Beaver Creek
Watershed Restoration Plan

November 2006

Acknowledgements

This plan was developed from the cooperative efforts of the partner organizations that make up the Knoxville/Knox County Water Quality Forum. It is intended to guide the Beaver Creek Task Force's efforts to restore Beaver Creek and its tributaries to fully supporting status for all designated uses, and to protect public health and well being by addressing water quality issues that accompany agricultural and urban land uses. This restoration 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.

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*** Denotes an EPA-required component for watershed plans (EPA, 2003)**

List of Acronyms

AnnAGNPS	Annualized Agricultural Non-Point Source Pollution
BCTF	Beaver Creek Task Force
BMP	Best Management Practice
DEM	Digital Elevation Model
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
HPUD	Hallsdale-Powell Utility District
HSPF	Hydrologic Simulation Program FORTRAN
HUAP	Heavy Use Area Protection
HUC	Hydrological Unit Code
KGIS	Knoxville, Knox County, KUB Geological Information System
KLWC	Knox Land and Water Conservancy
KUB	Knoxville Utilities Board
MPC	Knoxville-Knox County Metropolitan Planning Commission
MS4	Municipal Separate Storm Sewer System
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PGA	Planned Growth Area
RA	Rural Area
STATSGO	State Soil Geographic Database
SWPPP	Stormwater Pollution Prevention Plan
TDEC	Tennessee Department of Environment and Conservation
TDOT	Tennessee Department of Transportation
TMDL	Total Maximum Daily Load
TVA	Tennessee Valley Authority
UGB	Urban Growth Boundary
UT	University of Tennessee
TNWRRC	Tennessee Water Resources Research Center, University of Tennessee
WKUD	West Knox Utility District

Executive Summary

The Beaver Creek Watershed (HUC TN-06010207-011) is located in the 630-square-mile Lower Clinch River Watershed of East Tennessee. Its 86 square miles lie entirely within the northern portion of Knox County. The 44 miles of main stem plus seven main tributaries wind through five different communities before emptying into the Clinch River.

The Beaver Creek Watershed is a rapidly urbanizing watershed with approximately 75,000 residents today and a projected population of 108,000 by the year 2030, an increase of 45%. Nearly all of Beaver Creek and its major tributaries are on the State of Tennessee's 303(d) list of impaired streams. Causes of impairment include phosphorus, nitrates, *E. coli*, low dissolved oxygen, loss of biological integrity due to siltation, and physical substrate habitat alteration. Pollution sources include major municipal point sources, pasture grazing, and discharges from Knox County's NPDES-permitted Municipal Separate Storm Sewer System (MS4). The Tennessee Department of Environment and Conservation (TDEC) has developed and EPA has approved Total Maximum Daily Load (TMDL) reports for Siltation and Habitat Alteration and Pathogens for the Lower Clinch River Watershed.

Beaver Creek's water quality problems have not gone unnoticed by local organizations, governmental agencies, and area residents. Through cooperative efforts, a great amount of information about the watershed has already been compiled and the essential groundwork has been laid for a multi-pronged approach to restoration, of which this plan is a key component.

This watershed restoration plan (WRP) was developed to provide a comprehensive plan for restoring Beaver Creek and its tributaries to fully support their designated uses and remove them from the 303(d) list. The plan focuses on promoting the use of Best Management Practices (BMPs) to reduce siltation, since siltation poses the more severe problem for Beaver Creek. Model results from AnnAGNPS and HSPF will be used to determine priority areas. A comprehensive riparian buffer assessment will be performed during year one of the project to help ground truth the models' results. Pathogens and nutrients will be addressed in a subsequent WRP.

Since Tennessee does not have water quality criteria for sediment, the recovery of biological communities is used to evaluate whether sediment reduction goals are being met. The plan has therefore been designed to include goals that are thought to be achievable and will result in the recovery of biological communities. Partners expect that it will take 15 years to reduce sediment by the amount necessary to delist the streams in the watershed. As a result, this WRP is being written to reflect the first 5 years (Phase I). During year 5, Phase II will be designed based on the accomplishments and monitoring of Phase I. The WRP's reduction goals may need to be revised upon reassessment of the biological communities.

The plan sets out a strategy for reducing sediment by 44% from agricultural areas, 20% from urban areas and 70% from construction sites. Using the North Fork Bullrun Creek Watershed, a similar adjacent watershed as a reference, analysis shows that a watershed-wide sediment reduction of 38% should be sufficient to support fish and aquatic life. Since there is a degree of uncertainty regarding the linkage between sediment and the biological communities, the plan acknowledges the need to reassess the biological community periodically to determine if the reduction goal is adequate for stream recovery.

This plan follows EPA's Section 319 watershed plan guidelines and addresses each of the nine required components. Sections of this plan that specifically address one of these nine components are indicated with an ***** after the section title.

1.0 Introduction

Background
The Beaver Creek Watershed (HUC TN-06010207-011) in East Tennessee drains an area of approximately 86 square miles in the southeastern part of the Lower Clinch River Watershed. Twenty-five miles long and 3.5 miles wide, the watershed is entirely contained within the northern portion of Knox County (Figure 1).

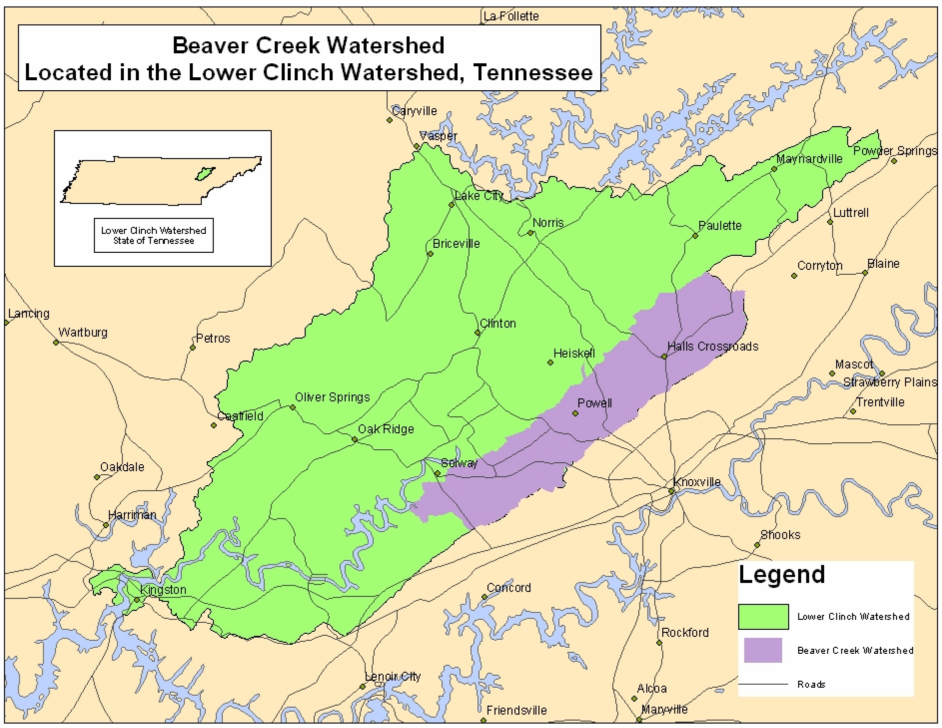

Figure 1 Beaver Creek Watershed Map

Beaver Creek has served as a vital natural resource for area residents for many generations. In the last 15 years, however, the watershed has seen a significant increase in the rate of development. This growth has been characterized by sprawling, low-density residential development and corridor commercial development, both of which are replacing farmland and open space at an unprecedented rate. Road improvement projects underway or planned for the near future will likely result in even more development pressure in the watershed.

According to the State of Tennessee's 2006 Draft 303(d) list (Table 1), approximately 43.7 miles of Beaver Creek are considered "impaired" and have been placed in "Category 5." "Category 5" indicates that one or more uses are not met and that a Total Maximum Daily Load (TMDL) value needs to be established for the listed pollutants. The designated use classifications for Beaver Creek include fish and aquatic life, recreation, irrigation, and livestock watering and wildlife. Portions of Beaver Creek are also designated for domestic and/or industrial water supply. Both Hallsdale Powell Utility District (HPUD) and West Knox Utility District (WKUD) draw water from Beaver Creek.

Waterbody ID	Impacted Waterbody	County	Miles/Acres Impaired	CAUSE /TMDL Priority	Pollutant Source	COMMENTS
TN06010207 011 – 1000	BEAVER CREEK	Knox	22.5	Phosphorus M Nitrates M Escherichia coli NA Low Dissolved Oxygen Loss of biological integrity due to siltation M Physical Substrate Habitat Alterations M	Major Municipal Point Source Pasture Grazing Discharges from MS4 Area	Stream is Category 5. Impaired, but EPA has approved a pathogen TMDL that addresses some of the known pollutants.
TN06010207 011 – 2000	BEAVER CREEK	Knox	13.7	Escherichia coli NA Loss of biological integrity due to siltation M Physical Substrate Habitat alterations M	Pasture Grazing Discharges from MS4 Area	Stream is Category 5. Impaired, but EPA has approved a pathogen TMDL that addresses some of the known pollutants.
TN06010207 011 – 3000	BEAVER CREEK	Knox	7.5	Escherichia coli NA Loss of biological integrity due to siltation M Physical Substrate Habitat alterations M	Pasture Grazing Discharges from MS4 Area	Stream is Category 5. Impaired, but EPA has approved a pathogen TMDL that addresses some of the known pollutants.

Table 1 TDEC 2006 Draft 303d List

Beaver Creek's major tributaries -- including Cox Creek, Willow Fork, Hines Creek, Knob Fork, Grassy Creek, Meadow Creek, and Plumb Creek – are also impaired waters and are on the State's 2006 Draft 303(d) list. These tributaries are also Category 5 streams impacted by discharges from Municipal Separate Storm Sewer Systems (MS4) areas. Many small tributaries are not assessed.

The primary impacts to Beaver Creek and its tributaries are sediment, nutrients and pathogens from agricultural and urban runoff; nutrients and pathogens from municipal point sources such as sewage treatment plants; and habitat alteration due primarily to land development. Tables 2 and 3 shows Total Maximum Daily Loads (TMDLs) for siltation and habitat alteration (TDEC, 2006b) and pathogens (TDEC, 2006c) have been developed for the Lower Clinch Watershed.

Sediment TMDLs for Subwatersheds with Waterbodies Impaired for Siltation/Habitat Alteration

HUC-12 Subwatershed (06010207__)	Waterbody ID	Waterbody Impaired by Siltation/Habitat Alteration	Level IV Ecoregion	Existing Sediment Load [lbs/ac/yr]	Target Load [lbs/ac/yr]	TMDL (Required Load Reduction) [%]
0301	06010207011_0500	Hines Branch	67f	775	399.8	48.4
	06010207011_0600	Knob Fork				
	06010207011_2000	Beaver Creek				
	06010207011_3000	Beaver Creek				
0302	06010207011_0700	Grassy Creek	67f	669	399.8	42.8
	06010207011_0800	Meadow Creek				
	06010207011_1000	Beaver Creek				
	06010207011_2000	Beaver Creek				

Note: Calculations were conducted for all HUC-12 subwatersheds containing waterbodies identified as impaired for siltation/habitat alteration. Some impaired waterbodies extend across more than one HUC-12 subwatershed.

Table 2 TDEC TMDL for sediment in Beaver Creek Watershed

Pathogens TMDLs for Subwatersheds with Waterbodies Impaired for Siltation/Habitat Alteration

HUC-12 Subwatershed (06010103__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	Required Load Reduction				
			Based on 90th Percentile		Based on 30-day Geometric Mean		TMDL [%]
			Fecal Coliform	E. Coli	Fecal Coliform	E. Coli	
0302	BEAVER CREEK	TN06010207011 – 1000	**86.0**	**>65.0**			**86.0**
	BEAVER CREEK	TN06010207011 – 2000	**72.6**	**53.4**			
0301	BEAVER CREEK	TN06010207011 – 3000	**79.7**	**57.8**			**79.7**

(TDEC, 2006c)

Table 3 TDEC TMDL for pathogens in Beaver Creek Watershed

Beaver Creek's declining water quality has not gone unnoticed by local organizations, governmental agencies, and area residents. Through cooperative efforts, a great amount of information about the watershed has already been compiled and the essential groundwork has been laid for a multi-pronged approach to restoration, of which this plan is a key component. Moreover, since the rapid development and declining water quality being experienced in the Beaver Creek Watershed is expected to occur in many other communities across the State, restoration efforts in the Beaver Creek Watershed could be used as a model for other communities dealing with similar growth issues.

Through its current and future efforts the Beaver Creek Task Force (BCTF) envisions the Beaver Creek Watershed remaining a highly desirable place to live, with its beautiful vistas and open spaces protected, its waters swimmable and fishable, and its floodplain returned to its natural function of storing waters during high flows. It envisions vibrant communities that are distinct in history and culture yet united by the valley corridor. Communities will have access to Beaver Creek and its tributaries to recreate and reflect so that they may be better able to appreciate its ecology and be inspired to preserve and protect it through their own actions.

Partnerships and Accomplishments

Cooperative efforts to address water quality issues in the Beaver Creek Watershed originated with the Water Quality Forum, an organization formed in 1990 to address water quality and water quantity issues in Knoxville and surrounding counties. In 1998, the BCTF was formed as an outreach effort of the Water Quality Forum. Its mission is to bring together public and private institutions to implement a program to restore Beaver Creek back to a healthy stream that is fully supporting its designated uses by implementing restoration practices and promoting sound economic development.

Since then, the number of partners enlisted by the BCTF has grown to 19 local, state, and federal agencies, local utility districts, and grassroots citizens groups. One of the most recent partners to join is the Environmental Protection Agency (EPA) Region IV, which became an active member in 2005 and has designated Beaver Creek a priority watershed. Table 1-4 lists active partners.

• Beaver Creek Watershed Association	• Knoxville/Knox County/Knoxville Utility

• CAC AmeriCorps	Board GIS
• City of Knoxville	• Tennessee Department of Environment and Conservation
• Environmental Protection Agency, Region IV	• Tennessee Department of Transportation
• Hallsdale-Powell Utility District	• Tennessee Valley Authority
• Knox County Engineering and Public Works Stormwater Management Division	• Tennessee Water Resources Research Center, University of Tennessee
• Knox County Health Department	• USDA Natural Resources Conservation District
• Knox County Parks and Recreation	• United States Geological Survey
• Knox County Soil Conservation District	Water Quality Forum
• Knox Land and Water Conservancy	• West Knox Utility District
• Knoxville-Knox County Metropolitan Planning Commission	

Table 4 Beaver Creek Task Force Partners

Working together, these partners have accomplished a great deal. For example, one key accomplishment was adoption of the Knox County Stormwater Ordinance (2005). Reducing stormwater runoff from existing and new development is a top priority for the short and long term. Using a Center for Watershed Protection process, the Site Planning Roundtable made 21 recommendations to Knox County which were incorporated into the new stormwater manual that interprets the new ordinance. This code establishes site development criteria, design standards for detention and retention ponds, erosion and sediment control requirements, and stormwater facility maintenance responsibilities. It also expanded the no build/no fill zone in floodplains.

For a complete timeline of accomplishments to date, a brief description of the tasks accomplished by the BCTF, and a summary of cost-sharing dollars brought in from various sources to improve Beaver Creek, see Appendix A.

Purpose of this Plan

This Watershed Action Plan proposes to build on growing interest in water quality in the Beaver Creek Watershed by combining the technical capabilities and resources of multiple agencies and the private sector to promote the use of best management practices (BMPs) that will minimize impacts on water resources. For now, efforts will be focused on reducing sediment since it is the more serious problem for Beaver Creek and there is a greater potential for significant gains through BMPs. A subsequent watershed action plan will address impairment due to *E. coli* and nutrients.

This plan follows the current EPA Section 319 watershed plan guidelines and addresses each of the nine required components (USEPA, 2003). It serves as a guide to the BCTF partners and outlines their actions to restore water quality in the Beaver Creek Watershed. It also contains details for a 5-year effort to this end. Periodically, efforts and results will be re-evaluated and adapted as necessary to achieve goals. At completion, success of the restoration plan will be measured and evaluated through data results.

2.0 Description of Watershed

2.1 Physical Characteristics

Topography
The topography of the Beaver Creek watershed is characterized by a broad floodplain and rolling hills between two ridges. The watershed is bordered on the northwest by Copper Ridge and along the southeast by Black Oak Ridge. A third ridge, Beaver Ridge, is contained within the watershed and runs along the south bank of Beaver Creek.

A tributary of the Clinch River, Beaver Creek is a low gradient valley stream, falling 300 feet as it winds for 44 miles from the northeastern part of Knox County to the southwest part, passing through the watershed communities of Gibbs, Halls, Powell, Karns, and Solway. The channel gradient of 0.1% is typical of higher order streams in the region.

Climate
Air temperature in Knoxville ranges from an average January low of 38º F to an average high of 87º F in July. In the average year, there are 48.2" of total rain, 9.9"of snow, and 128 wet days (NWS, 2006).

Ecoregion
Beaver Creek is in the Level IV Southern Limestone/Dolomite Valleys and Low Rolling Hills Ecoregion, identified as Ecoregion 67f. Ecoregion 67f is a heterogeneous area, composed mainly of limestone and dolomite, but includes other rock formations and strata with varying characteristics.

Soil
To get an estimate of the types of soils present in the watershed, as well as how prevalent each is, the State Soil Geographic (STATSGO) Database was used. The STATSGO data base (USDA, 1997) is primarily for river basin, state, and multi-county resource planning, management and monitoring. Soil maps for STATSGO were made by generalizing the detailed soil survey maps. When detailed maps were not available, data on geology, topography, vegetation, and climate were assembled, together with satellite images. Rough percentages of STATSGO soil coverage are as shown in Table 5 and in Figure 2.

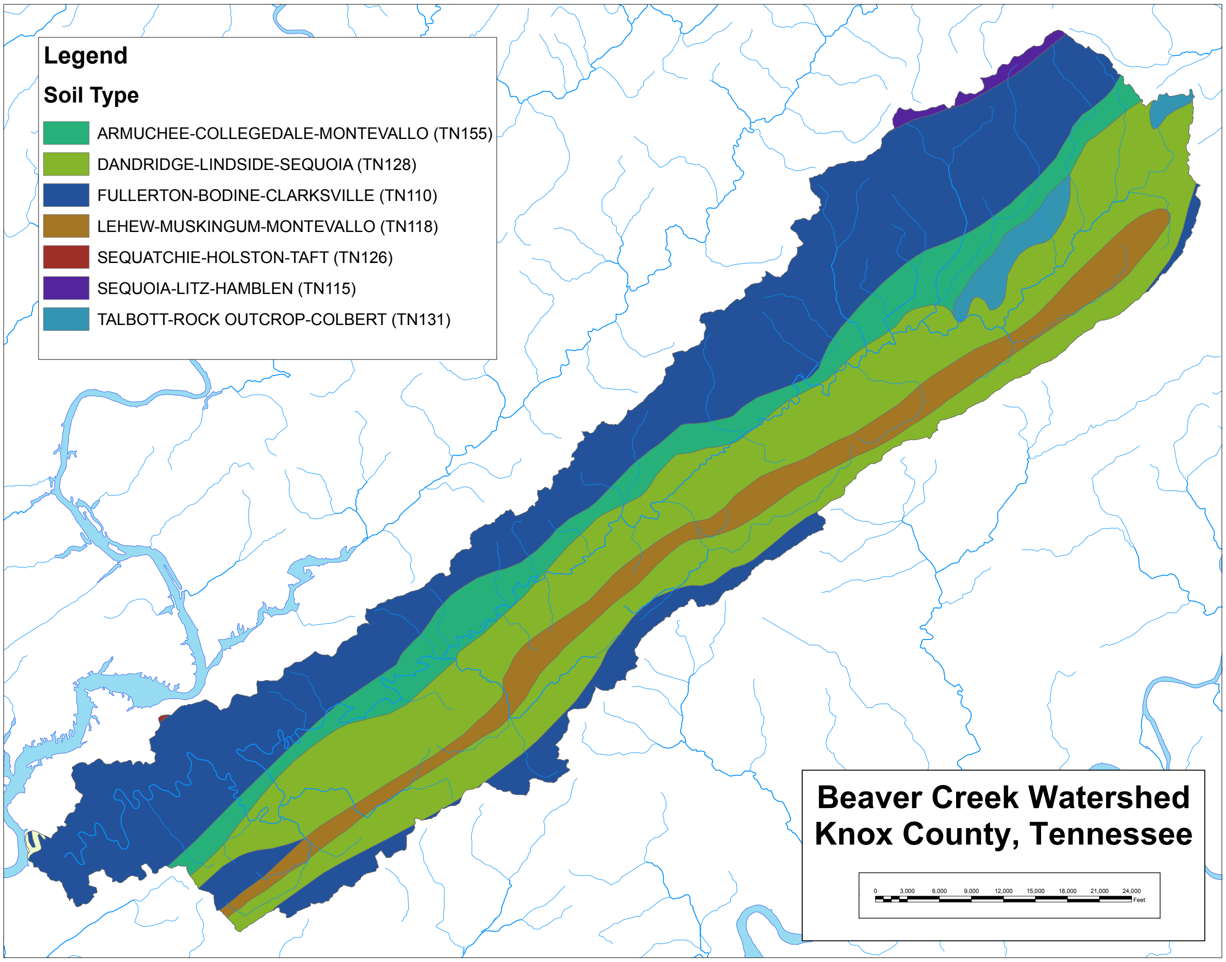

Figure 2 STATSGO Soil types for Beaver Creek

Soil Type	Percentage
Fullerton-Bodine-Clarksville (TN 110)	41
Dandridge-Lindside-Sequoia (TN 128)	36
Armuchee-Colledgedale-Montevallo (TN 155)	12
Lehew-M Usking Um-Montevallo (TN 118)	9
Sequoia-Litz-Hamblen (TN 115)	1
Talbott-Rock outcrop-Colbert (TN 131)	0.2

Table 5 Percentage by soil type in Beaver Creek

Threatened or Endangered Species

No federally listed threatened or endangered species have been identified in the Beaver Creek Watershed, though there are some species that can be found in the watershed that have been listed by the State (Table 6). Greater detail on codes used in species rankings in provide in the Appendix E.

060102070301 Beaver Creek, Upper		Federal Status	State Status	Global Rank	State Rank
Flowering Plant					
Carex alopecoidea	Foxtail Sedge		E-P	G5	SH
Carex gravida	Heavy Sedge		S	G5	S1
Bird					
Gallinula chloropus	Common Moorhen	No Status	D	G5	S1B

060102070302 Beaver Creek, Lower		Federal Status	State Status	Global Rank	State Rank
Flowering Plant					
Aureolaria patula	Spreading False-foxglove		T	G3	S3
Carex alopecoidea	Foxtail Sedge		E-P	G5	SH
Carex gravida	Heavy Sedge		S	G5	S1
Panax quinquefolius	American Ginseng		S-CE	G3G4	S3S4
Bird					
Tyto alba	Common Barn-owl		D	G5	S3

Table 6 Rare and vulnerable species in Beaver Creek Watershed

Livestock Population

According to TDEC, there are approximately 2,100 beef cattle, 150 milk cows, no poultry, 145 hogs, 110 sheep and 615 horses in the Beaver Creek Watershed (TDEC, 2006c).

Human Population

According to the Knoxville-Knox County Metropolitan Planning Commission (MPC), the population of the Beaver Creek Watershed is approximately 74,400. The MPC has projected population increases for transportation purposes, using the assumption that recent growth rates will continue. The MPC projects that the population within the watershed will increase to 108,000 by the year 2030, an increase of 45%.

Septic Systems

Sewer connections are available in the more developed portions of the watershed. Hallsdale-Powell Utility District (HPUD) operates a wastewater treatment plant that serves areas in north Knox County, including the watershed communities of Gibbs, Halls, Powell, and part of Karns. West Knox Utility District (WKUD) operates a wastewater treatment facility that serves the northwest part of Knox County, which includes the watershed communities of Karns and Solway. According to state data represented in the pathogen TMDL, approximately 33,328 people are served by septic systems in the Beaver Creek watershed (TDEC, 2006c).

Beaver Creek land use/land cover data were combined with sewer system data provided by HPUD. The results were used in the HSPF model. Approximately 20% of residences in the watershed depend on septic systems to treat waste. Rates are higher in more rural parts of Beaver Creek, with a maximum of 72% in the Knob Fork subwatershed.

Channelization and Impoundments

The lone impoundment on Beaver Creek is located at stream mile 10.1. It is known locally as Coward Mill Dam.

Using the data from the Knoxville, Knox County, KUB Geographic Information System (KGIS), the four-foot contour data indicates the top of the dam is at an elevation of approximately 912 feet. Analyzing the contour data and comparing it to the dam elevation can roughly approximate the impoundment distance, which appears to extend approximately one mile upstream of the dam. Monitoring data also indicates that the dam significantly influences the hydrology of the stream. Data retrieved from field velocity measurements 2 miles upstream of the dam and 2 miles downstream show that at these locations, the velocity downstream of the dam is nearly double the velocity of the water upstream of the dam.

These preliminary estimations suggest the dam is significantly influencing the creek and therefore the effect of the dam merits additional investigative resources. Recognizing the lack of formal information available, the Task Force has recommended that a detailed scientific assessment be performed to determine the impact of the dam on the creek. The analysis will include, but not be limited to, compiling all relevant historical data, identifying information gaps, isolating areas of further research, analyzing all data sets, and concluding whether the dam is a detriment or asset to the creek.

Streambank Erosion

Visual assessments have shown that many stream segments within the watershed have actively eroding streambanks. Such stream degradation can be expected in urbanizing watersheds, because of higher peak flows and other hydrologic impacts from increased imperviousness (Caraco, 2000).

The Annualized Agricultural Nonpoint Source Pollutant (AnnAGNPS) model provided estimates of streambank erosion potential as a function of soil type, land use conditions and channel dimensions. Bank erosion was estimated in the model using a drainage network automatically derived by AnnAGNPS using a digital elevation model (DEM). Model results shown in Figure 3 categorize areas of bank erosion by the amount of sediment load in tonnes/hectare/year.

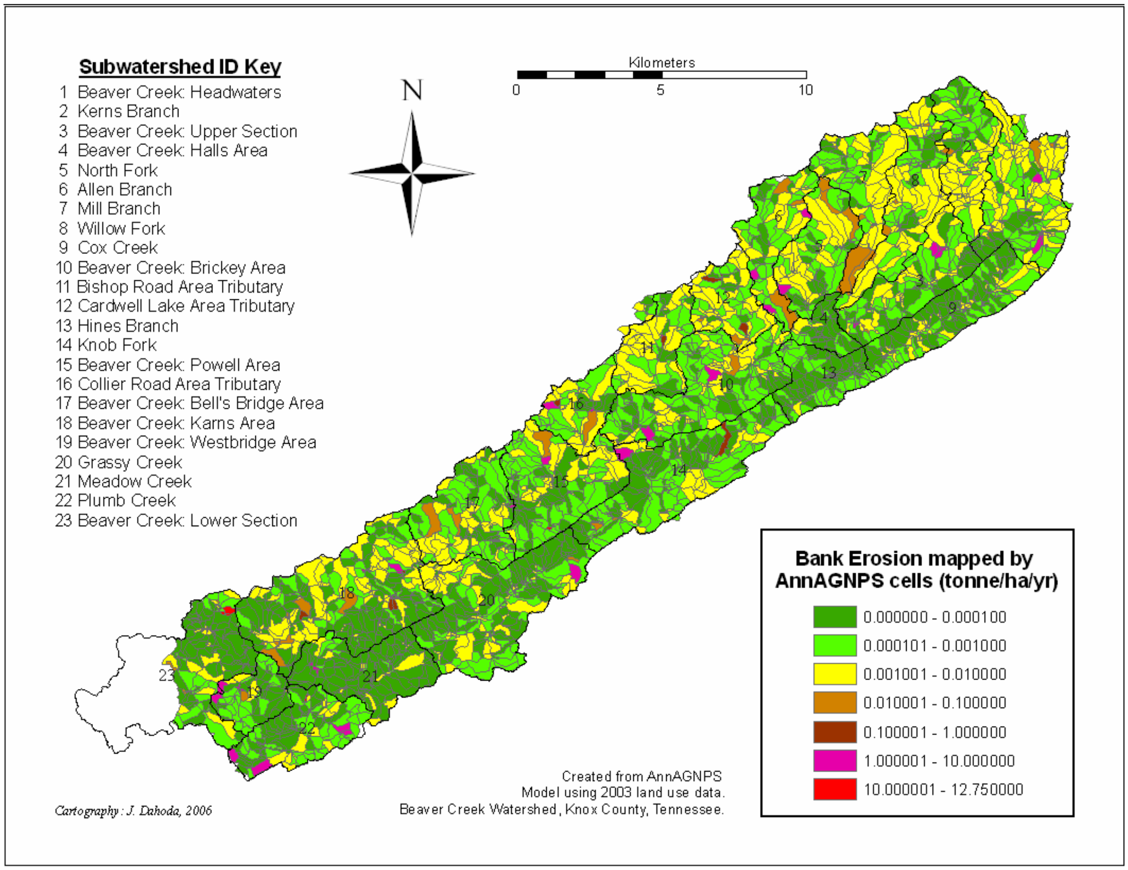

Figure 3 Streambank erosion mapped by AnnANPS

Stream Buffers

The quality and extent of the buffer zone has a direct relationship to the potential ecological health and water quality of a stream. Trees provide shade, maintaining moderate stream temperatures during hot months. Leaf fall is a critical food source for the aquatic insects at the base of the food chain, and fallen trees and branches provide large woody debris (LWD) inputs into the channel for habitat maintenance. Tree roots strengthen stream banks and help prevent erosion. Vegetation and soil filters pollutants transported by overland flow adjacent to streams and protect banks from excessive surface erosion.

Studies performed by the University of Tennessee (UT) have assessed riparian buffer conditions at 24 sites within six subwatersheds within Beaver Creek. Of the 24 sites assessed, the sites varied from 0% riparian area intact to 100% intact. Most sites were rated at about 50% to 84% intact (Sain, 2006).

Current Land Use/Land Cover

High quality 4-meter resolution aerial photographs taken in August 2003 were used to develop the Beaver Creek land use data base. The photographs, obtained from KGIS, were mosaiced and manually interpreted by the University of Tennessee Geography Department using ArcMap GIS software version 9.1. The results provided current high-resolution land use data required for modeling.

Approximately 35% of the land in the Beaver Creek Watershed is used for residential land purposes compared to 6% for commercial and industrial uses (Figure 4). Agricultural land uses occupy 21% of the watershed, and forest covers 35%. Imperviousness was measured by MPC GIS analysts. They used the road and building footprint coverages and calculated impervious for each land use/land cover polygon. Driveways on private land that are not mapped were also estimated. Overall imperviousness in the watershed was measured at 8.7% (Table7).

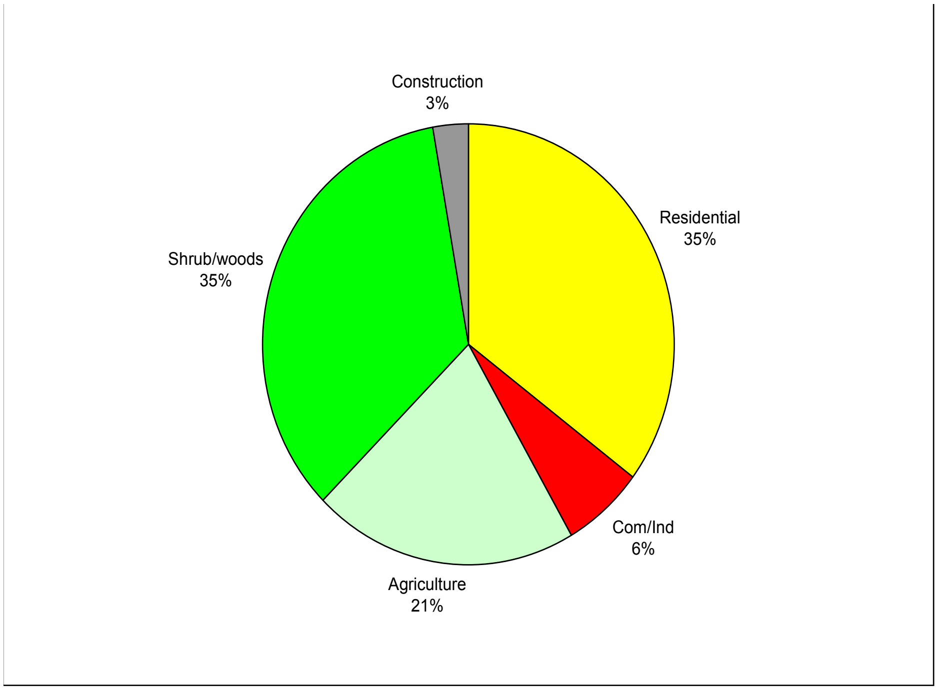

Figure 4 Land use in Beaver Creek Watershed from 2004 data

Subwatershed	Percent Imperviousness
1	5.5
2	8.4
3	28.5
4	11.3
5	14.4
6	9.3
7	8.7
8	10.6
9	4.3
AB	5.7
BR	8.5
CL	6.6
CR	11.5
CX	5.8
GC	7.5
HB	15.0
KB	3.8
KF	10.0
MB	4.6
MC	8.5
NF	12.5
PC	13.7
WF	4.0
Beaver Creek Total	**8.7**

Table 7 Percent imperviousness by subwatershed

2.2 Water Resource Conditions

According to TDEC standards, Beaver Creek and its tributaries are impaired. They are unable to support fish and aquatic life as well as recreation at the same level as the ecoregion reference stream. Recent physical, chemical and biological monitoring results from the Beaver Creek Watershed are summarized below.

Fish Community Assessment

Beaver Creek's fish assemblage has been assessed since 1995 at several sites by TDEC, Tennessee Valley Authority (TVA), and by Ogden Environmental & Energy Services (a private contractor retained to conduct a flood study in the Beaver Creek Watershed), using the Index of Biotic Integrity (IBI). Scores vary from 26 (very poor/poor) in 1995 at Knob Fork to an excellent rating of 56 at Cox Creek in 1996. However, most IBI scores for the last decade have shown both tributary and main stem Beaver Creek scores to be poor. The most recent IBI scores range from 30 to 42 and rated poor to fair and are summarized in Table 8. The table shows the lower sites on the Beaver Creek main stem had lower ratings than tributary streams and upper sections of Beaver Creek.

Most recently, as part of a University of Tennessee (UT) study of 24 sites in the watershed, 7185 fish were shocked and identified, yielding 21 species of 7 families of fish (Table 2-6). Study data indicated that some species showed significant decline with increased percent urbanization (Sain, 2006).

Sub watershed name	Sample Date	TVA Fish Score(s)		TDEC Fish Score(s)		TVA EPT Families		TVA Habitat
	Date	Score	Fish Rating	Score	Fish Rating	Score	Rating	Score
Willow Fork	04/08/2004[TDEC]			42	fair			
Willow Fork	04/08/2004[TDEC]			40	fair			
Grassy Creek	06/28/2004[T]	38	poor/fair			1	poor	30
Beaver Creek Halls area (RM 37.1)	05/19/2004[T]	38	poor/fair			8	fair	29
Beaver Creek 25W bridge (RM 24.6)	06/30/2004[T]	28	poor			3	poor	21
Beaver Creek Lower Section (RM 5.46)	06/30/2004[T]	30	poor			4	poor	31

[T] = TVA
[TDEC] = Tennessee Department of Environment and Conservation

Table 8 Index of Biotic Integrity (IBI) scores for Beaver Creek Watershed

Scientific Name	Common Name	Occurance Frequency	Total Abundance	Tolerance	Trophic Guild	Reproductive Guild
Catostomidae						
Catostomus commersonii	White sucker	18	225	tolerant	omnivore	Lithophilic
Hypentelium nigricans	Northern hog sucker	20	158	HW intol	insectivore	Lithophilic
Centrarchidae						
Ambloplites rupestris	Rock bass	8	34	intolerant	Top Carniv	
Lepomis auritus	Redbreast sunfish *	19	265	n/r	insectivore	
Lepomis cyanellus	Green sunfish	14	78	tolerant	insect	
Lepomis macrochirus	Bluegill	19	340	n/r	insect	
Micropterus puntulatus	Spotted bass	1	2	n/r	Top Carniv	
Micropterus salmoides	Largemouth bass	11	52	n/r	Top Carniv	
Cottidae						
Cottus carolinae	Banded sculpin	20	294	n/r	insect	
Cyprinidae						
Campostoma oligolepis	Largescale stoneroller	23	1354	n/r	omnivore	
Luxilus chrysocephalus	Striped shiner	23	1640	tolerant	omnivore	Lithophilic
Luxilus coccogenus	Warpaint shiner	1	1	HW intol	spec insect	Lithophilic
Lythrurus lirus	Mountain shiner	8	342	HW intol	spec insect	Lithophilic
Pimephales notatus	Bluntnose minnow	2	9	n/r	omnivore	
Rhinichthys atratulus	Blacknose dace	22	1321	n/r	insect	Lithophilic
Semotilus atromaculatus	Creek chub	23	588	tolerant	insect	
Ictaluridae						
Ameriurus natalis	Yellow bullhead	8	34	tolerant	omnivore	
Percidae						
Etheostoma blennioides	Greenside darter	12	51	n/r	spec insect	Lithophilic
Etheostoma flaballare	Fantail darter	13	79	intolerant	spec insect	
Etheostoma jessiae	Blueside darter	9	39	intolerant	spec insect	Lithophilic
Etheostoma simoterum	Snubnose darter	16	147	n/r	spec insect	Lithophilic
Poeciliidae						
Gambusia affinis	Western mosquitofish *	7	132	tolerant	insectivore	

Table 9 Fish collected during UT study (Sain, 2006). Introduced species*

Benthic Macroinvertebrate Community Assessment

TVA and Ogden Environmental Services performed benthic community surveys throughout the watershed from 1995 to 2004. Scores vary from poor to excellent; most sites ranked poor. Data from the 2004 surveys is reported in Table 8. TVA collected benthic data at one tributary site, Grassy Creek and three Beaver Creek sites. The upper segment of Beaver Creek, sampled at river mile 37.1, scored an eight which is rated fair. The three other sites were rated poor.

Habitat Assessment

For a recent study exploring the effects of urbanization on habitat structure, 24 sites in six subwatersheds of the Beaver Creek Watershed were monitored. Since previous studies have shown that stream fishes depend on a diversity of habitat structure, such as those found in scour pools and riffles, data was recorded on the depth, area, volume, etc. of pools and riffles in the creek at the various sites. The data is summarized in Table 10.

Habitat Metrics: Shows Physical measurements taken in the field for twenty-four sites in six sub-watersheds of Beaver Creek drainage.

Site	Stream Names	Average Wetted Width m	Average Water Depth m	# of Units	% Pools	Max Pool depth m	Avg Pool area m2	Pool volume m3	% Runs	% Riffle	Avg Riffle depth m	Average Riffle Length m	% Glide
1	Beaver 1	5.66	0.32	14.00	0.49	0.82	196.76	81.36	0.11	0.37	0.25	25.28	0.03
2	Beaver 2	3.53	0.16	9.00	0.68	0.64	98.92	22.36	0.07	0.25	0.06	14.33	0.00
3	Beaver 3	4.74	0.20	5.00	0.75	0.71	129.63	30.46	0.00	0.25	0.08	34.00	0.00
4	Beaver 4	3.05	0.15	10.00	0.42	0.59	59.21	12.73	0.15	0.23	0.06	14.17	0.19
5	Cox 1	5.20	0.16	20.00	0.36	0.51	85.89	14.93	0.07	0.43	0.08	32.86	0.15
6	Cox 2	4.36	0.20	17.00	0.69	0.63	57.47	13.05	0.07	0.15	0.11	8.93	0.10
7	Cox 3	4.04	0.20	16.00	0.76	0.66	65.13	15.97	0.00	0.19	0.06	15.47	0.05
8	Cox 4	2.29	0.12	13.00	0.49	0.42	24.58	3.43	0.13	0.18	0.07	9.93	0.19
9	Grassy 1	2.86	0.18	12.00	0.55	0.69	42.58	11.57	0.10	0.26	0.10	15.33	0.09
10	Grassy 2	3.36	0.16	10.00	0.34	0.59	50.17	11.37	0.07	0.41	0.16	13.15	0.18
11	Grassy 3	2.79	0.13	7.00	0.39	0.41	58.98	8.70	0.00	0.34	0.19	28.00	0.26
12	Grassy 4	2.63	0.20	12.00	0.65	0.45	43.79	6.88	0.00	0.14	0.05	10.15	0.21
13	Hines 1	2.71	0.16	26.00	0.76	0.52	44.09	8.88	0.02	0.21	0.05	15.66	0.01
14	Hines 2	3.13	0.19	12.00	0.88	0.58	50.63	10.16	0.00	0.08	0.08	14.80	0.04
15	Hines 3	3.09	0.18	21.00	0.60	0.63	44.53	10.91	0.18	0.22	0.08	9.40	0.00
16	Hines 4	3.41	0.15	12.00	0.44	0.65	37.08	8.30	0.23	0.33	0.05	11.08	0.00
17	Knob 1	4.51	0.26	9.00	0.77	1.08	103.79	36.67	0.00	0.18	0.07	16.10	0.05
18	Knob 2	4.25	0.16	10.00	0.53	0.57	76.52	17.14	0.11	0.29	0.09	14.13	0.08
19	Knob 3	2.02	0.14	9.00	0.52	0.53	34.24	6.99	0.00	0.48	0.06	15.80	0.00
20	Knob 4	2.82	0.10	10.00	0.35	1.34	39.04	5.47	0.00	0.57	0.07	16.64	0.08
21	Willow 1	3.35	0.20	6.00	0.55	0.53	48.03	10.57	0.12	0.00			0.33
22	Willow 2	2.88	0.20	10.00	0.57	0.69	46.15	12.00	0.05	0.30	0.14	12.33	0.08
23	Willow 3	3.32	0.23	8.00	0.31	0.57	56.30	13.57	0.46	0.18	0.13	16.05	0.05
24	Willow 4	3.42	0.12	13.00	0.28	0.32	28.64	3.97	0.36	0.31	0.11	9.20	0.05

Habitat Metrics (continued): Shows Physical measurements taken in the field for twenty-four sites in six sub-watersheds of Beaver Creek drainage.

Site	Stream Names	% Bedrock	% Boulders	% Cobble	% Gravel	% Fines	% Intact Riparian	% incised bank	% point bar	Total # Single Pieces	Volume m3 LW Singles	# of Aggregate Pieces	Aggregate pieces/ 100 m2	# of Root Wads
1	Beaver 1	4%	0%	4%	43%	49%	67%	46%	20%	11	754	476	3400	15
2	Beaver 2	0%	3%	6%	48%	43%	67%	59%	25%	4	6	22	244	8
3	Beaver 3	0%	2%	8%	60%	30%	59%	63%	25%	4	8	34	680	2
4	Beaver 4	0%	2%	5%	28%	63%	0%	71%	18%		0	53	530	
5	Cox 1	16%	32%	7%	27%	20%	67%	42%	26%	3	6	153	765	12
6	Cox 2	16%	54%	8%	6%	17%	50%	52%	0%	0	1	141	829	0
7	Cox 3	46%	6%	5%	9%	34%	84%	59%	14%	4	32	191	1194	3
8	Cox 4	18%	38%	8%	15%	22%	67%	29%	6%	1	0	41	315	1
9	Grassy 1	0%	0%	0%	47%	53%	25%	79%	20%		0	16	133	
10	Grassy 2	0%	0%	1%	50%	49%	84%	85%	33%	4	13	44	440	
11	Grassy 3	9%	1%	0%	46%	44%	17%	89%	34%	7	15	36	514	
12	Grassy 4	19%	3%	12%	38%	28%	100%	73%	14%	3	5	32	267	
13	Hines 1	44%	0%	1%	0%	55%	59%	47%	21%	0	0	80	308	1
14	Hines 2	5%	3%	4%	59%	29%	34%	77%	8%		0	73	608	
15	Hines 3	1%	10%	9%	53%	27%	50%	39%	18%	5	64	73	348	4
16	Hines 4	0%	9%	13%	38%	41%	50%	40%	24%	1	0	99	825	
17	Knob 1	0%	0%	0%	48%	52%	50%	74%	18%	1	0	29	322	
18	Knob 2	8%	0%	7%	44%	41%	50%	70%	29%	3	5	59	590	
19	Knob 3	0%	1%	2%	64%	33%	25%	52%	18%	1	0	216	2400	
20	Knob 4	4%	1%	5%	64%	26%	75%	68%	50%	1	0	108	1080	
21	Willow 1	9%	18%	15%	7%	51%	50%	36%	0%	2	0	25	417	
22	Willow 2	9%	4%	9%	50%	26%	67%	75%	19%	2	1	156	1560	
23	Willow 3	5%	0%	0%	54%	41%	34%	87%	14%	2	0	56	700	
24	Willow 4	32%	21%	15%	19%	13%	100%	29%	0%	2	5	42	323	

Table 10 Habitat assessed during UT study (Sain, 2006)

Total Suspended Solids Data

Monthly grab samples were collected for one year from 13 sites on Beaver Creek (six on the main channel; seven on tributaries). The sites were selected by TDEC as part of a 5-year monitoring program. Eleven of the samples were collected at base flow; one was collected during a rain event. Collected samples were then analyzed in TDEC's Knoxville lab.

TSS concentration varies among sampling sites in the Beaver Creek Watershed during low flows and TSS concentrations at the main stem sites were generally higher than concentrations from the tributary streams. Figure 4, shows Median (top of bar), 25th percentile (bottom of line), and 75th percentile (top of line) of total suspended solids (TSS) in 2004-2005 samples. Figure 2-5 demonstrates the elevated TSS concentrations during high flows, using the value for the only high-flow sample. There is not a state standard for TSS, though total suspended sediment load reductions in the TMDL are 42.8% to 48.4% (TDEC, 2006b). The 75th percentile of TSS samples from ecoregion reference sites is shown on Figure 4. This concentration (5mg/l) is the pollution goal against which the success of this initiative will be judged.

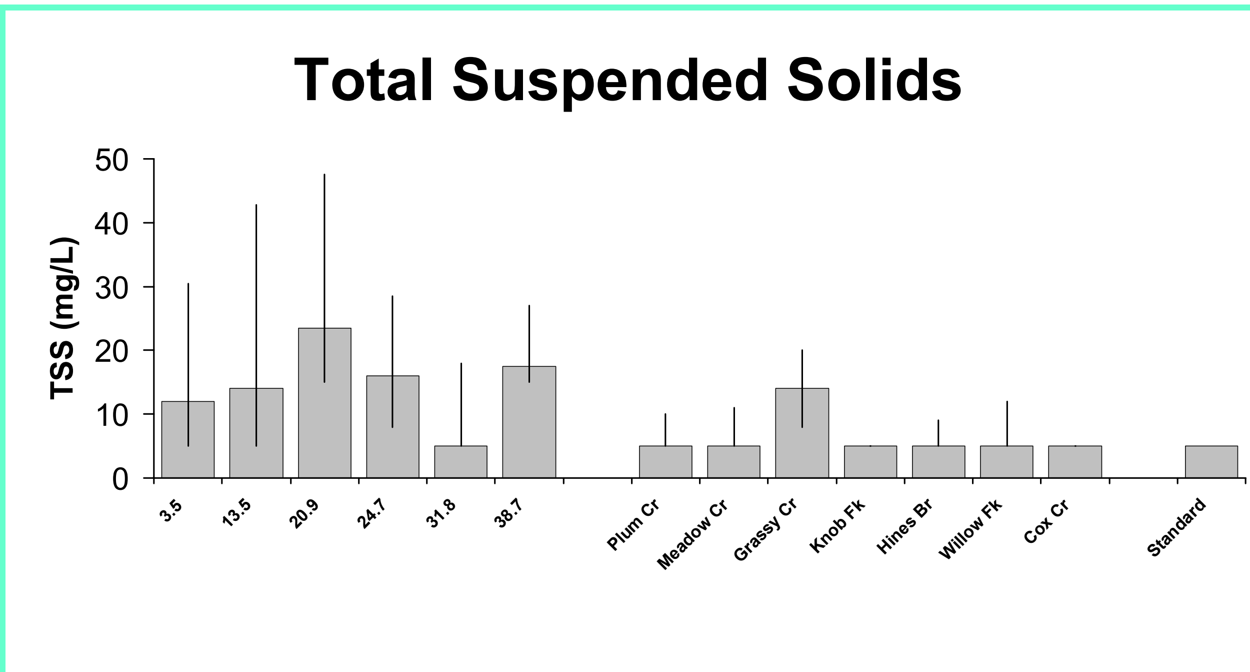

Figure 5 Total suspended solids data from 2004 sampling

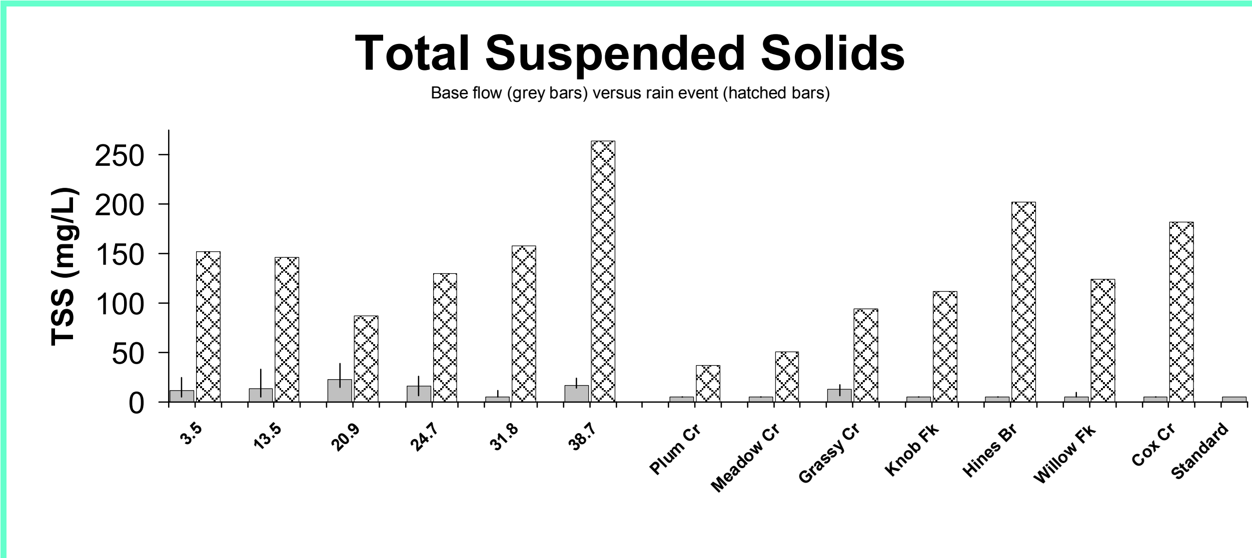

Figure 6 Total suspended solids data from 2004 sampling

3.0 Causes and Sources of Pollution*

Causes and sources of pollutants in the Beaver Creek Watershed have been determined based on water sample analyses and modeling of collected data.

Nonpoint Sources

The primary pollutant in the Beaver Creek Watershed is sediment. The two major sources of sediment transported by streams are derived from upland erosion and in-channel bank erosion. Upland erosion largely is a function of land use/cover, and the modifications to this land cover by humans changing its use. Because of the amount of cover, root structure, and organic matter on the surface, forest land generates very little sediment. Grassland generates more, and soil exposed for row crop cultivation or during construction generates more yet. Urban land development can severely impact streams by causing excessive sediment yield from a development site when runoff occurs, especially when sites lack adequate erosion control measures. Developed urban land generates sediment and rates similar to grassland, but the increased runoff from impervious surfaces can cause increased rates of channel erosion and channel enlargement.

Sediment becomes a “pollutant” when excessive amounts that enter the stream cause biological impairment. Biological impairment is measured by indices of biotic integrity using benthic macroinvertebrates. Standard bioassessment protocols are used to score stream samples, and protocols are specific to ecoregion designation. Beaver Creek is in Ecoregion 67f. Biological impairment by sediment is believed to be caused by habitat alteration, in which fine sediment smother the streambed, or become embedded in riffle substrates. Owing to the complexity of the problem, habitat may become degraded from the modification of hydrology, which in turn changes the sediment transport dynamics. Thus, it may appear that sediment is the problem but its root cause is hydromodification. Through a combination of modeling, monitoring, and ground truthing, likely sources of pollutants can be identified and specific subwatersheds targeted for BMPs. Still, because of the uncertainties involved, implementation of watershed sediment BMPs must ultimately be holistic with the end result improving in-stream habitat and the benthic macroinvertebrate community.

Figure 7 shows the sediment loading by source according to the HSPF model. Runoff from residential areas accounts for 36% of the sediment load. The other two primary contributors are runoff from agriculture (29%) and land under development (23%).

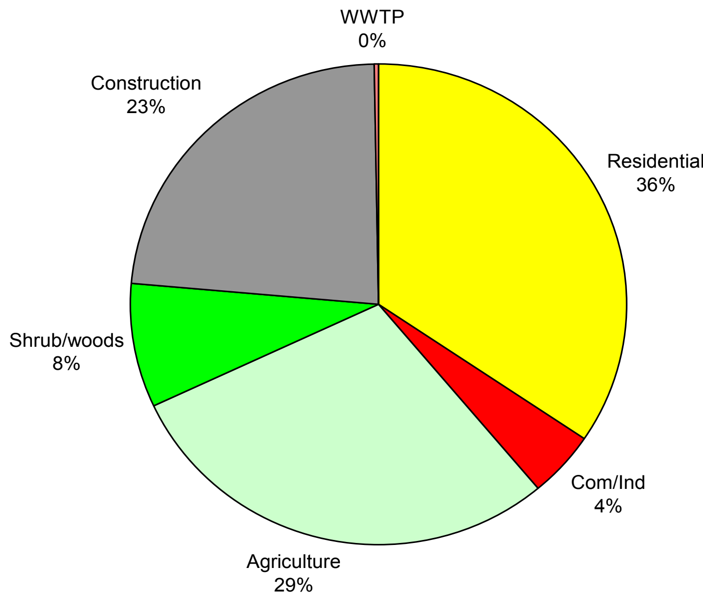

Figure 7 Sediment loading by source according to HSPF

Point Sources

There are two NPDES facilities that discharge within the Beaver Creek Watershed:

TN0024287 (Hallsdale-Powell Utility District STP) discharges to Beaver Creek @ RM 23.5
TN0060020 (West Knox Utility District-Karns Beaver Creek STP) discharges to Beaver Creek @ RM 10.7.

Though HPUD and WKUD have a history of non-compliance with discharge standards, the violations were primarily parameters other than TSS and these plants have been undergoing modernization to prevent future incidents, so they are not the focus of this plan.

4.0 Estimated Load Reductions*

Loading targets
In March of 2006, TDEC completed a siltation and habitat alteration TMDL for the watersheds of the Lower Clinch River. For the Beaver Creek Watershed, this TMDL requires a 42.8% to 48.4% reduction in sediment load. The TMDL uses an ecoregion reference stream within a forested watershed to define the desired sediment load In the development of the Beaver Creek restoration plan, it was felt that a less pristine but still fully-supporting stream might provide a less restrictive goal, while providing adequate improvement in the health of the biological community.

To calculate a modified sediment reduction goal for Beaver Creek, water quality and stream biological health were examined within Beaver Creek Watershed and Bullrun Creek Watershed, an adjacent watershed. Beaver Creek tributaries that are not listed for siltation are listed for other pollutants, so these did not seem acceptable. North Fork Bullrun Creek is not impaired and contains some low to moderate density development and agriculture. This area is also in the same predominant ecoregion as Beaver Creek. Therefore North Fork Bullrun Creek Watershed was deemed suitable as the basis for sediment load reduction goals.

Once this watershed was selected, it was necessary to generate a sediment loading estimate that was consistent with the Beaver Creek methodology. Loading rates developed from Hydrological Simulation Program - FORTRAN (HSPF) modeling in Beaver Creek were applied to land use data developed for the Bullrun Creek Watershed plan. The results of this analysis were that the North Fork Bullrun Creek Watershed yields approximately 0.21 tons/acre/year of total suspended solids (TSS), compared to the 0.34 tons/acre/year for the Beaver Creek Watershed. The analysis indicates that reducing loading rates in Beaver Creek Watershed by 38% will produce similar sediment loads and biological health as seen within North Fork Bullrun Watershed. By setting the reduction target at 38%, Beaver Creek Watershed streams should be able to support fish and aquatic life once this target is reached. This target will be reevaluated as the restoration plan is implemented and adjustments will be made as needed to restore Beaver Creek and its tributaries.

Allocation among nonpoint sources
Programs and procedures are available to address TSS from agricultural and construction sources. In Beaver Creek, according to the HSPF model, 52% of the total TSS is generated by agriculture and construction (Figure 7). Professional experience among the members of the Beaver Creek Task Force technical committee indicates that the maximum practical TSS reduction is about 40% for agricultural sources (predominantly pasture) and about 70% for construction. Even if the agricultural allocation is increased to 44%, a significant reduction is needed from existing built-up areas to reach the reduction goal, so the goal was set for a 20% loading reduction from urban areas.

Reductions will take place in three phases, each of which will be 5 years in duration (Table 11).

		----Percent of reduction target----		
		Agriculture	**Urban**	**Construction**
Phase 1	2007-2012	31%	4.8%	10%
Phase 2	2012-2017	35%	48%	45%
Phase 3	2017-2022	35%	48%	45%

Table 11 Phased approach to load reductions

Agricultural loading reductions will begin quickly using existing programs. However, construction and urban loading reductions will require development of local programs, so reduction rates will be slower in the first phase. Outreach and education and compliance monitoring programs must be developed for construction practices. Education programs must also be developed for urban TSS control practices, and procedures and program capacity must be developed to identify BMP locations, design modifications, and manage construction.

5.0 Restoration Strategies and Best Management Practices*

Since water quality criteria for TSS has not been set in Tennessee, the recovery of biological communities is used to evaluate whether TSS reduction goals are being met. Because there is a degree of uncertainty regarding the linkage between TSS and the biological communities, the TSS goals set forth in this restoration plan may need adjustment. As implementation of the restoration plan commences and TSS load reductions are realized, the biological community will be reassessed to determine if the TSS goal was adequate for stream recovery suitable to biological communities.

Model results from AnnAGNPS and HSPF will be used to predict priority areas and successfully reduce erosion and sedimentation from both upland and channel processes.

Subwatershed Strategy
The Beaver Creek watershed has been subdivided into 23 smaller drainage basins, or subwatersheds. Ten of these subwatersheds have been identified by HSPF modeling analysis of TSS loading in tons per year as the primary contributors of TSS loading. These subsheds have been divided into two groups and will be the focus of initial restoration efforts. The two groups are:

1st group: Allen Branch
Bishop Rd. tributary
North Fork
Plumb Creek
Collier Rd. tributary

2nd group: Knob Fork
Grassy Creek
BC Headwaters
BC Bell's Bridge
BC Westbridge

In-depth visual assessments are now underway in these subwatersheds. These assessments are pinpointing the locations of detention basins and disturbed land in upland areas as well as streambank erosion hot spots and buffer conditions. Assessments for Group 1 will be complete by March 2007 and assessments for Group 2 will be complete by July 2007.

Urban
In order to reach the loading goals (as set out in Section 4 of this plan), it is necessary to reduce sediment loads from existing residential, commercial, and industrial areas. Some of the reduction can be realized by improved management practices, such as improved turf maintenance practices, but much of this improvement must be provided by structural water quality improvement BMPs. Such structures remove sediments by settling and filtration. In the process, other pollutants are removed, and erosion of the stream channels is reduced because of increased storage of stormwater runoff either in ponds or in the soil.

The most cost-effective structural practice is converting existing detention basins into extended detention basins so that they retain and treat water from small storms and hold water for large storms longer, resulting in effective water quality treatment in addition to the flood control for which they were originally designed. This generally requires only minor enlargement of the pool and modification of the water release structure, though many would also require rehabilitation to restore the original design volume. Because much of the development in the Beaver Creek Watershed has occurred in the last two decades, approximately half of the developed area has existing detention basins which could be rehabilitated and modified. This high percentage means that modifying existing detention basins can be the emphasis of the urban strategy. Other practices, such as wet ponds or constructed wetlands, will be used where applicable for their wildlife habitat, groundwater recharge, and aesthetic characteristics.

A TSS loading reduction of 20% for residential areas requires the modification of about 700 detention basins (or equivalent) throughout the Beaver Creek Watershed. Using cost estimates based on Schueler (1987), this will require about $3.5 million for construction costs. Engineering, permitting, and land acquisition could incur significant additional costs. Commercial and industrial areas will need an additional 210 extended detention conversions. Though more expensive practices may be preferable in some locations, which would tend to increase the overall cost, reductions from voluntary measures should tend to keep the overall average down and close to the estimated cost, above.

Tables 12 and 13 show strategies and associated costs for reducing TSS by 20.0% from residential areas and 20.2% from industrial/commercial areas, respectively. See Appendix B for a description of how a scenario spreadsheet was used to generate these strategies in order to reach the target goals.

Residential									
Practice	**TSS reduction rate for practice**	**Percent area treated**	**Acres treated**	**Units installed**	**Load reduction**	**Cost per acre treated**	**Total cost**	**Cost share rate**	**Budget**
Outreach							$ -		
Individual lot practices	40%	2.0%	422	1280	0.8%	$ 2,000	$ 844,896	10%	$ 84,490
retrofit extended detention pond	61%	30.0%	6337	634	18.3%	$ 500	$ 3,168,359	100%	$ 3,168,359
New ext det pond	61%	0.0%	0	0	0.0%	$ 2,273	$ -	100%	$ -
wet pond	80%	0.2%	42	2	0.2%	$ 5,207	$ 219,954	100%	$ 219,954
wetland	76%	0.4%	84	4	0.3%	$ 821	$ 69,368	100%	$ 69,368
Biofilter	86%	0.2%	42	42	0.2%	$ 7,728	$ 326,482	75%	$ 44,861
Pervious pave	95%	0.0%	0	0	0.0%	$ 1,820	$ -	100%	$ -
Swale	81%	0.2%	42	8	0.2%	$ 8,191	$ 346,045	100%	$ 346,045
Streambank	80%	0.1%	21	84	0.1%	$ 20,802	$ 439,388	75%	$ 329,541
Totals		33.1%	6992		20.0%		$5,414,491		$ 4,462,618

Table 12 Strategies and costs for reducing TSS through residential BMPs

Commercial/industrial									
Practice	TSS reduction rate for practice	Percent area treated	Acres treated	Units installed	Load reduction	Cost per acre treated	Total cost	Cost share rate	Budget
Outreach									
Individual lot practices	40%	1.0%	32	6	0.4%	$ 1,000	$ 31,977	10%	$ 3,198
Retrofit extended detention pond	61%	30.0%	959	192	18.3%	$ 1,000	$ 959,304	50%	$479,652
New ext det pond	61%	0.0%	0	0	0.0%	$ 3,968	$ -	50%	$ -
Wet pond	80%	0.2%	6	1	0.2%	$ 8,204	$ 52,469	50%	$ 26,234
Wetland	76%	0.0%	0	0	0.0%	$ 1,679	$ -	50%	$ -
Biofilter	86%	1.0%	32	32	0.9%	$ 7,728	$ 247,127	50%	$123,564
Pervious pave	95%	0.5%	16	16	0.5%	$ 3,575	$ 57,159	50%	$ 28,579
Swale	81%	0.0%	0	0	0.0%	$ 8,191	$ -	50%	$ -
Streambank	80%	0.2%	6	1	0.2%	$ 0,802	$ 133,036	50%	$ 66,518
Totals		33%	1046		20.2%		$ 481,071.7		$ 727,745

Table 13 Strategies and costs for reducing TSS through commercial BMPs

Agriculture
The great majority of agricultural land in the watershed is in pasture and hay. The strategy to reduce sediment loading from this land is to apply a package of conservation practices that represents a typical conservation plan to each farm to improve vegetative cover, provide stream buffers, and stabilize stream banks. BMPs included in the packet are: exclusion of cattle from stream access, cross fencing for rotational grazing, alternative watering systems, heavy use area pads, riparian buffers, stream bank stabilization and pasture renovation.

In order to reach the load improvement goal for pastures, analysis indicates that at least 3600 acres (depending on the willingness of the largest sediment sources to improve their practices) of pasture need to be improved from a status of fair, overgrazed, or poor to a status of good. This represents about 40% of the total pasture area. Land use analysis provided information on quality of cover for this land, but it did not provide information about the stream channel condition. Agricultural practices and stream corridor impacts are assumed to be similar in the Beaver Creek Watershed and the adjacent Bullrun Creek Watershed. Consequently, the Beaver Creek data can be used to determine the extent of treatment necessary and the Bullrun Creek data can be used to estimate the average cost for a comprehensive treatment plan (Table 14). Restoration strategies for agricultural lands include BMPs for riparian buffers and streambanks as part of the pasture packet.

Units Treated Per Acre	**Unit**	**Cost Per Unit**	**Total Cost per acre for described treatment**
1	Acre Pasture Renovation	$150.00	$150.00
50	ft cross fence	$2.50	$125.00
0.01	Water and HUAP	$20,000.00	$200.00
0.017	Acre Buffer (based on 20 ft width and 37 ft in length)	$6,000.00	$102.00
2.85	ft streambank stabilization	$45.00	$128.25
0.005	misc -- critical area, stream crossings		$60.00
Total Cost of Pasture Package per acre			**$765.25**

Table 14 Average cost for comprehensive agricultural treatment plan

Emphasis for improvement would be on the areas contributing the greatest sediment loads. With the combination of cost-share and technical assistance from TVA, Tennessee Department of Agricultural (TDA), and Natural Resources Conservation Service (NRCS), landowners and stakeholders in the Beaver Creek Watershed have a low-cost opportunity to address privately-owned critical areas with the implementation of conservation measures. Total cost to reach the goal would be about $3.6 million.

There are about 340 acres (3% of the agricultural land) in the land cover database that are indicated as being in row crops. These areas are dispersed through the watershed, and little is known about management practices. During the early phases of plan implementation, these areas would be investigated for actual land use, cropping practices, and potential for loading reductions.

Construction Certification
Knox County Stormwater will develop and implement a policy whereby every development requiring a grading permit, building permit, or other permit where soil is disturbed will be required to designate or retain the services of an individual certified through the TDEC Water Pollution Control Erosion Prevention and Sediment Control training class. This designee will be required to be on-site any time soil is disturbed. Additional training may be required.

Construction Runoff
Existing and future National Pollutant Discharge Elimination System (NPDES)-regulated construction activities disturbing one acre or more are required to implement BMPs as specified in NPDES Permit No. TNR10-0000, General NPDES Permit for Stormwater Discharges Associated With Construction Activity. The permit requires the development and implementation of a site-specific Stormwater Pollution Prevention Plan (SWPPP) prior to the commencement of construction activities. The SWPPP must be prepared in accordance with good engineering practices and the Tennessee Erosion and Sediment Control Handbook. The SWPPP must also identify potential sources of pollution at a construction site that would affect the quality of stormwater discharges and describe practices to reduce pollutants in those discharges.

Strict compliance with the provisions of the General NPDES Permit for Stormwater Discharges Associated with Construction Activity (TDEC, 2005e) is expected to reduce sediment loads. The primary challenge for the reduction of sediment loading from construction sites is the effective compliance monitoring of all requirements specified in the permit and timely enforcement against construction sites not found to be in compliance with the permit.

The monitoring plan described in Section 8 includes TSS monitoring at 13 sites throughout the watershed along with more intensive monitoring of priority subwatersheds. Sources of any episodes of high TSS found while implementing this monitoring plan will be investigated to determine the source. Any construction site permit violations will be reported to TDEC.

Streambank Erosion
Streambank erosion can be attributed to a combination of upland land use and instream processes. The AnnAGNPS model showed the stream segments that are potentially vulnerable to excessive channel erosion and HSPF identified subwatersheds where BMP installation would effectively reduce peak flow and sediment loads. The reduction in peak flow would help lessen the pressures on streambanks and reduce channel erosion. With the blending of these model results, we can choose priority areas to reduce channel erosion.

Bank erosion areas identified by AnnAGNPS, shown in Figure 3, will be ground truthed during year one of the plan by the BCTF. The resulting site assessment information will be used to guide the prioritization of streambank stabilization efforts. Planned BMPs include bioengineered and hard armor structures, depending on site suitability. NRCS and SCD will lead efforts to restore eroding streambanks adjacent to agricultural land as part of a comprehensive farm conservation plan. BCTF will lead suburban projects to repair eroding streambanks. Most streambank stabilization projects will also incorporate riparian buffers which can protect the structures from potential damage and provide additional soil stabilization benefits from root growth.

Stream Buffers

Enhancement or creation of riparian buffers throughout the watershed will benefit the water quality. Initial assessments of selected watersheds indicate that much of the watershed lacks adequate buffers. During the first year of the plan, a comprehensive inventory of stream buffer conditions will be conducted by UT to help prioritize subwatersheds for buffer projects.

For agricultural lands, buffer projects will be included in the conservation plans. As for nonagricultural lands, such as residential and commercial, BCTF has a successful riparian tree give-away program that promotes the planting and maintaining of vegetative buffers along the streams. Through additional educational outreach efforts outlined in Section 6.0 of this plan, participation in programs to restore and protect suburban riparian areas will increase. Buffer areas will be included in a conservation easement to ensure the protection of the riparian buffer. Knox County Stormwater ordinances, outlined below, will also support riparian buffer installation and protection.

New County Stormwater Ordinance

In 2006, Knox County's stormwater ordinance was updated with recommendations from the Knox County Site Planning Roundtable. Community leaders with diverse perspectives on development and environmental protection achieved consensus on how to enhance the ordinance to address non-structural control options, such as low impact development (LID), stream buffers, open space, and conservation easements. The updates also will enhance water quality-based design standards for both structural and non-structural options. The resulting ordinance is directly targeted at implementing priority recommendations of the 2003/2005 Assessment, which include but are not limited to:

- Flood Mitigation—e.g., determining best use of undeveloped parcels, bond-funded
- Environmental restoration, encouraging/requiring good landscape design
- Wetlands Preservation and Mitigation—e.g., easements, acquisitions, and restoration
- Streambank Stabilization—e.g., bank restoration and riparian buffers with native plants
- Slope and Ridgetop Protection—e.g., limits on development, land use activities, easements
- Parks and Greenways—easements, land acquisition, greenway enhancement, new parks

Ecological Credit Trading

In 2006, the Environmental Protection Agency awarded Knox County Engineering and the BCTF a $353,000 grant to develop and pilot test a water pollution credit trading program. This 3-year study will develop a market-based credit trading program for sediment and nutrients that will accelerate the restoration of the Beaver Creek Watershed to a healthy ecosystem. For more information about this program, see Appendix C.

6.0 Information and Education*

The information/education component has been designed to enhance public understanding of the project and encourage early and continued community involvement. Five years ago, the Task Force developed an outreach/education plan that includes goals and objectives, key messages, planned and actual activity completion dates, and measures for identifying success. The plan has been revised and updated each year and is designed to get key messages to our target audiences while keeping us focused.

A three-tiered approach has been taken in order to reach target audiences with key messages and provide them with opportunities for involvement. First, the focus is on building awareness, filling in knowledge gaps, and clearing up misconceptions. Second, more extensive education through workshops, brochures, etc. takes place. Third, specific ways are identified to involve each of the audience members so they gain a sense of ownership of the watershed and put into practice the key messages.

Target audiences in the Beaver Creek Watershed include rural and suburban residents, local organizations and businesses, local developers and builders, and subcontractors and utilities. Primary messages that have been identified as currently important to convey include:

- A watershed is an area of land that drains to a waterbody. The Beaver Creek Watershed drains approximately 90 square miles.

- Activities throughout the watershed can have a substantial impact on its water quality.

- Rapid development of the Beaver Creek Watershed is impacting creek water quality with increased sediment input, riparian habitat destruction, and cumulative input of household and business-generated pollutants.

- Each person plays a part in contributing to local water quality problems and each of us can be a part of the solution.

- Here are ways to make a difference …. and here is how to become involved…

The Task Force partners have invested 12 years in improving the water quality in the Beaver Creek Watershed including initiating a comprehensive approach to building community awareness about local watershed issues and educating and involving targeted audiences in watershed involvement projects. However, with the continued residential and commercial growth in the Beaver Creek Watershed and its continued listing on the TDEC 303(d) list, there is much yet to be done. The following list shows past and current education and outreach strategies. For more information about these projects, see Appendix D.

Awareness strategies:

- Conducting a residential knowledge and attitudinal survey
- Posting watershed entry signs
- Maintaining a presence in the media

- Conducting civic and community presentations
- Sponsoring the development of the Beaver Creek Watershed Association
- Creating stormwater management techniques demonstration sites
- Updating website

Educational strategies:

- Kids-in-the-Creek
- Water-on-Wheels
- Construction site stormwater management program
- Adopt-A-Watershed

Involvement strategies:

- Adopt-A-Stream
- Riparian restoration with native seedling give-away
- Beaver Creek Watershed Association
- Adopt-A-Watershed service projects
- Stakeholder meetings
- Community-wide creek clean-ups

In addition, BCTF partners accomplished the following educational tasks:

- published a 16-page tabloid on Beaver Creek that was distributed to stakeholders as inserts in local newspapers
- partnered with the TN Water Resource Research Center to implement the Adopt-A-Watershed Program in six watershed high schools and middle schools
- partnered with the Hallsdale-Powell Utility District, with its traveling environmental education program for elementary schools in the watershed; and
- gave educational presentations to over 25 stakeholder groups.

The Task Force plans to maintain and/or expand the scope of its existing projects while adding new projects designed to deepen the knowledge and involvement of watershed residents. Initial plans for new project strategies include the following, although all strategies will be periodically re-evaluated and adapted as necessary to ensure their relevance and effectiveness:

Awareness strategies:

- Re-survey watershed residents about watershed knowledge
- Develop and implement a comprehensive marketing campaign based on social marketing principles

Educational strategies:

- Design and implement an adult nonpoint source pollution program for residents
- Develop and implement a detention basin management program
- Develop and implement a stormwater management and Low Impact Development (LID) practices program.
- Develop and implement a streambank restoration techniques tour.

Involvement strategies:

- Recognition program for residents who have implemented stormwater management techniques to reduce sediment
- Free soil testing to residents
- Other technical support to homeowners implementing residual BMPs

7.0 Implementation Plan* and Milestones*

Beaver Creek Timeline Year 1 Year 2 Year 3 Year 4 Year 5

Year	2007				2008				2009				2010				2011			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Activity																				
INFORMATION AND EDUCATION																				
Marketing																				
Develop Comprehensive Marketing Plan	x	x	x	x																
Implement Comprehensive Marketing Plan					x				x				x				x			
Education																				
Publish newspaper articles	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Manage website	x		x		x		x		x		x		x		x		x		x	
Adults/Kids-in-the-Creek	x	x			x	x			x	x			x	x			x	x		
Develop Homeowner NPS program	x	x	x	x																
Implement Homeowner NPS program				x		x		x		x		x		x		x		x		x
Develop and implement streambank restoration techniques tour									x	x	x				x				x	
Implement construction site stormwater management program				x		x		x	x	x										
Develop and implement stormwater awareness and LID practices program							x	x	x		x				x				x	
Implement Adopt-A-Watershed in 6 schools	x	x		x	x	x	x		x	x	x	x		x	x	x	x		x	x
Outreach Activities																				
Implement Adopt-a-Stream	x				x				x				x					x		
Community-wide creek clean ups				x				x				x					x			

RESTORATION PRACTICES

Agricultural BMPs																				
Pasture planting 410 acres	x		x	x	x		x	x	x											

Cross fencing 20,500 linear feet			x	x	x		x	x	x											
Alternative watering systems and heavy use area pads 4 units	x		x	x	x		x	x	x											
Riparian buffer 7 acres	x		x	x	x		x	x	x											
Stream crossings 2 units	x		x	x	x		x	x	x											
Streambank stabilization 1,169 linear feet	x		x	x	x		x	x	x											
Nonagricultural BMPs																				
Residential stormwater retrofit 20 units						x	x	x		x	x	x		x	x	x		x	x	x
Commercial stormwater retrofit 3 units														x	x	x		x	x	x
Riparian buffer and workshop 2 acres	x				x				x				x				x			
Streambank stabilization 2,400 linear feet			x				x				x				x					
MONITORING																				
Monthly physical, chemical, bacteriological monitoring	x	x	x	x					x	x	x	x	x	x	x	x	x	x	X	x
Five *E. coli* samples within 30 days			x								x				x					
Collect and analyze stormwater samples	x	x	x	x					x	x	x	x	x	x	x	x				
Sediment particle size analysis	x	x	x	x					x	x	x	x	x	x	x	x				
Flow monitoring	x	x	x	x									x	x	x	x				
Benthic community samples at 3 sites			x								x				x					
Habitat assessment at 13 sites	x		x								x				x					
Fish community assessment at 3 sites			x								x				x					
Erosion pins at 5 sites	x	x	x	x					x	x	x	x								
EVALUATION																				
Compile and analyze quarterly assessment results			x	x		x	x													
Evaluate progress, adapt monitoring plan if necessary				x			x													
Compile and analyze final assessment results																	x	x	x	
Evaluate success in achieving pollution reduction goals																			x	
Adapt Watershed Action Plan																			x	x

8.0 Monitoring* and Evaluation*

Water Quality Monitoring Plan

Physical, chemical, and biological conditions will be monitored to track progress, identify pollution sources, and evaluate the success of efforts to restore the Beaver Creek Watershed and remove the impaired stream segments from the 303(d) list. Since Beaver Creek and its major tributaries are listed as impaired due to loss of biological integrity due to siltation, low dissolved oxygen, physical substrate habitat alterations, phosphorus, nitrate, and *E. coli,* monitoring of a variety of parameters is necessary to develop baseline data and create a comprehensive restoration plan. All monitoring will follow TDEC's Standard Operating Procedures. The monitoring plan is outlined below:

Siltation and Habitat Alteration

Numeric water quality criteria have not been established for siltation or sediment in Tennessee. The Lower Clinch River Watershed Siltation and Habitat Alteration TMDL (TDEC, 2005c) was established based on a numeric interpretation of the narrative water quality standard for protection of fish and aquatic life. An average annual sediment loading from biologically healthy watersheds located within the same ecoregion was used for the comparison value.

Biologically healthy watersheds were identified from the State's ecoregion reference sites. These reference sites have similar characteristics and conditions as the majority of streams within the ecoregion. In general, land use in ecoregion reference watersheds contain less pasture, cropland, and urban areas, and more forested areas when compared to the impaired watersheds.

The biologically healthy (reference) watersheds are considered the "least impacted" in an ecoregion. Sediment loading from these watersheds serves as TMDL targets. The Watershed Characterization System Sediment Tool was used to calculate the average annual sediment load for each reference watershed. The geometric mean of average annual sediment loads of the reference watersheds serve as target values for the Lower Clinch River Watershed Siltation and Habitat Alteration TMDL.

The TMDL for the Lower Clinch Watershed calls for annual sediment load reductions in impaired sections of Beaver Creek Watershed from 42.8% to 48.4%. Since these reduction goals are based on a model that has not been calibrated to actual conditions in the Beaver Creek Watershed, attainment of these goals cannot be documented by monitoring instream conditions.

The basis for the TMDL is the narrative water quality standard for protection of fish and aquatic life. The strategy for evaluating success will be to document that benthic macroinvertebrate and physical habitat scores meet State standards. Benthic community (square kick protocol) and physical habitat will be assessed at three sample sites during year one and year three of this initiative.

In addition to benthic community and physical habitat assessment, the following monitoring will be performed to better identify sediment sources and track interim progress:

- Total suspended solids (TSS) grab samples will be collected at thirteen sites at base flow. At least four rain event samples will be collected each year. Year one will provide baseline data which will serve as a comparison for future monitoring. Results will also be compared with concentrations in ecoregion reference watersheds.
- Sediment particle size distribution will be determined at thirteen sample sites during year one, two and three. This information will provide an indicator of stream bed habitat conditions. Target conditions will be determined based on comparison with ecoregion reference watersheds.
- Stream bank erosion rate will be estimated at five sites using bank pins. This information will be used to improve estimates of the relative importance of various sediment sources.

Pathogens
This watershed plan focuses on sediment, not pathogens. However, Beaver Creek Watershed does have stream segments listed as impaired due to *E. coli* and these impairments will be addressed in a subsequent watershed restoration plan. With this in mind, bacteriological samples at thirteen sites will be collected and analyzed as part of the larger monitoring efforts in Beaver Creek. This information will provide baseline data to be used in the upcoming watershed restoration strategies to address pathogens. The data will also be used to identify any progress in pathogen reduction that was achieved while addressing sediment loading. *E. coli* samples will be collected at the thirteen sites monthly during year one and year two and monthly during year four of this initiative. In addition to monthly samples, at least 5 *E. coli* samples will be collected, each year, during a 30 day period in July and August. The additional *E. coli* sampling and analysis will enable calculation of geometric means in accordance with State protocol.

Total Phosphorous and Nitrogen
Approximately 23 miles of Beaver Creek are listed as impaired due to nutrients. Although there is not currently a TMDL to address nutrients in the Lower Clinch Watershed, initial efforts to reduce sediment loads in the watershed may also prove to be effective for nutrient reductions. Monitoring will be performed for nitrate, nitrite, total nitrogen, total Kjedahl nitrogen, ammonia, orthophosphorus, and total phosphorus at the thirteen sites during year one. As with bacteriological data, this data will serve as a baseline for the restoration project and can be used to develop future reduction goals specific to Beaver Creek.

Flow
Staff gages have been installed at the 13 sample sites to provide a visual indication of water level Staff gage levels will continue to be monitored several times each year coinciding with instream flow measurements at these sites. Rating curves will be developed using this information to establish an estimate of instream flow measurements based on gage height. The gages will be maintained and replaced or repaired as needed.

Additional Assessments
During grab sampling, multiparameter probes will be used to assess dissolved oxygen, conductivity, temperature, and pH.

Habitat assessments will be performed within the immediate vicinity of the thirteen sample sites and the erosional pin sites. This will aid in the interpretation of sediment loading sources.

A comprehensive riparian buffer assessment will be performed during year one of the project. This will help ground truth the predictions of AnnAGNPS instream sediment processes and ensure that the priority areas are addressed.

In addition to all of the monitoring and evaluation described above, in 2009, TDEC will conduct sampling in the Beaver Creek Watershed. In 2010, the Task Force will review activities based upon TDEC's results and adapt as necessary.

9.0 Estimated Budget and Sources of Funding*

Budget category	319(h) funding	Grantee match		Non-Matching contributions		Total
		Funds	Funding source	Funds	Funding source	**Total**
Outreach and Education						
Salery and benefits		$45,500	BCTF partners			$45,500
Printing, rentals	$16,000	$21,000	Knox Co., TVA, HPUD, BCWA			$37,000
Supplies	$75,000					$75,000
Programing		$75,000	BCTF partners, land owners			$75,000
BMPs/retrofits						
AG - implementation	$320,465	$70,000	BCTF partners, land owners	$250,000	NRCS programs	$640,465
Urban - implementation	$338,000	$100,000	BCTF partners, land owners			$438,000
Technical assistance	$50,000			$150,000	NRCS	$200,000
Salery and benefits		$100,000	BCTF partners			$100,000
Monitoring						
Salary and Benefits		$10,000	BCTF partners			$10,000
Lab analysis		$77,500	TDEC, HPUD, WKUD			$77,500
Evaluation						
Salary and benefits		$10,000	BCTF partners			$10,000
Project Management						
reports		$25,000	TNWRRC			$25,000
total	$799,465	$534,000		$400,000		$1,733,465

Table 15 Budget for Phase I of the restoration plan

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Appendices

Appendix A

BEAVER CREEK TASK FORCE TIMELINE AND ACCOMPLISHMENTS

During the past eight years, member organizations of the BCTF have made significant contributions toward the assessment, understanding, and restoration of the impacts to the Beaver Creek Watershed. Hundreds of hours of staff time and over $750,000 dollars have been spent in this effort to date. Below is a timeline of BCTF accomplishments followed by a brief summary of some of the most significant achievements.

Timeline

- 1998: Beaver Creek Task Force Formed
- 1998: Updated FEMA Flood Study
- 2000: Floodplain no-fill line expanded
- 2002: Initial BCW Assessment complete
- 2002: Tennessee Growth Readiness
- 2002: Site Planning Roundtable convened
- 2003: BC Watershed Association formed
- 2003: Part--ime Watershed Coordinator hired
- 2003: Intensive Watershed Education initiated
- 2004: USA/USSR assessments for 23 sub-basins
- 2004: Water Quality sampling and analysis
- 2005: Green Infrastructure plan completed
- 2005: GIS Land Use Map update
- 2005: Awarded 604(b) Watershed Planning Grant
- 2005: BMP projects initiated
- 2005: Water quality models developed
- 2005: Watershed Plan process initiated
- 2005: Stakeholder Advisory Council convened
- 2006: Awarded an EPA Cooperative Agreement Grant to create and test a Pilot Ecological Credit Trading Market
- 2006: Models calibrated
  - HSPF for sediment and nutrients
  - AnnAGNPS for sediment
- 2006: Developed Watershed Plan

Appendix A (cont.)
BCTF MAJOR ACCOMPLISHMENTS:

Since its inception, the BCTF has been undertaken a number of major projects. A brief description of some of these projects follows:

Flood study: From 1998-2000, Knox County updated the FEMA flood study for Beaver Creek in response to extreme development pressure and related stormwater/flooding issues. Using data and findings from the flood study, a Beaver Creek Watershed Stormwater Master Plan was written to determine a regulatory mechanism that could address future flooding and environmental issues. This plan considered future build-out conditions in the watershed in order to allow Knox County to enact current regulations to mitigate future damages in the watershed caused by the anticipated level and pattern of development. The "no fill line" policy which expanded the preserved floodplain area well beyond FEMA minimums followed this study as a key management measure for new construction.

Watershed inventory: From 1998 – 2002, Task Force members identified future development patterns and road construction projects, environmentally sensitive areas, potential greenway routes, flood hazards and storage areas, and cultural and historic sites. A report titled the "The Beaver Creek Assessment" summarized the results of this project. Areas with multiple benefits were designated priority areas.

Outreach and education: In 1999, a telephone survey by the University of Tennessee provided valuable information about the knowledge and attitudes of watershed residents about water quality issues. Results of the telephone survey indicate that an outreach/education campaign was needed for watershed stakeholders to be effective in participating in the development of a watershed plan. An Outreach Committee was formed to educate stakeholders about basic water quality problems, inform them about the watershed initiative and encourage them to get involved.

Since 2000, the BCTF Outreach Committee has developed an ongoing communication plan and has overseen its implementation. The communication plan includes: a list of activities, a defined target audience, clear and consistent messages, and a timetable with methods of delivery.

BCTF Outreach Committee activities include: frequent articles in local newspapers, presentations to community groups, a 16-page Beaver Creek supplement to the local newspaper, the Adopt-A-Watershed program in middle and high schools, an Environmental Learning Center targeting elementary school students, the Adopt-A-Stream program, demonstrations, and promotion of improved stormwater treatment, sediment and erosion control training, public meetings, and a wetland and riparian buffer educational campaign.

In recent years the BCTF Outreach Committee has developed outdoor classroom space for Halls and Powell High Schools and Brickey Elementary.

Tennessee Growth Readiness Initiative: The Tennessee Growth Readiness Initiative (TGRI) is an educational program developed by TVA and BCTF partners to educate the public, local officials, and other decision makers about the sources and impacts of nonpoint source pollution, how different land uses affect water quality, and what communities can do to protect water quality. In the spring of 2002 Knox County served as the pilot area for TGRI.

Site Planning Roundtable: In the fall of 2002, several BCTF partners assisted in convening the Knox County Site Planning Roundtable, a diverse committee that included representatives of county, city and state government agencies, environmentalists, lawyers, bankers, developers, builders and homeowners. Roundtable committees reviewed current planning and zoning ordinances and compared them to "model development ordinances." In 2005 the Roundtable reached consensus on recommended changes to development rules and processes. 21 of these recommendations have been incorporated into the new Knox County Stormwater Regulations.

The Roundtable also recommended that Low Impact Development demonstration sites be developed in the Beaver Creek Watershed. A pervious concrete parking lot has been completed at the new Powell Library; construction has begun on a low impact Town Center development named Bell Meadow in Powell next to the new library; and construction is set to begin on a low impact design for the new Hallsdale Powell Utility District headquarters.

Beaver Creek Watershed Association (BCWA): In 2003 the BCTF provided funding and support for the formation of the Beaver Creek Watershed Association. The BCWA is a non-profit (501c3) organization for stakeholders in the Beaver Creek Watershed. The BCWA now boasts over 250 members and is involved in a number of education and restoration initiatives in the watershed. The BCTF took the lead in developing a wetland education project in the Halls community. Also, in 2003, the BCTF provided funding for a part time for a part time Watershed Coordinator for Knox County.

Water Resource Assessment and Modeling: Funding through a TDEC TMDL Support Grant enabled representatives from the Department of Civil and Environmental Engineering at The University of Tennessee to collect 12 sampling runs over a period of one year at 13 sites in the Beaver Creek watershed and to develop a sediment load model. Water quality parameters include those necessary to generate models for sediment, phosphorus, nitrate, and pathogens. Two water quality models subsequently have been developed for sediment and nutrients. Samples were collected in 2004 and models were completed in 2006.

Green Infrastructure: In 2005, a Green Infrastructure Plan was created by the BCTF for the Beaver Creek Watershed. Green infrastructure is the supporting system the landscape provides for a community; an interconnected system of natural areas and other open spaces managed for the benefits to both people and the environment.

The plan identifies ways to connect communities and natural areas; develop a program for individual conservation easements; identify conservation buffer areas, lands for greenway development, and lands with significant historic, recreational, or visual value; and recommend implementation strategies.

A report entitled “The Beaver Creek Green Infrastructure Plan” has been published and is being used to help identify areas in the Beaver Creek Watershed that are best suited for development and the areas that are best suited for conservation

Watershed Action Plan: In 2005 the Tennessee Department of Environment and Conservation awarded the BCTF a $54,000 grant to develop a Watershed Action Plan (WAP) for the Beaver Creek Watershed. A draft of the WAP plan will be complete in November of 2006 and will be published in early 2007. An important part of the development of the Beaver Creek WAP was done by a Stakeholder Advisory Council composed of developers, farmers, residents, and public officials.

Best Management Practices: By the end of 2006 the Beaver Creek Task Force will have installed Best Management practices on approximately 25 Beaver Creek properties including pasture renovation and cattle exclusion fencing on farms, bioengineered solutions to stormwater problems on private property, wetland and riparian restoration, and other treatments.

Ecological Credit Trading: In 2006 the Environmental Protection Agency awarded Knox County Engineering and the BCTF a $353,000 grant to develop and pilot test a water pollution credit trading program. This 3-year study will develop a market-based credit trading program for sediment and nutrients that will accelerate the restoration of the Beaver Creek Watershed to a healthy ecosystem.

Appendix B

Scenario Generator Spreadsheet

This spreadsheet helps determine amount of treatment and total budget to reach a TSS reduction goal. The user manipulates the combinations of practices; the percent of TSS reduction, acres of treatment, and costs are then calculated.

Columns

<u>TSS reduction rates</u> for each practice are provided, expressed as a percent reduction.

<u>Percent area treated</u> *is the main user input column*. This column selects the total extent of each treatment.

<u>Acres treated</u> is calculated by multiplying percent area treated times total acres in the particular land use.

<u>Units installed</u> calculates the number of practices installed, based on average acres treated for each practice.

<u>Load reduction</u> is the percent reduction from initial total load generated by the particular land use. It is calculated by multiplying percent of acres treated by percent reduction for that practice.

<u>Costs per acre treated</u> are calculated in supporting parts of the spreadsheet. Treated land includes any area draining to a structural practice or improved by a non-structural practice. Only construction costs are accounted for in this estimate; neither land costs nor maintenance are included.

<u>Total cost</u> is calculated by multiplying acres treated times cost per acre.

<u>Cost-share rate</u> is the portion of the cost of the practice paid for by funds accounted for in this plan. The remaining portion of the costs must be supported by the land owner. The cost-share rate is a policy decision.

<u>Budget</u> is the total cost multiplied by the cost-share rate.

Rows

<u>Outreach</u> efforts support public participation, and are a necessary part of the plan. However, it is difficult to assign numbers for load reduction or cost per acre treated. The best estimate of the funding necessary to meet communication goals is entered in cell K1.

<u>Individual lot practices</u> are changes in management that occur at the individual land-owner level. These practices include such things as stream buffers, improved turf and vegetation management, rain barrels, and rain gardens. The TSS reduction rate is intended to reflect the amount of improvement when an average parcel is converted to optimal management. This rate is a

professional estimate. The participation rate is limited by the willingness of the public to participate and the ability of the outreach programs to change public behavior. It is initially assumed that no more than 2% of the residential land area will see this change (mathematically equivalent to 4% of the area seeing 50% effectiveness). It is anticipated that the only cost to the Beaver Creek programs will be for demonstration projects and most of the cost of these measures will be born by individual land owners, so the (equivalent) cost-share rate is low. However, participation rates are presumably driven by the size of the outreach budget.

<u>Extended detention ponds</u> are outwardly similar to conventional detention ponds. Extended detention ponds store water longer and detain runoff from small storms, allowing more effective water quality treatment. Extended detention ponds also frequently have a small wetland cell for enhanced pollutant removal.

Existing detention ponds can usually be converted to extended detention by adapting the outlet structure and expanding the capacity somewhat. These modifications allow treatment of small storms and more effective downstream channel protection by modifying the hydrograph.

TSS removal efficiencies are from Winer (2000). Cost per acre treated is based on equations in Schueler (1987). Costs reflect differences in imperviousness between residential and commercial/industrial. Cost as a function of treated area for each facility is not linear (there are economies of scale), so I assumed that the average residential facility treats 10 acres* (a subdivision) and the average commercial/industrial facility treats 5 acres* (a single parcel). I assumed that 10% of the residential and 20% of the commercial/industrial extended detention ponds installed for this project were modifications of existing conventional detention ponds*.

<u>Wet Ponds</u> (or retention ponds) have permanent pools and very long detention times. They are very effective at pollutant removal and provide landscape and habitat features, but require more land and more excavation than extended detention ponds.

TSS removal efficiencies are from Winer (2000). Cost per acre treated is from Wossink and Hunt (2003). Cost estimates do not differentiate between residential areas and commercial areas because there is so much difference in design guidelines that the difference is lost in the noise. The cost estimate could be tightened somewhat by deciding on sizing standards.

<u>Stormwater treatment wetlands</u> are functionally similar to wet ponds, except they are much shallower, and therefore require larger areas for the same treatment effectiveness. They also require larger drainage areas in order to maintain at least a little perennial flow to support wetland vegetation; both of these factors tend to limit the application of this practice.

TSS removal efficiencies are from Winer (2000). Cost per acre treated is from Wossink and Hunt (2003). Cost estimates do not differentiate between residential areas and commercial areas because there is so much difference in design guidelines that the difference is lost in the noise. The cost estimate could be tightened somewhat by deciding on sizing standards.

<u>Biofilters</u> also know as bioretention areas or rain gardens are areas treated to maximize infiltration and subsurface flow through soil while creating optimum conditions for pollutant removal by biological activity and physical filtering. They are usually attractively landscaped.

TSS removal efficiencies are from Winer (2000). Cost per acre treated is from Wossink and Hunt (2003). Costs vary significantly between sandy and clay soils because of the need for underdrains and soil replacement in clay areas. A weighted average between Winer's numbers for sandy soil and clay soil (twice the weight for clay) has been used. Cost estimates do not differentiate between residential areas and commercial areas because there is so much difference in design guidelines and soils that the difference is lost in the noise. The cost estimate could be tightened somewhat by deciding on sizing standards.

Pervious paving allows infiltration in paved areas. Pervious areas are usually a small part of the total paved area. For proper functioning, an open gravel or sand base is required to provide water storage. Underdrains are needed if the soil does not perc adequately. Effective use of this practice for retrofit can be challenging.

TSS removal efficiencies are from Winer (2000). Costs are the average of two numbers in EPA (1999). Sizing is estimated by assuming storage for a 1.5" rain event and an effective gravel depth of 4' (including some flow to gravel under adjacent impervious pavement).

Swales are functionally similar to biofilters. Assumptions are similar except for the assumed size of the drainage area.

Streambank stabilization is the repair of local bank failures and includes the development of buffers. The application of this practice is limited to the sites on the creek with bank failures.

TSS removal efficiencies could be greater than 100% compared to the average lot, but the initial estimate used was 80%. This initial estimate takes into account that most lots do not drain entirely to the buffer; some of the lot usually drains to the stormwater drainage system.

Costs are from the Bullrun Creek watershed plan. They are based on the NRCS estimate guide and consultation with the District Conservationists and Conservation District personnel in Anderson, Knox, and Union counties. A 100' lot depth has been assumed for calculating acres treated.

Appendix C

Press Release

EPA Awards Knox County Ecological Credit Trading Grant

The Environmental Protection Agency has awarded a $353,303 Cooperative Watershed Agreements Grant to Knox County Engineering and the Beaver Creek Task Force to develop and pilot test an Ecological Pollution Credit Trading Program in the Beaver Creek Watershed to improve water quality. The Beaver Creek Task Force is a Knox County Stormwater-led partnership of agencies, utilities, institutions, and non-profits dedicated to restoring Beaver Creek to its intended uses, such as making the creek swimmable and fishable, and developing programs and procedures that will be used to restore other watersheds around Knox County and the surrounding region. This three year project will help accelerate restoration in the Beaver Creek Watershed by providing a cost effective way for developers and wastewater dischargers to comply with their regulatory requirements. The Environmental Protection Agency will use this program as a model for other communities in Tennessee and around the Southeast Region.

The objective of water quality trading programs is to accelerate the achievement of environmental goals by developing a market based program whereby qualified landowners can do approved Best Management Practices on their properties and “sell” credits to qualified “buyers” who need to comply with the pollution limits of permits or regulations. Credits are bought and sold in predetermined ratios that ensure that a greater environmental benefit is achieved by the transaction than would be achieved without it. The program will benefit stakeholders in the watershed by keeping utility rates and housing costs down.

The concept of water quality trading (particularly involving nonpoint sources or pollution caused by runoff) remains in its infancy, but States and interested stakeholders around the country are moving quickly to develop and establish working programs. Over the course of the past 30 years, the EPA has approached water pollution reduction by systematically regulating point sources (for example discharges from wastewater treatment plants) through the application of discharge permits. While there have been improvements in water quality, currently there is very little being done to control non-point source pollution. The concept of ecological trading credits will serve to address this disparity by giving point source permitees and developers subject to the new Knox County Stormwater Ordinance an opportunity to improve water quality through best management practices and thereby offset their loading. The Ecological Credit Trading Program will also address two sources of pollution identified and regulated by the Tennessee Department of Environment and Conservation, sediment and nutrients. The Ecological Credit trading program will create:

- A quantitative, benefit-oriented framework to generally support implementation of the new Knox County Stormwater Ordinance.
- A quantitative, benefit oriented framework for Utilities to meet the limits for phosphorus and nitrogen set forth in their Wastewater Treatment Permits
- A means of evaluating trade-offs between different types of control options.
- A system that will provide incentives and reward additional investments in priority actions.

A successful credit market where units are defined in relation to the performance measures in the Stormwater Ordinance and Wastewater Treatment Permits will facilitate and accelerate compliance with the EPA Clean Water Act by providing explicit proof when requirements are met, creating incentives to exceed minimum standards, and establishing pre-set mechanisms for accessing offsite solutions when onsite alternatives are limited.

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Appendix D

Description of Federal and State Ranks & Status Codes

GLOBAL RANK - The global or world-wide rank of a species which is a non-legal rank indicating the rarity and vulnerability of a species

G1	Extremely rare and critically imperiled in the world with five or fewer occurrences, or very few remaining individuals, or because of some special condition where the species is particularly vulnerable to extinction
G2	Very rare and imperiled within the world, six to twenty occurrences, or few remaining individuals, or because of some factor(s) making it vulnerable to extinction
G3	Rare and uncommon in its range or found locally in a restricted range, generally from 21-100 occurrences
G4	Widespread, abundant, and apparently secure globally, but with cause for long-term concern
G5	Demonstrably widespread and secure globally
GH	Of historical occurrence throughout its range, e.g. formally part of the established biota, with the expectation that it may be rediscovered
GU	Can not be ranked using available information
GX	Believed to be extirpated throughout its range
HYB	Hybrid within its range in Tennessee
SSYN	Synonym for another species
_Q	Questionable taxonomy (GRANKs only)
_T#	Subspecific taxon rank (GRANKs only)

STATE RANK - The state rank of a species in Tennessee. Like the G_rank this is a non-legal rank indicating the rarity and vulnerability of a species at the state level.

S1	Extremely rare and critically imperiled in the state with five or fewer occurrences, or very few remaining individuals, or because of some special condition where the species is particularly vulnerable to extinction
S2	Very rare and imperiled within the state, six to twenty occurrences, or few remaining individuals, or because of some factor(s) making it vulnerable to extinction
S3	Rare and uncommon in the state, from 21-100 occurrences
S4	Widespread, abundant, and apparently secure within the state, but with cause for long-term concern
S5	Demonstrably widespread and secure in the state
SH	Of historical occurrence in Tennessee, e.g. formally part of the established biota, with the expectation that it may be rediscovered
SU	Can not be ranked using available information
SX	Believed to be extirpated from the state
S#S#	Denotes a “range rank” because the rarity of the species is uncertain (e.g. S1S3)
S?, S_?	Unranked at this time or rank uncertain
SE	Exotic species established in the state
SE#	Exotic numeric (e.g. the Asian clam *Corbicula fluminea* would be SE5)
SP	Potentially occurring in Tennessee, but not yet documented by DNH
_N	Occurs in Tennessee in a non-breeding status (mostly applies to vertebrates)

Description of Federal and State Ranks & Status Codes

_B	Breeds in Tennessee
SA	Accidental or casual in the state (several birds)
SR	Reported from the state, but insufficient data to assign rank
SRF	Reported falsely from the state
HYB	Hybrid within its range in Tennessee
SSYN	Synonym for another species
_Q	Questionable taxonomy (GRANKs only)
_T#	Subspecific taxon rank (GRANKs only)

FEDERAL STATUS - The federal listing under the U.S. Endangered Species Act

LE, Listed Endangered	Taxon is threatened by extinction throughout all or a significant portion of its range
E/SA,Endangered by Similarity of Appearance	Taxon is treated as an endangered species because it may not be easily distinguished from a listed species
LT, Listed Threatened	Taxon is likely to become an endangered species in the foreseeable future
T/SA,Threatened by Similarity of Appearance	Taxon is treated as a threatened species because it may not be easily distinguished from a listed species
PE, Proposed Endangered	Taxon proposed for listing as endangered
PT, Proposed Threatened	Taxon proposed for listing as threatened
C, Candidate species* **	Taxon for which the USFWS has sufficient information to support proposals to list the species as threatened or endangered, and for which the Service anticipates a listing proposal
(PS) Partial Status (based on taxonomy)	Taxon which is listed in part of its range, but for which Tennessee <u>subspecies</u> are not included in the Federal designation
(PS:status) Partial Status (based on political boundaries)	Taxon which is listed in part of its range, but for which Tennessee <u>populations</u> are not included in the Federal designation e.g. (PS:LE)
(XN) Non-essential experimental population in portion of range	Taxon which has been introduced or re-introduced in an area from which it has been extirpated, and for which certain provisions of the Act may not apply

Description of Federal and State Ranks & Status Codes

STATE STATUS -The legal listing in Tennessee

E, Endangered	Any species or subspecies whose prospects of survival or recruitment within the state are in jeopardy or are likely to become so within the foreseeable future
T, Threatened	Any species or subspecies that is likely to become an endangered species within the foreseeable future
D, Deemed in Need of Management	Any species or subspecies of nongame wildlife which the executive director of the TWRA believes should be investigated in order to develop information relating to populations, distribution, habitat needs, limiting factors, and other biological and ecological data to determine management measures necessary for their continued ability to sustain themselves successfully. This category is analogous to "Special Concern."
S, Special Concern	Any species or subspecies of plant that is uncommon in Tennessee, or has unique or highly specific habitat requirements or scientific value and therefore requires careful monitoring of its status.

Additional Modifiers for Plants

PE, Proposed Endangered	Any species or subspecies of plant nominated by the Scientific Advisory Committee to be added to the list of Tennessee's endangered species. After approval by the commissioner of the Dept. of Environment & Conservation and the concurrence of the commissioner of Agriculture, these plants will formally become State endangered.
PT, Proposed Threatened	Any species or subspecies of a plant nominated by the Scientific Advisory Committee to be added to the list of Tennessee threatened species. After a public hearing, these plants will formally become State threatened.
E-PT, Endangered-Proposed Threatened	Species which are currently on the state list of endangered plants, but are proposed by the Scientific Advisory Committee to be down-listed to threatened. After approval by the commissioner of the Dept. of Environment & Conservation and the concurrence of the commissioner of Agriculture, these plants will formally become State threatened.
E-PS, Endangered Proposed Special Concern	Species which are currently on the state list of endangered plants, but are proposed by the Scientific Advisory Committee to be down-listed to special concern. After approval by the commissioner of the Dept. of Environment & Conservation and the concurrence of the commissioner of Agriculture, these plants will formally become State special concern.
T-PE, Threatened Proposed Endangered	Species which are currently on the state list of threatened plants, but are proposed by the Scientific Advisory Committee to be listed on the state endangered list. After approval by the commissioner of the Dept. of Environment & Conservation and the concurrence of the commissioner of Agriculture, these plants will formally become State endangered.

Description of Federal and State Ranks & Status Codes

T-PS, Threatened Proposed Special Concern	Species which are currently on the state list of threatened plants, but are proposed by the Scientific Advisory Committee to be down-listed to special concern. After a public hearing, these plants will formally become State special concern.
P, Possibly Extirpated	Species or subspecies that have not been seen in Tennessee for the past 20 years. May no longer occur in Tennessee.
C, Commercially Exploited	Due to large numbers being taken from the wild and propagation or cultivation insufficient to meet market demand. These plants are of long-term conservation concern, but the Division of Natural Heritage does not recommend they be included in the normal environmental review process.

Appendix E

GLOSSARY

- **303(d) list** - a compilation of Tennessee streams and lakes that have one or more properties that violate water quality standards.
- **Adopt-A-Watershed Program -** a national model program that uses the local watershed as a living laboratory to teach and enhance the science curriculum for students in grades K-12. This model encourages the students to understand the relationships among all living things and apply this knowledge to their local environment. It is also a school-community learning experience, one that excites kids through real problem solving community action projects. In Knox County AAW has over 25 teachers in 15 middle and high schools implementing AAW activities.
- **AmeriCorps -** the domestic Peace Corps that involves over 40,000 Americans in an intensive year of doing service in their community. The local CAC AmeriCorps program focuses on service projects addressing water quality, solid waste/recyclying and food production for inner city residents.
- **Best Management Practice (BMP) -** schedules of activities, prohibitions of practices, maintenance procedures, structural controls, and other management practices designed to prevent or reduce water pollution.
- **Confluence -** the location at which two bodies of water come together.
- **Conservation Easement -** a legal agreement between a landowner and a conservation organization or government agency that permanently limits a property's uses in order to protect the property's conservation values. Called a "conservation restriction" in some states; also may be called an agricultural preservation easement, historic preservation easement, scenic easement, or forever wild easement, etc. depending on the resources it protects.
- **Development Concept Plan** - a conceptual land development design plan required as a preliminary step in the MPC development review process. Concept plans are required with some zones.
- **Drainage Basin** - the entire land area that delivers water to the stream, lake or other body of water. A watershed. In this document, drainage basin is used to refer to sub-watersheds within the Beaver Creek watershed.
- **Flood -** water from a stream, river, watercourse, lake or other body of standing water that temporarily overflows and inundates adjacent lands.
- **Flood Hazard -** a quantified (by probability of occurrence) risk of flooding. FEMA defines flood hazard areas based on engineering studies. These areas are shown as shaded areas on FEMA Flood Insurance Rate Maps.
- **Flood Storage and Drainage Easement -** area legally designated for temporary storage and flowage of stormwater. An easement may be required by Knox County during the design process. An easement differs from a "right-of-way" because legal ownership of the property is retained by the original land owner. The owner of the easement has the authority to inspect the easement, enter for purposes of inspection or maintenance, or require the property owner to make repairs to ensure proper function of the easement.
- **Flood Study -** the official report provided by the Federal Emergency Management Agency containing elevations of the base flood, floodway widths, flood velocities, and flood profiles.

- **Floodplain -** the part of a stream valley which is covered with water during a flood situation. Typically used associated with a flood which could occur at a given frequency (for example, the edges of a 100-year floodplain would be covered with water only during floods expected to occur less frequently than once in 100 years.)
- **Geographic Information System (GIS) -** a computer based system designed for the collection, storage, and analysis of information where geographic location is an important characteristic.
- **Grading and Erosion Control Permit -** a land development permit required by Knox County prior to the beginning of any grading, clearing, excavating, filling or other disturbance of natural terrain. A grading permit typically requires a site grading and erosion control plan to be submitted to Knox County Engineering. The permit is effective for a maximum of one year.
- **Greenway -** a protected vegetated corridor, extending through an urban or developing area, or providing access through rural areas. Greenways may serve many functions but the first and foremost is to preserve and protect environmentally important open space. Often, a greenway will contain a trail, offering alternative transportation and recreational opportunities.
- **Impervious -** any material that can not be penetrated by water.
- **Karst Topography -** an area where the underlying rocks are composed of limestone, and sinks, underground streams, and caverns are common
- **Knox County Growth Plan -** Tennessee Public Chapter 1101, the Tennessee growth management law, requires city and county governments to prepare a 20 year Growth Plan for each county. The Knox County Growth Plan classifies all Knox County land as either rural, planned growth area, or inside an urban growth boundary. The Knox County plan has been adopted by the City of Knoxville, Knox County, and the Town of Farragut.
- **Mitigation -** a measure used to lessen the impact of an action on the environment.
- **Native Plants -** species naturally occuring in a region. Native plants have many inherent qualities and adaptive traits that make them aesthetically pleasing, pratical and ecologically valuable for landscaping
- **No Build/No Fill Zone -** The area in the flood fringe where construction fill that alters the conveyance and storage capacity of the natural floodplain is prohibited. In Knox County, the no build/no fill zone is defined by a boundary on both sides of a stream that is one-half the linear distance between the floodway line and the 100-year floodplain line.
- **Nonpoint Source Water Pollution -** water pollution originating over a broad geographic area rather than from a single (point) source. Examples include urban runoff from parking lots and streets, agricultural runoff, and runoff from construction sites.
- **Nutrients** - substances such as phosphorus and nitrate that stimulate algae growth in streams and cause problems with low dissolved oxygen.
- **Pathogens -** microorganisms that are associated with human and animal wastes.
- **Planned Growth Area (PGA) -** land identified in the Knox County Growth Plan that is not contiguous to an existing municipality and where medium to high density development is expected. The PGA must be sufficient to accommodate growth expected to occur in unincorporated areas over the next 20 years. Land in a PGA is not subject to annexation by a municipality.
- **Rural Area (RA) -** land identified in the Knox County Growth Plan to be preserved for farming, recreation, and other non-urban uses.

- **Riparian Buffers -** The vegetation growing on or near the banks of streams or other body of water on soils that exhibit some wetness characteristics during some portion of the growing season.
- **Rosgen Stream Morphology Study –** one of several approaches for describing the physical condition of streams and provide guidance on stream rehabilitation.
- **Sector Plan -** a 15-year development plan, along with a 5-year implementation plan, for one of the twelve geographic sectors into which Knox County is divided by MPC for planning purposes. Most of the Beaver Creek watershed lies in the Northwest, the North, and the Northeast sectors.
- **Sediment -** solid matter, such as dirt, small particles or rock, etc., that enter streams and rivers
- **Sinkhole -** the differential weathering of the carbonate bedrock and "flushing" or "raveling" of overburden soils into the cavities in the bedrock leaving a depression or cavity on the ground surface.
- **Slope Protection Area -** Areas with steep slopes identified by MPC as suitable for open space or for residential development at a maximum of 2 acres/dwelling unit.
- **Stormwater Management Ordinance -** a Knox County ordinance which regulates storm drainage facilities, grading, excavation, clearance, and other alteration of the land in order to limit the dangers of personal injury or property damage that may be caused by stormwater runoff, and to secure eligibility for flood insurance.
- ***Streambank Stabilization -***
- **Sustainable Development -** development which integrates economic, environmental, and social values during planning, distributes benefits equitably across socioeconomic strata and gender upon implementation, and ensures that opportunities for continuing development remain undiminished to future generations.
- **Topography -** the slope or lay of the land.
- **Tributary -** a secondary stream or creek that feeds a larger body of water.
- **Urban Growth Boundary (UGB) -** land identified in the Knox County Growth Plan contiguous to an existing municipality (Knoxville or Farragut) where high-density growth is expected. Land within the UGB must be reasonably compact but adequate to accommodate all of the city's expected growth for the next 20 years. Land inside a city's UGB is subject to annexation by the city.
- **Volume Control Design Requirements -** engineering site design requirements which address the control of the total volume of stormwater runoff generated by the site. Typical engineering site design requirements address a peak flow rate of water leaving a site, but not the total quantity generated.
- **Watershed -** an area of land draining into a specific river, river system, or body of water
- **Watershed Association -** a citizen based organization (or non-profit organization) formed to improve and/or protect water quality in a watershed.
- **Wellhead Protection Zone -** An area around a spring used by a utility as a water source. TDEC requires the utility to develop a wellhead protection plan for each defined zone. In addition, any new development plan within or near a wellhead protection zone must be reviewed by MPC prior to approval by Knox County Commission.
- **Wetland -** an area that due to ground water or surface water is wet for sufficient periods of time to develop wetland soils and that support a unique plant community
- **Wetland Signature -** characteristics unique to wetlands, such as saturated soil, distinct vegetation communities, and standing water, that are used to map potential wetland areas

Beaver Creek Watershed Restoration Plan

<u>Addendum for *E. coli*</u>

Name of Project: Beaver Creek Watershed Restoration Initiative
Lead Organization: Knox County Stormwater Management Department
Watershed ID: Beaver Creek Watershed, Knox County
HUC TN06010207011_1000_2000_3000

1.0 Introduction

The Beaver Creek Restoration Initiative has actively targeted sediment and habitat restoration for the past 12 years using the Beaver Creek Watershed Restoration Plan created by the Beaver Creek Task Force as a guide (BCTF, 2006). This ongoing effort has been effective in reducing sediment loading to Beaver Creek. However, sediment is just one of the two primary pollutants in Beaver Creek. The other is *E. coli.* According to the **Tennessee Department of Environment and Conservation 2017 Total Maximum Daily Load (TMDL) for the Lower Clinch Watershed**, the entire main stem and six of the seven major tributaries of Beaver Creek fail to meet Tennessee *E. coli* standards (TDEC, 2017). The intent of this addendum is to provide a plan to reduce *E. coli* in Beaver Creek and its tributaries to meet state standards.

2.0 Sources and Causes of Pollutants and Impairments

According to the TDEC 2018 303d list the primary causes of *E. coli* impairment in the Beaver Creek system are sanitary sewer overflows (SSOs), grazing in riparian zones and municipal (urbanized high density areas) as reflected in Tables 1 and 2 below (TDEC, 2018). In addition, a Knox County Stormwater Management GIS analysis shows that significant areas of the 1000 section of Beaver Creek (from Willow Fork to the headwaters) are unsewered. The 2017 TMDL for *E. coli* estimates that 24.7% of all households in Knox County are on septic systems. A national survey (US EPA, 2000) indicated that more than half of existing septic systems are more than 30 years old and that at least 10% are failing at any given time. In 1998 the Environmental Protection Agency (EPA) did a STEPL analysis (US EPA, 1999) for the Beaver Creek Watershed and estimated that a total of 8,209 households in Beaver Creek were on septic systems with an estimated failure rate of 2.85% (Table 3). Sewer infrastructure expanded in the watershed as development has increased, however few people on septic systems voluntarily hook up to sewer unless their system has failed. EPA estimated that there are 3,989 septic systems in the Upper Beaver Creek Watershed in 1999. A Knox County desk top analysis estimates that there are still over 2,000 households in the 1000 section alone on septic systems. According to EPA estimates a 2.85% to 10% failure rate could lead to as many as 57 to 200 systems failing in the Upper Beaver Creek Watershed at any given point in time.

An analysis of Health Department complaints for failed septic systems shows a significant number of these systems are failing and contributing to the *E. coli* impairment. Although sewer is mostly available to households in the 2000 and 3000 sections of the Beaver Creek Watershed, there are still places where houses are on septic systems according to complaints received by the Health Department. Figures 1a and 1b show the Upper and Lower Beaver Creek sewered and unsewered areas.

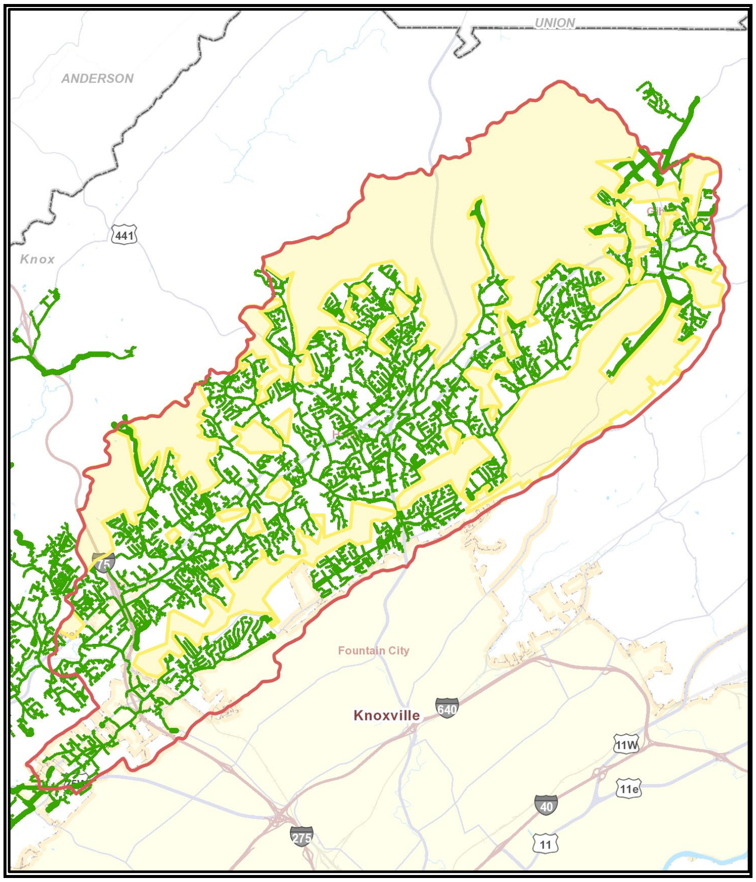

Figure 1a Upper Beaver Creek Watershed
(Yellow represents unsewered, green represents sewer infrastructure, red is the watershed boundary)

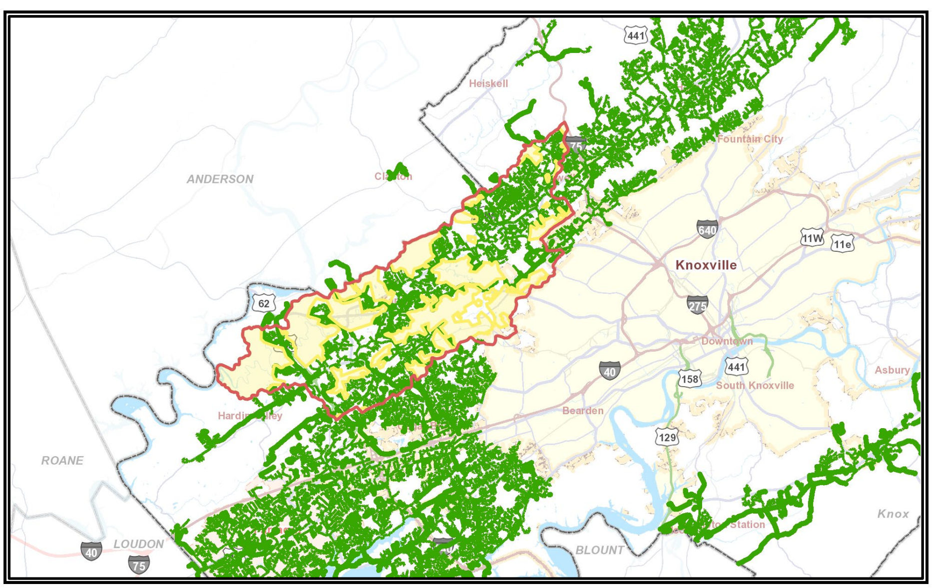

Figure 1b Lower Beaver Creek Watershed
(Yellow represents unsewered, green represents sewer infrastructure, red is the watershed boundary)

The Beaver Creek Watershed is becoming increasingly urbanized as farmlands are converted primarily to residential housing. Knox County operates under an MS4 NPDES Phase II Permit that is designed to reduce non-point source pollution. MS4 Urban Impacts is listed as a primary source of *E. coli* impact to the Beaver Creek system. Knox County addresses these non-point source impacts through management measures outlined in its NPDES Phase II Permit.

Agriculture is still a dominant land use in Beaver Creek and is listed as a major source of *E.* coli in Beaver Creek. The 2017 TMDL for *E. coli* in the Lower Clinch estimates that 12,000 acres, or 22%, of the Beaver Creek Watershed is in farmland.

In summary, the primary sources for *E. coli* in Beaver Creek are MS4 impacts, sanitary sewer overflows, grazing in riparian zones (poor pasture), and failing septic systems.

Table 1. TDEC 2018 303d List of Impaired Waters, Beaver Creek Main Stem

HUC #	Waterbody	Location	River Mile	Pollutant	Source
TN06010207011_1000	Beaver Creek	Knox Co	22.5	*E. coli*	SSOs
TN06010207011_1000	Beaver Creek	Knox Co	22.5	*E. coli*	Pasture Grazing
TN06010207011_2000	Beaver Creek	Knox Co	13.7	*E. coli*	MS4 Urban Impacts
TN06010207011_2000	Beaver Creek	Knox Co	13.7	*E. coli*	Pasture grazing
TN06010207011_2000	Beaver Creek	Knox Co	13.7	*E. coli*	SSOs
TN06010207011_3000	Beaver Creek	Knox Co	7.5	*E. coli*	SSOs
TN06010207011_3000	Beaver Creek	Knox Co	7.5	*E. coli*	MS4 Urban Impacts
TN06010207011_3000	Beaver Creek	Knox Co	7.5	*E. coli*	Pasture Grazing

Table 2. TDEC 303d List of Impaired Waters, Beaver Creek Tributaries

HUC #	Waterbody	Location	River Mile	Pollutant	Source
TN06010207011_0200	Willow Fork	Knox Co	5.9	*E. coli*	MS4 Urban Impacts
TN06010207011_0500	Hines Branch	Knox Co	3.2	*E. coli*	MS4 Urban Impacts
TN06010207011_0600	Knob Fork	Knox Co	8.1	*E. coli*	MS4 Urban Impacts
TN06010207011_0700	Grassy Creek	Knox Co	8.2	*E. coli*	MS4 Urban Impacts
TN06010207011_0800	Meadow Creek	Knox Co	4.96	*E. coli*	MS4 Urban Impacts
TN06010207011_0900	Plumb Creek	Knox Co	5.3	*E. coli*	MS4 Urban Impacts

Table 3. EPA STEPL Data Report for Septic Systems in the Beaver Creek Watershed (1999 Data)

Watershed Name	HUC 12	Septic Systems	% Failure Rate	Failed Systems
Beaver Creek Upper	060102070201	3,989	2.85	114
Beaver Creek Lower	060102070202	4,220	2.85	120
Total				**234**

The primary source of *E. coli* in the Beaver Creek Watershed is sanitary sewer overflows. Sanitary sewer utility providers Hallsdale Powell and West Knox are under consent orders to upgrade their systems to prevent sanitary sewer overflows. Both utilities are upgrading their systems with a goal of preventing SSOs. Knox County does not have jurisdiction over utilities and can only address the other contributing factors. Secondary sources are failing septic systems and agricultural inputs. Many of the septic systems in Beaver Creek are 30-50 years old and many are not functioning properly. The majority of Beaver Creek's livestock operations and septic systems are in the upper portion of the watershed. However, there are still some Ag properties and households on septic systems in the lower watershed. Most livestock operations allow access to the creek and over grazing is common. The combination of sparse pasture vegetation along with minimal riparian buffers contributes to *E.coli* loading.

2.1 Lower Clinch River Watershed 2017 TMDL for *E. coli*

According to the 2017 TMDL for *E. coli* in the Lower Clinch Watershed all three segments of the main stem of Beaver Creek and six of seven tributaries have exceeded the state's standard for recreational use since 1999. The latest data set (a geometric mean calculation derived from five *E. coli* samples in 30 days) for Beaver Creek in the TMDL is from 2013. In order to have more recent data Knox County conducted monitoring in 2017 on the six tributaries listed in the TMDL and in 2018 monitoring was conducted on three main stem sites. All testing was done using TDEC protocol at designated TDEC sites. The results of Knox County's monitoring were consistent with the TMDL data on Beaver Creek. All sites exceeded the state standard for *E. coli* with the highest geomeans being in the 1000 section, the headwater area. View the Knox County results in Table 4.

Table 4. Knox County monitoring results for Beaver Creek (2018) and its tributaries (2017)

Fall 2017

Tributary Name	**303d list**	Station ID	Geometric mean of 5 samples in 30 days	Recreation criteria for coliform
Willow Fork	impaired	WILLO000.5KN	404	impaired
Hines Branch	impaired	HINES000.2KN	606	impaired
Knob Fork	impaired	KNOB000.3KN	237	impaired
Meadow Creek	impaired	MEADO000.2KN	233	impaired
Plumb Creek	impaired	PLUMB000.3KN	251	impaired
Grassy Creek	impaired	GRASS000.3KN	335	impaired

Fall 2018

Beaver Creek Segment	**303d list**	Station ID	Geometric mean of 5 samples in 30 days	Recreation criteria for coliform
3000	impaired	BEAVE003.5KN	142	impaired
2000	impaired	BEAVE024.7KN	337	impaired
1000	impaired	BEAVE037.0KN	1020	impaired

Since the results of Knox County's geomean monitoring are consistent with the values determined by TDEC through multiple 5-year cycles, it is evident that TMDL reduction targets are still valid. Table 5 shows the reduction targets in the 2017 TMDL.

Table 5. TMDL Calculated Load Reductions Based on Geomean Data

Beaver Creek Segment	**River Mile**	**Geometric Mean**	**Calculated Reduction to Target Geomean**	**Calculated Reduction to Target Margin of Safety**
3000	RM 03.5	142.7	11.7%	20.8%
2000	RM 24.7	414.8	69.6	72.8
1000	RM 40.1	1084	88.4	89.6

3.0 Estimate of Load Reductions Expected from Management Measures

The goal of this plan is to reduce *E. coli* levels in Beaver Creek and its tributaries to the point where they meet TDEC standards and the entire system can be removed from the 303d list. This can be accomplished by addressing SSOs, poor pasture on agricultural lands, and failing septic systems. Most properties in Beaver Creek have access to sanitary sewer; and failing septic systems with access to sewer will be connected to the available sewer. It is the responsibility of Hallsdale Powell Utility District and West Knox Utility District to address SSOs in their service areas. Implementing recommended BMPs for poor pasture, riparian cover, and failing septic systems in combination with SSO reduction will reduce the *E. coli* levels to meet the state standard.

Management practices for agriculture and septic systems will be implemented simultaneously. The Knox County SCD and NRCS will work to install agricultural BMPs on identified properties focusing on livestock exclusion fencing, watering systems, riparian zones, and pasture management. Knox Co. Stormwater will partner with the Knox Co. Health Department to identify and fix failing septic systems. After three years of BMP implementation, Stormwater staff will conduct a 5-in-30 geometric mean analysis at the TDEC sample sites for comparison with 2017 and 2018 geomeans. The plan will then be adapted to reflect the results. The BMPs suggested for this plan will reduce *E. coli* and other pollutants of concern; primarily phosphorus, nitrogen, and sediment. The BMPs necessary to reach *E. coli* targets were modeled using EPA's STEP-L model show that annual load reductions can be reduced by 23,764 lbs. for nitrogen, 2,216 lbs. for phosphorus, and 440 tons for sediment. The modeled results are shown in Table 6.

Table 6. Nitrogen, Phosphorus, and Sediment Load Reductions

Practice	Amount	N Reduction Factor	lbs nitrogen/year
Riparian Buffer	26,136 ft.	0.28	7,318.08
Exclusion Fencing	28,000 ft.	0.11	3,080.00
Cross Fencing	12,000 ft.	0.25	3,000.00
Watering Facility	12	70.23	842.76
Pipeline	12,500 ft.	0.13	1,625.00
Heavy Use Area	36,000 sq. ft.	0.09	3,240.00
Stream Crossing	3	160.98	482.94
Septic System Repair	35	119.28	4,174.80

Practice	Amount	P Reduction Factor	lbs phosphorus/year
Riparian Buffer	26,136 ft.	0.02	522.72
Exclusion Fencing	28,000 ft.	0.01	280.00
Cross Fencing	12,000 ft.	0.02	240.00
Watering Facility	12	5.88	70.56
Pipeline	12,500 ft	0.02	250.00
Heavy Use Area	36,000 sq. ft.	0.01	360.00
Stream Crossing	3	17.425	52.28
Septic System Repair	35	12.58	440.30

Practice	Amount	Sediment Reduction Factor	tons Sediment/year
Riparian Buffer	26,136 ft.	0.002	52.27
Exclusion Fencing	28,000 ft.	0.001	28.00
Cross Fencing	12,000 ft.	0.006	72.00
Watering Facility	12	0.004	.05
Pipeline	12,500 ft	0.006	75.00
Heavy Use Area	36,000 sq. ft.	0.002	72.00
Stream Crossing	3	5.375	16.13
Septic System Repair	35	3.564	124.74

4.0 BMP List, Educational Activities, and Budget

The focus of this project plan is to install agricultural BMPs and repair failing septic systems in the Beaver Creek Watershed. Applied agricultural practices will include changing land management to promote infiltration of storm water; excluding livestock from creeks or controlling access; and creating riparian and other zones to filter runoff. Each farm that participates in the project will be assessed individually, to determine the BMPs that will best help to protect the natural resources both on and downstream of the farm while protecting the sustainability of the farming operation and the land. The Knox County SCD and NRCS will interface with landowners and install BMPs on properties following NRCS and Knox County SCD standards and specifications to insure maximum impact. Where appropriate the agricultural operation will install some or all of the following practices: riparian forest buffers, exclusion/access control fencing, prescribed rotational grazing plan, cross fencing (to allow rotational grazing and improve pasture quality and infiltration), alternate watering systems, stream crossings, heavy use areas (for watering and/or feeding), and pipeline for alternate watering systems.

Failed septic systems will be identified through a ground-truthing process by Knox County Stormwater and by complaints submitted to the Knox County Health Department. Health Department Environmental Specialists will inspect systems, develop plans for repair, provide installation oversight, and conduct final inspections. Homeowners with failed systems may have to replace septic tanks, and/or drain field lines. Some failing systems may be connected to existing sewer. All work will be performed by Health Department approved contractors.

The Beaver Creek Restoration Initiative will prioritize projects that are expected to have the highest benefit in terms of reducing *E.coli* loading to impacted creeks.

4.1 Budget and BMP List

Table 7 shows the specific quantity of BMPs necessary to make a significant impact in water quality. The cost of each BMP is based on the NRCS 2018 state average cost list.

Table 7. Budget

Best Management Practices and Community Outreach	Quantity	Cost	Unit	Budget Estimate
Agricultural and Residential BMPs				
Riparian Forest Buffer	21	$842.40	Ac	$17,690
Access Control/Livestock Exclusion Fencing	28,000	$2.54	Ft	$71,120
Cross Fencing for Rotational Grazing	12,000	$1.82	Ft	$21,840
Tanks for Watering Facilities	12	$1,308.00	Ea	$15,696
Heavy Use Area for Watering Facilities	12	$1,470.00	Ea	$17,670
Pipeline for Watering Facilities	12,500	$2.60	Ft	$32,500
Heavy Use Area Feeding Pads	3	$2,608.00	Ea	$7,824
Stream Crossings	3	$6,298.00	Ea	18,894
Septic System Repairs	35	$5,000.00	Ea	175,000
Community Engagement				
Farmer's Breakfasts	2	$750.00	Ea	$1,500
Farm Field Days	1	$2,500.00	Ea	$2,500
Marketing	Mailings, Septic Awareness Events, Scoop the Poop brochure, misc.			$15,000
			Total Project Budget	**$382,234**

4.2 Community Engagement

The Beaver Creek Watershed Initiative has been conducting community engagement activities in the watershed for years and has a good understanding of the social Infrastructure in the watershed. Knox County and its partners will include bacteria pollution reduction education and outreach into its community engagement activities. These activities are divided into two categories: one is "general watershed awareness/education" aimed at the population-at-large within the watershed and the other is "targeted outreach" with activities that have a narrower purpose/message and are directed at a specific subpopulation.

"General Awareness/Education" activities include:

- Newspaper articles in the local Shopper News, Knox TN Today, Focus, etc. discussing problems and solutions to water quality problems in the Beaver Creek Watershed.
- Presentations about Beaver Creek to community groups and professional organizations.
- Addition of an *E. coli* section to the Beaver Creek page on the Knox County Stormwater Management website.
- A social media campaign on reducing bacteria pollution

"Targeted Outreach" activities include:

- Participation in select community events.
- "Farmer's Breakfasts" to introduce agricultural operators to the Knox County SCD and NRCS. Breakfasts will include a presentation on a relevant water quality issue and provide information on septic maintenance and repair and NRCS/SCD cost share assistance programs.
- Farm Field Days to discuss and demonstrate BMPs.
- Targeted mailings to farmers offering cost share programs.
- Targeted mailings to homeowners with septic systems. Mailings will include maintenance tips and offer cost share assistance to homes with identified failing septic systems.
- Creation of a "Scoop the Poop" campaign for homeowners.
- Social media outreach via Facebook, Instagram, and Twitter.

5.0 Project Tasks, Timeline, and Assessment of Progress

The Beaver Creek Watershed Initiative for *E. coli* will be implemented in three phases over a 10 year period. Phase I will be four years long with the first year focused on public education about sources and causes of *E. coli* in the Beaver Creek Watershed. The remainder of the 1st phase will focus on BMP implementation on farms and on properties with failing septic systems. Community engagement will be continuous throughout the 3 phases. Phases II and III will each be conducted over three years with their primary focus on restoration. 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. TDEC has determined impacts stem from SSOs, limited riparian cover and poor pasture on Ag lands. Knox County has determined that failing septic systems are an additional cause. Projected tasks under Phase I are as follows, with a timeline of these tasks further delineated in Table 6.

5.1 Phase 1 Tasks

<u>Task 1. Implement the following Community Engagement activities by the 4th quarter of 2023.</u>

Building awareness of the *E. coli* issues in the Beaver Creek Watershed and how residents can help to solve these issues is critical to the success of this plan. Initial awareness activities will begin in 2020 and will include watershed-focused articles in the Shopper News and other community publications, an update to the Knox County Beaver Creek webpage, and social media posts. *E. coli* awareness will be incorporated into community events and presentations. Based on an inventory of the social organizations and networks, a succession of presentations over the course of Phase I will be conducted for targeted groups. A "Scoop the Poop" campaign will be developed in 2020 and incorporated into the outreach campaign. In 2021, the first Farmer's Breakfasts will be held and in 2022 the first Farm Tour will be conducted.

Task 2. Implement Ag BMP program by the 4th quarter of 2023.

Poor pasture and poor riparian cover have been identified by TDEC as one of the primary causes of *E. coli* impairment to Beaver Creek. Outreach efforts including mailings, newspaper articles, targeted presentations, and Farmers Breakfasts will inform farm owners of voluntary cost share opportunities. Many farm owners on Beaver Creek have already installed BMPs. However, in order to meet water quality goals in Beaver Creek the following additional practices will need to be installed:

- 28,000 feet exclusion fencing
- 12,000 feet cross fencing for rotational grazing
- 12 alternative watering systems
- 3 stream crossings
- 3 heavy use area feeding pads
- 21 acres of riparian buffer

Task 3. Implement failed septic system repair program by the 4th quarter of 2023.

According to analysis conducted by Knox County Stormwater Management one of the causes of *E. coli* impairment in Beaver Creek is septic system failure. Historical septic system complaint information from the Knox Co. Health Dept. substantiates this analysis. Knox County Stormwater will provide cost share funds to fix septic systems for 15 homeowners identified as having septic failures by the end of the 4th quarter of 2023. This will be accomplished by partnering with the Health Department to offer assistance to qualified homeowners.

Task 4. Monitoring and Evaluation

Overall progress towards achieving Beaver Creek Watershed Restoration Initiative goals will be assessed in quarterly Steering Committee meetings starting in 2020 and lasting the duration of the project. Bi-annual qualitative and quantitative monitoring efforts over Phase I will be undertaken by the Knox County Stormwater Management and the data will be used to assure the project is on track.

At the completion of Phase I in 2023, TDEC's *E. coli* measurements will be compared to baseline data from 2017 and 2018. This analysis will determine if changes need to be made to the *E. coli* reduction strategies for Phase II and III implementation. Phase I milestones including the above BMPs, septic system repairs and education/targeted outreach efforts will be evaluated based on the effectiveness of their execution. The overall project will be considered successful when the *E. coli* loads and concentrations are low enough for Beaver Creek and its tributaries to be removed from the 303(d) list.

5.2 Phase I Timeline

Table 8. Timeline

Plan Year	2020				2021				2022				2023			
Quarter	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Activity																
Community Engagement																
Implement outreach: newspaper articles, website, presentations, social media	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Scoop the Poop Campaign development and implementation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Farmer's Breakfasts							X				X					
Farm Tours										X						
Targeted mailings - septic							X									
Targeted mailings - agriculture						X										
Community events		X	X			X	X			X	X			X	X	
Septic Repair Program																
Repair failed septic systems							X	X	X	X	X	X	X			
Agriculture BMP Program																
Implement BMPs on farms				X	X		X	X		X	X	X		X	X	
Monitoring and Evaluation																
5 in 30 Geomean Analysis															X	
Bi-annual single sample and analysis for *E. coli*			X								X					

6.0 Criteria to Assess Achievement of Load Reduction Goal

Phase I of this ten year watershed initiative will be assessed based on the completion of its interim milestones and on *E.coli* data from 2020 through 2023. Interim milestones include the installation of agricultural BMPs, septic system repairs and the implementation of community engagement activities. Quarterly meetings with Beaver Creek Watershed partners will be used to assess whether interim milestones are on track with the above timeline. Community engagement will be considered successful if scheduled activities are effectively conducted and outreach materials are created and disseminated. Quarterly assessments of project milestones will determine if adaptive management measures are needed.

Overall, *E.coli* load changes will be measured by comparing TDEC's most current *E. coli* measurements against baseline data from 2017 and 2018. The 2023 data will be analyzed to determine if changes to Phase II and III restoration strategies need to be made. The Watershed Initiative will be deemed successful when *E. coli* loads and concentrations are low enough Beaver Creek and its tributaries in their entirety are removed from the 303(d) list.

7.0 Monitoring and Documenting Success

TDEC monitors its sites in the Beaver Creek Watershed for *E. coli* levels on a five-year cycle. Knox County monitored those sites in 2017 and 2018. Knox County will conduct geomean monitoring at TDEC's sites in 2023. The monitoring data will be compared with pre-project baseline data and the most current TDEC data to determine the effectiveness of the restoration efforts. Qualitative data on land use adjacent to creeks and measurements of *E.coli* levels will be collected bi-annually by Knox County Stormwater Management and used to help adapt the plan as needed.

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