HARPETH RIVER WATERSHED ASSOCIATION

HARPETH RIVER HEADWATERS WATERSHED RESTORATION PLAN

Harpeth River Headwaters, Cheatham Branch

Harpeth River Watershed Association

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Summary

The Harpeth River Headwaters Watershed Restoration Plan (Plan) was developed for an area near Eagleville in Rutherford County, Tennessee. The Harpeth River Headwaters (Headwaters) includes the main branch of the Harpeth River, Cheatham Branch, Kelly Creek, Concord Creek, Puckett Branch, and associated tributaries (Figure 1). The Plan provides information about the current water quality and stream ecosystem health status of streams in the Headwaters, geographical descriptions (e.g., land cover), and a history of implementation tasks completed to date. Importantly, the Plan includes the Nine Elements required by the United States Environmental Protection Agency (EPA): identification of causes and sources of water quality impairment, pollution load reduction estimates, descriptions of nonpoint source management measures (best management practices), cost estimates, information and education components, schedules for implementation, measurable milestones, criteria for determining load reductions and water quality improvements, and monitoring strategies to evaluate Plan effectiveness over time. The primary nonpoint source management measures to be implemented by this Plan are riparian buffer restoration, streambank stabilization, urban and residential stormwater mitigation, and agricultural BMP adoption. Total costs for implementation of all BMPs in the Headwaters Watershed during the 20-year span of this Plan are estimated at $2,773,875. The total estimated load reduction for all BMP installations in the watershed is 177,619 pounds per year (lbs/yr) of nitrogen, 26,426 lbs/yr of phosphorus, and 7,711 lbs/yr of sediments.

Background

The State Scenic Harpeth River flows 126 miles from near Eagleville in Rutherford County to its confluence with the Cumberland River in Cheatham County. Over 1,000 miles of tributary streams help drain an 867-square mile watershed. Among these are four creeks in the upper watershed or “headwaters”: Concord Creek, Puckett Branch, Kelly Creek, and Cheatham Branch. All of these streams except Puckett Branch, which has not been assessed, are listed as impaired by the Tennessee Department of Environmental Quality (TDEC).

The Harpeth Headwaters Watershed encompasses 22,593 acres (35.3 square miles) of land and water. Both Kelly Creek and Cheatham Branch have some forest, scrub/shrub, and grassland in upper watershed areas, but the mid and lower watershed land cover is predominantly agriculture. Agriculture in the headwaters accounts for approximately 50% of the land cover and is the primary source of stream water quality degradation, though urban and residential land use invariably contributes to the problem as well (Table 1, Figure 2).

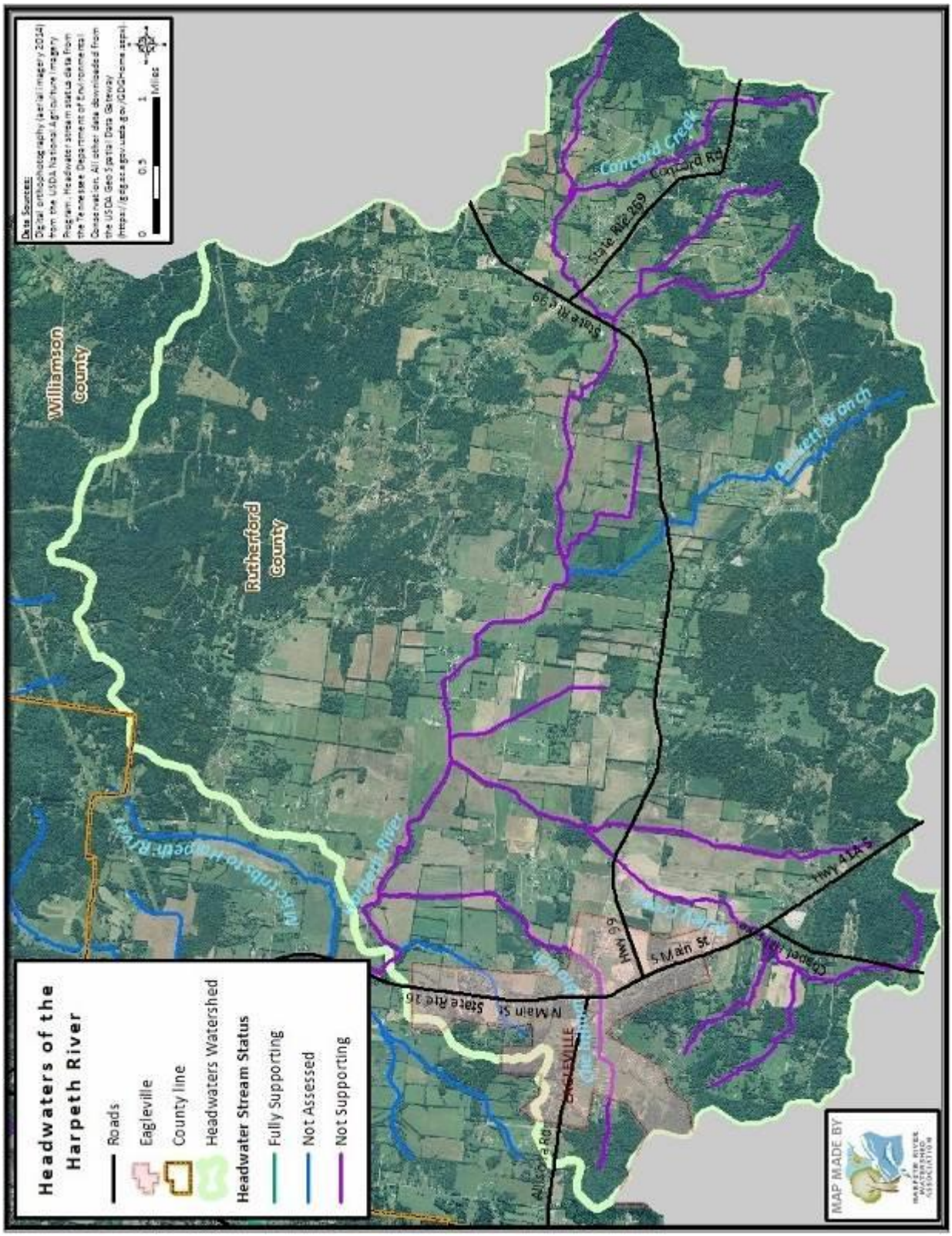

Figure 1. Headwaters of the Harpeth River.

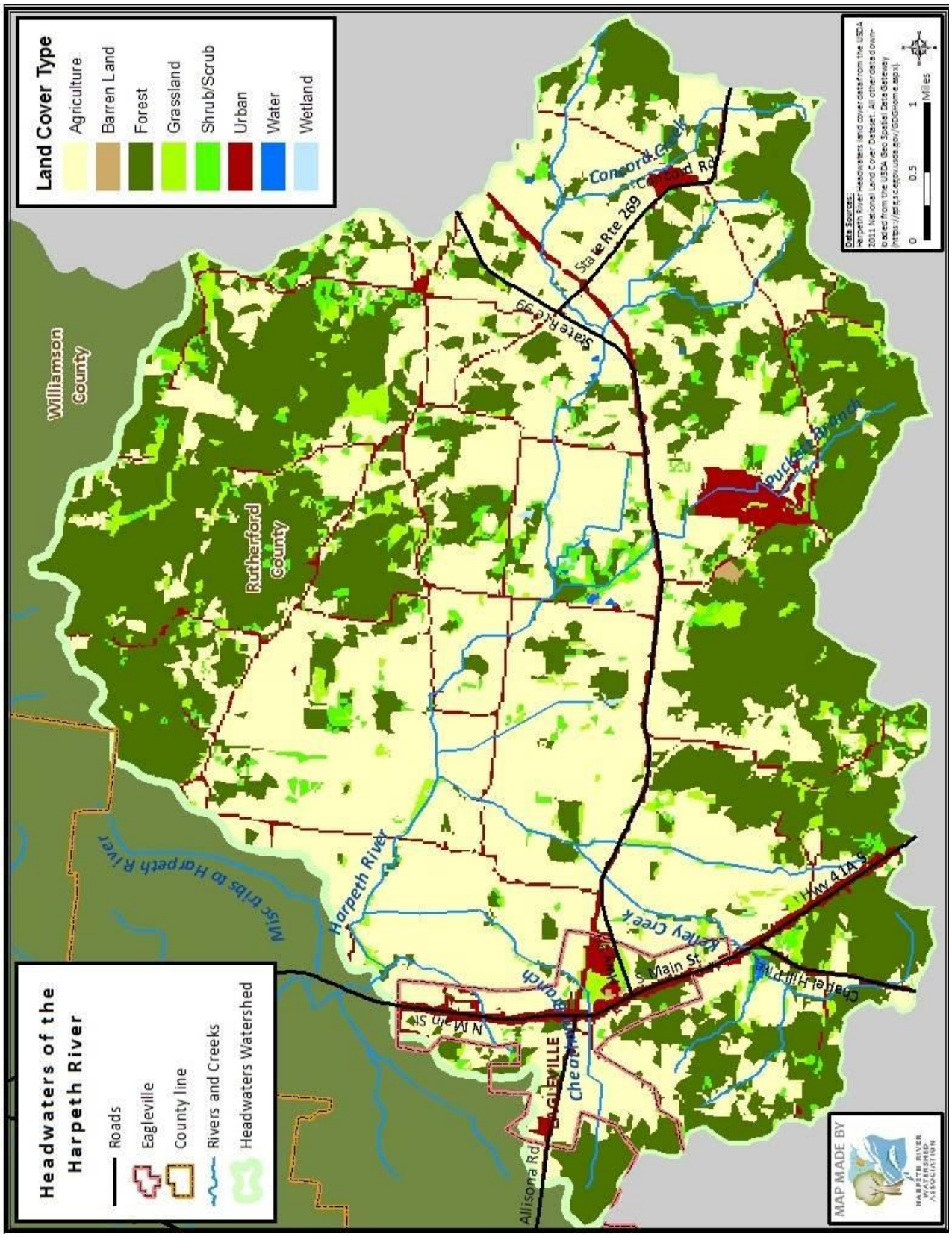

Figure 2. Land cover 2011 in Headwaters of the Harpeth River.

Table 1. Land cover 2011 in the Harpeth River Headwaters.

Land Cover Type	Acres	Square Miles	Percent
Agriculture	11282.27	17.63	49.94%
Barren Land	18.21	0.03	0.08%
Forest	8515.83	13.31	37.69%
Grassland	895.18	1.40	3.96%
Shrub/Scrub	674.06	1.05	2.98%
Urban	1173.08	1.83	5.19%
Water	18.10	0.03	0.08%
Wetland	17.11	0.03	0.08%
TOTAL	22593.82	35.30	100.00%

There are 77 USDA SSURGO soil types in the Harpeth Headwaters, consisting primarily of silty-loam types (34%), silty-clay-loam (22%), and rocky or rock outcrop (43%). The Cheatham Branch flows through largely silty-loam soils interspersed with some silty-clay-loam. Soils in the upper reaches of Kelly Creek consist of rock outcrop or rocky, but the majority flows through silty-clay-loam with some silty-loam mixed in. Soil surveys show that most of the watershed is low gradient with only 4% of the area with slopes greater than 12%.

Implementation History

HRWA has successfully completed five 319 Tennessee Department of Agriculture (TDA) Nonpoint Source (NPS) grants. These grants have resulted in community outreach and education on best management practices, production of watershed plans, completion of stormwater restoration projects, and implementation of numerous stream assessment and restoration projects in both agricultural and suburban settings. As a result of the 319 grant-funded projects, as well as other water resource protection and restoration projects, HRWA has developed strong relationships with many members of the community and local governments.

During Phase 1 of Plan implementation, HRWA utilized TDA-NPS 319 funds awarded in 2007 to plan and carry out restoration projects in the Eagleville area. Stream margins were restored via riparian reforestation and streambank stabilization projects. Multiple agricultural best management practices (BMPs) were installed at local farms, including pipelines and watering systems, heavy use areas, exclusion fencing and dedicated stream access areas.

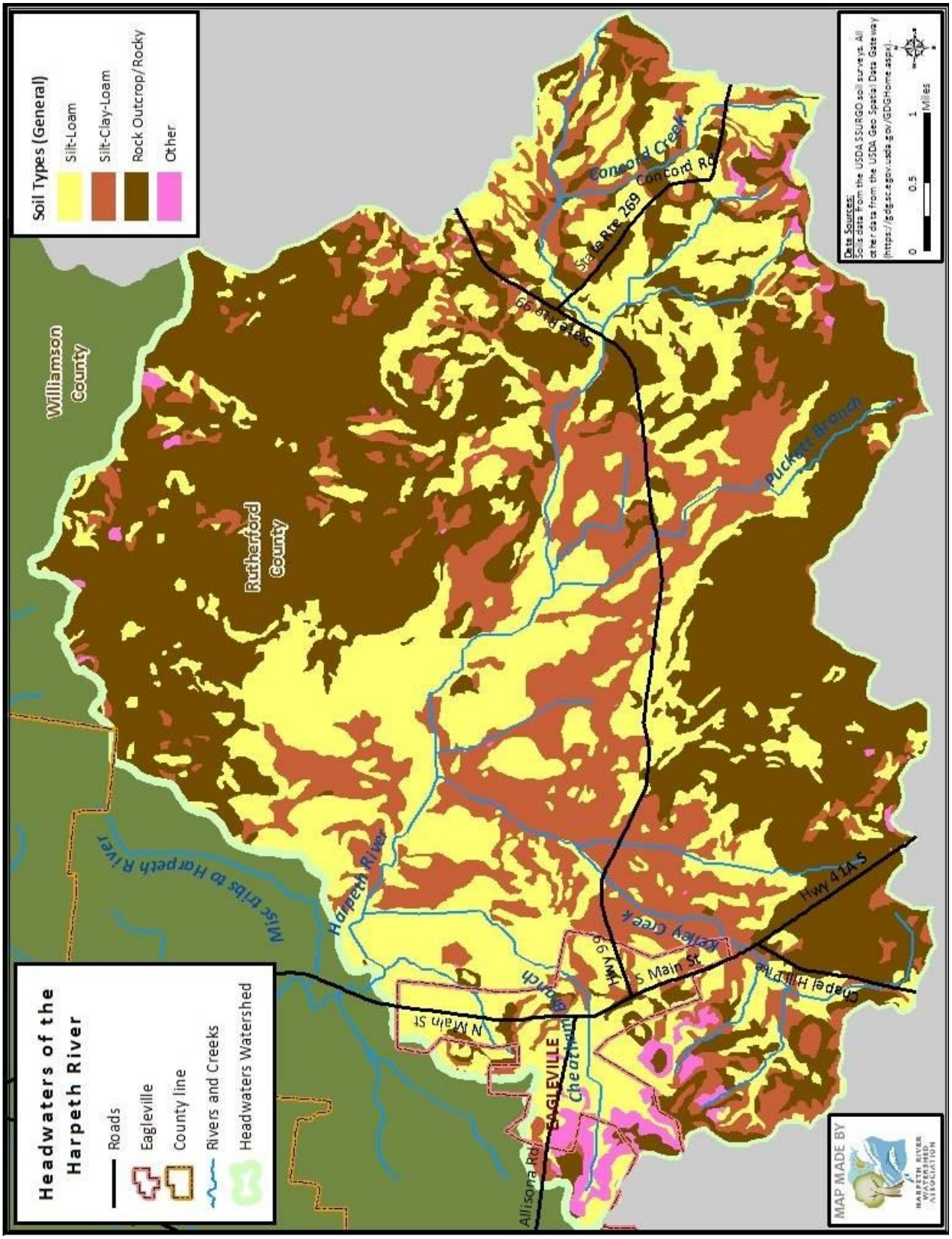

Figure 3. Soils in the Harpeth River Headwaters.

In 2012, HRWA was awarded a 319 grant to carry out Phase II of the Plan. In Phase II, HRWA coordinated agricultural BMP installation at two farms on Headwater streams, including livestock exclusion fencing, heavy-use protection areas, watering facilities, prescribed grazing, streambank stabilization, and riparian vegetation improvements. In terms of education and outreach, HRWA collaborated with the Eagleville COOP on basic do-it-yourself BMPs and with Eagleville High School to assess stream water quality changes due to agricultural BMP projects. HRWA also worked concurrently with Middle Tennessee State University (MTSU) biologists to conduct a microbial source study that found extremely high levels of human-source pathogens in the creeks around Eagleville. As a result of this study, city officials secured a U.S. Department of Agriculture Federal Community Development Block Grant to build a non-discharging sewer system to serve the town and the school. HRWA helped in this endeavor by arranging meetings with key groups, attending hearings, and getting funding commitments from the county school board, Rutherford County, and the State of Tennessee.

In 2014, HRWA was awarded another 319 grant to carry out Phase III of the Plan. Phase III resulted in BMP installations at two more farms in the Headwaters, both adjacent to Concord Creek. In partnership with the USDA and Rutherford County Conservation District, conservation plans were developed and BMPs installed, including exclusion fencing, watering facilities and pipelines, heavy use areas, and a dedicated livestock stream crossing. Additional outreach, education, and BMP promotion activities were included in this grant-funded project.

Water Quality of the Harpeth River Headwaters

TDEC Division of Water Resources has monitored water quality at seven sites in Rutherford County at the headwaters of the Harpeth River including Puckett Branch, Cheatham Branch, Kelley Creek, and Concord Creek. Water quality parameters monitored include ammonia, carbonaceous biochemical oxygen demand, conductivity, dissolved oxygen, *Escherichia coli (E. coli)*, *Enterobacter,* fecal coliform, hardness (Ca + Mg), inorganic nitrogen, kjeldahl nitrogen, organic carbon, pH, total suspended solids, total dissolved solids, turbidity, total phosphorus, soluble phosphorus (orthophosphate), discharge (flow), and water temperature. All publically available data for these sites were downloaded by HRWA from the National Water Quality Monitoring Council's Water Quality Portal. HRWA summarized and analyzed the water quality data using water quality criteria from TDEC and EPA for sub-ecoregion 71i.

Total Maximum Daily Loads (TMDL) were developed by TDEC and EPA for steams in the Harpeth River Watershed from 2002 to 2006. The *E. coli* TMDL from 2004 includes Kelley Creek. The organic enrichment/low dissolved oxygen from 2006 TMDL includes Concord Creek and Kelley Creek. The siltation and habitat alteration TMDL from 2002 includes Concord Creek, Puckett Branch, Cheatham Branch, Kelly Creek and the Harpeth River in the Headwaters.

TDEC and EPA's Fish and Aquatic Life Criteria for Tennessee surface waters include:

- Dissolved Oxygen (DO) – DO shall not be less than 5.0 milligrams per liter (mg/L).
- pH - The pH value shall not fluctuate more than 1.0 unit over a period of 24 hours and shall not be outside the following ranges: 6.0 – 9.0 in wadeable streams and 6.5 – 9.0 in larger rivers, lakes, reservoirs, and wetlands.
- Turbidity, Total Suspended Solids (TSS), or Color - There shall be no turbidity, total suspended solids, or color in such amounts or of such character that will materially affect fish and aquatic life. In wadeable streams, suspended solid levels over time should not be substantially different than conditions found in reference streams.
    - Note: McDaniel Road in Williamson County and Anderson Road in Cheatham County are used as reference sites for TSS and turbidity data comparisons. At the Anderson Road site, averaged TSS was 11.867 mg/L and turbidity was 7.89 Nephelometric Turbidity Units (NTU). At McDaniel Road, averaged TSS was 14.07 mg/L and turbidity was 10.96 NTU.
- Temperature - The maximum water temperature change shall not exceed 3 degrees Celsius (°C) relative to an upstream control point. The temperature of the water shall not exceed 30.5°C and the maximum rate of change shall not exceed 2°C per hour. There shall be no abnormal temperature changes that may affect aquatic life unless caused by natural conditions.
- Nutrients - The waters shall not contain nutrients in concentrations that stimulate aquatic plant and/or algae growth to the extent that aquatic habitat is substantially reduced and/or the biological integrity fails to meet regional goals. Additionally, the quality of downstream waters shall not be detrimentally affected.
    - For sub-ecoregion 71i, EPA recommends numeric nutrient criteria of 755 micrograms per liter (µg/L) for total nitrogen and 160 µg/L total phosphorus.
- Coliform Bacteria - The *E. coli* group concentration shall not exceed 630 colony forming units per 100mL (CFU/100mL) as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of less than 30 consecutive days. The *E. coli* group concentration in any individual sample shall not exceed 2,880 CFU/100mL.
- Discharge – Stream flows shall support the fish and aquatic life criteria.

TDEC and EPA's Recreation Criteria for Tennessee surface waters include:

- DO - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.
- Coliform Bacteria- The *E. coli* group concentration shall not exceed 126 CFU/100mL, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days. The *E. coli* group concentration in any individual sample taken from any other waterbody shall not exceed 941 CFU/100mL. Additionally, the concentration of the E. coli group in any individual sample

taken from a lake, reservoir, State Scenic River, Exceptional Tennessee Water or ONRW (0400- 40-03-.06) shall not exceed 487 colony forming units per 100mL.

- pH, TSS, Turbidity, Water temperature, Nutrients, and Discharge match criteria stated above for use of fish and aquatic life.

Harpeth River

According to TDEC's Year 2016 303(d) List draft, the Harpeth River in the Headwaters, extending 7.39 miles, is designated as impaired due to low dissolved oxygen, sedimentation/siltation, *E. coli*, and alteration in stream-side or littoral vegetative covers. TDEC monitoring data are available for three sites on the Harpeth River: at College Grove Road; Swamp Road; and Highway 41-A.

College Grove Road

The Harpeth River near College Grove Road was monitored by TDEC once in early April 2012 at river mile 112 (Table 2). The drainage area of this section is 41.45 acres. Water quality parameters monitored include DO, NOx, Kjeldahl nitrogen, total phosphorus, pH, water temperature, and TDS. Based on one sampling event, all measurements met water quality standards and/or recommendations (Table 3).

- DO: The 11.52 mg/L measurement met water quality standards.
- pH: The 8.72 measurement met water quality standards.
- Nitrogen: Total nitrogen concentration of 550 μg/L met EPA criteria.
- Phosphorus: The 89 μg/L concentration was below recommended limits.
- Solids: TDS measured 200 mg/L.
- Water Temperature: The 22.75°C measurement met water quality standards.

Swamp Road

Swamp Road site was regularly monitored by TDEC three times every 5 years from 2001 to 2012 at river mile 117.30 (Table 2). The site's drainage area is 5.35 acres. Water quality data at Swamp Road are available for the following parameters: DO, *E. Coli*, NOx, Kjeldahl nitrogen, soluble reactive phosphorus (orthophosphate), total phosphorus, pH, water temperature, TSS, turbidity, and discharge (Table 3).

- DO: All measurements met water quality standards, ranging from 5.38 mg/L to 14.7 mg/L and averaging 8.43 mg/L.
- pH: Measurements ranged from 6.88 to 8.28 and averaged 7.55. All readings met standards.
- Nitrogen: Total nitrogen ranged from 130 μg/L to 950 μg/L, with an average of 498 μg/L. One reading from 2002 (950 μg/L) exceeded EPA recommended limits.
- Phosphorus: The lone total phosphorus measuring 31 μg/L met criteria recommended by EPA.

- *E. coli*: Concentrations ranged from 25 to 2400 CFU/100mL, with an average of 922.78 CFU/100mL. During three sampling events in 2001 and 2002, *E. Coli* exceeded the recreational use standard.
- Solids and Turbidity: TSS readings ranged from 10 to 40 mg/L and the average was 17.6 mg/L. Turbidity measurements ranged from 1.4 - 65.4 NTU with an average of 17.08 NTU. Averaged turbidity and TSS readings at Swamp Road were much higher than reference sites.
- Water Temperature: The 21 measurements ranged from 8.39◦C to 23.59◦C, and averaged 16.6◦C. All measurements met water quality standards.
- Discharge: Measurements ranged from 0.54 to 91.57 cfs and averaged 27.19 cfs.

Table 2. Number of Water Quality Samples for Harpeth River Headwaters streams.

	Harpeth River, College Grove Rd	Harpeth River, Swamp Road	Harpeth River, Highway 41-A	Puckett Branch	Concord Creek	Cheatham Branch	Kelley Creek
Dissolved Oxygen	1	20	10	7	14	4	8
Water Temp.	1	21	10	7	14	4	8
pH	1	20	10	7	14	4	8
E. Coli	0	9	14	7	18	4	9
NOx	1	12	13	7	19	4	8
Kjeldahl N	1	10	13	7	18	4	0
Total Nitrogen	1	9	13	7	18	4	0
Total Phosphorus	1	1	13	0	0	4	9
Orthophosphates	0	11	0	7	19	4	0
TSS	0	20	13	7	18	4	8
TDS	1	0	0	0	0	0	0
Turbidity	0	9	11	7	18	4	8
Discharge	0	8	0	7	6	4	0

Table 3. Water quality data for Harpeth River Headwater streams.

Monitoring Parameter	Units	Harpeth River, College GroveRd (2829)	Harpeth River, Swamp Road (2831)	Harpeth River, Highway 41-A (2830)	Puckett Branch	Concord Creek	Cheatham Branch	Kelley Creek
Discharge (flow): Low	cfs	ND	0.54	ND	0.01	0.01	0.01	ND
Discharge (flow): High	cfs	ND	91.57	ND	2.57	0.29	1.74	ND
Discharge (flow): Average	cfs	ND	27.20	ND	0.96	0.15	0.50	ND
Dissolved Oxygen: Low	mg/L	11.52	5.38	2.79	7.01	3.12	9.39	5.40
Dissolved Oxygen: High	mg/L	11.52	14.70	10.20	10.77	9.74	12.83	10.94
Dissolved Oxygen: Average	mg/L	11.52	8.43	7.64	9.087	7.83	11.18	8.25
E. Coli: Low	cfu/100mL	ND	25.00	40.00	20.00	18.00	35.00	16.00
E. Coli: High	cfu/100mL	ND	2400	2420	820	2400	270	2420
E. Coli: Average	cfu/100mL	ND	992.78	458.00	246.00	353.50	148.75	434.89
Nitrogen, Total: Low	µg/L	550.00	130.00	590.00	190.00	130.00	330.00	ND
Nitrogen, Total: High	µg/L	550.00	950.00	3180.00	380.00	590.00	2420.00	ND
Nitrogen, Total: Average	µg/L	550.00	497.78	1310.00	280.00	325.00	992.50	ND
Nitrogen, NOx: Low	µg/L	230.00	30.00	580.00	90.00	30.00	190.00	0.00
Nitrogen, NOx: High	µg/L	230.00	610.00	1500.00	280.00	480.00	2320.00	590.00
Nitrogen, NOx: Average	µg/L	230.00	332.50	856.15	167.10	164.20	882.50	268.00
pH: Low	units	8.72	6.88	7.22	7.29	7.17	7.68	7.45
pH: High	units	8.72	8.28	7.95	7.84	8.56	7.96	7.96
pH: Average	units	8.72	7.55	7.58	7.54	7.73	7.805	7.71
Phosphorous, Total: Low	µg/L	89.00	31.00	64.00	ND	ND	ND	50.00
Phosphorous, Total: High	µg/L	89.00	31.00	350.00	ND	ND	ND	590.00
Phosphorous, Total: Average	µg/L	89.00	31.00	125.00	ND	ND	ND	187.20
Phosphorous, Soluble: Low	µg/L	ND	4.00	ND	4.00	4.00	4.00	ND
Phosphorous, Soluble: High	µg/L	ND	187.00	ND	20.00	560.00	150.00	ND
Phosphorous, Soluble: Avg.	µg/L	ND	68.70	ND	9.57	82.40	78.00	ND
Solids, Suspended, Total: Low	mg/L	ND	10	0	10	10	10	0
Solids, Suspended, Total: High	mg/L	ND	40	64	21	22	11	32
Solids, Suspended, Total: Avg.	mg/L	ND	17.60	5.77	13.71	11.06	10.25	4.00
Solids, Dissolved, Total: Low	mg/L	200	ND	ND	ND	ND	ND	ND
Solids, Dissolved, Total: High	mg/L	200	ND	ND	ND	ND	ND	ND
Solids, Dissolved, Total: Avg.	mg/L	200	ND	ND	ND	ND	ND	ND
Turbidity: Low	NTU	ND	1.4	1.28	3.71	1.69	2.65	1.99
Turbidity: High	NTU	ND	65.4	49.5	37.3	51.5	5.98	50.00
Turbidity: Average	NTU	ND	17.08	9.46	18.24	10.08	4.98	13.03
Water Temperature: Low	^{o}C	22.75	8.39	8.44	9.46	7.57	10.05	7.30
Water Temperature: High	^{o}C	22.75	23.59	27.05	15.09	20.61	15.49	22.15
Water Temperature: Average	^{o}C	22.75	16.66	15.97	12.17	11.94	13.63	14.21

**Total N was calculated by HRWA staff by combining inorganic nitrogen and Kjeldahl nitrogen.*

*** All pH readings fell within 6.0 to 9.0 range required by EPA for all Tennessee surface waters.*

**** ND means no data.*

Highway 41-A

TDEC monitored the river along Highway 41-A at river mile 114.50 from 2012 to 2013. The site's drainage area is 25.80 acres. Water quality parameters monitored by TDEC at Highway 41-A included DO, *E. Coli*, NOx, Kjeldahl nitrogen, total phosphorus, pH, water temperature, TSS, and turbidity (Table 3). Individual parameters were measured from 10 to 26 times (Table 2).

- DO: Measurements ranged from 2.79 to 10.2 mg/, with an average of 7.64 mg/L. One measurement was below the standard of 5 mg/L.
- pH: readings ranged from 7.22 to 7.95 and averaged 7.58. All pH readings fell within the range of 6.0 to 9.0, meeting water quality standards.
- Nitrogen: Total nitrogen ranged from 590 μg/L to 3180 μg/L and averaged 1310 μg/L. 12 Over 90% of readings (12) exceeded EPA recommended limits.
- Phosphorus: Total phosphorus ranged from 125 μg/L to 650 μg/L, with an average of 350 μg/L. EPA recommended limits were exceeded during two sampling events in 2012.
- *E. coli*: Concentrations ranged from 40 CFU/100mL to 2400 CFU/100mL, with an average of 458 CFU/100mL. Two samples with high concentrations in 2012 and 2013 did not meet standards for recreational use.
- Solids and Turbidity: TSS ranged from 0 to 64 mg/L, with an average of 5.76 mg/L. Turbidity ranged from 1.28 to 49.5 NTU, with an average of 9.46 NTU. Averaged TSS at Highway 41-A was lower than both reference sites. Averaged turbidity was higher than the reference site at Anderson Road (7.89 NTU), but not at McDaniel's Road.
- Water Temperature: Water temperature ranged from 8.44 to 27.05°C, with an average of 15.97°C. All measurements met EPA requirements for fish and aquatic life.

Concord Creek (TN05130204018_0200)

According to TDEC's Year 2016 303(d) List draft, 13.65 miles/acres of Concord Creek are impaired. TDEC lists impairment causes as alteration in stream-side or littoral vegetative cover and loss of biological integrity due to sedimentation/siltation. TDEC monitoring data were collected near Ditch Lane 50' at river mile 3.10 in 2001 and 2002 (Table 2). Water quality parameters monitored by TDEC included DO, *E. Coli*, inorganic nitrogen, Kjeldahl nitrogen, orthophosphate, pH, water temperature, TSS, turbidity, and discharge (Table 3).

- DO: The 14 measurements ranged from 3.12 mg/L to 9.74 mg/L, with an average of 7.83 mg/L. The DO concentration of 3.12 mg/L recorded in June 2002 was below the standard of 5.0 mg/L to support fish and wildlife. Note that stream flow was very low (0.01 cfs) and water temperature high (20.61°C) during the June 2002 sample event.
- pH: The 14 pH measurements ranged from 7.17 to 8.56, with an average of 7.73. All measurements met water quality standards.
- Nitrogen: Total nitrogen ranged from 130 μg/L to 590 μg/L, averaged 325 μg/L, and all levels were below EPA recommended limits.

- *E. coli*: The 18 measurements ranged from 18 to 2400 CFU/100mL, with an average of 353.5 CFU/mL. The March 2002 measurement was extremely high (2400 CFU/100mL) and did not meet EPA recreational use standards.
- Solids and Turbidity: TSS ranged from 10 to 22 mg/L, with an average of 11.06 mg/L. Turbidity ranged from 1.69 to 51.5 NTU, with an average of 10.08 NTU. Averaged TSS at this site was slightly below the average at the McDaniel and Anderson Road reference sites. Average turbidity was higher than Anderson Road, but lower than McDaniel Road.
- Water Temperature: Readings ranged from 7.57°C to 20.61°C, with an average of 11.94°C, meeting water quality standards.

Puckett Branch (TN05130204018_0210)

The Puckett Branch flows through Champions Run Golf Course and is considered an unassessed waterbody. TDEC monitored one site off of North Lane Road seven times from 2001 to 2002 (Table 2). Water quality parameters monitored include DO, *E. Coli*, NOx, Kjeldahl nitrogen, orthophosphate, water temperature, TSS, turbidity, and discharge (Table 3).

- DO: Measurements ranged from 7.01 mg/L to 10.77 mg/L, averaged 9.09 mg/L, and met water quality standards.
- pH: Measurements ranged from 7.29 to 7.84 and averaged 7.54. All measurements met water quality criteria.
- Nitrogen: Total nitrogen concentrations ranged from 190 µg/L to 380 µg/L, averaged 280 µg/L, and were all below recommended limits.
- *E. coli*: Concentrations ranged from 20 CFU/100mL to 820 CFU/100mL, with an average of 246 CFU/100mL. All E. coli levels met individual sample standards for both recreation and fish and aquatic use.
- Solids and Turbidity: TSS ranged from 10 to 21 mg/L, with an average of 13.71 mg/L. Turbidity ranged from 3.71 to 37.3 NTU, with an average of 18.24 mg/L. Averaged TSS was lower than the McDaniel Road reference site, but higher than Anderson Road. Averaged turbidity was much higher than both reference sites. Puckett Branch had the highest averaged turbidity readings among all Headwaters streams.
- Discharge: Stream flow ranged from 0.01 cfs to 2.57 cfs, with an average of 0.96 cfs.
- Water Temperature: Measurements ranged from 9.46°C to 15.09°C , averaged 12.17°C, and all met water quality standards.

Kelley Creek (TN05130204018_0300)

According to TDEC Year 2016 303(d) List draft, Kelley Creek is impaired. Causes include alteration in stream-side or littoral vegetative cover, loss of biological integrity due to siltation, and *Escherichia coli*. Water quality data were collected by TDEC at river mile 0.30 off of highway 99 in 2012 and 2013 (Table 2). Water quality parameters measured by TDEC include DO, *E. coli*,

total nitrogen, pH, water temperature, TSS, turbidity, and total phosphorus (Table 3). The drainage area for this stream section is 3.03 acres.

- DO: The 8 measurements ranged from 5.4 to 10.94 mg/L, averaged 8.25 mg/L, and all met water quality standards.
- pH: ranged from 7.45 to 7.96, with an average of 7.71. All measurements met water quality standards.
- Nitrogen: NOx ranged from 0 μg/L to 590 μg/L, and averaged 268 μg/L.
- Phosphorus: Total phosphorus ranged from 50μg/L to 590μg/L and averaged 187.2 μg/L. High concentrations during two sampling events in 2012 and 2013 were well above EPA recommended limits and contributed to the high average.
- *E. coli*: Concentrations ranged from 16 CFU/mL to >2420 CFU/mL, with an average of 434.89 CFU/100mL. The >2420 CFU/mL value from 2012 did not meet the individual sample standards for recreational use.
- Solids and Turbidity: TSS ranged from 0 to 32 mg/L, with an average of 4.0 mg/L. Turbidity ranged from 1.99 to 50 NTU, with an average of 13.025 NTU. Averaged TSS was much lower than reference sites, while averaged turbidity was higher.
- Water Temperature: Measurements ranged from 7.3°C to 22.15°C, averaged 14.21°C, and all met water quality standards.

Cheatham Branch (TN05130204018_0400)

The Cheatham Branch is considered impaired by TDEC due to alteration in stream-side or littoral vegetative cover and loss of biological integrity due to siltation. Water quality data were collected by TDEC four times at River Road (river mile 0.10) in 2001 and 2002 (Table 2). Water quality parameters monitored by TDEC include DO, *E. Coli*, inorganic nitrogen, Kjeldahl nitrogen, soluble phosphorus, pH, water temperature, TSS, turbidity, and discharge (Table 3).

- DO: DO ranged from 9.39 to 12.83 mg/L, averaged of 11.18 mg/L, and consistently met water quality standards.
- pH: Measurements ranged from 7.68 to 7.96, averaged 7.805, and all met water quality standards.
- Nitrogen: Total nitrogen concentrations ranged from 330 μg/L to 2,420 μg/L and averaged 992.50 μg/L. Only one of the four measurements exceeded EPA recommended limits, but was so high that it caused the average to exceed limits.
- *E. coli*: Concentrations ranged from 35 to 270 CFU/100mL, averaged of 148.75 CFU/100mL, and met standards for individual samples.
- Solids and Turbidity: TSS varied little, ranging from 10 to 11 mg/L and with an average of 10.25 mg/L. Turbidity ranged from 2.65 to 5.98 NTU, with an average of 4.98 NTU. Averaged TSS and turbidity were less than those of reference sites.
- Discharge: Flow ranged from 0.01 to 1.74 cfs, with an average of 0.4975 cfs.

- Water Temperature: Measurements ranged from 10.05◦C to 15.49◦C, averaged 13.63 ◦C, and met water quality standards.

1. Identification of Causes and Sources (or Groupings)

The Tennessee Department of Environment and Conservation (TDEC) 303(d) List includes causes and sources of impairment specific to individual Headwater streams. The Headwater streams are regularly surveyed by the Rutherford County Stormwater Department (RCSD) using the Maryland Department of Natural Resources Stream Corridor Assessment survey protocols (2001). The most recent stream corridor assessment data from RCSD were collected in 2012. In addition, remote assessments of Headwater stream riparian buffer vegetation and channel erosion were conducted by HRWA using digital orthophotography from the 2014 USDA National Agriculture Imagery Program. Stream riparian buffer vegetation was considered "poor" in remote assessments if stream margins had few or no trees. TDEC, RCSD, and HRWA information and assessment data are presented for Headwater streams in the following section.

Concord Creek (TN13204018-0200)

All 14 miles of Concord Creek and associated tributaries are identified as impaired by TDEC and on the state's 303(d) list. The causes and sources of impairment include:

- Sedimentation/siltation due to grazing in riparian or shoreline zones.
- Sedimentation/siltation due to specialty crop production
- Alteration in stream-side or littoral vegetative covers due to grazing in riparian or shoreline zones.
- Alteration in stream-side or littoral vegetative covers due to specialty crop production.
- Habitat impairment.

TDEC's notes state that sod farming is the specialty crop polluting Concord Creek. Stream assessment surveys by RCSD show 35 pipe outfalls and one channel alteration in the Concord Creek Watershed (Figure 4, Table 4). Based on aerial imagery analyses, the riparian buffer vegetation is considered poor in nearly 52,000 feet of stream margins and about 5,800 feet of stream channel suffer from erosion.

Puckett Branch (TN05130204018_0210)

Puckett Branch is a 3.3-mile tributary of Concord Creek that remains unassessed by TDEC. Stream assessment surveys by RCSD show 8 pipe outfalls (Figure 4, Table 4). Based on aerial imagery analyses, riparian buffer vegetation is considered poor in nearly 10,000 feet of stream margins.

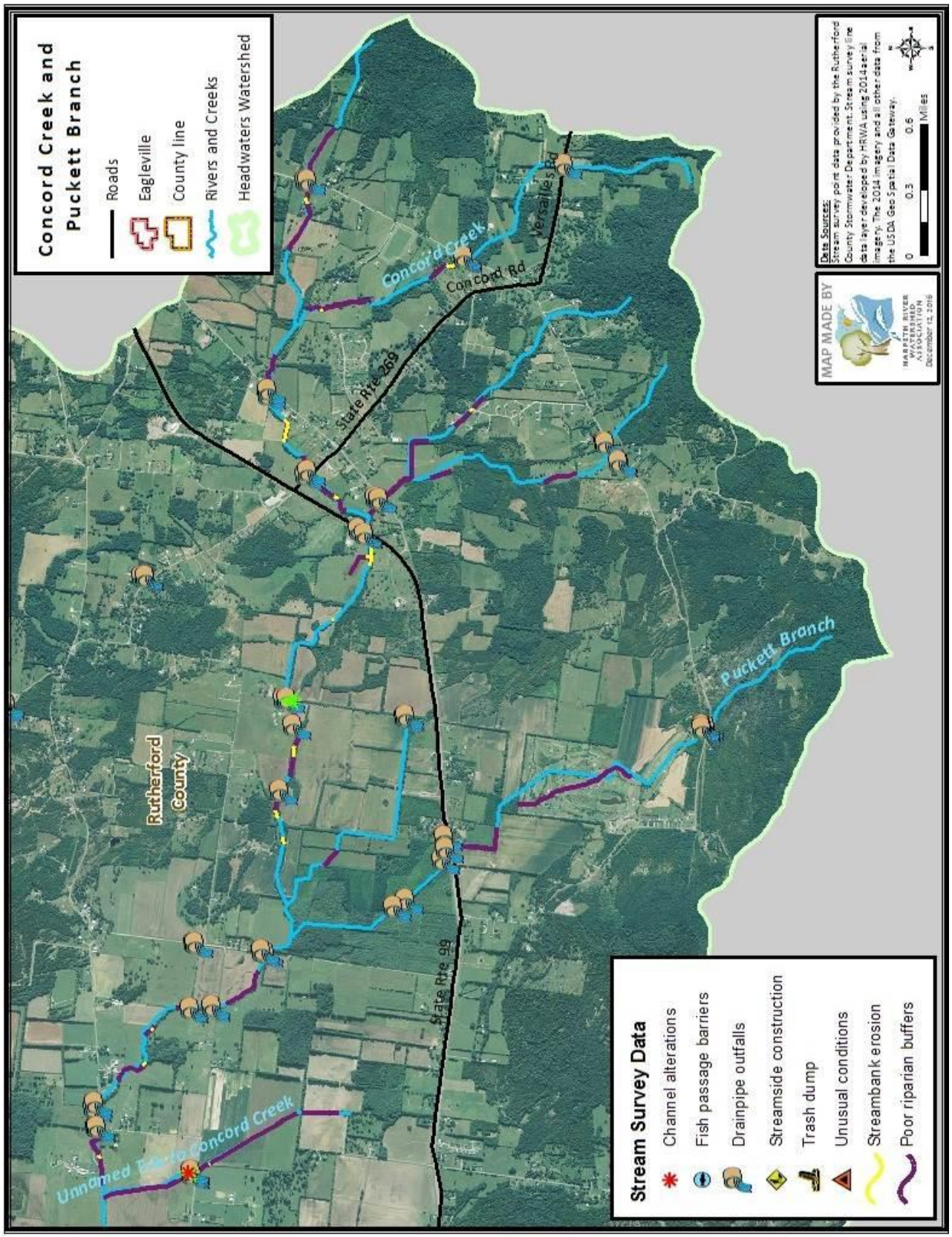

Figure 4. Stream assessment results for Concord Creek and Puckett Branch

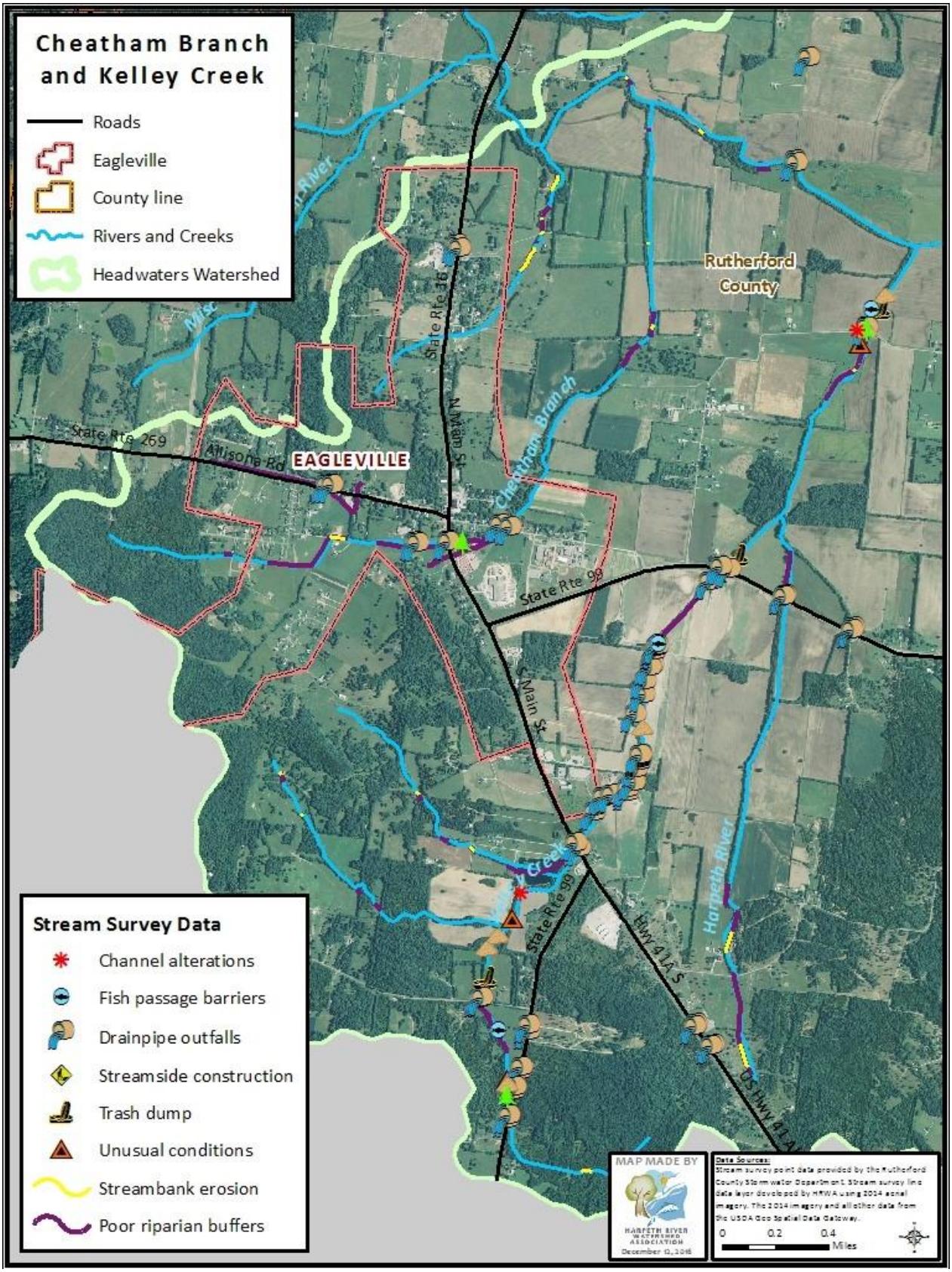

Figure 5. Stream assessment results for Cheatham Branch and Kelley Creek.

Table 4. Stream corridor assessment results for Headwater streams.

Stream Name	Degraded Buffer (feet)	Channel Erosion (feet)	Pipe Outfalls	Fish Passage Barriers	Channel Alterations	Trash Dump
Cheatham Branch	20,508	610	8	0	0	0
Kelly Creek	14,812	2,172	39	3	1	2
Concord Creek	51,876	5,798	35	0	1	0
Puckett Branch	9,854	0	8	0	0	0
Harpeth River	12,269	1,796	6	1	1	1
Unnamed Harpeth Tributary	5,910	1,966	0	0	0	0
TOTAL	115,229	12,342	96	4	3	3

**Degraded buffers and channel erosion determined by HRWA using 2014 aerial imagery and 2012 Rutherford County Stormwater (RCS) data. All other data from RCSD 2012 surveys.*

Harpeth River (TN05130204018_3000)

The entire 5.3 miles of Harpeth River main channel in the Headwaters is identified as impaired by TDEC and on the state's 303(d) list. The causes and sources of impairment include:

- Escherichia coli due to grazing in riparian or shoreline zones.
- Alteration in stream-side or littoral vegetative covers due to grazing in riparian or shoreline zones.
- Low dissolved oxygen due to grazing in riparian or shoreline zones.
- Sedimentation/siltation due to grazing in riparian or shoreline zones.
- Habitat impairment.

Stream assessment surveys by RCSD show 6 pipe outfalls, one fish passage barrier, one channel alteration, and one trash dump in the Harpeth (Table 4, Figure 5). Based on aerial imagery analyses, riparian buffer vegetation is considered poor in over 12,000 feet of stream margins and erosion is occurring in about 1,800 feet of stream channel.

Unnamed Tributary to Harpeth River (TN05130204018_0999)

There is a short 1.3-mile unnamed tributary of the Harpeth River on the north side of Eagleville that has not been assessed by TDEC. There are no RCSD stream corridor assessment data for this tributary, but aerial imagery analyses estimate approximately 5,900 feet of poor riparian vegetation buffers and nearly 2,000 feet of channel erosion (Table 4, Figure 5).

Kelly Creek (TN05130204018-0300)

The various branches of Kelly Creek total nearly six miles of channel length, all of which are listed as not supporting by TDEC and on the state's 303(d) list. The causes and sources of impairment include:

- Escherichia coli due to grazing in riparian or shoreline zones.
- Alteration in stream-side or littoral vegetative covers due to specialty crop production.
- Sedimentation/siltation due to specialty crop production.
- Habitat impairment.

Additional sources that should be considered include a large sod farm operation that may in fact be a major contributor of sediment and thus nutrients to the Kelly Creek system, even though the operator is very conscious of fertilizer loss. TDEC classifies the impairment in Category 4a.

Stream assessment surveys by RCSD show that Kelly Creek has 39 pipe outfalls, which is more than any other Headwater stream (Table 4, Figure 5). The high number of outfalls probably contribute to the three fish passage barriers documented in the creek. In addition, one channel alteration and twos trash dumps were found in Kelly Creek. Based on aerial imagery analyses, the riparian vegetation buffer is considered poor in nearly 15,000 feet of stream margins and erosion is occurring in nearly 2,200 feet of stream channel.

Cheatham Branch (TN05130204018-0500)

All 3.4 miles of the Cheatham Branch are considered impaired by TDEC and on the State's 303(d) list. The causes and sources of impairment include:

- Sedimentation/siltation due to grazing in riparian or shoreline zones.
- Alteration in stream-side or littoral vegetative covers due to grazing in riparian or shoreline zones.
- Habitat impairment.

Based on conversations with community partners and subsequent bacteriological monitoring conducted by MTSU, malfunctioning septic systems are a likely source of pollution to Cheatham Branch.

Stream assessment surveys by RCSD show that Cheatham Branch has 8 pipe outfalls (Table 4, Figure 5). Based on aerial imagery analyses, the riparian buffer vegetation is considered poor in over 20,000 feet of stream margins and erosion is occurring in roughly 600 feet of stream channel.

2. Description of Nonpoint Source Management Measures (BMPs)

Throughout the last 15 years, outreach, education, monitoring, and restoration efforts by HRWA and partners have resulted in the establishment of strong relationships with community leaders, natural resource management professionals, agricultural producers, businesses, and other community members in the Headwaters region. These relationships are the key to continued implementation of nonpoint source management measures that effectively restore Headwaters streams. Ultimately, collaborative restoration efforts that improve Headwater streams' water quality and stream ecosystem integrity will result in removal of these streams from the 303(d) list.

The primary nonpoint source management measures to be implemented by this Plan include riparian buffer restoration, streambank stabilization, urban and residential stormwater mitigation, and agricultural BMP adoption. In addition, septic system maintenance and upgrade measures are needed to improve and protect water quality. The following section elaborates on these measures.

Riparian Buffer Restoration

Riparian zone degradation has occurred in all Headwaters streams. Over 115,000 feet of stream margins in Headwater streams are estimate to be in poor condition (Table 4). Factors contributing to degradation include vegetation loss and stream margin erosion, which are caused primarily by humans and livestock. Climate change can also exacerbate these problems. To effectively restore the riparian zone, management measures need to address both the problem and the source. Collaborations among diverse watershed partnerships will facilitate implementation of nonpoint source pollution management measures. HRWA will work with NRCS, TDA, University of Tennessee Extension (UT Extension), private native plant nurseries, local landscaping companies, Eagleville Public Schools, and community volunteers to plan and implement riparian buffer restoration projects.

Exclusion fencing and dedicated livestock access points and crossings will be installed to reduce livestock access to and degradation of riparian zones. Exclusion fencing will be installed as far as possible from surface waters, at a minimum of 35 feet from the water's edge, but ideally 100 feet or more. Dedicated livestock access points and crossings will include installation of heavy use area BMPs, such as stone or concrete underfootings, to provide stable access that prevents erosion and reduces risk of livestock injury. In cases where livestock do not have dedicated access to the stream, alternative water supplies will be installed. Alternative water supplies typically consist of a pipeline that conveys water from a water source, whether well, municipal, or surface water, to a waterer for livestock outside the exclusion zone. Waterer locations also include installation of a heavy use area to reduce erosion. After livestock are excluded from the riparian zone and alternative water supply provided, riparian buffer restoration can occur.

Outreach and education efforts directed toward land owners are needed to reduce human impacts. Riparian property owners will be encouraged to establish or maintain a streamside buffer of diverse native trees, shrubs, and herbaceous plants by creating “no mow” areas and implementing reforestation projects. United States Department of Agriculture Natural Resource Conservation Service (NRCS) recommendations for a minimum 35-foot buffer along rivers and streams will be used, but 100-foot or greater buffers will be encouraged because research shows much greater benefits to the stream ecosystem (Wenger, 1999). However, there may be instances where the riparian buffer is less than 35 feet due to site-specific circumstances or land owner objections based on loss of land for crops and grazing or other reasons.

Revegetating riparian zones will be accomplished through active planting reforestation projects and/or natural recolonization and growth. The active planting approach is preferred because it accelerates the restoration process in terms of riparian buffer enhancements and stabilizing soils to reduce and prevent erosion. Furthermore, active planting with a variety of native species can produce desirable diversity that benefits native organisms while reducing invasive species impacts.

Exclusion and reforestation efforts are expected to address erosion in riparian areas extending from the upper streambank away from the stream. Any severe erosion in riparian areas apart from the stream channel will be corrected with methods similar to those used for streambank stabilization, such as grading and installation of seeded natural fiber blankets.

Streambank Stabilization

Streambank erosion is a serious problem in the Headwaters Watershed, contributing excessive sediments and nutrients to creeks and the Harpeth River. Survey estimates show erosion occurring along more than 12,000 linear feet of Headwater streambanks. A variety of factors contribute to streambank erosion, including vegetation removal by livestock and humans, stream access by livestock and humans, obstructions in the stream channel (including natural obstructions), poorly sized or placed culverts, and hydrological changes resulting in flashier stream flows. Most problems can be corrected through BMP installation, but hydrological issues may require more extensive remediation involving upstream urban and agricultural BMPs. Partnerships for streambank stabilization projects will include HRWA, NRCS, TDA, UT Extension, community volunteers, and local businesses, such as landscaping companies and engineering firms.

Similar to riparian buffer restoration, approaches to streambank stabilization include treating the problem and the source. To treat the source, livestock access to streambanks will be eliminated or reduced via installation of exclusion fencing, alternative watering facilities and associated pipelines, and dedicated stream crossings. Any locations where human access

causes erosion will be rectified through funneling traffic to installed erosion-resistant access structures.

Approaches to streambank stabilization will vary depending on individual circumstances, such as erosion severity, bank height, bank slopes, bank soil types, substrate types, water depths, flow velocities, bank seepage, nearby tributaries, surface runoff, channel bends, and vegetative cover in eroding areas. Bio-erosion control techniques (soft engineering) will be utilized to correct erosion, including removal of in-stream obstacles, placement of in-stream structures to deflect flow energy, tree revetment installations, streambank regrading or terracing, coir bundle installation, appropriately sized rock placement at the toe, natural fiber blankets on the upper bank, and revegetation. Most streambank erosion areas are expected to require a mix of these techniques.

Urban and Residential Stormwater Mitigation

Stormwater runoff is produced when precipitation on to impervious surfaces (e.g., paved streets, parking lots, and rooftops) and saturated soils accumulates and flows over land, instead of infiltrating into the ground. As the runoff flows over the land or impervious surfaces, it picks up pollutants that can adversely affect water quality. Sediments from fields and roads, nutrients in lawn and agricultural fertilizers, leaked automotive fluids, and animal wastes are among the many nonpoint source pollutants that stormwater runoff carries into surface waters. In addition, unnaturally high volumes of stormwater discharged into creeks and rivers can cause flooding, channel scouring, and in-stream habitat degradation.

The negative impacts of stormwater runoff in the Headwaters Watershed will be mitigated through a combination of outreach and education and the installation of physical BMPs. Mitigation will be planned and implemented via collaborations between HRWA, the City of Eagleville, Rutherford County, community volunteers, and local businesses, such as landscaping companies and engineering firms.

Outreach and education efforts will be implemented to increase public awareness about stormwater runoff and how it degrades streams and other surface waters. Information and resources regarding behaviors and practices that can be adopted to reduce the negative impacts of stormwater runoff will be provided to watershed residents. Examples of behaviors and practices include establishing no-mow zones in stream margins, washing vehicles on lawns, cleaning up after pets, allowing grass to grow longer, and disposing of oil and hazardous waste at appropriate facilities.

Stormwater BMPs will be installed to filter pollutants in the runoff, reduce overland flow velocities, and encourage infiltration of stormwater into the ground. A variety of control structures and techniques will be utilized to mitigate stormwater runoff impacts, including rain

barrels, rain gardens, infiltration basins, retention and detention ponds, oil-grit separators, grassy swales, pervious pavers, and terrain grading. Depending on the project location and available resources, a combination of BMPs may be installed to achieve the best results.

Agricultural BMP Adoption

Considering that agriculture accounts for approximately 50% of the watershed's land cover, nonpoint source pollution impacts to Headwaters streams undoubtedly stem from agricultural activity. In addition to agricultural BMPs described in previous sections, producers will be educated on and encouraged to adopt or install other management measures, including development and adoption of nutrient management plans, installation of grassed waterways, and planting winter cover crops. The additional measures have the potential to greatly decrease nonpoint source pollution loads to Headwaters streams. Agricultural BMP planning and implementation will be accomplished through partnerships among HRWA, TDA, NRCS, UT Extension, and local engineering firms.

Other Management Measures

Septic system failure or mismanagement can contaminate groundwater and surface waters with pollutants such as bacteria, nutrients, and pharmaceuticals. Leachate from failing septic systems migrates to nearby streams via shallow groundwater paths and degrades aquatic ecosystem health. Toxins and pathogens in the leachate have direct negative impacts on aquatic biota, whereas nutrient-induced algae blooms, eutrophication, and bio-magnification of pollutants impact stream health indirectly. In addition, the contamination of drinking water and recreational surface waters resulting from malfunctioning septic systems poses a danger to public health. Age, improper maintenance, faulty construction, obsolete designs, and mechanical breakdowns are some of the factors leading to septic system failure.

Septic system improvements in the Headwaters Watershed will be accomplished through a blend of outreach and education, system evaluations, and system repairs or replacements. Outreach and education efforts will be implemented to raise awareness about potential impacts to surface and drinking water. Educational efforts will also provide residents with information regarding septic system maintenance and replacement.

Septic system malfunction in the Headwaters Watershed will be assessed via evaluations at individual residences. Evaluations include site surveys to document features relating to water quality, such as surface drainage patterns, lawn and soil characteristics, septic system location, and excessive aquatic plant or algae growth. In addition, a series of ground and/or surface water samples are collected from multiple locations along the stream edge for preliminary testing. If preliminary tests expose abnormalities, then additional tests of parameters such as nutrients and bacteria are performed in suspect areas. Furthermore, fluorescent dye tracer may be flushed through the system to determine if there is direct movement of effluent between

the septic system and surface water. Septic systems found to be malfunctioning will be repaired or replaced. HRWA will work with the Rutherford County Health Department to plan and implement septic system improvement projects.

Fish passage barriers were found by RCWD surveys at four locations in the Harpeth River Headwaters Watershed and it is likely that there are many other undocumented barriers. In cases where the barrier is human caused, such as faulty culverts or in-stream obstructions, there are generally nonpoint source pollution impacts caused by unnatural channel erosion. Therefore, fish passage barriers will be removed or fixed where feasible via partnerships between HRWA, the Tennessee Wildlife Resource Agency, Rutherford County Highway Department, and local consulting firms.

3. Cost Estimates

Costs estimates are provided for BMP elements according to total number, area, or linear footage estimates for individual streams in the Harpeth Headwaters Watershed. Total costs for implementation of all BMPs in the watershed are estimated at $2,773,875.

Table 5. Amount and costs of livestock exclusion BMP installations.

Stream Name	Exclusion Fencing[1] (feet)	Fence Cost[1] (HD=$2.5/ft)	Pipeline[2] (ft)	Pipe Cost[2] ($2.75/ ft)	Watering Facility[3]	Facility Costs[3] ($1625 ea.)	Water Pump Cost[4] ($1375)	Stream Crossing[5] ($6/sq ft)	HUA Costs[6] ($0.35/ sq ft)
Concord Creek	10,000	$25,000	5,000	$13,750	5	$8,125	$6,875	$24,000	$3,500
Puckett Branch	2,000	$5,000	1,000	$2,750	1	$1,625	$1,375	$4,800	$700
Harpeth River	2,400	$6,000	1,200	$3,300	1	$1,625	$1,375	$4,800	$700
Harpeth Tributary	1,200	$3,000	600	$1,650	1	$1,625	$1,375	$4,800	$700
Kelley Creek	3,000	$7,500	1,500	$4,125	2	$3,250	$2,750	$9,600	$1,400
Cheatham Branch	4,000	$10,000	2,000	$5,500	2	$3,250	$2,750	$9,600	$1,400
TOTAL	22,600	$56,500	11,300	$31,075	12	$19,500	$16,500	$57,600	$8,400

[1]Approximately 20% of degraded buffer areas. NRCS Eqip costs for heavy duty fence.

[2]1000' pipeline project for every 2,000' of exclusion fencing. NRCS Eqip 2000-psi 2" pipeline costs.

[3]One watering facility for every 1000' of pipeline. NRCS Eqip 4 ball watering facility cost.

[4]One water pump per watering facility. NRCS Eqip 5-HP water pump cost

[5]One stream crossing/2000 ft of fence x 800 sq ft per crossing. Costs based on locally completed projects.

[6]One 1000 sq ft Heavy Use Area/watering facility and two 500 sq ft HUA/crossing. NRCS Eqip HUA costs.

Table 6. Amount and costs of streambank/margin and stormwater BMP installations.

Stream Name	Reforest Area[1] (acres)	Reforest Costs[1] ($3000/ acre)	Strbank Mitigate[2] (feet)	Mitigate Costs[2] ($100/ ft)	Rain Gardens[3] (number)	Garden Costs[3] ($20/sq ft)	Perm. Pavers[4] (sq ft)	Paver Costs[4] ($5/sq ft)	Detent. Ponds[6] ($40K/ ac-ft)
Concord Creek	60	$179,063	3,000	$300,000	0	$0	10,000	$50,000	$0
Puckett Branch	10	$30,992	0	$0	0	$0	0	$0	$0
Harpeth River	14	$42,011	1,000	$100,000	0	$0	5,000	$25,000	$0
Harpeth Tributary	7	$20,661	1,000	$100,000	0	$0	5,000	$25,000	$0
Kelley Creek	17	$50,964	1,000	$100,000	0	$0	10,000	$50,000	$0
Cheatham Branch	23	$68,870	300	$30,000	10	$80,000	50,000	$250,000	$200,000
TOTAL	131	$392,560	6,300	$630,000	10	$80,000	80,000	$400,000	$200,000

[1]Approximately half of degraded buffer length x 100' width, cost based on completed local projects.

[2]Approximately half of unstable streambanks. One grade structure/100'. Critical area planting = feet x 10' wide. Costs based on Bonham and Stephenson study.

[3]Rain garden installations in Eagleville. Ten 20'x20' gardens. Approximate cost from www.lid-stormwater.net.

[4]Estimated 5000 sq ft/project. Includes asphalt, concrete, gravel/grass, and interlocking blocks. Approximate average cost from www.lid-stormwater.net

[5]One heavy use area per watering facility of 1000 sq ft

[6]One stream crossing/2000 ft of fence x 800 sq ft per crossing

Table 7. Amounts and costs of additional agricultural BMPs and septic system improvements.

Stream Name	Grassed Swale[1] (feet)	Grassed Swale[1] (acres)	Grassed Swale Costs[1] ($645/10 feet)	Winter Cover Crop[2] (acres)	Cover Crop Costs[2] ($20.60/ acre)	Nutrient Manage[3] (acres)	Nutrient Manage Costs[3] ($610/ farm)	Septic Improve Projects[4] (number)	Septic Improve Costs[4] ($10K/ septic)
Concord Creek	3,000	7	$193,500	2,000	$41,200	3,000	$9,150	12	$120,000
Puckett Branch	1,000	2	$64,500	300	$6,180	400	$1,220	3	$30,000
Harpeth River	1,000	2	$64,500	500	$10,300	600	$1,830	5	$50,000
Harpeth Tributary	500	1	$32,250	200	$4,120	400	$1,220	1	$10,000
Kelley Creek	1,500	3	$96,750	500	$10,300	1,400	$4,270	4	$40,000
Cheatham Branch	1,000	2	$64,500	200	$4,120	600	$1,830	2	$20,000
TOTAL	8,000	18	$516,000	3,700	$76,220	6,400	$19,520	27	$270,000

[1]Acres approximated by agricultural land cover area. Cost = $650/linear foot (10'wide) based on Tourte et. al. estimates, UC Extension.

[2]Acres approximated by agricultural land cover area. Costs based on Schnitkey et. al. estimates, University of Illinois.

[3]Number of farms (averaged at 200 acres/farm) estimated from agricultural land cover area. Costs based on NRCS estimates for region.

[4]Estimated based on sewer system availability and residence numbers in sub-watersheds. Costs for repair or replacement range from $200-$50,000 depending on circumstances.

Sources of Technical and Financial Resources

Varied and profuse technical resources are available from current watershed partners. HRWA, NRCS, TDA, UT Extension, and other partners provide the majority of expertise required to plan and implement BMP projects. Furthermore, HRWA and partners have demonstrated capacity to

reach out and form new partnerships to fill technical resource gaps. Authorities that could play a role in plan implementation include the EPA, TDA, TDEC, TWRA, Rutherford County, City of Eagleville, and potentially other regional and local entities, such as the United States Fish and Wildlife Service.

Implementation funding will be sought from a large variety of sources. Many BMP implementation projects will require diverse sources of funding. Potential funding sources include TDA NPS 319 grants, NRCS Conservation Innovation Grants, EPA Five Star and Urban Waters Restoration Grants, the City of Eagleville, private foundations such as the Fish and Wildlife Foundation, private businesses and individual donors and landowners. To date, several successful fundraising efforts have been completed for river restoration projects in the Headwaters. In general, a large percentage of BMP implementation costs (%75-85) have been covered by grant funds, whereas the remainder comes from local sources, such as land owners and local governments. This successful cost-share approach will be continued.

4. Load Reduction Estimates

Load reduction estimates were calculated for individual Headwater streams using the Pollutant Load Reduction Estimation Tool provided by the TN-NPS program. The total estimated load reduction for all BMP installations in the Headwaters Watershed during the 20-year span of this Plan is 177,619 pounds per year (lbs/yr) of nitrogen, 26,426 lbs/yr of phosphorus, and 7,711 lbs/yr of sediments.

Table 8. Concord Creek pollutant load reduction estimates.

Stream Name	BMP	Amount	Nitrogen Reduction Factor	Nitrogen Reduction (lbs N/yr)	Phosph. Reduction Factor	Phosph. Reduction (lbs P/yr)	Sediment Reduction Factor	Sediment Reduction (lbs/yr)
Concord Creek	Access Control (fence)	10,000	0.11	1,100.00	0.01	100.00	0.00	10.00
Concord Creek	Pipeline	5,000	0.13	650.00	0.02	100.00	0.01	30.00
Concord Creek	Watering Facility	5	70.23	351.15	5.88	29.40	0.00	0.02
Concord Creek	Stream Crossing	5	50.30	251.50	7.50	37.50	2.80	14.00
Concord Creek	Heavy Use Area	10,000	0.09	900.00	0.01	100.00	0.00	20.00
Concord Creek	Riparian Forest Buffer	60	308.40	18,504.00	22.60	1,356.00	3.00	180.00
Concord Creek	Streambank Protection	3,000	1.75	5,250.00	0.17	510.00	0.05	141.00
Concord Creek	Grade Stabilization Struc	30	246.82	7,404.60	25.79	773.70	4.22	126.72
Concord Creek	Critical Area Planting	0.69	100.04	68.90	13.56	9.34	0.06	0.04
Concord Creek	Grassed Waterway	7	913.20	6,392.40	220.00	1,540.00	89.40	625.80
Concord Creek	Winter Covercrop	2,000	11.40	22,800.00	2.40	4,800.00	0.84	1,680.00
Concord Creek	Nutrient Management	3,000	6.31	18,930.00	1.02	3,060.00	0.28	846.00
Concord Creek	Septic Improvements	12	119.28	1,431.36	12.58	150.96	3.56	42.77
Concord Creek	**TOTAL**			**84,033.91**		**12,566.90**		**3,716.35**

Table 9. Puckett Branch pollutant load reduction estimates.

Stream Name	BMP	Amount	Nitrogen Reduction Factor	Nitrogen Reduction (lbs N/yr)	Phosph. Reduction Factor	Phosph. Reduction (lbs P/yr)	Sediment Reduction Factor	Sediment Reduction (lbs/yr)
Puckett Branch	Access Control (fence)	2,000	0.11	220.00	0.01	20.00	0.00	2.00
Puckett Branch	Pipeline	1,000	0.13	130.00	0.02	20.00	0.01	6.00
Puckett Branch	Watering Facility	1	70.23	70.23	5.88	5.88	0.00	0.00
Puckett Branch	Stream Crossing	1	50.30	50.30	7.50	7.50	2.80	2.80
Puckett Branch	Heavy Use Area	2,000	0.09	180.00	0.01	20.00	0.00	4.00
Puckett Branch	Riparian Forest Buffer	10	308.40	3,084.00	22.60	226.00	3.00	30.00
Puckett Branch	Grassed Waterway	2	913.20	1,826.40	220.00	440.00	89.40	178.80
Puckett Branch	Winter Covercrop	300	11.40	3,420.00	2.40	720.00	0.84	252.00
Puckett Branch	Nutrient Management	400	6.31	2,524.00	1.02	408.00	0.28	112.80
Puckett Branch	Septic Improvements	3	119.28	357.84	12.58	37.74	3.56	10.69
Puckett Branch	**TOTAL**			**11,862.77**		**1,905.12**		**599.10**

Table 10. Harpeth River pollutant load reduction estimates.

Stream Name	BMP	Amount	Nitrogen Reduction Factor	Nitrogen Reduction (lbs N/yr)	Phosph. Reduction Factor	Phosph. Reduction (lbs P/yr)	Sediment Reduction Factor	Sediment Reduction (lbs/yr)
Harpeth River	Access Control (fence)	2,400	0.11	264.00	0.01	24.00	0.00	2.40
Harpeth River	Pipeline	1,200	0.13	156.00	0.02	24.00	0.01	7.20
Harpeth River	Watering Facility	1	70.23	70.23	5.88	5.88	0.00	0.00
Harpeth River	Stream Crossing	1	50.30	50.30	7.50	7.50	2.80	2.80
Harpeth River	Heavy Use Area	2,000	0.09	180.00	0.01	20.00	0.00	4.00
Harpeth River	Riparian Forest Buffer	14	308.40	4,317.60	22.60	316.40	3.00	42.00
Harpeth River	Streambank Protection	1,000	1.75	1,750.00	0.17	170.00	0.05	47.00
Harpeth River	Grade Stabilization Struc	10	246.82	2,468.20	25.79	257.90	4.22	42.24
Harpeth River	Critical Area Planting	0.23	100.04	22.97	13.56	3.11	0.06	0.01
Harpeth River	Grassed Waterway	2	913.20	1,826.40	220.00	440.00	89.40	178.80
Harpeth River	Winter Covercrop	500	11.40	5,700.00	2.40	1,200.00	0.84	420.00
Harpeth River	Nutrient Management	600	6.31	3,786.00	1.02	612.00	0.28	169.20
Harpeth River	Septic Improvements	5	119.28	596.40	12.58	62.90	3.56	17.82
Harpeth River	**TOTAL**			**21,188.10**		**3,143.69**		**933.48**

Table 11. Unnamed Harpeth River tributary pollutant load reduction estimates.

Stream Name	BMP	Amount	Nitrogen Reduction Factor	Nitrogen Reduction (lbs N/yr)	Phosph. Reduction Factor	Phosph. Reduction (lbs P/yr)	Sediment Reduction Factor	Sediment Reduction (lbs/yr)
Harpeth Tributary	Access Control (fence)	1,200	0.11	132.00	0.01	12.00	0.00	1.20
Harpeth Tributary	Pipeline	600	0.13	78.00	0.02	12.00	0.01	3.60
Harpeth Tributary	Watering Facility	1	70.23	70.23	5.88	5.88	0.00	0.00
Harpeth Tributary	Stream Crossing	1	50.30	50.30	7.50	7.50	2.80	2.80
Harpeth Tributary	Heavy Use Area	2,000	0.09	180.00	0.01	20.00	0.00	4.00
Harpeth Tributary	Riparian Forest Buffer	7	308.40	2,158.80	22.60	158.20	3.00	21.00
Harpeth Tributary	Streambank Protection	1,000	1.75	1,750.00	0.17	170.00	0.05	47.00
Harpeth Tributary	Grade Stabilization Struc	10	246.82	2,468.20	25.79	257.90	4.22	42.24
Harpeth Tributary	Critical Area Planting	0.23	100.04	22.97	13.56	3.11	0.06	0.01
Harpeth Tributary	Grassed Waterway	1	913.20	913.20	220.00	220.00	89.40	89.40
Harpeth Tributary	Winter Covercrop	200	11.40	2,280.00	2.40	480.00	0.84	168.00
Harpeth Tributary	Nutrient Management	400	6.31	2,524.00	1.02	408.00	0.28	112.80
Harpeth Tributary	Septic Improvements	1	119.28	119.28	12.58	12.58	3.56	3.56
Harpeth Tributary	**TOTAL**			**12,746.98**		**1,767.17**		**495.62**

Table 12. Cheatham Branch pollutant load reduction estimates.

Stream Name	BMP	Amount	Nitrogen Reduction Factor	Nitrogen Reduction (lbs N/yr)	Phosph. Reduction Factor	Phosph. Reduction (lbs P/yr)	Sediment Reduction Factor	Sediment Reduction (lbs/yr)
Cheatham Branch	Access Control (fence)	4,000	0.11	440.00	0.01	40.00	0.00	4.00
Cheatham Branch	Pipeline	2,000	0.13	260.00	0.02	40.00	0.01	12.00
Cheatham Branch	Watering Facility	2	70.23	140.46	5.88	11.76	0.00	0.01
Cheatham Branch	Stream Crossing	2	50.30	100.60	7.50	15.00	2.80	5.60
Cheatham Branch	Heavy Use Area	4,000	0.09	360.00	0.01	40.00	0.00	8.00
Cheatham Branch	Riparian Forest Buffer	23	308.40	7,093.20	22.60	519.80	3.00	69.00
Cheatham Branch	Streambank Protection	300	1.75	525.00	0.17	51.00	0.05	14.10
Cheatham Branch	Grade Stabilization Struc	3	246.82	740.46	25.79	77.37	4.22	12.67
Cheatham Branch	Critical Area Planting	0.07	100.04	6.90	13.56	0.94	0.06	0.00
Cheatham Branch	Rain Garden	4,000	0.16	632.00	0.06	240.00	0.01	24.00
Cheatham Branch	Sediment Basin	5	199.41	997.05	33.92	169.60	6.11	30.55
Cheatham Branch	Grassed Waterway	2	913.20	1,826.40	220.00	440.00	89.40	178.80
Cheatham Branch	Winter Covercrop	200	11.40	2,280.00	2.40	480.00	0.84	168.00
Cheatham Branch	Nutrient Management	600	6.31	3,786.00	1.02	612.00	0.28	169.20
Cheatham Branch	Septic Improvements	2	119.28	238.56	12.58	25.16	3.56	7.13
Cheatham Branch	**TOTAL**			**19,426.63**		**2,762.63**		**703.06**

Table 13. Kelley Creek pollutant load reduction estimates.

Stream Name	BMP	Amount	Nitrogen Reduction Factor	Nitrogen Reduction (lbs N/yr)	Phosph. Reduction Factor	Phosph. Reduction (lbs P/yr)	Sediment Reduction Factor	Sediment Reduction (lbs/yr)
Kelley Creek	Access Control (fence)	3,000	0.11	330.00	0.01	30.00	0.00	3.00
Kelley Creek	Pipeline	1,500	0.13	195.00	0.02	30.00	0.01	9.00
Kelley Creek	Watering Facility	2	70.23	140.46	5.88	11.76	0.00	0.01
Kelley Creek	Stream Crossing	2	50.30	100.60	7.50	15.00	2.80	5.60
Kelley Creek	Heavy Use Area	4,000	0.09	360.00	0.01	40.00	0.00	8.00
Kelley Creek	Riparian Forest Buffer	17	308.40	5,242.80	22.60	384.20	3.00	51.00
Kelley Creek	Streambank Protection	1,000	1.75	1,750.00	0.17	170.00	0.05	47.00
Kelley Creek	Grade Stabilization Struc	10	246.82	2,468.20	25.79	257.90	4.22	42.24
Kelley Creek	Critical Area Planting	0.23	100.04	22.97	13.56	3.11	0.06	0.01
Kelley Creek	Grassed Waterway	3	913.20	2,739.60	220.00	660.00	89.40	268.20
Kelley Creek	Winter Covercrop	500	11.40	5,700.00	2.40	1,200.00	0.84	420.00
Kelley Creek	Nutrient Management	1,400	6.31	8,834.00	1.02	1,428.00	0.28	394.80
Kelley Creek	Septic Improvements	4	119.28	477.12	12.58	50.32	3.56	14.26
Kelley Creek	**TOTAL**			**28,360.75**		**4,280.29**		**1,263.12**

5. Outreach/Education

The goal of outreach and education is to impart an understanding of restoration needs and options and encourage active participation in the restoration process among Harpeth Headwaters Watershed communities. Outreach and education efforts will focus on riparian landowners, but will also be extended to the broader community. Varied approaches will be used to inform and educate the public, including public presentations about nonpoint source pollution, development and distribution of informational brochures, press releases, electronic distribution of information through web sites and social media, smart phone applications,

public demonstration projects, and volunteer monitoring and restoration activities. Topics will include the current status of Headwater streams, nonpoint source pollution and sources, NPS pollution impacts to streams, behavioral BMPs, structural BMPs, permanent land conservation, and funding options and opportunities. In addition, the community will be regularly informed about Plan implementation activities and opportunities for involvement.

Fieldtrips will be planned and implemented to provide stakeholders and residents the opportunity to visit sites where BMPs have been successfully implemented and in particular, those installed as part of Plan implementation. Local agricultural producers will be able to visit other farms, see BMPs first-hand, and learn about the process and benefits directly from peers. Government officials, business owners, and residents will have the chance to see a variety of effective urban and residential stormwater BMPs, as well as gain perspective about transitioning from understanding restoration principles and practices to implementation. Fieldtrips could also include visits to demonstration or research sites. These excursions will increase community awareness of the benefits of BMPs, in both ecological and economic terms, and facilitate recruitment of participants into the restoration program.

Existing partnerships between HRWA, Eagleville Schools, the City of Eagleville, NRCS and others will support and promote continued outreach and education efforts. New partnerships will be established to enhance efforts, such as a partnership with Land Trust for Tennessee to help inform watershed residents of available land protection tools. This collaborative approach to outreach and education efforts will improve community awareness of nonpoint source pollution and water quality issues, promote stewardship of water resources, gain support for BMP implementation, and ultimately improve the water quality and ecosystem integrity of Headwater streams.

6. Schedule for Implementation

Since 2007, three implementation phases have occurred. Although multiple BMPs have been installed or adopted during these phases, experience shows that significant time investment is needed to build relationships with the community and develop and implement restoration projects. Considering the pace of implementation since development of the original Plan in 2007, an additional 20 years are deemed necessary to implement this updated version. The following table provides a schedule for implementation tasks, goals achieved by completion of each task, partner responsibilities for task implementation and potential funding sources.

Table 14. Schedule for implementation.

Implementation Task	Years	Goals	Responsible Partners	Funding Sources
Implementation strategy	1-2	Strategy developed	HRWA, NRCS, TDA	HRWA, NRCS, TDA
Continued collaboration	1-20	Meetings 1 time/year	HRWA	HRWA, NRCS, TDA
Establish new partnerships	2-20	1 new partner/4 years	HRWA	HRWA, NRCS, TDA
Education/outreach strategy	1-4	Strategy developed	HRWA, NRCS, UT Ext, TWRA, Eagleville	TDA, EPA, TWRA, UT Ext, Foundations
Education/outreach implementation	1-10	4 programs implemented	HRWA, NRCS, UT Ext, TWRA, Eagleville	TDA, EPA, TWRA, UT Ext, Foundations
Education/outreach implementation	11-20	2 new programs implemented	HRWA, NRCS, UT Ext, TWRA, Eagleville	TDA, EPA, TWRA, UT Ext, Foundations
Identify restoration sites	1-18	200 sites identified	HRWA, NRCS, TDA, TDEC, Rutherford, Eagleville	TDA, NRSC
Identify behavioral BMP residents and organizations	1-18	160 residents/ orgs. identified	HRWA, NRCS, Rutherford, Eagleville	TDA, NRSC
Contact landowners at restoration sites	1-18	Landowners of 200 sites contacted.	HRWA, NRCS, Eagleville	TDA, NRSC
Encourage BMP adoption by residents & orgs.	1-18	160 residents/ orgs. contacted	HRWA, NRCS, TDA	TDA, NRSC
Behavioral BMPs adopted by producers	2-20	60 producers adopt BMPs	HRWA, NRCS, TDA, UT Ext, Land Trust TN	TDA, NRSC, TWRA, Foundations
Behavioral BMPs adopted by residents	2-20	80 residents adopt BMPs	HRWA, NRCS, TDA, UT Ext, Land Trust TN, Eagleville, Rutherford	TDA, NRSC, TWRA, Foundations
Behavioral BMPs adopted by organizations	2-20	20 residents adopt BMPs	HRWA, NRCS, TDA, UT Ext, Land Trust TN, Eagleville, Rutherford	TDA, NRSC, TWRA, Foundations
Structural BMP installations: agriculture	2-20	100 BMPs installed	HRWA, NRCS, TDA	TDA, NRSC, EPA, USFWS, Rutherford
Structural BMP installations: residences	2-20	40 BMPs installed	HRWA, NRCS, TDA, Eagleville, Rutherford	TDA, NRSC, EPA, USFWS, Rutherford
Structural BMP installations: organizations	2-20	20 BMPs installed	HRWA, NRCS, TDA, Eagleville, Rutherford	TDA, NRSC, EPA, USFWS, Rutherford
Project evaluation: education/outreach	12-20	4 programs evaluated	HRWA, UT Ext, TWRA	TDA, EPA, TWRA, UT Ext, Foundations
Project evaluation: behavioral BMPs	5-20	120 BMPs evaluated	HRWA, NRCS, TDA, UT Ext, Land Trust TN	TDA, NRSC, TWRA, Foundations
Project evaluation: structural BMPs	5-20	120 BMPs evaluated	HRWA, NRCS, TDA, Rutherford	TDA, NRSC, EPA, USFWS, Rutherford
Project evaluation: streams	9-10, 19-20	2 change assessments completed	HRWA, TDEC, TWRA, TDA, EPA, USGS, USFWS	TDA, TDEC, EPA, USGS, USFWS
Project evaluation: Plan	10, 18-20	Plan effectiveness and progress evaluated	HRWA, TDA, EPA, TDEC, TWRA, NRCS	TDA, EPA

7. Watershed Restoration Milestones

Measurable milestones developed to track and evaluate progress in Plan implementation include the following:

1. Watershed Management Partnership Coordination
    a. Coordinate project with existing partners
        i. MILESTONE: Plan implementation strategy developed by year 2. Existing partners meet and communicate during years 1 and 2 to discuss and strategize Plan implementation.
        ii. MILESTONE: At least 1 meeting per year among Plan partners to ensure collaborative efforts continue.
    b. Establish new partnerships
        i. MILESTONE: At least 1 new partner contacted every 2 years during Plan implementation.
        ii. MILESTONE: 1 new partnership established every 4 years of Plan implementation.
2. Outreach and Education
    a. Outreach and Education strategy
        i. MILESTONE: Overarching Outreach and Education strategy developed by year 4 via communications and meetings among project partners, community organizations, and community members.
    b. Outreach and Education planning and implementation.
        i. MILESTONE: 4 projects or programs planned implemented by year 10.
        ii. MILESTONE: 2 new projects and programs planned and implemented by year 20 while continuing previous programs and projects as necessary.
3. Site, Resident, and Organization Determinations for BMPs
    a. Identify specific sites, individuals, or organizations for BMPs, utilizing most recent survey information and partner knowledge.
        i. MILESTONE: 200 restoration sites identified by year 18 (70 sites by year 5, 70 additional by year 10, and 60 additional by year 18).
        ii. MILESTONE: 160 residents and organizations (i.e., businesses, local governments) identified for behavioral BMPs (50 by year 5, 50 additional by year 10, and 60 additional by year 18).
    b. Enlist residents and organizations for BMPs.
        i. MILESTONE: landowners at 200 restoration sites contacted by year 18 (70 site by year 5, 70 additional by year 10, and 60 additional by year 18) to discuss and encourage BMP installations.

ii. MILESTONE: at least 160 residents and organizations contacted by year 18 (50 by year 5, 50 additional by year 10, and 60 additional by year 18).) to discuss and encourage BMP adoption.

4. Behavioral BMP Adoptions
    a. Agricultural producers adopt BMPs, including nutrient management planning, winter cover crop planting, and riparian buffer protection.
        i. MILESTONE: 60 producers adopt behavioral BMPs by year 20 (3 per year).
    b. Watershed residents and organizations adopt BMPs, such as cleaning up after pets, washing vehicles on lawns, nutrient management planning, riparian buffer protection, proper disposal of hazardous waste, and water conservation.
        i. MILESTONE: at least 80 residents adopt BMPs by year 20 (4/year).
        ii. MILESTONE: at least 20 organizations adopt BMPs by year 20 (1/year).
5. Structural BMP Installations
    a. Agricultural BMP installations, including livestock exclusion, dedicated livestock stream access, streambank stabilization, and riparian zone restoration.
        i. MILESTONE: 100 BMPs installed by year 20 (5 BMPs/year). Multiple BMPs expected to be installed in each project.
    b. Urban and residential BMP installations, including rain gardens, rain barrels, infiltration pits, detention ponds, permeable pavers, and riparian restoration.
        i. MILESTONE: 40 BMPs installed at residences by year 20 (2 BMPs/year). Multiple BMPs could be installed in each project.
        ii. MILESTONE: 20 BMPs installed at organizations by year 20 (1 BMP/year). Multiple BMPs expected to be installed in each project.
6. Project Evaluations
    a. Outreach and Education evaluations.
        i. MILESTONE: 4 projects or programs evaluated by year 20 (1 evaluation/2 years from year 12 to year 20).
    b. Behavioral BMP evaluations.
        i. MILESTONE: 45 producers surveyed and evaluated by year 20 (15 producers every 5 years from year 5 to year 20).
        ii. MILESTONE: 60 residents surveyed and evaluated by year 20 (20 residents every 5 years from year 5 to year 20).
        iii. MILESTONE: 15 organizations surveyed and evaluated by year 20 (5 organizations every 5 years from year 5 to year 20).
    c. Structural BMP evaluations.
        i. MILESTONE: 75 agricultural BMPs visited and evaluated by year 20 (25 BMPs every 5 years from year 5 to year 20).
        ii. MILESTONE: 30 BMPs at residences visited and evaluated by year 20 (10 BMPs every 5 years from year 5 to year 20).

iii. MILESTONE: 15 BMPs at organizations visited and evaluated by year 20 (5 BMPs every 5 years from year 5 to year 20).

d. Headwater Streams evaluation: compile current data, assess status, and evaluate trends, particularly for parameters associated with impairment.
    i. MILESTONE: Stream water quality data compiled and evaluated. Trends assessed in relation to Plan implementation. Years 9 and 10.
    ii. MILESTONE: Stream water quality data compiled and evaluated. Trends assessed in relation to Plan implementation. Years 19 and 20.
    iii. MILESTONE: Pollutant load reductions over time determined and compared to estimated load reductions from Plan implementation tasks completed (year 20).
e. Plan evaluation.
    i. MILESTONE: Plan implementation progress evaluated at year 10.
    ii. MILESTONE: Plan implementation progress and effectiveness evaluated from years 18-20. Recommendations for changes to Plan provided.

8. Criteria for Load Reduction Goal Assessments

Considering the causes of impairment in Headwaters streams and BMP implementation recommendations provided in this Plan, the following criteria will be used to assess achievement of load reduction goals.

1. For streams with sedimentation/siltation impairment, criteria include:
    a. Suspended solids concentrations (SSC) and loads.
    b. Total dissolved solids concentrations and loads.
    c. Turbidity.
    d. Substrate embeddedness in riffles.
    e. Water temperatures, continual with temperature loggers.
2. For streams with low dissolved oxygen impairment, criteria include:
    a. Dissolved oxygen concentrations and diurnal patterns.
    b. Water temperatures, continual with temperature loggers.
    c. Phosphorus (total and soluble) concentrations and loads as indirect variables contributing to low dissolved oxygen as a result of eutrophication.
    d. Nitrogen (total and NOx) concentrations and loads as indirect variables contributing to low dissolved oxygen as a result of eutrophication.
    e. Chlorophyll-a concentrations as indirect measurement of phytoplankton densities, which can contribute to low dissolved oxygen concentrations.
    f. Periphytic algae cover (areal extent) and density, which can contribute to low dissolved oxygen concentrations.

3. For streams with bacteria (*E. coli*) impairment, criteria include:
    a. E. coli concentrations in individual sample events.
    b. Geometric mean of *E. coli* concentrations from at least 5 samples collected in not more than a 30-day period.
    c. Riparian footage lacking exclusion fencing in livestock areas.
    d. Number of malfunctioning septic systems within 300 feet of surface waters.
4. For streams with alteration in stream-side or littoral vegetative cover impairment, criteria include:
    a. Riparian vegetation areal extent, excluding turf grass and grazing or crop areas, within 300' of surface waters.
    b. Vertical structure of vegetation in riparian areas within 300' of surface waters, including ground cover, understory, and overstory.
    c. Plant species diversity in riparian areas within 300' of surface waters.
    d. Plant density in riparian areas within 300' of surface waters.
    e. Riparian footage lacking exclusion fencing in livestock areas.
    f. Streambank erosion in terms of linear footage and area.
    g. Water temperatures.
5. For streams with habitat impairment, criteria include:
    a. In-stream habitat complexity.
    b. Substrate embeddedness in riffles.
    c. Channel sinuosity.
    d. Streambank erosion in terms of linear footage and area.
    e. Riparian vegetation areal extent, excluding turf grass and grazing or crop areas, within 300' of surface waters.

9. Monitoring Components to Evaluate Effectiveness

Restoration activities conducted as part of Plan implementation will be shared with TDEC-Division of Water Resources, so that their watershed assessments can be scheduled to track progress of the restoration work. Provided that Quality Assurance Protection Plans are developed and approved by TDEC and/or EPA prior to fieldwork, surveys and monitoring activities conducted by other agencies and organizations, including EPA, USGS, HRWA, and Rutherford County, will also be used to evaluate Plan effectiveness. TDA-NPS 319 funds will not be spent on water quality monitoring supplies or activities.

Progress towards attaining water quality standards resulting from Plan implementation will be determined using the following criteria. Appropriate reference sites in sub-ecoregion 71i for individual parameters will be determined with guidance from TDEC, TWRA, EPA, and TDA. Note

that natural drought-induced flow reductions, or at times complete negation, in some stream reaches can produce conditions that would potentially falsely indicate impairment.

1. SSC, TDS, and turbidity measurements equal to or below reference sites described in the Plan's Water Quality summary.
2. Sediment loads reduced by 37.3% as specified in the TMDL.
3. Substrate embeddedness < 50% in 90% of riffles and <25% in 50% of riffles.
4. Water temperatures equal to or below reference sites.
5. Dissolved oxygen concentrations consistently above 5.0 mg/L, as specified in the TMDL.
6. Chlorophyll-a concentrations equal to or below reference sites.
7. Periphytic algae growth density and areal extent equal to or below reference sites.
8. Total phosphorus concentrations reduced to meet criteria recommended by EPA in the TMDL.
9. Phosphorus loads reduced by 42.4% as specified in the TMDL.
10. Total nitrogen concentrations reduced to meet EPA recommended limits in the TMDL.
11. Nitrogen loads reduced by 20% as specified in the TMDL.
12. Based on the TMDL approved by EPA in 2006 for Kelley Creek, the percent load reduction of E. coli CFU should be greater than 65%. Otherwise, E. coli concentrations should consistently meet individual sample standards.
13. Number of malfunctioning septic systems within 300' buffer of surface waters reduced by 50%.
14. Riparian footage lacking exclusion fencing in livestock areas reduced by 80%.
15. Streambank erosion corrected in 80% of problematic areas.
16. Minimum 35' riparian vegetation buffers consisting of mixed structure and at least moderate density and diversity along 75% of stream channels; minimum 100' riparian vegetation buffers along 50%; and minimum 300' riparian vegetation buffers along 25%.
17. In-stream habitat improved in over 30% of areas identified as degraded.
18. Natural channel sinuosity restored in at least 10% of channelized stream sections.

If Plan implementation does not result in substantial progress toward the water quality attainment goals described above, then Plan revisions are advised.

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