Oostanaula Creek Watershed Restoration Plan

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Ex Summary

The US Federal Clean Water Act was amended in 1987 adding Section 319 requiring states to develop restoration or management plans for impaired waterbodies to curb nonpoint sources of pollution. Section 319 also authorizes the EPA to issue federal funds to states to aid in implementing appropriate management programs to address these nonpoint sources. By targeting specific areas and land practices within a watershed, available federal and state cost-sharing funds can be used more efficiently to address known or potential pollution problems and protect water quality. This restoration initiative aims at developing an effective and integrated land management and monitoring approach for community stakeholders, which include local land owners, communities, authorities and resource managers, as they are required to make coherent, informed decisions regarding land resources and their future.

The Oostanaula Creek Watershed (OCW) in McMinn and Monroe Counties of southeast Tennessee covers 44,864 acres of which forest and pasture-based beef operations are the primary land covers surrounding a centrally located urban pocket. Segments of the primary stream running through the watershed are listed as only partially supporting, or not supporting, their designated uses according to the 2006 Tennessee 303(d) list of impaired waterways prepared by the Tennessee Department of Environment and Conservation (TDEC). Sources of impairment include pathogens, sediment and habitat alteration, and phosphorus. Pollution sources include major municipal point sources, surface erosion, pasture grazing, livestock in stream, and discharges from Athen's NPDES-permitted Waste Water Treatment Facility. TDEC has developed and EPA has approved Total Maximum Daily Load (TMDL) reports for Siltation and Habitat Alteration and Pathogens for the Hiwasee River Watershed.

To successfully remove Oostanaula Creek from the Tennessee 303(d) list will require a reduction of 54.2 to 72.2% in *E. coli* loads based on a TMDL for pathogens developed for Hiwasee; a reduction of phosphorus (TP) of 79.2% based on ecoregion reference streams; and based on a TMDL for sediment, a reduction of sediment and siltation by 59.4%. This watershed restoration plan was developed to provide a comprehensive plan for meeting these reduction targets and restoring Oostanaula Creek and its tributaries to fully support their designated uses. The plan focuses on promoting the use of Best Management Practices (BMPs) to reduce siltation from urban and agricultural sources, pathogens from livestock sources, and phosphorus from urban sources. Model results from a TVA developed land use analysis and pollutant loading model will be used to determine priority areas and post-plan pollutant fates and volumes.

The municipality of Athens, with a 2006 population estimate of over 14,000, is nested near the center of the watershed and is rapidly growing. A population increase of 20% is projected through 2025, leading to many rural areas

becoming urbanized. Traditional agriculture issues and pollutants (e.g. soil erosion) are giving way to construction and urban runoff impacts. As residential and commercial growth continues to encroach on agriculture land of east Tennessee, local officials and residents will need to establish water quality control measures for both agricultural and urbanization problem areas. Athens and McMinn County are still in the early phases of responding to growth and development pressures. There is thus a tremendous opportunity to further existing efforts in implementing smart growth principles and policies that will help strengthen those attributes of the region so valued by residents. To meet these challenges, the OCW will need to focus particular attention on: 1) preventing pollution from occurring, 2) reducing the amount of runoff and pollutants, 3) intercepting runoff and pollutants prior to entering the creek, and 4) promoting public participation and enforcement.

In support of TMDL implementation, effective partnerships have been forged to address various agricultural and urban components of an implementation plan. Through cooperative efforts, much of the essential groundwork has been laid for a multi-faceted approach to restoration, of which this plan is a key component. With support from various state and federal sources, the project has offered technical and financial resources for over 65 best management practices, or BMPs, to be installed and/or implemented since 2000. Additionally, several local outreach activities and materials have already been developed promoting the restoration campaign.

Spanning 15 years broken into three Phases, this plan proposes Goals, Objectives, and specific Tasks to achieve the targets set forth by the state. Tasks include streambank stabilization, livestock exclusion fencing, sediment trapping devices, NPDES monitoring, among others and are spearheaded by an extensive outreach campaign. Total estimated financial need for the Oostanaula Watershed Restoration effort is $2,032,636, with 96% of this going towards on-the-ground BMP installation and implementation. Apart for simply implementing land or water BMPs, it is imperative that this restoration plan brings about changes in existing practices, vision, objectives and principles of individuals living within or making decisions for the watershed. The remaining 4% of the proposed budget is intended for education and outreach activities and materials.

At the conclusion of Phase 1, notable milestones include reductions of 10% in pathogen levels, 25% in TP levels, and 10% in soil losses. Phase 2 milestones include reductions of 50% in pathogens, 75% on TP levels, and 50% in soil losses. Included in Phase 2 milestones is a public participation rate of over 15%. It is acknowledged, however, that there is a need to reassess BMPs, outreach activities and even reduction targets as this restoration initiative gets underway. As such, this restoration plan should be considered a blueprint for improvement with room for evaluation and adjustment. It is believed that through the implementation and installation of the proposed tasks and BMPs that these numeric goals may be achieved at the times suggested.

List of Acronyms

AUB	Athens Utility Board
BMP	Best Management Practice
BST	Bacteria Source Tracking
CAFO	Concentrated Animal Feeding Operation
CFU	Colony Forming Unit
CNMP	Comprehensive Nutrient Management Plan
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentive Program
GIS	Geographic Information System
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
IPSI	Integrated Pollution Source Inventory
MST	Microbial Source Tracking
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Services
OCW	Oostanaula Creek Watershed
PLM	Pollutant Loading Model
RUSLE	Revised Universal Soil Loss Equation
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment and Conservation
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Sediment
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USDA	United States Department of Agriculture
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
UT	University of Tennessee; University of Tennessee Extension
WWTF	Wastewater Treatment Facility

1.0 Introduction

The study of the effects of land use changes on the functioning of ecosystems and their ability to provide goods and services has attracted much attention from applied ecologists and land managers. In particular, scientists predict that a decrease in water quality will lead to reductions in aquatic ecosystem functioning and land managers in turn predict this drop in functioning will lead to a decline in the quality or quantity of services. Both forecasts are valid and gaining interest in today's environment of urbanization.

Linking land use (change) with stream and habitat condition is a critical step in aquatic resource management. If water quality changes predictably with land cover, then assessments of land use can be used as an indirect measure of local water quality. This is especially true with agriculture impacts, but poorly reflected in urban settings. Maintaining the ecological and aesthetic values of streams as urbanization occurs is a growing and difficult challenge for managers and planners.

The Athens area of McMinn County is growing with many rural areas becoming urbanized. Traditional agriculture issues such as nonpoint sources of pollution (e.g. soil erosion) are giving way to construction and urban runoff impacts. As residential and commercial growth continues to encroach on agriculture land of east Tennessee, local officials and residents will need to establish water quality control measures for urbanization problem areas. For example, such problems can be minimized if developers, contractors and city planners make the effort to eliminate sediment loss and high stormwater discharges. However, unsustainable agricultural practices remain contributing factors to suboptimal water quality.

The Oostanaula Creek Watershed (OCW) in McMinn and Monroe Counties covers 44,864 acres of which forest and pasture-based beef operations are the primary land covers. The city of Athens is also nested near the center of the watershed. Segments of the primary stream running through the watershed are listed as only partially supporting, or not supporting, their designated uses according to the 2006 Tennessee 303(d) list of impaired waterways prepared by the Tennessee Department of Environment and Conservation (TDEC). The State of Tennessee's final 2006 306(d) list (TDEC 2006) was approved by the U.S. Environmental Protection Agency (EPA), and is an update of the 2004 version.

Under the 1977 U.S. Clean Water Act, states are required to establish water quality standards and create Total Maximum Daily Loads (TMDL) for impaired waters. A TMDL is a calculation of the maximum amount of a pollutant load that a waterbody can receive and still meet water quality standards described by Section 303 of the Clean Water Act. The final version of a pathogen TMDL for Hiwasee River Watershed, the reservoir into which Oostanaula Creek deposits, cites *Escherichia coli* as a cause of impairment for 48.9 river miles and phosphates and siltation leading to loss of biological integrity as priorities for 7.4 river miles (TDEC 2005a).

The TMDL identifies pollutant sources such as surface erosion, pasture grazing, livestock in stream, all nonpoint sources of pollution, and municipal point source discharges, such as Municipal Separate Storm Sewer System (MS4) discharge and discharges from Athen's NPDES-permitted Waste Water Treatment Facility (WWTF). The Athens Utility Board (AUB) operated Oostanaula Creek WWTF discharges to the creek at mile 30.1. In December 2005 TDEC Nashville had the draft TMDL for pathogens for the Hiwasee River Watershed approved by EPA (TDEC 2005a). A copy of this document can be found at the TDEC website at:

http://tennessee.gov/environment/wpc/tmdl/approvedtmdl/HiwasseePath.pdf

In January, 2006 TDEC had a TMDL for siltation and habitat alteration for the Hiwasee River Watershed approved (TDEC 2005b), which can be reviewed at:

http://tennessee.gov/environment/wpc/tmdl/approvedtmdl/HiwasseeSed.pdf

Based on the priorities and load allocations defined in these documents, this restoration plan was developed for the watershed, suggesting best management practices, and the subsequent post-plan estimates of pollution. The pathogen, phosphate and siltation reduction goals for Oostanaula Creek outlined in these TMDLs will form the basis of this watershed restoration plan. Due to the inherent difficulty in estimating nonpoint sources of pollutants, few, if any, watershed restoration plans have been developed that consider these sources. Using the best tools available we identified and proposed practices that all minimize relevant point and nonpoint sources of pollution. This restoration plan will be critical for not only predicting, but also directing future paradigms that will result from the evolution of environmental, socioeconomic and political conditions.

1.1 Location

Oostanaula Creek (HUC: TN06020002083) is a tributary of the Hiwasee River watershed of southeastern Tennessee, southwestern North Carolina, and Northeastern Georgia (Figure 1.1). The headwaters of the Hiwassee River begin in the mountains of northern Georgia and flow through North Carolina before veering west into Tennessee to join the waters of the Tennessee River. The entire Hiwassee River basin drains 2,700 square miles of land, much of which lies in the Chattahoochee (Georgia), Nantahala (North Carolina), and Cherokee (Tennessee) National Forests.

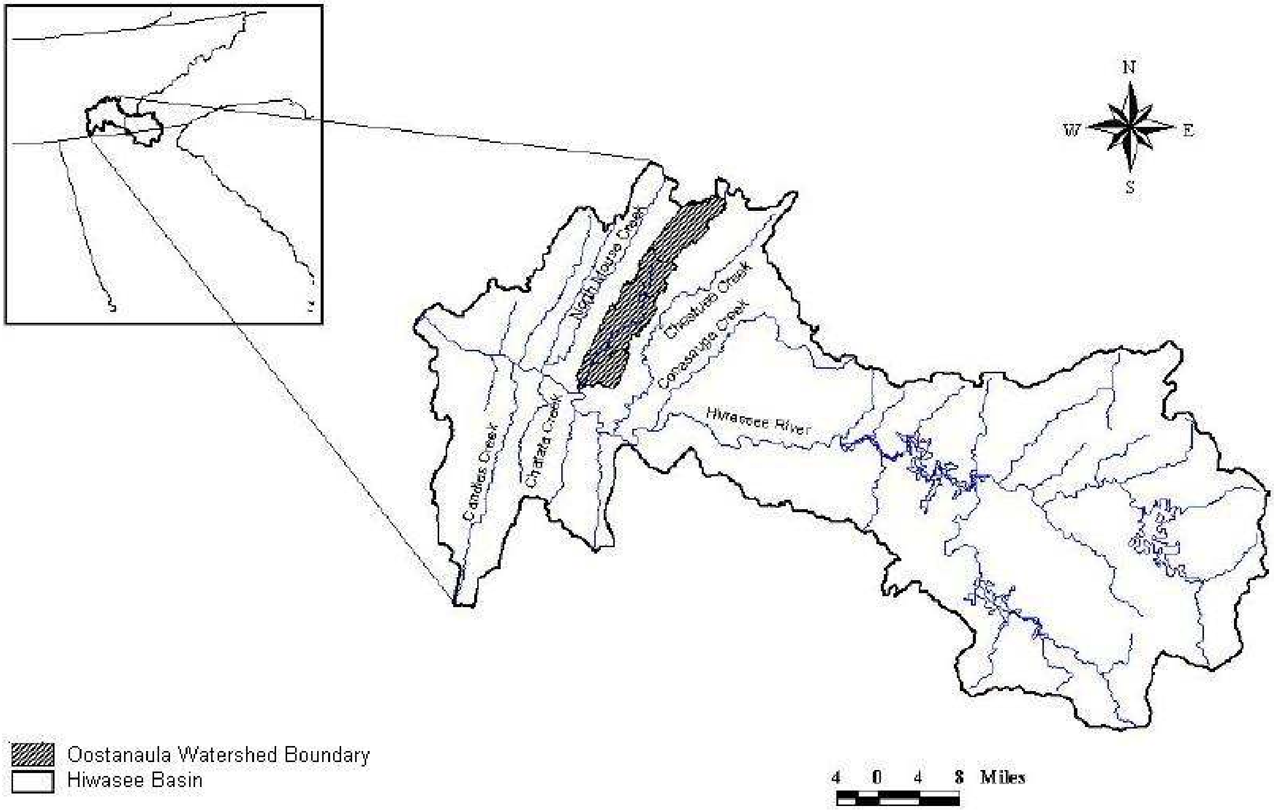

Figure 1.1. Location of the Hiwasee River and Oostanaula Creek of Tennessee.

Oostanaula Creek flows south to southwest from southern sections of Monroe through the center of McMinn Counties, entering the Hiwasee River at mile 19.8. The metropolitan area of Athens (US Census 2000 pop. 13,220) is positioned in the center section of the OCW and in the adjacent North Mouse Creek Watershed. OCW lies within the Ridge and Valley Ecoregion (67) defined by the EPA. This is a relatively low-lying region between the Blue Ridge Mountains to the east and the Cumberland Plateau on the west.

1.2 Partnerships

Preserving and sustaining the ecological values of waters in the face of other societal needs (especially in urban settings) is difficult and requires the participation of scientists, managers, economists, engineers and sociologists. Partnerships are therefore crucial to ensure a comprehensive and effective approach to restoring and maintaining water quality. Such integrations pool resources and experience and facilitate the dissemination of information among participants and local organizations. They also provide important arenas to exchange ideas, common projects, expertise, and knowledge for the establishment of integrated management plans.

Past and present cooperating partners in monitoring and restoration activities for Oostanaula Creek include the city of Athens, Athens Utility Board (AUB), McMinn and Monroe counties, Soil and Water Conservation Offices of McMinn and Monroe Counties, Tennessee Department of Agriculture (TDA), Tennessee Department of Environment and Conservation (TDEC), Tennessee Wildlife Resources Agency (TWRA), Tennessee Department of Health (TDH), the University of Tennessee and University of Tennessee Extension (UT), Agriculture Extension agents of McMinn and Monroe Counties, Tennessee Valley Authority (TVA), Environmental Protection Agency (EPA) and USDA - Natural Resources Conservation Service (NRCS).

AUB's Water Division provides water in the city of Athens and parts of McMinn County. Water from local springs and wells is pumped to AUB's filter plant where state-licensed operators work to meet and surpass state and national water quality standards. AUB's Wastewater Division is responsible for treating the water from both industry and residential customers across the service region. A substantial amount of the resulting waste from treatment and clarification discharges into Oostanaula Creek at mile 30.1. AUB has played an active role in the restoration process of OCW, including monthly water quality sampling.

Lead by TDA and TVA, regularly scheduled stakeholder meetings have been held creating new partnerships, strengthening existing partnerships and fostering trust and commitment. Outputs from these meetings include the coordination and development of educational projects and events aimed at improving the knowledge of local citizens, landowners and elected officials concerning the origins and prevention of nonpoint source pollution. TDA has also allocated federal funds to the OCW restoration initiative. Funds were granted from the competitive 319-grant pool and a Unified Watershed Assessment grant to specifically address nonpoint source pollution issues and problems. These grants have been instrumental in installing and implementing on-the-ground BMPs for water quality improvements.

TDEC has been instrumental in documenting the status and trends of water quality of Oostanaula Creek. Using data collected by TDEC the Hiwasee River Watershed TMDL for pathogens, which specifies water quality of Oostanaula Creek, was developed. Seven water quality monitoring stations within the OCW provided data for waterbodies identified as impaired due to pathogens by TDEC, with one station having a collection history since December 1982. Data from historical and recent water quality samples were instrumental in the development of a TMDL for Fecal Coliform in Oostanaula Creek (TDEC 2002), a TMDL for Pathogens in the Hiwasee River Watershed (TDEC 2005a), and a TMDL for Siltation and Habitat Alteration in the Hiwassee River Watershed (TDEC 2005b).

In addition to coordinating demonstration BMPs and public awareness efforts, TVA has developed an Integrated Pollutant Source Identification (IPSI) suite of management tools to assist stakeholders to identify sources of pollution and estimate pollutant loads from the various sources. The management portfolio includes a detailed land analysis supported by a desktop Geographic Information System (GIS), a nonpoint pollutant source (NPS) inventory, and pollutant loading models (PLM). IPSI methodology and pollutant loading model inputs are further described in Section 3.1, NPS Inventory Methods.

1.3 Accomplishments

By involving the many groups and agencies listed above, a number of benefits have resulted from the integrated, cooperative, and voluntary watershed management approach. These include: (1) an increase in the quality and quantity of monitoring data; (2) better focused water quality assessments and planning; (3) more efficient and equitable permitting programs; (4) improved coordination and integration of state water program functions and goals; and (5) greater public involvement in state water quality program decision-making.

With support from the TVA, NRCS' EQIP grant funds, and Federal 319 grant funds, the project has offered technical and financial resources for over 65 best management practices, or BMPs, to be installed and/or implemented since 2000. Examples of installed and implemented BMPs include heavy-use protection areas, pasture improvement initiatives, waste utilization infrastructure, and alternative watering facilities for livestock (primarily on six large beef or dairy farms). Table 1.1 below provides an example of agricultural BMPs installed and/or implemented in FY2004.

Table 1.1. Agricultural BMPs and cost-share expenses in Oostanaula Creek watershed in FY04.

Stream Crossing	4
Stream Fencing to protect streambanks	10,985 ft
Cross-fencing for rotational grazing	6,235 ft
Manure transfer system (pipeline)	9,520 ft
Pump and pipeline	6,512 ft
Watering tanks	8
Heavy use are protection	7 feeding pads
Cropland conversion	25 acres
Roof water management	
Travel lane for livestock	565 ft
Total Costs	$127,955

In support of TMDL implementation, effective partnerships were forged to address various agricultural and urban components of an implementation plan. Examples of these partnership outcomes include: utilization of a Unified Watershed Assessment grant from TDA to asses agricultural operations in upper Oostanaula Creek; funding from TVA to AUB for installation of three new stream gauges; and cooperative public outreach and education efforts through the cooperation of Athens Public Works, AUB, Keep McMinn Beautiful, McMinn County Planning, and TVA.

The potential benefits of stakeholder involvement are now well-documented and involving the public early on in conservation planning not only produces decisions that are responsive to public opinion and values, but also helps to resolve conflict, build trust, and educate and inform the local public about their environment. The positive effects of public participation are however uncertain because they depend upon the nature of the participation effort, how sustained it is, and the historical and social context in which the campaign occurs. Developing effective participation, building social trust and achieving more democratic community decisions are not likely to be achieved by marginal, one-time, afterthought stakeholder programs.

Examples of outreach initiatives include educational booths set up at McMinn Farm-City Day (Athens, May 9 2006) which had appx. 660 people attend, and at Athens' Fishing Derby (Athens, Apr 22 2006, appx. 100 people). Booths were set-up demonstrating the importance of grass on retarding soil erosion, and demonstrating the abundance of local aquatic fauna. Media stories and a 17 x 22' color brochure insert into the Athens newspaper Daily Post Athenian (2006 circulation of 12,148) have also been conducted. These brochures were also distributed to local schools and city and county offices.

Monthly monitoring efforts are continuing by representatives from TDEC, AUB and McMinn County at 17 sites for one or all of the physical, chemical and biological parameters listed below:

Physical: temperature, electrical conductivity, turbidity, total dissolved solids, total solids, and total suspended solids
Chemical: pH, dissolved oxygen, nitrate-N, ammonia-N, total-N, chloride, sulphate, total phosphorus, and soluble phosphorus
Pathogens: total coliform, and *E. coli*

TDEC's Division of Water Pollution Control previously developed a Fecal Coliform TMDL for Oostanaula Creek based on water quality data collected at mile 28.4 during the period December 1982 through September 1999 (TDEC 2002). The required reduction in pathogens at mile 28.4, according to the 2002 document, was 96.5%. Recent pathogen data (*E. coli* and fecal coliform) collected at mile 28.4 and other monitoring locations along the creek warranted a re-examination and revision of the 2002 TMDL.

The recent analysis showed a significant decline in the number of fecal coliform counts which exceed the required state appointed optimum (Table 1.2). Data collected during the period December 1998 to June 2004 were used for comparison to original 2002 TMDL data, which are presented in a Load Duration Curve below in Figure 1.2. Results from Figure 1.2 and Table 1.2 clearly suggest significant improvements have been achieved for pathogen loading in Oostanaula Creek. Such results were used in the development of a new pathogen TMDL for Oostanaula, which required a reduction in pathogens at mile 28.4 at 67.7% (TDEC 2005a). While casual factors can not be identified at this time, the noted (-30%) improvement of pathogen loading in the local water is a clear example of a tangible accomplishment.

Table 1.2. Comparison of Fecal Coliform Load Duration Curve Analyses for Oostanaula Creek mile 28.4; from TDEC 2005a.

TMDL Analysis	**2002**	**2005**
Sample Dates	12/82-6/96	12/98-6/04
Number of Samples	51	32
Number > 1000 counts/100 mL	28 (54.9%)	6 (18.8%)
90th Percentile (Counts/100 mL) (High Flows)	73,000	6,630
90th Percentile (Counts/100 mL) (Moist Conditions)	27,800	2,384
90th Percentile (Counts/100 mL) (Mid-Range Flows)	13,190	1,260
90th Percentile (Counts/100 mL) (Dry Conditions)	6,990	788
90th Percentile (Counts/100 mL) (Low Flows)	3,770	861
90th Percentile (Counts/100 mL) (All Data)	19,200	2,790
Required Reduction (%)	95.3	67.7

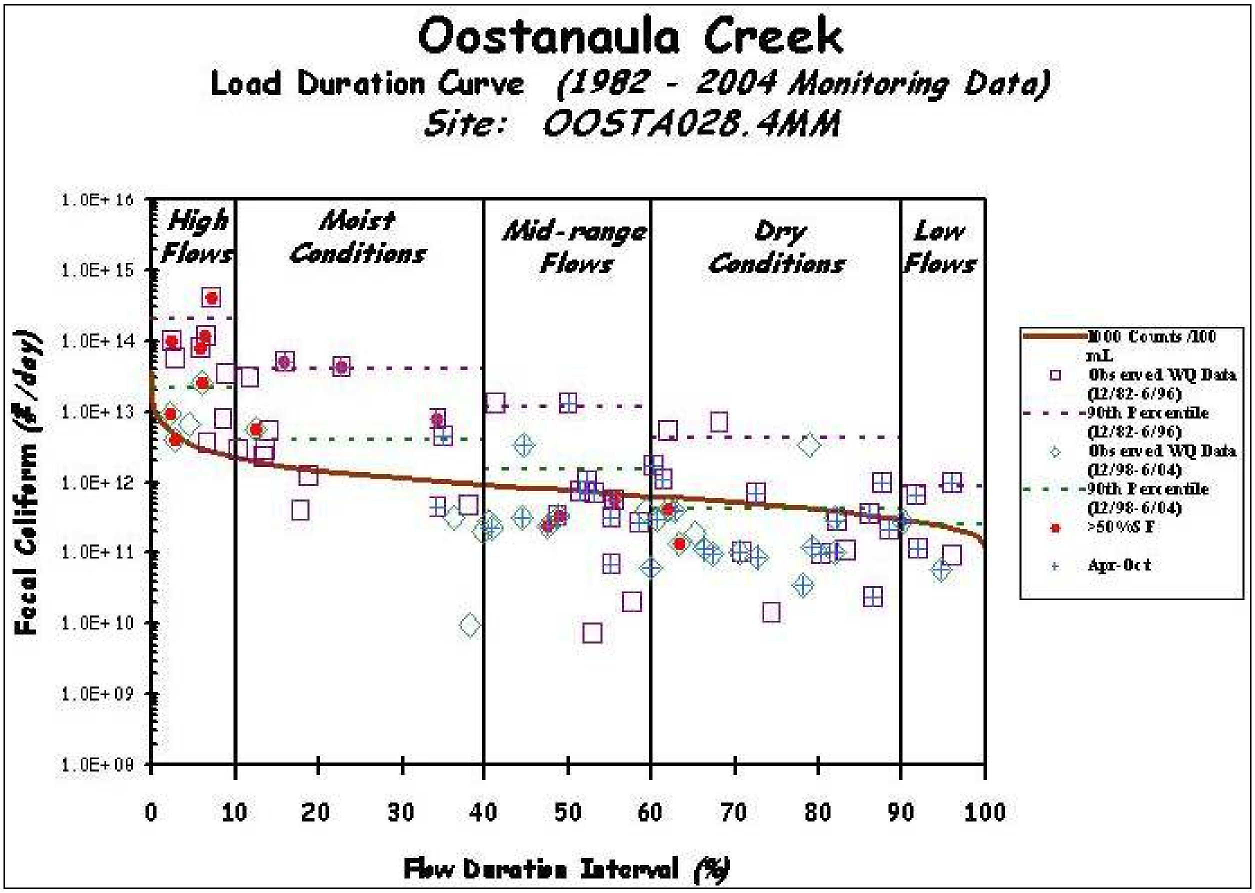

Figure 1.2. Flow duration curve for Oostanaula Creek mile 28.4 representing historical and recent pathogen monitoring data, from TDEC 2005a.

1.4 Plan Purpose

Societal concerns about human effects on the environment are embodied in a variety of legislative mandates, as reflected in the Clean Water Act of 1972 (and as amended, US Code title 33, section 1251-1387). The objective of this act is to “restore and maintain the chemical, physical and biological integrity of (the) Nation’s water’ (US Code title 33, chapter 26, subchapter 1, section 1251a). While much of this mandate has successfully addressed point sources of pollution, a new emphasis is being placed on nonpoint sources. With increasing urban populations and demands for freshwater, the number and magnitude of nonpoint source stressors will continue to grow at the expense of the structure and ecological function of watersheds.

Watershed restoration and sustainable management practices have been increasingly accepted as effective tools to improve watershed function and health, and thus maximize the ecological services such as clean and stable water resource supply. Watershed scale modeling is in fact the ‘policy scale’ and therefore the models used at this scale should contribute to our knowledge of processes at this scale (including the uncertainty) and be tailored closely to the policy needs of the area. However, modelers must embrace the ‘applied’ element of their work and work closely with communities to resolve the many multi-faceted problems arising from agriculture and urban environments and present and future development. This restoration effort therefore aims at developing an effective and integrated land management and monitoring approach for community stakeholders, which include local land owners, communities, authorities and resource managers, as they are required to make coherent, informed decisions regarding land resources and their future. In this context, the project has and will make use of local knowledge, GIS tools, and remote sensing technology to inform effective decision making.

Water quality data from the published TMDLs and current sampling collections are being incorporated into the pollutant load model described. UT is interpreting the results of this analysis to develop strategies to improve water quality in Oostanaula Creek in conjunction with input from local and federal officials and stakeholders of the watershed. Appropriate BMPs will be recommended to reduce erosion and/or pollutant problems from areas identified as critical. To estimate the potential benefits of implementing BMPs, default inputs to the model were altered to reflect the application of recommended management practices.

We use output from the IPSI and PLM simulation to drive hydrological and nutrient flux models to quantify fine-scale environmental responses to changing management practices. In this context, we are not predicting the exact nature of future land management changes in the watershed; rather our objective is to demonstrate how the effects of computer simulations of changing practices can be portrayed on a spatial scale that is meaningful to landowners, regulatory officials and researchers. The results of this, and any modeling and decision support tool, must be taken up by those who control the rural landscape, i.e. the stakeholders. It is proposed that this suite of scale appropriate tools is useable and defensible by the people who will either create future change (planners and policy makers) or be expected to change practices (i.e. farmers).

The results of the field monitoring, IPSI analysis and suggested practices for improving water quality for OC are summarized in this report. The outcomes from this watershed restoration plan will enhance economic, ecologic and social development through the dissemination of findings and the transfer of ideas to stakeholders and city, county, state and federal levels.

2.0 Overview of Oostanaula Creek Watershed

The Oostanaula Creek Watershed (OCW) is 44,864 acres, or 70 square miles, of which 226 acres is open water. Perennial streams provide water for livestock in many permanent pastures, while intermittent streams furnish water during the wet months. Springs, cisterns and drilled wells provide water for farm and rural home use. The municipal water supply of Athens utilizes Ingleside Spring and a wellfield within the Hiwasee watershed. Both Ingleside Spring and the wellfield are located within a high to moderate hazard karst or fractured crystalline rock aquifer (TDEC 2003).

The coding scheme used in this plan was adapted from a hierarchical system developed by the United States Geological Survey (USGS), commonly referred to as HUC, or hydrologic unit codes. To address spatial heterogeneity, the OCW has been divided into 18 subwatersheds ranging in area from 125 to 6260 acres. These 11-digit hydrologic units were derived from corresponding source streams or tributary watersheds (Figure 2.1). These delineations are used in this restoration document.

2.1. Physiography

Oostanaula creek is typical of the Ridge-and-Valley region of the eastern U.S., with rolling hills and many meandering tributaries and agriculture operations located in the low lying areas. Annual precipitation for the OCW ranges from 44-54 inches. Average summer temperatures range from 66 to 87 ºF, and January temperatures range from 26 to 45 ºF. Elevations in the OCW range from 800 to 1,100 feet, with the city of Athens at 880 ft. The lowest point is in the southwestern part of the watershed at Calhoun, where Oostanaula Creek runs in to the Hiwassee River and Chickamauga Lake. This location is about 690 feet above sea level. In most areas, the difference in elevation between the valleys and the adjacent ridges is between 100 and 200 feet.

Oostanaula Creek is in the Ridge-and-Valley physiographic system, also referred to as Level III Ecoregion 67, which is indicative, or occupies much of the eastern United States from central Mississippi to southern New York, along the Appalachian Mountain chain (Omernik 1987). This northeast-southwest trending, relatively low-lying, but diverse ecoregion is nestled between generally higher, more rugged mountainous regions with greater forest cover. As a result of extreme folding and faulting events, the region’s roughly parallel ridges and valleys have a variety of widths, heights, and geologic materials, including limestone, dolomite, shale, siltstone, sandstone, chert, mudstone, and marble. Springs and caves are relatively numerous.

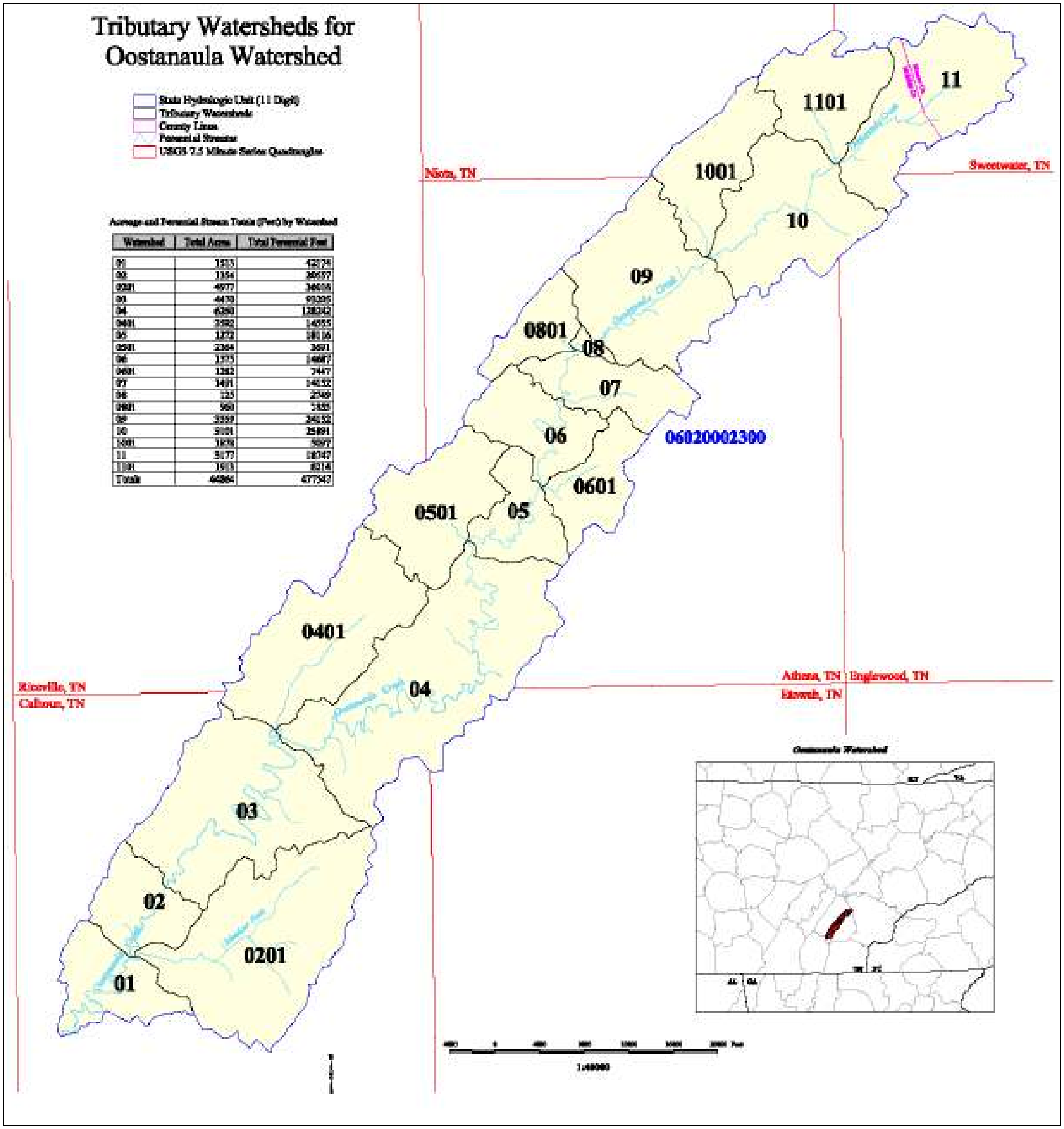

Figure 2.1. Delineation of subwatersheds throughout Oostanaula Creek Watershed.

The OCW lies in the Level IV Southern Limestone / Dolomite Valleys and Low Rolling Hills (67f) and Southern Dissected Ridges and Knobs (67i) Ecoregions, as illustrated in Figure 2.2 (Griffith et al. 1998).

The Southern Limestone / Dolomite Valleys and Low Rolling Hills (sub-ecoregion 67f) form a heterogeneous region composed predominantly of limestone and cherty dolomite. Landforms are mostly low rolling ridges and valleys, with few steep ridges. Bedrock geology consists of Quaternary cherty clay solution residuum and Ordovician dolomite and limestone. Soils vary in their productivity under the great group of Ultisols, and soil series Fullerton, Dewey, Decatur, Bodine, and Waynesboro (NRCS 2004). Table 2.1 below further describes characteristics of soils found within the planning area.

In ecoregion 67f white oak forests, bottomland oak forests, and sycamore-ash-elm riparian forests are the common forest types, with grassland barrens intermixed with cedar-pine glades also occurring. Land cover includes small discontinuous segments of thick forest and intensive agriculture, with agriculture lots and isolated urban areas common in the valleys.

The Southern Dissected Ridges and Knobs (67i) contain more crenulated or broken ridges, compared to the smoother, more sharply pointed sandstone ridges of ecoregion 67h. Although shale is common, there is a mixture and interbedding of geologic materials. The ridges on the east side of Tennessee's Ridge and Valley tend to be associated with the Cambrain and Ordovician-age Athens shale, including calcareous shale, limestone, siltstone, sandstone, and quartzose. The dominant soil orders are Inceptisols and Ultisols (Hapludults), with local series Steekee and Tellico (Table 2.1).

Appalachian oak forests (mixed oaks, hickory, pine, poplar, birch, maple) are typical for the higher elevations of the ridges, with areas of white oak, mixed mesophytic forest, and tulip poplar on the lower and less sloping lands. Due to the landforms of this ecoregion, fewer sites of urbanization or intensive agriculture occur here than in 67f.

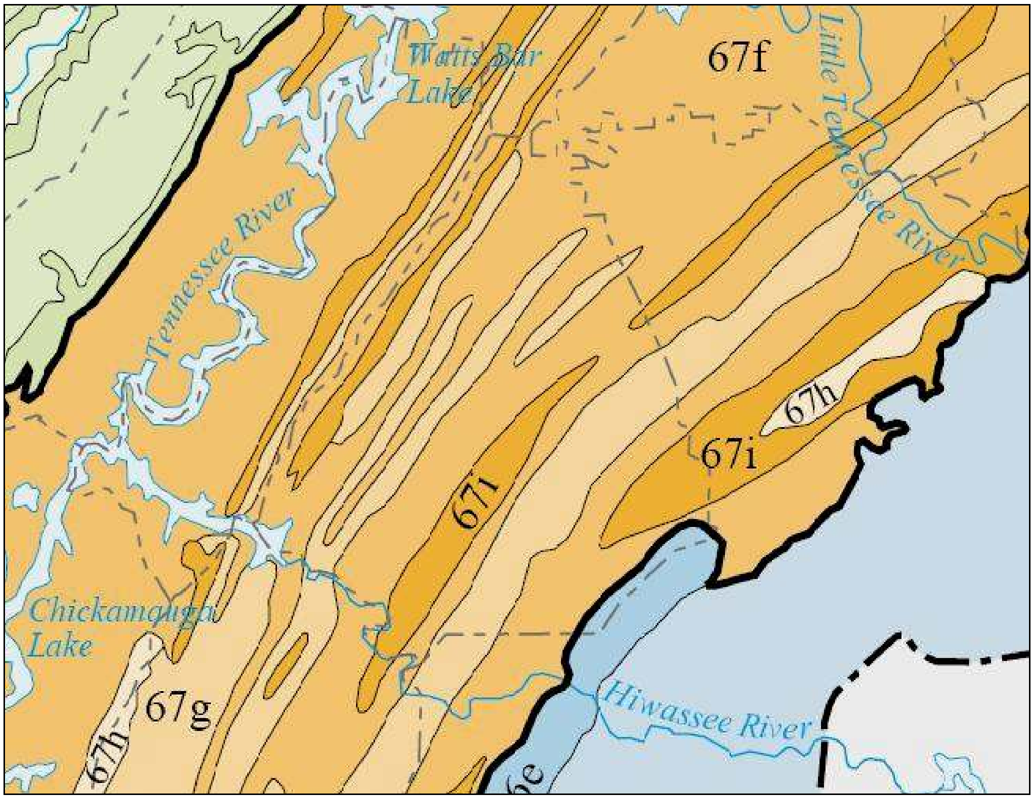

Figure 2.2. Level IV Ecoregions of the Oostanaula Creek Watershed and surrounding areas, from Griffith et al. 1998. Counties are delineated by dashed lines, with McMinn County in the center.

Table 2.1. Soil series within Oostanaula Creek Watershed classification and description; adapted from NRCS 2004. Very deep soil depth represents a non-limiting substrate.

Series	Depth	Drainage Class	Permeability	Landscape Position	Parent Material	Taxonomic Class
Bodine	'Very deep'; C horizon >60in	Excessively drained	Moderately rapid	Ridge crests, shoulder slopes, side slopes	Derived from cherty limestone and dolomite	Loamy-skeletal, siliceous, semiactive, thermic Typic Paleudults
Decatur	'Very deep'; to bedrock: 4-14ft; C horizon >67in	Well drained	Moderate	Ridge crests and side slopes	Old alluvium or colluvium underlain by residuum derived from limestone or dolomite	Fine, kaolinitic, thermic Rhodic Paleudults
Dewey	'Very deep'; to bedrock: 5-20ft; C horizon >70in	Well drained	Moderate	Ridge crests and side slopes	Old alluvium underlain by residuum derived from limestone or dolomite	Fine, kaolinitic, thermic Typic Paleudults
Fullerton	'Very deep'; to bedrock: 10-40ft; C horizon >60in	Well drained	Moderate	Ridge crests, shoulder slopes, side slopes	Derived from cherty limestone or dolomite	Fine, kaolinitic, thermic Typic Paleudults
Steekee	Shallow; to bedrock 20-60in	Well drained	Moderate to moderately rapid	Ridge crests, backslopes, and sideslopes	Derived from quartzose limestone, calcareous sandstone and shale	Loamy, parasesquic, thermic, shallow Ruptic-Ultic Dystrudepts
Tellico	'Very Deep'; to bedrock >60in	Well drained	Moderate	Ridge crests, backslopes, and sideslopes	Derived from quartzose limestone, calcareous sandstone and shale	Fine, parasesquic, thermic Typic Rhodudults
Waynesboro	'Very deep'; to bedrock: 2-20ft;	Well drained	Moderate	Ridge crests, stream terraces, side slopes	Old alluvium derived from sandstone, shale, and limestone	Fine, kaolinitic, thermic Typic Paleudults

2.2 Land Use

Positioned within McMinn and Monroe Counties, the OCW is primarily an agriculture land area, with the city of Athens as a centrally located incorporated municipality. McMinn County's main industry is manufacturing, with 35 percent of the county's workforce employed making products including newsprint, fiberglass shingles, automotive components, electric motors, hosiery, clothing, furniture, farm machinery, plastic goods, spas and chemicals. Notable large firms within the area include DENSO Manufacturing, Bowater Newsprint, Mayfield Dairy Farms and Goody's Family Clothing.

Many customary urban structures, and their drainage basins, are located outside of the OCW and have no immediate impact on the watershed. McMinn County airport is positioned to the east of Athens, and three large industrial parks and the Southeast Tennessee Trade and Conference Center are to the north and west. The major roadway Interstate 75 is also positioned to the north and west. These structures to the west are nested within the North Mouse Creek Watershed.

Outside of urban areas agricultural sites are common, especially dairy and beef cattle operations. McMinn County is the 2nd ranked dairy producer in Tennessee, with approximately 5,100 head (NASS 2006). Data from the USDA indicate that farms in McMinn County are generally small, averaging 106 acres in size in 2002 (Table 2.2), although some farms are much larger. Total land in farms declined by about 8% from 1997 to 2002, mostly stemming from decreases in pasture acreage. Agricultural data for the watershed area are not readily available, although the planning process (cf. Section 3) identified 11 Dairy, 150 Cattle, and 3 Poultry operations in the watershed. There are no protected conservation lands in the watershed, nor does any part of the Oostanaula watershed lie within National Forest or Park boundary.

Table 2.2. McMinn County agriculture data for 1997 and 2002, from 2002 Census of Agriculture. US Department of Agriculture, National Agricultural Statistics Service.

	1997	2002
Number of farms	1298	1204
Land in farms (ac)	138,840	127,609
Average farm size (ac)	107	106
Harvested cropland	33,704	32,228
Cropland for pasture/grazing	32,649	21,258

Estimates of residential numbers and densities were formulated by population numbers from US Census data that were later referenced with current aerial photography and consultation with city and county officials and agencies. The 2000 US Census had population figures for Athens at 13,220 and McMinn

County at 49,015. As of 2006, there are 14,100 people in Athens (Athens Chamber of Commerce, personal communication), however the city is dissected by a small ridge which separates out the northwestern part of the city from OCW. Due to this landform, only 54% of the city, or 4808 out of 8912 acres, lies within OCW (Athens Public Works, pers. comm.).

The population density of Athens is 976 people/mi^2 with a housing unit average density of 450 units/mi^2 (US Census 2000). This density of course declines as one leaves the city limits. Figure 2.3 displays 2005 census estimates of population densities for McMinn County. Estimated population density for the OCW immediately outside of Athens is 250 people/mi^2. Population density of the remaining area within the watershed is estimated at 61 people/mi^2. Through consultation with local officials, previous documents on the watershed, and Census data, we estimate the present population of the OCW at approximately 13,435 (Table 2.3).

It should be noted that a population of 13,435 people in the OCW is only an estimate and is certainly not static. These estimates do not include seasonal residents. Conflicting population values have been estimated for the area, however the absolute accuracy of this approximation is beyond the scope of this document. The Tennessee Center for Business and Economic Research projects 20% growth in this area from 2000 to 2025 (CBER 2003). Under this assumption, population estimates for the OCW will reach beyond 16,000 by 2025. No data are available on the source(s) of this growth, but it is widely believed that a substantial portion of it is driven by growth in the local market for second homes.

The present area of Athens is 13.925 mi^2 (October 2006), which is expected to increase in a short time. An urban growth boundary for the city extends to a total of 47.6 mi^2, suggesting that additional growth is permissible. Growth projects in review include a widening of SR 30 south of Athens extending towards Etowah (beginning Dec 2007), and a circumnavigating bypass of SR 30, either north or south of the city.

Athens and McMinn County have experienced a constant and sustainable growth surge, especially along established roads. Commercial and Industrial locations naturally trend towards development along and near interstate access. Since 2000, nearly 100 new commercial construction permits and over 300 new residential permits have been awarded (Athens Public Works, pers. comm.). To adequately account for present and future growth of this region, the proposed watershed restoration and management activities in this document will address present and projected sources of water pollution.

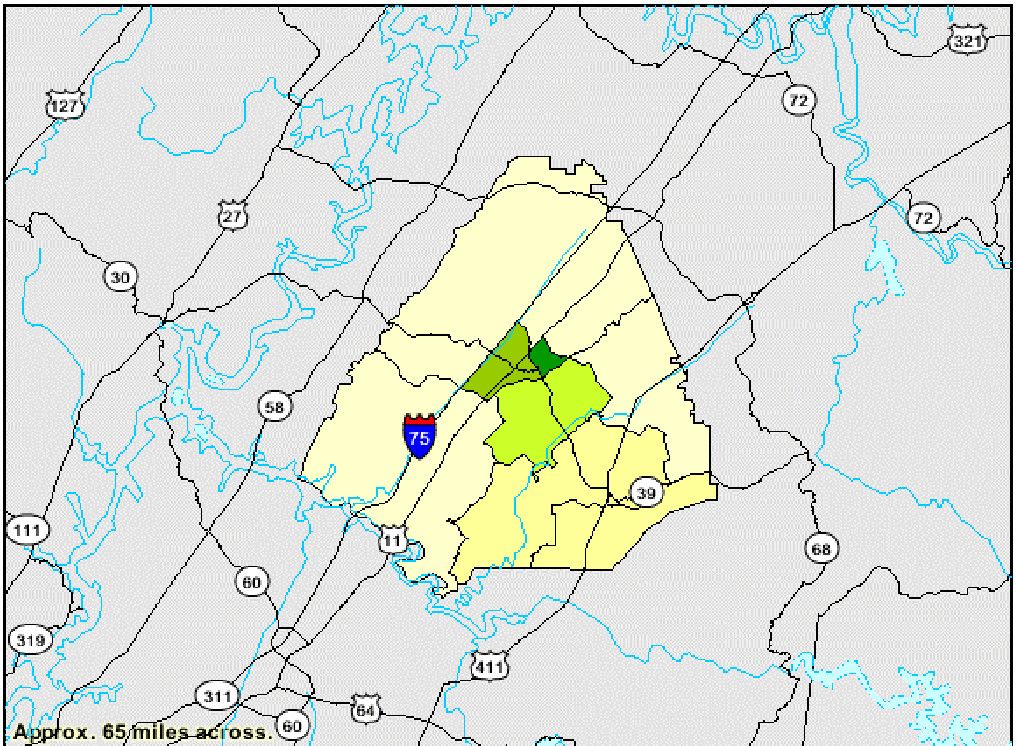

Figure 2.3. Population densities (people/mi^2) for McMinn County, with Oostanaula Creek running northeast-southwest south of US-11. Density estimates taken from 2000 US Census; Light yellow – 61-83 people/mi^2, Yellow – 110-129, Light green – 264-264, Med green – 563-563, Dark green – 1029-1029.

Table 2.3. Populations and household estimates for Oostanaula Creek Watershed. See text for methodology of estimates. na = not assessed.

	2006 est.	Number of Housing Units		
	Population	total	Public Sewer	Septic Tank
Athens	14,100	5755	4900	855
McMinn Co.	50,968	20803	na	na
Oostanaula watershed	13,435	5483	3333	2150

2.3 Water Quality Assessment

The Tennessee 303(d) list identifies 48.9 stream miles of Oostanaula Creek as impaired for one or more uses. Included in the watershed are 6.2 miles in Monroe County and 42.7 miles in McMinn County; 7.4 miles of impaired water is located in Athens city limits (TDEC 2004a, 2006). These waterways are designated as unable to support fish and aquatic life, and recreation at the same level as the ecoregion reference stream. Portions of the creek are also designated for irrigation, and livestock and wildlife watering. Identified causes of impairment are *E. coli*, phosphates, and siltation, stemming from pasture grazing, livestock in streams, municipal point sources and WWTF discharge (TDEC 2006).

The primary concern in OCW is elevated pathogen levels posing human health risks and prohibiting recreational opportunities. As such, data and assessments on fish populations and macroinvertebrate assessments will be minimally included in this plan. Instead, data compilation and analysis efforts will focus on data that will likely help characterize the likely sources of bacteria and nutrient loads to the stream.

Surface waters in this watershed have been monitored, and continue to be monitored, as part of the 5-year watershed management cycle. Past and recent chemical and biological monitoring results are summarized below.

2.3.1 Pathogens

As stated in Section 1.3 above, two separate pathogen TMDLs have been developed for OCW (TDEC 2002) and the broader Hiwasee River Watershed (TDEC 2005a). Based on water quality data collected at mile 28.4 during the period December 1982 through September 1999, several dates exhibited fecal coliform counts over 1,000 cfus/100mL (colony forming units, or a measure of viable bacteria numbers), with some observations greater than 30,000 cfus/100mL. The required reduction in pathogens at mile 28.4, according to the 2002 TMDL, was 96.5%. Since 2002, no fecal coliform count has exceeded 2000/100mL at this monitoring station, resulting in a new pathogen TMDL for OC, with new required reductions set at 67.7% (TDEC 2005a). Figure 2.4 and 2.5 display 2005 load duration curves for *E. coli* and fecal coliforms at mile 28.4 of OC. Curves for other sites along the creek appear similar.

An ongoing monitoring campaign conducted by TDEC, AUB, and McMinn County has resulted in a site-specific assessment of pathogen levels for Oostanaula Creek. A total of 17 water quality monitoring sites/stations are currently being utilized to determine biological, physical and/or chemical characteristics of the local surface water (Table 2.4). The majority of these stations are located in or north of Athens; only one station is located south of the city limits.

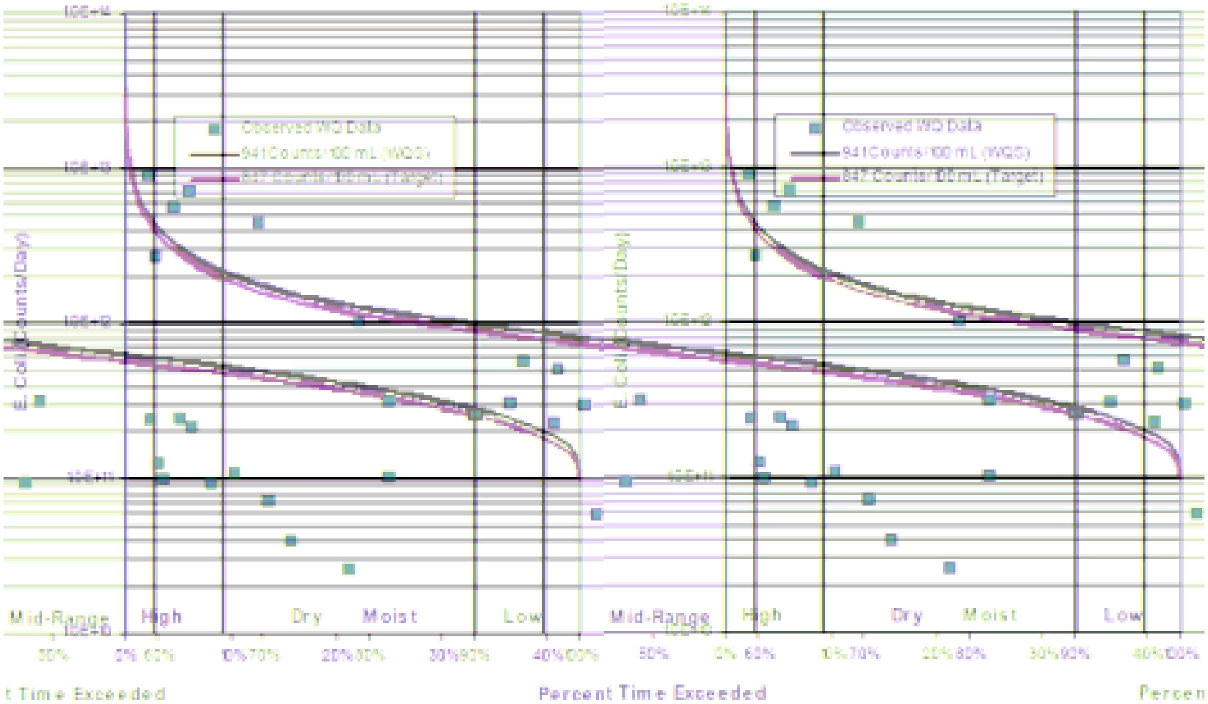

Figure 2.4. *E. coli* load duration curve for Oostanaula Creek, mile 28.4. From TDEC 2005a.

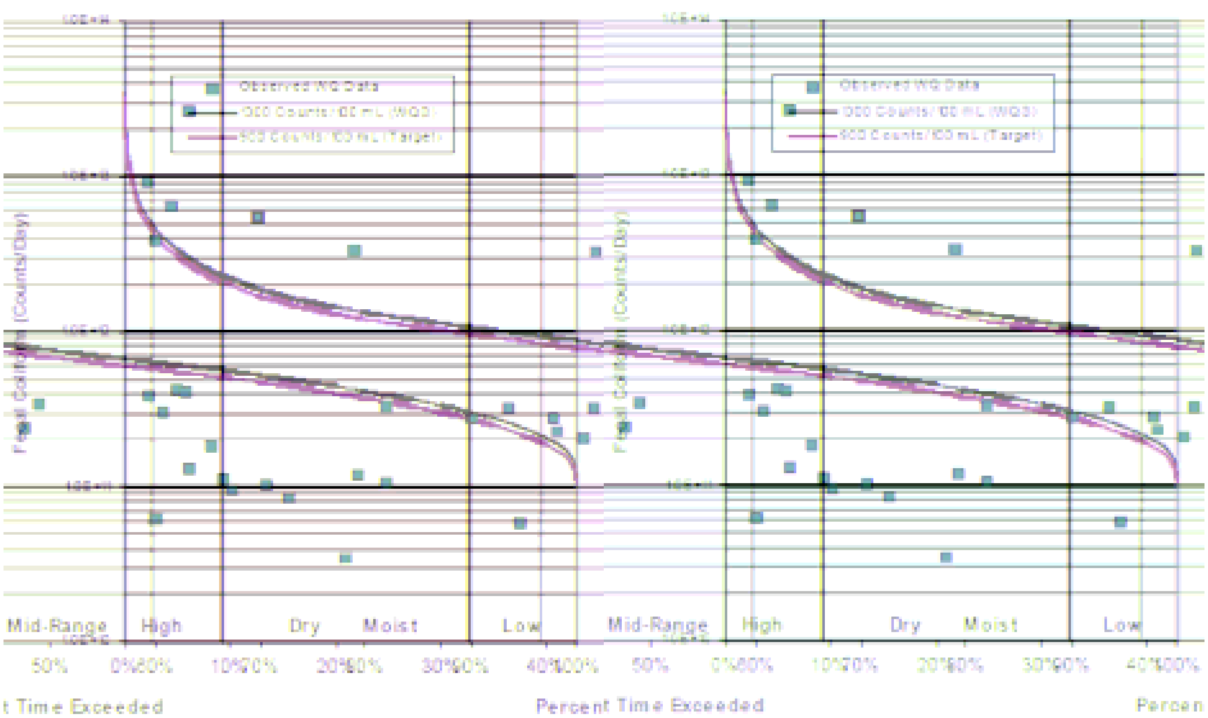

Figure 2.5. Fecal coliform load duration curve for Oostanaula Creek, mile 28.4. From TDEC 2005a.

Table 2.4. Location and description of water quality sample sites for Oostanaula Creek.

MM	Location	Parameters Sampled	Date range	Site Description	Responsible Agency
40.4	Off CR 307 in Monroe county	*E. coli*	8-05 to 9-06	Across County line at bridge	McMinn County
39.9	Near CR 401 and on CR 364 Intersection	*E. coli*, flow	8-05 to 9-06		McMinn County
39.4	Off CR 307 before Monroe county line	*E. coli*, flow	8-05 to 9-06	Downstream of dairy farm	McMinn County
-	At intersection of CR 361 and 360	*E. coli*	8-05 to 9-06	Trib to Oostanaula Creek	McMinn County
38.8	At CR 372 Bridge	*E. coli*	8-05 to 9-06		McMinn County
-	At CR 364	*E. coli*	8-05 to 9-06	Trib to Oostanaula Creek	McMinn County
35.7	Tellico Ave at bridge	*	10-02 to 8-05		AUB
35.1	Off CR 307, end of gravel road	*	10-02 to 8-05		AUB, TDEC
33.6	Spruce St.	*	10-02 to 8-05		AUB, TDEC
30.1	500 ft upstream of WWTF	*	10-02 to 8-05		AUB, TDEC
30.0	200 ft below WWTF effluent	*	10-02 to 8-05		AUB, TDEC
-	300 ft below WWTF effluent	*	10-02 to 8-05	Black Creek tributary	AUB
29.6	0.5 mi downstream of WWTF	*	10-02 to 8-05		AUB
28.4	Long Mill Rd. at bridge	*	12--82 to 8-05		AUB, TDEC
26.6	3.5 mi downstream of WWTF	*	10-02 to 8-05		AUB, TDEC
-	3.5 mi downstream of WWTF	*	10-02 to 8-05	Cedar Springs tributary	AUB
5.8	Sanford	fecal coliform	10-02 to 1-04		TDEC

* Fecal coliform, *E. coli*, Ammonia, NO2&NO3, TKN, TP, TOC, DO, Temperature, pH, Suspended Solids, BOD, and Turbidity

For the present analysis, the ten sites sampled within Athens were compared, as these sites had the most complete sampling regiment and record (October 2002 through present). This thorough and consistent monitoring regime is required by Monthly Operation Reports compiled and maintained by AUB and submitted to the TDEC local field office. To isolate problem locations, data points were averaged over time for each of the ten sites. Geometric means of *E. coli* counts are relatively low over all sites with a peak at the Black Creek site, an agricultural tributary to OC (Figure 2.6). This suggests that 1) the AUB WWTF is doing a sufficient job at removing pathogens from wastewater, and 2) Black Creek is a suspect area for pathogen release rather than urban sources. Data were then averaged over the sites to evaluate trends over time (months), with a disclaimer that water flow was not recorded. Apart from a single peak event (January 26, 2004 flow of 74ft^3/sec, compared to a 2004 average of 46 ft^3/sec), the general trend in *E. coli* counts since October 2002 is a decline (Figure 2.7).

State of Tennessee water quality standards (TDEC 2004b) for the *E. coli* group require that the concentration shall not exceed 126 cfus per 100 mL, as a geometric mean based on a minimum of 5 samples collected from a given site over a 30 day span. Individual samples can range from 1 to 941 cfus per 100 mL. The single sample standard, as designated by TDEC was exceeded on 31 dates over 210 samples spanning from 10-2002 to 8-2005.

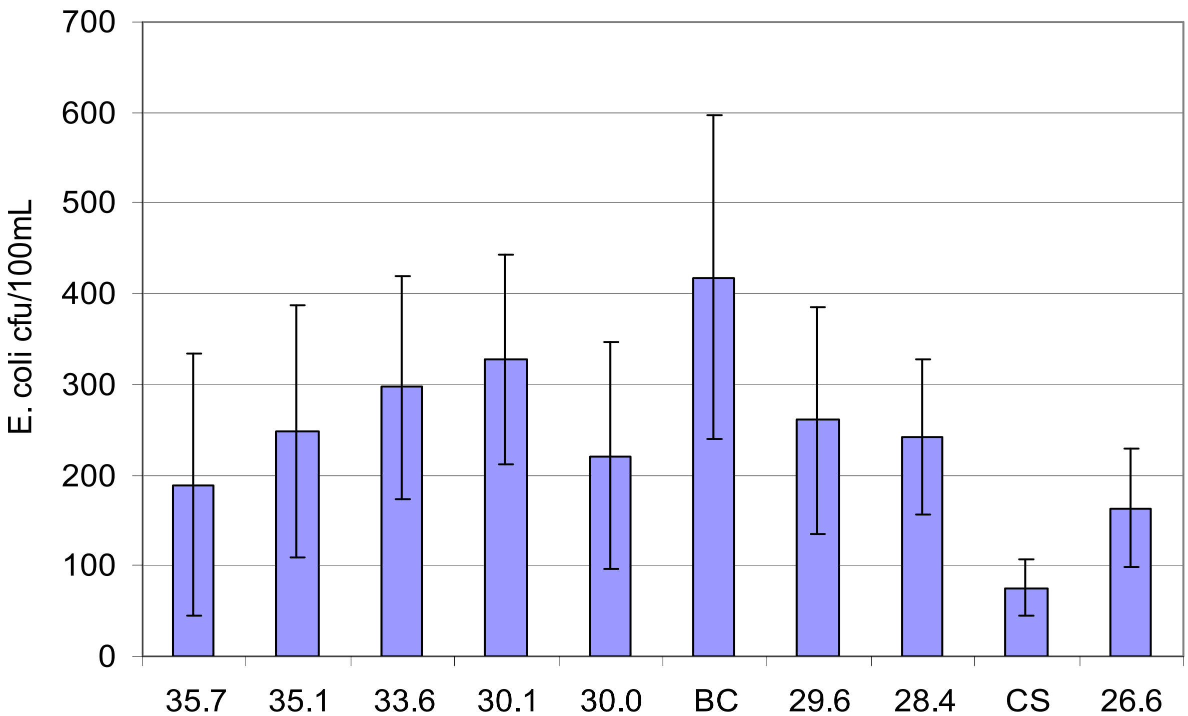

Figure 2.6. Geometric means (±1SE) of *E. coli* counts at various mile markers along Oostanaula Creek in Athens; unpublished data from Oct 2002 to Aug 2005 (N=35), from AUB and TDEC. BC and SC are tributaries to the creek.

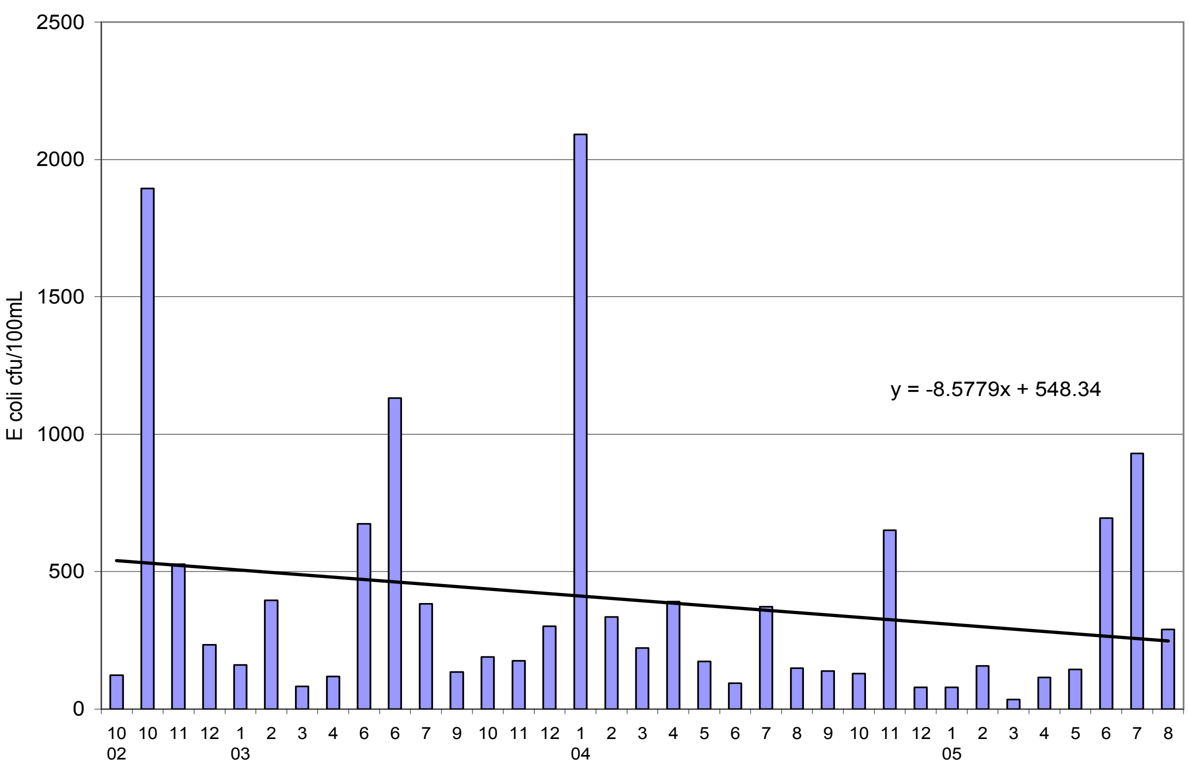

Figure 2.7. Geometric means of *E. coli* counts over time for Oostanaula Creek in Athens, mile markers 35.7 through 26.6; unpublished data from AUB and TDEC.

2.3.2 Nutrients

The state of Tennessee uses ecoregion reference streams as background data to assess the physical, chemical, and biological quality of streams also in that ecoregion. Reference streams are considered “control” streams of water quality in the ecoregion, as these waterways have the least amount of disturbance and impaction. The reference stream for OCW (ecoregion 67f) is Wolf Creek (TDEC site number ECO67F07; TN06010201070_1000), which is a Roane County tributary of Watts Bar Reservoir. No urban stream is currently designated as a reference stream, allowing no defendable definition of a ‘natural’ urban stream. This leaves open the question of what is the best possible condition of an urban stream.

The state 303(d) list defines phosphates as a priority within a 7.4 mile section of Athens city limits (TDEC 2004a, 2006). The target concentration of total phosphorus (TP) is 0.047 mg/L; based on ecoregion data. Sections of Oostanaula Creek within this 7.4 mile stretch display levels of TP in excess of this target level from October 2002 to December 2003, with one site being over 8 times greater (Figure 2.8); this source is likely the AUB WWTF situated between MM 30.1 and 30.0. The arithmetic mean TP concentration for OC miles 26.6 through 35.7 (Oct 2002 to Dec 2003, AUB) is 0.226 mg/L. The arithmetic mean concentration from January 2004 through May 2006 is 0.180 mg/L (geometric mean of 0.097 mg/L) suggesting some degree of recent phosphorus reduction in the 7.4 mile section of Oostanaula Creek originally cited as impaired. Figure 2.9 delineates this recent data by monitoring site. For these select monitoring sites, TP must be reduced 79.2% to reach target goals.

The target concentration of total nitrogen (TN) in the water is 0.610 mg/L, based on ecoregion reference stream data. The arithmetic mean TN concentration for OC miles 26.6 and 35.7 (Oct 2002 to Dec 2003, AUB) is 1.577 mg/L. Although not currently listed as a source of impairment, Oostanaula Creek is in excess of this target at every monitoring station from October 2002 to August 2003 (Figure 2.10) and should be reduced by 61.3% to meet the ecoregion target.

2.3.3 Sediment

Presently 7.4 miles of Oostanaula Creek are deemed impaired due to siltation, stemming from municipal point sources and surface erosion (TDEC 2005b). Siltation is the process by which sediments are transported and deposited on the bottom of rivers. Using a sediment loading model, TDEC (2005b) calculated an annual sediment load for OCW at 688 lbs/ac/yr. This value was then compared to the average annual sediment load for the ecoregion of 279 lb/ac/yr. Based on these two values, the TMDL for siltation required a reduction of sediment of 59.4%.

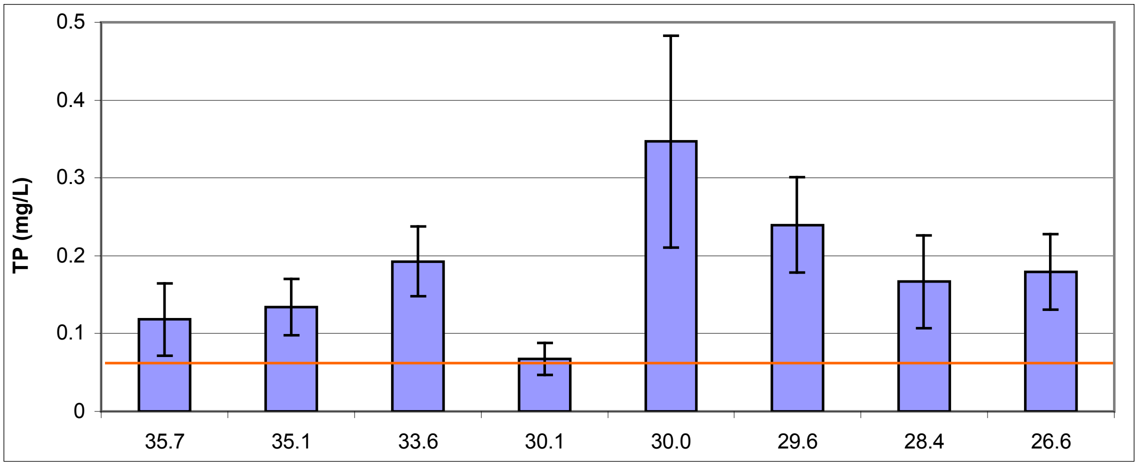

Figure 2.8. Mean phosphorus concentrations (1± SE) from October 2002 to August 2003 from select sites along Oostanaula Creek with the ecoregion target defined in a solid line.

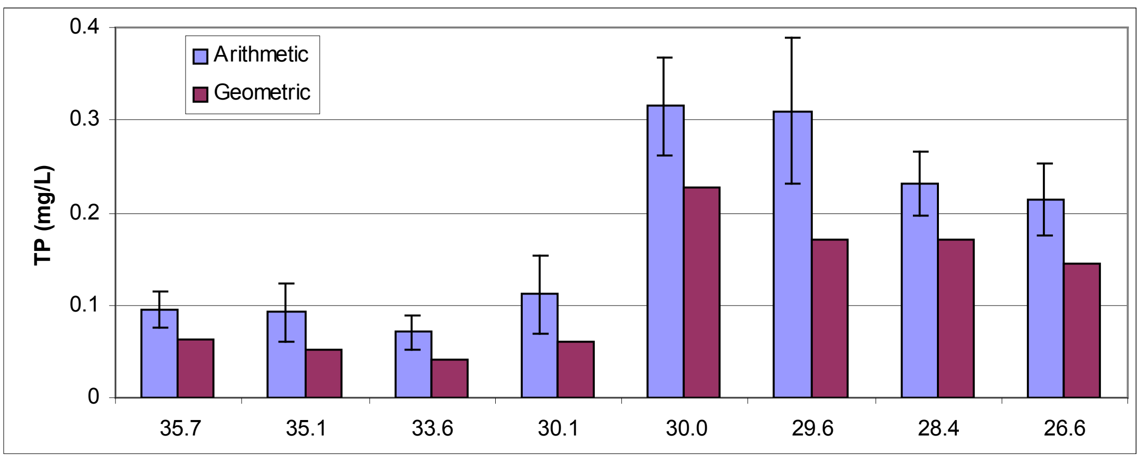

Figure 2.9. Mean phosphorus concentrations (1± SE) from January 2004 through May 2006 from select sites along Oostanaula Creek.

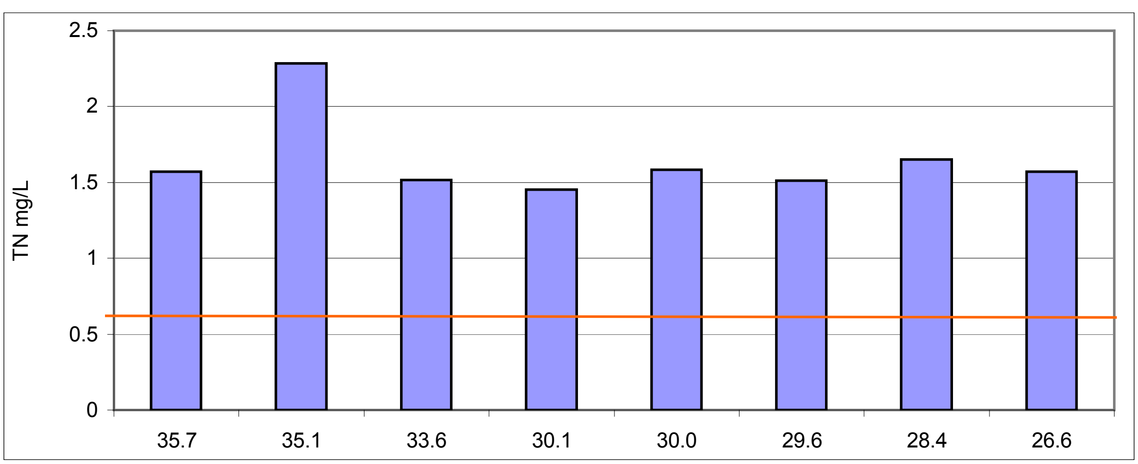

Figure 2.10. Mean nitrogen concentrations from October 2002 to August 2003 from select sites along Oostanaula Creek with the ecoregion target defined in a solid line.

A more recent analysis was conducted using an independently developed sediment loading model, and a new load estimate for the watershed is 395 lbs/ac/yr (cf. Section 3). This new value would require a 29.4% reduction in sediment loading.

Sediment from surface erosion is a major transport vehicle for nutrients, bacteria, and toxins; often resulting in spatially and temporally dynamic trends (Heathwaite et al. 2000). Due to such documented correlations between sediment, nutrients and pathogen fluxes, nutrient and sediment loading will be used as a proxy for pathogen loading for OCW where and when actual pathogen data may not be available. An extensive catalogue of literature currently exists for estimating nutrient loading from various land use classes, intensities and practices, including the Revised Universal Soil Loss Equation (RUSLE, Wischmeier and Smith 1978, Renard et al. 1997), from which we believe will be adequate to characterize and quantify pollutant fate and loads. A multi-year continuation of stream flow, pathogen and nutrient data will be required to better define this relationship.

2.3.4 Aquatic fauna and habitat

Physical characteristics of water (e.g. velocity, depth, temperature, turbidity) and geomorphic features of the channel (width, bank height) depend on streamflow. These characteristics and features define habitat units that create the physical template for stream ecosystems and given the magnitude of hydrologic changes resulting from urban development, urban streamflow patterns are likely to affect the biological conditions of streams. General effects of urbanization on macroinvertebrate species include decreased diversity in response to toxins and organic nutrients – especially evident in Ephemeroptera, Plecoptera, and Trichoptera; decreased abundances in response to toxins and siltation; and increased density (especially in Diptera) in response to nutrients. This response is correlated with impervious surface cover, housing density, human population density, and effluent discharge (Klein 1979, Kennen 1999).

Sediment is presumably having negative effects on fish populations in many areas, decreasing benthic invertebrate densities (food), although toxin-mediated impacts are also likely. Flow modification associated with urbanization, WWTF effluent, and road construction also affects stream fish. It is crucial, however, to recognize that all urban areas and growth does not have the same deleterious effects.

General fish response to urbanization includes: from 0 to 5% urban land use, sensitive species are lost; from 5 to 15%, habitat degradation occurs and functional feeding groups (benthic invertivores) are lost; and greater than 15% urban land use, toxicity and organic enrichment result in severe degradation of fish fauna (Schueler 1994, Yoder et al. 1999). Wang (2004) noted a decrease in

Index of Biotic Integrity (IBI) of near 65% and a drop in fish density of 50% with only 10% connected imperviousness. Similarly, Yoder and colleagues (1999) identified a 27% decline in IBI score with 10% urban land use.

Local assessments of fish, macroinvertebrate, and aquatic habitat have displayed positive trends over time, including: increases in number of fish species (including darter, sunfish and sucker species), number of fish observed, and overall IBI scores. IBI scores and supporting values are shown in Table 2.5.

Table 2.5. IBI analysis and scores for Oostanaula Creek; data from TVA.

Date	Station	Fish Count	Fish Species	IBI Score	IBI Ranking	EPT Score	EPT Ranking	Habitat Score
Jun-95	MM35.7	232	10	34	Poor	11	Fair	16
Aug-02	MM35.7	634	12	38	Poor/Fair	10	Fair	33
Apr-95	MM36.6	277	10	30	Poor	12	Fair/Good	20
Mar-02	MM36.6	523	14	34	Poor	11	Fair	17

2.3.5 Source assessment

An important part of water quality analysis is the identification of individual sources, or source categories of pollutants in the watershed that affect loading. Under the Clean Water Act, pollutants are classified as either coming from point or nonpoint sources, depending on the level of confinement and discrete conveyance from discharge. That is, how a pollutant arrives at a body of water defines its source.

As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters. Through aerial photograph interpretation of images from 1999, TVA has developed a map of point source discharge and suspect dump site locations, seen in Figure 2.11. This image has yet to be ground-truthed and many sites deemed as dump sites, may in fact need to be visually assessed.

OCW has at least one known, designated point source, centrally located in Athens, TN. Athens Utility Board's (AUB) Oostanaula Creek Wastewater Treatment Facility (WWTF) has been issued a NPDES permit for discharge of treated sanitary wastewater at mile 30.1. This facility had been cited for non-compliance for exceeding its Clean Water Act NPDES permit limit for *E. coli* in 2003 (US PIRG 2004, EPA 2006). The EPA designated this facility as a "major discharger", and forwarded a letter of violation to the site as recently at July 2005 due to non-compliant *E. coli* concentrations (EPA 2006).

It should be noted that the EPA has not cited this facility as non-compliant since 2005, and monthly averages of pathogen counts from effluent are well under regulatory limits for 2006 (Figure 2.6). Data from AUBs Oostanaula WWTF, as provided by TDEC, states that this operation is successful in removing bacteria from influent. For the months January to August of 2006, the mean concentrations of fecal coliform and *E. coli* in the effluent of this treatment plant were 1.71 and 1.66 cfu/100ml, respectively. The AUB Oostanaula WWTF is currently undergoing a $17.4 million upgrade, converting from a daily discharge capacity of 2.83 million gallons per day to 6.0. The new NPDES permit for the 6.0 facility states effluent discharge requirements at reduced rates from those of the 2.83 facility, e.g. 5.0 mg/L of N and 1.0 mg/L of P.

The watershed also contains a number of Tennessee Stormwater Multi-sector General Permits for industrial activities (TMSP), which allows substantial stormwater discharge. These include (as of 31 December 2006) Johnson Controls (metal products, 2 sites), Mayfield Dairy, M & H Car Parts, Seaton Iron and Metal (2 sites), Mills Products, Inc., Athens Plow Co. Inc., and Athens Furniture, Inc. Two Ready-mix Concrete Facilities (RMCF) with NPDES permits also reside in the area, Sequatchie Concrete and Bradley Concrete, both with maximum effluent limits set at 50 mg TSS/L. As of May 2006, only one CAFO is listed as located within the OCW: Carmichael Farms (poultry operation) on CR 732.

Discharges from NPDES-regulated construction activities are considered point sources of sediment loading to surface waters and occur in response to storm events. However, since construction activities at a site are of a temporary nature, the number of permitted sites at any given time or location varies. Since 2000, nearly 100 new commercial construction permits and over 300 new residential permits have been awarded. As of June 2005, the OCW had seven construction sites covered by NPDES Permit for Storm Water Discharges Associated with Construction Activity (TNR10-0000, TDEC 2005b).

While no site-specific information is available on the impacts of this construction, the potential for sediment inputs and, in some cases, on-going stormwater volume impacts is clear. Low density rural residential development has historically occurred throughout most of the project area, especially in areas of flat or rolling terrain. Development appears to have increased in recent years, with some of this newer development occurring at higher densities than more historic development. The use of stormwater management and/or smart growth practices are/is not evident in these areas.

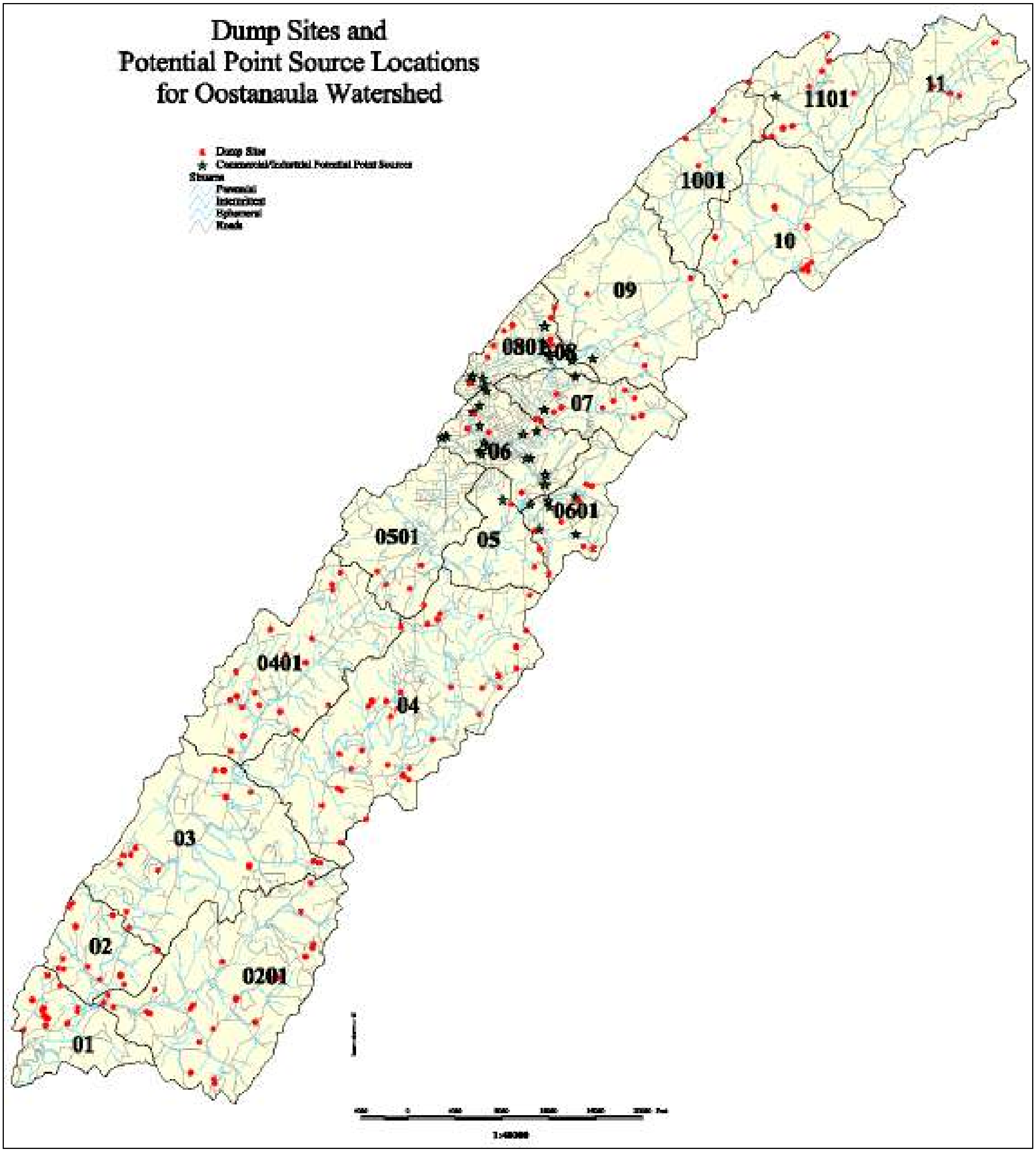

Figure 2.11. Point source discharge and suspect dump site locations in Oostanaula Creek Watershed, as identified via 1999 aerial photo interpretation conducted by TVA.

Nonpoint sources are diffuse sources that cannot be identified as entering a waterbody through a discrete and/or single location. These sources generally involve pollutant accumulation on land surfaces and wash-off as a result of storm events. Major contributors of this classification include natural soil weathering, livestock operations, cropland, wildlife, failing septic systems, impervious surfaces, and urban development. TDEC identifies the primary sources of nonpoint sediment loads as “agriculture, roadways and urban sources” (TDEC 2005b p21).

A nonpoint source inventory and assessment has been developed for the watershed to attempt to quantify nonpoint sources and pollutant loading estimates. The suite of tools collectively referred to as IPSI will be further expanded upon in a companion document, with highlights presented in the present document in Section 3. This set of tools provides pollutant load estimates by land use/land cover types, with which we can then offer potential BMPs to slow or minimize pollutant and sediment loading within OCW.

In addition to pollutant loading estimates derived from watershed modeling, source tracking of pathogens in the creek has been conducted using methods known as Bacterial Source Tracking (BST). BST is a collective term used for various emerging biochemical, chemical, and molecular methods that have been developed to distinguish sources of human and non-human fecal pollution in environmental samples (EPA 2002). In general, these methods rely on genotypic (also known as “genetic fingerprinting”), or phenotypic (relating to the physical characteristics of an organism) distinctions between the bacteria of different sources. Three primary genotypic techniques are available for BST: ribotyping, pulsed field gel electrophoresis (PFGE), and polymerase chain reaction (PCR).

Samples collected from seven sites in June 2005 were analyzed for *Bacteroides* using methods developed by Dr. Alice Layton, University of Tennessee - Center for Environmental Biotechnology to track bacterial sources (Layton et al. 2006). Total fecal, human fecal and bovine fecal concentrations (mg/L) were determined using real-time PCR assays directed towards measuring *Bacteroides* 16S rRNA gene sequences. Concentrations were determined using human fecal dilutions for the total and human fecal *Bacteroides* real-time PCR assays and using bovine fecal dilutions for the bovine *Bacteroides* real-time PCR assays. The percentage of feces attributable to humans and bovines was determined by dividing the mg/L of the host-specific assay by the mg/L obtained in the total assay. The results of this BST analysis are displayed in Table 2.6.

All fecal coliform measured exceeded the 200 cfu/100ml regulatory threshold by at least a factor of 10. The site with the highest fecal counts was on Walker Branch, south of the WWTF and downstream of a suspect dairy site. The Black Creek tributary also contributed a substantial fecal load to the waterway downstream of the city limits. The dominant fecal source in all water samples tested was cattle, providing support for the efficiency of AUB's WWTF in removing pathogens from influent. These results suggest that 1) fecal sources are presently stemming from agriculture operations and sites; and 2) fecal sources outside of Athens city limits contributed larger fecal loads to Oostanaula Creek than sites within the city on this sample date. These statements will be considered when proposing BMPs to reduce pathogen loads in the OCW

Table 2.6. Fecal load and source identification in Oostanaula Creek; data courtesy of A. Layton, UT Center for Environmental Biotechnology.

Site Location	River mile	Fecal coliforms (cfu/100ml)	Total Fecal (mg/L)	Source Identification (% attributable)
CR 360 off of 307	55.0	9133	133	Bovine (52%)
Stage at impoundment	35.7	5600	27	Bovine (92%) Human (7%)
Hwy 30 Bridge	31.5	4933	26	Bovine (32%)
Walker Branch	30.0	27000	1023	Bovine (79%)
Black Creek Trib	30.5	6320	58	Bovine (86%)
Longmill Rd	28.4	2167	20	Bovine (22%) Human (2%)
Sanford Rd	5.5	3533	28	Bovine (32%) Human (3%)

3.0 Nonpoint Source Pollution Inventory

The NPS inventory is based upon a geographic and numeric database originally developed by TVA that consists of information on local watershed features such as land use/land cover, streambank erosion sites, and livestock operations that are known or suspected to be nonpoint pollution sources. Values of acreage and land management practices are applied to characterize nonpoint sources of pollution, and the impact which they have. The present document highlights key outputs from the model described.

3.1 Methods

These databases are originally derived from remote sensing techniques used to acquire and interpret aerial photography and develop the NPS inventory and atlas. Frequent site visits were employed to reference, verify or overrule aerial photo interpretation. The structure of the GIS database and assumptions and equations used in the pollutant loading model are further defined in a companion document.

Soil loss was calculated for selected land use classes and other high-impact erosion features identified in the inventory. The amount of soil loss estimated was the total potential soil movement for the feature via detachment, transport and deposition, based on the RUSLE (Renard et al. 1997) originally developed by Wischmeier and Smith (1978).

A pollutant loading model was used to estimate pollutant loads for total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS) from the following sources: residential, commercial, industrial, transportation, cropland, pasture, forests, mined and disturbed lands, beef cattle, dairy cattle, swine, horses, and poultry. Nutrient characteristics (inputs) were based on literature values and calibrations to water quality data in previous studies of similar nature.

3.2 Land use classification

The dominant land use in the OCW is forest, comprising 47.6% of the total land area, which occurs primarily in the hill and ridge areas. A substantial amount of forested area is concentrated in southern subwatersheds 0201, 03 and 04, along Eledge Ridge, Gettys Ridge and Red Hills. In the valleys and flat regions of the OCW, pasture is dominant, occupying 30.7% of the total area. Additional land uses of the valleys are croplands, representing 5.3% of the watershed.

Residential areas represent 12.5% of the OCW, mostly in Athens and surrounding areas. Commercial and Industrial land uses total 2.3% which is also congregated around Athens. Wetlands and open water make up an additional 0.5 and 0.5% respectively, with the remaining 0.3% of land use in the form of mined or disturbed areas. Figures 3.1 and 3.2 summarize general land use patterns in Oostanaula Creek watershed.

The remote sensing process identified 116.5 miles of perennial stream contained within the watershed area, and a combined perennial and intermittent length of 258.5 miles. Collectively 17% of streambanks are classified as eroding and having visible, collapsed banks. Within the 44,864 acres of OCW, a total of 244.1 linear miles are classified as paved roads, and 137.7 miles are unpaved roads. Estimated length of eroding paved roads is 21.4 miles, or 8.8% of total paved roads. Estimated length of eroding unpaved roads is 52.7 miles, or 38.3%. It should be noted that all areas contained in and around the city of Athens had low percentages of streambanks and roadbanks considered eroding (<10%).

Total estimated livestock numbers are: 3,770 beef cattle, 1,135 dairy cows (with no additional delineation such as calves, dry cows, or lactating cows), 35 horses, and 200,000 chickens (140,000 broilers and 60,000 layers). Additional animals also reside in the watershed such as sheep, donkeys, hogs and llamas; however their population numbers are not available at time of document production. A total of 150 beef cattle sites were identified in the area, most classified as small (15-49 animals), and only two of the sites classified as large (>110 animals). Eleven dairy sites were reported: two large (>150 animals), eight medium (100) and 1 small (35). Three poultry operations were identified in the area, all having animal waste removed from the repective sites and subsequently designated as "no potential to discharge."

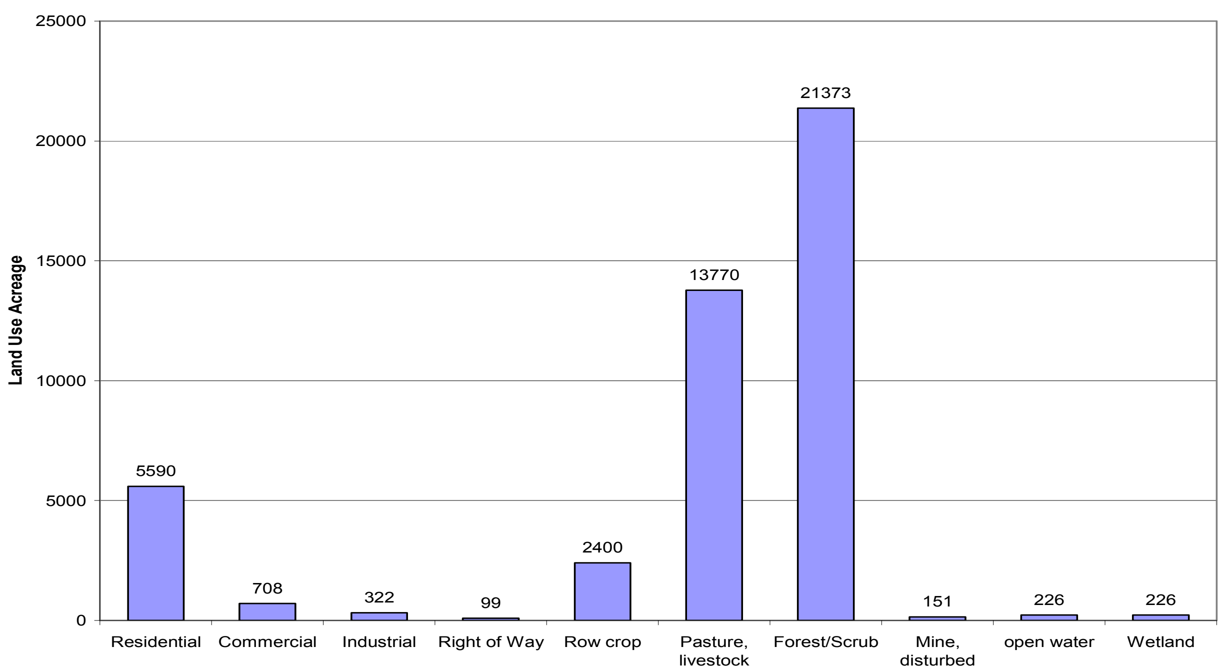

Figure 3.1. Major land use distribution (in acres) within Oostanaula Creek watershed.

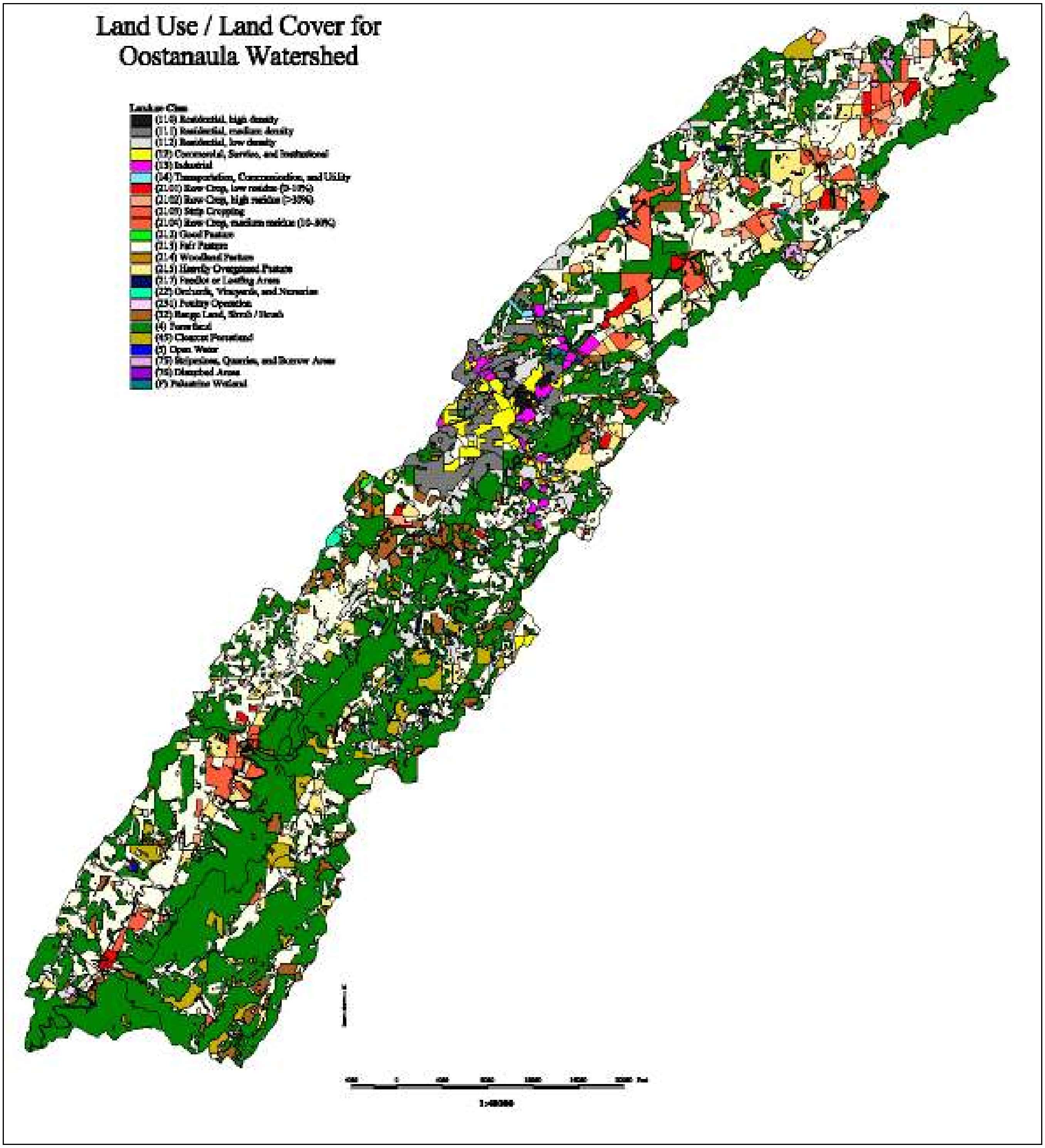

Figure 3.2. Land use classification map of Oostanaula Creek watershed. See text for methodology and delineations.

3.3 Soil Loss Estimates

Using RUSLE parameters and coefficients referenced in the methodology, the estimated soil loss for all of OCW is 61,220 tons/yr, or 1.36 tons/acre/year. The major source of soil loss in the watershed is eroding streambanks (19,262 tons per year), as this land class accounts for 31% of local soil loss; followed by crop lands with 23% and pasture with 21% (Figure 3.3). Forests and disturbed areas contribute 7 and 5% of all soil loss, respectively. Estimated soil loss for road banks is 3,521 tons per year, or 6% of all soil loss.

Within the OCW, disturbed and mined areas contributes the greatest soil loss per acre, both at 20.17 tons/ac/yr. Of the land classes categorized as agriculture, livestock feedlot/loafing areas (15.29 tons/ac/yr) and low-residue cropland (11.12) contributed the greatest per acre rate of soil loss. When expressed as absolute tons of soil loss per year over the entire watershed, heavily overgrazed pasture lands and medium-residue croplands were the dominant single agricultural land class of soil loss, contributing 13 and 14% of all soil loss. Other significant sources of annual soil loss are low residue cropland and harvested forest land, both contributing about 6% of all soil loss for the watershed. Forests and fair pastures make up the dominant land use types for the watershed, however contribute relatively small amounts of soil loss.

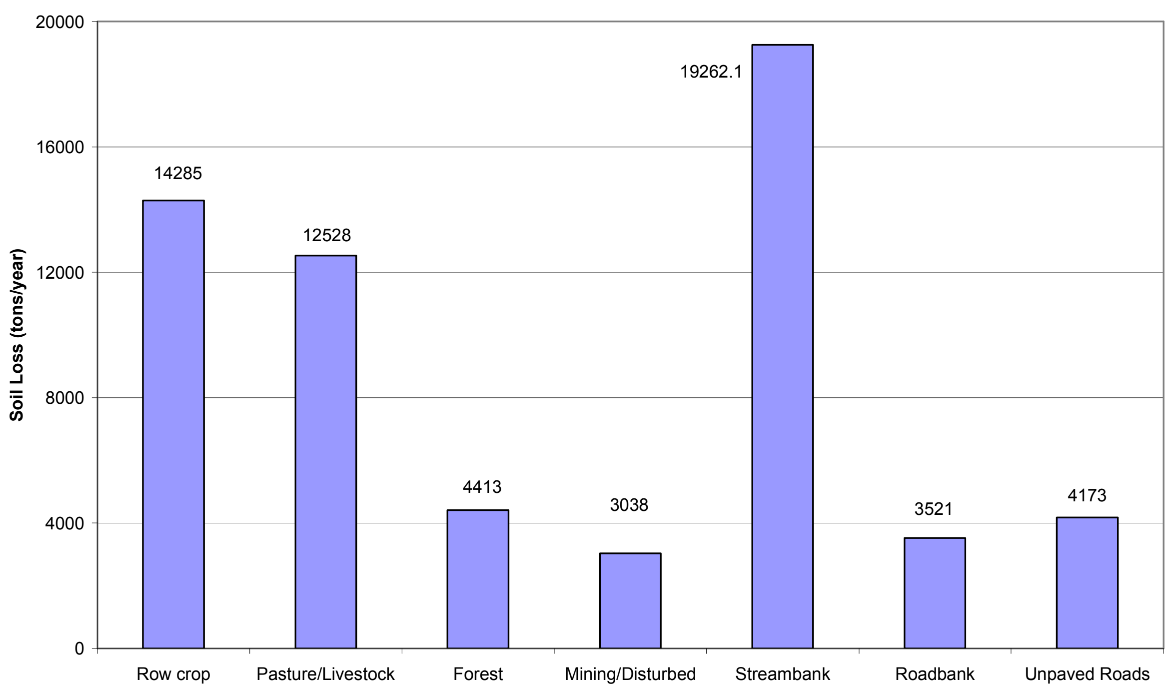

Figure 3.3. Soil loss estimates from select land classes in Oostanaula Creek watershed.

3.4 Nonpoint Pollution Sources

Total estimated loading from OCW was 22.13 tons TP/year, 81.66 tons TN/year, and 8877.65 tons TSS/year. Urban areas including residential, commercial and industrial lands accounted for 29% of annual TP loads, 47% of TN loads, and 17% of TSS loads. Such areas include lawns, parking lots, rooftops, sidewalks and other similar classes affiliated with urban landscapes. The WWTF in Athens contributed nearly 51% of all TP and 11% of TN to the OCW. Urban sources contributed 17%, and the WWTF in Athens accounts for less than 1% of TSS loading per year. Livestock operations had annual estimated TP and TN loads for the watershed, cumulatively contributing 11 and 13% of TP and TN respectively. TSS loading from livestock was less than 1% of all annual loads. Pollutant loads by land class are further defined in Table 3.1 and Figures 3.4, 3.5 and 3.6.

Estimates of annual TSS loads identified agriculture as the primary source, with croplands contributing 24% and pastures contributing 21% of all loading. TSS loading was also substantial from eroding streambanks, as this land class contributed nearly 18% of all TSS loading. The TDEC developed TMDL for siltation estimated TSS at 10,795 tons/yr, or 688 lbs/ac/yr, for the lower half of the watershed (est. 31,380 acres), with roads contributing 43% of this load (2005). Assuming a similar per acre loss, this would come to over 15,000 tons for the entire watershed. All of these values have been updated due to the oversimplification of land-use in the methodology described in that document. The current analysis estimates only 8,877 tons/yr, or 395 lbs/ac/yr.

As implied by the values and sources above, subwatersheds with large areas of source land uses, generated larger source values. Subwatersheds 05 and 06 are major contributors of TP and TN, stemming from the additional source of the WWTF in 05 and high concentrations of residential and commercial sites in both. Subwatersheds 09, 10, and 11, north of Athens, contribute substantial loads of TSS and soil loss, likely due to high densities of croplands in these areas. Areas 03 and 04 in the south also contribute high annual volumes of TSS and soil loss, as these areas hold high acreages of pasture land. However these areas contribute low per acre loads because these sites are also made up of lands with low capacities for runoff and erosion, such as forests.

Table 3.1. Nutrient loading expressed as tons per year for Oostanaula Creek watershed delineated by land use.

	TP		TN		TSS	
	(ton/yr)	(% of total)	(ton/yr)	(% of total)	(ton/yr)	(% of total)
Urban						
Residential	3.439	15.5	22.598	27.7	818.782	9.2
Commercial	2.301	10.4	10.740	13.2	383.579	4.3
Industrial	0.649	2.9	5.332	6.5	278.215	3.1
ROW	0.010	<0.1	0.101	0.1	5.061	0.1
Cropland						
Low Residue	0.169	0.8	1.686	2.1	589.990	6.6
High Residue	0.063	0.3	0.634	0.8	221.809	2.5
Strip Crop	0.015	0.1	0.154	0.2	53.852	0.6
Med. Residue	0.361	1.6	3.609	4.4	1263.229	14.2
Pasture						
Good Pasture	0.000	<0.1	0.001	<0.1	0.189	<0.1
Fair Pasture	0.128	0.6	1.277	1.6	446.809	5.0
Woodland	0.003	<0.1	0.008	<0.1	4.837	0.1
Overgrazed	0.683	3.1	3.413	4.2	1194.422	13.4
Feedlot	0.023	0.1	4.254	5.2	198.512	2.2
Forest						
Orchard	0.000	<0.1	0.001	<0.1	0.374	<0.1
Scrub/shrub	0.002	<0.1	0.022	<0.1	14.076	0.2
Forest	0.013	0.1	0.172	0.2	109.467	1.2
Clearcut	0.057	0.3	0.777	0.9	494.514	5.6
Other						
Mine	0.041	0.2	0.560	0.7	356.414	4.0
Disturbed	0.011	0.1	0.156	0.2	99.463	1.1
Streambank	0.317	1.4	4.365	5.3	1587.262	17.9
Road Bank	0.058	0.3	0.796	1.0	289.605	3.3
Unpaved Road	0.069	0.3	0.954	1.2	346.901	3.9
Livestock						
Beef Cattle	1.786	8.1	5.897	7.2	59.817	0.7
Dairy	0.652	2.9	4.788	5.9	50.425	0.6
Horse	0.001	<0.1	0.002	<0.1	0.362	<0.1
Swine	0.001	<0.1	0.002	<0.1	0.025	<0.1
Poultry	0.018	0.1	0.057	0.1	1.038	<0.1
Wildlife	0.003	<0.1	0.006	<0.1	0.116	<0.1
WWTF	11.257	50.9	9.302	11.4	8.504	0.1
Total	22.129		81.663		8877.646	

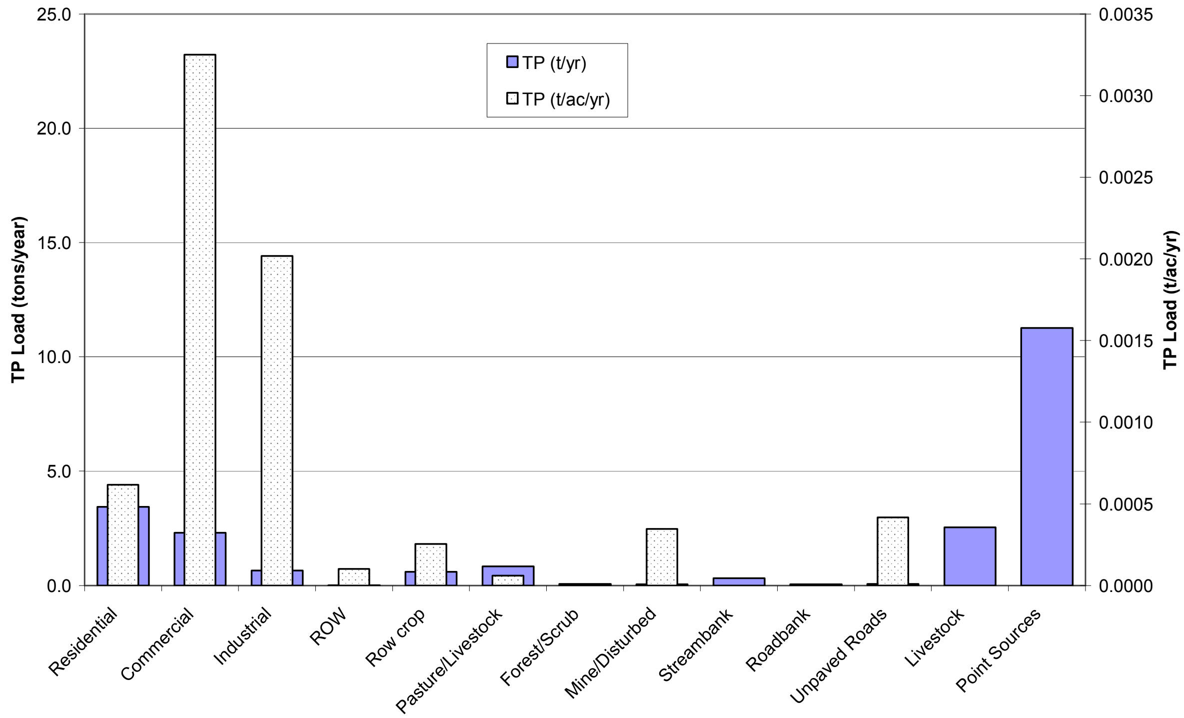

Figure 3.4. Total phosphorus loading by source for Oostanaula Creek watershed expressed as tons/year and tons/acre/year.

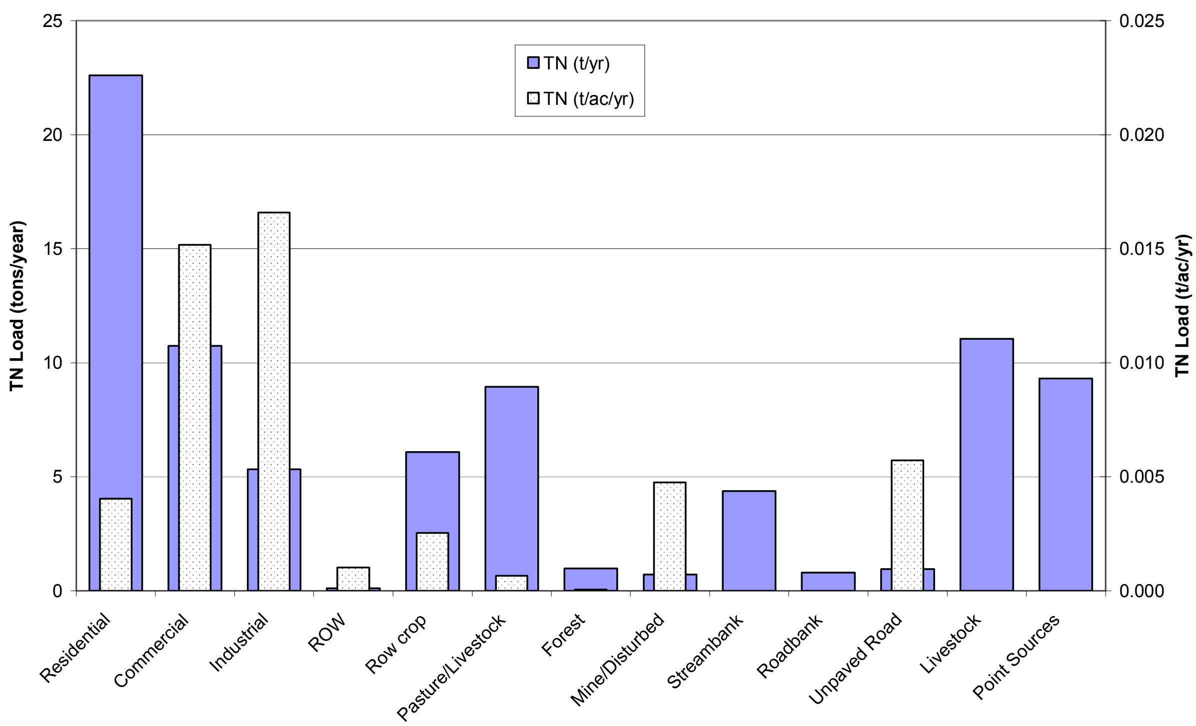

Figure 3.5. Total nitrogen loading by source for Oostanaula Creek watershed expressed as tons/year and tons/acre/year.

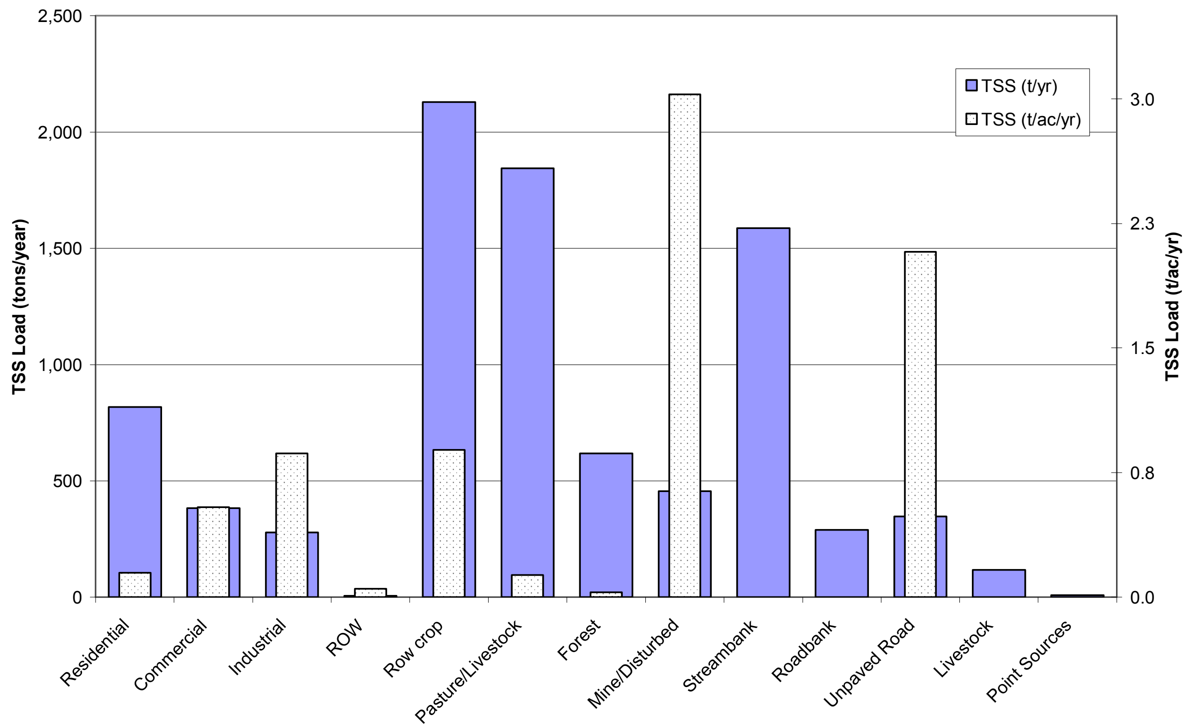

Figure 3.6. Total suspended solids loading by source for Oostanaula Creek watershed expressed as tons/year and tons/acre/year.

3.5 Projected 2010 Pollution Loads

In an effort to account for the sustainable growth experienced in the region, the default pollutant loading model was amended to reflect projected land use changes under a business-as-usual scenario. Based upon an updated land use inventory, the model was rerun with projected 2010 and 2015 (Tables 3.2 and 3.3). Population is expected to reach near 14,800 in the watershed by 2015, with an additional 50 septic units per year projected, totaling 2,600 septic units.

Residential areas are expected to increase by 38 acres per year, sacrificed from pastures and forestlands. Commercial acreage was increased by 60 acres, isolated in subwatersheds that lie on the perimeter of Athens, 801, 501 and 06. With the completion of a widening project of CR 30 south of Athens, an additional 7.5 acres of paved road, and an additional 9 acres of right-of-way were included. The AUB Oostanaula WWTP is expected to meet the requirements of a new permit for it’s 6.0 facility, which requires 1.0 mgP/L and 5.0 mgN/L in the effluent discharge. However, the model was amended to only show an increase in hydrologic capacity to 4.0 MGD at year 2015. Streambank and roadbank condition were held constant in the 2010 inventory, and erodability increased by 15% for a 2015 loading model.

Amended model outputs suggest annual TP loads are expected to decline, mostly as a function of low phosphorus discharge requirements for the WWTF. By 2010, annual TN loads are expected to increase 14% over the watershed, and by 19% by 2015. The AUB WWTF is currently meeting permit requirements for N effluent, and is expected to continue with this through 2015; however as discharge increase from 2.83 to 3.0 and 4.0 MGD, all effluent discharge will increase. Commercial and residential loads are expected to rise to match the rising number of units. Annual TSS and soil loss loads are projected to remain comparable to 2006 levels at 2010, but increase by 2015.

Table 3.2. Projected 2010 annual pollutant loading and major sources for the Oostanaula Creek Watershed, as defined in text. These values may and should be compared to those in Table 3.1 above.

ton/year			
TP 15.8 t/yr	TN 83.9 t/yr	TSS 8,934 t/yr	Soil Loss 61,216 t/yr
WWTF 29%	WWTF 12%	Ag 46%	Streambanks 31%
Residential 22%	Residential 28%	Streambanks 18%	Ag 44%
Comm/Industrial 16%	Ag 28%	Comm/Ind 5%	Unpaved Roads 7%
Ag 20%	Comm/Ind 14%	Residential 9%	Road Banks 6%

Table 3.3. Projected 2015 annual pollutant loading and major sources for the Oostanaula Creek Watershed, as defined in text. These values may and should be compared to those in Table 3.1 and 3.2 above.

ton/year			
TP 17.7 t/yr	TN 90.4 t/yr	TSS 9,248 t/yr	Soil Loss 63,951 t/yr
WWTF 34%	WWTF 15%	Ag 44%	Streambanks 35%
Residential 22%	Residential 29%	Streambanks 20%	Ag 42%
Comm/Industrial 14%	Comm/Industrial 13%	Comm/Ind 5%	Unpaved Roads 7%
Ag 9%	Ag 27%	Residential 10%	Road Banks 6%

4.0 Restoration Strategy and Estimated Load Reductions

Land management and restoration activities generally change the structure, function, or both, of the land to which it is applied. This transformation may be relatively minor and yet remain effective enough to result in noticeable improvements. Additionally, the observed effects may change significantly in the first few years (Roberts et al. 1988), or may continue for several decades (Ciolkosz et al. 1985). Positive impacts of appropriate BMPs may also lead to long-term, inadvertent impacts. For example, successful soil development promotes the natural establishment of vegetation which results in the addition of organic matter, increased number and size of soil aggregates, neutralization of acidity, and in turn, more successful establishment of vegetation.

There has been a steady shift towards modeling and model-based approaches as primary methods of quantifying watershed-wide BMP effectiveness. The advantages of using models include: 1) multiple BMPs can be studied simultaneously; 2) the impacts of individual BMPs can be determined while also determining the effects of BMP combinations; 3) location-specific responses can be obtained; and 4) modeling offers a practical means of analyzing various "what-if" management scenarios.

Utilizing the IPSI suite of tools described in Section 3, we are able to facilitate on-site decisions in order to minimize cost and maximize the benefits associated with BMP placement, constrained by field and/or lot level aspects, cost-share agreements, nutrient loading restrictions, and the physical aspects of the land itself. The approach uses detailed soil and hydrological information from the various land uses in the watershed to build an optimization model that will determine the cost-minimizing and benefit-maximizing way to select BMPs and the optimal spatial extent to which they should be implemented. The results will have implications for farm, lot, and watershed level strategic decisions concerning water quality management in agricultural watersheds.

Based on both water quality sample data and nonpoint source pollution inventory estimates, the OCW steering committee and stakeholders have developed the following strategies for reduction of nonpoint sources of pollutants in the creek. The following recommendations are an integrated approach and utilize a combination of both reactive and proactive measures to fully restore and enhance the watershed. Remediation of identified areas of degradation should include streambank erosion control, septic system maintenance and repair programs, abandoned mine and harvested forest land reclamation, and installation of BMPs at agriculture areas of concern. In order to provide for the long-term protection of the watershed, proactive measures need to be implemented. Proactive measures include such things as Information and Education programs, land use controls, zoning ordinances, continued water quality sampling, and establishment of riparian buffers.

Each recommendation integrates BMPs, education strategies, partnerships, and intergovernmental coordination. Each task targets a specific objective of the plan. To a great extent, the effectiveness of individual and collective BMPs depends on their location relative to hydrologically sensitive areas, as greater reductions can be obtained when BMPs are correctly sited. The steering committee acknowledges that different agricultural management options may be better suited for different sizes of agricultural operations. Deciding which recommendations will be implemented first will be based on stakeholder input and severity of load and site condition. In many cases the order of implementation activities will be determined by available funds. Many of the goals and recommendations listed below are targeted towards large-scale operations, as these are typically, but not always, larger nonpoint pollution sources. The general strategy here is that smaller operations will observe the positive impacts of these BMPs and subsequently accept them.

4.1 Restoration Prioritization

As an initial stimulus for broad water quality needs, subwatershed prioritization helps evaluate the potential effectiveness of watershed restoration. The process becomes geographically focused and resource-specific through targeting local subwatersheds. At this level, planning and implementation efforts may become efficiently focused to achieve major program goals. This focus on smaller units will provide better, targeted information for restoration opportunities. Much of this spatially concentrated effort will be based on primary land-use sources of estimated annual pollutant loading as defined in Table 3.1 of Section 3. This table identifies urban areas and (permitted) point sources as being strong candidates for initial efforts in reducing excess nutrients. Agricultural areas and streambanks will be concentrated for reductions in sediment, soil loss, and pathogens. As identified in supplemental source assessments (cf. Section 2.3.5), it is inferred that pathogens may be minimized through successful BMPs addressing livestock (bovine) sources.

In identifying local areas to focus project implementation, the steering committee looks at two primary characteristics of the local subwatershed: restoration need and opportunity. Restoration need refers to qualities of the watershed that indicate that it would benefit from BMPs to protect or improve water quality. Opportunity relates more to the feasibility of being able to implement BMPs in that specific area or land parcel.

In determining restoration need, the emphasis is on:

- Stream-use support ratings
- Location(s) of existing impacts, based on water sample data and pollutant loading model estimates
- Sensitive resources
- The location of existing BMPs
- Proximity to the creek or tributary to the creek
- Public comments received concerning water quality issues and needs

In determining potential restoration opportunity, the following information is considered:

- The hydrologic position of the subwatershed or land parcel in the watershed
- The location of existing BMPs
- Land use and development trends
- Potential restoration costs associated with BMP implementation and land use constraints
- Public comments received concerning restoration opportunities

4.2 Phases of Restoration

A key planning consideration of restoration and implementation is how the various objectives and tasks will be phased or sequenced in relation to one another over time. Restoration opportunities do not all occur simultaneously; nor can relevant organizations take on all challenges at once. The timing of restoration or investment decisions can have significant impacts on the ultimate restoration initiative, and a dynamic approach may best address how to prioritize sequence of restoration investments. Determining which actions will need to take place before other actions will be important in achieving the full potential of each task.

Benefits of phased implementation include: proper recording and attribution of water quality improvements; adequate time for developing public support, helping to ensure the most cost-effective practices are implemented initially; and allowing for the evaluation of the adequacy of the TMDL in achieving the water quality standard. The best order in which to implement BMPs will be based on a number of criteria such as ecological factors, elements of cost and funding, political realities, length of time for developing the BMP, and/or priority concerns within the watershed. Listed below are the three major phases under which most BMPs can be categorized in terms of their dependence on external factors. This phasing sequence is a recommendation only and individual circumstances may suggest alternative timing or phasing.

Phase 1: BMPs that can be initiated immediately, generally requiring minimal cost or planning, such as non-structural BMPs. Examples include education and outreach programs, soil testing, collection and adoption of baseline standards, and development of community goals, among others. Actions under this category may be implemented and completed in 1 to 5 years; however certain practices may be continuous.

Phase 2: BMPs that require significant planning and development, design specifications, and/or additional funding. Examples include design and construction of structural BMPs or development of site-specific vegetative BMPs. We propose that proper zoning, ordinance and regulation decisions and materials be established during this phase. Actions under this category may be completed in years 4– 12 years, or may be continuous.

Phase 3: BMPs for which success may depend on the success of a previously implemented BMP, such as most structural BMPs or an initiated ordinance or regulation. Examples include streambank restoration projects, pilot projects or demonstration sites. Timelines for this category fall between 8-15 years.

Due to the inherent complex ecological nature of the response of watersheds to management practices, it is difficult to accurately predict when these goals will be met. Some of the key practices and objectives may realistically be met in the next few years, whereas select ecological and/or structural objectives will require more study and improvements, and may take multiple permit cycles to achieve. Agricultural pollutant load reductions may begin quickly by utilizing many pre-existing (state and federal) programs and initiatives. Urban (including construction/ development) loading reductions may require establishment of new local programs, so reductions rates will likely be slower or delayed. Rather than attempting to predict when these goals and objectives will be achieved, the partners will continuously monitor and evaluate practices, goals and achievements.

The stakeholders will understand what progress is being made to meet these goals by using an iterative process of implementing BMPs and evaluating the effects of these by regularly monitoring the waterways for change and degree of change. It should be noted that information regarding pollutant removal efficiencies, costs, and designs of structural and non-structural BMPs is constantly evolving and improving. As such, information contained in this section is dynamic and subject to change. This document will evolve as needed as program partners gain more experience with implementing the performance standards and prohibitions.

4.3 Restoration Goals and Objectives

As described in Section 2, Oostanaula Creek is listed as an impaired waterbody due to pathogens (*E. coli*), phosphates and siltation (TDEC 2006). To successfully remove waters within the planning area from the Tennessee 303(d) list requires the following reductions: 67.7% reduction of pathogens based on the TMDL; 59.4% reduction in sediment based on the TMDL; and a 79% reduction of phosphorus based on Ecoregion reference streams.

Like many rural areas, Athens and McMinn County are still in the early phases of responding to growth and development pressures. There is thus a tremendous opportunity to further existing efforts in implementing smart growth principles and policies that will help strengthen those attributes of the region so valued by residents. To meet these challenges, the OCW will need to focus particular attention on: 1) preventing pollution from occurring, 2) reducing the amount of runoff and pollutants, 3) intercepting runoff and pollutants prior to entering the creek, and 4) promoting public participation and enforcement.

Goal 1. Prevent and Eliminate Pollution Generation

Task 1: Promote and enhance regional cooperation.

While the city of Athens is nested within McMinn County, there are substantial differences in policy opinion among the city and county officials regarding the growth pressures they are experiencing. Therefore it is important to coordinate growth planning and management between the county and town. An initial priority should be to establish community goals for water resources in the watershed that cross jurisdictional lines. As such, a transparent forum or outlet of communication and cooperation should be established between the town of Athens and the surrounding McMinn County.

Task 2: Provide sufficient data to make better land use decisions.

It is crucial that decision-makers and citizens have the data available that can enable them to make smart growth decisions that take the impact on the water into account. Residents and businesses move to the area for, among other reasons, the natural environment; so reminding these entities on their direct and indirect impacts on the environment will prove beneficial. State and local mapping and planning resources need to be made available and promoted as decision-making tools for local commissions and citizen groups. In addition, resources should be provided on how to make use of federal and state resources and tools to protect this area.

Task 3: Conduct watershed planning.

It is suggested that the OCW community develop a realistic and implementable comprehensive plan that illustrates the community’s vision for future growth and development. This plan should promote opportunities for restoration, plan for safe, adequate and affordable water supplies as a part of growth, and consider the cumulative impacts of growth management decisions on the watershed. The plan should also encourage development in strategic areas where it is most appropriate for watershed health. Delineation of such areas should consider the town's growth potential, presence of natural growth constraints and the availability or sewer and water services. Finally, this document should be revisited at least once every five years.

Task 4. Practice smart growth

Smart growth principles relevant to the planning area should be incorporated into the comprehensive management plan. Such principles include: mix land uses, create walkable communities, foster distinctive, attractive communities, revitalize the waterfront (to create a sense of place), strengthen and direct development toward existing communities, make development decisions predictable, fair and cost effective, and encourage community collaboration in development decisions.

Goal 2. Reduce the Amounts of Nutrients, Sediments, and Pathogens

Task 1. Renovate and restore pasture lands.
Task 2. Implement streambank stabilization measures.
Task 3. Convert low-residue crops and practices to high-residue.
Task 4. Vegetate barren lands such as mined, overgrazed, and clearcut areas.
Task 5. Minimize direct livestock access to waterways.
Task 6. Maintain the Storm Sewer System.
Task 7. Maintain and Repair Roadways and Roadside Areas.

Goal 3. Capture Pollution Before Leaving Critical Areas

Task 1. Install and maintain riparian/conservation buffers in critical areas.
Task 2. Install and maintain sediment trapping devices.
Task 3. Identify, repair and maintain failing septic systems.
Task 4. Monitor NPDES permitted point sources.

Goal 4. Increase the Public's Understanding of Pollution and Prevention.

Objective One: Promote personal watershed stewardship.
Task 1. Educate the public about stewardship in their watershed.
Task 2. Encourage public reporting of illicit discharge.
Task 3. Disseminate information on conservation easements, land donations and other means to permanently protect their lands.
Task 4. Provide materials and assistance to property owners regarding vegetative buffers, septic care and proper fertilizer application.
Task 5. Provide educational materials and technical assistance to local construction groups and land developers regarding on-site sediment control.

Objective two: Adopt and enforce local land use polices.
Task 1. Assist state and federal agencies streamline the planning processes.
Task 2. Continue a consistent water quality data collection regiment
Task 3. Educate local officials and staff on water quality related goods and services and pollution prevention.
Task 4. Assist local officials with the drafting of ordinances for the protection of water quality.

Specific structural and non-structural BMPs will be relevant to more than one goal, objective, or task as listed above. A non-exhaustive list of proposed BMPs for Oostanaula Creek watershed is presented in Table 4.1 below using NRCS defined practices. This table presents suggested BMPs as categorical numbers that will be used in subsequent pages on estimates of pollutant load reductions (Appendix 1). Table 4.2 presents a summary of estimated costs and load reductions from specific amended land classes and from the entire watershed. A detailed methodology of modeled load reductions is available in Appendix 1. The Appendix includes definitions of any modifications to the default pollutant loading model described in Section 3.0, specific areas to be modified, and origin of cost estimates.

Table 4.1. Recommended Agricultural BMPs for Oostanaula Creek watershed following NRCS terminology and code system. Numbers corresponding to suggested BMPs will be used in the text.

No.	Practice	NRCS Code
1	Animal Trails and Walkways	575
2	Conservation Crop Rotation	328
3	Cover Crop	340
4	Critical Area Planting	342
5	Fence	382
6	Filter Strips	393
7	Heavy Use Area Protection	561
8	Land reconstruction, Abandoned Mine	543
9	Pasture and Hay Planting	512
10	Pipeline	516
11	Prescribed Grazing	528
12	Residue and Tillage Management No Till	329
13	Riparian Herbaceous Cover	390
14	Streambank and Shoreline Protection	580
15	Tree/Shrub Establishment	612
16	Watering Facility	614

Table 4.2. Cost-benefit table for Oostanaula Creek Watershed restoration displaying estimated costs and % reduction in pollutant and nutrient for proposed BMPs. Efficiencies and Costs are estimated as defined in the Appendix. Efficiencies are for single BMPs and do not include cumulative effects, e.g. the combined effect of riparian buffers along with streambank stabilzation measures.

		Amended lands % change			Watershed % change		
Task Number and Description	Est. Costs	TP	Soil Loss	Pathogens	TP	Soil Loss	Pathogens
2.1. Pasture improvement	142,200	-38	-28		-1	-6	
2.2. Improve streambank stabilization	677,092	-52	-53		-<1	-17	
2.3. Improve crop residue	0	-21	-21		-<1	-5	
2.4. Revegetate barren lands	258,320	-61	-61		-<1	-6	
2.5. Fencing livestock from stream	82,974	-44		-40	-5		-39
2.6. Maintain storm sewer system		-15			-12		
2.7. Streetsweeping in Athens	351,000	-36			-12		
2.7. Roadway buffers in rural areas	6,450	-59	-60		-<1	-3	
3.1. Riparian buffers	9,600	-25	-25	-95	-1	-9	-31
3.2. Sediment trapping devices							
3.3. Repair/pump Septic Systems	430,000			-100			-3.4
3.4. Monitor NPDES permitees							
3.4. Complete WWTF upgrade		-59			-30		
Total % change in pollutant load					-50	-39	-46
Total proposed budget:	1,957,636						

5.0 Information and Education Campaign

Developing effective participation, building social trust, broadening the power of watershed residents, and achieving more informed and democratic decisions sensitive to local conditions requires a sustained information and education campaign that is not likely to be achieved by one-time, even well-intentioned stakeholder programs. A lack of any such public participation can impede the flow of relevant information, contribute to distrust between decision makers and publics, and heighten any problems involved in restoration implementation. The reality is that most important policy decisions are fundamentally public, with a need for some technical input, rather than technical with public input. The issues at stake are not only about informing interested and affected parties, but how to empower them to act.

In order to gain acceptance and promote a watershed-based restoration plan, this public education campaign was prepared to instill within the residents, commercial and industrial businesses, developers, visitors, and public officials a heightened level of awareness of the connection between individual actions and the health of their watershed and water resources. The objective of this section of the watershed management plan is to promote, publicize, and facilitate watershed education for the purpose of encouraging the public to reduce the discharge of point and nonpoint source pollutants in local waters to the maximum extent practicable. The current plan will serve as a developmental foundation of public involvement, which will be expanded and updated to meet long-term goals and objectives.

The main focus of the first and second year will be on communicating with residents within the watershed; with a concerted effort to reach large operation farmers and residents along waterways. The primary goal of this first phase will be to develop awareness within the communities of the area of the water cycle and how we impact the inputs and outputs. Educating residents, visitors and employees on practices and behaviors they can implement in their lives, which will result in improvement and protection of the watershed, will be a secondary emphasis. During Phase 2, messages will build upon those developed in the preceding years. An additional effort will be placed upon government (city and county) officials and staff, stressing the value of smart growth. It is the hope of the steering committee that implemented BMPs within the watershed will serve as learning tools on the effects of land uses and practices.

5.1 Proposed Public Education Activities

This section details the proposed educational activities designed to encourage the public to reduce the discharge of pollutants into local waterways. The overall goal is to create an awareness of water quality and watershed issues that will promote positive actions to protect and enhance the integrity of Oostanaula

Creek and the watershed. The recommendations presented herein will correspond with or supplement current community campaigns and activities. For example, Athens Parks and Recreation Department hosts an annual spring fishing event with which educational displays and/or publications can correspond. Such attachment to on-going community events will help to increase awareness of water quality issues in the creek through large audience participation.

After the development of specific objectives, target audiences were identified to maximize the potential results. It is recognized that land usage of the planning area is primarily agriculture, although old and new residential areas, commercial and industrial areas, and new developments are all found on the landscape. Specific water resource related behaviors are associated with these separate audiences and messages will be prioritized to those behaviors that will have the most impact on a specific objective of the plan. While this process is not exact, the major goal of this section will be used as a tool to increase awareness, understanding, and support for the OCW restoration plan and its recommendations.

Objective One: Promote personal watershed stewardship.
Overall target audiences: Residents, visitors, public employees, businesses, industries, construction contractors, and developers

Task 1. Educate the public about stewardship in their watershed.
Task 2. Encourage public reporting of illicit discharge.
Time Line: Annual and/or bi-annual materials will be created and disseminated during years 2 through 6, and every other year through year 15.
Budget: Educational materials including BMP calendars, brochures, newsletters, factsheets, stickers, and/or workshops costing $35,000 for Phase 1 (Years 1-5) and $6500 for Phase 2 (Years 6-12).

Task 3. Disseminate information discussing conservation easements, land donations and other means to permanently protect their lands.
Task 4. Provide educational materials and technical assistance to property owners regarding vegetative buffers, septic care and proper fertilizer application.
Task 5. Provide educational materials and technical assistance to local construction groups and land developers regarding on-site sediment control.
Time Line: Annually through Year 5; every other year through Year 15.
Budget: Educational materials including Construction BMP calendars, brochures, and/or workshops costing $20,000 for Phases 1 and 2 collectively.

Objective two: Adopt and enforce local land use polices.
Overall Target Audience: Public officials and employees, businesses, industries, construction contractors, and developers

Task 1. Assist state and federal agencies streamline the planning processes.
Timeline: Annually in Years 2 through 6 to streamline the planning and permitting process of many of the BMPs recommended. Meet again in years 10, 12, and 14.
Budget: Develop and host workshops for personnel at $5000 through Phases 1 and 2.

Task 2. Continue a consistent water quality data collection regiment.
Timeline: Monthly through Phase 2 of the restoration plan, and no less than quarterly through the end of Phase 3.
Budget: Monthly water sampling costing $2000 per year through Phases 1 and 2 totaling $10,000.

Task 3. Education of local government staff on water quality related goods and services and pollution prevention.
Task 4. Assist local officials with the drafting of ordinances for the protection of water quality.
Timeline: To begin annually in Year 2, or more often as deemed necessary.
Budget: Develop and host workshops for personnel at $5000 through Phases 1 and 2.

Proposed education and information activities will be updated and amended as necessary to compliment the objectives of the plan. Supplemental details regarding responsible parties, contacts and dates will need to be defined in task work plans as partnerships and funding resources are secured. The proposed messages stemming from the list of objectives and tasks are displayed in Table 5.1 below, delineated by audience(s). Table 5.2 illustrates proposed messages and targeted pollutant(s).

Table 5.1. Prioritized educational messages by target audience, based on current knowledge of audience behaviors.

	Households	Agriculture	Business	Local Government
Availability and utility of local and state agencies responsible for water quality issues	x	x	x	x
Watershed awareness: water cycle and watershed definitions and how we impact them	x	x	x	x
Water friendly lawn and garden practices; mowing habits; utilizing native plants	x			
Proper hazardous waste storage & disposal	x	x	x	x
Septic system maintenance	x			x
Surface water retention	x	x	x	
Advantages of and opportunities for buffer and filter strips	x	x		x
Impact of tillage practices		x		
Impact of fertilizer/pesticide use and mitigation options	x	x		
Impacts of livestock waste and mitigation options		x		
Opportunities for farmland conservation partnerships		x		x
Participation in watershed and education plan network	x	x	x	x
Identification and reporting of illicit discharge(s)	x		x	
Identification and reporting of cloudy, or odorous tap and/or creek water	x	x	x	x
Identification and protection of key habitats and features	x	x	x	x
Advantages of and opportunities for innovative stormwater management			x	x
Benefits of water conservation measures	x	x	x	

Table 5.2. Proposed educational messages and target pollutant(s).

	Sediment	Nutrients	Toxins	Pathogens
Residential and Homeowners				
Vehicle maintenance and repair	x		x	
Landscape irrigation and watering		x	x	
Pesticides and fertilization		x	x	
Native landscaping		x		
Household hazardous waste			x	
Sanitary sewer laterals and septics		x		x
Pet and animal waste		x		x
Slope and streambank stabilization	x	x		
Industrial and Commercial				
Outdoor loading and unloading	x	x	x	
Outdoor container storage			x	
Grounds maintenance		x	x	
Dumpster maintenance	x	x	x	x
Employee training	x	x	x	x
Spill prevention and control		x	x	x
Construction				
Stabilized construction entrance	x		x	
Construction road stabilization	x			
Construction scheduling	x	x		
Paving operations	x		x	
Ground cover (topsoil, mulch, sod)	x	x		
Seeding (grass, trees, shrubs)	x	x		
Geotextiles	x			
Silt fencing	x			
Detention Ponds	x	x		
Bank stabilization	x			

6.0 Monitoring and Evaluation

Although achievement of water quality standards is the goal of plan implementation, the Steering Committee recognizes the importance of a long-term water quality, quantity and biological monitoring program to determine where resources should be focused as they progress toward meeting those collective goals. Measurement and evaluation are important parts of planning for they can indicate whether or not efforts are successful and provide a feedback loop for improving project implementation as new information is collected an/or obtained. Additionally, if the monitoring and evaluation program displays positive results as they relate to improved water quality, the plan will likely gain support from partnering communities and agencies, as well as local decision makers, and overall increase the likelihood of project sustainability and success.

Monitoring and evaluation progress in the watershed will be conducted at the local level as this approach is the most cost effective and consistent if sampled is by one entity. Details regarding responsible parties, monitoring standards, sampling sites, and frequency of monitoring for qualitative and quantitative evaluation will need to be defined in project work plans as funding and manpower resources are secured. An established quantitative sampling regime is presently active by AUB and McMinn County for monthly grab samples at 17 sites, as defined in Section 2. This campaign has successfully served its purpose of gathering baseline data to which post-initiative sample data may be compared.

The technical and economic feasibility of pollutant treatment, recovery, or adjustment of the evaluation technique shall be considered in determining the time to be allowed for the development of practicable methods and for the specified correction. Based on pollutant loading and fate modeling conducted as part of this plan, it is anticipated that proposed restoration methods will effectively address the known and suspected sources of impairment in Oostanaula Creek watershed to allow the waters to meet State and Federal standards at the conclusion of this initiative.

6.1 Qualitative Evaluation

As an alternative to direct water quality sampling, a set of qualitative evaluation criteria can be used to determine whether substantial progress is being made towards attaining water quality standards. Conversely, these same criteria can be used to determine whether this restoration plan needs to be modified and revised at a future time in order to meet proposed standards. Although these methods of measuring progress are not direct proxies to water quality, it is assumed that the successes of these actions and programs, collectively and over time, will have a positive impact on the in-stream conditions of Oostanaula Creek.

Proposed indicators will include relatively easy-to-measure surrogates that can be used to demonstrate the actual health of the watershed based on the implementation of various BMPs or task elements. Useful indicators are often indirect measurements where the presence of the indicator suggests that a BMP or activity was successful. These qualitative measurements can be cost-effective methods of assessing the effectiveness of a BMP because direct, quantitative measurements may be too costly or time consuming to be practical. Additionally, individuals and residents with little or no technical training may conduct such qualitative evaluations.

Among some of the programmatic indicators that can be studied to evaluate recommended strategies using qualitative approaches are 1) number of illicit connections identified/corrected, 2) number of BMPs installed, inspected and maintained, 3) permitting and compliance, 4) growth and development (e.g. impervious amounts), and 5) on-site BMP performance monitoring. The non-exhaustive list of proposed qualitative evaluation strategies will be conducted quarterly during Phases 1, 2, and 3 at minimal cost or time. By evaluating the effectiveness of these programs, communities and agencies may be better informed about public response and success of these programs, how to improve the programs and which programs to (dis)continue.

6.2 Quantitative Evaluation

In addition to measuring the effectiveness of specific programs and BMPs via response of communities or agencies, it is beneficial to monitor immediate and long-term progress and effectiveness of watershed efforts in terms of water quality, quantity and biological monitoring. Physical, chemical and biological conditions of the water will be monitored to track progress, identify pollution source(s), and evaluate the success of efforts to restore Oostanaula Creek and remove it from the TN 303(d) list. Upon reviewing the data collected over the years 2002 through 2005 for this watershed, we believe that the types of parameters monitored, the number of sample locations in the watershed, and the frequency of monitoring are sufficient to address this evaluation strategy.

Measuring parameters to evaluate progress toward a goal requires the establishment of targets against which observed measurements may be compared. These targets are not necessarily goals themselves, because some of them may not be realistically obtainable. However, targets necessarily define water quality standards, as set forth by the State of Tennessee, or scientifically supported numbers that suggest trends to achieve said targets (Table 6.1). Utilizing these numerical targets as targets for success will assist the stakeholders in deciding how to improve programs to reach both restoration and preservation goals and know when these goals have been successfully achieved.

Table 6.1. Target values for physical, chemical and biological indicators to be used in documenting restoration for Oostanaula Creek.

Indicator	Target value	Reference
IBI	IBI score of 48	Simon 1991
Habitat Assessment	HA score of 131	TDEC 2001
Fecal coliform	452.4 cfu/100mL	Ecoregion reference
E. coli geometric mean	126 cfu/100mL	TDEC 2004b
E. coli individual sample	942 cfu/100mL	TDEC 2004b
Total Nitrogen	0.763 mg/L	75% of Ecoregion reference
Total phosphorus	0.059 mg/L	75% of Ecoregion reference

Pathogens

As noted in previous sections, the approved pathogen TMDL for the Hiwasee River watershed calls for a 54.2 to 72.2% reduction in *E. coli* loads in Oostanaula Creek (TDEC 2005). State of Tennessee water quality standards (TDEC 2004b) for the *E. coli* group require that the concentration shall not exceed 126 colony forming units per 100 mL, as a geometric mean based on a minimum of 5 samples collected from a given site. Individual samples can range from 1 to 941 units per 100 mL. In order to track progress towards achieving water quality goals, water quality samples will be collected and analyzed for pathogens at no less than 10 of the total 17 previously established sites as defined in Section 2.0 at least quarterly during Phases 1 and 2.

In addition to quarterly or monthly samples, at least four *E. coli* samples will be collected, each year, during a 30-day period. Additional analyses using bacteria source tracking methods defined in Section 2.3.5 are planned for future sampling events.

All *E. coli* sample data and analyses will enable calculation of geometric means in accordance with State protocol. Results will be compared with pre-restoration data and State of Tennessee standards to evaluate the success of this initiative. The goal is to document pathogen loading reduction of 10% from 2002 levels by the end of Phase 1, loading reduction of 50% by the end of Phase 2, and meet regulatory standards by Phase 3.

Phosphorus

While the state does not provide a numerical target concentration of phosphorus levels in state waters, regulatory language is such that TP shall be limited to the extent to prevent nuisance plant growth in receiving lakes and impoundments. To meet regulatory requirements, the total phosphorus content of select segments of Oostanaula Creek must be reduced to 0.059 mg/L. Current concentrations of TP within the 7.4 mile segment of the creek classified as impaired are suspected to decline following the successful establishment of a new WWTF with a substantially reduced TP permitted discharge.

During Phase 1, phosphorus samples will be collected from the established 10 sites along Oostanaula Creek within Athens city limits, no less than monthly, to determine the need for additional remediation. A sampling strategy for Phases 2 and 3 will be developed after an evaluation of sample analysis from Phase 1. It is the goal of this initiative to reduce TP levels by 25% from 2002 levels by the end of Phase 1, mostly due to reduced WWTF effluent, and to attain a reduction of 75% by the end of Phase 2.

Nitrogen

No form of nitrogen is currently listed as a cause of impairment in the watershed; however, TN concentrations of certain segments in Oostanaula Creek consistently exceed State standards (cf. Section 2.3). The State of Tennessee suggests that water nitrogen content be within 75% (or 75th quartile) of the identified ecoregion stream. To meet regulatory requirements, the total nitrogen content of Oostanaula Creek must be reduced to 0.7625 mg/L. Total nitrogen samples will be collected and analyzed monthly from the previously established 10 sites within Athens city limits which monitor this parameter during Phase 1 and no less than quarterly during Phase 2 to better identify the source of these pollutants and to monitor the success of this restoration plan.

Sediment and Habitat Alteration

The final 2006 303(d) list of Tennessee waters lists a 7.4 mile segment of Oostanaula Creek impaired for loss of biologic integrity due to siltation. This document identifies municipal point sources as likely causation. Numeric water quality criteria for siltation or habitat alteration in Tennessee have not been reported. However, to protect the designated uses of the creek, there are recommended qualitative and quantitative targets based on a scientific basis for which the creek should aim. In general terms, as defined by TDEC (2001), there shall be no distinctly visible solids, bottom deposits or sludge banks of such size or character as to interfere with biological integrity, natural or approved artificial aquatic habitat, livestock watering and wildlife. TDEC (2004b) specifically states:

> Biological Integrity - The waters shall not be modified through the addition of pollutants or through physical alteration to the extent that the diversity and/or productivity of aquatic biota within the receiving waters are substantially decreased or adversely affected, except as allowed under 1200-4-3-06.
>
> Habitat - The quality of instream habitat shall provide for the development of a diverse aquatic community that meets regionally-

based biological integrity goals. The instream habitat within each subecoregion shall be generally similar to that found at reference streams.

It is recommended that habitat assessment scores be above 131 (TDEC 2001), as determined by the site-specific ecoregion reference stream for Oostanaula Creek. To document progress, physical habitat will be assessed for at least one repeat site during both year 2 and year 5 of Phase 2. An assessment of Index of Biological Integrity, or IBI, will run concurrent with this habitat assessment at years 2 and 5. A target IBI score of 48 is set for the conclusion of year 5, Phase 2. These scores will be obtained using approved and duplicated methods established by TVA and analyzed and compared against baseline scores obtained from 1995 and 2002.

In addition to physical habitat assessment and IBI, quantitative monitoring will be performed to better identify sediment sources and track progress. TSS samples will be collected monthly during Phase 1, and at least quarterly during Phase 2, from no less than 10 sample sites along Oostanaula Creek. TSS data will be analyzed using load duration curves, and results compared with pre-initiative data and ecoregion reference streams. It is recommended that TSS concentrations less than 25 mg/L is good, TSS 25 – 80 mg/L is fair, and TSS greater than 80 mg/L is poor. The target, therefore, will be to maintain TSS below 80 mg/L in dry conditions for Phase 1. Data from 2004 through 2006 are consistently below this value, so we anticipate this target to be easily attainable.

Stream bank erosion rate will be estimated at no less than five sites from within the watershed. Preferably, sites will include streambanks north, south, and within Athens. This information will be used to improve estimates of rate and of the relative importance of various sediment sources. These data can then be used to calibrate the soil loss loading model.

6.3. Evaluation and Adaptive Management

It is imperative that this restoration plan brings about changes in existing practices, vision, objectives and principles of individuals living within or making decisions for the watershed. To ensure logical and successful progression throughout the life of the restoration initiative, the entire restoration planning, implementation and monitoring processes will be evaluated on at least an annual basis. If deemed necessary, restoration priorities, strategies and tasks will be reevaluated and adapted to better suit the process(es). The individual proposed tasks can and should be amended or sacrificed to satisfy the overriding goals and objectives. This type of evaluation helps to learn, reflect, readjust and improve the performance of all stakeholders involved.

Criteria to be evaluated include, but are not limited to:

- The processes and resources used to implement the restoration plan. This includes time, financial, technical and manpower resources.
- The tasks initiated and/or products developed. This shall include BMPs implemented, social marketing products developed, and technical workshops produced.
- The results of plan implementation, BMP installation and any and all changes associated. This category includes changes in stakeholder practices and behaviors, pollutant load reduction, streambank improvement, and habitat improvement.

7.0 Implementation Schedule and Milestones

The proposed implementation schedule for the Oostanaula Creek watershed restoration project is presented in Table 7.1 below. This 15-year timeline spanning 3 Phases of restoration will begin in Year 1 after approval of this restoration plan, or the date when funding would first become available, whichever occurs first. While the management values (e.g. feet or acres) may be amended to better suit the goals and objectives, the timeline should not.

The milestones in Table 7.2 will be tracked to document the major components and their success of this restoration plan. The identification of critical areas developed by the land analysis should be verified via site visits early in Phase 1. Critical agriculture areas include low residue croplands (< 10% residue), large livestock operations (dairy operations > 150 head and beef operations > 110 head) adjacent to the stream, disturbed and mined sites, overgrazed pastures, and poorly eroded streambanks. Urban sites which should be prioritized for BMP implementation include roadways, eroding streambanks alongside access points, and municipal storm sewer systems.

Table 7.3 presents quantitative restoration milestones for the pollutants listed. At the conclusion of Phase 1, notable milestones include reductions of 10% in pathogen levels, 25% in TP levels, and 10% in soil losses. Phase 2 milestones include reductions of 50% in pathogens, 75% on TP levels, and 50% in soil losses. Included in Phase 2 milestones is a public participation rate of over 15%. We believe that through the implementation and installation of the proposed tasks and BMPs that these numeric goals may be achieved at the times suggested.

Table 7.1. Schedule of implementation of the Oostanaula Creek watershed restoration plan. Goal 1 of preventing pollutant development is omitted, as proposed practices should be established annually.

Management Plan Component	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr10	Yr11	Yr12	Yr13	Yr14	Yr15
Goal 2. Reduce															
1. Pasture and hay planting on 240 ac.			x	x	x	x									
2. Stabilizing 4 mi of streambank			x		x	x	x	x							
3. Conservation tillage on 220 ac.		x	x	x	x										
4. Plantings on 50 ac of abandoned mine						x	x	x							
4. Revegetate 200 ac of clearcut land				x	x	x	x	x	x						
5. Install 3,000ft of fencing for grazing		x	x	x	x										
6. Identify problem storm sewer segments		x	x		x										
6. Repair storm sewer			x	x		x									
7. Establish buffers along 4.4 miles of road			x	x	x	x									
7. Streetsweeping on 65 miles per month	x	x	x	x	x	x	x	x	x	x					
Goal 3. Capture															
1. Establish 8,000 ft of riparian buffer			x	x	x	x	x								
2. Install sediment trapping	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
3. Repair 215 Septic Systems	x	x	x	x	x	x	x	x	x	x					
4. Monitor NPDES permitees		x		x		x		x		x					
Goal 4. Education and Outreach															
1.1. Bi-annual newsletter	x	x	x												
1.1. Annual newsletter				x	x	x		x		x		x		x	x
1.1. Participate in community events	x	x	x	x	x		x		x	x	x		x		x
1.2. Bi-annual hazardous waste collection	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1.3. NPS farm and home brochure	x	x	x		x		x		x						
1.4. Pasture management publication		x				x				x					
1.4. Tours and workshops for landowners			x		x		x	x	x	x		x	x	x	
1.4. Agriculture BMP calendar		x		x		x				x					
1.5. Construction BMP calendar	x		x		x				x						
2.1. Annual meeting with state officials		x	x	x	x	x				x		x		x	
2.2. Collect monthly/quarterly water samples	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2.2. Assessment of IBI					x					x					
2.3. Annual meeting with local officials	x				x	x	x	x	x	x					
2.3. Tours and workshops for local officials			x		x		x		x	x					x
2.4. Annual training sessions for officials	x	x		x		x		x		x					

Table 7.2. Planning and education milestones for successful restoration of Oostanaula Creek.

Milestone	Anticipated Completion
Planning	
Select sites to be remediated	Year 1 - ongoing
Develop site plans for BMP installations	Year 2 - ongoing
Secure funding and organize materials for structural BMP installation	Year 2 - ongoing
Contact all NPDES and TMSP permitees regarding TMDL-oriented activities	Year 2
Contact city and county officials regarding TMDL-oriented activities	Year 1
Create a program to certify developers, builders and other industry professional responsible for implementing bmps	Year 4
Conduct IBI assessment to compare with previous results to evaluate progress	Year 5 and Year 10
Education and Outreach:	
Organize and promote an agriculture BMP workshop program	Year 3
Host workshops for land developers on pollution prevention plans	Year 4
Develop and assemble educational packets (septic maintenance, maintaining conservation buffers, proper fertilizer application, etc.) to be distributed to riparian landowners	Year 2 - ongoing
Host workshops for local officials on growth readiness and smart growth principles	Year 2
Create an informational publication to be distributed at local commercial sites	Year 3
Adoption of updated water quality protection / stormwater ordinances for McMinn County	Year 8
Development of ordinace, permit, contract or other means of controlling pullutant entry into stormwater for Athens	Year 6

Table 7.3. Environmental and social indicators and interim, measurable milestones to track progress toward meeting Oostanaula Creek Restoration goals and standards.

Parameter	Pollutant	Indicator	Phase 1 Milestones
Biological	*E. coli*	concentration	Reduce geometric mean concentrations by 10% from 2005 levels
Biological	Sediment, nutrients	IBI score	Retain IBI score ≥ 40
Chemical	Nitrogen	concentration and loading	Attain 10% reduction of TN load from 2005 levels
Chemical	Phosphorus	concentration and loading	Attain 25% reduction of TP load from 2005 levels
Physical	Soil erosion and sediment	concentration and deposition	Attain 10% reduction of soil loss from 2005 levels; TSS loads ≤ 80 mg/L
Social	Sediment, nutrients, pathogens	participation	Attain 5% participation rate of residents for BMP installation
Social	Sediment, nutrients, pathogens	organization	Develop site plans, obtain permits, implement BMPs at 8 sites per year
Parameter	**Pollutant**	**Indicator**	**Phase 2 Milestones**
Biological	*E. coli*	concentration	Reduce geometric mean concentrations by 50% from 2005 levels
Biological	Sediment, nutrients	IBI score	Retain IBI score ≥ 44
Chemical	Nitrogen	concentration and loading	Attain 50% reduction of TN load from 2005 levels
Chemical	Phosphorus	concentration and loading	Attain 75% reduction of TP load from 2005 levels
Physical	Soil erosion and sediment	concentration and deposition	Attain 50% reduction of soil loss from 2005 levels; TSS loads ≤ 80 mg/L
Social	Sediment, nutrients, pathogens	participation	Attain 10% participation rate of residents for BMP installation above those from Phase 1
Social	Sediment, nutrients, pathogens	organization	Develop site plans, obtain permits, implement BMPs at 12 sites per year

8.0 Technical and Financial Needs

There exists an inherent problem of externalities in watershed management in that the user of water maintains the benefits, while shifting the costs to other users by lowering water quantity and/or quality. If the user had to bear the costs, he or she would be motivated to use the water in a manner consistent with quantity/quality demand by other users. On the other hand, the user may maintain or improve water quality, and not capture the full benefits, which then may shift to other users.

In residential and most urban settings, vegetation may be managed to enhance the aesthetic and economic value of the property. For example, parks offer primarily aesthetic value, but when located in proximity to residential property, they add to the value of adjacent properties. On these lands, the landowner is more willing to provide labor, time and costs of maintaining the landscape in exchange for heightened property value. On the other hand, agricultural landowners would have to sacrifice valuable productive lands, labor and subsequent income in order to establish and maintain often unprofitable lands for conservation. In these situations, a combination of land management education and conservation assistance would be needed to promote landscape restoration and management.

For these reasons, and several others, a substantial amount of funding is necessary to initiate, implement and promote the watershed restoration process. Included below in Table 8.1 is an itemized list of estimated costs associated with Oostanaula Creek watershed restoration as taken from past and concurrent restoration activity costs, local consultation, and NRCS cost estimates (2006). An itemized budget for each Task and/or BMP is described in the Appendix. Every effort was made to eliminate duplication of a BMP at a single location.

Total estimated financial need for the Oostanaula Watershed Restoration effort is $2,032,636, with 96% of this going towards on-the-ground BMP installation and implementation. The remaining 4% of the proposed budget is intended for education and outreach activities and materials.

Sources of funding include, but are not limited to, NRCS cost-share (Table 8.1), EPA Section 319 funding, TVA Clean Water Initiative funding, TN Department of Agriculture's Producer Diversification and Agribusiness Development Programs, and the Tennessee Stream Mitigation Program.

For appropriate fiscal management the timing and allocation of grant funds should be continuous throughout the planning process. However due to the phasing and milestone schedules proposed, concentrated financial goals should target years 1-10.

Table 8.1. Estimated costs and % cost share availability for recommended BMP installation for Oostanaula Creek. Symbols represent: # - site-by-site cost considerations, and * Devices should be installed at the expense of the contractor or grader.

Task Number and Description	Est. Costs ($)	Cost Share (%)
2.1. Pasture improvement	142,200	50
2.2. Improve streambank stabilization	677,092	50
2.3. Improve crop residue	0	50
2.4. Revegetate barren lands	258,320	50
2.5. Fencing livestock from stream	82,974	75
2.6. Maintain storm sewer system	#	
2.7. Streetsweeping in Athens	351,000	
2.7. Roadway buffers in rural areas	6,450	50
3.1. Riparian buffers	9,600	50
3.2. Sediment trapping devices	*	
3.3. Repair failing Septic Systems	430,000	
3.4. WWTF meeting TP permit req.		
4.1. Public educational materials through Yr 10	35,000	
4.1. Business & Industry educational materials	20,000	
4.2. Water quality sampling and analysis	10,000	
4.2. Develop and Host workshops	10,000	
Total proposed budget:	$2,032,636	

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Appendix

Cost-Benefit Methodology

Goal 2. Objective 1.
Renovation and revegetation of pasturelands

Model modifications:
Converted 1/2 of overgrazed pasture to fair. Kept RUSLE variables constant, as well as lands classified as woodland and feedlots.

Scenario results:
Acreages of fair and overgrazed pasture changed to 12,574 and 1,053 ac respectively. Estimates of tons/ac/yr of all pollutants stayed the same, or changed very little, as RUSLE variables were constant.

Over all pasture lands, soil loss dropped from 12,528 t/yr to 8,979, or -28%.
Nutrient loading also dropped considerably on a ton/yr basis as illustrated below.

	TP		TN		TSS		Soil Loss	
	t/yr	% diff	t/yr	% diff	t/yr	% diff	t/yr	% diff
Fair Pasture	0.139	+9	1.392	+9	487.2	+9	3297	+9
Overgrazed	0.357	-52	1.784	-48	624.3	-48	4249	-47
Total WS	21.814	-1	80.141	-2	8,345	-6	57,672	-6

Suggested BMPs:
3, 8, 9

Priority will be placed on areas with large and medium livestock operations as this land use has the greatest negative effect on pasture lands. The total amount of land to be converted from these subwatersheds is 948 ac of overgrazed. Pasture and Hay plantings (i.e., fescue and bermudagrass) of $150/acre will occur on 240 acres over 4 years, assuming successful CNMP development and adherence.

Area	3	601	9	9	10	10	11	Total
Site type	Large Beef	Med Dairy	L D	L D	L B	M D	M D	
Acres to be renovated	132	74	110	110	200	103	101	948 ac
Planting costs	19800	11100	16,500	16,500	30000	15450	15150	**$142,200**

Number of units to be modified:	948 ac
Estimated cost per unit:	150/ac
Total estimated cost:	$142,200

Goal 2. Objective 2.
Streambank stabilization via bioengineering

Model modifications:
Amended default erosion rate of eroding streambanks outside of Athens, by adjusting soil recession rate from 0.4 ft/yr to 0.1 (75% decline). This modification is conducted on perennial streams outside of Athens only.

Scenario results:
Stream length to be modified is 120,909 ft (22.8 miles) out of a total of 135,950 ft located in the watershed. Big declines are noted along streambanks with the proper addition of bioengineering such as live stakes and brush mattresses. Soil loss from the entire watershed is also noticeable.

	TP		TN		TSS		Soil Loss	
	t/yr	% diff	t/yr	% diff	t/yr	% diff	t/yr	% diff
Streambanks	0.15	-52	2.059	-53	748.8	-53	8803	-54
Total WS	21.96	-1	79.36	-3	8,039	-9	50,761	-17

Suggested BMPs:
Channel bank vegetation (322) or 14

It is proposed that 20% of 120,909 ft be repaired first to note any improvements in water quality, specifically soil loss. If this practice is indeed successful in limiting runoff, and any bacteria associated with runoff, 4 linear miles per year for 4 additional years should be subsequently repaired via bioengineering.

Number of units to be modified:	24,182 ft
Estimated cost per unit:	$28/LF
Total estimated cost:	$677,092

Goal 2. Objective 3.
Promote residue and tillage management through conversion to no-till/high-residue crops and practices.

Model modifications:
Converted ½ of all low-residue lands in pollutant loading model to medium residue and converted ½ of original medium-residue lands to high. Keep RUSLE factors constant. This modification decreases low residue acreage by ½, but also increases high areas.

Scenario results:
Load per acre remains constant as no RUSLE factor was amended.
All loads from low residue drops considerably, but loading from high-residue increases. Overall soil loss from cropland drops 21%; suspended sediment also declines by 21% from all croplands. The overall contribution of croplands drops from 24% of all TSS to 20% of all TSS.

	TP		TN		TSS		Soil Loss	
	t/yr	% diff	t/yr	% diff	t/yr	% diff	t/yr	% diff
Low Residue	0.085	-50	0.85	-50	297.4	-50	1969	-49
Med Residue	0.226	-37	2.26	-37	791.5	-37	5324	-38
High residue	0.153	+143	1.53	+143	535.8	+142	3599	+143
Total WS	22	-0.5	80.37	-2	8427	-5	58198	-5

Suggested BMPs:
12

The proposed acreage to convert from low to medium residue is 176, and the acreage to convert from medium- to high-residue is 705. There is little to no cost in the reduction of tillage, although there may exist cost savings.

Number of units to be modified:	881 ac
Estimated cost per unit:	
Total estimated cost:	0

Goal 2. Objective 4.
Revegetation of disturbed areas; including mine reclamation, and harvested forest lands.

Model modifications:
USLE C-factor has been amended to reflect vegetation on select areas based on USLE. Land acreages did not change.
For mine reclamation and disturbed areas: Table 10 from Wischmeier and Smith's (1978) handbook on USLE parameters states that lands with no appreciable canopy and 0-19% ground cover, should change from 1.0 to 0.45.
For clearcuts: (Tables 10 and 11 Wischmeier and Smith 1978), appreciable brush, 50% veg cover, 60% ground cover, > 2in duff layer, change from 0.150 to 0.050.

Scenario results:
Loading for all pollutants drops substantially: -55% of all loads ton/yr. These values will decline even greater over time as ground cover and vegetative canopy increase.

	TP		TN		TSS		Soil Loss	
	t/yr	% diff	t/yr	% diff	t/yr	% diff	t/yr	% diff
Mine	0.018	-56	0.252	-55	160.4	-55	1056	-55
Disturbed	0.005	-56	0.07	-55	44.8	-55	311	-55
Clearcut	0.019	-67	0.259	-67	164.8	-67	1189	-67
Total WS	22.06	-<1	80.75	-1	8,297	-7	57,572	-6

Suggested BMPs:
3, 4, 8, 15

Mine reclamation: Individual areas will be evaluated on a site-by-site basis for the determination of site preparation/land reconstruction requirements. Critical Area Plantings ($230/ac) would prove beneficial in these 150 acres, with priority placed in areas 11, 10, and 06 (94% of this land class). Total cost of $34,500.

Clearcuts: No site preparation is required for these specific sites, however individual sites will need to be evaluated to determine planting or seeding rates, supplemental water or other treatments. A combination of Critical Area Planting ($230/ac) and Tree/Shrub Establishment ($150/ac) would be beneficial on these 1,178 acres. Total cost of $223,820 (1/2 of 589 ac in each BMP).

Number of units to be modified:	1328 acres
Estimated cost per unit:	variable
Total estimated cost:	$258,320

Goal 2. Objective 5.
Limit direct access of livestock to stream:

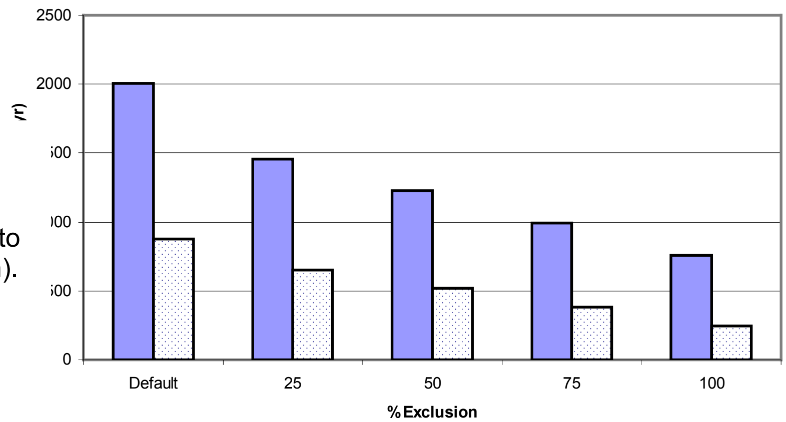
Model modifications:
Delivery ratio for livestock was amended to reflect various levels of exclusion from the stream. This animal relocation also increases c-factors for fair (+ 0.125), overgrazed and poor pasture (+ 0.25).

Scenario results:
Loading from pastures increases substantially according to % land conversion rate. The table below expresses pollutant loading from pastures with 50% land application.

	TP		TN		TSS		Soil Loss	
	t/yr	% diff	t/yr	% diff	t/yr	% diff	t/yr	% diff
Pasture	1.045	+24	10.747	+20	2430.3	+32	16,488	+32
Beef	0.978	-45	3.970	-33	38.94	-35		
Dairy	0.370	-43	3.004	-37	30.49	-40		
total								

Perhaps more importantly, direct manure loading into the stream drops from 2883 t/yr to 1742 t/yr (-40%) for all livestock with 50% exclusion.

Trends and values of manure (tons/yr) for Beef (solid bar) and Dairy (open bar) cows with progressively restricting access to the stream (0 to 100% exclusion).



Suggested BMPs from Table 4.1:
Develop site plans; 1, 5, 7, 10, 11, 16

Immediate priority to be placed on 2 large beef sites (110 head) adjacent to the creek in areas 03 and 10; 2 large dairy sites (150 head) in 09, and 3 medium dairy sites (100 head) in 601, 10 and 11.

Length and cost of wire per subwatershed are defined in the table below, under the general assumptions that a livestock site utilizes 25% of pasture land in an area, square acres, 50% exclusion rate and high-tensile wire (3-4 strands). We propose 10,830 ft of fencing to be installed over 2385 acres and 4 years.
Installation of alternative watering systems for relocated livestock is also defined. The estimated cost of 1 facility, 500 ft from a water source is $4300; we propose 13 systems over 4 years.

Number of units to be modified:	10,830ft
Estimated cost per unit:	2.50/ft + watering systems
Total estimated cost:	$82,974

	Total Pasture	# sites	Pasture area used (ac)	Avg. length of streamside (ft)	Length of fence required (ft)	Wire Cost
SubID	(ac)		ac*no.sites*.25	sqrt(ac.*43560)	length*.5 rate	length*$2.50
3	1640.1	1	410.0	4226.2	2113.1	5283
601	415.1	1	103.8	2126.1	1063.1	2658
9	1486.8	2	743.4	5690.6	2845.3	7113
10	1659.3	2	829.7	6011.6	3005.8	7515
11	1193.3	1	298.3	3604.9	1802.4	4506
	6394.6	7	2385.2	21,659.4	10,829.7	**$27,074**

	# sites	# animals relocated	Water systems required	Water facility	Pump	Pipeline trenching	Pipeline (6in)
SubID		no./site*.5	40 animals/unit	unit*$600	unit*$1300	unit*500ft*$1.5	unit*500ft*$3.3
3	1	55	2	1200	2600	1500	3300
601	1	50	2	1200	2600	1500	3300
9	2	150	4	2400	5200	3000	6600
10	2	105	3	1800	3900	2250	4950
11	1	50	2	1200	2600	1500	3300
	7	410	13	**$7,800**	**$16,900**	**$9,750**	**$21,450**

Goal 2. Objective 6.
Maintain the municipal storm sewer systems

Model modifications
Urban areas within those select subwatersheds that lie in Athens were amended to reflect well-maintained storm sewer and drainage systems. The current condition of the infrastructure is unknown at publication date, so it is assumed that maintenance and repair will decrease urban pollutant and nutrient loads by 15% (expressed s a reduction in the runoff coefficient). This is also expected to result in a 15% reduction in nutrient loads ingoing to the local WWTF.

Scenario results
Nutrient loads in these select subwatersheds decrease near 15% from all urban sources. Phosphorus loads decrease 12% from the watershed area. The reduction in influent to the WWTF contributes to the total decline. This practice is not anticipated to improve soil loss.

	TP		TN		TSS	
	t/yr	% diff	t/yr	% diff	t/yr	% diff
Res	2.91	-15	19.12	-15	692.8	-15
Comm	1.974	-14	9.21	-14	329.1	-14
Ind	0.556	-14	4.56	-14	238	-15
ROW	0.009	-12	0.09	-12	4.47	-12
WWTF	9.57	-15	7.91	-15	7.23	-15
Total WS	19.49	-12	74.48	-9	8655	-3

Intensive additional on-site evaluations will be required for proposing site-specific storm water management BMPs for the Oostanaula Creek Watershed. As such, no detailed infrastructure numbers or costs can be established at this time. It is suggested however that the Athens area (city limits with storm water drains) receive such evaluations by the end of Year 3 and consider the following list of management measures to reduce pollutant and nutrient transfer:

- Onsite infiltration via Infiltration trenches and/or basins, Riprap, and Stone or concrete flow spreaders
- Flow attenuation by vegetation via Grass swales, Filter strips, and/or Trees
- Retention structures/artificial wetlands such as Wet ponds, Artificial wetlands, Water quality detention structures, or Extended detention ponds
- General maintenance such as Culvert cleaning and repair; Pipe and drainage system cleaning and repair; and/or Catch basin cleaning and repair

Number of units to be modified:
Estimated cost per unit:
Total estimated cost:

Goal 2. Objective 7. Task 1
Maintain roadways. Establish 10-ft buffers along eroding paved and unpaved roadways in areas north and south of Athens (as the city is sufficient for roadway erosion)

Model modifications:
For eroding roads N and S of the city, the default erosion rate of 0.009 t/ft/yr was changed to 0.0027 (70% decline). Also changed ROW default runoff coefficient from 0.08 to 0.024.

Scenario results:
Soil loss and excess nutrients decline roughly 60% from road banks and ROW areas. Overall, soil loss declines 3%.

	TP		TN		TSS		Soil Loss	
	t/yr	% diff	t/yr	% diff	t/yr	% diff	t/yr	% diff
Road Bank	0.024	-59	0.334	-58	121.6	-58	1406.6	-60
ROW	0.003	-58	0.032	-58	1.6	-58		
Total WS	22.09	-0.1	81.13	-0.6	8706.2	-2	59106	-3

Land analysis identified 92,475 linear ft of eroding roadbank outside of Athens (Table 2.3 of NPS, p32).
10 ft buffer on both sides of 92,475 = 1,849,500 ft^2, or 43 acres of buffer required throughout the watershed, N and S of Athens. Filter strips should be established at a cost of $150/ac. A production rate of 462,000 ft^2 of roadway buffer repair (4.4 linear miles x 2 sides of the road, or 11 ac.) per year is suggested.

Additional BMPs for Maintaining and Repairing Roadways and Roadside Areas include: Roadside ditch cleaning; Vegetation management; Erosion control; Litter control; and Construction road stabilization. These practices should be includeded on various sites to evaluate their site-specific effectiveness.

Suggested BMPs:
6

Number of units to be modified:	43 ac
Estimated cost per unit:	$150/ac
Total estimated cost:	6,450

Goal 2. Objective 7. Task 2
Begin a streetsweeping regiment in the city of Athens.

Model Modifications:
Amended runoff concentrations of nutrients and suspended sediment in residential, commercial, industrial and ROW areas to reflect a 40% decline in said pollutants. Model was recalculated loading from areas within Athens: 0501, 06, 0601, 07, 08 and 0801.

Scenario Results:
Different studies have demonstrated various levels of effectiveness (20 to 80%) in removing suspended and/or solid particles sized more than 250 μm (Change et al. 2005, and references within). The current model estimates that street sweeping removes 20-36% of pollutants from areas within Athens. Nutrient and suspended sediment loads within Athens drop considerably.

	TP		TN		TSS	
	t/yr	% diff	t/yr	% diff	t/yr	% diff
Areas in Athens	3.01	-36	18.44	-35	1487.6	-20
Total WS	19.57	-12	66.15	-19	8283.4	-7

City officials state that there are 120 'city miles' of paved road in the city limits. Only 54% of the city lies within the watershed planning area leading to 64.8 city miles (120*0.54). Current estimates of labor range from $75-100/hr, or $25-45/mile; averaging 12 miles in one 8-hr day. A once-monthly streetsweeping regiment would thus cost $45/mile * 65 miles/month * 12 months = $35,100/year.

Number of units to be modified:	65 city road miles
Estimated cost per unit:	$45/mile for 12 months
Total estimated cost:	$35,100

Goal 3. Objective 1
Establish riparian buffers along perennial streams, assuming a buffer with 95% veg density with 75% being grass or grass-like and a width of 50 ft (25 ft on each side). Across the entire watershed, 56.4 % of eroding streambank is along pastures. 30.7 % of watershed is pasture.

Model modifications:
Streambank loading: determined area (%) of streambank by pasture and modified soil loss rate by converting to acre and using a soil loss rate of 0.003 for these areas only, as they are easily accessible.
Pasture loading: as modified by buffer above, modified c-factor by 0.75 (0.003*.75=0.0025, etc...).

Scenario results:
Nutrient and soil loading from pastures drop 25% for both ton/yr and ton/ac/yr.

	TP		**TN**		**TSS**		**Soil Loss**	
	(ton/yr)	(% diff)	(ton/yr)	(% diff)	(ton/yr)	(% diff)	(ton/yr)	(% diff)
Good Pasture	0.000	0	0.000	-17	0.14	-17	1	0
Fair Pasture	0.096	-25	0.957	-25	335.11	-25	2266	-25
Woodland	0.002	-25	0.006	-25	3.63	-25	23	-25
Overgrazed	0.512	-25	2.559	-25	895.82	-25	6055	-25
Feedlot	0.017	-26	3.190	-25	148.89	-25	1050	-25
Streambank	0.278	-12	3.817	-12	1388.08	-12	16833	-12
Total watershed	21.880	-1	78.870	-3	8217.3	-7	55,659	-9

Vegetated buffers intercept (reduce) 95 to 99.99% of microbial pathogens from fecal coliforms (Atwill et al. 2002, Trask et al. 2004, Tate et al. 2006) on applied lands. Application of buffers on select lands (eroding perennial streambanks along pasture lands) will reduce pathogens, in this case *E. coli*, 95 to 99.99 %, and on all lands by 30.7% (99.99% x 30.7% pasture in Oostanaula Creek).

Suggested BMPs:
13

Along pastures 41,727 ft of currently eroding perennial streambank X proposed 25 ft buffer width on both sides = 48 ac. We suggest establishing 8,000 l-ft of riparian buffers along pasture-side streambanks every year for 5 years.

Number of units to be modified:	48 ac
Estimated cost per unit:	200/ac
Total estimated cost:	$9,600

Goal 3. Objective 2.
Install and maintain sediment trapping devices.

Model modification
Not used in the model.
Although construction activities are deleterious to the watershed and the local creek, they are transient and scattered throughout the watershed. For these reasons, and others, the effectiveness of such practices can not be accurately inferred. As such, these activities, and their site-specific impacts, can not be accurately characterized in the present pollutant loading model. However the positive impact of such devices and/or practices should be further evaluated.

Scenario results
As with many other of the proposed BMPs in this restoration plan, sediment trapping devices associated with grading and construction activities should be considered on a case-by-case or site-by-site basis. Such devices and practices should be included in individual Stormwater Pollution Prevention Plans developed by permitted point source polluters, i.e. NPDES permitees. Additionally, such devices and practices should be installed and/ot implemented at the expense of the permitee.

Suggested sediment trapping practices for the planning area include, but are not limited to:

Stabilization practices (covering or maintaining an existing cover over soils):
Temporary seeding; Permanent seeding; Mulching; Sod stabilization; Vegetative buffer strips; Protection of trees. Specific examples relevant to the planning area include:

- pre-construction ground cover is not to be removed more than 20 days prior to grading or earth moving
- soil stabilization on unfinished areas (within seven days if soil will be exposed for 30 days or more)
- permanent soil stabilization after final grading

Structural practices (devices to divert flow, store flow, or limit runoff):
Earth dike; Silt fence; Drainage swales; Sediment traps; Subsurface drain; Temporary storm drain; Storm drain inlet protection; Rock outlet protection; Temporary sediment basins. Specific practices include:

- diversion of surface water flowing toward the construction area
- proper design of sediment control measures
- use of pipe or lined channel to prevent erosion
- treatment of muddy water from work areas

Goal 2. Objective 2. Task 1.
Repair failing septic systems

Model modifications:
Not used in loading model. Waste production numbers developed by various sources:

Potential source	Population in watershed[a]	Fecal coliform produced (x 10^6 cfu/head-day)	Fecal coliform daily load cfu x 109 (%)
Humans on Septic Systems	2,150	1,950[b]	4,193 (3.4)
Dairy cattle	1135	20,000[c]	22,700 (18.2)
Beef cattle	3770	25,800[e]	97,266 (77.9)
Horse	35	10,000	350 (0.3)
Wildlife	728	320[f]	233 (0.2)
			124,742

a. Estimates defined in Section 3.0, this document;
b Geldrich et al. 1977;
c Metcalf and Eddy 1979;
d. Based on weight ratio of heifer to milk cow and fecal coliform produced by milk cow;
e. Based on weight ratio of beef cattle to milk cow and fecal coliform produced by milk cow;
f. Mostaghimi et al. 2002

Scenario results:
Aerial photography interpretation, TDH data, and best-guesses identify 200 suspect septic systems out of an estimated 2150 households, or near 10%. The EPA estimates that 25% of US households are using septic systems with a failure rate between 5 and 35%; the higher rate pertinent to older systems and rural communities lacking decentralized sewage lines (US Census 1997).

From the estimates above we will assume that for the households that employ septic systems, 10% of potential pathogens, or 419 cfu x 10^9 per day goes to failing septic systems, or an annual load of nearly 153,000 cfu x 10^9. This fecal coliform is thereby transferred directly or indirectly to ground and/or surface waters. Repairing and improving existing septic systems will decrease the failure rate, and thereby decrease fecal coliform loading.

Suggested BMP:
Repair and/or upgrade failing septic systems

Professional estimates have been provided at $200 per septic flush. It is proposed that 10% of all 2150 septic systems be flushed annually (215/yr or 18/month), so as that by year 10 (end of Phase 3), all systems will be cleared and the cycle may begin again. The annual budget for this process will be $45,000.

Septic system repair and/or upgrade for select residential and commercial sites should be evaluated on a case-by-case basis.

Number of units to be modified:	2150 units
Estimated cost per unit:	200/unit
Total estimated cost:	$430,000

Goal 1. Objective 4. Task1.
Decrease TP effluent from WWTF

Model Modifications:
Update TP discharge from 2006 monthly mean of 2.612 to 1.0 (as stated in new permit); Keep TN discharge as-is, for it is inline with permitted effluent. Also update daily discharge from 2.83 MGD capacity to 3.0 MGD. The new facility has the hydrological capacity to treat 6.0 MGD, although the need is not currently there.

Scenario Results:
Regardless of increased discharge, TP effluent declines 59%; however both TN and TSS effluents increase as a function of increased discharge capacity.

	TP		TN		TSS	
	t/yr	% diff	t/yr	% diff	t/yr	% diff
WWTF	4.56	-59	9.86	+6	9.02	+6
Total	15.44	-30	82.22	0	8878	0