Watershed Management Plan

for

The Turkey Creek Watershed Initiative

Town of Farragut, Knox County, City of Knoxville, Tennessee

KNOX COUNTY
TENNESSEE
ENGINEERING & PUBLIC WORKS

CITY OF KNOXVILLE
STORMWATER MANAGEMENT

farragut
TENNESSEE

November 17, 2023

Table of Contents

Table of Acronyms

ACRONYM	DEFINITION
BMP	Best Management Practice
COK	City of Knoxville
EPSC	Erosion Prevention and Sediment Control
FEMA	Federal Emergency Management Agency
FUD-Knox	First Utility District of Knox County
HUC	Hydrologic Unit Code
KC	Knox County
LTC	Little Turkey Creek
MRLC	Multi-Resolution Land Characteristics Consortium
MS4	Municipal Separate Storm Sewer System
NFTC	North Fork Turkey Creek
NLCD	National Land Cover Database
NPDES	National Pollution Discharge Elimination System
NWI	National Wetland Inventory
RGA	Rapid Geomorphic Assessment
SCM	Stormwater Control Measure
STEPL	Spreadsheet Tool for Estimating Pollutant Loads
SWCD	Soil & Water Conservation District
TC	Turkey Creek
TDEC	Tennessee Department of Environmental Conservation
TMDL	Total Maximum Daily Load
TMI	Tennessee Macroinvertebrate Index
TOF	Town of Farragut
USEPA	United States Environmental Protection Agency

USGS	United States Geological Service
VSA	Visual Stream Assessment
WMP	Watershed Management Plan
WSA	Waste Load Allocation

Acknowledgements

This plan was developed through the cooperative efforts of the Town of Farragut, Knox County, and the City of Knoxville. It is intended to guide the Town of Farragut, Knox County, and the City of Knoxville in their efforts to restore Turkey Creek, Little Turkey Creek, and their tributaries to fully supporting status for all designated uses, and to protect public health and well-being by addressing water quality issues that accompany urban land uses. Assistance in plan development includes the University of Tennessee Spring 2022 semester ENVE 516 Watershed Planning and Management Class, including Cole Emmett, Jacob Johnson, Sam Jurek, Matthew Montgomery, Molly Muncy, Dr. John Schwartz, Jeronimo Silva, Jian Song, and Ethan Sweet. This watershed management plan conforms to EPA Section 319 watershed plan guidelines and addresses each of the nine required components identified by EPA as critical for achieving improvements in water quality.

Name of Project:

Turkey Creek Watershed Initiative

Lead Organizations:

Town of Farragut Stormwater Program

Knox County Stormwater Compliance

City of Knoxville Stormwater Program

Watershed Identification:

Turkey Creek Watershed, Knox County, HUC12 TN-060102010208

Turkey Creek waterbody, HUC ID 06010201340_1000

Little Turkey Creek waterbody, HUC ID 06010201037_1000

1.0 Introduction

The Turkey Creek Watershed (Figure 1) lies in the jurisdictions of the Town of Farragut (TOF), Knox County, and the City of Knoxville. Its 29.8 miles of streams discharge into Fort Loudoun Lake. Two streams, Turkey Creek (including the North Fork of Turkey Creek) and Little Turkey Creek, are addressed in this plan to manage the entire drainage basin. The drainage area for the Turkey Creek sub-basin is approximately 9,504 acres (14.85 mi^2) and the Little Turkey Creek sub-basin is approximately 7,590 acres (11.86 mi$^{2)}$). Farragut, which comprises a majority of the watershed, lies at an elevation of 883 ft, receives an average of 51.93 inches of rainfall annually, and has an average daily temperature of 59.5 °F.

Land use within the watershed is predominantly low density, single family residential with commercial use and limited agricultural land throughout. Most area within the entire watershed is considered developed (~80%), with only a small portion (~8%) of the land area covered by forest or grassland (Figure 2, Table 1). The Town of Farragut itself encompasses approximately 60% (10,000 acres) of the watershed area. The population of Farragut has steadily increased and currently totals 23,506 according to the latest census estimate in 2020. Most residences are in low density developments.

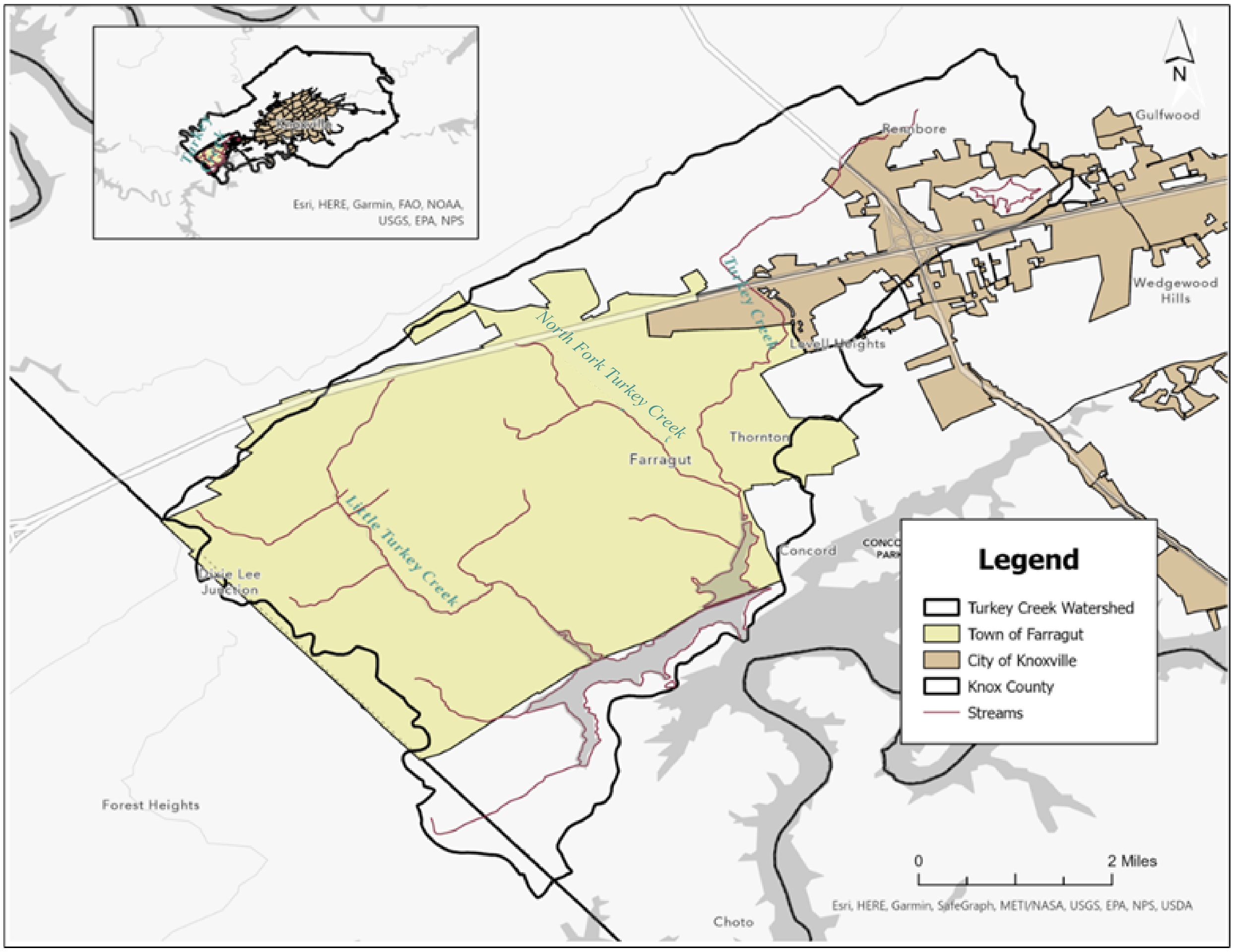


Figure 1. Map of the Turkey Creek Watershed. 29.8 miles of streams span this watershed and flow into Fort Loudoun Lake.

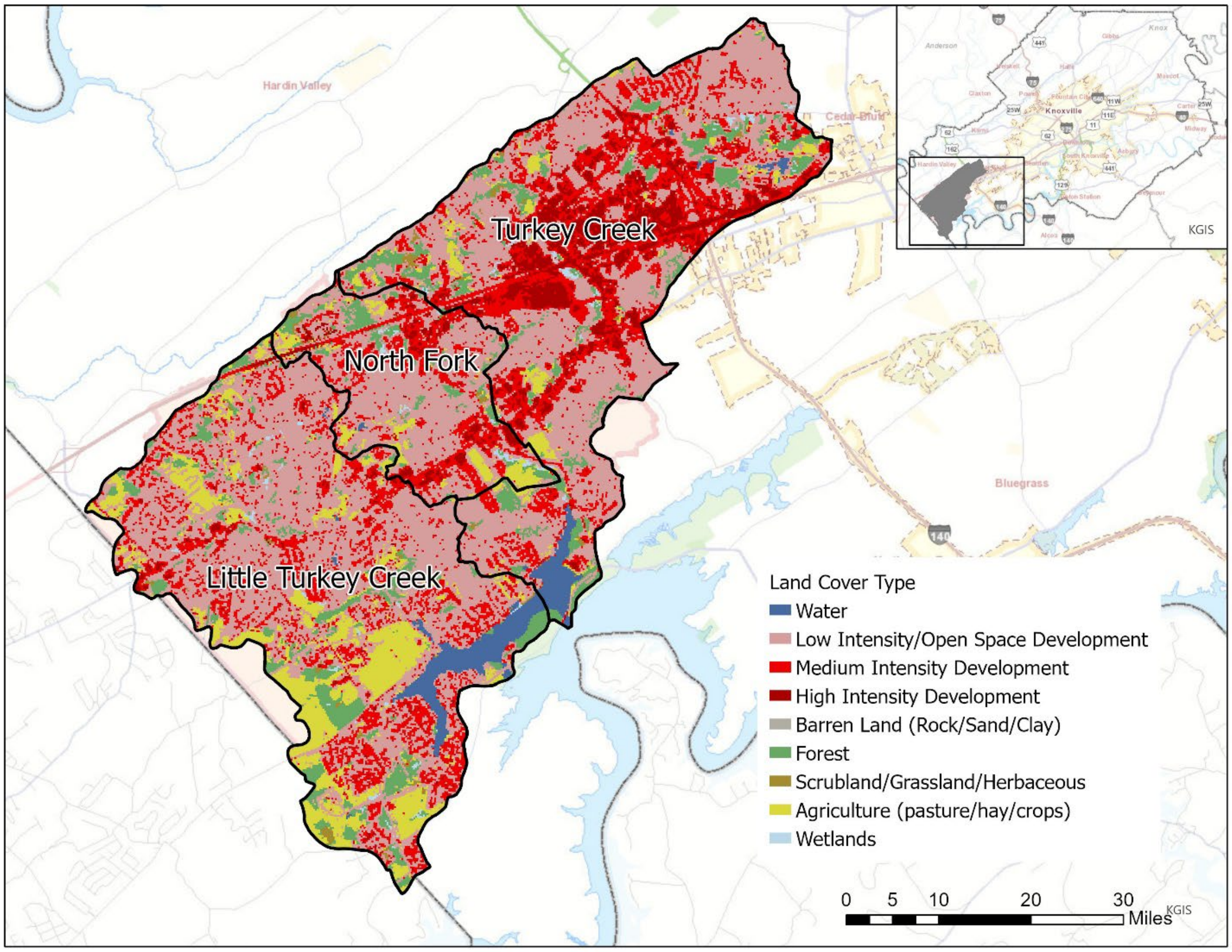


Figure 2. Land use and impervious surface map of the Turkey Creek Watershed. Turkey Creek, North Fork Turkey Creek, and Little Turkey Creek sub-basins are delineated (Note that land cover data is from the 2019 National Land Cover Database (NLCD); land uses may have changed).

Type	Area (acres)	Coverage (%)
Low Intensity/Open Space Development	8641.3	50.7
Medium Intensity Development	3664.6	21.5
Agriculture (Pasture/Hay/Crops)	1596.3	9.4
Forest	1307.2	7.7
High Intensity Development	1139.2	6.7
Water	472.0	2.8
Scrubland/Grassland/Herbaceous	103.8	0.6
Wetlands	98.8	0.6
Barren Land (Rock/Sand/Clay)	12.4	0.1
Total	17035.4	100.0

Table 1. Percent coverage and total area of land use in the Turkey Creek Watershed.

The geology and soils of the Turkey Creek Watershed are important for understanding pollutant sources and for planning the implementation of BMPs proposed herein. The Southern limestone/dolomite valleys and low rolling hills, identified as ecoregion 67f, is a heterogeneous region comprised of limestone and cherty dolomite (Figure 3). The soils within this watershed are comprised of mostly class B – moderate infiltration (~62%), with class C – slow infiltration soils comprising most of the remainder in the watershed (~34%). The average soil permeability throughout the watershed is between 1.35 and 1.95 inches/hour (USGS StreamStats). Soils developed from the limestone units within this watershed tend to have slower infiltration. Karst features such as springs, caves, and sinkholes are common in this area (Griffith, 1997). These features are especially common in the southwestern area of Little Turkey Creek.

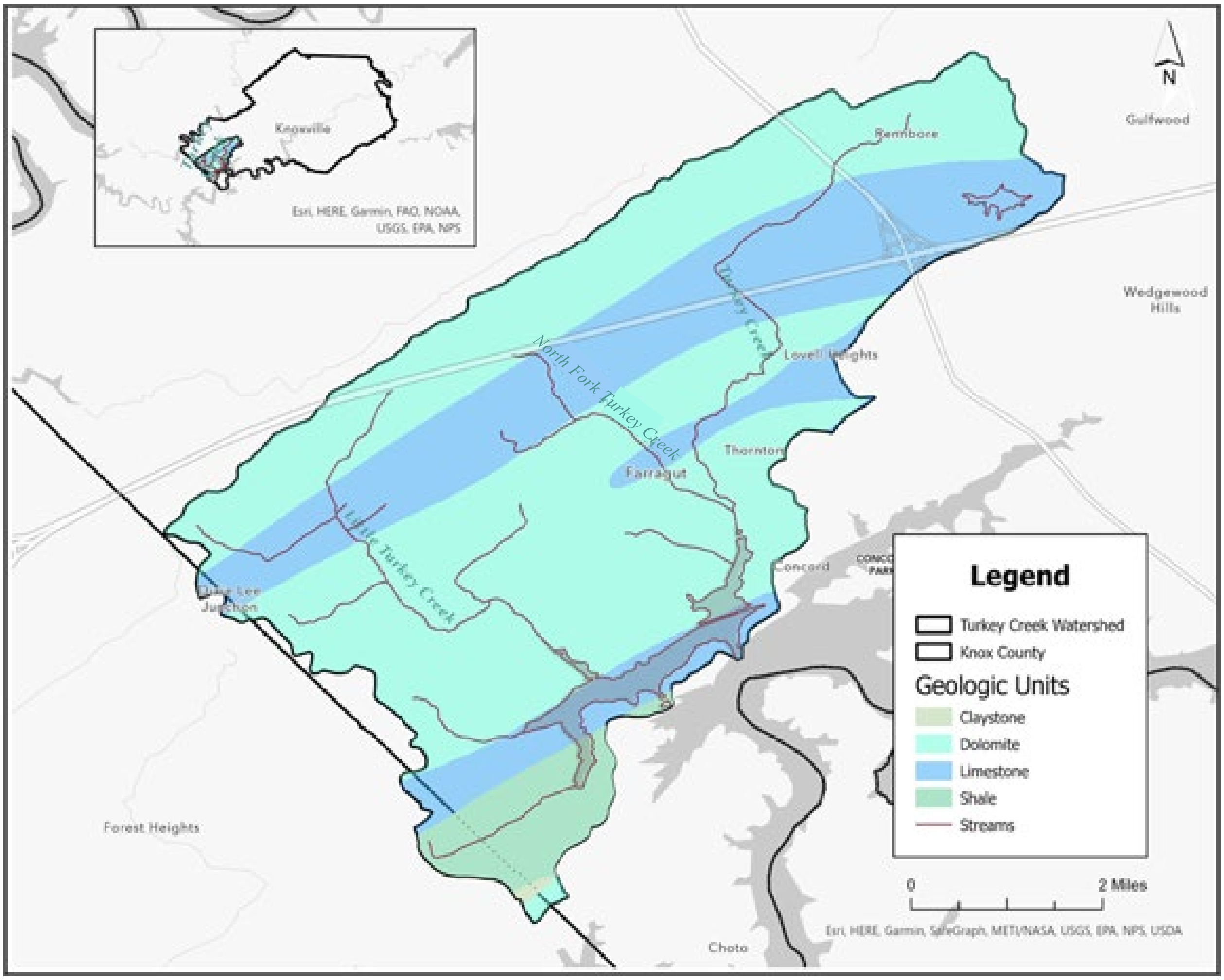


Figure 3. Map detailing the geological makeup of the Turkey Creek Watershed. Most of the watershed consists of dolomite and limestone.

The National Wetland Inventory (NWI) has identified 11 wetlands in the watershed, with most classified as forested/shrub or emergent wetlands. The approximately 70 acres of observed wetlands are located along creeks with most running parallel to roads and half existing in residential neighborhoods. The largest wetland in the watershed follows Little Turkey Creek and the majority is on Willow Creek Golf Club property.

The Turkey Creek Watershed consists of 29.8 miles of waterways with a mean slope of 1.61%. The most dominant steam type is “B” (Rosgen Stream Classification System). Type B streams are characterized by a lack of wide floodplains, entrenched channels, and low sinuosity. Bedform morphology is characterized by scour pools and “rapids”. Streams of this type generally experience low rates of streambank erosion and channel aggradation/degradation. However, as with any stream in an urban environment, conditions have been altered such that the streams may not meet all characteristics of a Type B stream.

There are 18 endangered and four threatened species in Knox County, with a range that may include the Turkey Creek Watershed. Endangered species include the gray bat, Anthony's River snail, and 15 freshwater mussel species. Endangered species confirmed in the Turkey Creek Watershed include the Sweetscent Ladies'-Tresses (*Spiranthes odorata*) and the Flame Chub (*Hemitiemia flammea*). Nearly 1.2 miles of Turkey Creek are listed by TDEC as Exceptional Tennessee Waters due to the presence of Sweetscent Ladies'-Tresses, from Fort Loudon Lake to Hwy 11. Unhealthy stream conditions can result in the loss of these species which will be detrimental to ecosystems within the watershed.

The purpose of this Watershed Management Plan is to establish a roadmap for restoring and maintaining a healthy and sustainable aquatic ecosystem in the Turkey Creek Watershed and removing its waterbodies from the State's List of Impaired and Threatened Waters (the 303(d) list). The Plan will provide guidance on project selection and implementation that may result in better flood control and improved stormwater quality for the watershed's residents, businesses, and visitors.

2.0 Causes and Sources of Nonpoint Source Pollution in the Watershed

The USEPA cites urban-related runoff from MS4s as the most probable source for sedimentation, bacterial pathogens, and alteration in stream-side or littoral vegetative covers (EPA, April 2022). Reported on the State's 303(d) List, TDEC lists both Turkey Creek and Little Turkey Creek as not meeting parameters for their designated uses of recreation and supporting fish and aquatic life (Table 2). In Turkey Creek, this is due to (1) sedimentation/siltation and habitat alteration, and (2) bacterial pathogens enumerated as *Escherichia coli* above water quality standards for human contact. Little Turkey Creek fails to meet parameters due to (1) sedimentation/siltation, and (2) alteration in streamside or littoral vegetative covers. These three pollutants and their potential sources are defined below.

Waterbody Segment ID	Waterbody Segment Name	Miles Impaired	Cause (Pollutant)	Potential Source of Pollutant
TN0601 0201340_1000	Turkey Creek	15.8	Loss of biological integrity due to sedimentation/siltation and *Escherichia coli*	Discharges from MS4 area, Urbanized high density area
TN0601 0201037_1000	Little Turkey Creek	14	Loss of biological integrity due to sedimentation/siltation and alteration in stream-side or littoral vegetative covers	Discharges from MS4 area, Urbanized high density area

Table 2. From the 2022 303(d) List, Stream Impairments for Turkey and Little Turkey Creeks (EPA. April 2022)

2.0.1 Sedimentation/Siltation

Two major potential sources of excess fine sediment in streams are upland erosion and in-channel bank erosion. Upland erosion is largely a function of developed land cover and land use practices. Bare, un-stabilized soils during land surface development can result in erosion during rainfall, in which eroded sediment is transported to streams in runoff (NRCS, March 2008). This commonly occurs at construction sites, but properly installed erosion and sediment controls can reduce sediment runoff. An increase in runoff volume and velocity resulting from impervious surfaces in urban areas may lead to in-channel erosion and bank failure (O'Driscoll et. al. 2010). Increased bank erosion also results from removal of riparian and bank vegetation that protects banks from high-velocity flows. Small ephemeral streams that originate as headcuts are often sources of sediment.

An additional source of excess fine sediment in the streams of urbanized areas is street dust. Street dust is the result of road surfaces and tires breaking down, brake dust, vehicle exhaust, and mineral material. Accumulated street dust is collected in stormwater runoff and conveyed through the storm sewer system to waterways.

The Visual Stream Assessments conducted by the TOF and Knox County from 2016 to 2019 (summarized in Section 2.1.1) provide documentation of the locations and extent of channel and bank erosion that are sources of sediment in Turkey and Little Turkey Creeks, along with habitat survey data from the municipalities and from surveys conducted by TDEC (TDEC, August 2017).

2.0.2 Bacterial Pathogens

The probable sources of pathogens in the Turkey Creek Watershed are leaks in the sewer system lines or sanitary sewer overflows, runoff from developed areas, pet waste, wildlife, and possibly geese presence in retention basins and small ponds. Numerous sanitary sewer crossings along Turkey and Little Turkey Creeks are also possible sources of elevated levels of *E. coli* throughout the watershed. Very few residences in the watershed have septic systems, but failures of these remaining systems in the headwaters of North Fork Turkey Creek should be addressed. Very little agricultural land exists in the headwaters of Turkey Creek and therefore it is not considered a significant source of *E. Coli.*

Sanitary sewer crossings and manholes in floodplains can be a potential source of fecal bacteria, particularly if lines are old and in disrepair and/or are under capacity. The sanitary sewer system in the Turkey Creek Watershed has 67 stream crossings within the main three stems as follows; Little Turkey Creek: 25 sewage pipe crossings (install range from 1977-2019), North Fork: 12 sewage pipe crossings (install range from 1972-2020), and Turkey Creek: 20 sewage pipe crossings (install range from 1972-2021). In 2019, FUD-Knox recorded sanitary sewer overflows at 18 sites. Identification of the oldest pipes can help with finding points where future sampling sites can be established, to see if the high levels of *E. coli* are coming from old pipe crossings. Figure 4 shows the sanitary sewer lines in the watershed as well as parcels with septic systems.

While sanitary sewer crossings and overflows are a significant source of pathogens in the Turkey Creek Watershed, this will not be addressed under the 319 Nonpoint Source Grant Program as they are considered point source pollution. This source will need to be addressed through further monitoring and partnerships with local utilities.

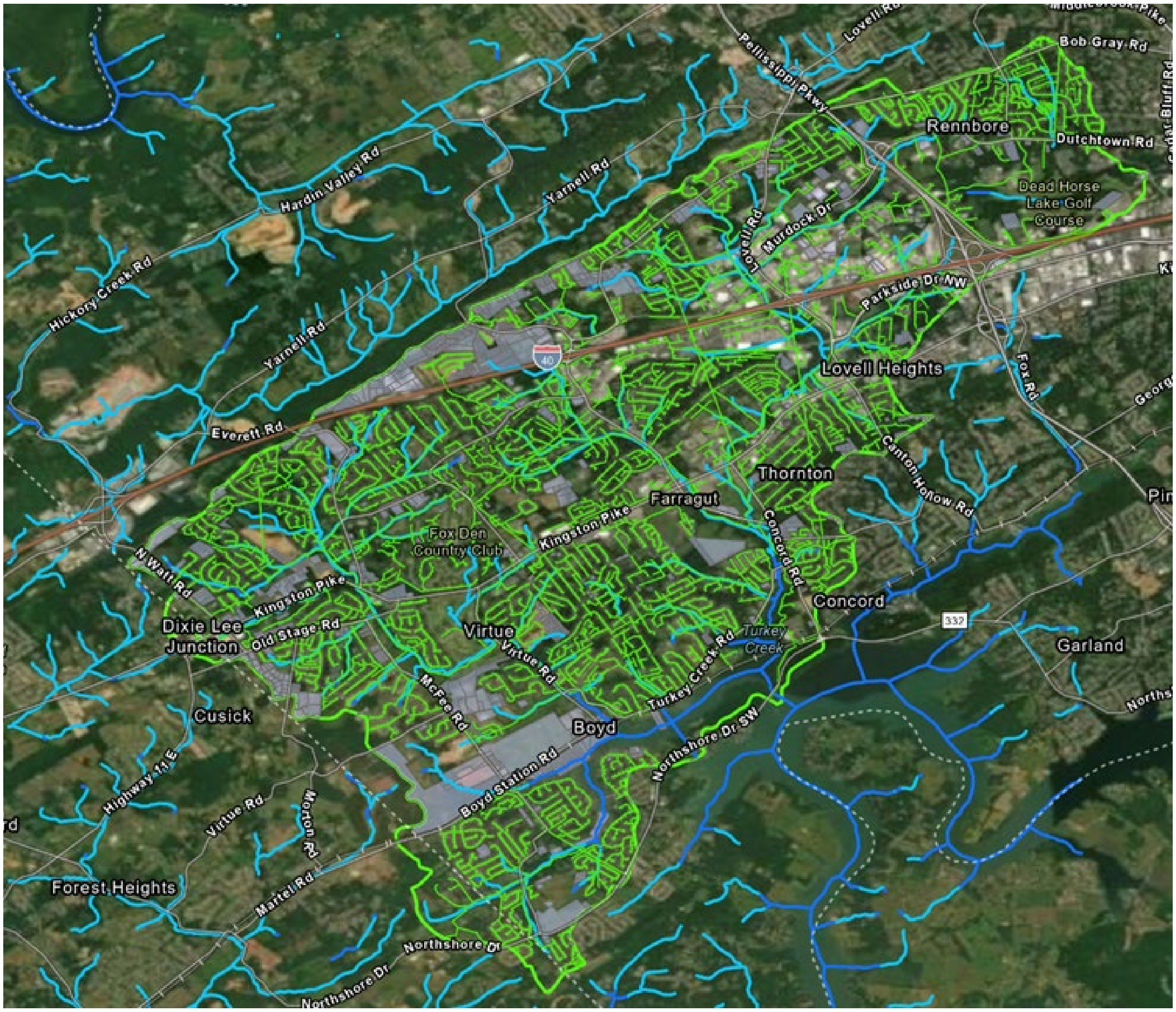


Figure 4. Map showing sanitary sewer lines (green), septic areas (grey), and streams (blue) in the Turkey Creek Watershed.

2.0.3 Riparian Corridor

Urban development has led to decreased quality and quantity of riparian corridors throughout the Turkey Creek Watershed. The lack of high-quality buffers has reduced the overall ability of riparian areas to effectively filter urban runoff. Additionally, urban infrastructure such as bridges and pipe crossings, culverts, adjacent roads, and other structures can cause impacts to the stream channel, both accelerating erosion and geomorphic incision. These alterations cause in-stream stressors that include altering water quality by reducing nutrient uptake/retention, increasing the amount of sediment from erosion, affecting the temperature via lack of shade, and surface flow, changing physical habitat via woody material decrease, decreasing energy sources due to organic matter reduction, and modification of stream channels (EPA, April 2022).

2.1 Monitoring Data and Habitat Assessment

Knox County, the Town of Farragut, and the City of Knoxville conducted Visual Stream Assessments (VSAs), *E. coli* sampling, and habitat and benthic macroinvertebrate assessments to identify potential problem areas in the watershed. Further bacteria sampling and habitat assessments were conducted by TDEC, as well as Rapid Geomorphic Assessments and a Bank Erosion Hazard Index assessment conducted by UT students. The results of these assessments and monitoring are discussed below.

2.1.1 Visual Stream Assessments

The Town of Farragut and Knox County completed visual stream assessments (VSAs) between 2016 and 2019 using Center for Watershed Protection (CWP) Unified Stream Assessment methods modified to fit the needs of each municipality respectively. These assessments collected non-analytical data on impacted buffer and bank erosion. Between 2016 and 2019 the Town of Farragut assessed approximately 15.5 miles of creek in their jurisdiction and found 2.8 miles of inadequate buffer and 1.2 miles of severe bank erosion. In 2018 Knox County assessed approximately 9.3 miles of stream and found 7.5 miles of impacted buffer and 3.4 miles of severe bank erosion/channel alteration (Figures 5-7). Knox County assessed small tributaries in addition to the streams mapped by TDEC. The data collected here supports the cause of impairment listed by TDEC of "Loss of biological integrity due to sedimentation/siltation and alteration in stream-side or littoral vegetative covers", and practices that reduce bank erosion and improve riparian cover are therefore considered in this plan.

Figures 5-7. Examples of severe bank erosion and channel alteration in the headwaters of Turkey Creek.

University of Tennessee students conducted Rapid Geomorphic Assessments (RGAs) at two locations in Turkey Creek in Spring 2022 (Upper Turkey Creek at Founders Park and Lower Turkey Creek below the Red Mill Dam. University of Tennessee students also performed a Bank

Erosion Hazard Index (BEHI) assessment at the Founders Park site. Sites were chosen for the RGA and BEHI assessments due to ease of access, for teaching purposes, and to get a better understanding of the watershed. However, these sites are not necessarily representative of bank stability and susceptibility to erosion throughout the watershed. Although bank erosion at the two sites studied was relatively low, areas of high bank erosion were identified during VSAs, which provide a more comprehensive assessment of streambank stability in the watershed.

The RGAs were conducted to evaluate channel stability based on geomorphological parameters and channel evolution stage at the time of the assessment. Results are summarized in Table 3. The Channel Stability Ranking Scheme (Appendix B, Figure 1) used to conduct this assessment sums the scores of 9 criteria with a range of 0-4 to provide an index of relative channel stability, with higher scores indicating greater instability; sites with values greater than 20 exhibit considerable instability; stable sites generally rank 10 or less. Intermediate values denote reaches of moderate instability. However, rankings are not weighted, thus a site ranked 20 is not twice as unstable as a site ranked 10. Lower Turkey Creek received a score of 5.5 (Stable) while Upper Turkey Creek received a score of 15 (moderate instability) (Table 3). Please refer to the field datasheet sheet (Figures 3 and 4) in Appendix B for specific parameters measured and scores received.

Parameters	**Upper Turkey Creek (Founders Park)**	**Lower Turkey Creek (Below Red Mill Dam)**
Primary bed material	0.5	0
Bed/bank protection	1	1
Degree of incision	0	0
Degree of constriction	0	0
Stream bank erosion	left = 1, right 2	left = 0, right 0
Stream bank stability	left = 0, right 0.5	left = 0, right 0
woody-vegetative cover	left = 1.5, right 1.5	left = 0.5, right 0
Occurrence of bank accretion	left = 1.5, right 1.5	left = 2, right 2
Stage of channel evolution	4	0
Total	**15**	**5.5**

Table 3. Rapid Geomorphic Assessment (RGA) for Upper and Lower Turkey Creek.

The purpose of the BEHI assessment is to evaluate the susceptibility of streambanks to erosion based on a combination of response variables that are sensitive to erosive processes. The BEHI is based on a score out of 50 points. A score closer to 50 indicates high susceptibility to erosion. At the assessment site (looking upstream), the left bank received a low, 12.5/50, and the right bank received a very low, 9.5/50, BEHI index score (Table 4). This indicates that both streams have overall low susceptibility to erosion in this location. However, this susceptibility is not necessarily representative of the watershed as a whole.

Side of Bank	Bank/ Bankful	Root Depth/	Root Bank Density	Bank Angle (degrees)	Surface Protection	Total Score (0-50)
Left Bank	1.5	1	1.5	7	1.5	12.5
Right Bank	1.5	1	1.5	3.5	3	9.5

Table 4. BEHI index details the susceptibility of stream bank erosion. The index is out of 50 points and a higher score indicates a higher concern for erosion.

2.1.2 *E. coli* Monitoring

Tennessee Water Quality Criteria for recreation states that the concentration of *E. coli* must not exceed 126 CFU per 100 ml as a geometric mean based on five samples collected from a given sampling site over a 30-day period. Water sampling and testing for *E. coli* has been conducted in the watershed and the results are presented here. Colony Forming Unit (CFU) and Most Probably Number (MPN) have differences in calculation mythology but are considered functionally equivalent and are used interchangeably in this document. To meet the water quality standards, the geometric mean of 5 individual samples in 30 days must be below 113 CFU/100mL, which includes a 10% margin of safety (MOS). In addition, the concentration of the *E. coli* group in any individual sample above 2,880 cfu per 100 ml indicates that the stream does not meet water quality standards (TDEC, 2019).

E. coli monitoring was conducted by TDEC, Knox County, the Town of Farragut, the City of Knoxville, and students from UT throughout the Turkey Creek Watershed (see Appendix B Table 1 for complete data). Although Little Turkey Creek is not listed on the 303(d) list for *E. coli*, samples taken have shown levels above the state standard, so Little Turkey Creek will continue to be monitored for *E. coli* and has been included in bacteria load reduction calculations in Section 3.3. Of 148 bacterial samples taken for *E. coli* testing, 110 were taken as part of 5-in-30 monitoring sequence, resulting in 22 available geomeans. The table below outlines the geomeans for *E. coli* samples taken at different locations along Turkey Creek and Little Turkey Creek from 2007 – 2022.

Location	Year					
	2007	**2012**	**2015**	**2017**	**2021**	**2022**
LTURK002.1KN[d]	35					
LTURK002.7KN[e]						181
LTURK003.8KN[e]						909
LTURK006.7KN[e]						215
TURKE001.7T0.7KN[e]						270
TURKE001.7T1.9KN[e]						324
TURKE001.8KN[e]						116
TURKE002.3KN[b]						133
TURKE002.5T0.1KN[b]						346
TURKE002.6KN[d]	370	504		690		
TURKE002.8KN[e]						193
TURKE003.3KN[e]						131
TURKE003.9KN[c]			262			
TURKE004.2KN[e]						208
TURKE004.7KN[b]					171	196
TURKE004.9KN[b]					236	
TURKE005.0KN[b]					960	176
TURKE006.3KN[e]						3,335

Table 5. Geomeans (MPN/100) of 5-in-30 monitoring for Turkey Creek and Little Turkey Creek between 2007-2022.

[b] Knox County Samples

[c] Town of Farragut Samples

[d] TDEC Samples

[e] UT Students Isabella Hamby and Alexandra Hospital Samples

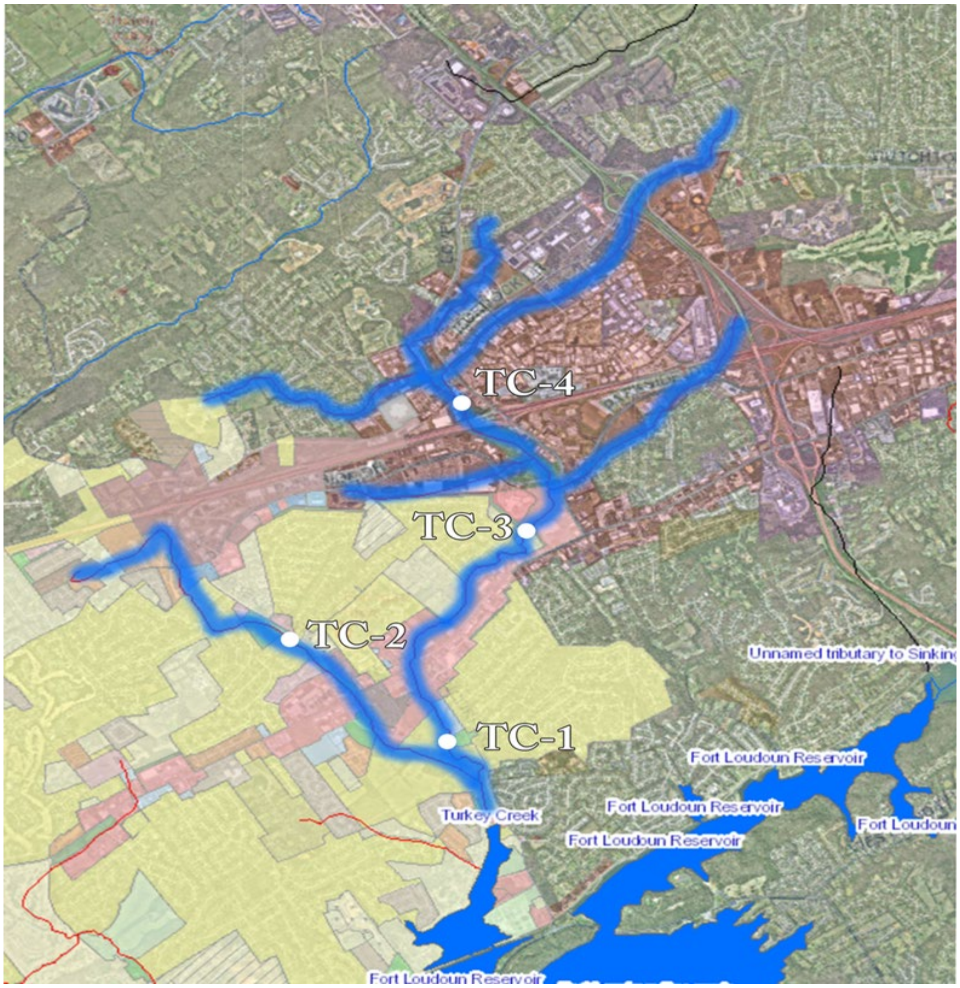


Figure 8. Sampling locations in Turkey Creek watershed for source tracking conducted by the Town of Farragut. TC1 (-84.150738°, 35.876158°) is located north of Campbell Station Road near Concord Road Intersection in the Turkey Creek sub-watershed. TC2 (-84.167019°, 35.887858°) is located at Founders Park in the North Fork Turkey Creek sub-watershed. TC3 (-84.144132°, 35.895758°) is located behind Costco, southwest of the Turkey Creek Wetlands in the Turkey Creek sub-watershed. TC4 (-84.149976°, 35.908179°) is located in Knox County, south of Outlet Drive in the Turkey Creek sub-watershed.

The Town of Farragut conducted source tracking to determine if bacterial contamination was coming from humans or animals. Four sample locations were used, all residing in the Turkey Creek sub-watershed aside from TC2, which is in the North Fork Turkey Creek sub-watershed at Founders Park (Figure 8). Figure 9 below shows wet weather sampling results of Bacteroidetes concentrations that were above the least quantifiable limit. Human genetic markers can be confidently reported as present in TC2 with the result qualifier reported above the practical quantification limit. Human source contamination could be an indication of septic tank failure or sanitary sewer leaks. Given the presence of septic systems concentrated in the headwaters of North Fork Turkey Creek, efforts focused on promoting septic tank repairs should be concentrated in that sub-watershed. Also, given the presence of genetic markers from dogs at TC1 and TC2, education on proper pet waste disposal and installation of pet waste stations should be focused in those areas.

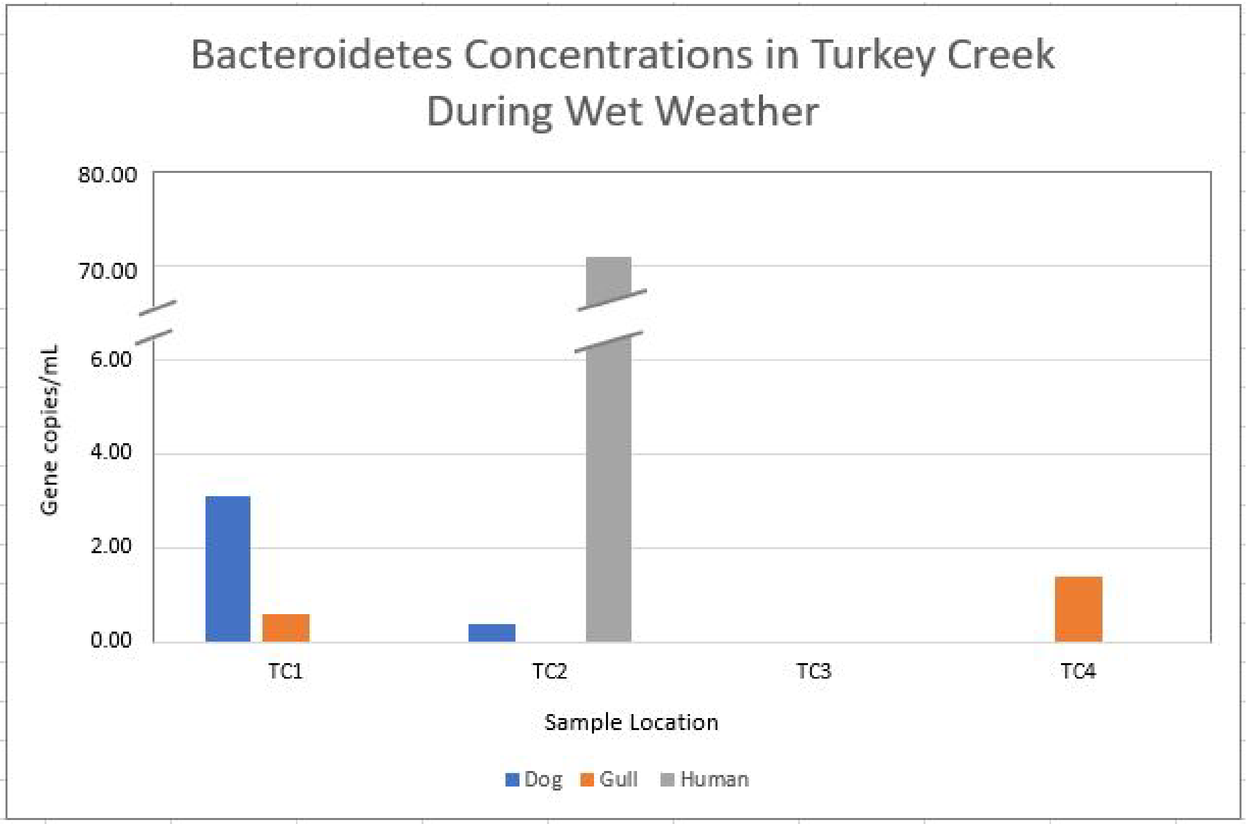


Figure 9. Bacteroidetes concentrations (gene copies/mL) at sampling locations in Turkey Creek during wet weather. It should be noted a scale break was made on the y-axis considering human Bacteroidetes concentration was much higher in TC2 in relation to other values on the graph.

2.1.3 Habitat and Benthic Macroinvertebrate Assessments

In August 2019, a Habitat and Benthic Macroinvertebrate Community Assessment was completed by Dinkins Biological Consulting for Knox County at monitoring location

TURKE004.5KN (Coordinates 35.9084, -84.1503). In this assessment, they noted that Turkey Creek has excessive siltation and a steeply incised channel due to the urbanization in the area. There were no real riffle areas found by surveyors. The habitat assessment had a score of 56 and the biocriteria assessment has a score of 18. Neither passed due to failing to meet the minimum scores outlined in Table 6 and Table 7. Table 6 shows the Lowest Habitat Score Passing TMI, Table 7 shows the Biocriteria Guidelines (DBC, 2019). In 2016, GEOServices completed benthic macroinvertebrate sampling and a habitat assessment on Little Turkey Creek for the Town of Farragut at monitoring location LTURK002.1KN (GPS N 35.8591º, W -84.1812º). The habitat assessment had a score of 140 and the biocriteria assessment had a score of 22, so the habitat assessment passed and the TMI did not pass (GEOServices, 2016).

TDEC also had different testing locations along Turkey and Little Turkey Creek where either one or both of the habitat and benthic macroinvertebrate scores did not pass. TDEC performed benthic and habitat assessments at two locations in LTC in 2016 (at TDEC sampling sites LTURK002.1KN and LTURK002.4KN). These sites passed the habitat assessment with scores of 139 and 151 respectively, but did not pass the TMI with scores of 20 and 24. At one sampling location in Turkey Creek, TURKE002.6, failed both tests, with a habitat assessment of 127 in 2022 and a TMI of 24 in 2017. At TURKE004.8KN, samples taken in 2019 also failed both tests, with a habitat assessment of 56 and a TMI of 14. TDEC's complete results for sampling locations in Turkey and Little Turkey Creek can be found in Appendix B, Table 2 A and B.

Lowest Habitat Score Passing TMI (Tennessee Macroinvertebrate Index)				
Habitat Type	Streams with > 2.5 sq. mile drainage		Streams with ≤ 2.5 sq. mile drainage	
High Gradient	Jan - June		July - Dec	
	≥ 131	≥128	≥ 133	≥123

Table 6. The lowest passing scores for the habitat assessment. Scores are dependent on time of year and drainage area.

Index Score Rating TMI (Tennessee Macroinvertebrate Index)	
Passing Biocriteria Guidelines	Not Passing Biocriteria Guidelines
≥ 32	< 32

Table 7. An index score of 32 or more results in a passing score for the Tennessee Macroinvertebrate Index (TMI).

UT students also performed a habitat assessment at two locations in Turkey Creek in Spring 2022 (Upper Turkey Creek at Founders Park and Lower Turkey Creek below the Red Mill Dam; results are summarized in Tables 8). The goal of the habitat assessment is to rate stream habitat criteria as “Optimal”, “Suboptimal”, “Marginal”, or “Poor” based on a combination of geomorphic, hydrologic, and biological parameters that contributed to stream habitat structure, availability, and function. Upper Turkey Creek received a “Suboptimal” rating while Lower Turkey Creek received a “Optimal" rating. Scores below 130 receive a “Marginal” or “Poor” rating.

Parameters	Upper Turkey Creek	Lower Turkey Creek
Epifaunal Substrate/Available Cover	18	4
Embeddedness of Riffles	17	3
Velocity Depth Regime	20	3
Sediment Deposition	14	18
Channel Flow Status	20	20
Channel Alteration	12	13
Frequency of re-oxygenation zones	20	10
Bank Stability	LB =5, RB = 5	LB =10, RB = 10
Vegetative Protective	LB = 1, RB = 1	LB =5, RB = 5
Riparian Zone Width	LB = 0, RB = 0	LB =8, RB = 10
Total	**133**	**141**

Table 8. Habitat Assessment for Upper and Lower Turkey Creek.

3.0 Estimates of Pollutant Load Reductions Expected from Management Measures

Focused management efforts will prevent further degradation and actively improve water quality through best management practices and education initiatives focused on non-point pollution sources, including sedimentation and *E. coli*, reduction. The US EPA Spreadsheet Tool for Estimating Pollutant Loads (STEPL) model was used to estimate pollutant load reductions for sediment and *E. coli* (EPA, 2022). This model computes load reductions based on the proposed management measures (BMPs). It computes watershed surface runoff, nutrient loads, and sediment delivery. For the Turkey Creek Watershed, 3 sub-watersheds were added to the STEPL model; sub-watershed 1 is Turkey Creek, sub-watershed 2 is North Fork Turkey Creek, and sub-watershed 3 is Little Turkey Creek. Inputs include watershed land use area (ac) and precipitation (in), agricultural animals, septic system and illegal direct wastewater discharge data, BMPs that will be implemented, gully dimensions, and impaired streambank dimensions. The model then calculates the total load with the BMPs that have been proposed. The cost to implement and available area was determined by each drainage area requiring a BMP, the length of stream to be stabilized, and length of gully to be stabilized.

Section 3.1 TMDLs

A Total Maximum Daily Load (TMDL) is the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. Pollution load reduction amounts are also provided and used here. The USEPA approved the TMDL for the Fort Loudoun Lake Watershed for siltation/habitat alteration in 2006 and the TMDL for *E. coli* in 2017 (TDEC, 2006; TDEC, 2017).

From the TMDL Development section of the TDEC Siltation/Habitat Alteration report, target sediment loads (lbs/acre/year) are based on the average annual sediment loads from biologically healthy watersheds. Nonpoint sources are expressed as a percent reduction in average annual sediment load required for a sub-watershed. Reductions of 47.7% in siltation are required for Turkey Creek and Little Turkey Creek to be removed from the 303(d) list and meet their designated uses. The (2006) report defines an existing sediment load of 759 lbs/ac/yr for Little Turkey Creek and Turkey Creek; the target load of sediment is 397.1 lbs/ac/yr, a total reduction of 362 lbs/ac/yr.

The *E. coli* TMDL for the HUC 8 (HUC 06010201) Fort Loudoun Lake Watershed is described in Section 3.3. *E. coli* data are summarized in Section 2.1.2, which included data collected in 2014 and 2016 by the TOF. These data were also assessed for source (human, dog, or gull) through genetic testing as described in Section 2.1.2. Additional *E. coli* data were provided by TDEC and COK.

3.2 Sedimentation/Siltation Load Reductions

The STEPL model was used to estimate sediment load reductions achieved by implementing the BMPs listed here. It was determined that using these BMPs in conjunction with gully and streambank stabilization that the stream could meet the TMDL for siltation and habitat alteration. According to the TMDL, is the sediment load for Turkey Creek is 759 lbs/ac/year and implementing the BMPs would allow for a predicted load below the 397.1 lbs/ac/year TMDL. Table 9 shows the sediment load reduction by sub-watershed from the STEPL model. The urban Stormwater Control Measures (SCMs) used in the STEPL model for these calculations are described in Table 10. Table 11 shows the conversion from tons per year to pounds per acre per year and the predicted load after BMP implementation. It is important to note that the lengths of gullies and streambank restoration used for these calculations (described in Section 4.0) are an estimate to reduce the sediment load to the TMDL and are not surveyed values.

Watershed	N Load (no BMP) lb/yr	N Reduction lb/yr	N Load (BMP) lb/yr	P Load (no BMP) lb/yr	P Reduction lb/yr	P Load (BMP) lb/yr	Sediment Load (no BMP) t/yr	Sediment Reduction t/yr	Sediment Load (BMP) t/yr
W1	55,054.64	2,657.36	52,397.28	9,093.76	959.13	8,134.63	2,643.01	1,236.07	1,406.94
W2	17,228.10	1,068.45	16,159.65	2,944.74	374.88	2,569.87	927.00	463.77	463.23
W3	52,385.66	1,842.30	50,543.36	8,630.33	663.54	7,966.79	2,426.21	855.56	1,570.65
Total	**124,668.40**	**5,568.11**	**119,100.29**	**20,668.84**	**1,997.55**	**18,671.29**	**5,996.21**	**2,555.39**	**3,440.82**

Table 9. Loads without BMPs, Reductions with BMPs, and Loads with BMPs for Nitrogen (red), Phosphorus (green), and Sediment (yellow) in each sub-watershed.

Urban SCM	Land Use Area	Drainage Area to Treat(acres)
Extended Wet/Dry Detention (retrofits)	Residential	125
Wetland Detention	Open Space	21
Bioretention Facility	Residential	11
Infiltration Trench	Commercial	11
Vegetated Filter Strip	Commercial	100
Grassy Swale	Residential	20
Grassy Swale	Transportation	80
Rain Barrels	Residential	5
Porous Pavement	Commercial	20

Table 10. Treatment areas of each Urban SCM used for STEPL load reduction calculations.

Watershed	Acres	Sediment Reduction t/year	Sediment Reduction lbs/ac/yr	Predicted Load (after BMPs) lbs/ac/year
W1	7026	1236.07	351.86	400.50
W2	2217	463.77	418.38	417.89
W3	7150	855.56	239.32	439.34

Table 10. Predicted load of sediment reduction after BMP implementation.

The implementation of Urban BMPs, gully stabilization, and streambank restoration used for the STEPL model calculations would achieve a total average sediment load of 419.8 lbs/ac/year. Two additional practices, septic system repairs and riparian buffer improvements, would remove an additional 27.02 lbs/ac/year (calculations shown in Table 12). This would allow for a total load of 393.8 lbs/ac/year, which would achieve the 397.1 lbs/ac/year load allocation from the TMDL.

BMP Name	BMP Amount	Units	N Reduction Factor*	N Reduction (lbs/yr)	N Reduction (lbs/ac/yr)	P Reduction Factor	P Reduction (lbs/yr)	P Reduction (lbs/ac/yr)	Sediment Reduction Factor	Sediment Reduction (tons/yr)	Sediment Reduction (lbs/ac/yr)
Septic Improvements**	31.00	unit	119.28	3,697.68	0.23	12.58	389.98	0.02	3.56	110.48	13.48
Riparian buffer***	37.00	acre	308.40	11,410.80	0.70	22.60	836.20	0.05	3.00	111.00	13.54
Total				**15,108.48**	**0.92**		**1,226.18**	**0.07**		**221.48**	**27.02**

Table 11. Sediment reduction of septic improvements and riparian buffer practices if implemented.

**From RFP*
***Based on approx. 1100 septic systems in watershed, with 2.85% failure rate estimated by the EPA=31 systems needing repair*
****Based on VSA-observed impacted riparian buffer*

3.3 Bacterial Pathogens (*E. coli*) Load Reductions

The current version of the STEPL model does not support the calculation of *E. coli* load or load reduction. As a result, an estimation of total *E. coli* load was calculated according to the geomean provided from TDEC sampling data, and a load reduction was calculated according to an estimated efficiency of the BMPs specified in the STEPL model for nutrients and sediment removal. Results of this estimation are shown below in Table 13.

Urban SCM	Land Use Type	Drainage Area Treated (acres)			Total Load (MPN/100 mL)			Total Load Reduction (MPN/100 mL)		
		W1	W2	W3	W1	W2	W3	W1	W2	W3
Extended Wet/Dry Detention (retrofits)	Residential	50	25	50	168.4	193	215.6	36.3	37.2	56.9
Bioretention Facility	Residential	3	3	5	13.4	15.5	17.2	2.2	4.5	5.7
Wetlands Detention	Open Space	7	7	7	145.1	163.2	205.3	4.0	8.2	7.0
Infiltration Trench	Commercial	3	3	5	18.3	13	9	3.3	4.2	3.4
Vegetated Filter Strips	Commercial	50	25	25	260.5	183.4	128.1	55.5	35.1	16.8
	Totals	113	63	92	605.7	568.1	575.2	101.3	89.2	89.7

Table 12. BMP estimated efficiency results following the STEPL model. Note that W1, W2, and W3 refer to Turkey Creek, North Fork Turkey Creek, and Little Turkey Creek respectively.

To obtain the above values, a total load for each sub-watershed area was assumed to be equal to the geomean of 689.97 MPN/100mL obtained from TDEC sampling results shown in Table 4. This geomean was then assumed to be distributed across each of the identified land use types according to the percentage of the total watershed area treated by each SCM. When multiple

SCMs were specified for a single land use type, the total load was distributed between each SCM according to the fraction of the total drainage area treated by a given SCM. When only one SCM was specified for a given land use type, it was assumed that this SCM treated all the load assigned to the land use area. The calculated total load does not equate to the total geomean as not all land use types were considered in this analysis. After estimating the total load, reductions were calculated using the SCM efficiencies given below in Table 14. The land use percentages used for each calculation are shown below in Table 15.

Urban SCM	Land Use Area	Drainage Area to Treat(acres)	BMP % Efficiency
Extended Wet/Dry Detention (retrofits)	Residential	125	60
Wetland Detention	Open Space	21	85
Bioretention Facility	Residential	11	45
Infiltration Trench	Commercial	11	65
Vegetated Filter Strip	Commercial	100	50

Table 13. Reduction of bacterial pathogens (E. coli) through urban SCMs. BMP efficiency percentages noted were estimated from the International Stormwater BMP Database.

Watershed	Total Area (acres)	Land Use Percentage			Land Use Total (acres)		
		Open Space	Residential	Commercial	Open Space	Residential	Commercial
1	7267.6	21.0	26.4	40.4	1526.2	1918.6	2936.1
2	2259.8	23.7	30.2	28.5	535.6	682.5	644.0
3	7551.9	29.8	33.7	19.9	2250.5	2545.0	1502.8

Table 14. Percentages of land use types used in the calculation of E. coli loads and reductions. Note that W1, W2, and W3 refer to Turkey Creek, North Fork Turkey Creek, and Little Turkey Creek respectively. Results were rounded to one decimal place.

An example calculation for the total load reduction by Bioretention Facilities in North Fork Turkey Creek is shown below:

$$Load\ Reduction = Geomean * Land\ Use\ \% * Load\ Fraction * Efficiency$$

$$MPN/100\ mL = (689.97\ MPN/100\ mL) * [(30.2)/(100)] * [(3\ acres) / (63\ acres)] * 0.45$$

$$Load\ Reduction = 4.5\ MPN/100\ mL$$

Through the implementation of SCMs listed in Table 14, the total *E. coli* reduction for Turkey Creek, North Fork Turkey Creek, and Little Turkey Creek are 101.2, 89.2, and 89.7 MPN/100 mL respectively. When subtracted from the total load, these values result in an average remaining load of 489.6 (Table 16) which does not meet the 113 CFU/100 mL TMDL goal. As a result, further actions related to education and implementation of BMPs will be taken to lower the remaining load to meet the TMDL. Some of these actions are discussed below as part of the Information and Education plan. Additionally, improvements to sanitary sewer lines, will likely reduce the *E. coli* loads, but were not included in calculations due to insufficient data and are considered outside of the scope of this plan.

Watershed	*E. coli* Load Reduction (MPN/100 mL)	*E. coli* Remaining Load (MPN/100 mL)
W1 (Turkey Creek)	101.3	504.4
W2 (North Fork Turkey Creek	89.2	478.9
W3 (Little Turkey Creek)	89.7	485.5

Table 15. Final estimates for E. coli load reductions and remaining loads after implementation of BMPs.

4.0 BMP List, Educational Activities, and Budget

Management measures (BMPs) required to achieve load reductions are described here as they pertain to sediment and to bacterial pathogens. The following BMPs should be sufficient to reduce pollution loads in the Turkey Creek Watershed to the point where streams would meet state water quality standards. The location of the BMPs is variable, but the total area required has been determined (Table 17-19).

4.1 BMP List

Stream Bank Restoration

The STEPL model incorporates stream bank stabilization, but for the health of the watershed, comprehensive stream restoration is needed in some areas. The goal is to reduce erosion along the creeks, restore aquatic ecosystems, and manage riparian zones. Through VSAs conducted by the participating municipalities throughout the watershed, stream segments were identified for restoration. The main types of erosion observed were sorted into five different categories and target restoration lengths (Table 17).

Bank Class	Height (Ft)	Lateral Recession	Erosion Rate (ft/yr)	Soil Texture	Dry Weight (ton/ft3)	Length (ft)
1	2	Moderate	0.15	Clay-loam	0.05	2,000
2	3	Severe	0.2	Clay	0.058	1,400
3	4	Severe	0.25	Clay-loam	0.045	1,400
4	2	Slight	0.05	Clay-loam	0.05	2,300
5	3	Moderate	0.01	Clay-loam	0.05	2,000

Table 16. Siltation/Habitat Alteration guide for fine sediment reduction through stream bank stabilization.

Note: All bank stability projects are assumed to have a BMP efficiency of 95%, and projects will consist of stream restoration using natural channel and eco-hydraulic design procedures. Stream restoration projects will include habitat enhancements, including riffle construction, removing concrete linings, physical habitat microstructures, and riparian tree planting. Bank Class #5 consists of riparian tree planting only to protect banks for the long-term and provide stream habitat.

To address siltation/habitat alteration (sedimentation) and high bacterial pathogens (*E. coli*) counts causing water quality impairment in the Turkey Creek Watershed, the planned BMPs and other activities are grouped by green infrastructure, SCM, and stream restoration practices such as:

- Riparian Buffer Restoration and Establishment
- Bank Stabilization using Natural Channel Design techniques
- Grade Control
- Stream Habitat Augmentation - Riffle Construction
- Implementation of wetlands in floodplains
- Removal of undersized culverts and artificial barriers to aquatic organism passage

Gully Stabilization

Gullies occur at the headwaters where water forms deep channels. It is important to stabilize these areas to reduce siltation. This will be completed through vegetative and structural measures. Similar to bank stabilization, gullies were sorted into three different categories from VSA observations and targeted restorable lengths were identified (Table 18).

Gully Class	Top Width (ft)	Bottom Width (ft)	Depth (ft)	Years to form	Soil Texture	Dry Weight (ton/ft3)	Length (ft)
1	6	2	3	1	Clay-loam	0.05	2,800
2	8	3	3	2	Clay-loam	0.05	2,450
3	10	4	4	3	Clay-loam	0.05	1,550

Table 17. Siltation/Habitat Alteration guide for fine sediment reduction through gully stabilization.

Note: All gully stabilization projects are assumed to have a BMP efficiency of 90%.

Erosion Prevention and Sediment Control (EPSC) Measures

In addition to BMPs for sediment reduction, EPSC monitoring at construction sites will consists of:

- Site plan review and approval by municipality staff.
- Applicable NPDES, ARAP, TVA, or other permits to be obtained for each project site.
- Preparation and submission of a complete stormwater pollution prevention plan (SWPPP) along with a Notice of Intent (NOI) to the Tennessee Department of Environment and Conservation, Division of Water Pollution Control (TDEC-WPC) to gain coverage under the Construction General Permit (CGP).
- Maintaining regulation with the TOF stormwater program.
- Monthly pre-construction meetings with operators of priority construction activities and inspections of sites.
- Photo documentation of a few stages of construction to be shared for educational purposes

Sanitary Sewer Line Rehabilitation

In addition to BMPs, the municipalities may partner with FUD-Knox on sewer line rehabilitation to address SSO and leaking pipes. The first step in this process is to perform a condition assessment survey on the sewer system, specifically in areas where the lines cross the creeks. This can be done by visual inspection or by CCTV sewer inspection. Sampling can also take place in sections above and below each sewer line crossing to determine if they are a source of *E. coli*. Once this is complete, areas of interest will be determined. Based on the location of the pipe, the actions that need to take place will be determined, whether it be replacing the pipe itself or using trenchless technologies.

Green Infrastructure / SCM Practices

Urban areas usually consist of several different land uses in proximity to one another. Across different land uses, there are several urban SCMs available for implementation to reduce fine sediment. Extended wet/dry detention basins, wetlands, bioretention facilities, grassy swales, infiltration trenches, vegetated filter strips, rain barrels, and porous pavement are green infrastructure/SCM practices that will be implemented to reduce siltation and high *E. coli* counts. Extended wet detention basins, which utilize permanent pool storage, and extended dry detention basins, which will hold stormwater longer than conventional dry detention, use extended detention time to treat runoff and will be retrofitted in older SCMs within the watershed. Wetlands use natural processes through vegetation, soil, and microbial communities to treat pollutants in runoff. Bioretention facilities have a similar treatment process to wetlands but are considered an upland-type system. Grassy swales and infiltration strips allow infiltration to settle-out soil and treat pollutants. A vegetated filter strip is a vegetation zone that acts as a buffer between a water source and potential pollutant source. Rain barrels collect and store runoff that could potentially transport sediment or other pollutants to a waterbody. Finally, porous pavement lowers the amount of runoff coming from pavement and allows for infiltration. The urban SCMs chosen for this plan described in more detail below (A-H), and their corresponding treatment area and land use is outlined in Table 10.

A. Extended Wet or Dry Detention (Retrofits)

Many detention ponds throughout the watershed were constructed in older residential areas for stormwater volume control only, prior to newer (post- 2008) codes requiring water quality treatment. Nearly 120 detention ponds in the County and City were identified as potential retrofit candidates (examples in Figures 10-13). The intention is to assess these systems and retrofit the systems lacking water quality treatment and owner maintenance agreements. This will allow for stormwater to be retained longer and allow for settling of suspended solids and reduce the peak runoff to streams during smaller storm events. Additionally, it will ensure that older systems continue to be maintained to allow proper functionality. As peak flows are reduced in the stream, in-stream erosion is also reduced, further reducing sediment loads. This will overall reduce the amount of sediment entering the water bodies.

Figures 10-13. Examples of detention pond retrofit candidates in the Turkey Creek Watershed.

B. Wetland Detention

The construction of wetlands in open spaces will allow stormwater to be retained and infiltrate. Like wet detention, these wetlands will have capacity to retain stormwater, reduce the peak runoff, and allow for settling of suspended solids. These systems will act as a filter and can also remove other nutrients through infiltration. These are more natural options than wet detention, and several natural wetlands already exist in this watershed.

C. Bioretention Facility

Bioretention facilities, such as rain gardens, are good to use to reduce sediment and nutrient loads. These systems are composed of layers of media and topped with mulch and dense vegetation. They are used to filter and retain stormwater and will be implemented in residential areas.

D. Grassy Swale

Grassy swales are used to convey stormwater and reduce pollutants. Implementing grassy swales around the watershed will allow for sediment to be removed more efficiently in comparison to water flowing through curb and gutter systems. These will be used in both residential and transportation areas.

E. Infiltration Trench

Infiltration trenches will replace areas that convey water over concrete in commercial areas. This will allow for infiltration to occur and will allow for sediment to be removed.

F. Vegetated Filter Strip

The addition of vegetated filter strips will allow for the removal of sediment and increase infiltration. These will be best used in areas that are near the creeks to act as a buffer where riparian corridors are not sufficient and in commercial areas that have construction and significant amounts of vehicle traffic.

G. Rain Barrel

Rain barrels will be used in residential areas to reduce the peak runoff during storms. Reducing the peak runoff helps decrease water velocity that can cause erosion. These systems will retain water and can be used for irrigation and other non-potable water applications.

H. Porous Pavement

Porous pavement will be used in commercial areas that do not receive high levels of traffic. Porous pavement allows water to infiltrate and acts as a filter to remove sediment. It is best to use this BMP when creating new parking lots to save on cost.

Septic System Repairs

Although most properties in the Turkey Creek Watershed are connected to sanitary sewer, some are still on septic, approximately 1,100 in total. The source tracking conducted by the Town of Farragut indicated a major spike in human-source *E. coli* in North Fork Turkey Creek, where approximately 280 properties on septic are concentrated in the headwaters. Repairs should be conducted throughout the watershed, since the majority of septic systems are spread throughout the Turkey and Little Turkey sub-basins, but concentrating on the NFTC headwaters would have the greatest impact on *E. coli* loads in that sub-basin.

Agricultural BMPs

Agriculture is not considered a significant land use in the Turkey Creek Watershed. However, if a need or interest for agricultural BMP projects is identified in the future, this plan will be updated accordingly.

4.2 Technical and Financial Assistance

In order to implement the management measures listed in Section 3.0, Table 20 shows the specific quantity of BMPs necessary to make a significant impact in water quality. The cost of each is based off NRCS's 2022 state average cost list and 2022 EPA BMP guidelines.

BMP Name	Quantity	Cost/Unit	Unit	Budget Estimate	Source of Cost/Unit Est.
Stream Stabilization (Shoreline Protection)	9100	$200.00	Linear foot	$1,820,000.00	NRCS
Gully Stabilization	6800	$85.00	Linear foot	$578,000.00	NRCS
Extended Wet/Dry Detention (Retrofits)	50	$10,000.00	Each	$500,000.00	EPA
Wetland Detention (Wetland Creation)	2	$3,548.50	Acre	$7,097.00	NRCS
Grass Swales	300,000	$2.30	Cubic foot	$690,000.00	EPA
Porous Pavement	700,000	$1.50	Square foot	$1,050,000.00	EPA
Rain barrel	800	$100.00	Each	$80,000.00	EPA
Vegetated Filter Strip (Filter Strip)	17	$234.50	Acre	$3,986.50	NRCS
Bioretention (Rain gardens)	2	$150,000.00	Acre	$300,000.00	EPA
Infiltration Trench	11	$70,000.00	Acre	$770,000.00	EPA
Riparian Corridor (Riparian Forrest Buffer)	37	$1,509.20	Acre	$55,840.00	NRCS
Septic System Repair	31	$10,000.00	Each	$310,000.00	Knox Co.
Pet Waste Dispensers	15	$1,000.00	Each	$15,000.00	EPA

Education	Quantity	Cost	Budget Estimate
Public Education Activities	9	$2,500.00	$22,500.00
Community Involvement Activities	5	$1,000.00	$5,000.00

Total Budget for Project
$6,207,423.50

Table 18. Budget for all BMPs and outreach needed for plan implementation.

One funding gap to be addressed in the future is for monitoring. VSAs, minor *E. coli* sampling, and some other monitoring methods are currently within the operating capacity of the municipalities within the watershed. However, for more specific source identification, especially for *E. coli* source tracking and more intensive, targeted sampling below sanitary sewer crossings, additional monitoring may be needed and funding sources will need to be identified.

4.3 Information and Educational Plan

Community Engagement

Community engagement is essential for the success of pollution reduction. Engagement activities will be divided into two categories: public education and community involvement. While public education efforts are essential for most aspects of successful pollution reduction, special attention will be placed on *E. coli* levels in Turkey Creek and Little Turkey Creek. These efforts will be aimed at further reducing *E. coli* levels to meet the TMDL.

Efforts will be made to raise awareness of urban *E. coli* sources, including failing septic systems, potential illicit discharges, and damaged sewer lines. Partnerships may be made with local institutions such as the University of Tennessee to promote continued monitoring and identify areas where sewer system repairs could be beneficial. Community presentations, school lessons, and digital and printed materials will be used to disseminate general information on pollutant impacts and actions community members can take, while active community involvement will be encouraged through a variety of events and workshops.

To raise awareness about siltation and habitat alteration in the Turkey Creek Watershed, similar means of education outreach will take place. Efforts will be made to raise awareness of urban impacts to water quality, best management practices for homes and businesses, the importance of saving riparian corridors, and for maintaining the BMPs that will be constructed. General activities in the education and involvement plan are shown below:

Public Education Activities

- Newspaper articles in local papers
- Public meetings
- Information on TOF, KC, and COK websites
- Maintaining a digital presence on social media
- K-12 lessons
- Presentations to community groups
- Presentation to HOAs and at neighborhood meetings
- Targeted education initiative for pet waste disposal and downspout disconnection

Community Involvement Activities

- Participation in community events
- Stream Clean-ups
- Stakeholder meetings
- Invasive Species Removal
- Make-it take-it Rain Barrel workshops, Rain Barrel sales

- Tree Giveaways
- Outdoor Classroom management
- Shade Your Stream Workshops
- Pet Waste Disposal Activities

5.0 Timeline, Tasks, and Assessment of Progress

The first three phases will be implemented over the course of a twelve-year period, with each implementation phase lasting three years and a year for monitoring and evaluation following each phase. Table 19 shows a general outline for what is planned for the first phase of project implementation and the monitoring and evaluation of plan efficacy period. Phase 1 will be directed towards gathering information about the watershed's social infrastructure and initiating community engagement programs in the first year, as well as installing BMPs. The goal for this phase is to focus on likely project sites, such as parks, neighborhood common areas, and publicly owned spaces. Phases 2 and 3 will be conducted over the following eight years with the primary focus being restoration and BMP installation, using knowledge of most effective projects gained in Phase I. This plan will be updated prior to these subsequent phases to include a more detailed implementation plan outline.

Public education and specific outreach activities will be conducted throughout all phases of the plan to increase public awareness and involvement. Monitoring and evaluation will be crucial to reach phase milestones and to document effectiveness of each phase. Milestones will be achieved according to this plan or altered if issues/concerns arise. At the end of each of the three phases quantitative geometric mean assessments for *E. coli* will be conducted using TDEC protocol to assess the effectiveness of BMP installations and this plan will be evaluated and altered as necessary.

5.1 Implementation Plan

	Phase 1												Monitoring & Evaluation			
Calendar Year	**Year 1**				**Year 2**				**Year 3**				**Year 4**			
Calendar Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Activity																
Public Education																
Newspaper articles in Farragut press	x		x		x		x		x		x					
Maintain a digital presence on social media	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
K-12 lectures			x	x			x	x			x	x			x	x
Mailer to Watershed Residents	x					x										
Presentations to Community Groups (as requested)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Specific Outreach																
Participation in Community Events	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Stakeholder Meetings		x				x				x						
Invasive Species Removal			x				x				x					
Stream Clean-ups				x								x				
Make-it take-it Rain Barrel Workshop				x								x				
Pet Waste Disposal Workshops/Dispenser Install	x	x	x	x	x	x	x	x	x	x	x	x				
Rain Barrel Sale					x				x							
Restoration/BMPs																
Grassy Swale	x	x	x	x	x	x	x	x	x	x	x	x				
Infiltration Trench	x	x	x	x	x	x	x	x	x	x	x	x				
Vegetated Filter Strips	x	x	x	x	x	x	x	x	x	x	x	x				
Wetlands Detention	x	x	x	x	x	x	x	x	x	x	x	x				
Bioretention Facility	x	x	x	x	x	x	x	x	x	x	x	x				
Detention Pond Retrofits	x	x	x	x	x	x	x	x	x	x	x	x				
Porous Pavement	x	x	x	x	x	x	x	x	x	x	x	x				
Riparian Buffer Plantings	x			x	x			x	x			x				
Stream Restorations	x			x	x			x	x			x				
Septic Repairs	x	x	x	x	x	x	x	x	x	x	x	x				
Monitoring																
Bacteriological Testing															x	x
Benthic Sampling														x	x	

Visual Streambank Assessment													x	x	x	x
Other Stream Assessments													x	x	x	x
Evaluation																
Collect and Analyze Monitoring Reports													x	x	x	x
Evaluate, and Adapt Monitoring, If Necessary													x	x	x	x
Adapt Watershed Plan as Needed													x	x	x	x

Table 19. Implementation plan for the first phase of the watershed plan.

5.2 Milestones

Phase I:

Years 1-3

- Within the first quarter of the contract, a mailer will be sent to landowners, residents, and business owners within the watershed in areas where BMPs/SCMs can be implemented.
- By the end of the second quarter, a community stakeholder meeting will be held in the watershed. Three stakeholder meetings will be held during the contract term (subject to change based on interest/attendance)
- 25 BMPs will be installed within the first contract term.
- Two articles about the project will be written in the Knox County Stormwater Strong Streams E-newsletter per term year
- The participating municipalities will utilize their social media and local newspapers to inform the community about the project. At least one post or article per quarter.
- Community group presentations, classroom lessons, and stream cleanups will be advertised and conducted throughout the contract term as requested, with a goal of one activity per contract year.
- Two make it-take it rain barrel workshops and one rain barrel sale will be conducted during the contract term.

Year 4- Monitoring and Evaluation Period (after grant contract term)

- Quantitative geometric mean assessments for *E. coli* will be conducted using TDEC protocol to assess the effectiveness of BMP installations for bacteria reduction from the first implementation phase.
- Watershed plan will be evaluated and altered as necessary.
- Watershed plan will be updated to include structured schedule for subsequent phases.
- Develop milestones for next implementation phase.

Phase II

Years 5-7

- Develop new marketing and outreach strategies based on lessons learned from previous phase
- Additional milestones will be set during Year 4.

Year 8- Monitoring and Evaluation Period (after grant contract term)

- Quantitative geometric mean assessments for *E. coli* will be conducted using TDEC protocol to assess the effectiveness of BMP installations for bacteria reduction from the first and second implementation phases.
- Watershed plan will be evaluated and altered as necessary.
- Watershed plan will be updated to include structured schedule for subsequent phases.
- Develop milestones for next implementation phase.

Phase III

Years 9-11

- Develop new marketing and outreach strategies based on lessons learned from previous phase
- Additional milestones will be set during Year 8.

Year 12-

- Quantitative geometric mean assessments for *E. coli* will be conducted using TDEC protocol to assess the effectiveness of BMP installations for bacteria reduction from previous implementation phases.
- Changes in pollutant loads and status of 303(d) list impaired streams will be assessed. This watershed plan will be amended based on data gathered during monitoring activities and the implementation plan will be extended for (an) additional phase(s) if necessary.

6.0 Criteria to Assess Achievement of Load Reduction Goals

This watershed-based plan outlines strategies to be implemented over three phases. Restoration activities do not have immediate effects and may take several years to appear; however, each phase of the plan will be assessed through monitoring of the different sub-watersheds, with a focus on the specific impairments to gauge levels of success. For *E. coli*, success will ultimately be measured against TDEC's 2022 monitoring data and compared to baseline data from 2017, with more specific sub-watershed level assessments conducted during the monitoring and evaluation period between each phase compared to geomean assessments completed by Farragut, Knoxville, Knox County, and UT. Targeted and regularly scheduled visual stream assessments will also be conducted by the participating municipalities to gauge improvement in the stream corridor over time. Having consistent locations and adopting similar standards to TDEC for analysis and assessment will be crucial to effectively monitor each sub-watershed.

Quarterly assessments of BMP implementation will be used to determine if interim milestones are being met, and adaptive management measures will be taken if necessary. The project will be considered successful when the above BMPs and education activities are completed, and *E. coli* and sedimentation loads and concentrations are low enough for the creeks in the watershed to be removed from the 303(d) list.

7.0 Monitoring and Documenting Success

As described above, monitoring will occur between work phases of the project and will be conducted and funded by the grantee and partners rather than through 319 grant monies. Later phases in the plan will be updated for any problem areas or unresolved issues, and more phases can be added to the plan as necessary. Successes and any revisions will be documented after the end of each phase, improving the effectiveness of the plan. Additionally, quarterly meetings with the grant partners will be used to assess whether the project is on schedule. Education and outreach will be considered successful if scheduled events are completed and outreach materials are completed and disseminated. The data collected by TDEC during their 5-year monitoring cycle will also be used to document project success.

Siltation/ Riparian Corridor

As part of the adaptive management strategy, additional study of channelization and its impacts to siltation and habitat alteration may be performed in future years. Studies to further identify and quantify the effects of channel alteration could provide useful information in determining if management strategies such as reintroducing sinuosity, reconnecting floodplains, or adding instream structures to dissipate energy and increase habitat are more suitable approaches for stream restoration than more traditional BMPs. Channelization studies, visual streambank assessments, erosion pin studies, benthic community sampling, and pebble counts could include comparative assessments of channelized and un-channelized reaches. If necessary, restoration priorities and strategies will be reevaluated and adapted, and future amendments to this plan will be considered.

Bacterial Pathogens (*E. coli*)

The three Turkey Creek municipalities will conduct 5 in 30 geometric mean analyses for *E. coli* for each of the sub-watersheds in addition to one at the TDEC monitoring station. The same procedures TDEC uses will be adopted to maintain similarity between monitoring data. Additionally, samples upstream and downstream of sewer line stream crossings may be taken in future years through partnerships with utility districts. This would help determine if leaky sewer lines are contributing to elevated *E. coli* counts.

References

Dinkins Biological Consulting. December 2019. *Habitat and Benthic Macroinvertebrate Community Assessment of Streams in Knox County, TN.*

EPA. April 2022. *EPA Approved Lists of Impaired and Threatened Waters.* https://www.tn.gov/environment/program-areas/wr-water-resources/water-quality/water-quality-reports---publications.html#:~:text=EPA%20Approved%20Lists%20of%20Impaired%20and%20Threatened%20Waters

EPA. *2008. Handbook for Developing Watershed Plans to Restore and Protect Our Waters.* EPA 841-B-08-002. Environmental Protection Agency. https://www.epa.gov/nps/handbook-developing-watershed-plans-restore-and-protect-our-waters

EPA. March 2022. *Sediments*. https://www.epa.gov/caddis-vol2/sediments

EPA. 2022. *Spreadsheet Tool for Estimating Pollutant Loads (STEPL) and Region 5 Model.* https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl-and-region-5-model#overview

EPA. April 2022. *Urbanization - Riparian/Channel Alteration.* https://www.epa.gov/caddis-vol2/urbanization-riparianchannel-alteration

GEOServices. November 8, 2016. *Benthic, E.Coli, & Habitat Assessments for Town of Farragut MS4 Program Knox County, Tennessee.*

Griffith,G.(1997)Ecoregions of Tennessee, https://store.usgs.gov/assets/MOD/StoreFiles/Ecoregion/21632_tn_front.pdf

O'Driscoll et. al. September 13, 2010. Urbanization Effects on Watershed Hydrology and In-Stream Processes in the Southern United States. https://www.mdpi.com/2073-4441/2/3/605/pdf Water 2010, 2, 605-648

Tennessee Department of Environmental Compliance. August 2017. *Quality System Standard Operating Procedure for MACROINVERTEBRATE STREAM SURVEYS.* https://www.tn.gov/content/dam/tn/environment/water/documents/DWR-PAS-P-01-Quality_System_SOP_for_Macroinvertebrate_Stream_Surveys-081117.pdf

TDEC. 2006. *TOTAL MAXIMUM DAILY LOAD (TMDL) For Siltation and Habitat Alteration in The Ft. Loudoun Lake Watershed (HUC 06010201) Blount, Knox, Loudon and Sevier Counties, Tennessee.* Tennessee Department of Environment and Conservation Division of Water Pollution Control.

TDEC. 2017. *TOTAL MAXIMUM DAILY LOAD (TMDL) for E. Coli in the Fort Loudoun Lake Watershed (HUC 06010201) Blount, Knox, Loudon, and Sevier Counties, Tennessee.* Tennessee Department of Environment and Conservation Division of Water Resources.

United States Geological Survey. June 5, 2018. Bacteria and E. Coli in Water. https://www.usgs.gov/special-topics/water-science-school/science/bacteria-and-e-coli-water

Appendix A

List of Figures

List of Tables

Appendix B: Monitoring Data

Table 1. *E. coli* samples taken in Turkey Creek and Little Turkey Creek, 2007-2022.

Location	Date	*E. coli* [MPN/100mL]	Geomean [MPN/100mL]
Downstream NFTC[c,f]	11/3/2010	150	-
LTURK002.1KN[d]	8/8/2007	22	35.20
	8/13/2007	1	
	8/15/2007	299	
	8/20/2007	249	
	8/21/2007	33	
LTURK002.1KN[d]	8/22/2007	96	-
LTURK002.1KN[d]	8/27/2007	86	-
LTURK002.1KN[d]	9/18/2007	64	-
LTURK002.1KN[d]	10/17/2007	21	-
LTURK002.1KN[d]	11/20/2007	99	-
LTURK002.1KN[d]	1/15/2008	96	-
LTURK002.1KN[d]	2/19/2008	60	-
LTURK002.1KN[d]	3/18/2008	41	-
LTURK002.1KN[d]	4/17/2008	44	-
LTURK002.1KN[d]	5/20/2008	36	-
LTURK002.1KN[d]	7/15/2008	387	-
LTURK002.1KN[d]	9/17/2008	30	-
LTURK002.1KN[d]	10/28/2008	25	-
LTURK002.1KN[d]	11/21/2008	23	-
LTURK002.1KN[d]	12/18/2008	160	-

LTURK002.1KN[d]	3/3/2009	70	-
LTURK002.7KN[e,f]	Summer 2022	115	181.46
	Summer 2022	235	
	Summer 2022	260	
	Summer 2022	200	
	Summer 2022	140	
LTURK003.8KN[e,f]	Summer 2022	760	909.15
	Summer 2022	2030	
	Summer 2022	1220	
	Summer 2022	600	
	Summer 2022	550	
LTURK006.7KN[e,f]	Summer 2022	310	215.09
	Summer 2022	180	
	Summer 2022	250	
	Summer 2022	165	
	Summer 2022	200	
TKD[a]	11/17/2021	17	-
TKM[a]	11/17/2021	30	-
TKU[a]	11/17/2021	41	-
TURKE001.7T0.7KN[e,f]	Summer 2022	305	270.34
	Summer 2022	555	
	Summer 2022	220	
	Summer 2022	165	
	Summer 2022	235	
TURKE001.7T1.9KN[e,f]	Summer 2022	210	324.02
	Summer 2022	395	
	Summer 2022	185	
	Summer 2022	245	
	Summer 2022	950	
TURKE001.7T2.2KN[c,f]	6/12/2013	62	-
TURKE001.7T2.6KN[c,f]	6/12/2013	370	-
TURKE001.7T2.6KN[c,f]	6/12/2013	44	-
TURKE001.8KN[e,f]	Summer 2022	35	116.22
	Summer 2022	130	
	Summer 2022	175	
	Summer 2022	355	
	Summer 2022	75	
TURKE002.3KN[b]	9/19/2022	270	132.63
	9/21/2022	93	
	9/27/2022	99	
	9/29/2022	96	

	10/3/2022	172	
TURKE002.5T0.1KN[b]	9/19/2022	345	346.45
	9/21/2022	365	
	9/27/2022	579	
	9/29/2022	326	
	10/3/2022	210	
TURKE002.6KN[d]	8/8/2007	345	370.42
	8/13/2007	1203	
	8/15/2007	308	
	8/20/2007	613	
	8/21/2007	89	
TURKE002.6KN[d]	8/22/2007	411	-
TURKE002.6KN[d]	8/27/2007	1203	-
TURKE002.6KN[d]	9/18/2007	436	-
TURKE002.6KN[d]	10/17/2007	140	-
TURKE002.6KN[d]	11/20/2007	250	-
TURKE002.6KN[d]	1/15/2008	387	-
TURKE002.6KN[d]	2/19/2008	488	-
TURKE002.6KN[d]	3/18/2008	158	-
TURKE002.6KN[d]	4/17/2008	147	-
TURKE002.6KN[d]	5/20/2008	236	-
TURKE002.6KN[d]	7/15/2008	411	-
TURKE002.6KN[d]	9/17/2008	179	-
TURKE002.6KN[d]	10/28/2008	88	-
TURKE002.6KN[d]	11/21/2008	101	-
TURKE002.6KN[d]	12/18/2008	166	-
TURKE002.6KN[d]	3/3/2009	12	-
TURKE002.6KN[d]	8/7/2012	2420	504.02
	8/9/2012	326	
	8/21/2012	236	
	8/23/2012	285	
	8/28/2012	613	
TURKE002.6KN[d]	7/10/2017	770	689.97
	7/12/2017	488	
	7/17/2017	613	
	7/26/2017	1046	
	8/3/2017	649	
TURKE002.6KN[d]	7/14/2022	1732.9	-
TURKE002.6KN[d]	8/16/2022	816.4	-
TURKE002.8KN[e,f]	Summer 2022	340	192.99
	Summer 2022	125	

	Summer 2022	90	
	Summer 2022	350	
	Summer 2022	200	
TURKE003.3KN[e,f]	Summer 2022	185	131.03
	Summer 2022	240	
	Summer 2022	60	
	Summer 2022	100	
	Summer 2022	145	
TURKE003.9KN[c]	7/16/2015	170	262.14
	7/17/2015	370	
	7/17/2015	240	
	7/20/2015	200	
	7/28/2015	410	
TURKE004.2KN[e,f]	Summer 2022	105	207.52
	Summer 2022	265	
	Summer 2022	100	
	Summer 2022	520	
	Summer 2022	266	
TURKE004.7KN[b]	9/28/2021	225	171.19
	9/30/2021	214	
	10/12/2021	152	
	10/14/2021	124	
	10/18/2021	162	
TURKE004.7KN[b]	9/19/2022	140	196.35
	9/21/2022	116	
	9/27/2022	179	
	9/29/2022	326	
	10/3/2022	308	
TURKE004.9KN[b]	9/28/2021	387	236.45
	9/30/2021	214	
	10/12/2021	236	
	10/14/2021	137	
	10/18/2021	276	
TURKE005.0KN[b]	9/28/2021	1733	960.10
	9/30/2021	2420	
	10/12/2021	816	
	10/14/2021	548	
	10/18/2021	435	
TURKE005.0KN[b]	9/19/2022	148	175.54
	9/21/2022	86	
	9/27/2022	260	

	9/29/2022	138	
	10/3/2022	365	
TURKE006.3KN[e,f]	Summer 2022	3480	3334.95
	Summer 2022	2800	
	Summer 2022	2400	
	Summer 2022	4200	
	Summer 2022	4200	
Upstream NFTC[c,f]	11/2/2010	310	-

Table 1. Comprehensive Table of Samples taken in Turkey Creek and Little Turkey Creek for E. coli monitoring from 2007-2022.

[a] City of Knoxville Samples
[b] Knox County Samples
[c] Town of Farragut Samples
[d] TDEC Samples
[e] UT Students Isabelle Hamby and Alexandra Hospital Samples
[f] Samples originally reported in CFU/100mL

Table 2, A + B. TDEC Habitat and Benthic Macroinvertebrate Assessment Data

DWR Station ID	Location Name	Activity Date	Habitat Type	Habitat Score	Epifaunal Substrate	Embedded-ness	Velocity Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency Of Reoxygenation	Bank Stability LDB	Bank Stability RDB	Vegetative Protection LDB	Vegetative Protection RDB	Riparian Width LDB	Riparian Width RDB
LTURK002.1KN	Little Turkey Creek	5/25/16	HG	**139**	16	14	14	13	16	12	17	7	6	6	5	9	4
LTURK002.1KN	Little Turkey Creek	7/24/07	HG	**154**	14	16	14	17	15	18	18	9	9	7	7	8	2
LTURK002.1KN	Little Turkey Creek	7/26/12	HG	**144**	11	15	15	15	11	15	16	8	8	8	8	5	9
LTURK002.1KN	Little Turkey Creek	9/10/03	HG	**144**	8	18	13	18	14	18	14	9	8	6	6	7	5
LTURK002.4KN	Little Turkey Creek	5/25/16	HG	**151**	16	16	15	14	16	14	18	8	7	8	6	9	4
LTURK002.1KN	Little Turkey Creek	10/9/15	HG	**142**	16	15	15	10	17	14	18	6	6	5	5	9	6
LTURK004.6KN	Little Turkey Creek	10/21/08	HG	**112**	11	9	13	10	16	11	11	4	6	6	5	2	8
LTURK002.1KN	Little Turkey Creek	10/21/08	HG	**158**	17	16	18	16	16	13	16	9	8	9	6	9	5
TURKE002.6KN	Turkey Creek	8/8/22	HG	**127**	15	13	13	13	15	13	15	5	7	5	5	3	5
TURKE002.6KN	Turkey Creek	7/24/07	HG	**138**	15	17	14	15	17	15	9	6	8	6	7	2	7
TURKE002.6KN	Turkey Creek	7/18/17	HG	**136**	11	17	15	13	17	10	15	6	6	8	8	5	5
TURKE002.6KN	Turkey Creek	8/3/12	HG	**143**	15	15	15	15	15	15	15	8	8	8	8	3	3
TURKE004.8KN	Turkey Creek	8/30/19	HG	**56**	2	1	4	5	16	5	3	3	3	5	5	1	3
TURKE002.6KN	Turkey Creek	9/10/03	HG	**125**	15	15	13	13	14	14	12	4	7	6	6	3	3

Table 2A. TDEC Habitat Assessment data. The highlighted column represents the total habitat scores for each assessment.

DWR Station ID	Location Name	Activity Date	Activity Type	TMI	Total Individuals	TR	EPT	ETO	%EPT-Cheum	%OC	NCBI	%Clingers-Cheum	%TNutol
LTURK002.1KN	Little Turkey Creek	10/9/15	Sample-Routine	**12**	238	17	3	-	13.4	52.9	6.2	23.9	63.9
LTURK002.1KN	Little Turkey Creek	7/24/07	Sample-Routine	**28**	190	23	3	-	56.3	6.8	5.15	33.2	17.4
LTURK004.6KN	Little Turkey Creek	10/21/08	Sample-Routine	**16**	248	11	2	-	12.5	17.3	5.68	24.2	74.2
LTURK002.1KN	Little Turkey Creek	10/21/08	Sample-Routine	**22**	229	11	3	-	22.7	3.5	5.25	52.4	47.6
LTURK002.4KN	Little Turkey Creek	5/25/16	Sample-Routine	**20**	189	28	3	-	37	39.7	5.66	15.9	33.9
LTURK002.1KN	Little Turkey Creek	7/24/07	Quality Control	**34**	215	29	3	-	57.2	13.5	4.96	38.1	20
LTURK002.1KN	Little Turkey Creek	7/26/12	Sample-Routine	**36**	191	18	4	-	64.9	15.2	4.62	61.8	27.2
LTURK002.1KN	Little Turkey Creek	5/25/16	Sample-Routine	**24**	184	23	5	-	32.6	48.4	5.33	19	31
TURKE002.6KN	Turkey Creek	8/3/12	Sample-Routine	**24**	199	20	5	-	31.7	19.6	5.51	43.7	52.8
TURKE004.8KN	Turkey Creek	8/30/19	Sample-Routine	**14**	168	23	1	-	0	35.1	6.91	17.9	38.1
TURKE002.6KN	Turkey Creek	7/24/07	Sample-Routine	**24**	177	19	4	-	31.6	14.7	5.2	42.4	54.2
TURKE002.6KN	Turkey Creek	7/18/17	Sample-Routine	**24**	180	22	6	-	20.6	8.3	5.56	42.8	65

Table 2B: TDEC's Tennessee Macroinvertebrate Index data. The highlighted column represents the total TMI scores for each sample.

Sample Name	Parameter	Parameter Description	Dry Weather Sampling Result	Result Qualifier	Wet Weather Sampling Result	Result Qualifier	Sample Location
TC1	CGBACT-1	Goose-1	4.50E+00	<	8.10E+00	<	Turkey Creek just north of Campbell Station Road near Concord Road intersection
TC1	CGBACT-2	Goose-2	4.50E+00	<	8.10E+00	<	
TC1	DBACT	Dog	4.50E+00	<	**3.10E+00**	J	
TC1	Gull-CAT	Gull	4.50E+00	<	**6.00E-01**	J	
TC1	HF183	Human	4.50E+00	<	8.10E+00	<	
TC2	CGBACT-1	Goose-1	4.80E+00	<	5.60E+00	<	Founders Park
TC2	CGBACT-2	Goose-2	4.80E+00	<	5.60E+00	<	
TC2	DBACT	Dog	4.80E+00	<	**4.00E-01**	J	
TC2	Gull-CAT	Gull	4.80E+00	<	5.60E+00	<	
TC2	HF183	Human	4.80E+00	<	**7.15E+01**	=	
TC3	CGBACT-1	Goose-1	5.20E+00	<	6.00E+00	<	Behind Costco southwest of the Turkey Creek Wetlands
TC3	CGBACT-2	Goose-2	5.20E+00	<	6.00E+00	<	
TC3	DBACT	Dog	5.20E+00	<	6.00E+00	<	
TC3	Gull-CAT	Gull	5.20E+00	<	6.00E+00	<	
TC3	HF183	Human	5.20E+00	<	6.00E+00	<	
TC4	CGBACT-1	Goose-1	5.40E+00	<	5.90E+00	<	In Knox County south of Outlet Drive
TC4	CGBACT-2	Goose-2	5.40E+00	<	5.90E+00	<	
TC4	DBACT	Dog	5.40E+00	<	5.90E+00	<	
TC4	Gull-CAT	Gull	5.40E+00	<	**1.40E+00**	J	
TC4	HF183	Human	5.40E+00	<	5.90E+00	<	

Table 3. Comprehensive results of source tracking conducted by the Town of Farragut.

< Not Detected

J Estimated below PQL but above LQL

= Above PQL

Figures 1-3. Channel Stability Ranking Sheets for Rapid Geomorphic Assessments (RGAs)

CHANNEL-STABILITY RANKING SCHEME

River_________________________ Site Identifier____________________________________

Date _____________ Time_______ Crew _______________ Samples Taken_________________________

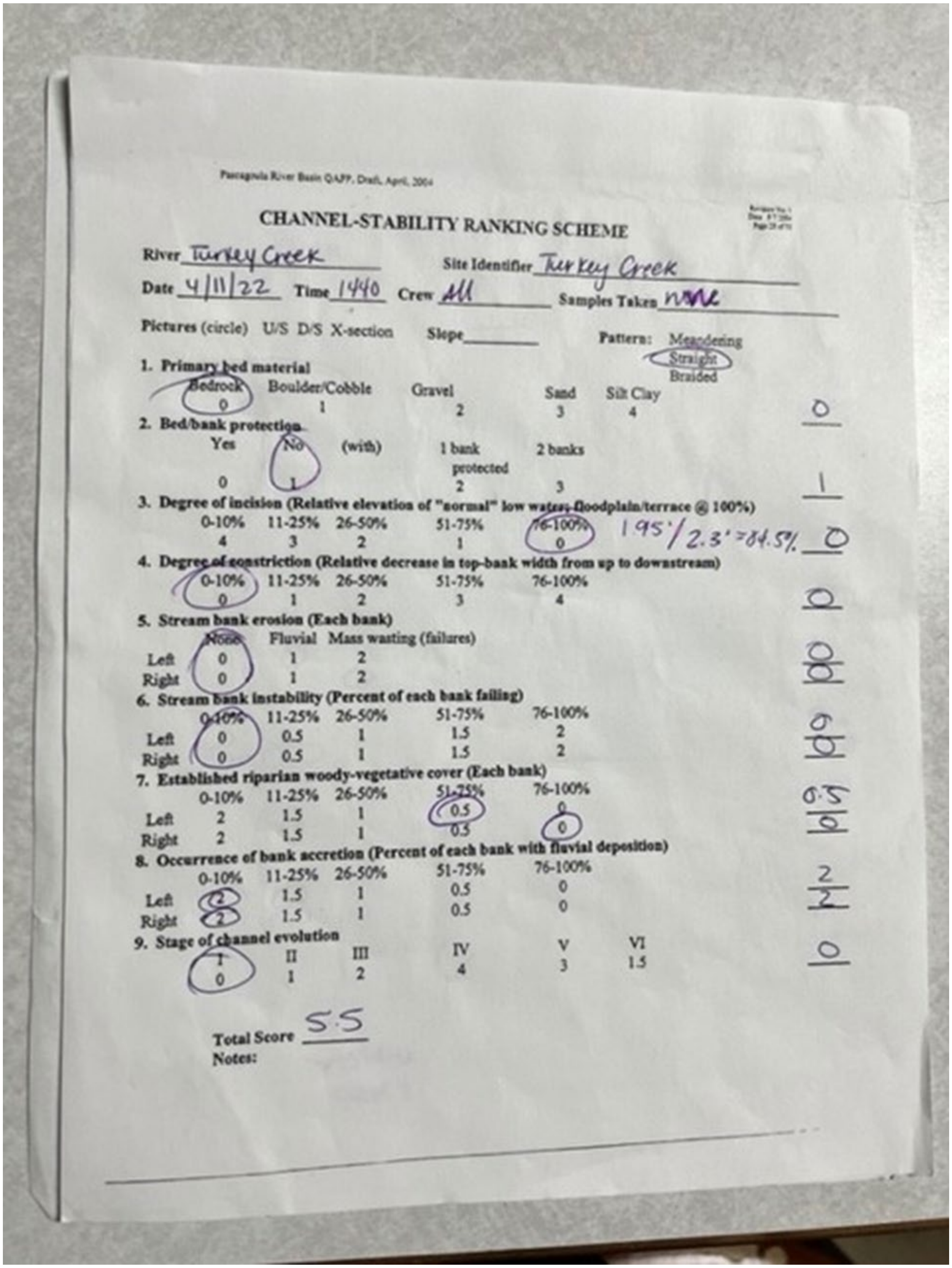
Pictures (circle) U/S D/S X-section Slope__________ Pattern: Meandering

Straight

Braided

1. Primary bed material							
	Bedrock	Boulder/Cobble		Gravel	Sand	Silt Clay	
	0	1		2	3	4	_____
2. Bed/bank protection							
	Yes	No	(with)	1 bank	2 banks		
				protected			
	0	1		2	3		_____
3. Degree of incision (Relative elevation of "normal" low water; floodplain/terrace @ 100%)							
	0-10%	11-25%	26-50%	51-75%	76-100%		
	4	3	2	1	0		_____
4. Degree of constriction (Relative decrease in top-bank width from up to downstream)							
	0-10%	11-25%	26-50%	51-75%	76-100%		
	0	1	2	3	4		_____
5. Stream bank erosion (Each bank)							
	None	Fluvial	Mass wasting (failures)				
Left	0	1	2				_____
Right	0	1	2				_____
6. Stream bank instability (Percent of each bank failing)							
	0-10%	11-25%	26-50%	51-75%	76-100%		
Left	0	0.5	1	1.5	2		_____
Right	0	0.5	1	1.5	2		_____
7. Established riparian woody-vegetative cover (Each bank)							
	0-10%	11-25%	26-50%	51-75%	76-100%		
Left	2	1.5	1	0.5	0		_____
Right	2	1.5	1	0.5	0		_____
8. Occurrence of bank accretion (Percent of each bank with fluvial deposition)							
	0-10%	11-25%	26-50%	51-75%	76-100%		
Left	2	1.5	1	0.5	0		_____
Right	2	1.5	1	0.5	0		_____
9. Stage of channel evolution							
	I	II	III	IV	V	VI	
	0	1	2	4	3	1.5	_____

Figure 1. Channel stability ranking scheme used to conduct rapid geomorphic assessments RGAs. The channel stability index is the sum of the values obtained for the nine criteria.



Pascagoula River Basin QAPP, Draft, April, 2004

CHANNEL-STABILITY RANKING SCHEME

River Turkey Creek Site Identifier Turkey Creek

Date 4/11/22 Time 1440 Crew All Samples Taken none

Pictures (circle) U/S D/S X-section Slope________ Pattern: Meandering [✓ Straight] Braided

1. Primary bed material

[✓ Bedrock]	Boulder/Cobble	Gravel	Sand	Silt Clay	
[✓ 0]	1	2	3	4	0

2. Bed/bank protection

Yes	[✓ No]	(with)	1 bank protected	2 banks	
0	[✓ 1]		2	3	1

3. Degree of incision (Relative elevation of "normal" low water; floodplain/terrace @ 100%)

0-10%	11-25%	26-50%	51-75%	[✓ 76-100%]	
4	3	2	1	[✓ 0]	1.95'/2.3' = 84.5% 0

4. Degree of constriction (Relative decrease in top-bank width from up to downstream)

[✓ 0-10%]	11-25%	26-50%	51-75%	76-100%	
[✓ 0]	1	2	3	4	0

5. Stream bank erosion (Each bank)

	[✓ None]	Fluvial	Mass wasting (failures)	
Left	[✓ 0]	1	2	0
Right	[✓ 0]	1	2	0

6. Stream bank instability (Percent of each bank failing)

	[✓ 0-10%]	11-25%	26-50%	51-75%	76-100%	
Left	[✓ 0]	0.5	1	1.5	2	0
Right	[✓ 0]	0.5	1	1.5	2	0

7. Established riparian woody-vegetative cover (Each bank)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	2	1.5	1	[✓ 0.5]	0	0.5
Right	2	1.5	1	0.5	[✓ 0]	0

8. Occurrence of bank accretion (Percent of each bank with fluvial deposition)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	[✓ 2]	1.5	1	0.5	0	2
Right	[✓ 2]	1.5	1	0.5	0	2

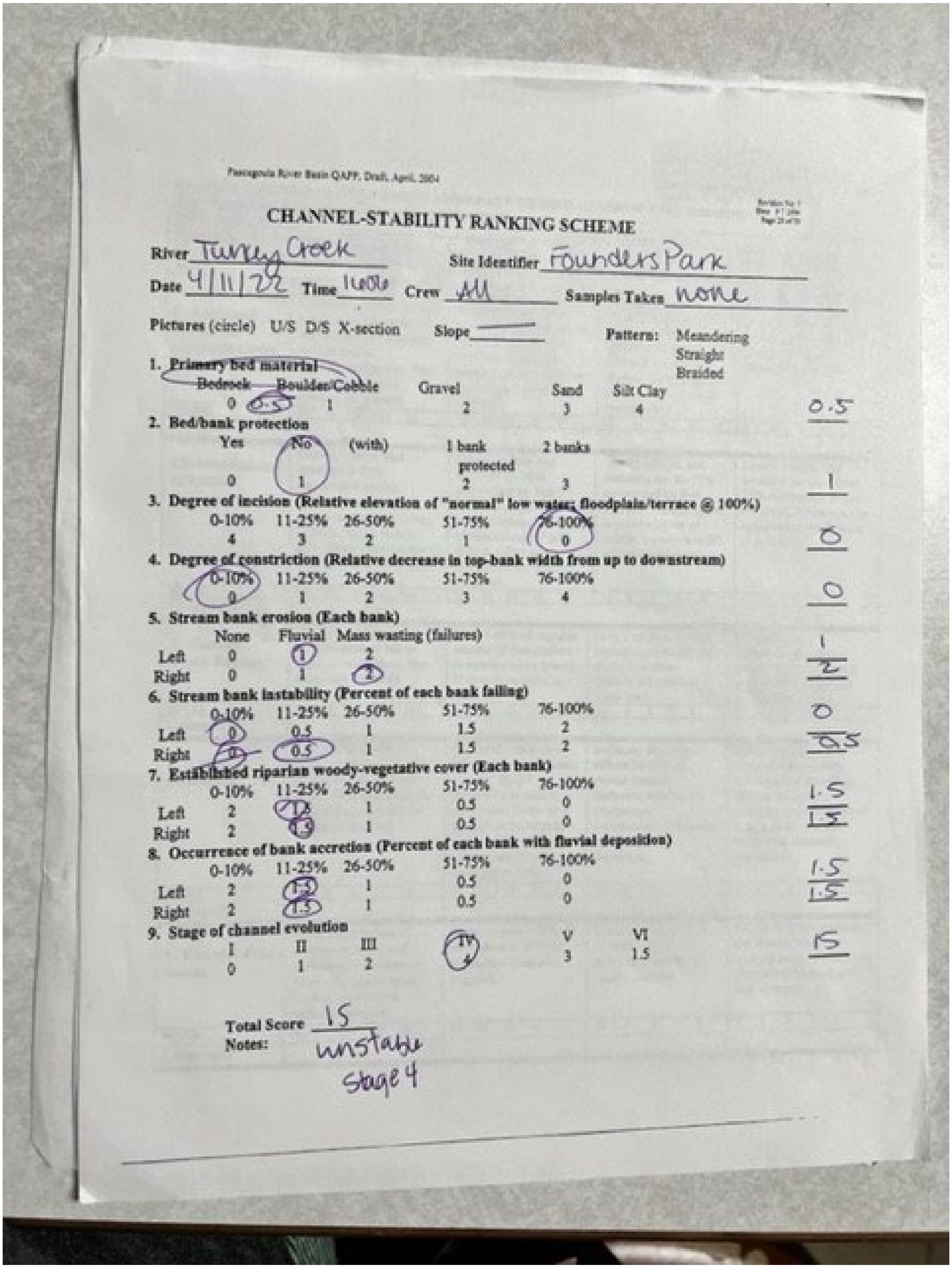
9. Stage of channel evolution

[✓ I]	II	III	IV	V	VI	
[✓ 0]	1	2	4	3	1.5	0

Total Score 5.5

Notes:

Figure 2. RGA field data sheet for Turkey Creek below Red Mill Dam



Pascagoula River Basin QAPP, Draft, April, 2004

CHANNEL-STABILITY RANKING SCHEME

River Turkey Creek Site Identifier Founders Park

Date 4/11/22 Time 1600 Crew All Samples Taken none

Pictures (circle) U/S D/S X-section Slope ______ Pattern: Meandering
Straight
Braided

1. Primary bed material

Bedrock		Boulder/Cobble	Gravel	Sand	Silt Clay
0	[✓ 0.5]	1	2	3	4

0.5

2. Bed/bank protection

Yes	No	(with)	1 bank protected	2 banks
0	[✓ 1]		2	3

1

3. Degree of incision (Relative elevation of "normal" low water; floodplain/terrace @ 100%)

0-10%	11-25%	26-50%	51-75%	76-100%
4	3	2	1	[✓ 0]

0

4. Degree of constriction (Relative decrease in top-bank width from up to downstream)

0-10%	11-25%	26-50%	51-75%	76-100%
[✓ 0]	1	2	3	4

0

5. Stream bank erosion (Each bank)

	None	Fluvial	Mass wasting (failures)
Left	0	[✓ 1]	2
Right	0	1	[✓ 2]

1
2

6. Stream bank instability (Percent of each bank failing)

	0-10%	11-25%	26-50%	51-75%	76-100%
Left	[✓ 0]	0.5	1	1.5	2
Right	[✓ 0]	[✓ 0.5]	1	1.5	2

0
0.5

7. Established riparian woody-vegetative cover (Each bank)

	0-10%	11-25%	26-50%	51-75%	76-100%
Left	2	[✓ 1.5]	1	0.5	0
Right	2	[✓ 1.5]	1	0.5	0

1.5
1.5

8. Occurrence of bank accretion (Percent of each bank with fluvial deposition)

	0-10%	11-25%	26-50%	51-75%	76-100%
Left	2	[✓ 1.5]	1	0.5	0
Right	2	[✓ 1.5]	1	0.5	0

1.5
1.5

9. Stage of channel evolution

I	II	III	IV	V	VI
0	1	2	[✓ 4]	3	1.5

15

Total Score 15

Notes: unstable
stage 4

Figure 3. RGA Field Data Sheet for North Fork Turkey Creek at Founders Park

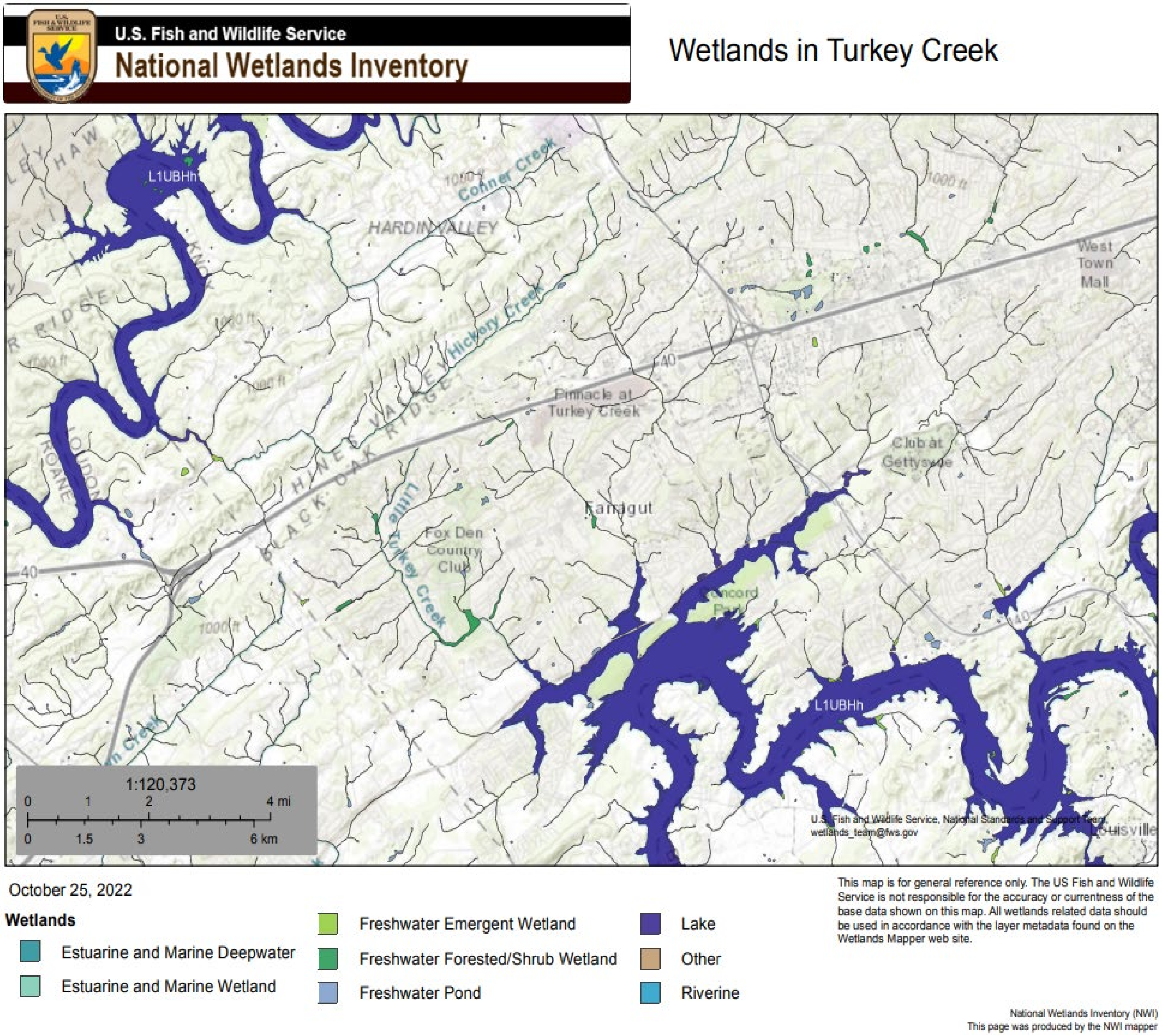


Figure 4. Wetlands in Turkey Creek

Watershed	Gully	Top Width (ft)	Bottom Width (ft)	Depth (ft)	Length (ft)	Years to Form	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Nutrient Correction Factor	Annual Load (ton)	Load Reduction (ton)
W1	Gully1.1	6	2	3	1250	1	0.9	Clay loam	0.0375	1.15	562.50	506.25
W1	Gully1.2	8	3	3	1100	2	0.9	Clay loam	0.0375	1.15	340.31	306.28
W1	Gully1.3	10	4	4	950	3	0.9	Clay loam	0.0375	1.15	332.50	299.25
W2	Gully2.1	6	2	3	650	1	0.9	Clay loam	0.0375	1.15	292.50	263.25
W2	Gully2.2	8	3	3	450	2	0.9	Clay loam	0.0375	1.15	139.22	125.30
W2	Gully2.3	10	4	4	100	3	0.9	Clay loam	0.0375	1.15	35.00	31.50
W3	Gully3.1	6	2	3	900	1	0.9	Clay loam	0.0375	1.15	405.00	364.50
W3	Gully3.2	8	3	3	900	2	0.9	Clay loam	0.0375	1.15	278.44	250.59
W3	Gully3.3	10	4	4	500	3	0.9	Clay loam	0.0375	1.15	175.00	157.50

Table 4. Gully Dimensions of Sub-watersheds.

Watershed	Strm Bank	Length (ft)	Height (ft)	Lateral Recession	Rate Range (ft/yr)	Rate (ft/yr)	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Nutrient Correction Factor	Annual Load (ton)	Load Reduction (ton)
W1	Bank1.1	1000	2	2. Moderate	0.06 - 0.2	0.13	0.95	Clay loam	0.0375	1.15	9.75	9.26
W1	Bank1.2	700	3	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	1.15	29.40	27.93
W1	Bank1.3	700	4	3. Severe	0.3 - 0.5	0.4	0.95	Clay loam	0.0375	1.15	42.00	39.90
W1	Bank1.4	1150	2	1. Slight	0.01 - 0.05	0.03	0.95	Clay loam	0.0375	1.15	2.59	2.46
W1	Bank1.5	1000	3	2. Moderate	0.06 - 0.2	0.13	0.95	Clay loam	0.0375	1.15	14.63	13.89
W2	Bank2.1	300	2	2. Moderate	0.06 - 0.2	0.13	0.95	Clay loam	0.0375	1.15	2.93	2.78
W2	Bank2.2	210	3	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	1.15	8.82	8.38
W2	Bank2.3	210	4	3. Severe	0.3 - 0.5	0.4	0.95	Clay loam	0.0375	1.15	12.60	11.97
W2	Bank2.4	345	2	1. Slight	0.01 - 0.05	0.03	0.95	Clay loam	0.0375	1.15	0.78	0.74
W2	Bank2.5	300	3	2. Moderate	0.06 - 0.2	0.13	0.95	Clay loam	0.0375	1.15	4.39	4.17
W3	Bank3.1	700	2	2. Moderate	0.06 - 0.2	0.13	0.95	Clay loam	0.0375	1.15	6.83	6.48
W3	Bank3.2	490	3	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	1.15	20.58	19.55
W3	Bank3.3	490	4	3. Severe	0.3 - 0.5	0.4	0.95	Clay loam	0.0375	1.15	29.40	27.93
W3	Bank3.4	805	2	1. Slight	0.01 - 0.05	0.03	0.95	Clay loam	0.0375	1.15	1.81	1.72
W3	Bank3.5	700	3	2. Moderate	0.06 - 0.2	0.13	0.95	Clay loam	0.0375	1.15	10.24	9.73

Table 5. Impaired Streambank Dimensions in Sub-watersheds.

Table 6 A-C. Reference Values for Tables 3 and 4 Above.

Soil Textural Class	Dry Density (tons/ft3)	Correction Factor
Clay	0.035	1.15
Clay loam	0.0375	1.15
Fine Sandy loam	0.05	0.85
Loams, sandy clay loams	0.045	0.85
Organic	0.011	1.5
Sands, Loamy sands	0.055	0.85
Sandy clay	0.045	0.85
Sandy loam	0.0525	0.85
Silt Loam	0.0425	1
Silty clay loam, silty clay	0.04	1

Category	LRR (ft/yr)	Medium Value
1. Slight	0.01 - 0.05	0.03
2. Moderate	0.06 - 0.2	0.13
3. Severe	0.3 - 0.5	0.4
4. Very Severe	0.5+	0.5

Category	Description	Lateral Recession Rate (ft/yr)
Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative	0.01 - 0.05
Moderate	Bank is predominantly bare with some rills and vegetative overhang.	0.06 - 0.2
Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.	0.3 - 0.5
Very Seve	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and streamcourse or gully may be meandering.	0.5+

Source: Steffen, L.J. 1982. Channel Erosion (personal communication), as printed in "Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual," June 1999 Revision; Michigan Department of Environmental Quality - Surface Water Quality Division - Nonpoint Source Unit. EQP 5841 (6/99).