation.

All of the estimated costs in Table 18 are given in current 2022 dollars. It is expected that inflation will increase costs over time, and those increases will be reflected in cost estimates in future 5-year plan revisions of the plan.

Table 18. Summary of cost estimates for implementation of the Greater Bonne Femme Watershed-based Plan, over the 21-year milestone period, excluding urban BMPs.

Implementation Cost Category	Phase 1 Years 1-7 (30% implementation)	Phase 2 Years 8-14 (60% implementation)	Phase 3 Years 15-21 (90% implementation)	Total Estimated Cost
Watershed-wide BMP Installation*	**$135,018.93**	**$135,018.93**	**$135,018.93**	**$405,056.79**
Cover Crops Pilot, Subwatershed 42**	**$14,700.00**	**$29,400.00**	**$44,100.00**	**$88,200.00**
Demonstration Project	**$30,000.00**			**$30,000.00**
Information and Outreach	**$119,950.00**	**$204,950.00**	**$89,950.00**	**$414,850.00**
Septic Pump-out Program	**$6,000.00**	**$6,000.00**	**$6,000.00**	**$18,000.00**
Monitoring	**$68,296.20**	**$68,296.20**	**$68,296.20**	**$204,888.60**
Administrative	**$28,000.00**	**$28,000.00**	**$28,000.00**	**$84,000.00**
Total Estimated Cost	**$401,965.13**	**$471,665.13**	**$371,365.13**	**$1,244,995.39**

*For the most conservative cost estimate, the Watershed-wide BMP Installation estimate is the most costly of the ranges of Primary and Alternative BMP options. BMP cost estimation details are found in Appendix J.
**Max assumes all 70 new cover crop acres installed in first year and existing and new cover crop acres are kept in cover crops throughout each 7-year milestone period. Also assume that $20,000 lifetime cost-share maximum for cover crops per landowner is not met during the 21-year milestone period.

8.2 Urban BMP Costs

Although urban BMPs are recommended by Geosyntec Consultants in subwatershed 243 to aid in GBFW *E. coli* load reductions, the load reductions obtained by implementing the recommended urban BMPs are not essential to achieve the *E. coli* load reductions needed for GBFW streams to attain WQS for *E. coli*. Since there are no known funding sources at this time to implement these BMPs, their costs were left out of Table 18 and are included in Table 19 as a resource should a funding source become available. After the WBP has been approved, the plan will be presented to the City of Columbia and the City of Ashland for ratification, but any stormwater regulations for existing or new construction or city stormwater infrastructure are completely within the jurisdiction of these separate incorporated entities. Project partners hope to work in collaboration with these cities in managing their stormwater runoff to reduce loading of all POCs to GBFW streams.

Table 19. Summary of estimated costs for the urban BMP implementation portion of Greater Bonne Femme Watershed-based Plan; no markup for inflation.

Urban BMP	Area	Cost	Total
Bioretention Basins (area is total area for multiple basins)	7.3 acres (317,998 sq ft)	$14.68/sq foot*	$4,668,064.00
Detention Ponds (area is total area for multiple basins)	4.4 acres (191,664 sq ft)	Variable**	Variable**

*Cost estimate for all costs of basin installation, including design and construction, from contractor in Boone County who regularly performs this type of work.

** According to the EPA, typical costs for wet detention ponds range from $17.50-$35.00 per cubic meter ($0.50-$1.00 per cubic foot) of storage area. Dry detention basins typically cost around $10 per square meter ($0.30 per cubic foot) for smaller basins and $5 per square meter ($0.15 per cubic foot) for larger basins. However, the total cost for a pond or detention basin needs to include allowances for permitting, design and construction, and maintenance costs. Permitting costs may vary depending on state and local regulations.

8.3 Potential Sources for Technical and Financial Assistance

The range of costs for planning and implementation of the full suite of recommended BMPs, again with the exception of the Urban BMPs, is from $1,839,790-$2,086,489 over 21 years. The total reflected in Table 18 is the higher number to be conservative in the cost projection. (Cost estimates do not include any BMPs that are the sole responsibility of the landowner due to pre-existing permit requirements – specifically in subwatershed 181, Cartwright Technology Park's stormwater management plan obligation with the City of Ashland.)

All attainable funding and technical sources will be considered, including federal, state, local and private contributions, including all sources of match available from project partners. State and federal cost-share availability for agricultural practices is well established and is evolving to potentially include and/or prioritize new practices, particularly due to the increased interest in conservation agriculture / soil health / agroforestry practices (discussed at the end of Section IV). Consequently, the following list is a snapshot of options for technical and financial assistance for the agricultural BMPs that make up the majority of WBP recommendations, and assistance options include but are not limited to those presented here. Current technical and cost-share partners for overall plan implementation include the United States Department of Agriculture (USDA), USDA Natural Resource Conservation Service (NRCS), the Missouri Department of Conservation, the Missouri Department of Natural Resources, Boone County Soil and Water Conservation District (BCSWCD), and the Missouri Section 319 Nonpoint Source program at MDNR. Direct and in-kind contributions from current and future project partners will be considered for and used as match where appropriate. Examples of potential match for future WBP implementation projects include state and landowner contributions towards cost-share implementation practices, demonstration project partner contributions, Boone County Regional Sewer District contributions towards *E. coli* lab analysis, technical and administrative services provided by Boone County, etc. A summary table of partners currently able to provide funding for components of the implementation plan is included below as Table 20. Appendix J lists current practice numbers for agricultural and streambank BMPs with cost-share available through BCSWCD and NRCS.

Table 20. Agencies with funding currently available for BMPs, Information / Outreach, and Monitoring activities recommended in the Greater Bonne Femme Watershed-based Plan

Agency	Cost type	Portion of Total Cost Projection
Boone County Soil and Water Conservation District	BMP Installation, Cover Crops Installation	$452,751.00
Section 319 Implementation Grants	Other allowable costs (costs not allowable for 319 funding will be funded through other means, including through Boone County or partner match*)	$1,633,738.60

*See list of partners and their roles in Section IX – Partnerships.

In the short term, Boone County Resource Management plans to submit an application for the first implementation phase grant to the Missouri Section 319 Nonpoint Source program in 2022. If accepted, the first proposed implementation project would last for a period of three years. Boone County Resource Management would manage implementation phase grant funds for the WBP. Funding would be strategically allotted so that BMP funding available from other sources, specifically BCSWCD and NRCS, are not duplicated by Missouri Section 319 Nonpoint Source funds. Using this plan as a guide, initial BMP implementation would be prioritized to the most critical subwatersheds identified in the Catchment Prioritization Index (Figure 15).

9.0 Partnerships

Boone County, as the lead for WBP implementation facilitation, welcomes and encourages the continued involvement of agencies, governments, non-governmental organizations and individuals represented by the Technical Advisory Team, the Steering Committee, and the Information and Education Subcommittee, as well as other partners working with the Greater Bonne Femme Watershed Project. Boone County hopes to encourage partner participation in the implementation of the WBP, and also desires to work with partners as they develop management strategies to increase resilience of local ecosystems to climate variability and other issues.

Table 21. Existing and potential partners for the Greater Bonne Femme Watershed Project.

Partner name	**Role**
Ashland YMCA	Educational partner
Boone County Regional Sewer District	Wastewater management; Lab analysis
Boone County Soil Conservation District	Technical partner; Cost-share availability
City of Ashland, Missouri	Incorporated entity in GBFW
City of Columbia, Missouri	MS4 partner; Incorporated entity in GBFW
City of Columbia / Boone County Health Department	On-site wastewater management
Columbia Center for Urban Agriculture	Education and liaison for producer marketing
Columbia Public Schools	Educational partner
Greenbelt Land Trust	Technical partner; Conservation easements
Lincoln University	Technical partner; Water quality monitoring
State and local agricultural organizations	Communication and education
Missouri Department of Conservation	Technical partner; Cost-share availability; Nature School education
Missouri Department of Natural Resources	Technical partner; Section 319 program and funding
Missouri Prairie Foundation	Prairie strips research; Education
Missouri River Bird Observatory	Education
Missouri River Relief	Education
Missouri Soybean Association	Education
Missouri State Parks (Rock Bridge Memorial)	Landowner in watershed; Research and education
Missouri Stream Teams	Water quality monitoring and education
Pheasants Forever / Quail Forever	Habitat for wildlife; Education
Southern Boone Learning Garden	Educational partner
USDA / NRCS	Technical partner; Cost-share availability
University of Missouri (various departments)	MS4 partner; Research and monitoring

10.0 Implementation Strategy for the Greater Bonne Femme Watershed-Based Plan (Elements F and G); (Element H, Criteria 2, 3 and 4)

10.1 Overall WBP Implementation Strategy

Upon approval of the final WBP by MDNR and US EPA, the WBP will be presented to local governments and MS4 partners in the GBFW, specifically the City of Columbia, the City of Ashland, and the University of Missouri, for ratification and implementation in incorporated and unincorporated areas of the GBFW in Boone County. Ratification by the WBP by local governments will indicate a strong and united movement toward implementation of the WBP in the GBFW. Specifically, project partners would like to see a more unified regulatory framework for residential and commercial stormwater management (including best management practice implementation), on-site wastewater management and sensitive area protections.

The project partners envision a twenty-one-year timeline for the implementation of the Greater Bonne Femme Watershed-Based Plan. The project will proceed in three phases corresponding with the milestones below (Element G). Targeted recruitment will be used to identify likely implementation sites in critical areas of the watershed (or other priority areas, if needed), and implementation will proceed according to buy-in from recruitment efforts. The extent of BMP implementation in the watershed will be evaluated using a combination of reporting / collaboration with cost-share partners, and GIS analysis of land cover imagery over time.

Boone County has already developed relationships with project partners including Boone County Soil and Water Conservation District, the Natural Resources Conservation Service, Green Belt Land Trust, and the Missouri Department of Conservation. During implementation of the WBP, these partnerships will help to engage with and recruit landowners interested in participating with the project and BMP installation. Additionally, the members of the Steering Committee will be instrumental in helping to get the message out to potential landowner partners in their respective jurisdictions. If recruitment efforts in the target critical subwatersheds for watershed-wide BMPs are not successful at any given time, project partners will focus implementation recruitment on subwatersheds close to target subwatersheds to identify opportunities for the application of appropriate BMPs as listed in Table 12 or others that have a demonstrated effectiveness towards addressing *E. coli* pollution and the other GBFW water quality concerns of nutrient and sediment control. While recruitment efforts will focus first and foremost on the target critical subwatersheds, or nearby subwatersheds, and since the entire GBFW is prioritized for implementation because all subwatersheds provide flow to impaired streams, BMP implementation anywhere that will reduce the loading of pollutants of concern to impaired watershed streams will be encouraged.

The ability to assist landowners with the cost of BMP implementation through use of available cost-share programs is key to success in the BMP adoption recruitment effort. Various

approaches for showcasing the BMPs available using cost-share will be considered, including, but not limited to, installation of pilot projects that can be toured by prospective landowner partners.

Achieving the restoration and protection goals of the WBP will rely upon how effective Boone County and project partners are in recruiting landowners to install the WBP's recommended practices. Project partners expect to conduct the following information and outreach activities on an annual basis to inform and engage GBFW stakeholders and encourage BMP adoption as part of the WBP implementation strategy:

- Water quality Monitoring Blitz at six sites in and around Rock Bridge Memorial State Park (Spring and Fall of each year)
- Greater Bonne Femme Watershed Festival
- Land Management Workshops
- Promote and offer scholarships for agricultural producer attendance at technical workshops
- Farm tour/consultation with Understanding Ag or similar consultant
- Farm tours of demonstration project and pilot project sites
- Septic Pump-out and Awareness Program
- Maintenance of watershed signs on major roadways in the GBFW
- Promote volunteer water quality monitoring and stream adoption through Missouri Stream Team
- Watershed clean-ups
- Stormwater Champions program awards
- Presentations to school and other student groups
- Storm drain marking in the GBFW
- Frequent update of information on the website

Additional information and outreach activities from Section VI and Appendix K will be undertaken as time, circumstances, and resources allow.

A detailed schedule with dates and milestones of specific BMP implementation and information and outreach activities will be included in any future Section 319 implementation projects.

10.2 Implementation Milestones and Schedule

10.2.1 Phase 1 – Years 1-7 (Short Term)

Because the plan recommends several practices that GBFW landowners have not implemented in the past, the first few years (1-5) will focus on getting landowners familiar with the practices and how they can simultaneously benefit landowners and help improve the stream water quality. The overall BMP implementation strategy for Phase 1 will be to initially focus upon recruitment of landowners to adopt and implement pilot projects to showcase watershed-wide BMPs selected for implementation in the GBFW. In particular, the initial focus will be on BMPs on pastureland

to the east of Highway 63. In addition to the recommended BMPs, project partners will encourage conservation agriculture practices throughout the watershed. Cover crops can be planted, and conservation tillage can be used anywhere that there is agricultural row crop production in the GBFW and will improve soil health and water quality wherever the practices are implemented. For landowners that are unfamiliar with or hesitant to try practices that can provide soil health (and water quality) benefits, conservation tillage and cover crops provide an easily accessible introduction and demonstration of their worth. Additionally, these practices are less resource intensive than a number of the other BMPs proposed by Geosyntec for implementation in the GBFW.

Phase 1 – Implementation Milestones: Watershed-wide BMPs are implemented at 30% of the applicable land use area or stream length in the critical areas of the watershed as delineated by Table 12, or as close to the critical areas as practicable depending upon voluntary landowner engagement in the practices. Information and Outreach techniques will be used, as well as any other resources available to project partners, to engage landowners and recruit them to create a demonstration project (or several small projects) for BMP installation in the GBFW. Phase 1 will also include the beginning of the Cover Crop Pilot in subwatershed 42, plus water quality monitoring, annual information and outreach events, initiation of the Septic Pump-out and Awareness program, social marketing training and technical assistance for project partners to assist with WBP implementation, and installation of a demonstration project along Gans Creek at South Farm owned by the University of Missouri. Review and revision of the WBP will occur at years 5-7 of implementation.

10.2.2 Phase 2 – Years 8-14 (Medium Term)

During Phase 2, project partners will begin with an evaluation of the effectiveness of the watershed-wide BMPs installed and overall strategy employed during Phase 1 of the implementation projects. Load reductions achieved by those projects will be assessed to determine if they are on track with reductions needed to achieve *E. coli* WQS by the end of the 21-year plan period. A determination will be made as to which watershed-wide BMPs, will be implemented to achieve 60% (cumulative) coverage of the applicable land use area or stream length in the critical subwatersheds (or subwatersheds as close to those critical subwatersheds as possible depending upon voluntary landowner engagement in the practices). The evaluation of effectiveness of the watershed-wide BMPs will be coordinated through a Soil Health Working Group made up of members of the Technical Advisory Team, local producers, and research scientists from the local universities.

Phase 2 – Implementation Milestones: Watershed-wide BMPs are implemented at 60% of the applicable land use area or stream length in the critical areas of the watershed as delineated by Table 12, or as close to the critical areas as practicable. Project partners will continue to use Information and Outreach techniques and other resources to engage landowners and recruit them to install watershed-wide BMPs. More frequent Farm Days at sites with demonstration projects are envisioned to show prospective landowners how BMPs work on the landscape. Phase 2 will also include the continuation of the Cover Crop Pilot in subwatershed 42, quarterly water quality

monitoring, annual information and outreach events, continuation of the Septic Pump-out and Awareness program, and completion of a Return on Environment Study for the GBFW. Review and revision of the WBP will occur at years 5-7 of Phase 2.

10.2.3 Phase 3 – Years 15-21 (Long Term)

During Phase 3, project partners will begin with an evaluation of the effectiveness of the watershed-wide BMPs installed and overall strategy employed during years 1 through 14 of the implementation projects. Load reductions achieved by those projects will be assessed to determine if they are on track with reductions needed to achieve *E. coli* WQS by the end of the 21-year plan period. A determination will be made as to which watershed-wide BMPs, including the specific BMP types proposed by Geosyntec and cropland and pastureland practices generally, will be implemented to achieve 90% (cumulative) coverage of the applicable land use area or stream length in the critical subwatersheds (or subwatersheds as close to those critical subwatersheds as possible depending upon voluntary landowner engagement in the practices).

Phase 3 – Implementation Milestones: Watershed-wide BMPs are implemented at 90% of the applicable land use area or stream length in the critical areas of the watershed, or as close to the critical areas as practicable. Project partners will continue to use Information and Outreach techniques and other resources to engage landowners and recruit them to install watershed-wide BMPs. More frequent Farm Days at sites with demonstration projects are envisioned to show prospective landowners how BMPs work on the landscape. Phase 3 will also include the continuation of the Cover Crop Pilot in subwatershed 42, quarterly water quality monitoring, annual information and outreach events, and continuation of the Septic Pump-out and Awareness program. Review and assessment of WBP implementation and success will occur at years 5-7 of Phase 3.

10.2.4 Annual BMP Adoption Rates and Costs

It is useful to have estimates of annual BMP adoption rates as a guide to implementation and a way to track WBP implementation progress. Developing these estimates is difficult, however, due to the voluntary nature of BMP implementation – and the estimates given in Tables 23-25 should only be used as a guide, and not be interpreted as a rigid schedule of implementation.

Landowner adoption and installation of the best management practices outlined in the Proposed Management Measures section of this watershed-based plan is completely voluntary. For this reason, the stated values for the Greater Bonne Femme WBP Overall Implementation Schedule of Milestones, the Primary BMP schedule of annual adoption rates and costs, the Alternative BMP schedule of annual adoption rates and costs, and Total annual costs for Primary and Alternative BMP Implementation (Tables 22-25) are proposed as estimates only (Element F, Criteria 1).

Table 22. Greater Bonne Femme WBP Overall Implementation Schedule of Milestones.

Implementation Category	**Phase 1** **Years 1-7** **(30% implementation)**
Watershed-wide BMP Installation	Implementation of 30% of critical area land use area or stream length identified, or as close as practicable
Cover Crop Pilot, Subwatershed 42	70 acres of the cropland acres in watershed
Monitoring	7 sites in GBFW, monitored quarterly
Information and Outreach	See list of annual events; Social marketing training and technical assistance
Septic Pump-out and Awareness Program	30 septic pump-outs and/or inspections
Demonstration Project	Installation of demonstration project on Gans Creek at South Farm, University of Missouri
WBP Update	WBP will be reviewed and updated at year 5 of Phase 1
Implementation Category	**Phase 2** **Years 8-14** **(60% implementation)**
Watershed-wide BMP Installation	Implementation of additional 30% of critical area land use area or stream length identified, or as close as practicable
Cover Crops Pilot, Subwatershed 42	70 cropland acres in subwatershed 42 continue in cover crops; 70 additional cropland acres put in cover crops
Monitoring	7 sites in GBFW, monitored quarterly
Information and Outreach	See list of annual events; Return on Environment Study completion
Septic Pump-out and Awareness Program	30 septic pump-outs and/or inspections
Demonstration Project	Ongoing use of demonstration project site for research and education
WBP Update	WBP will be reviewed and updated at year 5 of Phase 2
Implementation Category	**Phase 3** **Years 15-21** **(90% implementation)**
Watershed-wide BMP Installation	Implementation of additional 30% of critical area land use area or stream length identified, or as close as practicable
Cover Crops Pilot, Subwatershed 42	140 cropland acres in subwatershed 42 continue in cover crops; 70 additional acres put in cover crops
Monitoring	7 sites in GBFW, monitored quarterly
Information and Outreach	See list of annual events
Septic Pump-out and Awareness Program	30 septic pump-outs and/or inspections
Demonstration Project	Ongoing use of demonstration project site for research and education
WBP update	WBP implementation success will be assessed at year 5 of Phase 3

Table 23. Primary BMP schedule of annual adoption rates and costs.

Primary BMPs - Annual Adoption (treated units)									
Year	**Fencing (feet)**	**Grazing Management (acres)**	**Livestock Exclusion (acres)**	**Stream-bank Buffer (acres)**	**Vegetated Buffer (acres)**	**Vegetated Buffer w/ Trees (acres)**	**Vegetative Filter Strip (acres)**	**Demo Project**	**Cover Crops Pilot (acres)**
2	630.54	12.44	0.16	0.10	1.60	0.14	0.80		70.00
3	630.54	12.44	0.16	0.10	1.60	0.14	0.80	1	70.00
4	630.54	12.44	0.16	0.10	1.60	0.14	0.80		70.00
5	630.54	12.44	0.16	0.10	1.60	0.14	0.80		70.00
6	630.54	12.44	0.16	0.10	1.60	0.14	0.80		70.00
7	630.54	12.44	0.16	0.10	1.60	0.14	0.80		70.00
8	630.54	12.44	0.16	0.10	1.60	0.14	0.80		140.00
9	630.54	12.44	0.16	0.10	1.60	0.14	0.80		140.00
10	630.54	12.44	0.16	0.10	1.60	0.14	0.80		140.00
11	630.54	12.44	0.16	0.10	1.60	0.14	0.80		140.00
12	630.54	12.44	0.16	0.10	1.60	0.14	0.80		140.00
13	630.54	12.44	0.16	0.10	1.60	0.14	0.80		140.00
14	630.54	12.44	0.16	0.10	1.60	0.14	0.80		140.00
15	630.54	12.44	0.16	0.10	1.60	0.14	0.80		210.00
16	630.54	12.44	0.16	0.10	1.60	0.14	0.80		210.00
17	630.54	12.44	0.16	0.10	1.60	0.14	0.80		210.00
18	630.54	12.44	0.16	0.10	1.60	0.14	0.80		210.00
19	630.54	12.44	0.16	0.10	1.60	0.14	0.80		210.00
20	630.54	12.44	0.16	0.10	1.60	0.14	0.80		210.00
21	630.54	12.44	0.16	0.10	1.60	0.14	0.80		210.00
Primary BMPs - Annual Cost (dollars)*									
2	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		2450.00
3	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32	30000.00	2450.00
4	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		2450.00
5	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		2450.00
6	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		2450.00
7	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		2450.00
8	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		4200.00
9	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		4200.00
10	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		4200.00
11	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		4200.00
12	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		4200.00
13	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		4200.00
14	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		4200.00
15	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		6300.00
16	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		6300.00
17	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		6300.00
18	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		6300.00
19	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		6300.00
20	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		6300.00
21	844.92	3730.50	121.13	251.69	1624.06	379.51	1134.32		6300.00
Primary BMPs Total Cost*:							161,722.60		
Cover Crops Pilot Total Cost:									88,200.00

*Annual costs for Vegetated Buffer do not include $500/ac 10-year renewal costs as calculated in Appendix J and considered for Table 18 Summary of Cost Estimates for implementation of the Greater Bonne Femme Watershed-based Plan.

Table 244. Alternative BMP schedule of annual adoption rates and costs.

Alternative BMPs - Annual Adoption (treated units)									
Year	Fencing (feet)	Grazing Management (acres)	Livestock Exclusion (acres)	Stream-bank Buffer (acres)	Vegetated Buffer (acres)	Vegetated Buffer w/ Trees (acres)	Vegetative Filter Strip (acres)	Demo Project	Cover Crops Pilot (acres)
2	906.27	9.92	0.80	0.17	0.10	0.16			70.00
3	906.27	9.92	0.80	0.17	0.10	0.16		1	70.00
4	906.27	9.92	0.80	0.17	0.10	0.16			70.00
5	906.27	9.92	0.80	0.17	0.10	0.16			70.00
6	906.27	9.92	0.80	0.17	0.10	0.16	1		70.00
7	906.27	9.92	0.80	0.17	0.10	0.16	1		70.00
8	906.27	9.92	0.80	0.17	0.10	0.16	1		140.00
9	906.27	9.92	0.80	0.17	0.10	0.16	1		140.00
10	906.27	9.92	0.80	0.17	0.10	0.16	1		140.00
11	906.27	9.92	0.80	0.17	0.10	0.16	1		140.00
12	906.27	9.92	0.80	0.17	0.10	0.16	1		140.00
13	906.27	9.92	0.80	0.17	0.10	0.16	1		140.00
14	906.27	9.92	0.80	0.17	0.10	0.16	1		140.00
15	906.27	9.92	0.80	0.17	0.10	0.16	1		210.00
16	906.27	9.92	0.80	0.17	0.10	0.16	1		210.00
17	906.27	9.92	0.80	0.17	0.10	0.16	1		210.00
18	906.27	9.92	0.80	0.17	0.10	0.16	1		210.00
19	906.27	9.92	0.80	0.17	0.10	0.16	1		210.00
20	906.27	9.92	0.80	0.17	0.10	0.16	1		210.00
21	906.27	9.92	0.80	0.17	0.10	0.16	1		210.00
Alternative BMPs - Annual Cost (dollars)*									
2	1214.40	2974.50	598.88	446.72	97.21	425.64			2450.00
3	1214.40	2974.50	598.88	446.72	97.21	425.64		30000.00	2450.00
4	1214.40	2974.50	598.88	446.72	97.21	425.64			2450.00
5	1214.40	2974.50	598.88	446.72	97.21	425.64			2450.00
6	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		2450.00
7	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		2450.00
8	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		4200.00
9	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		4200.00
10	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		4200.00
11	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		4200.00
12	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		4200.00
13	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		4200.00
14	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		4200.00
15	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		6300.00
16	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		6300.00
17	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		6300.00
18	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		6300.00
19	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		6300.00
20	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		6300.00
21	1214.40	2974.50	598.88	446.72	97.21	425.64	18000.00		6300.00
Alternative BMPs Total Cost*:							403,146.81		
Cover Crops Pilot Total Cost:									88,200.00

*Annual costs for Vegetated Buffer do not include $500/ac 10-year renewal costs as calculated in Appendix J and considered for Table 18 Summary of Cost Estimates for implementation of the Greater Bonne Femme Watershed-based Plan.

Table 255. Total annual costs for Primary and Alternative BMP Implementation, including Demonstration Project and Cover Crops Pilot costs.

Year	Primary BMPs	Alternative BMPs
2	$10,536.13	$8,207.34
3	$40,536.13	$38,207.34
4	$10,536.13	$8,207.34
5	$10,536.13	$8,207.34
6	$10,536.13	$26,207.34
7	$10,536.13	$26,207.34
8	$12,286.13	$27,957.34
9	$12,286.13	$27,957.34
10	$12,286.13	$27,957.34
11	$12,286.13	$27,957.34
12	$12,286.13	$27,957.34
13	$12,286.13	$27,957.34
14	$12,286.13	$27,957.34
15	$14,386.13	$30,057.34
16	$14,386.13	$30,057.34
17	$14,386.13	$30,057.34
18	$14,386.13	$30,057.34
19	$14,386.13	$30,057.34
20	$14,386.13	$30,057.34
21	$14,386.13	$30,057.34
Totals:	**$279,922.60**	**$521,346.81**

10.3 Overall WBP Implementation

Progress on BMP installation is completely dependent upon voluntary landowner participation, so it is difficult to provide additional or precise detail on the implementation timeline with the WBP.

Work on BMP installation will proceed when practicable due to the influences of season and agricultural planting and harvest schedules. For example, BMP installation should not interfere with agricultural producers' use of the land for normal operations. (Element F)

The expected load reductions for each implementation phase are presented in Tables 13-16 and summarized in Table 17 (Element H, Criteria 2).

Implementation phase grant funding from Missouri Section 319 Nonpoint Source grants is potentially available in three-year intervals. This shorter review period within the longer seven-year milestones will allow for adaptive management as project partners move forward on restoration and protection measures in the GBFW. Additionally, the WBP will be reviewed every five years for an update and revision. The review and revision process will be conducted by project partners and the TAT based upon all data and information available for plan implementation progress and water quality results to date, with input and further review by the Steering Committee comprised of local government representatives. (Element H, Criterion 4).

11.0 Pursuit of Category 5-alt Designation for Impaired Segments

Upon acceptance of this WBP, project partners will make a formal request to the Missouri Department of Natural Resources to subcategorize the water quality impairments in the GBFW as Category 5-alt on the 303(d) List of Impaired Waters. If the request is successful, the implementation plan under the WBP would be used over the 21-year milestone period to achieve water quality standards, and MDNR would evaluate progress under the WBP in considering whether to reduce the priority of issuing TMDLs on the impaired streams during the milestone period. Water quality will be monitored during the milestone period to ensure that *E. coli* load reductions are being achieved pursuant to the WBP, and MDNR will continue to evaluate progress under the implementation plan and adjust the TMDL priority of the impaired waters if needed.

11.1 Category 5-alt Components

1. **Description of the alternative approach to be used and how it is expected to result in attainment of water quality standards**

   The Greater Bonne Femme Watershed-based Plan will serve as the guidance document for the reduction of *E. coli* nonpoint source loading to attain water quality standards and designated uses in the impaired stream segments in the GBFW (Table 2 summarizes information regarding the impaired stream segments). Priority subwatersheds for implementation of BMPs were identified (Figure 15) using load duration curves, load reduction efficiencies (Table 9), and modeling techniques performed by Geosyntec Consultants and presented in their Greater Bonne Femme Watershed Modeling Report. Load duration curves for *E. coli* are based on applicable water quality criteria for each stream and represent the maximum loading the streams can accept and still meet water quality standards. For this reason, these targets are the same or similar to what would be included in a TMDL. Implementation of this watershed-based plan and the recommended BMPs (Table 12) is expected to attain water quality standards over the 21-year period outlined in the schedule of milestones (Table 22).

2. **Identification of specific impaired water bodies and pollutants that are addressed by the alternative approach**

   This watershed-based plan addresses *E. coli* water quality impairments as identified on Missouri's approved 2020 Section 303(d) list of impaired waters. The locations of the impaired water bodies in the GBFW are shown in Figure 2; Table 2 includes a list of the GBFW impaired waters, their WBID, impaired use, size and HUC-12 designation. Recommended BMPs will primarily focus on *E. coli* load reduction, with a secondary goal of reducing nutrient and sediment loading in the priority subwatersheds. Many of the recommended BMPs will address all POCs simultaneously.

3. **Identification of sources causing and contributing to the impairment**

   The WBP discusses nonpoint sources causing and contributing to the impairment in Section II. Any point sources in these watersheds are regulated through Missouri State Operating Permits that would include limits or conditions that, when achieved, would not cause or contribute to these water quality impairments. Point sources violating such limits or conditions are subject to MDNR enforcement action. For these reasons, nonpoint sources are the primary contributors to the impairment and pollutant reduction from nonpoint sources in accordance with this watershed-based plan is expected to result in attainment of water quality standards.

4. **Description of the implementation strategy and an estimate or projection of the time when water quality standards will be met. Address point or nonpoint sources as necessary to attain water quality standards.**

   The Implementation Strategy for the Greater Bonne Femme Watershed is found in Section X of the 9-element WBP. The implementation strategy consists of BMP installation across the priority subwatersheds (or in proximity thereto as discussed in the WBP) as detailed in Section V, monitoring water quality to track changes in POC loading (Section VII), and an extensive Information and Outreach campaign (Section VI). Project partners will build upon current and existing partnerships to accomplish the goals of the WBP. Water quality standards are expected to be attained at 90% BMP implementation by the end of the plan's 21 year implementation period (Table 17). The focus of the WBP is on load reduction from nonpoint sources identified through land-use land cover mapping (Table 3 and Figure 5) and the modeling performed by Geosyntec Consultants.

5. **Identification of available funding for implementation**

   Potential funding sources for implementation are identified in Section VIII of the WBP. Many of the recommended BMPs have cost-share available through the Boone County Soil and Water Conservation District (BCSWCD), and this agency will be a key partner in the implementation process for both funding and technical assistance. The private lands conservationist with the Missouri Department of Conservation will be another key partner in the implementation process, particularly with providing technical assistance to landowners. USDA NRCS and MDNR Section 319 Nonpoint Source Implementation Grants will also provide potential funding for WBP implementation.

6. **Identification of all parties committed, and additional parties needed, to implement the alternative approach and their role in implementation**

   Project partners, existing and potential, are identified in Section IX of the WBP (Table 21).

7. **Plan for effectiveness monitoring and periodic evaluation to determine if plan is still expected to result in attainment of water quality standards more rapidly than pursuing development of a TMDL**

   Effectiveness monitoring is discussed in Sections VI and VII of the WBP. Project partners plan to use local laboratories (University of Missouri Limnology Laboratory, WRO at Lincoln University) to analyze water quality samples throughout the implementation period of the WBP. The WBP will be updated every five years, and any new data collected during the implementation period of the WBP will be used to inform future BMP implementation and planning.

12.0 Concluding Remarks

Management at the watershed level is complex, with many moving parts – goals, strategies, stakeholders, science, policy – the list is long. Project partners are hopeful that this plan will provide a guide for management of the GBFW for the next 21 years, with reevaluation and plan updates every 5 years. Project partners plan to assess the amount of implementation progress at each 5-year plan update to see if it is on track proportionately with the 7-14-21 year milestones in the WBP, and make appropriate plan revisions as needed. The interdisciplinary approach proposed should allow flexibility as we move forward to restore and protect streams in the GBFW. Boone County will continue to take the lead on review and modification of the WBP at 5 year intervals, with assistance of project partners. The Technical Advisory Team will continue to meet quarterly during the initial 5 year implementation phase of the plan.

One of the most important components of this plan is outreach and engagement. Project partners are willing to meet people where they are, and hope that even in these difficult times, those people will be receptive to new ideas and strategies for improvement of water quality in the GBFW.

13.0 References (see Appendix L)

14.0 Appendices

Appendices are found in the companion document to this plan:
Greater Bonne Femme Watershed-Based Plan - Appendices

List of Appendices found in that document:

- Appendix A
  Existing Environmental Protections

- Appendix B
  History of Water Pollution and Protection for Devil's Icebox Cave and Bonne Femme Watershed Streams

- Appendix C
  Dr. Robert Lerch's Full Water Quality Report

- Appendix D
  Missouri Agriculture – 2016 Economic Contributions of Agriculture and Forestry

- Appendix E
  2007 Watershed Management Plan Goals

- Appendix F
  Integrating the Greater Bonne Femme Watershed-based Plan into the Boone County, City of Columbia, University of Missouri MS4

- Appendix G
  Greater Bonne Femme Watershed Modeling Report

- Appendix H
  Agricultural BMP Mode of Action and Pollutants Addressed

- Appendix I
  Load Duration Curves and Pollutant Reduction Estimates for Six Impaired Streams in Boone County, Missouri

- Appendix J
  WBP Implementation Budget Summary and Cost Estimate Calculations

- Appendix K
  Information and Outreach Strategies and Examples

- Appendix L
  References

Hunters Cave in October, 2020 framed in asters.