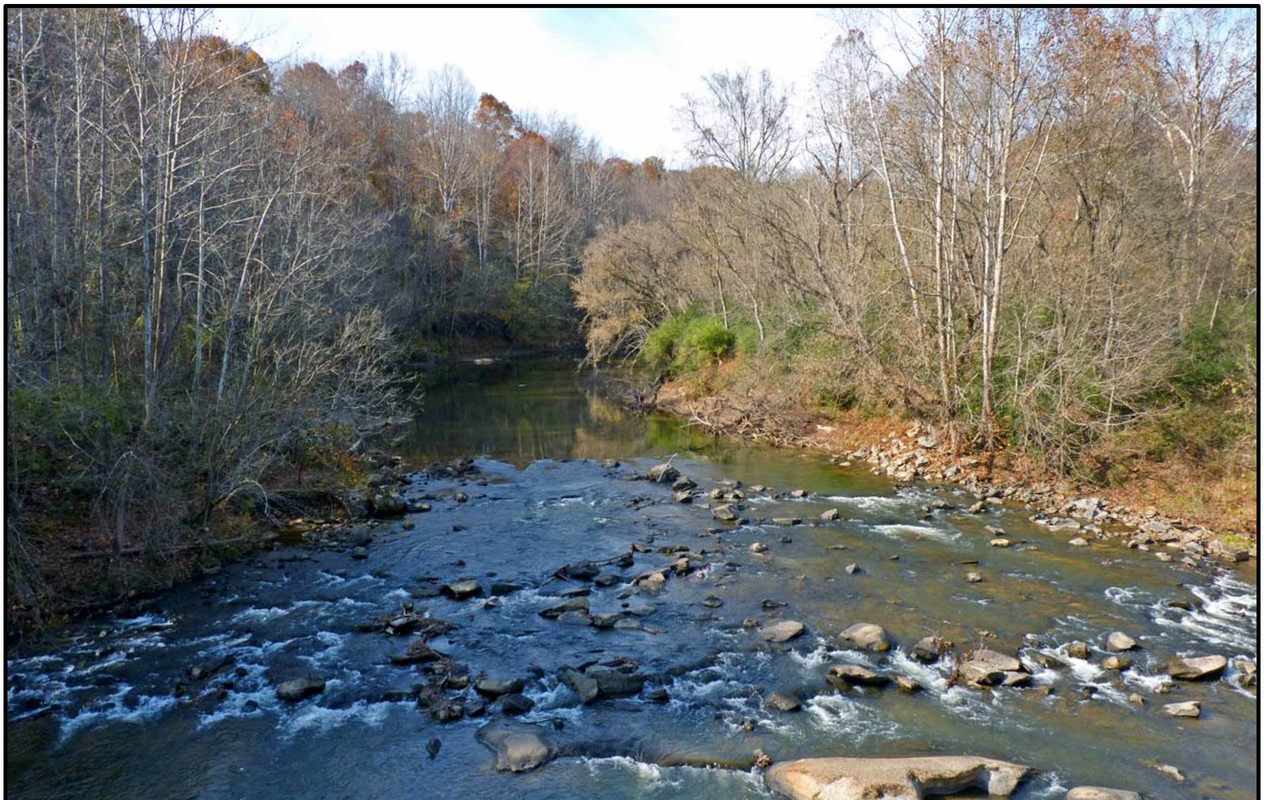
WATERSHED ASSESSMENT REPORT

Ararat-Pilot Mountain Local Watershed Plan
(Surry and Stokes Counties, NC)



Ararat River at Pilot Power Dam Road (Surry County, NC).

Prepared by Hal Bryson and Andrea Leslie
NC DENR – Ecosystem Enhancement Program (EEP)
February, 2013

Ecosystem Enhancement PROGRAM

TABLE of CONTENTS — Page

LIST of FIGURES — Page

LIST of TABLES — Page

Ararat – Pilot Mountain Local Watershed Plan (LWP)
Watershed Assessment Report

EXECUTIVE SUMMARY

This *Watershed Assessment Report* documents the objectives, methods and findings of Phase II of the Ararat-Pilot Mountain (APM) Local Watershed Plan (LWP) initiative in the Toms and Pilot Creek watersheds in the upper Yadkin River Basin (Cataloging Unit 03040101). The Phase II activities took place from early 2011 through the summer of 2012 and included the following major tasks:

- Review of key data (and preliminary identification of major stressors) from the fast-track Ararat LWP effort in 2008 [see Section II];
- Biological and physical/chemical water quality monitoring by NC DWQ, NC EEP and NC DOT;
- Field reconnaissance and habitat assessment by staff of NC DWQ and NC EEP;
- GIS-based evaluation of riparian buffer quality and width by Wildlands Engineering, Inc. (Wildlands);
- GIS-based screening and scoring of potential stream and wetland restoration projects, and stormwater BMP project sites (by Wildlands, with input from LWP stakeholders);
- Field evaluation of stormwater BMP candidate sites by Wildlands and EEP;
- Completion of the final Water Quality Technical Memorandum by NC DWQ-WAT;
- Completion of Technical Memorandum #1 by Wildlands (documenting results of the GIS-based buffer analysis and project identification & scoring);
- Four full LWP stakeholder meetings (and two meetings with staff of Surry and Stokes Counties and the Town of Pilot Mountain) to help determine LWP assessment goals, priority local issues, problem areas, and potential project sites;
- Data analysis and GIS evaluation by EEP staff to identify wetland areas;
- Data analysis and GIS evaluation by EEP staff to develop subwatershed functional assessment ratings; and
- Development of this document, the Ararat-Pilot Mountain LWP *Watershed Assessment Report* (WAR).

The WAR consists of four major sections:
I – Introduction & Background
II – Preliminary Characterization of the LWP Focus Area
III – Methods
IV – Results & Discussion.

Section I provides background on the NC Ecosystem Enhancement Program (EEP) and the purpose, scope and methods of its LWP initiatives. It also summarizes the initial (2008) 'fast-track' LWP effort in the Ararat River watershed and presents the goals and objectives of the re-started LWP effort in the smaller Ararat-Pilot Mountain *focus area* (Toms and Pilot Creeks).

Section II presents a characterization of the Ararat-Pilot Mountain LWP focus area, including physical characteristics (e.g., soils, geology, hydrography), land use/land cover, ecological features (terrestrial and aquatic), population and development trends, land use plans and local ordinances related to water quality and habitat protection. This section also includes a description of surface water classifications and impaired waters within the LWP watersheds (Toms and Pilot Creeks).

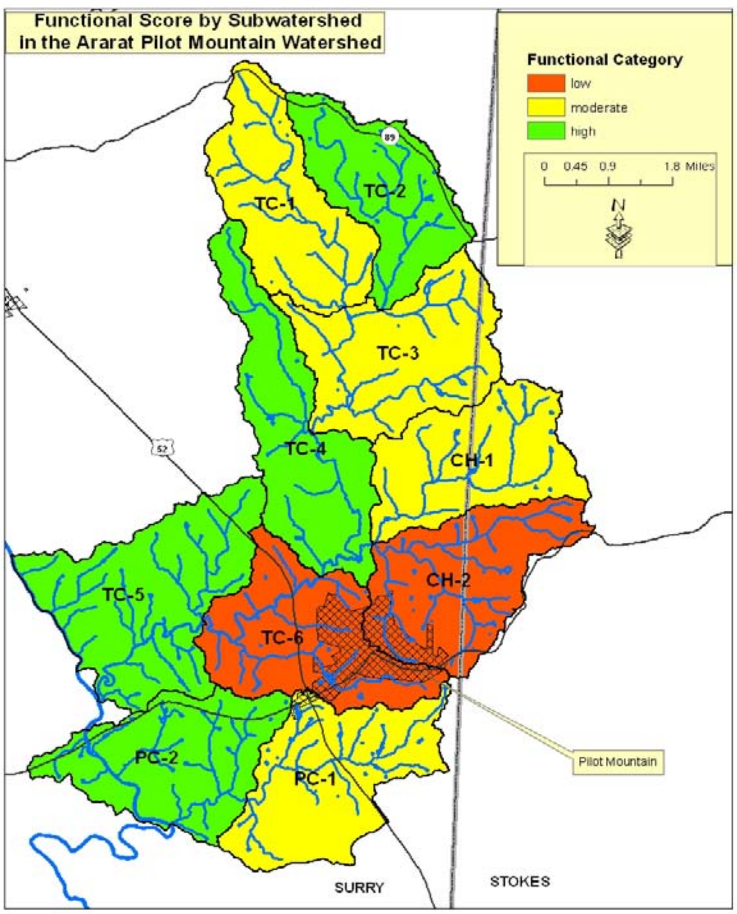
Section III describes the GIS and field methods used during Phase II to assess watershed conditions across the LWP area, including stream data (biological, physical/chemical, and habitat & channel) and wetlands data.

Section IV presents the results of the watershed data collection and analysis (including maps, photographs and tables), along with a discussion of the major findings, organized as follows:

A. Stream and wetland data
B. Stressors and sources
C. Problem areas
D. Subwatershed functional assessment (see Figure ES-1)
E. Watershed assets.

The map figure below illustrates the subwatershed functional ratings determined for the Ararat-Pilot Mountain LWP area. These ratings represent the overall ecological condition for each of the 10 subwatersheds (of about five square miles each) based on assessment data/metrics related to water quality, habitat and hydrologic functions.

Figure ES-1. Subwatershed Functional Ratings for the LWP Area.



The **Appendix** (Volume 2 of this document) includes supporting documents produced during the phase II work by the NC Division of Water Quality (DWQ) Watershed Assessment Team (WAT), the NC DWQ Biological Assessment Unit (BAU), the NC DOT Biological Surveys Group, and Wildlands.

The Table below presents a summary of major functional stressors in the APM LWP area. The "X"s indicate in which subwatersheds they have been observed or measured at multiple sites (or across a significant area), based on GIS data sets, field recons and water quality monitoring. See Section IV-B (Stressors and Sources) for a discussion of the major stressors and their impacts.

Table ES-1. Summary of Major Stressors Observed/Measured within the APM Subwatersheds.

	Subwatershed(s) in which Stressor is Most Significant									
Primary Stressors	**TC-1**	**TC-2**	**TC-3**	**TC-4**	**TC-5**	**TC-6**	**CH-1**	**CH-2**	**PC-1**	**PC-2**
Excess Sediment	X	X	X	X		X		X		
Lack of Riparian Buffer	X		X			X	X	X	X	
Stormwater Runoff						X		X	X	
Secondary Stressors										
Nutrients						X		X	X	X
Fecal Coliform						X		X	X	

I. INTRODUCTION & BACKGROUND

NC EEP and Local Watershed Planning

The North Carolina Ecosystem Enhancement Program (EEP) uses watershed planning as a primary tool to meet its central program goal, which is to implement ecologically effective compensatory mitigation (stream, wetland and riparian buffer restoration projects) for permitted impacts to aquatic resources across the state. Watershed planning is conducted by EEP Planners at two scales: (1) basinwide - in which Targeted Local Watersheds, 14-digit hydrologic units (HUs) that represent priority areas for EEP restoration projects, are identified within each of the 17 river basins across the state; and (2) local – in which a detailed assessment of watershed conditions is conducted within selected TLWs in order to develop focused solutions for local watershed problems.

The second scale of planning noted above falls under the umbrella of EEP Local Watershed Planning (LWP) initiatives, which are typically conducted in three distinct phases over a two- to three-year period.

- <u>Phase I</u> is a compilation and review of all readily available existing data (e.g., historical water quality monitoring) about local watershed conditions, and may include analysis of GIS datasets, windshield surveys and/or rapid field reconnaissance. The goal is to preliminarily identify major watershed stressors and their sources, to scope out additional data collection activities that may be needed and to begin to involve local and regional stakeholders in the watershed planning effort. It's important during this phase to convene a core group of watershed stakeholders and to solicit their input in identifying priority watershed issues and goals. This phase typically results in a *Preliminary Findings & Recommendations* (PFR) report.
- <u>Phase II</u> is a more detailed/intensive assessment of watershed conditions, designed to fill in key data gaps and collect up-to-date, representative data to more fully characterize the major stressors to water quality, hydrology and habitat. The scope and timeline of Phase II activities is largely dependent on the budget available to the EEP watershed planner(s) overseeing the LWP work. The major Phase II product is a *Watershed Assessment Report* that summarizes watershed assessment methods and results, including identification of major functional stressors and their sources, specific problem areas (or 'hot spots'), major ecological assets and the development of functional ratings for delineated subwatersheds within the LWP study area.
- <u>Phase III</u> is the process whereby all the watershed assessment results are considered and weighted by the EEP project team and local watershed stakeholders to develop recommendations for the *Watershed Management Plan*, including the ranking/scoring of various project types to be included in a *Project Atlas*. The Project Atlas includes both traditional stream and wetland mitigation (restoration/enhancement) projects as well as 'non-traditional' projects such as agricultural and urban BMPs.

In some cases in the past, when significant mitigation needs had to be met within a shorter timeframe, EEP adopted a 'fast track' watershed planning approach. The fast-track approach is essentially an expanded/enhanced Phase I effort that seeks to quickly identify major watershed stressors and priority subwatersheds for mitigation projects within about a 12-month timeframe. Such an approach was initially used within the upper Yadkin River basin (Cataloging Unit 03040101) in 2008.

Summary of the Upper Yadkin-Ararat River LWP Fast-Track Initiative (2008)

In the spring of 2008, EEP contracted with the John R. McAdams Company (EcoEngineering) and the NC Division of Water Quality Watershed Assessment Team (DWQ-WAT) to support a fast-track watershed assessment and planning effort. This was intended to be a 12-month initiative whose primary objectives were to (1) conduct a streamlined assessment of watershed conditions over a relatively large LWP study area (seven 14-digit HUs and portions of two more, comprising ~235 square miles) within Yadkin 03040101 in Surry County [see Figure 1-1]; (2) identify priority subwatersheds within the LWP study area for EEP stream mitigation projects plus urban and agricultural BMPs; and (3) develop a Project Atlas for mitigation and BMP sites within the priority subwatersheds. At the time the fast-track work was being scoped and budgeted in early 2008, EEP had a significant mitigation need within this 8-digit CU (in terms of stream mitigation units, or SMUs) and a relatively short turnaround time for delivering mitigation project sites/opportunities to satisfy this need.

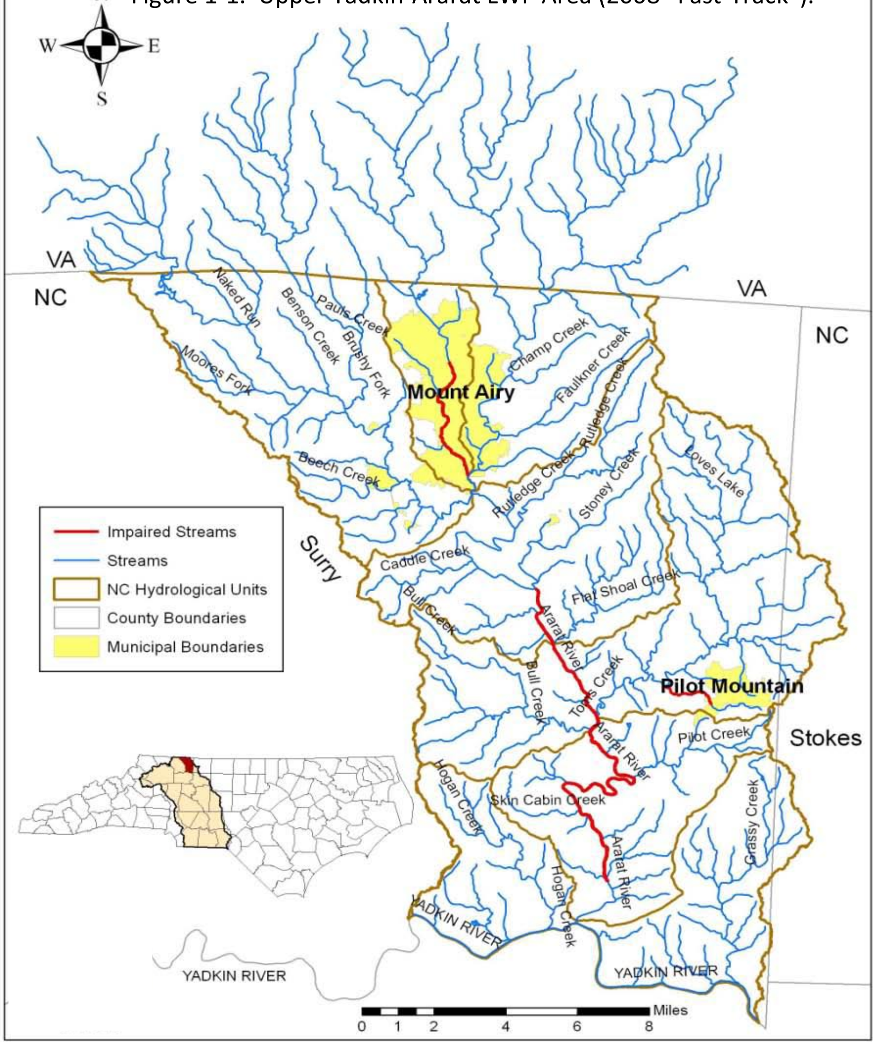


Figure 1-1. Upper Yadkin-Ararat LWP Area (2008 “Fast-Track”).

A core group of local watershed stakeholders was convened to support the EEP fast-track LWP for the Upper Yadkin-Ararat River study area, including representatives from Surry Soil & Water Conservation District (SWCD), Surry Natural Resources Conservation Service (NRCS), Surry County Planning Department, Town of Pilot Mountain, City of Mount Airy, NC Wildlife Resources Commission (WRC), NC Division of Parks, NC Clean Water Management Trust Fund (CWMTF), Pilot View RC&D, Northwest Piedmont COG, Piedmont Land Conservancy (PLC), Trout Unlimited (TU) and the Resource Institute, Inc. The full stakeholder group (or Local Advisory Team, LAT) met only twice during the fast-track LWP effort, in July and October of 2008; however, smaller meetings, phone conversations and email correspondence with subgroups and individuals within the LAT were held on several occasions to solicit input regarding subwatershed priorities, project ranking criteria and to identify potentially interested/willing landowners.

Fast-track watershed assessment and monitoring activities conducted by DWQ-WAT and DWQ's Biological Assessment Unit (BAU) include:

- Compilation and summary of existing water quality data for the upper Yadkin and Ararat River (NC DWQ, 2008a);
- Water quality screening 'blitz' and field reconnaissance at 34 sites across the LWP study area in March 2008 (NCDWQ, 2008b);
- Benthic sampling (macro-invertebrates) and habitat assessments at 14 sites in September 2008 (NC DWQ-BAU, 2009);
- Monthly baseflow water chemistry sampling at eight of the 14 benthic sites (including three sites in the Toms Creek HU), October 2008 to January 2009;
- Stream corridor assessments ("stream walks") to identify major stressors/sources along two urban streams in February 2009 (including Heatherly Creek in Pilot Mountain, an impaired tributary to Toms Creek);
- *Final Integrated Water Quality Report* for the Upper Yadkin-Ararat River LWP (NCDWQ-WAT, 2009).

Major fast-track tasks conducted by McAdams/EcoEngineering include:

- Delineation of 46 subwatersheds (of approximately 5.1 square miles each) within the 235-square mile study area;
- Compilation and analysis of multiple GIS datasets for (i) overall characterization of the LWP study area; (ii) calculation of impervious cover estimates for urban subwatersheds; and (iii) subwatershed prioritization (scoring and ranking) in three categories – stream restoration & agricultural BMPs, preservation; and stormwater BMPs;
- Preparation of *Task 2 Technical Memorandum – Subwatershed Characterization and Prioritization* (McAdams-EcoEngineering, 2008);
- Progress toward development of a preliminary Project Atlas of mitigation sites and BMPs within 20 priority subwatersheds.

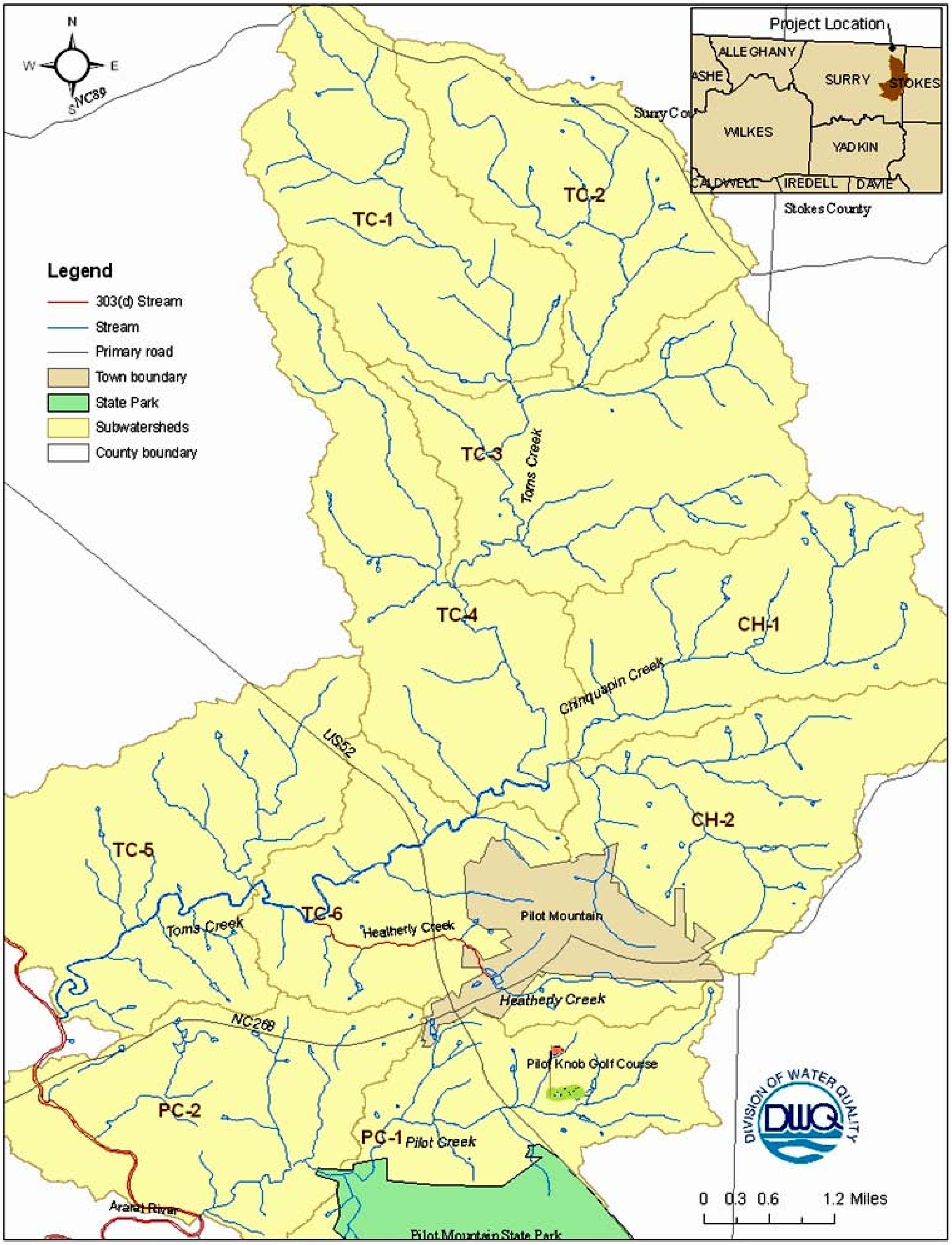
Major documents produced during the 2008 fast-track effort, including the *Task 2 Technical Memo - Subwatershed Characterization and Prioritization* (McAdams-EcoEngineering, 2008) and the *Integrated Analysis Report of Water Quality* (NC DWQ-WAT, 2009), are available for downloading from the LWP Factsheet at the NC EEP website.

By late 2008 EEP program priorities had shifted with regard to mitigation needs in the upper Yadkin River sub-basin (Cataloging Unit 03040101), and the upper Yadkin-Ararat River LWP effort was placed on hold. From 2008 to 2011, EEP Project Management staff continued to work with Surry County SWCD staff as needed to identify willing landowners for possible mitigation project implementation within the fast-track LWP area, using the preliminary Project Atlas produced by McAdams/EcoEngineering as a "road map" for project opportunities within priority subwatersheds.

LWP Re-start and Selection of Focus Area (late 2010-early 2011)

EEP programmatic mitigation needs within Yadkin 03040101 increased again in the fall of 2010 and there was a renewed desire to complete the LWP process that began with the Ararat fast-track effort in 2008 -- but to do so within a smaller, more manageable focus area within the original 235-square mile study area. Email and phone contacts were made in the fall of 2010 to the same group of stakeholders (originally convened in 2008) to determine the level of local interest in re-starting the LWP process and to solicit their input in selecting a smaller focus area in which to complete watershed assessment, plan development and project atlas production. Based upon significant stakeholder interest in late 2010, ongoing stormwater and greenways initiatives in the Pilot Mountain area, the inclusion of priority subwatersheds as determined in 2008, a good mix of land use/land cover, presence of a 303(d)-listed (impaired) stream that could show measurable functional uplift over time, presence of a municipal water supply watershed, and the likelihood of good mitigation and BMP opportunities, the Focus Area selected for the LWP re-start includes the Toms Creek watershed (HU 03040101110030) and the contiguous Pilot Creek watershed (a subwatershed of the lower Ararat River HU, 03040101110050). As shown in Figure 1-2, this Focus Area comprises approximately 50 square miles – mostly in eastern Surry County, including the Town of Pilot Mountain, and a small portion (about five square miles) of western Stokes County. The Ararat-Pilot Mountain (APM) area, the name selected by a majority of the attendees at the first stakeholder meeting in early 2011, represents 21 percent of the initial fast-track LWP study area and includes three of the 20 priority subwatersheds identified in 2008.

Figure 1-2. Ararat-Pilot Mountain LWP Focus Area (2011 Re-start).



New scopes of work were developed with DWQ-WAT (to provide watershed assessment/monitoring services) and Wildlands Engineering (to provide GIS analyses, project screening, BMP site evaluation and modeling and Project Atlas support) in early 2011 to support the APM LWP. A 'kick-off' meeting with stakeholders for the APM LWP was held in February 2011 to develop the overall goals for the re-started LWP and to identify specific watershed assessment objectives for the APM focus area. As of December 2012, a total of five stakeholder meetings have been held with the full APM stakeholder group.

Goals of the APM LWP

Primary goals of the APM LWP initiative were developed at the initial stakeholder meeting in February 2011. These goals address EEP programmatic needs as well as the broader goals of stakeholder participation. EEP's primary LWP goals are to identify major watershed stressors and work with local stakeholders and resource professionals to develop consensus recommendations for improving watershed conditions (water quality, habitat and hydrology functions). The final products of EEP LWP efforts include a Project Atlas of mitigation opportunities and a Watershed Management Plan.

The major stakeholder and local resource professional goals for the LWP area, as identified at the initial stakeholder meeting, include:

- (i) Coordinating any stream restoration or preservation projects (and other watershed management recommendations) with local greenways and trails planning initiatives;
- (ii) Ensuring consistency of LWP recommendations with Surry County and Town of Pilot Mountain land use plans;
- (iii) Integrating urban stormwater management recommendations with findings of the Pilot Mountain Stormwater Study (Baker Engineering, 2009);
- (iv) Including agricultural BMPs and riparian buffer preservation opportunities in the final Plan documents;
- (v) Contributing to improved water quality in the Ararat River (to support local fisheries);
- (vi) Highlighting EEP expenditures as a match for various grant opportunities.

Objectives of the Phase II Watershed Assessment

In addition to broader LWP goals noted above, specific objectives and tasks related to the Phase II watershed assessment were also identified during the initial stakeholder meeting in February 2011. Primary watershed assessment objectives included: characterization of fish and macroinvertebrate communities at selected stream locations; identification of major stressors and sources for Heatherly Creek (impaired); identification of fecal coliform and nutrient 'hot spots' and possible sources; characterization of aquatic habitat conditions, with a special focus on sediment impacts and sources; and characterization of riparian buffer health throughout the watershed.

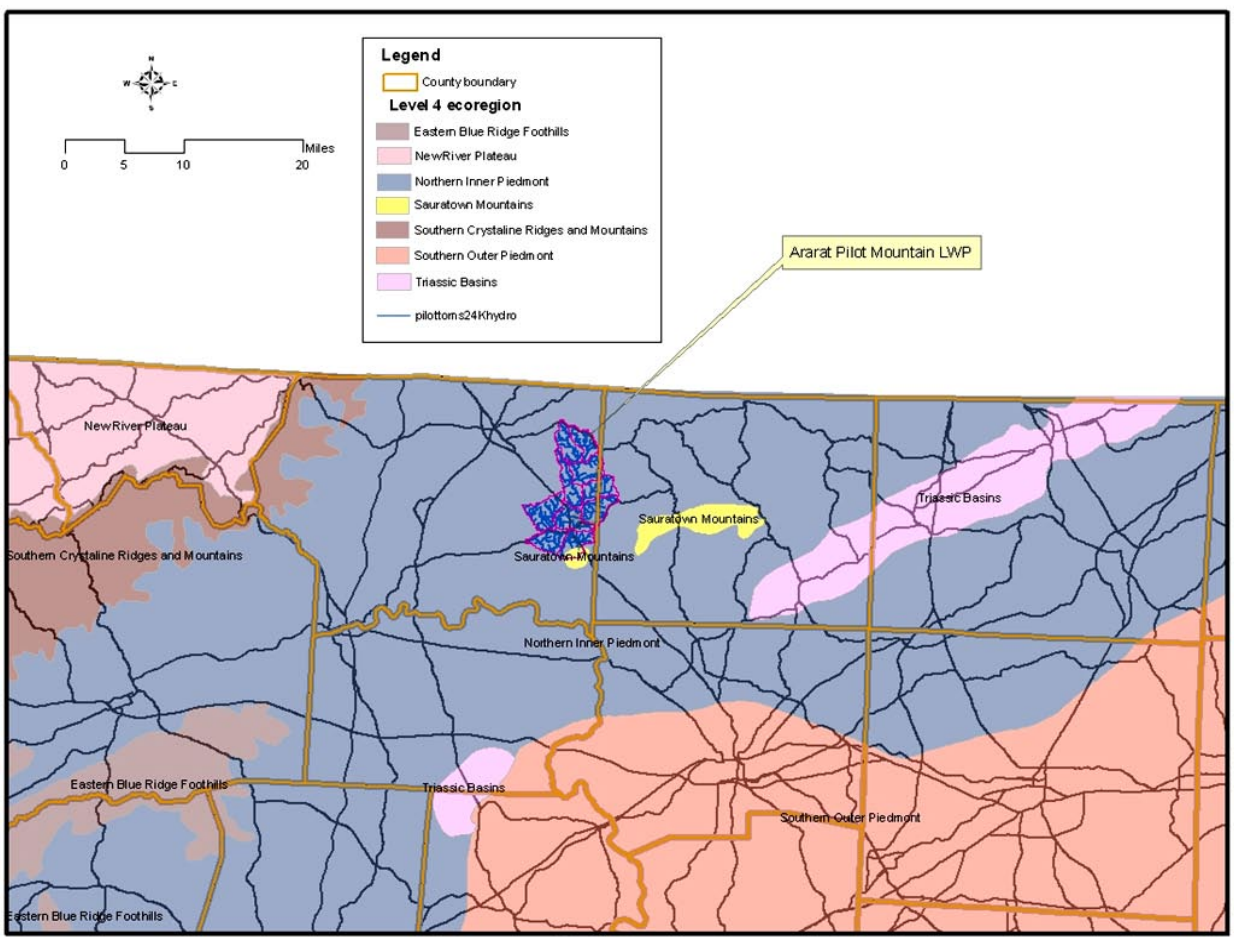
II. PRELIMINARY CHARACTERIZATION OF THE ARARAT-PILOT MOUNTAIN (APM) FOCUS AREA

Physical Characteristics and Land Use

Topography, Soils and Geology

The Ararat-Pilot Mountain (APM) LWP area is located in eastern Surry County (with a small portion in western Stokes County) within the Piedmont physiographic province and the Northern Inner Piedmont ecoregion [as defined by Griffith et al (2002)]. The Piedmont province represents the transitional area between the mostly mountainous Appalachians to the northwest and the relatively flat coastal plain to the southeast. It comprises a complex mosaic of very old (Precambrian and Paleozoic) metamorphic and igneous rocks, with moderately dissected plains and hills. The rolling to hilly Northern Inner Piedmont is characterized by higher elevations, more rugged topography, higher stream gradients and more mountain outliers than other areas of the Piedmont province (Griffith et al, 2002). A small area of the LWP area (Pilot Mountain State Park in the southern portion of the upper Pilot Creek subwatershed) falls within the Sauratown Mountains Level IV ecoregion; this region is characterized by prominent ridges and knobs that rise more than 1,000 feet above the rolling Piedmont landscape that surround them. Pilot Mountain represents an isolated mountain outlier (or "monadnock") formed by caps of erosion-resistant quartzite (Griffith et al, 2002).

Figure 2-1. Level IV Ecoregion Boundaries (Griffith et al, 2002) and the Ararat-Pilot Mountain LWP Area.



Geologically, the LWP area is within the Inner Piedmont Belt, consisting primarily of metamorphic and igneous intrusive rocks of late Proterozoic (Precambrian) to early Paleozoic ages (~ 1 billion to 400 million years ago). The LWP study area also includes a relatively small area of quartzite of the Sauratown Mountains anticlinorium, also of Precambrian age, at Pilot Mountain State Park along the southernmost border of the LWP area. In addition to the major bedrock units, surficial geologic materials in the LWP area include alluvium along stream bottoms and floodplains, and colluvial deposits at the bases of mountain flanks and steeper hill slopes. Intensively weathered residuum (saprolite formed from millions of years of in-place weathering of metamorphic and igneous bedrock) forms the parent material for many of the soil types found within the LWP area.

A local geologic map is shown in Figure 4-4 (in Section IV), illustrating the major geologic units mapped across the area. Some of these formations are discussed in greater detail in Section IV.A (Results) in relation to possible sources of sandy sediments in stream channels.

In terms of topographic relief, the highest elevations within the LWP area are the Chestnut Ridge drainage divide forming the northwestern boundary of upper Toms Creek (elevations of 1,500 to 1,700 feet above MSL) and the northwestern flanks of Pilot Mountain, forming the southern border of the upper Pilot Creek subwatershed (peak elevations of approximately 2,200 feet). Elevations along the easternmost drainage divide for Toms, Chinquapin, Heatherly and Pilot Creeks average about 1,200 feet above MSL. The lowest elevations within the LWP area are at the confluence of Toms and Pilot Creeks with the Ararat River (approximately 840 to 880 feet).

Major soil groups within eastern Surry County include residual Piedmont soils (formed in saprolite weathered derived from metamorphic gneisses and schists and granitic intrusions), alluvial Piedmont soils formed in recent and old alluvium adjacent to perennial streams, and colluvial soils of the Pilot Mountain area (Randall et al, 1995). According to the Soil Survey of Surry County (USDA-NRCS, 2007), major soil units and associations mapped within the Ararat-Pilot Mountain LWP area include:

- *Fairview* – sandy clay loam (surface) and clay loam (subsoil) on Piedmont uplands (inter-stream divides; ridges and low hills) – predominant soil type mapped across a broad swath within the LWP area.
- *Woolwine-Fairview* – gravelly and gravelly sandy loam (surface) and clay loam (subsoil) on Piedmont uplands – occurs primarily in upper Toms Creek subwatersheds and portions of Pilot Creek subwatersheds.
- *Chestnut-Peaks* – gravelly fine sandy loam (surface) and very gravelly fine sandy loam (subsoil) – formed on northwestern flanks of Pilot Mountain, primarily within the upper Pilot Creek subwatershed (PC-1).
- *Toast-Rhodhiss-Bannertown* – coarse sandy loam to gravelly sandy loam (surface) and sandy clay to coarse sandy loam (subsoil) – formed on granite and granite gneiss residuum in small portion of upper Toms Creek (subwatershed TC-2) and areas within Town of Pilot Mountain (Heatherly Creek TC-6 subwatershed and Chinquapin Creek CH-2 subwatershed).
- *Colvard-Suchs* – fine sandy loam (surface) and fine sandy loam to clay loam (subsoil) – formed on recent alluvium in floodplains of perennial streams; relatively minor percentage of total LWP area, but important in terms of possible aquatic habitat impacts from eroding stream banks (see Section IV).

Land Use/Land Cover

Land cover and impervious cover for the Ararat Pilot Mountain LWP study area were summarized from datasets developed by the NC Center for Geographic Information and Analysis for High Rock Lake watershed (NCCGIA, 2008). These datasets were developed from three satellite images taken 2006-2007.

Table 2-1 and Figure 2-2 illustrate the major land use patterns across the LWP area:

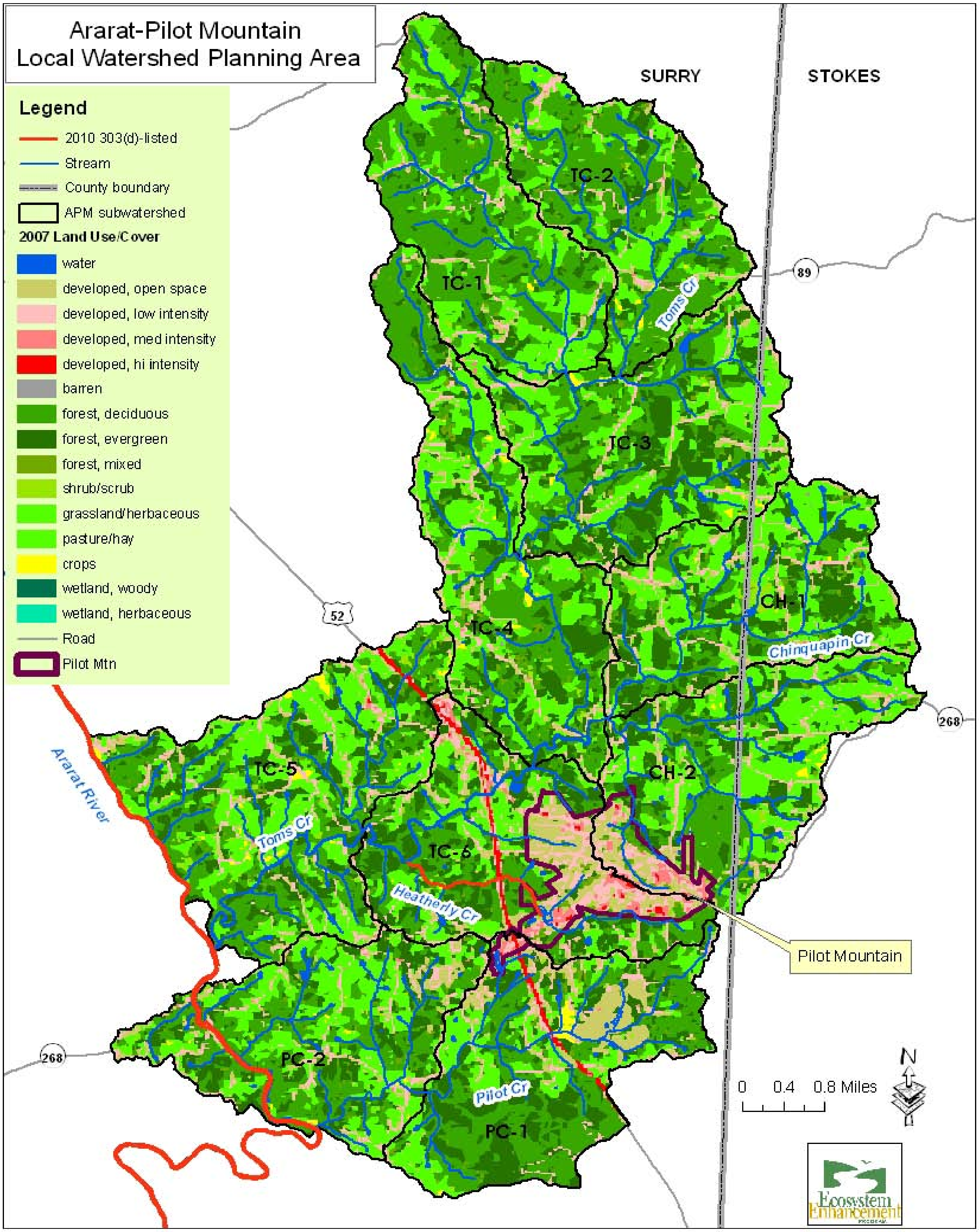
- Subwatersheds TC-1 and TC-2 (upper Toms Creek) and PC-1 (upper Pilot Creek, including Pilot Mountain State Park) have the highest percentage of undeveloped forest cover;
- The Chinquapin Creek subwatersheds (CH-1 and CH-2) contain the highest percentage of grassland and pasture;
- Cropland percentages are highest in subwatersheds TC-4 and TC-5 (middle to lower Toms Creek) and PC-1 (middle to upper Pilot Creek outside of Pilot Mountain State Park); and
- The highest concentration of developed lands (and impervious cover) is found within subwatersheds TC-6, CH-2 and PC-1 (the Town of Pilot Mountain and adjacent commercial/residential areas).

Table 2-1. Percent cover of various land use/cover types and impervious surface by subwatershed for the Ararat Pilot Mountain study area (NC CGIA, 2008).

Sub-watershed	Open space, developed[1]	Developed	Forest/shrub/ wetland	Grassland/ pasture	Cropland	Other	Impervious cover
TC-1	3.3	4.6	**63.4**	28.5	0.1	0.0	2.2
TC-2	3.6	5.0	**68.7**	22.1	0.5	0.0	2.5
TC-3	4.0	4.8	56.7	33.4	0.7	0.4	2.3
TC-4	4.9	5.2	57.7	31.0	**1.0**	0.1	2.5
CH-1	6.4	5.8	49.3	**37.9**	0.2	0.4	2.7
CH-2	9.8	**10.2**	43.8	**35.1**	0.6	0.6	**4.9**
TC-5	5.5	6.5	52.7	33.8	**1.3**	0.3	3.3
TC-6	15.5	**17.1**	49.6	17.3	0.1	0.4	**9.0**
PC-1	11.7	**8.4**	**61.7**	16.9	**1.1**	0.2	**4.6**
PC-2	7.7	6.3	52.2	31.6	0.4	1.8	3.3

[1]Note: "Open space, developed" = mostly managed vegetation in the form of lawn grasses, parks, golf courses or other settings developed for recreation (e.g., ball fields) with impervious cover < 20%. "Developed" = more intensively developed areas, including roads, houses and other structures, sidewalks, etc. with an impervious cover ≥ 20 percent (NC CGIA, 2008).

Figure 2-2. Land use/cover in the Ararat-Pilot Mountain LWP area (2006-2007).



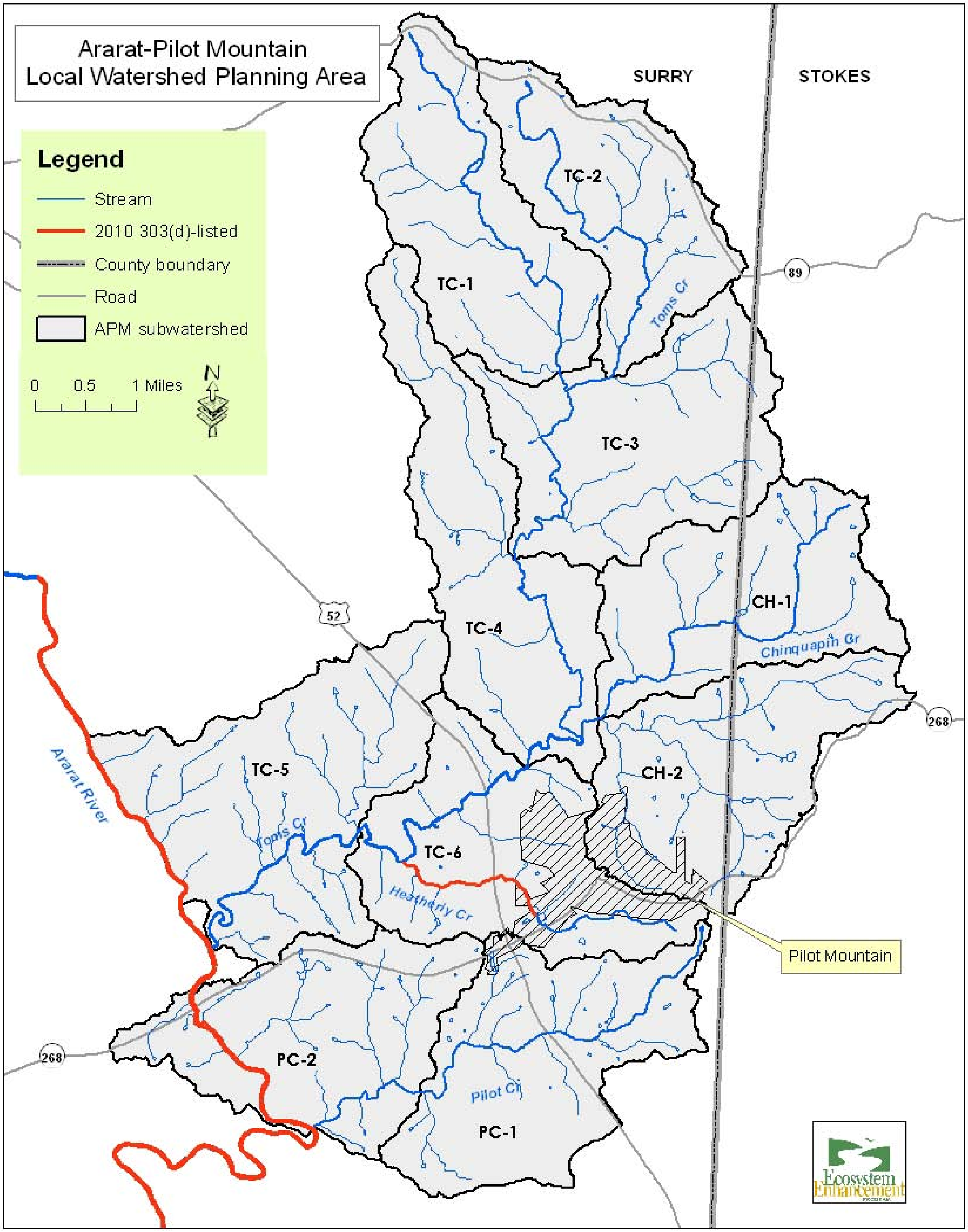
Major Hydrography

The LWP focus area consists of the Toms Creek and Pilot Creek watersheds in eastern Surry County (and a small portion of western Stokes County). Toms Creek comprises a 14-digit Hydrologic Unit (03040101110030) amounting to 40 square miles, and includes two major tributary streams, Chinquapin Creek (9.4 square miles) and Heatherly Creek (2.4 square miles). Several unnamed tributaries flow to Toms Creek and Chinquapin Creek across the central and northern portions of the LWP area. Toms Creek flows into the Ararat River just north of NC-268, approximately four miles west of the Town of Pilot Mountain. Pilot Creek has a drainage area of 9.8 square miles and represents a sub-watershed within the Hydrologic Unit (03040101110050) immediately south of the Toms Creek HU. Pilot Creek flows into the Ararat River approximately three river miles downstream (southeast) of the Ararat-Toms confluence near Pinnacle View Church Road. Unnamed tributaries to Pilot Creek drain the northwestern slopes of Pilot Mountain State Park and the suburban and rural landscapes just south and southwest of the Town of Pilot Mountain.

Using the stream classification system of Strahler (1952), Toms Creek is a 3rd and 4th order stream throughout most of its length. Chinquapin, Heatherly and Pilot Creeks are all predominantly 2nd order. There are no USGS stream gauging stations on Toms or Pilot Creeks, and no stream flow monitoring was conducted as part of the LWP watershed assessment work. The closest USGS stream discharge site is located at Dalton, NC on the Little Yadkin River, about five miles southeast of Pilot Creek in Stokes County. At this gauge station [USGS No. 02114450], the drainage area is 42.8 square miles (slightly larger than Toms Creek) and the upstream landscape is very similar to that of the Toms and Pilot Creek watersheds. Monthly mean stream discharges for the past 20 years at this site range from 25 cfs (July-August) to 75 cfs (March), and peak annual stream flows range from 550 to 6,800 cfs, with the majority of them in the 1,000 to 4,000 cfs range [waterdata.usgs.gov and waterwatch.usgs.gov].

The major streams of the Ararat-Pilot Mountain LWP area are depicted in Figure 2-3.

Figure 2-3. Major Hydrography and Subwatersheds in the LWP Area.



Ecological Characteristics
The Ararat-Pilot Mountain LWP area falls within the Northern Inner Piedmont ecoregion [Level IV ecoregion of Griffith et al, 2002; Figure 2-1.] This ecoregion is characterized by many mountain-disjunct plant species. Streams have higher gradients than in the Outer Piedmont region and contain many mountain-type macroinvertebrate species. The LWP area also includes a relatively small portion of the Sauratown Mountains ecoregion (Pilot Mountain State Park along the southern border of the LWP area, within the upper Pilot Creek subwatershed). The Sauratown Mountains region contains both Piedmont and Blue Ridge vegetation communities, mostly oak and oak-pine forests, with mountain flora including Carolina hemlock, rhododendron, azalea, galax, mountain laurel and various ferns (Griffith et al, 2002).

Outside of Pilot Mountain State Park, there are no significant natural heritage species (aquatic or terrestrial) within the LWP area [see *Natural Heritage Features* below].

<u>Terrestrial Habitat</u>
The landscape across the LWP area is, in general, highly altered due to over 300 years of human settlement and agricultural (farming and logging) activities. Terrestrial habitat is generally most highly altered in the developed portions within and immediately surrounding the Town of Pilot Mountain, where significant portions of the land cover are occupied by impervious surfaces. In addition, subwatersheds dominated by agriculture (cattle, crops, logging), such as TC-1 and CH-1, are significantly impacted. However, as noted in the *GIS: Riparian Buffers* subsection of Section IV and Figure 4-3, significant stretches of wide and relatively undisturbed (wooded) riparian buffers still exist along some streams, especially within the middle and lower Toms Creek subwatersheds (TC-4 and TC-5) and the upper Pilot Creek subwatershed (PC-1) along the northwestern flanks of Pilot Mountain. As shown in Table 2-1 and Figure 2-2 above, the highest proportion of forest cover within the LWP area (over 60%) is found within the upper Toms Creek subwatersheds (TC-1 and TC-2) and the upper Pilot Creek subwatershed (PC-1). The upper Pilot Creek subwatershed includes a significant area within Pilot Mountain State Park, where habitat quality is exceptional as compared to other portions of the LWP study area.

<u>Aquatic Habitat and Water Quality</u>
For a detailed discussion of aquatic habitat and water quality conditions within the LWP study area, see Section IV-A (Results), subsections on biological, water column (physical/chemical) and habitat and channel data. [Also, see the DWQ-WAT *Water Quality Technical Memorandum for the Ararat-Pilot Mountain LWP Area* (August, 2012) in the Appendix.] In general, water quality and aquatic habitat are not significantly impaired or degraded across the LWP area. However, there are at least isolated locations ('hot spots') were elevated concentrations of nutrients and fecal coliform are present as water quality stressors. Also, there are some stream sites where nutrient enrichment and in-stream sedimentation (abundance of fine sediments comprising the substrate) has clearly impacted aquatic habitat conditions.

<u>Natural Heritage Features</u> (Ecological Assets)
Pilot Mountain State Park, a significant portion of which falls within the southern LWP area (subwatershed PC-1), is a designated Significant Natural Heritage Area (SNHA). The NC Natural Heritage Program (NHP) defines SNHAs as terrestrial and aquatic areas or sites of "special biodiversity significance", due to the presence of rare species, unique natural communities or other important ecological features. Natural Heritage Element Occurrences (NHEOs) are specific sites where rare plant and animal species or exemplary/unique natural communities or animal assemblages have been documented. The only NHEOs within the LWP focus area, as mapped by the state's Natural Heritage

Program, are terrestrial elements within Pilot Mountain State Park -- including the pine-oak/heath community, large witch alder (*Fothergilla major*), peregrine falcon (*Falco peregrines*) and timber rattlesnake (*Crotalus horridus*). Two aquatic NHEOs (freshwater mussel species) are located several miles downstream of the Toms Creek-Ararat River confluence, on the main stem of the upper Yadkin River: the brook floater (*Alasmidonta varicose*) and the creeper (*Strophitus undulates*).

Population, Land Use and Development

Population

Population data and projections covering the LWP area are presented in the Surry County Land Use Plan 2015 (Surry County Planning Board, 2006) and Town of Pilot Mountain Land Use Plan, 2005-2015 (Pilot Mountain Planning Board, 2005). The sources of population data in these Land Use Plans include the U.S. Census Bureau, the State Data Center and the Office of State Budget and Management. The *Upper Yadkin LWP Task 2 Technical Memorandum* (McAdams-EcoEngineering, 2008) also includes data on parcel density and population density within the subwatersheds comprising the Ararat-Pilot Mountain LWP focus area.

In 2000, the estimated population within the Ararat-Pilot Mountain LWP area (Toms and Pilot Creek watersheds) – which roughly corresponds to the Pilot and South Westfield Townships – was 5,500 (Surry County Planning Board, 2006). Nearly a quarter of that population (1,281) was concentrated within the municipal boundaries of the Town of Pilot Mountain. According to the latest online U.S. Census data (censusviewer.com), the 2010 population of Pilot Mountain was 1,477 (a 15.3% increase from 2000). Assuming the Town's population continues to represent ~ 25% of the total in the two townships comprising the LWP area, then the total population within the Toms and Pilot Creeks watersheds in 2010 was approximately 5,900. Assuming the same growth rate as 2000 to 2010, by 2020 the Town's population is projected to reach 1,700, and the two townships representing the LWP area approximately 6,800 persons.

Population density within Pilot Mountain in 2000 was 742 persons per square mile; overall in Surry County the population density was approximately 135 persons per square mile. Outside of the Town of Pilot Mountain, within the more rural areas of the Toms, Chinquapin and Pilot Creek watersheds, population densities range from less than 50 to approximately 200 persons per square mile (McAdams-EcoEngineering, 2008).

Land parcel densities (parcels per square mile), based on the County tax parcel dataset obtained by EcoEngineering in 2008, range from 63 in upper Toms Creek (subwatershed TC-1) to 212 in subwatershed TC-6, which includes Heatherly Creek and the urban core of Pilot Mountain. Parcel density was a metric used to help identify priority subwatersheds for rural and urban watershed projects (and BMPs) across the initial LWP study area during the 2008 fast-track initiative

Local stakeholders, including the Surry County Planner, have noted that much of the recent population growth and residential development in the LWP area is within the Pilot Creek subwatershed, due to its proximity to the Town, to Pilot Mountain State Park, and to increasing residential/suburban sprawl from Winston-Salem in Forsyth County (southeast of the LWP study area).

A map depicting current development patterns and 2010 population densities in the greater Piedmont Triad region (including Surry County) can be found online at the Surry County Planning and Development web page.

Development Trends

Although population growth and new residential and commercial development within the LWP area (and the Town of Pilot Mountain) has been relatively slow over the past few decades, there are signs of increasing residential sprawl from nearby Forsyth County and the City of Winston-Salem – especially along the U.S. Highway 52 corridor that bisects the southern tier of the LWP area. Several local stakeholders have noted that the Pilot Creek watershed (immediately north and northwest of Pilot Mountain State Park) is the fastest growing area within the LWP in terms of new residential construction and home sales. Accordingly, viewshed protection and recreational and greenways planning in this area are two of the priority issues identified by local stakeholders. The conversion of farmland and wooded lots to residential and commercial development represents a significant trend in terms of potential impacts to water quality and aquatic habitat throughout the LWP area, but especially in these southernmost subwatersheds within the LWP area.

Historical Land Use and Watershed Impacts

Land use within the LWP area – as with much of North Carolina's Piedmont region outside of major towns and cities – has been dominated historically by farming and logging. Farming was the primary source of income for early settlers across the Piedmont of North Carolina in the 18th and 19th centuries, including wheat, corn, oats, rye, apples and tobacco. From the late 1700s to the mid-1800s, cotton and forest products became important to the Surry County economy. By the second half of the 20th century, tobacco had become the major cash crop produced in Surry and Stokes counties. Tobacco farming dominated rural land use in Surry County up until around 2000, and there is still some limited contract farming for tobacco production. Today, cattle, corn, soybeans and hay production are the primary farming activities in the region within and surrounding the APM LWP area (Tony Davis; personal communication, 2011). County-wide, poultry production is now the largest source of farm income in Surry County (McIntyre et al, 2012), but no poultry operations were observed during any of the DWQ or EEP field reconnaissance activities within the LWP area.

In terms of water quality and aquatic habitat impacts, tobacco farming in the area was very fertilizer-intensive and rarely employed agricultural BMPs such as no-till, contour cropping, riparian buffer protection, field rotation or cover crops (Tony Davis; personal communication, 2011). Corn and soybean production, now the primary cash crops in eastern Surry County, employ no-till methods and are much less likely to create erosion and sedimentation problems. Significant amounts of so-called 'legacy' sediment from intensive tobacco farming and logging in the 18th and 19th centuries were deposited into stream channels and onto floodplains. Also, some stream reaches were deepened and straightened ("channelized") in the past to improve bottomland drainage and maximize the land area available for farming. With the advent of modern conservation practices and the increased funding/implementation of agricultural BMPs over the past couple of decades, many stream systems have at least partially recovered from these historical land use impacts. But sandy stream substrates and active channel incision and stream bank erosion still characterize certain streams and stream reaches within the LWP area. The legacy of past agricultural land use practices (farming and logging) remains an important factor in assessing current watershed conditions.

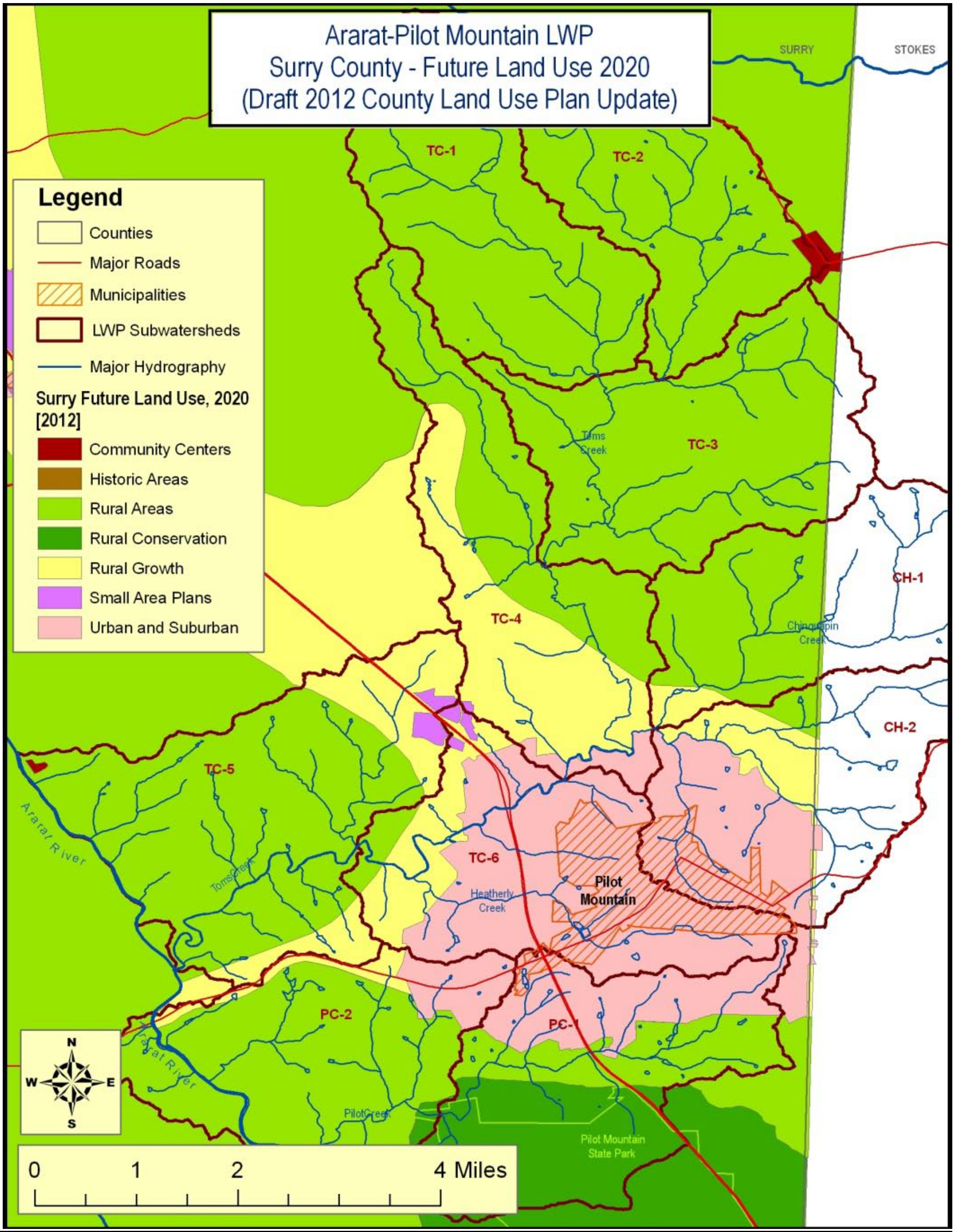
Land Use Plans and Initiatives

Current and Future Land Use

Current land use and land cover for the LWP subwatersheds is presented in Table 2-1 and Figure 2-2 above. Outside of the Town of Pilot Mountain, predominant land use within the LWP area is rural, dominated by forest/shrub and grassland/pasture cover. Scattered livestock farms, forested tracts, open fields and low-density rural residential development characterize the vast majority of the LWP area outside of the urban portions of subwatersheds CH-2 and TC-6. The small community of Westfield along the western drainage divide for Toms Creek (subwatershed TC-2) is a rural cross-road with some limited commercial and residential development.

The most recent Land Use Plan for Surry County (Surry County Board of Commissioners, 2012) provides a summary of current land use, as well as a blueprint for future land use and development within the LWP area. There are seven major land use/zoning categories in the County, six of which fall within the LWP area:
- *Community Activity Centers* (burgundy) – Nodes/intersections where non-residential development may occur to provide services to surrounding rural areas. Limited to the community of Westfield within the LWP area.
- *Rural Areas* (light green) – Lands whose highest use is for agriculture, forestry, low-density residential, water supply and mining/extraction; extension of urban/suburban services (e.g., water and sewer lines) not currently anticipated. By area, the dominant land use category outside of Pilot Mountain's urban/suburban core.
- *Rural Conservation Areas* (darker green) – Scenic, pristine, ecologically fragile, high-hazard and other lands necessary to maintain a healthy natural environment. Limited to Pilot Mountain State Park and about a ½-mile buffer immediately surrounding park boundaries in the Pilot Creek subwatersheds.
- *Rural Growth Areas* (light yellow) – Lands where local government plans to accommodate medium-density development during the 15-year planning period, and where necessary public services will be provided; these areas are projected to see the highest concentration of new development. This area generally surrounds the urban/suburban core of the Town of Pilot Mountain and stretches northwestward along U.S. Highway 52 toward the City of Mount Airy. The size of this area has been revised downward from the 2015 vision to the 2020 strategy (see discussion below).
- *Small Area Plans* (dark pink) – Areas in the immediate vicinity of selected road-highway interchanges (U.S. 52/Cook School Road within subwatersheds TC-5 and TC-6); scheduled to receive water and sewer services to accommodate dense commercial and industrial growth.
- *Urban and Suburban* (light pink) – Lands where existing population density is moderate to high and where there are a variety of land uses which have the necessary public services; the urban core of Pilot Mountain and suburban residential/commercial areas surrounding the town (primarily in subwatersheds TC-6, CH-2 and PC-1).

Figure 2-4. LWP Future Land Use **2020** (Surry County Board of Commissioners, 2012).



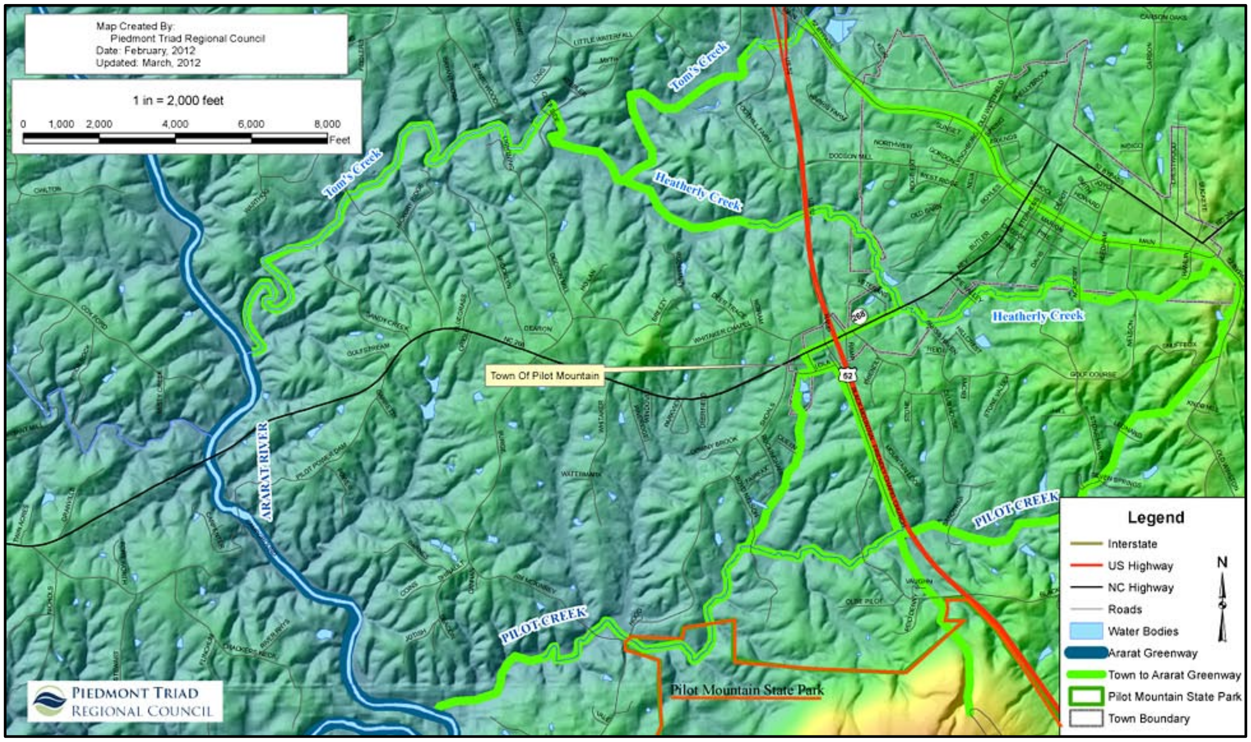
Surry County's former Land Use Plan (2006) was updated in 2012 to reflect a renewed vision for future growth. Figure 2-4 depicts proposed future land use for *2020* within and surrounding the Ararat-Pilot Mountain LWP area (Surry County Board of Commissioners, 2012). For the APM area, the only significant change in future growth strategy is a significant decrease in the land area planned for Rural Growth (the light yellow shading), which reflects a desire for less suburban sprawl and less residential/commercial development within the area surrounding the Town of Pilot Mountain -- and a corresponding expansion of the area within the Pilots Creek, Chinquapin Creek and lower to middle Toms Creek subwatersheds considered Rural Areas (the light green shading). The purpose of this revision is a "more practical and compact growth management approach" and enhanced viewshed protection for eastern Surry County near the Town of Pilot Mountain and the State Park (Kim Bates, personal communication, 2012).

No land use or zoning category shapefiles were available for the Stokes County portion of the LWP area, which consists of approximately five square miles of upper Chinquapin Creek subwatersheds CH-1 and CH-2. Both of these subwatersheds drain to Toms Creek and are part of the WS-II water supply watershed serving the Town of Pilot Mountain. See additional discussion below (Local Ordinances section) pertaining to land use and development regulations within the Stokes County portion of the LWP area.

Greenways and other initiatives

There are several significant greenways initiatives in at least the planning/concept stages within Surry County and the greater upper Yadkin region at present, including: NC DOT Safe Routes to School program, Yadkin Valley Heritage Corridor (YVHC), Piedmont-Triad Regional Council (PTRC), National Park Service's Overmountain Victory National Historic Trail (OVNHT), Mountains-to-Sea Trail (MST), Pilot Mountain State Park, Surry County Greenways Master Plan and Town of Pilot Mountain Recreational & Greenways Plan. The local stakeholders decided that one objective of this Local Watershed Plan should be to coordinate greenways-related recommendations within the LWP area (Toms and Pilot Creek watersheds) with maps and plans already developed by these existing greenways initiatives/programs. Specific recommendations related to greenways trails/connectors within the LWP area will be included in the final Ararat-Pilot Mountain *Watershed Management Plan*. Figure 2-5 below depicts a local greenways map with proposed connectors from the LWP area to the Ararat River, developed by the PTRC in spring of 2012 (Allred, 2012).

Figure 2-5. Proposed Greenways/Connectors to Ararat River (Allred, 2012).



The *Surry County Farmland Preservation Plan* (McIntyre et al, 2012) was completed in February of 2012 as a collaborative effort involving the Piedmont Land Conservancy, the Surry County Cooperative Extension Service, Surry County Soil and Water Conservation District (SWCD), Surry County Board of Commissioners, Surry County Voluntary Agriculture District Board and other local partners and landowners. This Plan provides a blueprint for protecting agricultural lands within the county (including the LWP area) and includes sections addressing the following: the value/benefits of agriculture in the county; Agricultural Priority Areas within the county; farmland preservation tools (e.g., tax and land use policies); recommendations for enhancing agriculture in the county; available funding sources (state, federal and local); and farmland preservation partners. The Shoals Area, including Pilot Mountain State Park and Shoals Road (extending southward from the Town of Pilot Mountain through the Pilot Creek subwatersheds), is identified as one of three *Agricultural Priority Areas* for farmland preservation. This area of the county (and the Pilot Creek subwatersheds within the LWP area) is at high risk for residential development encroaching from Forsyth County, and is therefore a priority area for farmland preservation and protection of relatively undisturbed rural landscapes. Expansion of the existing Voluntary Ag District (VAD) program in Surry County -- under which participating farm owners/operators receive financial and legal benefits, and special recognition and signage -- is one of several recommendations for farmland protection within this area.


Photo Credit: McIntyre et al, 2012.

Local Rules & Ordinances

The primary sources of information regarding local zoning and subdivision ordinances related to watershed protection within the LWP area are the Surry County Land Use Plan 2015 (2006), Surry County Land Use Plan 2020 (2012); the Pilot Mountain Land Use Plan 2005-2015 (2005), online documents outlining the subdivision and zoning ordinances (Surry County; Town of Pilot Mountain; Stokes County), and communications with Surry County Planner Kim Bates, Pilot Mountain Town Manager Homer Dearmin and Stokes County Planner David Sudderth.

County Zoning Ordinances (Surry and Stokes)

Established Zoning Districts

In Surry County, which comprises 90 percent of the Ararat-Pilot Mountain LWP area, several zoning districts have been established in order to carry out the goals (and general growth strategy) of the County's Land Use Plan (Surry County Planning Board, 2006), including objectives related to environmental quality and open space protection. Established districts include:

- Rural Agricultural – designed to maintain a rural development pattern (single family housing intermingled with agricultural uses) not having access to public water and sewer systems; also designed to protect rural areas from the intrusion of non-agricultural land uses that could "present a danger to the natural environment".
- Residential – includes subcategories (e.g., Restricted Residential, Residential General) designed to maintain established and planned medium-density residential neighborhoods (stick-built and modular homes), provided that adequate water and sewer systems are available.
- Multi-family Residential – provide a place for high-density residential development where adequate water and sewer services are available.
- Manufactured Home Park – high-density development of manufactured homes in a park-like setting.
- Business – subcategories include Rural, Community and Highway business districts designed to accommodate retail, service and related businesses at intersections and along major roadways, with access to public water and sewer systems.
- Manufacturing Industrial – locations for intensive industrial and/or manufacturing, processing and assembly uses (and to protect adjacent rural/residential areas from such uses).
- Conservation Protected – designed to preserve and limit development within certain land and/or water areas which serve as wildlife refuges, possess natural beauty, provide for outdoor recreation, provide needed open space, and are environmentally sensitive.
- Planned Residential Conditional – areas designed to provide certain development privileges in exchange for planning and design considerations; provide an alternative to conventional subdivision design by promoting the conservation and creation of viable, connected open space and more flexible lot design options; and
- Watershed Overlay – water supply watershed areas subject to special provisions of the County Watershed Ordinance (see subsection below).

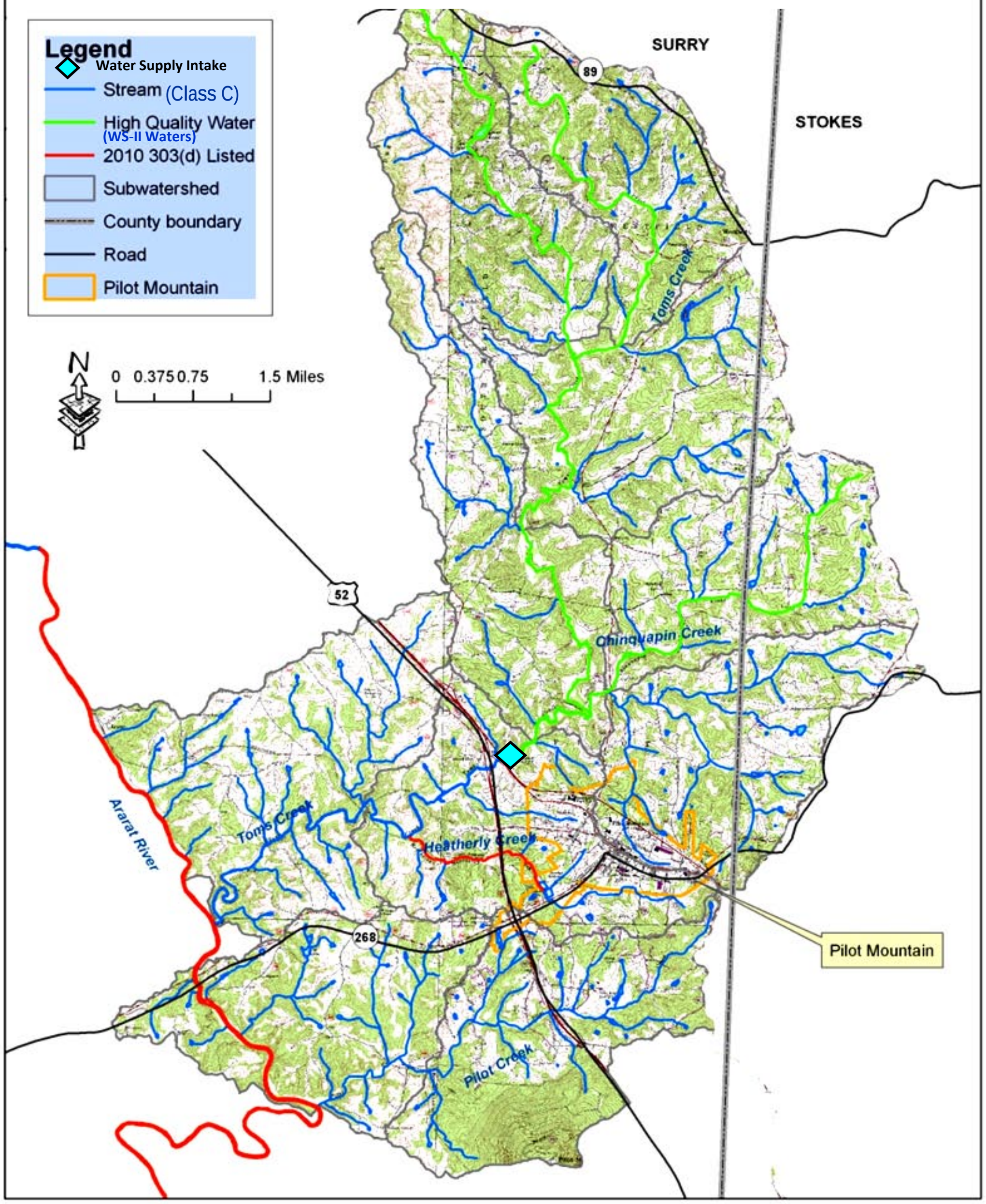
The major land use/zoning classes within the Ararat-Pilot Mountain LWP area (outside of the Town of Pilot Mountain – see *Municipal Ordinances* below) are Rural Agricultural and low- to medium-density Residential. As noted above, areas designated for Rural Growth have become more limited in the latest County Land Use Plan (for 2020), reflecting a goal of more compact development (and less suburban sprawl) surrounding the Town.

Watershed Overlay District

Approximately five square miles (10 percent) of the Ararat-Pilot Mountain LWP area, comprising the upper reaches of the Chinquapin Creek subwatersheds, is in Stokes County. The CH-1 and CH-2 subwatersheds drain to Toms Creek (in Surry County) above the water supply intake for the Town of Pilot Mountain, and therefore fall within the Toms Creek designated Water Supply Watershed (classified as WS-II and HQW waters by NC DWQ). The zoning ordinances of both Surry and Stokes County establish Watershed Overlay Districts, within which designated Watershed Areas are subject to special development regulations. The Toms Creek Watershed *Critical Area* (CA) includes all land area in the watershed within a ½-mile radius upstream of the water supply intake [see Figure 2-6]. The CA development rules limit new residential development to a maximum of one dwelling unit per two acres, and all other development to no more than six percent (6%) built-upon area. Landfills and residuals (wastewater, sludge or petroleum-contaminated soils) application sites are banned within the Critical Area. The *Balance-of-Watershed* (BW) area within the Toms Creek water supply watershed, which comprises approximately 28.6 square miles (57% of the total LWP area; the entire drainage area of middle to upper Toms Creek and both Chinquapin Creek subwatersheds), is subject to similar, but less stringent, development rules:

- Single family residential shall not exceed one dwelling unit per acre;
- All other development shall not exceed twelve percent (12%) built-upon area;
- Special intensity allocation (SIA) areas and cluster developments are allowed, but only in accordance with special provisions, including the minimization of stormwater runoff and incorporation of best management practices (BMPs) to minimize water quality impacts;
- Storage of toxic and hazardous materials is prohibited, unless an approved spill containment plan is in place.

Figure 2-6. LWP Area Stream Classifications and Water Supply Intake.



Stream Buffers

Undisturbed natural (vegetative) stream buffers are required to be maintained on all perennial streams within the Watershed Overlay Districts (water supply watershed areas) of both Surry and Stokes County. In Surry County (the bulk of the LWP area), a minimum 50-foot undisturbed buffer is required. In Stokes County (upper Chinquapin Creek subwatersheds), a minimum 30-foot buffer is required. No new development is allowed within the stream buffers, except for water-dependent structures (which result in only minimal increases in impervious cover) or public projects such as road crossings and greenways (where no practical alternative exists).

Throughout Surry County, regardless of whether in a Water Supply Watershed or not, **a 50-foot undisturbed natural buffer is required on all perennial streams**. In addition, including within the Ararat-Pilot Mountain LWP area, a 50-ft undisturbed natural buffer is required along all property that adjoins Pilot Mountain State Park.

Floodplain Development

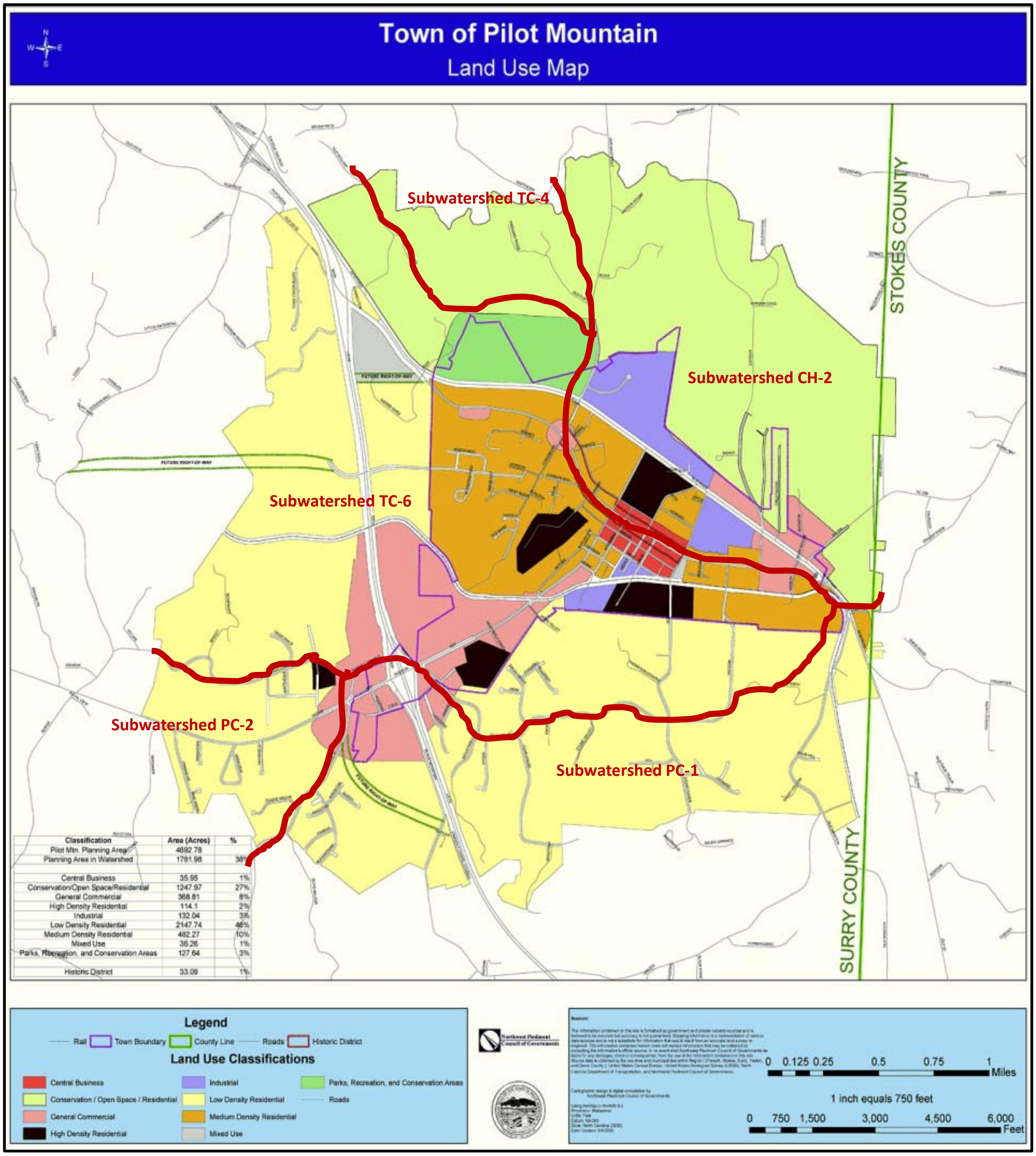
Article 20 of the Surry County Zoning Ordinance addresses filling, grading, dredging and all other development activities within Special Flood Hazard Areas, as identified on FEMA Flood Insurance Rate Maps (FIRM) for the county. [SFHAs are defined as land areas in the floodplain subject to a one percent (1%) or greater chance of being flooded in any given year.] Special application, permit and elevation certification requirements apply to development within flood hazard areas, including flood zones and floodways. Construction standards (including a Regulatory Flood Protection Elevation and stream setbacks) for flood hazard reduction are established in the ordinance, and no waste disposal facilities, salvage yards or chemical storage are allowed within designated flood hazard areas. Where no Base Flood Elevation (BFE) data have been provided by FEMA, no encroachments -- including fill, new construction, substantial improvements or new development -- shall be permitted within a distance of twenty (20) feet each side from top of bank, or five times the width of the stream, whichever is greater.

Municipal Ordinances (Town of Pilot Mountain)

The Town's subdivision and zoning ordinances can be found in Title XV (Land Usage) of their municipal code. Figure 2-7 below presents the Land Use Map for the Town of Pilot Mountain (NWPCOG, 2005), which accompanies the Town's 2005-2015 Land Use Plan (Pilot Mountain Planning Board, 2005). The established zoning districts reflect the development strategy presented in the 2005-20015 Land Use Plan. The Town's planning jurisdiction covers 7.3 square miles, or approximately 15 percent of the Ararat-Pilot Mountain LWP area. Figure 2-7 includes LWP subwatershed boundaries in addition to land use/zoning classes. Medium-Density Residential (orange), General Commercial (pink), Industrial (lavender), and High-Density Residential (dark burgundy) land uses dominant the urban core of the Town. West and south of the urban core (in subwatersheds Toms Creek TC-6 and Pilot Creek PC-1 and PC-2), the dominant land use/zoning class is Low-Density Residential (light yellow). North of the Highway 52 bypass, in the upper reaches of subwatersheds Toms Creek TC-4 and Chinquapin Creek CH-2, Conservation/Open Space (light green) and Parks/Recreation and Conservation Areas (medium green) occupy the Town's planning jurisdiction.

The zoning (planned/allowable land uses) for the northern areas of the Town of Pilot Mountain, which are predominantly Conservation-Open Space and Parks-Recreation, may provide some benefit to water quality and aquatic habitat within the Chinquapin Creek tributaries in subwatershed CH-2 and a small portion of middle Toms Creek (subwatershed TC-4) near the Town's water supply intake. The Low-Density Residential zoning south of town doesn't afford the same level of protection for tributaries to Pilot Creek in subwatersheds PC-1 and PC-2, although it's better than higher-density residential or commercial/industrial land uses.

Figure 2-7. Town of Pilot Mountain Land Use Map (NWPCOG, 2005).



Surface Water Classifications and Existing Impairment

Surface Water Classifications are designations applied to surface water bodies (streams, rivers and lakes) by the NC Division of Water Quality (NC DWQ), which define the best uses to be protected within these waters -- for example swimming, fishing, drinking water supply -- and which carry with them an associated set of water quality standards to protect those uses. Each classification has associated standards that are used to determine if the designated uses are being protected. The NC DWQ Classification and Standards Unit's home page provides details on stream classifications, water quality standards, action levels and hyperlinks to a database that identify the surface water quality classifications for all streams in North Carolina.

All streams within the Ararat-Pilot Mountain LWP area are classified as Class C or carry a Water Supply (WS-) classification (Figure 2-6). Toms Creek (*above the Town of Pilot Mountain's drinking water intake)* and Chinquapin Creek are also assigned a High Quality Waters (HQW) supplemental classification since they are designated water supply (WS-II) waters. The pertinent DWQ stream classifications are defined as follows:

> Class C - Waters protected for uses such as secondary recreation, fishing, wildlife, fish consumption, and aquatic life, including propagation, survival and maintenance of biological integrity, and agriculture. *Secondary recreation* includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent or incidental manner.
>
> Water Supply II (WS-II) - Waters used as sources of water supply for drinking, culinary, or food processing purposes where a WS-I classification is not feasible. These waters are also protected for Class C uses. WS-II waters are generally in predominantly undeveloped watersheds. All WS-II waters are HQW by supplemental classification. For more information, see the Water Supply Watershed Protection Program Homepage.

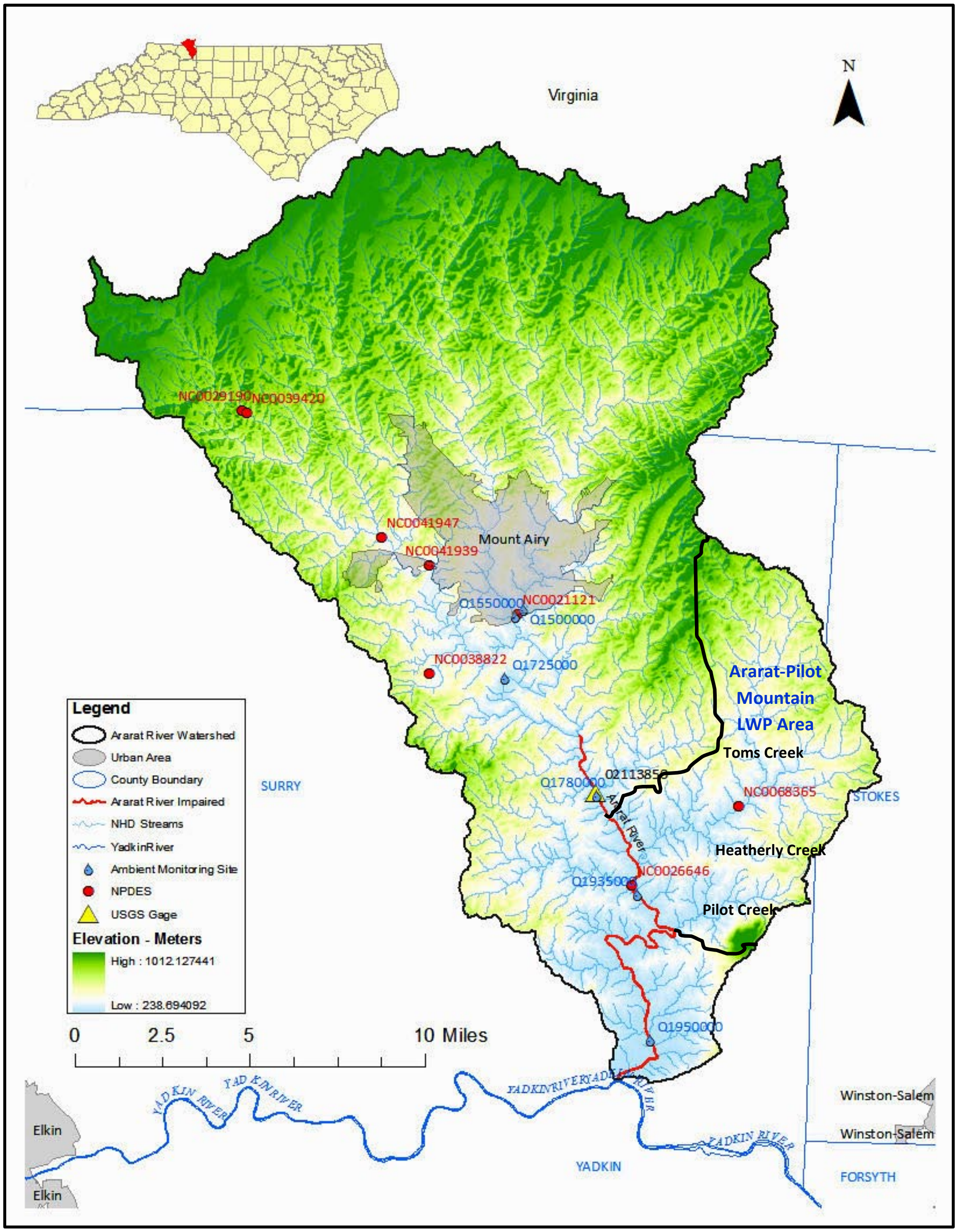
Impaired Waters

Section 303(d) of the Clean Water Act (CWA) requires states to develop a list of waters not meeting NCDWQ water quality standards or which have impaired uses. Listed waters must be prioritized, and a management strategy must subsequently be developed for all listed waters. The following link provides more information about the impaired streams list. Two stream segments within the LWP area are listed as impaired on NCDWQ's draft 303(d) list for 2012 (NCDWQ, 2012):

1. **Heatherly Creek** (1.4 miles) from NC 268 to Toms Creek (in LWP subwatershed TC-6; drains portions of the Town of Pilot Mountain) – Biological impairment (benthos). Subsequent data collected for Heatherly Creek since its initial publication on the 303(d) list (1998) suggest it should be removed from the list of impaired streams [next update to the statewide 303(d) report will be 2014]. This is discussed further in Section IV, Results & Discussion.
2. **Ararat River** (15.7 miles) from Stoney Creek (~5 miles upstream of LWP area) to Yadkin River -- Turbidity standard violations. A turbidity TMDL (as TSS, total suspended solids, including suspended sediment) was approved by EPA in November 2011 for this reach of the lower Ararat River (into which both Pilot and Toms Creek flow directly). *Total Maximum Daily Load (TMDL)* is defined as the total amount of pollutant that can be assimilated by the receiving water body, from both point and nonpoint source loads, while achieving water quality standards. TSS reductions can be achieved through voluntary watershed management measures, including best management practices (BMPs) for agriculture/forestry and urban stormwater runoff. Runoff from NC DOT roadways and construction projects is considered a major contributor to the turbidity standard violations in the lower Ararat River, and the DOT has been assigned a 54% TSS

loading reduction goal within the Ararat River watershed, in order to meet the water quality standard for turbidity (50 NTU). For more information, visit the NC DWQ Modeling and TMDL Unit. Figure 2-8 below shows the Ararat River watershed, the impaired stream reach and the LWP area.

Figure 2-8. Ararat River Watershed, showing impaired reach and the Ararat-Pilot Mountain LWP area. [Adapted from NC DWQ, 2008 – *Yadkin River Basin Water Quality Plan*.]



III. METHODS

A set of basic information, such as that for soils, species and habitats of concern, local rules and ordinances, and stream classification and impairment, is presented in Section II of this document. Section III summarizes methods used in the development and analysis of various GIS and field datasets during Phase II of this effort, which took place primarily during 2011 and 2012. A variety of data were used to conduct the Ararat-Pilot Mountain LWP area assessment, including the following:

- GIS data, including riparian buffer and wetland datasets
- Biological community data, including those of fish and benthic macroinvertebrate communities
- Physical/chemical water quality data, focusing primarily on nutrients, fecal coliform bacteria, and ambient characteristics
- Stream habitat data collected at numerous locations throughout the watershed.

A. Stream Data

1. Biological data

Benthic macroinvertebrates

NC Division of Water Quality (NCDWQ) assessed benthic macroinvertebrate communities at twelve sites in May-June 2011 (Tyndall, 2011; for full report, see Appendix B) and assessed three sites in November 2011. The 4-sample “Qual 4” method was used at all sites sampled except for two of the three sites sampled in November, where the 10-sample “Full Scale” method was used. These sampling protocols are summarized in NCDWQ’s standard operating protocol (2011a).

Bioclassifications of Excellent, Good, or Good-Fair (all considered “Fully Supporting” by NCDWQ) or Fair or Poor (considered “Impaired” by NCDWQ) were assigned to most sites. Mountain biocriteria were used. All sites with drainage areas <3 mi^2 were rated with the Small Streams Biocriteria protocol (NCDWQ, 2009) except the one sampled in November, which was rated with the small mountain stream biocriteria (which rate streams as either Not Rated or Not Impaired). Those with drainage areas $\geq$3 mi^2 were rated with either EPT (Ephemeroptera, Plecoptera, and Trichoptera) richness criteria if sampled with the Qual 4 method or with EPT and Biotic Index (BI) criteria if sampled with the Full Scale method (NCDWQ, 2011a).

Generally, the higher the EPT richness value, the healthier the community. In contrast, a high BI indicates a greater dominance by pollution-tolerant taxa; the lower the BI, the more sensitive a community is to pollution and disturbance.

Fish

The NC Department of Transportation (NCDOT) Biological Surveys Group assessed fish communities at six locations in June 2011 (Medlin, 2011; see Appendix C) and NCDWQ assessed the fish community at one site on lower Toms Creek in June 2011 (NCDWQ, 2011b).

NCDWQ used its standard fish sampling protocol, which involves electro-shocking, identifying, and examining fish in a 600-meter reach of stream (NCDWQ, 2006). A bioclassification of either Excellent, Good, or Good-Fair (all considered “Fully Supporting” by NCDWQ) or Fair or Poor (considered “Impaired” by NCDWQ) was assigned to the site using NC’s Index of Biotic Integrity, which uses multiple metrics to characterize the fish community.

NCDOT used its Biological Surveys Group fish collection protocols, which involves sampling all habitat types and flow regimes in the stream (Medlin, 2011). Fish were electro-shocked and identified. Bioclassifications were not assigned to streams sampled, but the fish data collected were generally evaluated using the metrics developed by the NCDWQ for its Index of Biotic Integrity.

2. Water column data

NCDWQ staff collected water column data for the Ararat-Pilot Mountain study area in 2011 and 2012. Physical and chemical monitoring methods are reported in "Water Quality Technical Memorandum for the Ararat Pilot Mountain Local Watershed Planning Area" (NCDWQ Watershed Assessment Team, 2012), in Appendix A.

DWQ assessed physical and chemical water quality parameters at baseflows (or flows not primarily influenced by storms) throughout the study area. A site on a tributary to Pilot Creek which drains primarily Pilot Mountain State Park land served as a reference site (location B14 on Figure 4-1). Two types of monitoring were performed: synoptic and hot spot monitoring. Synoptic monitoring was performed to gauge conditions throughout the watershed; an initial sweep of 40 sites throughout the watershed was performed in order to characterize field meter parameters (dissolved oxygen, pH, specific conductance, and temperature). For a subset of these sites, nutrients (nitrite-nitrate, total Kjeldahl nitrogen, total phosphorus, and ammonia) and/or fecal coliform bacteria were also analyzed. Results of this initial sweep were used to determine 'hot spots', where follow-up work was performed to better understand pollutant levels and their sources.

Additional synoptic monitoring was performed in order to characterize water quality by subwatershed. Data collected during the initial sweep was supplemented with additional samples taken at some of the same sites, and additional sites were chosen to represent each subwatershed. Each subwatershed was then represented by at least 2-3 sites which were sampled at least three times. Parameters assessed for subwatershed synpotic sampling were nitrite-nitrate nitrogen (NOx), fecal coliform bacteria, as well as field meter parameters.

3. Habitat and channel data

Habitat was assessed by DWQ and/or EEP staff at all 14 fish and benthic macroinvertebrate sites and an additional 11 sites using DWQ's standard habitat assessment protocol for mountain and piedmont streams (NCDWQ, 2011a). This protocol assigned a numerical score from 1-100 for a stream reach, summing the scores for eight habitat metrics, including channel modification, in-stream microhabitat, bottom substrate type and degree of embeddedness, pool variety and frequency, riffle frequency and size, bank stability and vegetation, light penetration/canopy coverage, and riparian zone width and integrity. This method was also used by DWQ staff during hot spot investigations to better understand habitat degradation in the watershed.

At each fish and benthic site, an additional metric was assessed--the proportion of the stream reach covered by various substrate sizes (bedrock, boulder, cobble, gravel, sand, and silt). This assessment and the 'bottom substrate type and degree of embeddedness' metric of the DWQ habitat assessment protocol were used to determine the extent of fine sedimentation at each site. EEP staff expanded on this dataset by assessing the same two metrics at an additional 18 sites, chosen to represent conditions in each of the 10 subwatersheds.

4. GIS data

The riparian buffer dataset developed by Wildlands Engineering (WEI) was based on a detailed evaluation of the most recent (2010) aerial photo coverage available for Surry and Stokes Counties. The buffer assessment was conducted on streams included in the 1:24K hydrography dataset obtained from the North Carolina Center for Geographic Information and Analysis (CGIA). WEI used the aerial photos to estimate the width of the woody riparian buffer along both banks of all streams included in the 1:24K hydrography layer within the study area (not including ponds). The buffer widths of all reaches were then grouped into five categories:

- No buffer on either side
- Minimal buffer on both sides (<30 feet)
- Adequate buffer (>30 feet) on one side
- Adequate buffer (>30 feet) both sides
- Excellent (>100 feet) buffer both sides.

The width of the riparian buffers was based on the width of woody vegetation along the stream banks visible in the aerial photography. For the purposes of this assessment, woody vegetation included forests, timber stands, early successional zones, and shrub/scrub areas. The result of the assessment was a new GIS layer of reaches broken as described above and attributed with the buffer width category classification. For additional details on development of the riparian buffer GIS dataset, see the WEI report, *Technical Memorandum 1: Review of Existing GIS Data Sets, GIS-Based Riparian Buffer Assessment, and GIS-Based Project Prioritization* (2012) in Appendix D.

B. Wetland data

The extent of wetlands in the Ararat-Pilot Mountain LWP area was determined in two ways. The ‘woody wetlands’ and ‘emergent herbaceous wetlands’ area from the satellite-imagery based 2006-2007 land use/cover GIS dataset for the High Rock Lake watershed (NCCGIA, 2008) were summed for each subwatershed. In addition, the wetland extent mapped in the National Wetlands Inventory (NWI) dataset, which was developed by analyzing aerial photographs from the 1980s, was also used [see U.S. Fish & Wildlife Service NWI website]. NWI identified ponds as well as large rivers as wetland systems; these two types of systems were not included in the wetland analysis for the Ararat-Pilot Mountain LWP area.

Due to site accessibility issues (remote locations and/or lack of landowner permission), field verification of many wetland areas was not possible. However, a team of EEP, DWQ and Surry SWCD staff were able to investigate 12 potential restoration/enhancement sites in January 2013 to identify the most promising wetland sites for the APM *Project Atlas*.

IV. RESULTS & DISCUSSION

Section IV of this report provides an analysis of conditions in the Ararat-Pilot Mountain LWP area based on all the Phase II data collected and evaluated. The *Results* subsection presents stream and wetland data, including field and GIS data collected or developed during Phase II. Major stressors, sources and problem areas (hot spots) are then summarized and discussed. A functional analysis of each subwatershed is presented as well, based on various field and GIS metrics related to habitat, hydrology and water quality. Finally, major watershed assets are described.

A. RESULTS

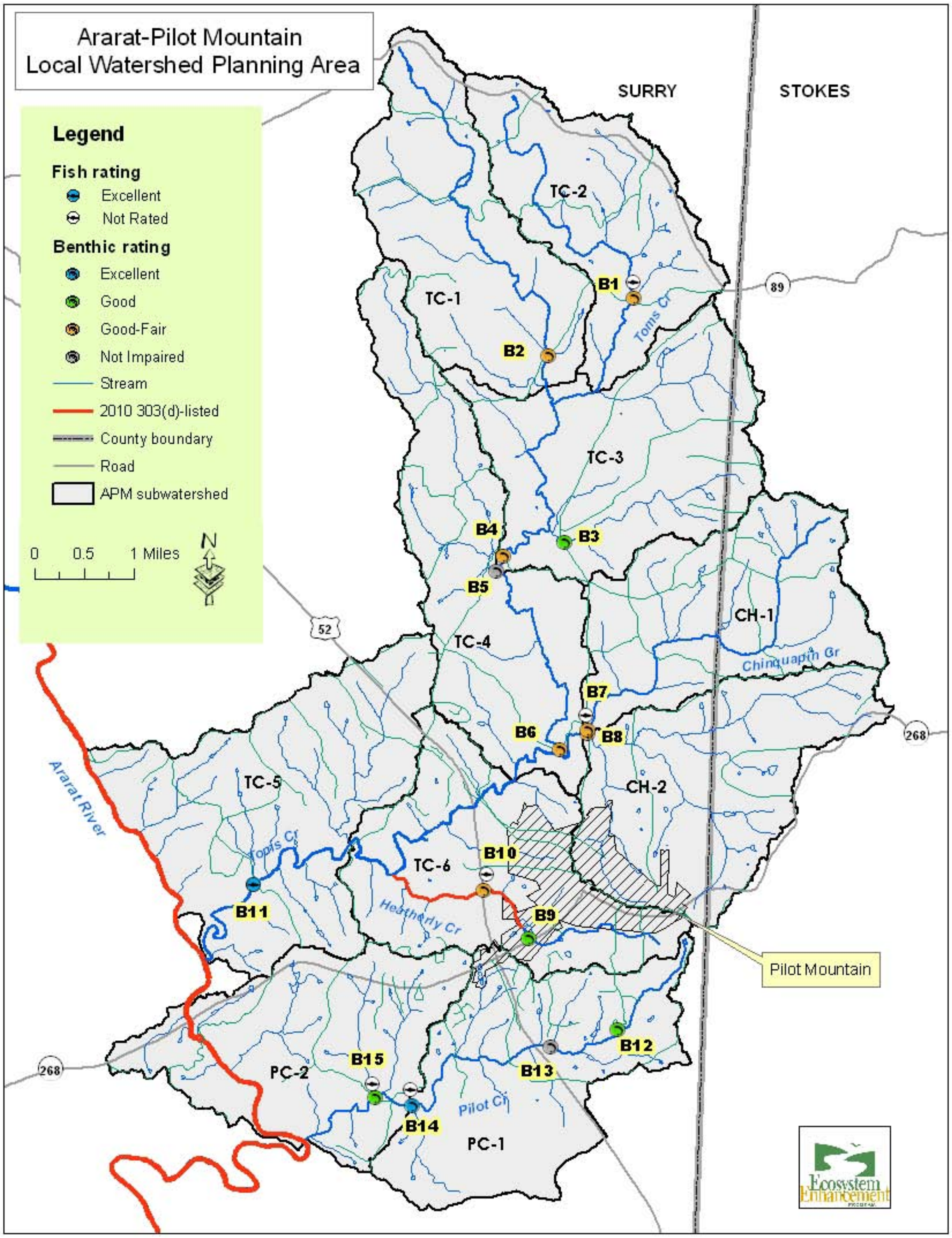
1. Stream Data

Biological data

NC Division of Water Quality (DWQ) assessed benthic macroinvertebrate communities (or benthos) at twelve sites in May-June 2011 (Tyndall, 2011; see Appendix) and re-assessed three sites in November 2011 to provide a more extensive picture of benthic community conditions in the Ararat-Pilot Mountain LWP area (see Figure 4-1 and Table 4-1). Past benthic sampling had been performed at a limited number of sites, including those sampled in 2008, which included Heatherly Creek at US 52, Chinquapin Creek at Matthews Rd, and Toms Creek at Matthews Rd.

DWQ monitors the fish community at one large site—Toms Creek at Toms Creek Rd—once every five years, including in 2011. To understand the fish community present at smaller sites in the watershed, NC Department of Transportation assessed six additional sites in the watershed in June 2011 (Medlin, 2011; for full report, see Appendix C).

Figure 4-1. 2011 benthic macroinvertebrate and fish community assessment sites in the Ararat-Pilot Mountain LWP area. [Site numbers correspond to those in Table 4-1.]



Toms Creek watershed upstream of Chinquapin Creek (subwatersheds TC-1, TC-2, TC-3, and TC-4)

Six sites in this area were sampled:

- Toms Creek at Toms Creek Church Rd (B1): *fish and benthos*
- Unnamed tributary (UT) to Toms Creek at Cleo Cain Rd (B2): *benthos*
- UT to Toms Creek at Old Westfield Rd (B3): *benthos*
- Toms Creek at Jessup Grove Church Rd (B4): *benthos*
- UT to Toms Creek off Jessup Grove Church Rd (B5): *benthos*
- Toms Creek at Matthews Rd (B6): *benthos.*

Benthic macroinvertebrates were assessed at three smaller sites in the northeast section of the watershed (B1, B2, B3) and characterized by a mix of stressor (such as pollutants or degraded habitat)-intolerant and stressor-tolerant taxa, and were rated Good or Good-Fair. Although the benthic communities at all three sites did have some sensitive (or stressor-intolerant) taxa, they also indicated nutrient enrichment. These sites had some of the lowest habitat scores in the study area. Although all sites were similar in terms of their biotic index values, the site at Old Westfield Rd (B3) had far fewer EPT taxa (16 taxa compared to 24 and 25 taxa at the other two sites). This can be partly explained by B3's smaller drainage area, which at 1.5 mi^2 is half of that of the other two sites. However, a site with a comparable size (1.6 mi^2), Pilot Creek at Stone Haven Dr (B12), had 25 EPT taxa, and the reference site at UT to Pilot Creek (B14) was even smaller (0.8 mi^2) and had 30 EPT taxa. The low EPT richness at the Old Westfield Rd site was likely influenced by the very silty conditions (20% of the bottom substrate) at the site and possible water quality impacts from an upstream low earthen dam, which was actively eroding and contributing to the turbid water at the site.
The fish community was assessed at only one of these three sites—Toms Creek at Toms Creek Church Rd (B1), which was not rated. A large number of fish were collected here, many of which were omnivores or herbivores, indicating nutrient enrichment. In addition, this site had the lowest taxa richness, perhaps a reflection of little in-stream habitat and the abundance of shifting sand at that site.

The benthic macroinvertebrate community at Toms Creek at Matthews Rd (B6) was sampled in June 2011 and received a Fair rating, which is an impaired rating. The site was characterized by low EPT richness (16) for such a large site (18.3 mi^2). Habitat was impacted by a large amount of silt and sand (85% of the bottom substrate), with very embedded riffles and silty runs and pools. Nutrient enrichment was evident in the algal growth on surfaces, as well. In September 2008, the same site was sampled, and a degraded benthic community was also present, characterized by low EPT richness (18) and a much higher biotic index, indicating an even more stressor-tolerant community. However, since 2008 was a drought year, DWQ did not rate the site, which would have been Fair.

Because the 2011 Fair rating could have led to a 303(d)-listing of Toms Creek, DWQ project staff requested a repeat sample of the benthic macroinvertebrate community at the site along with the assessment of a site on Toms Creek further upstream and a major tributary between the two Toms Creek sites. In November 2011, benthic communities at the two sites on Toms Creek (B4, B6) and the UT to Toms Creek (B5) off Jessup Grove Church Rd were sampled. In contrast to the June 2011 sample at the same site, B6 was rated Good-Fair, with 27 EPT taxa. A more extensive sampling method was used, which is considered more appropriate for large streams; this sampling method likely accounted partly for the increase in EPT taxa richness. However, the benthic community indicated continued impacts from nutrient enrichment and sedimentation.

The upstream site on Toms Creek (B4) was also rated Good-Fair, with similar biotic index and EPT richness to B6. Habitat at this site was moderate to good, with a total score of 76. However, the benthic community and habitat assessment indicated impacts from nutrient enrichment and sedimentation as at B6.

The UT to Toms Creek off Jessup Grove Church Rd (B5) was rated Not Impaired (or at least Good-Fair), with the same EPT richness and very similar biotic index to the UT to Toms Creek site on Cleo Cain Rd (B3). It had a mix of intolerant and tolerant taxa. Its habitat was also moderate to good (total score = 77), but it was impacted by excessive sedimentation.

Chinquapin Creek watershed (subwatersheds CH-1 and CH-2)

Two sites in this area were sampled:

- Chinquapin Creek at Old Westfield Rd (B7) : *fish and benthos*
- UT to Chinquapin Creek at Old Westfield Rd (B8) : *fish and benthos.*

The two Chinquapin Creek watershed sites were sampled just above their confluence. Benthic macroinvertebrate communities were both rated Good-Fair and had a similar EPT taxa richness (24 and 25), similar moderate habitat scores, and similar amounts of sand and silt (45 and 50% of bottom substrate). They were both characterized by a number of stressor-intolerant EPT taxa and some moderately tolerant taxa. The UT to Chinquapin Creek site had a lower biotic index score, indicating a generally more intolerant (or sensitive) community; this stream also had a lower specific conductance (53 umho/cm) than Chinquapin Creek (74 umho/cm), indicating that there are likely more pollutant inputs in Chinquapin Creek. Unexpectedly, the UT to Chinquapin Creek watershed is the more developed of the two watersheds, with its headwaters in the Town of Pilot Mountain.

The fish communities at these two sites were very similar, with no remarkable characteristics revealing specific stressors. Neither of these sites was rated. Two intolerant species were present at both sites—highback chub (*Hybopsis hypsinotus*) and piedmont darter (*Percina crassa*).

Heatherly Creek watershed (subwatershed TC-6)

Two sites were sampled:

- Heatherly Creek at NC 268 (B9): *benthos*
- Heatherly Creek at US 52 (B10): *fish and benthos.*

Heatherly Creek has been on the 303(d) list due to the presence of a severely impacted benthic community, first sampled in 1987. The lower site at US 52 was rated Poor in 1987 and 1994, with 0-2 EPT taxa collected. However, with the movement of the Town of Pilot Mountain's wastewater treatment plant (WWTP) to the Ararat River in 1996, the benthic community recovered markedly. It was sampled in 2001, 2004, 2006, and 2008 and showed definite improvements, with EPT taxa richness ranging from 11 to 17. However, due to a change in benthic community rating methods, these samples could not be rated.

Recently, new methods to rate benthic communities of small streams have been developed, and the 2011 benthic samples could be rated. The lower site (B10) was rated Good-Fair, characterized by one of the two highest (or most tolerant) biotic index values (5.21). It had the lowest number of EPT (14) of the study, with the more sensitive taxa being represented by few individuals; it also had a high number of *Chironomus*, or red midges, which are characteristic of low dissolved oxygen values, which could be due to low flows or organic pollution, such as sewage.

The fish community at B10 was characterized by the lowest number of individual fish at any site sampled. Low water levels and limited flow at the time of sampling may have contributed to the low number of fish at this site. This site did have the highest proportion of stressor-tolerant fish of all sites sampled, which may be due to urban runoff. This site was not rated.

The benthic community at the upper site at NC 268 (B9), with a drainage area of half the size of the lower site, was rated Good, characterized by a less impacted community, with 15 EPT and a much lower biotic index value (4.11). As at the lower site, sensitive taxa were rare in number, indicating that stream conditions are not ideal for these organisms.

Both sites drain an urban watershed, characterized by flashy stormwater flows and pollutants. The upper site had a high amount of sand and silt (70% of the bottom substrate) likely originating from eroding stream banks and unstablized upland sites. It also had very few leafpacks, a key organic habitat, which can be swept away by flashy urban stormflows. The lower site seems to have downcut to bedrock, perhaps from years of high energy stormflows.

<u>Lower Toms Creek (subwatershed TC-5)</u>

One site was sampled:

- Toms Creek at Toms Creek Rd (B11): *fish.*

The Toms Creek at Toms Creek Rd is the most downstream site in the Toms Creek watershed, draining upper Toms Creek, Chinquapin Creek, and Heatherly Creek. It is also the largest site in the watershed (drainage area 37.7 mi^2), and would naturally support higher fish richness due to its size. The fish community at this site was rated Excellent in 2011, just as it was in 2001 and 2006. This site was characterized by a high habitat score (86), with wide riparian buffers and good pools and riffles. Fish were abundant, diverse, and trophically balanced.

<u>Pilot Creek watershed (subwatersheds PC-1 and PC-2)</u>

Four sites were sampled:

- Pilot Creek at Stone Haven Dr (B12): *benthos*
- Pilot Creek at Sandtrap Ln (B13): *benthos*
- UT to Pilot Creek at Pilot Mountain State Park Rd (B14): *fish and benthos*
- Pilot Creek at Shoals Rd (B15): *fish and benthos.*

The benthic communities at two upper sites on Pilot Creek [at Stone Haven Dr (B12) and Sandtrap Ln (B13)] bracket the Pilot Knob golf course. The upper site (B12) was the smallest site sampled in the study (0.5 mi^2) but was rated Good, characterized by a relatively high EPT richness and low biotic index value, indicating a higher dominance of stressor-intolerant taxa. Habitat at the site was limited by abundant sand and silt (50% of the bottom substrate), which embedded the riffles. Edge habitat was very limited, as well, with root mats isolated above the water's surface. Despite the degraded habitat, the benthic community was still relatively rich, indicating good water quality. The site on Sandtrap Lane (B13) was rated Not Impaired (or at least Good-Fair) and had similar EPT richness to B12. However, the biotic index value increased a notable amount (from 4.05 at B12 to 5.27 at B13), indicating a change to a much more stressor-tolerant community. This biotic index value was the highest of all study sites. The benthic community indicated nutrient enrichment at the site, where a heavy covering of algae was present. In addition to water quality issues, B13 was also characterized by the poorest habitat of all study sites, as part of the reach was in a channelized section of the stream with very little shade and little in-stream habitat.

Most of Pilot Creek between Stone Haven Dr and Sandtrap Lane runs through the Pilot Knob golf course. However, there is a small portion of the stream which is bordered on one side by a crop field which was in tobacco in 2011. The reach sampled on Sandtrap Lane was bordered on one side by this tobacco field, which could also be a source of nutrients to the site.

The UT to Pilot Creek site within Pilot Mountain State Park (B14) served as a small reference site for the study. This site had the best habitat of all study sites (score of 88), with an excellent riparian buffer and good in-stream habitat. The benthic macroinvertebrate community rated Excellent, with 30 EPT taxa and the lowest biotic index score of all sites, indicating a dominance of stressor-sensitive taxa. The fish community at this site had the lowest proportion of omnivores and herbivores (13%), indicating a higher dominance of fish that specialize on particular food types other than algae. However, the fish community also had a relatively high proportion of stressor-tolerant fish at the site (13%).

The downstream site on Pilot Creek on Shoal Rd (B15) also had relatively good habitat (75 total points), characterized by a considerable amount of boulder and cobble, with a set of step-pool riffles within a mature riparian forest within the park to the west of Shoal Rd. A considerable amount of silt (10% of the bottom substrate) was present, even in the higher gradient sections of this reach. The west side of Shoal Rd runs through a farm field and is quite different in terms of habitat — minimal riparian buffer, lower gradient system with a lot of silt and sand in the pools and runs. The benthic community at this site rated Good, with the highest EPT richness of all study sites and a relatively low biotic index (3.79), indicating a more stressor-intolerant community.

The fish community at B15 was characterized by the highest number of fish species (15) and the highest number of individual fish of all study sites, including the reference site (B14). The two intolerant species also caught at the two Chinquapin Creek watershed sites—the highback chub and the piedmont darter—were present. However, this site was also characterized by the highest proportion of ominvores and herbivores (49%), which is likely a reflection of nutrient enrichment and the increased sunlight in the agricultural section of the reach, which had little shade and more algal growth.

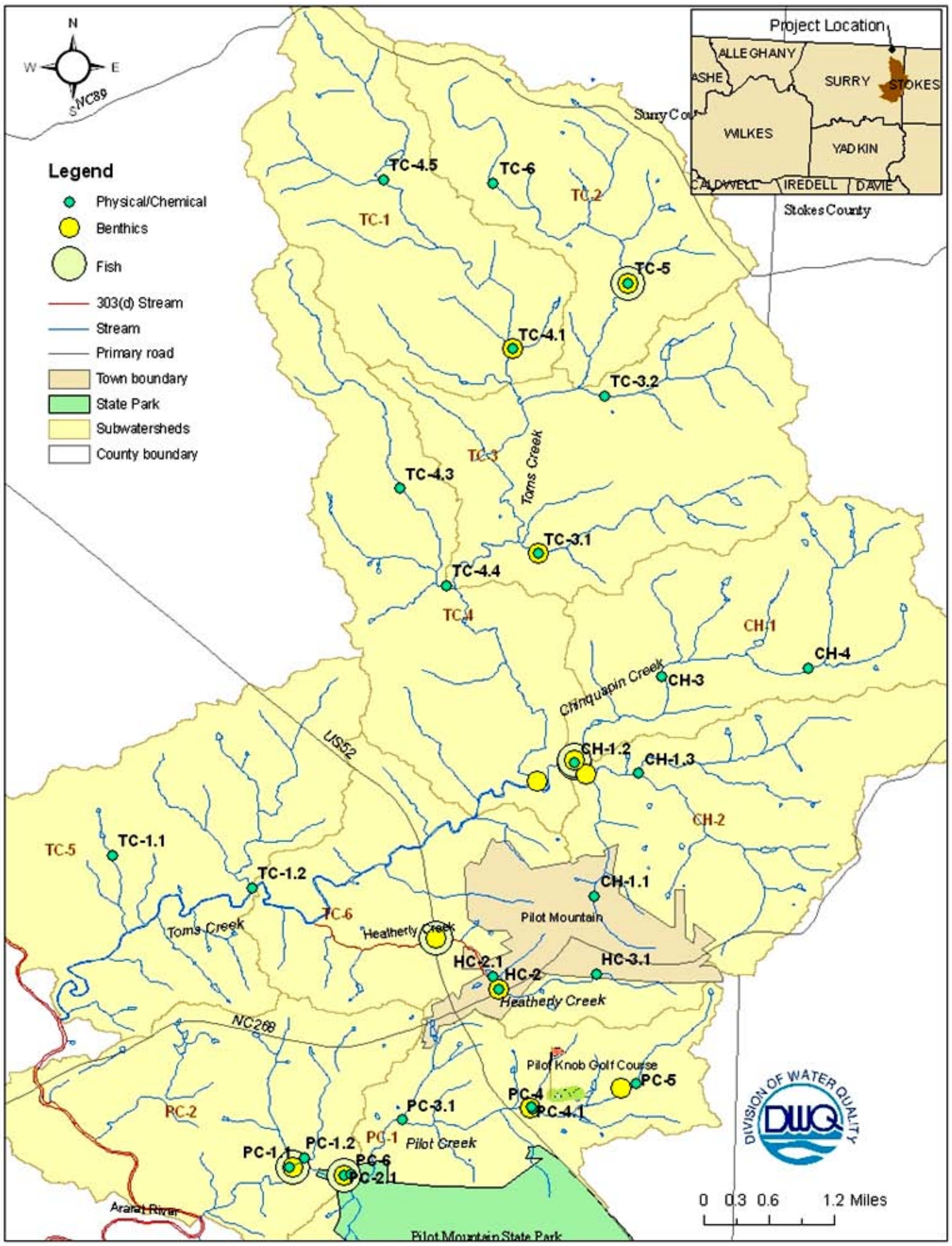
Table 4-1. 2011 benthic macroinvertebrate and fish assessment results for the Ararat-Pilot Mountain LWP study area.
*Map numbers correspond to site labels in Figure 4-1 below.

Location	Map number*	Fish bioclass	Benthic bioclass	Benthic metrics		Habitat score	% Sand+silt	Water quality & habitat stressors indicated	Site drainage area
				EPT richness	Biotic index				
Toms Creek at Toms Cr Church Rd (SR 1808)	B1	Not Rated	Good-Fair	25	4.34	46	90	nutrient enrichment, excess sediment	3.3
UT to Toms Creek at Cleo Cain Rd (SR 1811)	B2		Good-Fair	24	4.74	44	75	nutrient enrichment, excess sediment	3.6
UT to Toms Creek at Old Westfield Rd (SR 1809)	B3		Good	16	4.64	52	70	nutrient enrichment, excess sediment	1.5
Toms Creek at Jessup Grove Church Rd (SR 1812)	B4		Good-Fair	23	4.59	76	50	nutrient enrichment, excess sediment	16.0
UT to Toms Creek off Jessup Grove Church Rd (SR 1812)	B5		Not Impaired	16	4.58	77	45	excess sediment	2.5
Toms Creek at Matthews Rd (SR 1830): 6/2011	B6		Fair	16	4.41	58	85	nutrient enrichment, excess sediment	18.3
Toms Creek at Matthews Rd (SR 1830): 11/2011	B6		Good-Fair	27	4.97			nutrient enrichment, excess sediment	
Chinquapin Creek at Old Westfield Rd (SR 1809)	B7	Not Rated	Good-Fair	25	4.62	62	45		4.4
UT to Chinquapin Creek at Old Westfield Rd (SR 1809)	B8	Not Rated	Good-Fair	24	4.15	59	50		4.9
Heatherly Creek at NC 268	B9		Good	15	4.11	66	70	excess sediment, stormflow scour	0.8
Heatherly Creek at US 52	B10	Not Rated	Good-Fair	14	5.21	65	35	low dissolved oxygen, stormflow scour	1.6
Toms Creek at Tom Cr Rd (SR 2024)	B11	Excellent				86	45		37.7
Pilot Creek off Stone Haven Dr (SR 2144)	B12		Good	25	4.05	60	50		0.5
Pilot Creek at Sand Trap Lane	B13		Not Impaired	27	5.27	41	55	nutrient enrichment	1.4
UT to Pilot Creek at Pilot Mtn SP Rd	B14	Not Rated	Excellent	30	2.68	88	35		0.8
Pilot Creek at Shoal Rd (SR 2047)	B15	Not Rated	Good	33	3.79	75	35	excess sediment	6.0

Water column data

As noted in the *Methods* section above, NCDWQ staff collected water column data for the Ararat-Pilot Mountain study area in 2011 and 2012. Physical and chemical monitoring methods and results are reported in the *Water Quality Technical Memorandum for the Ararat Pilot Mountain Local Watershed Planning Area* (NCDWQ Watershed Assessment Team, 2012) in Appendix A. Figure 4-2 includes all the physical/chemical (water column) sampling locations in the LWP area.

Figure 4-2. Physical/chemical and biological sampling locations in the LWP area.



Synoptic monitoring

Synoptic monitoring refers to periodic, short-duration (e.g., one-time 'grab samples') sampling and field measurements of physical/chemical water parameters that are designed to broadly characterize water quality conditions over a relatively large area and over a relatively short time period (e.g., six months to a year, typically). These data can provide a cost-effective 'synopsis' of water quality conditions at locations across the study area that supports overall watershed assessment goals, including the identification of major stream stressors/pollutants and their possible sources.

Specific conductance – a measure of dissolved solids/pollutants in the water column (including major inorganic species such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron) – both from natural (e.g., weathered bedrock) and human sources (e.g., road runoff, fertilizers, leaking sewer/septic systems); a good field indicator of where water quality problems may exist. The reference value (collected on UT to Pilot Creek upstream of Shoals Road, flowing out of Pilot Mountain State Park) was 44 uS/cm (micro-Siemens per centimeter). The highest measured values (~100 to 240 uS/cm) occurred within subwatersheds CH-2, PC-1 and TC-6, which drain portions of the Town of Pilot Mountain and Pilot Knob Golf Course (about a mile south of town).

Nutrients – nutrient data (as dissolved nitrate + nitrite, or NOx) are useful as possible indicators of excess fertilizer use, sewer line leaks or septic tank failures, or degraded riparian buffer zones. Together with field observations of biofilm growth on stream substrates (periphyton/algae, bacteria), data on NOx concentrations provide evidence of excess nutrient inputs that may be stressing water quality and habitat in streams. The NOx reference value for LWP streams (median of 4 samples) was 0.23 mg/L. The highest median values within the LWP area (~0.5 to 1.0 mg/L) occurred in subwatersheds TC-6 (Heatherly Creek and tributary), CH-2 (UT to Chinquapin Creek) and the Pilot Creek subwatersheds (PC-1 and -2). In Pilot subwatershed PC-1, a tributary draining the golf course and tobacco fields yielded samples with NOx values among the highest measured. The lowest value (< 0.1 mg/L) was from a mostly forested catchment of a tributary to upper Toms Creek (subwatershed TC-3).

Fecal coliform bacteria – these bacteria are used as potential indicators of pathogenic organisms found in human and animal waste, indicating possible upstream sources such as leaking sewer lines, sewer overflows, failing septic tanks and livestock/cattle in streams. Measured values were highly variable across the LWP area, and even at individual sites across sampling events, ranging from less than 100 colony-forming units (CFUs) per 100 ml to over 1,000 CFUs per 100 ml. Only subwatershed CH-1 (Chinquapin Creek) had all values at or below about 100 CFU/100 ml. The highest geometric mean values generally occurred in samples from subwatershed CH-2 (UTs to Chinquapin Creek) and subwatershed TC-6 (Heatherly Creek and tributaries), in streams draining the urban core of the Town of Pilot Mountain.

Hot spot monitoring/investigations

Follow-up investigation of stressors (and possible sources) by staff of DWQ-WAT included walking/assessing nearly six miles of stream channel in subwatersheds with potential water quality issues and 'hot spots', as determined from the synoptic physical-chemical sampling discussed above. The follow-up work included observations and photos for all sites, and sampling and field measurements for nutrients, fecal coliform and specific conductance at selected new locations. Results are summarized below for selected catchments (drainage areas within subwatersheds). Figures 4-3(a) to 4-3(d) illustrate the fecal coliform, nutrient/specific conductance and sediment/erosion hot spot locations identified by DWQ-WAT.

***Heatherly Creek** investigations*
(subwatershed TC-6) –

UT to Heatherly Creek near WWTP (HC-2.1): Elevated fecal coliform counts suggest that there may be a sewer line leak or previous sewer overflows near location HC-A. Stream channel scour and bank erosion downstream of a perched stormwater culvert draining a detention pond at a housing development on S. Boyles Street (upstream of location HC-B) represent another urban hot spot on this UT to Heatherly Creek.

UT to Heatherly Creek near S. Davis Street: NOx higher than any other site in the LWP area and elevated specific conductance at tributary location HC-3.1; elevated specific conductance and algal/bacterial biofilm in headwaters of UT at site HC-3.1.1. Possible sources include urban/residential runoff and lift station for a septic system (upstream of W. Pine Street). A small tributary (ephemeral) channel with a large head cut and channel erosion/scouring was noted near the rail line that crosses the HC-3.1 tributary.

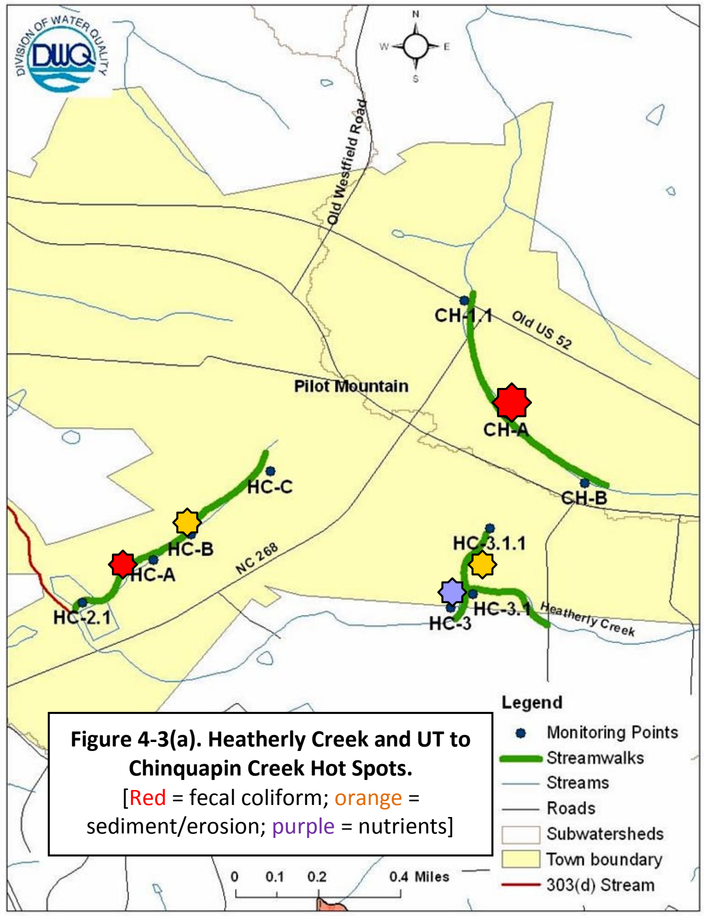


Figure 4-3(a). Heatherly Creek and UT to Chinquapin Creek Hot Spots.
[Red = fecal coliform; orange = sediment/erosion; purple = nutrients]

***Chinquapin Creek** investigations* (subwatershed CH-2) –
UT to Chinquapin at Old U.S. 52 (CH-1.1): Elevated fecal coliform levels at locations CH-1.1 and CH-A suggest possible sewer line leak(s) along this stream reach (see photo below).

UTs to Chinquapin at SR 1837-Carson Road (CH-1.3 and 1.4):
No elevated fecal coliform counts were detected in samples from these two locations, which were investigated due to previously high fecal coliform data downstream (UT to Chinquapin Creek; site CH-1.2).

Chinquapin Creek at SR 1830-Matthews Road (CH-1): Extreme channel incision, high unstable stream banks and in-stream sedimentation (see photo at right).

Chinquapin Creek at SR 1835-Presbyterian Church Road (CH-3): Follow-up monitoring for fecal coliform, specific conductance and NOx indicated no significant water quality impacts.

***Toms Creek** investigations* (subwatershed TC-4) –
Toms Creek at SR 1830-Matthews Road (site TC-2):
Several segments of extreme bank erosion and in-stream sedimentation were noted at site TC-2 (see photo below) and at discontinuous locations upstream on Toms Creek, plus some areas of nutrient enrichment (algae/periphyton on stream substrate), despite generally excellent buffer conditions.

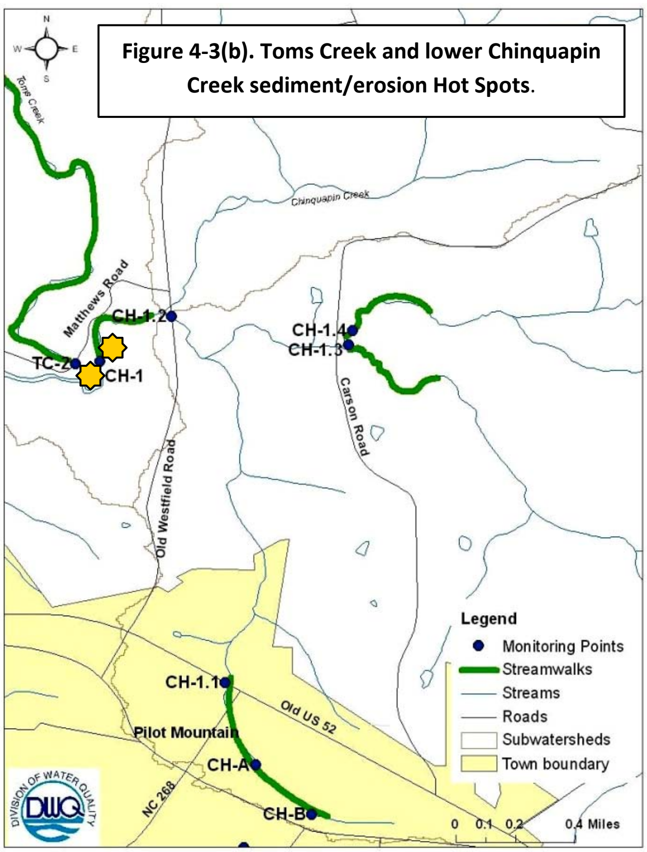


Figure 4-3(b). Toms Creek and lower Chinquapin Creek sediment/erosion Hot Spots.

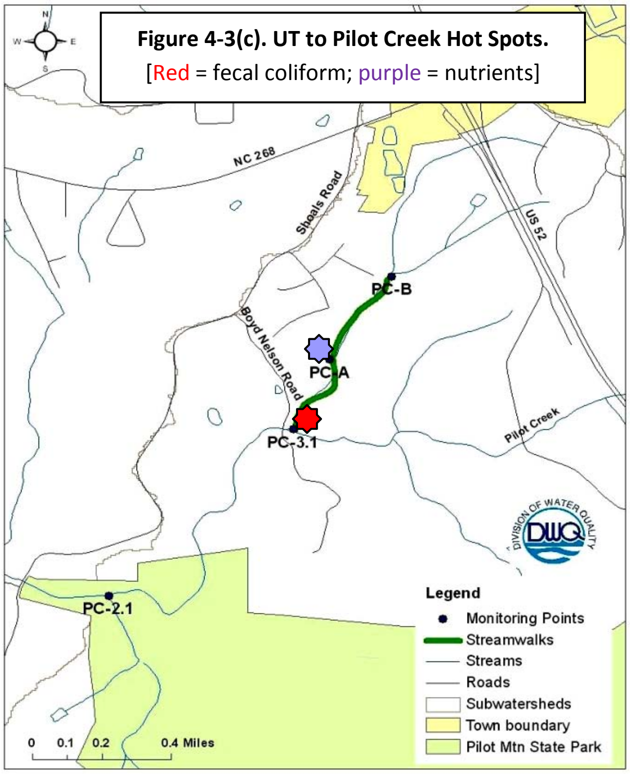


Figure 4-3(c). UT to Pilot Creek Hot Spots.
[Red = fecal coliform; purple = nutrients]

***Pilot Creek** investigations* (subwatershed PC-1) – UT to Pilot at SR 2954-Boyd Nelson Road (site PC-3.1 and upstream): Elevated specific conductance values were measured at all three locations on this tributary to Pilot Creek, and were especially high at PC-A, downstream of a suburban residential neighborhood. Nutrients (as NOx) were not re-sampled here. The source(s) of the elevated specific conductance are unknown, but may include septic tank failures. Deer and other wildlife may have contributed to high fecal coliform counts detected at site PC-3.1 earlier in the summer of 2011.

Pilot Creek mainstem and UT to Pilot Creek at Pilot Knob Park (golf course): Monitoring for nutrients (NOx) was conducted at main stem locations upstream and downstream of the Pilot Knob Golf Course, and on a tributary to Pilot Creek at Sandtrap Lane, to determine if the golf course was a significant source of nutrient inputs to Pilot Creek. Results suggest that the golf course is not a major source of nutrients to the main stem of Pilot Creek. However, the PC-4.1 tributary site did exhibit elevated NOx levels and fecal coliform counts; potential sources include adjacent tobacco fields, residential lawns and septic tank systems, and a portion of the golf course.

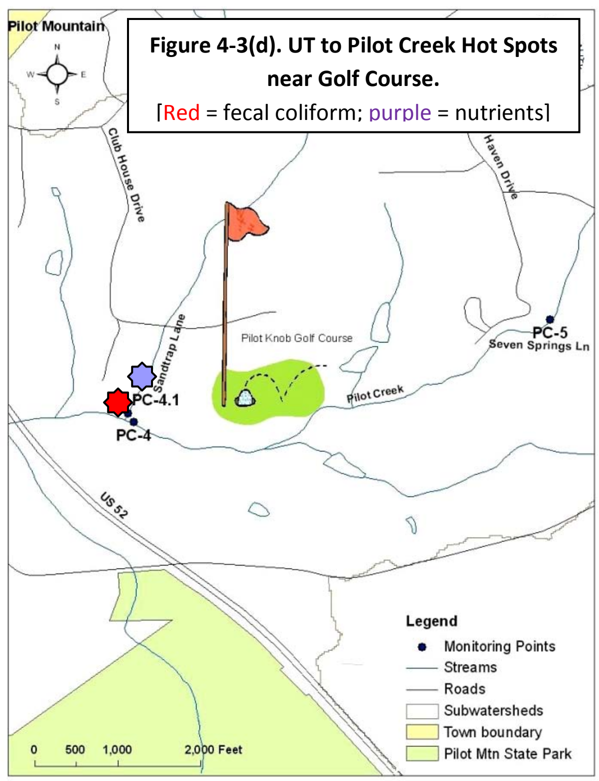


Figure 4-3(d). UT to Pilot Creek Hot Spots near Golf Course.
[Red = fecal coliform; purple = nutrients]

Results of the follow-up investigations described above confirm that hot spots of water quality pollution (fecal coliform and nutrients) occur within the LWP area, most notably within the urban catchments of Pilot Mountain (Heatherly Creek and tributaries, UT to Chinquapin) in subwatersheds TC-6 and CH-2; but also on at least two tributaries to Pilot Creek, in the rural residential landscape just south of Town. The hot spots appear to be generally limited in extent/area, amounting to stream reaches of approximately 500 feet to 2,000 feet. However, pinpointing specific sources of fecal coliform and nutrients (and elevated specific conductance, in general) has not been possible in this study and needs further investigation. There is a recurring group of *potential* sources within the investigated catchments, including leaking sewer lines, overflowing sewer manholes, failing septic systems, tobacco fields, a golf course, residential lawns, and even wildlife. Water quality impacts from nutrient and fecal coliform are exacerbated by other stream stressors that occur discontinuously across the landscape of certain subwatersheds, most notably: degraded riparian buffers, livestock access, unstable stream banks, incised stream channels and sediment loading from upland disturbances (land clearing, logging, agriculture, new construction).

Habitat and channel data

Habitat was assessed by DWQ and/or EEP staff at 14 fish and benthic macroinvertebrate sites and an additional 11 sites using DWQ's standard habitat assessment protocol for mountain and piedmont streams (NCDWQ, 2011a). The mean habitat score was 67 out of a maximum of 100 (Table 4-2). Conditions at individual sites varied considerably, with the best habitat at the UT to Pilot Creek reference site in Pilot Mountain State Park, UT to Pilot Creek at SR 2954, and lower Toms Creek at Toms Creek Rd, with total scores of 88, 88, and 86. Pilot Creek at Sand Trap Lane had the lowest habitat score, with a total score of 41 [Table 4-1; see also Tables 3, 5, 8, and 11 in DWQ-WAT's *Technical Memorandum* (2012) in Appendix A].

Table 4-2. Mean scores for habitat metrics across the Ararat-Pilot Mountain study area.

Habitat score	Mean score	Maximum possible score
Channel modification	4.0	5
In-stream habitat	13.4	20
Bottom substrate	8.2	15
Pool variety	7.3	10
Riffle habitats	9.7	16
Bank stability/vegetation	9.6	14
Light penetration	8.3	10
Riparian zone width	6.5	10
Total Habitat	66.9	100

The habitat submetrics that were the most limiting when all sites are considered are in-stream habitat, bottom substrate, riffle habitats, bank stability and vegetation, and riparian zone width. In-stream habitat, bottom substrate and riffle habitats were all impacted by fine sediment deposition. Sand and silt embedded riffles and were often a large proportion of the substrate. Low scores for bank stability and vegetation and riparian zone width were reflections of narrow forested riparian zones and bank erosion. Bank erosion itself was often linked to a very narrow and/or young forested riparian buffer. The lack of a mature forested riparian buffer also influenced in-stream habitat—leafpacks, undercut banks and root mats, and large woody debris are all dependent on a riparian forest.

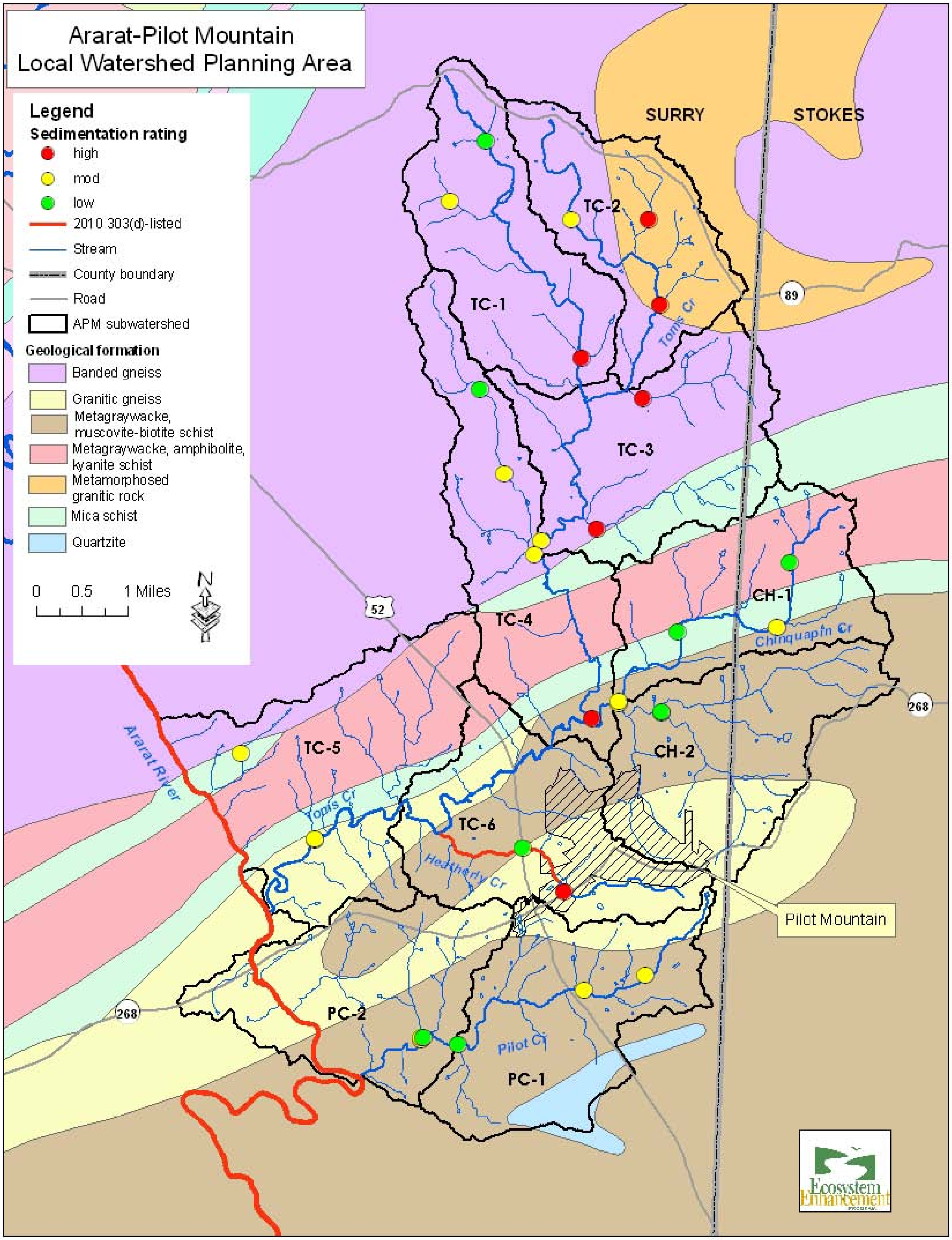
The extent of fine sedimentation across the study area was further examined by evaluating the dominance of sand + silt at 32 sites across the watershed. A sedimentation rating was given to each site as follows:

- 0-35% sand + silt: low
- 36-60% sand + silt: moderate
- 61-100% sand + silt: high.

Sand + silt ranged from 20% to 90% of the total bottom substrate across the study area, with a mean value of 51%. Most sites with a high sedimentation rating were in the northeastern portion of the study area (Figure 4-4). These sites are likely influenced by local geology. Highly erodible metamorphosed granitic rock is present in that portion of the watershed, which can serve as a source of sand in those streams (B. Cattenach, NC Geological Survey, personal communication, 2011). In addition, past land uses have likely influenced the bed load of fine sediments found in study area streams. Until about ten years ago, tobacco was grown in a considerable portion of the study area, including the northeastern portion. Tobacco farming practices often involved planting rows perpendicular to the stream's edge so that fields drained directly into the stream. This practice likely served as a considerable source of sediment (T. Davis and T. Smith, Surry and Stokes County SWCD, personal communication, 2011). Eroding stream banks were found at locations throughout the study area and serve as an additional source of sediment.

Heatherly Creek at NC 268, within the Town of Pilot Mountain, also had a high sedimentation rating. This site receives much of the town's stormwater and indications of flashy stormflows were present throughout the stream; stream banks were often high and eroding, and leafpack habitat was rare. On stream surveys, DWQ staff found at least one commercial site with a stormwater drainage ditch that was severely eroding, serving as a source of sediment to the stream.

Figure 4-4. Sedimentation ratings and geological formations in the Ararat-Pilot Mountain study area.



GIS data: riparian buffers

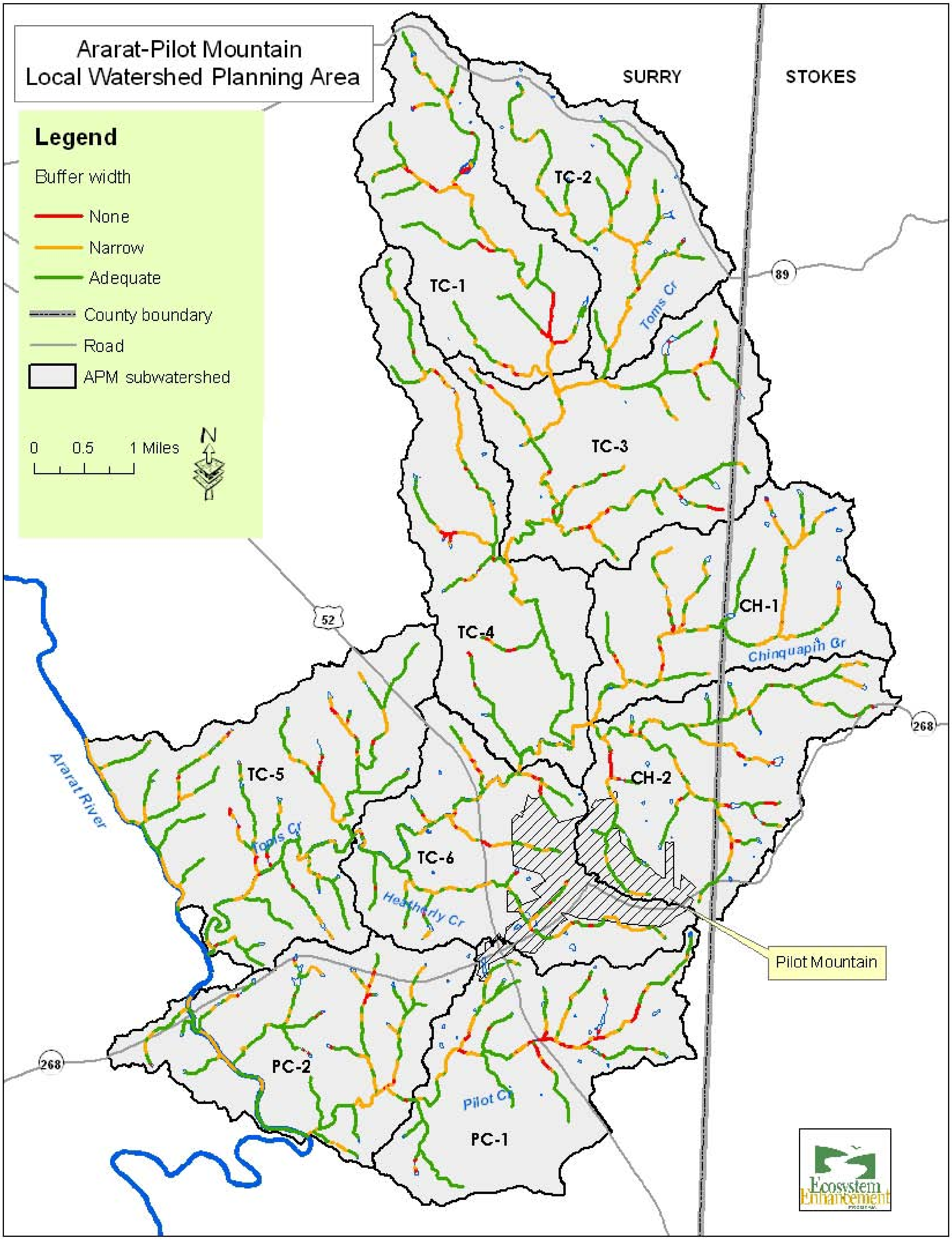
Riparian conditions in the Ararat-Pilot Mountain study area vary by subwatershed (Table 4-3, Figure 4-5). Overall, 63% of streams in the LWP area have adequate forested buffer (>30 ft on both sides of the stream), and a majority of these have buffers of >100 ft on both sides. Buffers were most intact in the western portion of the watershed, with subwatersheds TC-4 and TC-5 having the highest proportions (69% and 70%, respectively) of adequately buffered streams. The subwatershed with the worst buffer condition is CH-1, where only 50% of the streams are adequately buffered. Subwatersheds with the most stream lacking buffer were TC-1 and P-1, where 13% and 14% of the streams have no forested buffer. Unbuffered streams were primarily associated with farmland in TC-1, where as in PC-1 much of the unbuffered stream length was in the Pilot Knob golf course.

Table 4-3. Riparian condition in Ararat-Pilot Mountain LWP area subwatersheds.*

Subwatershed	% stream length with **no buffer**	% of stream length with **narrow** buffer	% of stream length with **inadequate** buffer	% of stream length with **adequate buffer (>30 ft)**	% of stream length with **wide buffer (>100 ft)**
TC-1	**13%**	28%	**41%**	59%	49%
TC-2	1%	34%	34%	**66%**	**50%**
TC-3	6%	37%	**43%**	57%	46%
TC-4	5%	26%	31%	**69%**	**57%**
CH-1	4%	46%	**50%**	50%	38%
CH-2	7%	29%	36%	64%	41%
TC-6	5%	35%	40%	60%	41%
TC-5	3%	27%	30%	**70%**	**57%**
PC-1	**14%**	22%	36%	64%	**55%**
PC-2	3%	31%	34%	**66%**	**52%**
Total	6%	31%	37%	63%	49%

*"Narrow"= does not have adequate buffer (i.e., is <30 ft.) on both sides, but has >0 ft on at least one side. "Inadequate"= any stream without >30 ft buffer on both sides (is the sum of % streams with narrow buffer and no buffer). "Adequate" = both sides have a woody buffer of >30 ft. Includes wide buffer. "Wide" = both sides have a woody buffer of >100 ft. Is a subset of adequate buffer.

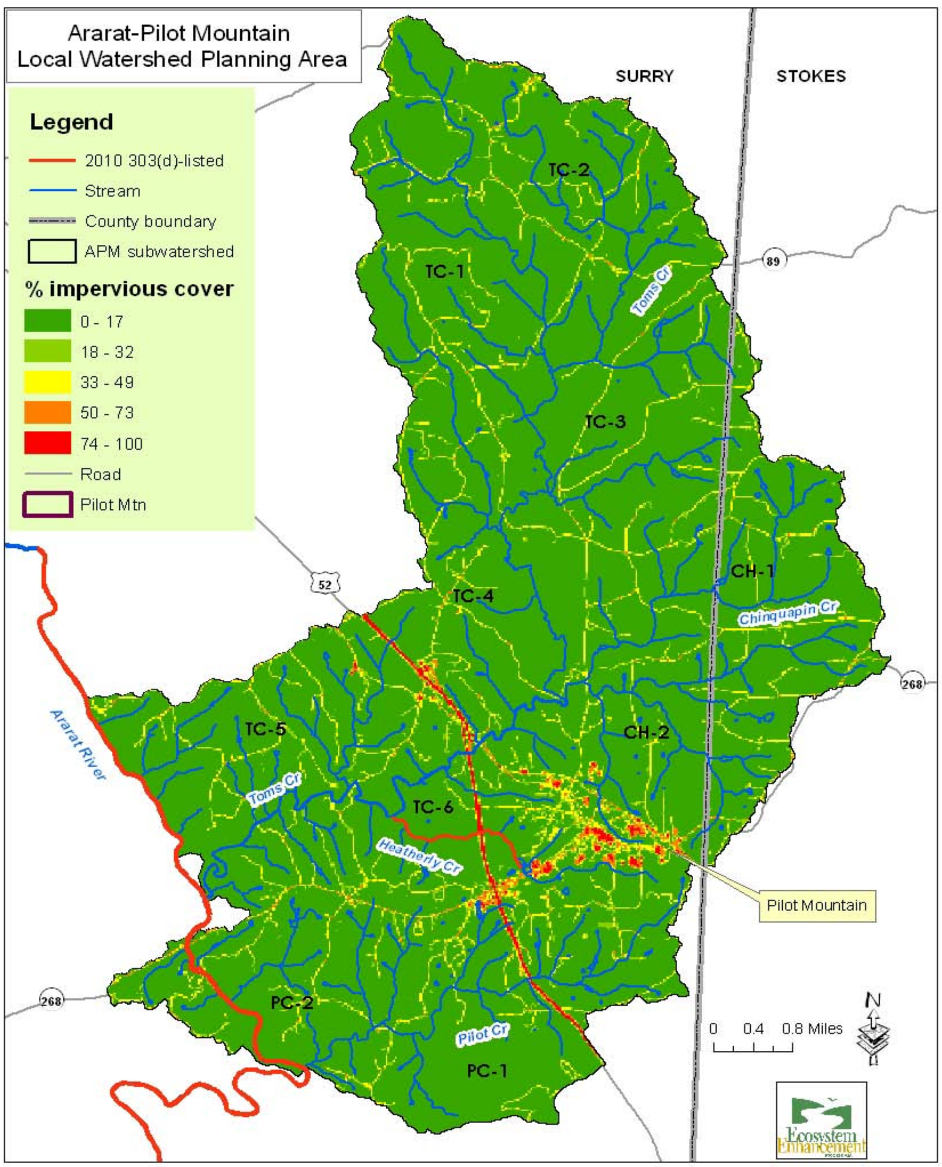
Figure 4-5. Riparian buffer condition in the Ararat-Pilot Mountain study area.



GIS data: impervious cover

Land cover and impervious cover for the Ararat Pilot Mountain LWP study area were summarized from datasets developed by the NC Center for Geographic Information and Analysis for High Rock Lake watershed (NCCGIA, 2008). These datasets were developed from three satellite images taken 2006-2007. Table 2.1 (in the *Land Use/Land Cover* sub-section) presents impervious cover data for each of the 10 subwatersheds, and Figure 4-6 below depicts ranges of impervious cover across the LWP area. Subwatershed impervious covers range from 2.2 to 2.7 percent in upper to middle Toms Creek (TC-1 through TC-4) and Chinquapin Creek (CH-1), to a high of 9.0 percent in subwatershed TC-6, which includes most of the Town of Pilot Mountain and all of the Heatherly Creek drainage. Significant areas of impervious cover are also found in subwatershed CH-2 (UTs to Chinquapin Creek), at 4.9 percent overall, and PC-1 (upper Pilot Creek and tributaries), at 4.6 percent. Proximity to the urban core of Pilot Mountain and the U.S. Highway 52 corridor are the major determinants of impervious cover concentrations in the LWP area.

Figure 4-6. Impervious cover in the Ararat-Pilot Mountain LWP area, 2006-2007 (NC CGIA, 2008).



2. Wetland Data

There are few intact (non-impacted) wetlands in the Ararat-Pilot Mountain LWP area. The National Wetlands Inventory dataset, which was developed by analyzing aerial photographs from the 1980s, identified approximately 20 acres of wetlands in the study area. The NWI methodology is based on the Cowardin classification system (Cowardin et al, 1979) and uses high-altitude aerial photography to identify potential wetland areas. Being based on relatively old photography, the NWI methodology likely over-estimates the number and areal extent of current wetland areas within the LWP area. The High Rock Lake land use/cover GIS dataset from 2006-2007 satellite imagery identified approximately 15 acres of wetlands in the watershed. About half of those areas identified by the more recent land use/cover dataset were also identified by the National Wetlands Inventory. When both wetland datasets are added and adjustments made to ensure no double-counting, a total of approximately 27 acres were identified by the two methods. Almost half of these wetland acres are in one subwatershed—TC-4, along Toms Creek (Table 4-4, Figure 4-7).

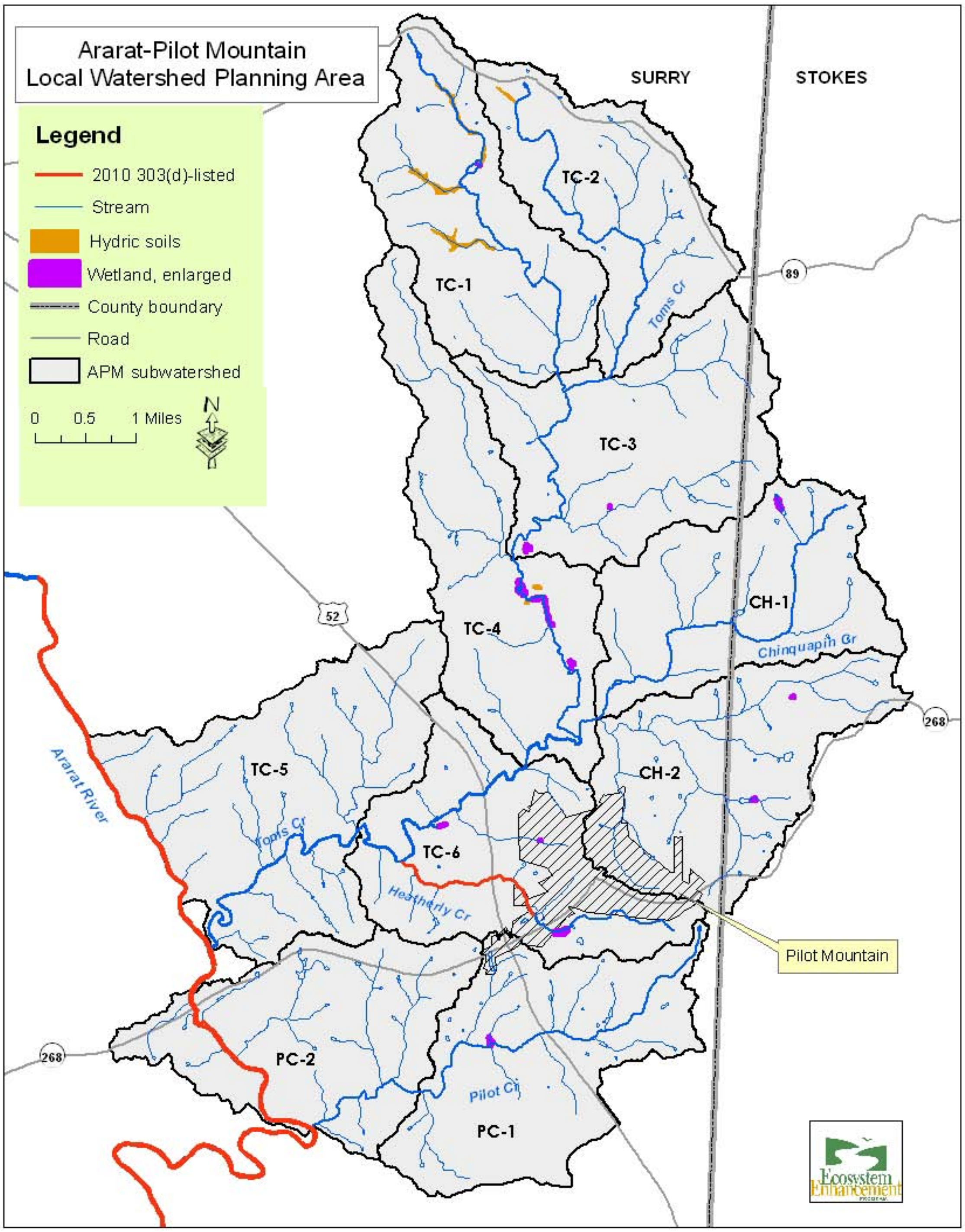
Table 4-4. Wetlands identified by the National Wetlands Inventory and the High Rock Lake land use/cover datasets in the Ararat-Pilot Mountain study area.

Subwatershed	NWI wetlands (ac)	Land use/cover wetlands (ac)	Total wetland area (ac)*
TC-1	0.7	-	0.7
TC-3	1.8	1.9	2.6
TC-4	9.7	5.0	11.8
CH-1	1.9	1.9	2.5
CH-2	0.6	0.9	1.3
TC-6	4.1	3.9	6.2
PC-1	1.4	1.0	1.8
Total	20.3	14.7	26.9

*Total wetland area was calculated by adding both the NWI and land use/cover wetland acreage and subtracting the area that was double-counted.

Hydric soils (soils formed under conditions of saturation, flooding or ponding of sufficient duration to develop anaerobic conditions in their upper part during the growing season) can indicate where wetlands are or may have been at one time. Using digitized soil survey mapping units compiled as a GIS dataset, hydric soils for Surry and Stokes Counties were identified , and those soils with a high likelihood of being hydric [Bandana-Tate-Nikawsi complex (BaC) and Hatboro loam (HaA)] were mapped and compared to wetlands identified by the NWI and the land use/cover dataset (Figure 4-6). These hydric soils were present in only a few locations--on northern tributaries in TC-1 and TC-2 (which were not identified as wetlands), and near the wetlands identified along Toms Creek in TC-4. These soils represent what are likely to be the wettest mapped soil units within the LWP area, but are simply one possible indicator of current (or past) wetland areas on the landscape.

Figure 4-7. Wetlands identified by the National Wetlands Inventory and the High Rock Lake land use/cover dataset in the Ararat-Pilot Mountain study area. Wetland areas have been enlarged for better viewing.



In addition to the GIS-based identification of potential wetland areas by EEP, Wildlands Engineering also conducted an exercise to identify the largest (greater than two acres) potential wetland restoration/enhancement sites across the LWP area – those wetland sites most likely to have cleared or altered vegetation and/or to have been drained or otherwise hydrologically altered. This was accomplished using the digitized soils data layer (SSURGO) to identify A-rated hydric soils (those most likely to be hydric based on field indicators), and 2010 aerial photography to identify areas of mapped hydric soils that had little or no forest cover or were mainly in crops or pasture, and had evidence of drainage ditches or channelized streams. Twenty such sites were identified as potential wetland restoration or enhancement sites for the LWP Project Atlas (to be finalized by summer, 2013; see Wildlands Engineering, 2012). Eight of these high-priority wetland areas, totaling approximately 37 acres, were field-investigated in January 2013 to assess their feasibility as potential wetland mitigation sites. Most of the wetland sites investigated in the field, despite being located in floodplains, had soils with bright colors (Munsell chroma) in the upper 12 inches or so, and only occasional hydric indicators (e.g., redoximorphic features), a common problem in trying to identify true wetland soils in the Piedmont and Blue Ridge physiographic provinces of the state, where channel incision/deepening and drainage ditches have dried out many former wetland areas. However, they all had wetlands vegetation (e.g., *Juncus* spp.) and were all probably intact riparian wetlands in the recent past.

In terms of the specific type of wetlands represented by these sites, most of them (being in the geomorphic floodplains of second-order and larger streams) would likely key out as Bottomland Hardwood Forest wetlands within the NC Wetland Assessment Method (NC WAM; see NC Wetland Functional Assessment Team, 2010). The vast majority of wetland areas identified by the EEP and Wildlands GIS exercises are likely to be bottomland hardwood forests impacted (to varying degrees) by vegetation removal, logging or agriculture. Other possible NC WAM wetland types in the LWP area include Seeps (hillside or toe-of-slope, just outside riparian zones) and Headwater Forests. This is consistent with field observations made during watershed reconnaissance and stream walking by EEP and DWQ staff in 2011 and 2012. Many of these wetland areas are not readily accessible and/or did not have landowner permissions for site access granted during the Phase II time period, so field verification of hydric soils, wetland type, degree of impact and feasibility of restoration/enhancement was not possible at many of the tentatively identified wetland sites.

B. STRESSORS and SOURCES

Stressors are biological, physical or chemical agents and/or processes that negatively affect (impact) water quality, habitat or hydrologic functions in the local watershed. Broadly speaking, stressors include physical/chemical pollutants that impair water quality, sources of biological/habitat degradation and causes of physical alteration of natural hydrologic or geomorphologic processes or systems. Sources (root causes or source areas/points where stressors originate) are sometimes difficult to distinguish from specific stressors, as many stressors are the product of interrelated processes on the landscape and in the stream system. A physical/chemical water quality stressor (e.g., pollutants like sediment, nutrients) may also stress (impact) habitat and biological functions; and a hydrologic stressor (e.g., increased storm runoff and channel discharge due to high impervious cover in a subwatershed) may directly impact both water quality and habitat functions (increased channel scour and stream bank instability, causing sediment loading in the water column, as well as degraded/embedded riffle habitat). Mature riparian buffers can mitigate/reduce certain water quality stressors through the buffer's streamside sediment filtering (and nutrient transformation) function; conversely, degraded buffers (and livestock within them) can act as a direct stressor of water quality and habitat functions.

Identifying specific point sources of certain watershed stressors is difficult to achieve -- in part because of limited resources for conducting detailed/intensive watershed studies (e.g., every mile of every stream in the LWP area's ~50-square mile drainage network cannot be walked and assessed), but also because some sources (e.g., specific sections of leaking sewer pipeline) are not readily apparent during stream/buffer investigations, and would require additional testing to pin-point. A major source (cause) of multiple watershed stressors is human activities leading to altered land use/land cover; most notably, agriculture (crops, pasture, livestock, logging) and urban/suburban development (increased impervious cover).

Primary stressors are those stressors that create the most significant and widespread impact on one or more watershed functions, based on all the available evidence (monitoring data, field observations, GIS analyses, etc.). These are the stressors that have the potential to impact water quality and habitat within streams and riparian buffers across entire subwatersheds (delineated areas of ~ 5 square miles within the LWP). *Secondary stressors* are those that are measured at high levels at certain locations in the watershed, but which don't appear to be causing as widespread or significant an impact (in terms of area impacted or number of streams affected). Secondary stressors have the potential to create relatively isolated problem areas (hot spots) within certain subwatersheds (or smaller catchments, of ~ 1 square mile area maximum, within subwatersheds).

A summary of major watershed stressors -- including their sources, their impacts, and where they've been observed/measured within the LWP area -- is presented below:

Primary stressors

- **Excess sediment**

Sources: unstable/incising stream channels and eroding stream banks; past land use (e.g., legacy sediment from tobacco farming) and lack of agricultural BMPs; cattle/livestock in streams and buffer zones; erodible soils/bedrock; land clearing in upland areas/sites; lack of soil/erosion control BMPs during new construction; logging on private lands.
Impacts/effects: aquatic habitat degradation (riffle embeddedness; filling of pools); water quality impacts/impairment (excessive turbidity; attached pollutants); increased cost of drinking water treatment.

Major locations/subwatersheds:
Stream impacts (or high potential for impacts) from sediment inputs based on habitat sub-metrics (riffle embeddedness, bottom substrate, bank instability), fine sedimentation (high % sand-silt), highly erodible soils and mapped bedrock units, and other direct observations of high sediment loading or channel incision in streams (e.g., stormflow scour) were documented in subwatersheds TC-1 through TC-4 (upper to middle Toms Creek) and a portion of subwatershed TC-6 (middle to upper Heatherly Creek). Recent land clearing from logging activity has been noted throughout many portions of the upper and middle Toms Creek subwatersheds, as well as subwatershed CH-2 (tributaries to Chinquapin Creek). Localized hot spots of sediment inputs from channel scour, unstable stream banks and old dams were also noted on tributaries to upper Heatherly Creek in Pilot Mountain (subwatershed TC-6), a tributary to middle Toms Creek (earthen dam upstream of Old Westfield Rd.; subwatershed TC-3), on lower Chinquapin Creek at SR 1830-Matthews Road (subwatershed CH-1) and on Pilot Creek near the Pilot Mountain State Park boundary (old cinder block dam; subwatershed PC-1).

- **Lack of riparian buffer**

Sources: rural logging/clearing (farms, rural residential); livestock damage; urban/suburban clearing and mowing (lawns, recreational areas/parks, commercial businesses, industrial parks); land clearing for new development (commercial and residential).
Impacts/effects: degraded habitat (terrestrial and aquatic), streambank instability, increased temperatures, decreased dissolved oxygen in water column; lack of detrital inputs and woody debris; lack of pollutant filtering/removal from runoff; visual/esthetic impacts.
Subwatersheds: the two subwatersheds with the highest percentage of stream length with no woody/forested buffer are TC-1 (upper Toms Creek) and PC-1 (upper to middle Pilot Creek), at 13% and 14%, respectively. [Interestingly, upper Pilot Creek (PC-1) also has one of the highest percentages of stream length with wide buffers on both sides (55%).] Subwatersheds with the highest overall extent of inadequate buffer (less than 30 feet on both sides) are CH-1 (50%), TC-3 (43%), TC-1 (41%) and TC-6 (40%). Subwatersheds with high percentages of poor/minimal buffer widths do not necessarily correlate with high agricultural land use (pasture and cropland) across the subwatershed scale; although some individual farms were observed to have inadequate stream buffers. Heatherly Creek through certain urban reaches of Pilot Mountain does suffer from poor buffer width and quality, but also has some stretches of wide, healthy riparian buffers. Based on field observations made in January 2013, recent logging along stream buffers is particularly intensive within subwatershed CH-2.

- **Stormwater runoff**

Sources: impervious cover (roads, parking lots, sidewalks, rooftops); stormwater piping; stream channelization; streambank hardening.
Impacts/effects: channel scour, urban/suburban and agricultural pollutant loading to streams, flooding, water quality impairment, aquatic habitat degradation; note: these impacts are exacerbated by lack of adequate stormwater management and BMPs.
Major locations/subwatersheds: GIS datasets and field observations indicate subwatershed TC-6 (the upper Heatherly Creek urban catchment in particular) as having the highest concentration of impervious cover (9.0 percent) within the LWP area, followed by subwatersheds CH-2 (4.9%) and PC-1 (4.6%). Subwatershed CH-2 includes UTs to Chinquapin Creek immediately north of the Town of Pilot Mountain, while the PC-1 drainage area includes upper Pilot Creek and unnamed tributaries immediately south of Town. Stormwater piping and related infrastructure is most heavily concentrated within urban and suburban portions of the Town, and some 'hot spots' of channel scour and habitat degradation associated with stormwater runoff have been noted especially within the upper to middle Heatherly Creek stream reaches (see photo at right). NC DOT-maintained roadways -- especially U.S. Highway 52, which runs from southeast to northwest across the heart of subwatersheds PC-1 and TC-6 – are another source of significant stormwater runoff that may locally impact Pilot Creek, Heatherly Creek and mainstem Toms Creek (below the Town's drinking water intake).


Location HC-2.1: tributary to middle Heatherly Creek near NC-268 in Town of Pilot Mountain.

Secondary stressors

- **Nutrients**

Sources: agricultural and residential fertilizer usage; livestock in stream; failing septic systems, leaking sewer lines, faulty pump stations.
Impacts/effects: nutrient enrichment, algal blooms, eutrophication; aquatic habitat impacts; increased cost of drinking water treatment; esthetic (visual/odor/taste) impacts.
Major subwatersheds/locations: Some areas of nutrient enrichment in streams were noted at benthic sampling locations within upper to middle Toms Creek (subwatersheds TC-1 through TC-4), which is not surprising for areas with 25 to 35% agricultural land use/cover. However, nitrogen/nutrient (NOx) levels were not especially high in samples collected from these Toms Creek subwatersheds. The highest nutrient (NOx) concentrations were detected in water samples collected in subwatersheds TC-6 (Heatherly Creek and tributaries), CH-2 (UTs to Chinquapin Creek) and PC-1 and -2 (Pilot Creek). In subwatershed PC-1, a tributary stream draining a portion of the golf course, tobacco fields and suburban lawns yielded samples with especially high nutrient values (location PC-4.1 near Sandtrap Lane). A tributary to upper Heatherly Creek in Pilot Mountain (location HC-3.1 near South Davis Street) had the highest NOx concentrations within the LWP area; possible sources include urban/residential runoff, failing septic systems and leaking sewer lines.

- **Fecal coliform bacteria**

Sources: livestock in stream; failing septic systems; faulty/aging sewer infrastructure (leaking sewer lines; pump stations; manhole overflows).
Impacts/effects: possible hazard to human health; increased cost of water treatment; esthetic (visual/odor) impacts.
Major subwatersheds/locations: The highest geometric mean values occurred in samples from subwatersheds CH-2 (UTs to Chinquapin Creek) and TC-6 (Heatherly Creek) in tributaries draining the urban core of the Town of Pilot Mountain. Follow-up monitoring revealed fecal coliform hot spots at locations HC-A (UT to Heatherly Creek near NC 268) and CH-A (UT to Chinquapin Creek near Old U.S. 52), with urban sewer line leaks or overflows the most likely sources. In subwatershed PC-1, elevated fecal coliform counts occurred in two north-side tributaries to middle Pilot Creek (locations PC-3.1 and PC-4.1), with septic tank malfunctions and wildlife as possible sources. Fecal coliform levels are notoriously variable in streams draining both urban/developed and rural/agricultural landscapes.

C. PROBLEM AREAS

Specific problem areas (localized 'hotspots' or stream reaches where watershed stressors are especially significant) include those locations noted immediately above and discussed in further detail in the *Synoptic monitoring* and *Hot spot monitoring/investigations* subsections in Section IV.

To summarize by subwatershed:

- TC-1: nutrient enrichment and excess sediment at one site
- TC-2: nutrient enrichment at one site; excess sediment at two sites (may be connected to geology)
- TC-3: nutrient enrichment at one site; excess sediment at two sites
- TC-4: nutrient enrichment and excess sediment at one site; moderate sediment at two sites
- TC-5: no significant problems noted; moderate sediment at two tributary sites
- TC-6: excess sediment at one site; stormflow scour, elevated specific conductance, elevated NOx, and elevated fecal at three or more sites
- CH-1: no significant problems noted; moderate specific conductance at one site; moderate sediment at two sites

- CH-2: moderate sediment at one site; elevated specific conductance, elevated fecal coliform, elevated NOx at two or more sites
- PC-1 (outside of Pilot Mountain State Park): nutrient enrichment at two sites; moderate sediment at two sites; elevated specific conductance and NOx at two or more sites
- PC-2: excess sediment at one site; moderate specific conductance at three sites; excess NOx at two tributary sites.

D. FUNCTIONAL ASSESSMENT

In the spring of 2012, EEP developed a functional assessment method to characterize the overall ecological functioning of subwatersheds in the APM LWP focus area. Three subfunctions were considered—habitat, water quality, and hydrology. Indicators of these subfunctions were developed from GIS and field datasets, and were used to develop an overall functional rating for each of the 10 delineated subwatersheds. The following indicators were used to score subwatershed function:

1. Percent forested area. The extent of forested cover in each subwatershed was calculated from the 2006-2007 land use/cover dataset developed for the High Rock Lake watershed (NCCGIA, 2008).
2. Percent impervious cover. The extent of impervious cover in each subwatershed was calculated from the 2006-2007 impervious cover dataset developed for the High Rock Lake watershed (NCCGIA, 2008).
3. Percent of streams with adequate forested buffer. The proportion of streams in a subwatershed with an adequate buffer was calculated from the buffer dataset developed by Wildlands using 2010 aerial photographs and 1:24,000 hydrography. A forested buffer of >30 ft on both sides of the stream was considered adequate.
4. Bioclassification of fish and benthic samples collected by Division of Water Quality. Benthic and fish samples collected in 2011 were used to represent subwatersheds. If >1 sample was collected in a subwatershed, then the bioclassifications were averaged.
5. EPT richness of benthic samples collected by Division of Water Quality. Benthic samples collected in 2011 were used to represent subwatersheds. If >1 sample was collected in a subwatershed, then the richness scores were averaged.
6. Percent sand + silt within the stream bed. Degree of fine sediment deposition was measured at multiple sites in each subwatershed in 2011. Proportion of sand and silt within a 100 ft reach was estimated for each site. Sand + silt percentages for all sites sampled in a subwatershed were averaged.
7. Mean nitrite-nitrate values. Nitrite-nitrate was measured multiple times (generally 3 to 5 dates) at multiple sites in each subwatershed between 2011 and 2012. Mean concentrations were calculated for each site, and site means were averaged for a subwatershed average NOx concentration.
8. Mean fecal coliform bacteria values. Fecal coliform bacteria were measured multiple times (generally 3 to 5 dates) at multiple sites in each subwatershed between 2011 and 2012. Geometric means were calculated for each site, and site geometric means were averaged for a subwatershed average fecal coliform bacteria count.

Each indicator was evaluated to determine how directly it might influence (or be reflective of) hydrology, habitat, and water quality functions at the subwatershed scale (Table 4-5). Each indicator was given a weight according to the number of functions it was most directly associated with.

Table 4-5. Subwatershed functional Indicators and corresponding weights

Metric	Habitat	Water Quality	Hydrology	Weight
% Forested		x	x	2
% impervious cover		x	x	2
Riparian buffer condition	x	x		2
Bioclassification	x	x		2
EPT richness		x		1
% sand + silt	x			1
Nitrite-nitrate		x		1
Fecal coliform bacteria		x		1
Total				**11**

A scoring system was developed for each indicator, with each indicator's possible values divided up into three tiers—high, moderate, and low. These tiers were developed with reference values described in literature, with standards or metric breaks used by the Division of Water Quality, and through best professional judgment as described in Table 4-6. To achieve a total subwatershed score, scores for each indicator were developed, multiplied by their indicator weight, and then added to achieve a total raw score. Since one subwatershed did not have a benthic sample and the EPT indicator could not be used, its total raw score was normalized to the maximum possible total of 33 points. Total subwatershed scores were translated into low, moderate, and high functional categories using natural breaks in numerical scores.

Not surprisingly, the subwatershed functional ratings determined from this analysis [see Table 4-7 and Figure 4-8] are generally consistent with the occurrences of major stressors and problem areas (fecal coliform, nutrient or sediment hot spots) noted in earlier discussions. Subwatersheds TC-6 and CH-2, which include the urban/suburban areas of Pilot Mountain (the most highly altered landscape within the LWP area), have the lowest functional rating scores. Subwatersheds TC-4 and TC-5 have the highest functional rating scores; a reflection of low impervious cover, high-quality buffers, healthy biota (bioclassification scores) and low fecal coliform levels. It's important to stress, however, that this 'model' for subwatershed functioning is based on a lumping together of several assessment metrics (indicators) collected from a limited number of sites in each subwatershed.

Table 4-6. Functional indicators and corresponding score ranges.

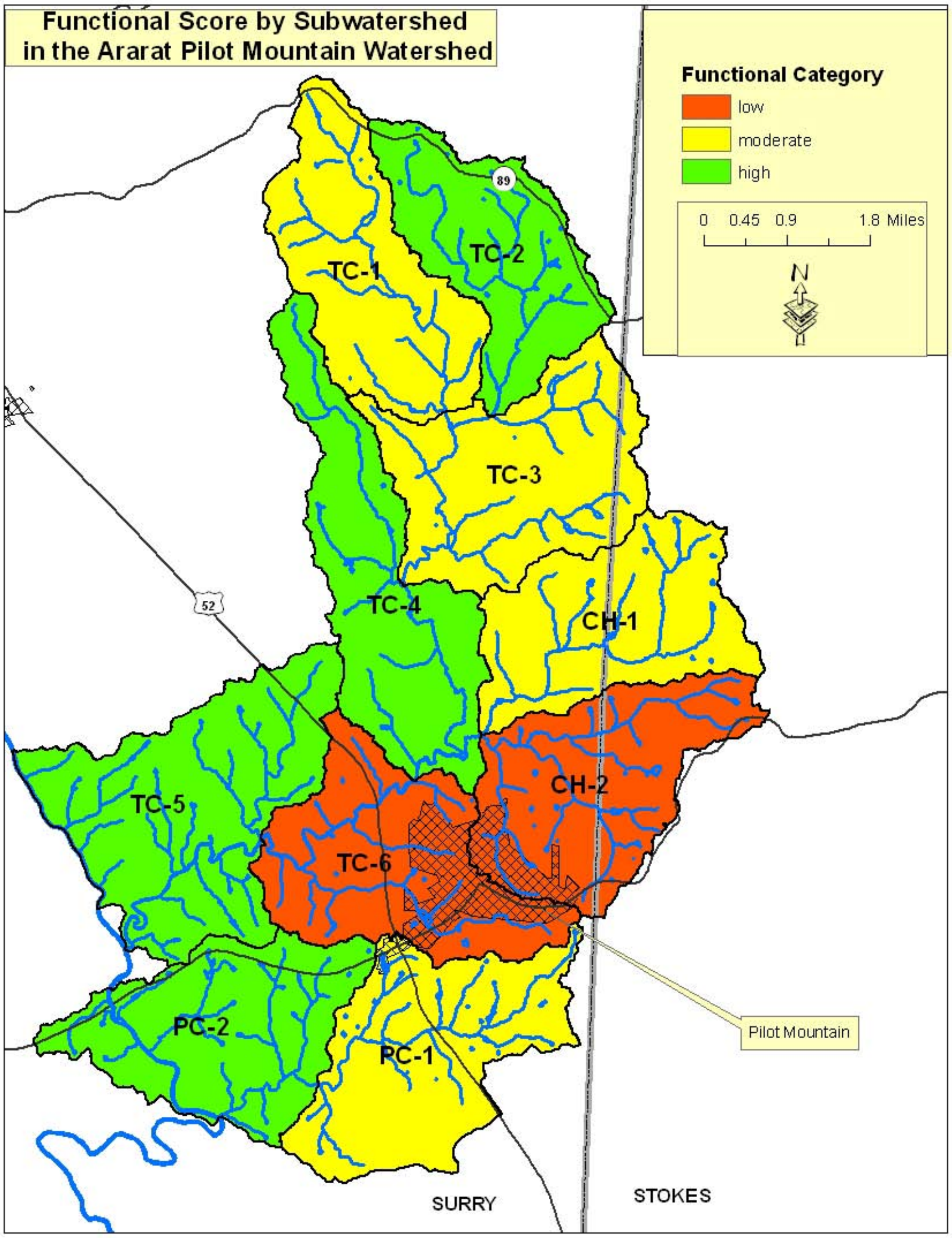
Indicator	Indicator Weight	Indicator Ranges & Ratings			Rating Justification
		High (3 pts)	Moderate (2 pts)	Low (1 pt)	
% Forested	2	≥65%	50-64%	<50%	hi/mod--References: Booth et al (2002), Price & Leigh (2006); mod/low--spread of values in WS
% IC or developed	2	<4%	4-10%	>10%	hi/mod--References: Gilliam et al (2005); mod/low--References: Gilliam et al (2005), CWP (2003)
% Adequate forested buffer (≥30 ft on both sides of stream)	2	<69%	60-69%	>60%	natural breaks in data
Bioclassification	2	Excellent or Good	Good-Fair	Fair or Poor	DWQ bioclassification
EPT richness	1	>27	19-27	<19	DWQ EPT richness criteria for EPT samples; >27 is rated Good or Excellent, 19-27 is rated Good-Fair, <19 is rated Fair or Poor
% sand + silt	1	≤35%	36-64%	≥65%	Spread of values in watershed; BPJ
Nitrite-nitrate (average of site mean concentrations)	1	<0.23 mg/L	0.23-0.42 mg/L	>0.42 mg/L	3 tiers based on percentiles of site median concentrations; 0.23 represents the 33rd percentil and 0.42 represents the 66th percentile
Fecal coliform bacteria (mean of site geometric means)	1	<150 colonies/100 mL	150-200 colonies/100 mL	>200 colonies/100 mL	200 colonies/100 mL is the state standard. Low score given to those subwatershed medians above 200. All moderate scored subwatersheds also had at least 2 sites with geometric means > 200.

Table 4-7. Subwatershed indicator scores and functional ratings*

Subwatershed ID	% Impervious Cover (IC)	IC Score	% Forested Cover	Forested Cover Score	% Adequate Buffer	Buffer Score	Average Bioclassification	Bioclassification Score	Average EPT Richness	EPT Richness Score	Average % Sand + Silt	Sedimentation Score	Average of Nitrite/Nitrate Site Medians	NOx Score	Average of Fecal Coliform Bacteria Site Geometric Means	Fecal Coliform Bacteria Score	Total Raw Score	**TOTAL SCORE (normalized to 33 point max)**	**Functional Category**
CH-1	2.7	3	47.0	1	50.3	1	Good-Fair	2	25	2	40	2	0.20	3	80	3	22	**22**	**moderate**
CH-2	4.9	2	42.8	1	63.8	2	Good-Fair	2	24	2	38	2	0.40	2	157	2	20	**20**	**low**
PC-1	4.6	2	61.1	2	64.2	2	Good	3	27	2	47	2	0.35	2	112	3	24	**24**	**moderate**
PC-2	3.3	3	51.5	2	65.8	2	Good	3	33	3	47	2	0.61	1	124	3	26	**26**	**high**
TC-1	2.2	3	62.7	2	59.0	1	Good-Fair	2	24	2	48	2	0.39	2	110	3	23	**23**	**moderate**
TC-2	2.5	3	67.3	3	65.8	2	Good-Fair	2	25	2	68	1	0.39	2	54	3	26	**26**	**high**
TC-3	2.3	3	55.4	2	56.7	1	Good-Fair+	2.5	19.5	2	67	1	0.15	3	417	1	21.5	**22**	**moderate**
TC-4	2.5	3	56.5	2	69.2	3	Good-Fair+	2.5	21.5	2	52	2	0.37	2	59	3	27.5	**28**	**high**
TC-5	3.3	3	51.4	2	70.3	3	Excellent	3	-	-	52	2	0.23	3	108	3	27	**30**	**high**
TC-6	9.0	2	48.8	1	59.7	1	Good-Fair+	2.5	14.5	1	52	2	0.61	1	169	2	16.5	**17**	**low**

**Impervious cover, forested cover, bioclassification and buffer scores were all doubled (twice the weight) for the total raw score. All other scores were summed as they are.*

Figure 4-8. Subwatershed functional categories for the Ararat-Pilot Mountain LWP area.



E. **Watershed assets**

As noted in the *GIS: Riparian Buffers* subsection above (see Table 4-3 and Figure 4-4), there are several relatively wide and undisturbed (forested) riparian reaches outside of Pilot Mountain SP boundaries that could be the focus of conservation efforts. Subwatersheds TC-4 and TC-5 (middle to lower Toms Creek) contain the highest percentage of stream length (57%) with riparian buffers of 100 feet or greater. [Sampling site B11 (Figure 4-1) on lower Toms Creek in subwatershed TC-5 had the highest habitat score of any site in the LWP area (excluding the reference location) and an Excellent fish bioclassification.] The preservation of wide, woody (forest and shrub) buffers -- especially along headwater streams -- is important in protecting downstream water quality and aquatic habitat.

In addition to wide riparian buffers along some stream reaches, there are relatively large riparian wetland areas within the LWP area (Figure 4-7), most notably in subwatersheds TC-1 (upper Toms Creek) and TC-4 (middle Toms Creek) that represent potential opportunities for habitat protection (or restoration), and which play a vital role in protecting water quality in adjacent streams and providing flood storage.

Relatively undisturbed and wide riparian corridors -- including along sections of Toms Creek, Pilot Creek and the Ararat River -- also represent a local watershed asset as potential sites for recreational greenways and trails. Recommendations related to greenways planning and acquisition were cited as a priority goal for the LWP initiative by several local stakeholders.

In terms of their habitat value, large forested areas represent another local watershed asset. Table 4-7 shows that the highest percent of forest cover in LWP subwatersheds outside of Pilot Mountain State Park, at 63 to 67%, occurs within upper Toms Creek (TC-1 and TC-2).

Contiguous to and downstream of the LWP focus area, the Ararat River represents another notable local watershed asset. From a point approximately two miles upstream of the Toms Creek confluence extending downstream to the Pilot Creek confluence, the Ararat River forms the southwestern boundary of the LWP area. It is considered an important recreational fishery by local stakeholders, including members of the NC Wildlife Resources Commission (WRC). As a major tributary to the upper Yadkin River, water quality in the Ararat River is important to the ecological health of downstream reaches of the Yadkin River. The upper Yadkin River east of Elkin downstream to Winston-Salem is considered a priority watershed for freshwater conservation (NC WRC Wildlife Action Plan, 2005). It is home to rare (endangered or threatened) mussels, including the creeper (*Strophitus undulates*) and the brook floater (*Alasmidonta varicosa*), as well as the trophy small-mouth bass fishery downstream to Donnaha (northwestern Forsyth County).

V. REFERENCES

Allred, Marc, 2012. Proposed connectors to Ararat River greenway (color map). Updated March, 2012. Piedmont Triad Regional Council.

Baker Engineering, 2009. Town of Pilot Mountain Stormwater Drainage Study. Prepared for the Town of Pilot Mountain, Resource Institute, Inc. and the Clean Water Management Trust Fund. Michael Baker Engineering, Inc., November 2009.

Booth, D. B., D. Hartley, and R. Jackson, 2002. Forest cover, impervious surface areas, and the mitigation of stormwater impacts. Journal of the American Water Resources Association. 38(3): 835-845.

Center for Watershed Protection, 2003. Impacts of Impervious Cover on Aquatic Systems. Watershed Protection Research Monograph No. 1. Center for Watershed Protection. Ellicot City, MD.

Cowardin, L.M., Carter, V., Golet, F.C. & LaRoe, E.T., 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish & Wildlife Service, 103 pp.

Gilliam, J., F. Cakir, and T. MacPherson, 2005. Urbanization and decline in water quality: do statistically identifiable thresholds exist? Paper presented at the 2005 Conference of the Water Resources Institute of North Carolina. April 5, 2005. Raleigh, NC.

Griffith, Glenn E., Omernik, James M. et al, 2002. Ecoregions of North Carolina and South Carolina (color poster with map); Reston, Virginia, U.S. Geological Survey: map scale 1:1,500,000.

McAdams-EcoEngineering, 2008. Upper Yadkin basin Local Watershed Plan (Surry County, NC) – Technical memorandum, Task 2. October, 2008. http://portal.ncdenr.org/c/document_library/get_file?uuid=4cb57e2f-834a-4f40-b46c-8068e5651a6f&groupId=60329

Medlin, N., 2011. Summary of fish collections in the Toms Creek and Pilot Creek watersheds, Surry County. NCDOT Natural Environment Section/PDEA Biological Surveys Group Memorandum to EEP. November 2011.

McIntyre, Palmer S., M. Mock and J. Senges (Piedmont Land Conservancy), 2012. Surry County Farmland Preservation Plan – preserving our agricultural heritage and future. February 2012.

North Carolina Center for Geographic Information and Analysis (NC CGIA), 2008. Final project report: GIS land cover for the High Rock Lake watershed, High Rock Lake TMDL. Prepared for NC Division of Water Quality. Raleigh, NC.

NCDWQ, 2006. Standard Operating Procedure. Stream Fish Community Assessment Program. August, 2006. http://portal.ncdenr.org/c/document_library/get_file?uuid=36784c06-f53d-430e-90f9-2f643c9b645b&groupId=38364

NCDWQ, 2008a. Summary of existing water quality data for the Ararat River watershed. NC Division of Water Quality, May 2008.

NCDWQ, 2008b. Water quality screening data summary for the Ararat River watershed. NC Division of Water Quality – Watershed Assessment Team, June 2008.

NCDWQ, 2008c. Yadkin-Pee Dee River Basinwide Water Quality Plan, 2008. NC DWQ Basinwide Planning Unit.

NCDWQ-BAU, 2009. Benthic sampling results for EEP study in Surry County, NC, September 2008. NC Division of Water Quality – Biological Assessment Unit, Memorandum, February 2009.

NCDWQ, 2009. Small Streams Biocriteria Development. May, 2009. http://portal.ncdenr.org/c/document_library/get_file?uuid=2d54ad23-0345-4d6e-82fd-04005f48eaa7&groupId=38364

NCDWQ, 2011a. Standard Operating Procedures for Collection and Analysis of Benthic Macroinvertebrates. Version 3.0. December, 2011. http://portal.ncdenr.org/c/document_library/get_file?uuid=c2fdf380-aa8a-481e-8388-a6e6596c6a96&groupId=38364

NCDWQ, 2011b. Toms Creek summary report. For Toms Creek at SR 2024 (station QF57), sampled on June 21, 2011. September, 2011.

NCDWQ, 2012. Final 303(d) List, 2012; approved by USEPA, August 2012. NC DWQ Modeling & TMDL Unit.

NCDWQ Watershed Assessment Team (WAT), 2009. Integrated analysis report of water quality for the Ararat River LWP study area. July, 2009.

NCDWQ Watershed Assessment Team (WAT), 2012. Water quality technical memorandum for the Ararat Pilot Mountain Local Watershed Planning area. August, 2012.

N.C. Wetland Functional Assessment Team, 2010. N.C. Wetland Assessment Method (NC WAM), User Manual, Version 4.1, October 2010.

NC Wildlife Resources Commission (WRC), 2005. North Carolina Wildlife Action Plan.

Northwest Piedmont Council of Governments (NWPCOG), 2005. Town of Pilot Mountain Land Use Map. Created May 5, 2005.

Pilot Mountain Planning Board, 2005. Town of Pilot Mountain Land Use Plan, 2005-2015. Approved September 6, 2005.

Price, K. and D. Leigh. 2006. Morphological and sedimentological responses of streams to human impact in the Southern Blue Ridge mountains, USA. Geomorphology 78: 142-160.

Randall, John (UNC-G), A. Somers (UNC-G) and M. Lipscomb (VPI&SU), 1995. Natural Areas Inventory for Surry County, North Carolina. Sponsors: NC Natural Heritage Program; Foothills Nature Science Society; Surry County.

Strahler, A.N. 1952. Hypsometric (area-altitude) analysis of erosional topography. *Geological Society of America* Bulletin. 63: 1117-1142.

Surry County Board of Commissioners, 2012. Land Use Plan 2020 for Surry County, North Carolina. Adopted by the Surry County Board of County Commissioners September 5, 2012. Updated from *Land Use Plan 2015* by The Surry County Planning Board and The Surry County Planning and Development Department, Kim Bates, AICP, Director.

Surry County Planning Board, 2006. Land Use Plan 2015: a ten-year vision for Surry County, NC. Adopted October 2, 2006.

Tyndall, C. 2011. Benthic sampling results for the Ararat-Pilot Mountain Local Watershed Plan. Yadkin River Basin Subbasin 03; HUC 03040101. NCDWQ Memorandum to EEP. October, 2011.

US Fish and Wildlife Service. National Wetlands Inventory. http://www.fws.gov/wetlands/NWI/index.html

U.S. Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS), 2007. Soil survey of Surry County, North Carolina. Issued 2007.

Wildlands Engineering, 2012. Technical Memorandum 1: Review of existing GIS datasets, GIS-based riparian buffer assessment, and GIS-based project prioritization. Ararat-Pilot Mountain Local Watershed Plan. Prepared for NC DENR – Ecosystem Enhancement Program. August 2012.

VI. APPENDICES [Volume 2]

A – NC DWQ-WAT Technical Memoranda (Physical/Chemical)

B – NC DWQ-BAU Technical Memorandum (Benthics)

C – NC DOT Biological Surveys Group Report (Fish)

D – Wildlands Engineering Technical Memorandum
(GIS-based Buffer Analysis and Project Screening)

WATERSHED ASSESSMENT REPORT
Ararat-Pilot Mountain Local Watershed Plan

VOLUME 2 – APPENDICES

A. NC Division of Water Quality (DWQ) – Technical Memoranda

B. NC DWQ – BAU Benthics Memorandum

C. NC DOT Biological Surveys Group Report

D. Wildlands Engineering Technical Memorandum

APPENDIX A – NC DWQ-WAT Technical Memoranda

Division of Water Quality
Watershed Assessment Team
April 1, 2011

Memo

To: Steve Kroeger

From: Dave Wanucha, Tom Yocum

CC: Andrea Leslie; Hal Bryson (NCEEP) and Cathy Tyndall (WAT)

Subject: **Report** discussing reconnaissance work in Heatherly Creek, Pilot Creek, Chinquapin and Toms Creeks for the Ararat-Pilot Mountain Local Watershed Planning area.

Background

The North Carolina Ecosystem Enhancement Program (EEP) has begun a re-start of the local watershed planning process for four named streams (listed above) draining to the Ararat River that are within the 14-digit hydrologic unit code (HUC) 03040101 110 030 and a portion of 110 050 in the headwaters of the Yadkin River. The focus area is referred to as the Ararat, Pilot Mountain Local Watershed Plan (APM LWP). In order to draft a Scope of Work (Scope) a recon needs to be conducted as described in section C.2. of the Standard Scope document dated June 23, 2010, version 1.0. Segments of the above referenced streams were assessed previously in 2008 as part of the initial LWP effort but many portions of streams and catchments were not assessed due to the large area (~230 square miles) and short timeframe in which to work (the project was put on hold). Below are descriptions and results of the recon efforts that will be used to provide a framework for the Scope to be drafted over the next few weeks.

Windshield Reconnaissance

A windshield survey was conducted over a two-day period on January 4th (in Heatherly and Pilot Creeks sub-watersheds) and 6th (in Toms and Chinquapin Creeks sub-watersheds) to gain familiarity with the area and to begin planning for a more in depth recon at a later date. The windshield survey consisted of driving through each watershed to observe land-use patterns making notes of potential problem areas and identifying locations where monitoring and assessments may occur. Photos and latitude and longitude data were collected to help with mapping and planning tasks. Neither samples nor field measurements were collected during this preliminary recon because it would consume too much time preventing a complete spatial review of each sub-watershed. Other tasks associated with this recon were a review of 2009 deliverables including maps, reports, water quality data and a review of 2008 Google Earth aerial photography to estimate land-use patterns and to help pin point potential problems areas that could not be observed during the windshield survey.

Field Reconnaissance

More in-depth recons were conducted throughout the planning area (Figure 1) on March 8th, 15th, 21st and 23rd as described below. The purpose of this recon was to conduct field measurements and collect fecal coliform and nutrient samples at several road-accessible locations to rapidly assess chemical and physical water quality conditions throughout the planning area. These data will help to prioritize where further monitoring needs to occur that will in turn help pinpoint stressors to water quality functions and may lead to the identification of potential stream restoration projects and best management practices (BMPs).

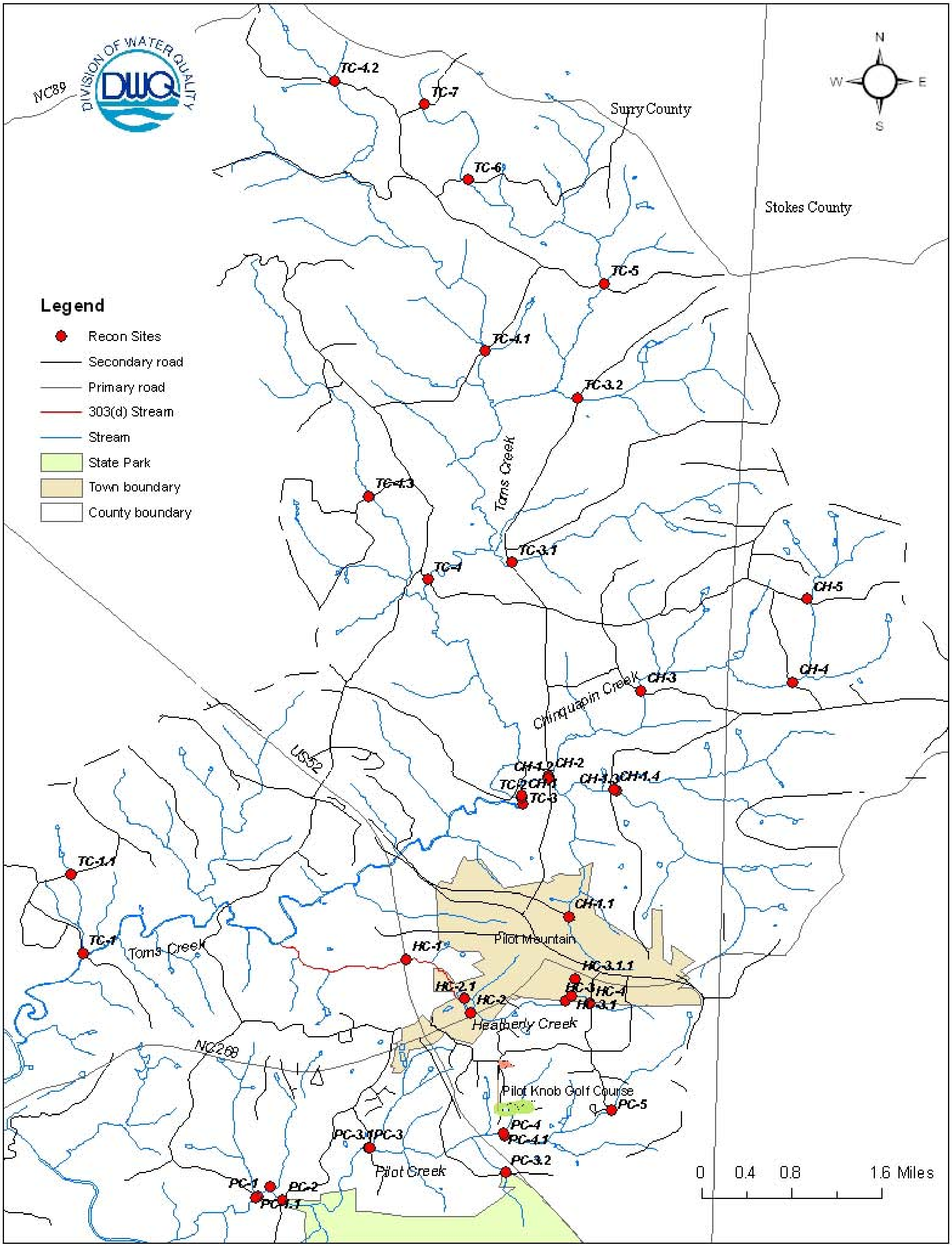


Figure 1. Recon sites monitored in March 2011. The reference site in Hanging Rock State Park is not shown on this map.

Table 1. Results of physical/chemical and bacterial measurements conducted during the recon in March 2011. Notable values are in bold. Values with U indicate that concentrations were below laboratory detection limits.

Location	Code	Specific Conductance (uS/cm)	Nitrate-Nitrite (mg/L)	Ammonia-N (mg/L)	Total Kjeldahl-N (mg/L)	Total Phosphorus (mg/L)	Fecal Coliform (cols/100mL)
Indian Creek at SR1001 State Park Rd (ref)	IC-1	15	0.02U	0.02 U	0.20 U	0.02U	
Chinquapin Creek at SR1830	CH-1	57					
UT to Chinquapin Creek at Old 52	CH-1.1	**129**	**0.93**	0.02 U	0.20 U	0.02 U	
UT to Chinquapin Creek at SR1809	CH-1.2	66	0.39	0.02 U	0.27	0.02	**390**
UT to Chinquapin Creek at 1837	CH-1.3	63					
UT to Chinquapin Creek at 1837	CH-1.4	45					
Chinquapin Creek at SR1809	CH-2	52	0.25	0.02 U	0.27	0.03	100
Chinquapin Creek at SR1835	CH-3	46	0.25	0.02 U	0.32	0.07	
Chinquapin Creek at SR1202	CH-4	41					
Chinquapin Creek at SR1204	CH-5	35	0.39	0.02 U	0.29	0.05	
Heatherly Creek at US52	HC-1	87	0.45	0.02	0.21	0.03	90
Heatherly Creek at NC268	HC-2	87	**0.52**	0.02	0.20 U	0.03	22
UT to Heatherly Creek at WWTP	HC-2.1	**93**	**0.69**	0.04	0.22	0.03	**250**
Heatherly Creek near S Davis St	HC-3	81					
UT to Heatherly Creek near S Davis	HC-3.1	**238**					
UT to Heatherly Creek at Pine St	HC-3.1.1	**236**					
Heatherly Creek at Academy St	HC-4	67					
Pilot Creek at SR2047	PC-1	71	0.42	0.02 U	0.20	0.02 U	63
UT to Pilot Creek at SR2047	PC-1.1	83	0.55	0.02 U	0.24	0.02	130
UT to Pilot Creek at Private Drive	PC-1.2	**106**					18
Pilot Creek at SR2048	PC-2	64					
Pilot Creek at Boyd Nelson Rd	PC-3	67					
UT to Pilot Creek at Boyd Nelson Rd	PC-3.1	**125**					49
UT to Pilot Creek at SR2097	PC-3.2	51					
Pilot Creek at Stone Valley Rd	PC-4	69					
UT to Pilot Creek at Stone Valley Rd	PC-4.1	74					
Pilot Creek at Seven Springs Ln	PC-5	80					
Toms Creek at SR2024 Toms Creek Rd	TC-1	62	0.17	0.02 U	0.20 U	0.02	40
UT to Toms Creek at Community Bldg Rd	TC-1.1	57	0.17	0.02	0.27	0.05	**4600**
Toms Creek at SR1830	TC-2	48					
Toms Creek below confluence with Chinquapin Creek	TC-3	51					
UT to Toms Creek at SR1809	TC-3.1	39					
UT to Toms Creek at SR1809	TC-3.2	51	0.23	0.02 U	0.22	0.05	

Table 1. Results of physical/chemical and bacterial measurements conducted during the recon in March 2011. Notable values are in bold. Values with U indicate that concentrations were below laboratory detection limits.							
Location	**Code**	**Specific Conductance (uS/cm)**	**Nitrate-Nitrite (mg/L)**	**Ammonia-N (mg/L)**	**Total Kjeldahl-N (mg/L)**	**Total Phosphorus (mg/L)**	**Fecal Coliform (cols/100mL)**
Toms Creek at SR1812	TC-4	49					160
UT to Toms Creek at SR1811	TC-4.1	44	0.43	0.02 U	0.20 U	0.02	18
UT to Toms Creek at SR1807	TC-4.2	35					
UT to Toms Creek at SR1825	TC-4.3	42					
Toms Creek at SR1811	TC-5	52	0.39	0.02 U	0.20 U	0.02	
Toms Creek at SR1804	TC-6	43					
Toms Creek at SR1806	TC-7	38					

Figures 2 through 4 below portray specific conductance, fecal coliform bacteria and nitriate-nitrite concentrations geospatially. The other field measurements and nitrogen species were not portrayed because they were within water quality standards, low or below detection limits. Chemical data not portrayed in the Figures can be reviewed in Table 1 above.

Additionally, aquatic habitat conditions (e.g., the extent of stream bank erosion, composition of substrate, degree of embeddedness and riparian conditions) were observed and noted to begin building a picture of local habitat conditions. These observations will help identify where more detailed biological and habitat assessments should occur to determine stressors that may be degrading habitat functions. These data will in turn help identify where stream restoration projects and BMPs may need to be located as well.

A nearby biological reference site recognized by the Division's Biological Assessment Unit (BAU) in Hanging Rock State Park was visited on March 21 to collect field measurements and nutrient samples. The stream (Indian Creek at SR1001) drains a mostly undisturbed, forested catchment (~1.0 square mile). Specific conductance was 15 uS/cm and all nutrient concentrations (nitrogen species and total phosphorus) were below laboratory detection limits. These data along with benthic macroinvertebrate data may be used to help interpret data collected within the planning area.

Heatherly Creek

Land-use in the Heatherly Creek drainage area (1.7 square miles at US52) is a mix of commercial, industrial, residential and forest. Most of the Town of Pilot Mountain drains to Heatherly Creek. As reported in 2009 as part of the initial planning, Heatherly Creek was listed on North Carolina's 303(d) Impaired Waters List for biological impairment in 2006 and 2008. It is on the 2010 List as well. Plausible causes for impairment noted in 2009 included scouring (i.e. removal of both habitat and aquatic insects) by increased storm runoff due to a high percentage of imperviousness and toxicity related to pollutants in stormwater runoff.

The recon for Heatherly Creek was conducted on March 8th approximately 40 hours following a storm event of approximately two inches over a less than 24-hour period. Very little turbidity was evident. Four mainstem and three tributary locations were visited. Field measurements (dissolved oxygen, pH, temperature and specific conductance) were conducted at all locations. Nutrients (nitrite/nitrate, ammonia, total Kjeldahl nitrogen and total phosphorus) were collected from two mainstem locations and from one tributary location. Fecal coliform samples were not collected since the data would likely be skewed as a result of the storm event, however, samples were collected on March 23rd from two mainstem and one tributary location.

Field readings were within NC water quality standards (WQSs) for pH, temperature and dissolved oxygen. Mainstem specific conductance measurements ranged from 67 uS/cm at the most upstream location in Heatherly Creek at Academy Street (HC-4) to 87 uS/cm at the most downstream location at US52 (HC-1). Higher readings were observed in tributary locations. The highest reading (238 uS/cm) was recorded in an unnamed tributary (UT) near South Davis Street (HC-3.1) that drains a small urban catchment. One contributing factor may be stored construction equipment adjacent to this tributary (Photo 1). The second highest reading (93 uS/cm) was recorded in a UT (HC-2.1) near the Town's wastewater water treatment plant (WWTP) that drains a mix of commercial and residential land-use. By comparison, specific conductance in the reference stream was 15 uS/cm.

Fecal coliform contamination is a concern in the UT near the WWTP (HC-2.1). Concentrations were reported at 250 cols/100 mL. Concentrations of 90 and 22 cols/100 mL were reported for the US52 (HC-1) and NC268 (HC-2) locations respectively and are not of concern at this time.

All nitrogen species (ammonia, total Kjeldahl nitrogen, nitrate-nitrite) and total phosphorus (TP) were higher in the UT near the WWTP (HC-2.1) than in any other sampled location in Heatherly Creek (Table 1 and Photo 2). Periphyton was more evident on submerged rocks and cobbles at this location as well. The next highest nitrate-nitrite concentration was 0.52 mg/L in Heatherly Creek at NC268 (HC-2). Overall, nutrient concentrations were not excessively elevated at any location; although, mostly higher than the nearby reference stream (Indian Creek at SR1001) in Hanging Rock State Park where all nutrient species and TP were below laboratory detection limits. The one exception was in Heatherly Creek at NC268 (HC-2) where total Kjeldahl nitrogen (TKN) was also below detection limits (Table 1).

In general, habitat conditions in Heatherly Creek and its tributaries were observed to possess a good mix of habitat types (e.g., rocks, root mats, sticks) with a variety of pools. Riffle embeddedness was nearly 50%. The channel was over-widened at the US52 location (HC-1) exposing important root mat habitats and undercut banks (Photo 3). Stream bank erosion and bedload sediment was evident throughout (Photo 4) with some extreme erosion noted at the NC268 (HC-2) location. An adequate riparian vegetation zone was present throughout except for some tributary locations in town.

Pilot Creek

Land-use in the Pilot Creek drainage area (0.0 square miles at SR2047) is a mixture of commercial, agriculture (pasture/hay and some patches of cropland) and forest along with a mix of single family homes and housing developments. A golf course is located in the headwater area.

The recon for Pilot Creek was conducted on March 21st. Five mainstem and and six tributary locations were visited. Field measurements were collected for all locations. Nutrients were collected from one mainstem and one tributary location. Fecal coliforms were collected from one mainstem location and three tributary locations.

Field readings were within state WQSs for pH, temperature and dissolved oxygen. Mainstem specific conductance measurements ranged from 64 uS/cm in the lower segment at SR2048 (PC-2) to 80 uS/cm in the headwater area upstream of the golf course at Seven Springs Lane

(PC-5). A wider range of readings were recorded for tributary locations. Tributaries ranged from 51 uS/cm for a UT that drains a small, mostly forested portion of Pilot Mountain State Park at SR2097 (PC-3.2) to 125 uS/cm for a UT that drains a housing development along Boyd Nelson Road (PC-3.1) and a commercial area along NC268 and US52. The second highest specific conductance reading (106 uS/cm) was for a UT at SR2047 (PC-1.2) which drains a mostly forested catchment with some pasture and two housing developments adjacent to NC268.

Fecal coliform levels in the streams sampled indicated little concern at this time ranging from 18 to 130 cols/100mL. The highest concentration was in a UT at SR2047 (PC-1.1). See Table 1 for results for all locations.

As in Heatherly Creek, nutrient concentrations were not excessively high. Ammonia, TKN and TP were below laboratory detection limits in Pilot Creek at SR2047 (PC-1) and nitrate-nitrite concentrations were 0.42 mg/L. Nitrate-nitrite in a UT to Pilot Creek at SR2047 (PC-1.1) were slightly higher at 0.55 mg/L, as were total Kjeldahl nitrogen and TP (Table 1). Ammonia nitrogen was below detection limits at this tributary location.

In general, habitat conditions in Pilot Creek and its tributaries possess a good mix of habitat types (rocks, sticks, logs and undercut banks). Riffle embeddedness was nearly 50% in many locations. Bedload appears to be less of a problem than in Toms and Chinquapin Creeks. Riparian buffers were lacking along the golf course and in other locations as well (Photos 5 and 6).

Chinquapin Creek

Chinquapin Creek is a tributary to Toms Creek both of which supply water to the Town of Pilot Mountain and are designated as Water Supply (WS-II) with a supplemental High Quality Waters (HQW) classification. Land-use within the Chinquapin Creek drainage area (9.4 square miles at SR1830) is mostly rural with a mix of forest and agriculture (mostly pasture/hay with patches of cropland). A portion of the Town of Pilot Mountain drains to a UT to Chinquapin Creek.

The recon for Chinquapin Creek was conducted on March 8th and 15th. Five mainstem and four tributary locations were visited. Nutrients were collected from three mainstem locations and two tributaries. Fecal coliform bacteria samples were collected from one mainstem and one tributary. Field measurements were collected for all locations.

Field readings were within state WQSs for pH, temperature and dissolved oxygen. Mainstem specific conductance measurements ranged from 35 uS/cm at the most upstream location to 57 uS/cm at the most downstream location. Tributary locations were higher, ranging from 45 to 129 uS/cm. The highest measurement (129 uS/cm) was taken from a headwater area in a tributary at Old US52 (CH-1.1) that drains a small urban/commercial catchment in the Town of Pilot Mountain.

Fecal coliform bacteria in the mainstem location at SR1809 (CH-2) were low at 100 cols/100 mL. The UT to Chinquapin Creek at SR1809 (CH-1.2), which drains a portion of the Town of Pilot Mountain, concentrations were higher at 390 cols/100 mL and are of concern.

The most notable nitrate-nitrite concentration detected (0.93 mg/L) was for the UT to Chinquapin Creek at Old US52 (CH-1.1) which is where the highest specific conductance reading was also recorded (as mentioned above). Concentrations of nitrate-nitrite and other nitrogen species at the other locations were unremarkable (Table 1). Concentrations of TP were slightly elevated for samples collected on March 8th due to slightly elevated suspended sediment levels in-stream at the time of sampling. As mentioned above, this was due a storm event that ended 40 hours previous to the recon.

In general, habitat conditions in Chinquapin Creek are plagued with excessive sediment most likely due to stream bank erosion. See Photos 7 and 8. Most types of habitats were present (e.g., rocks, logs and sticks) but may not all be favorable for benthos colonization. There were a variety of pool sizes. Riffles were embedded (approaching 50%) but had a good mix of gravel and cobbles. Wide riparian woody vegetative zones were present in some locations but were absent in others. For example, upstream along the UT to Chinquapin Creek at SR1809 (CH-1.2) there was a nearly 2000 feet long segment where no woody vegetation was evident along the stream.

Toms Creek

Toms Creek has the largest drainage area (37.7 square miles at SR2024). Land-use is mostly rural consisting of forested and agricultural areas mostly in pasture/hay with scattered fields of cropland throughout. As mentioned above in the Chinquapin Creek section Toms Creek is a Water Supply watershed (WS-II) with a supplemental HQW classification upstream of the raw water intake location. Downstream of this point it is Class C.

The recon for Toms Creek was conducted on March 8th and 15th. Seven mainstem and six tributary locations were visited. Nutrients were collected from two mainstem locations and three tributaries. Fecal coliform bacteria were collected from two mainstem locations and two tributaries. Field measurements were collected for all locations.

Field readings were within state WQSs for pH, temperature and dissolved oxygen. Mainstem specific conductance readings were similar to Chinquapins Creek's in value and pattern. Values mostly increased slightly from upstream to downstream. The lowest value (38 uS/cm) recorded was in the most upstream location at SR1806 (TC-7) and the highest value (62 uS/cm) was recorded in the most downstream location at SR2024 (TC-1). Tributary levels were similar to the mainstem's. The lowest measurement was 35 uS/cm in a UT to Toms Creek at SR1807 (TC-4.2). The highest measurement was 57 uS/cm in a UT to Toms Creek at Community Building Road (TC-1.1).

The most notable fecal coliform bacteria concentrations were found in a tributary location for a small catchment near the most downstream portion of the sub-watershed at Community Building Road (TC-1.1) where 4600 cols/100 mL were reported. The other three locations had concentrations that ranged from 18 to 160 cols/100 mL.

The most noteworthy nutrient levels were detected in the small catchment where fecal bacteria were elevated at a UT to Toms Creek at Community Building Road (TC-1.1). TKN concentrations were highest here relative to the other locations sampled in Toms Creek at 0.27 mg/L. The highest nitrate-nitrite concentration (0.43 mg/L) was measured in a UT to Toms Creek at SR1811 (TC-4.1). This sampling site is located within sizeable cattle pastures where cattle have access to the stream and riparian vegetation is mostly lacking (See Photo 9). Excessive algae and periphyton were not observed in any location.

Habitat conditions throughout the Toms Creek drainage area were similar to those observed throughout the planning area. Stream bank conditions suggest that erosion occurs with almost every storm event. Large amounts of bedload sediments were observed within the channel. Riffle habitats were mostly embedded with sand, gravel and cobbles. Pool habitats were favorable with many different sizes present. There were stream segments where riparian zones were wide and forested but many riparian zones were devoid of trees and mostly vegetated with grasses (Photo 9).

One notable occurrence observed at a UT to Toms Creek at SR1809 (TC-3.1) on March 15th where an unknown upstream activity caused stream turbidity (See Photo 10). Immediately upstream of the road crossing an earthen dam was present that was eroding. Further upstream, the turbidity continued as far as the eye could see but it was not clear as to the cause.

Summary

In terms of water quality chemistry as reflected by specific conductance, there were few major areas of concern observed except for three tributaries within the Town of Pilot Mountain two of which drain to Heatherly Creek and one which drains to Chinquapin Creek. Two tributaries draining to Pilot Creek were slightly elevated along with one mainstem location in the headwater area.

At this point in the assessment, fecal coliform bacteria contamination concerns are primarily isolated to a few tributaries; one each in Toms, Heatherly and Chinquapin Creeks where levels were elevated.

Nutrient levels do not appear to be problematic at this point. Two tributary locations one in Heatherly Creek and one in Chinquapin Creek (which drains a portion of the Town of Pilot Mountain) exhibited slightly elevated nitrate-nitrite concentrations as did the mainstem location at NC268. Algae and periphyton were observed at the tributary in the Heatherly Creek drainage.

Habitat conditions were similar throughout the planning area. A major stressor is likely sediment from stream bank erosion and bedload. Livestock have access to the stream channel in some locations. There were a good mix of habitat types including rocks, sticks and undercut banks. Riffle embeddedness was nearly 50%. A variety of pools were apparent. The condition of riparian zones was mixed with some wide and forested and others with little to no woody vegetation.

Recommendations for further chemical and biological assessment work will be addressed in the forthcoming scope of work.

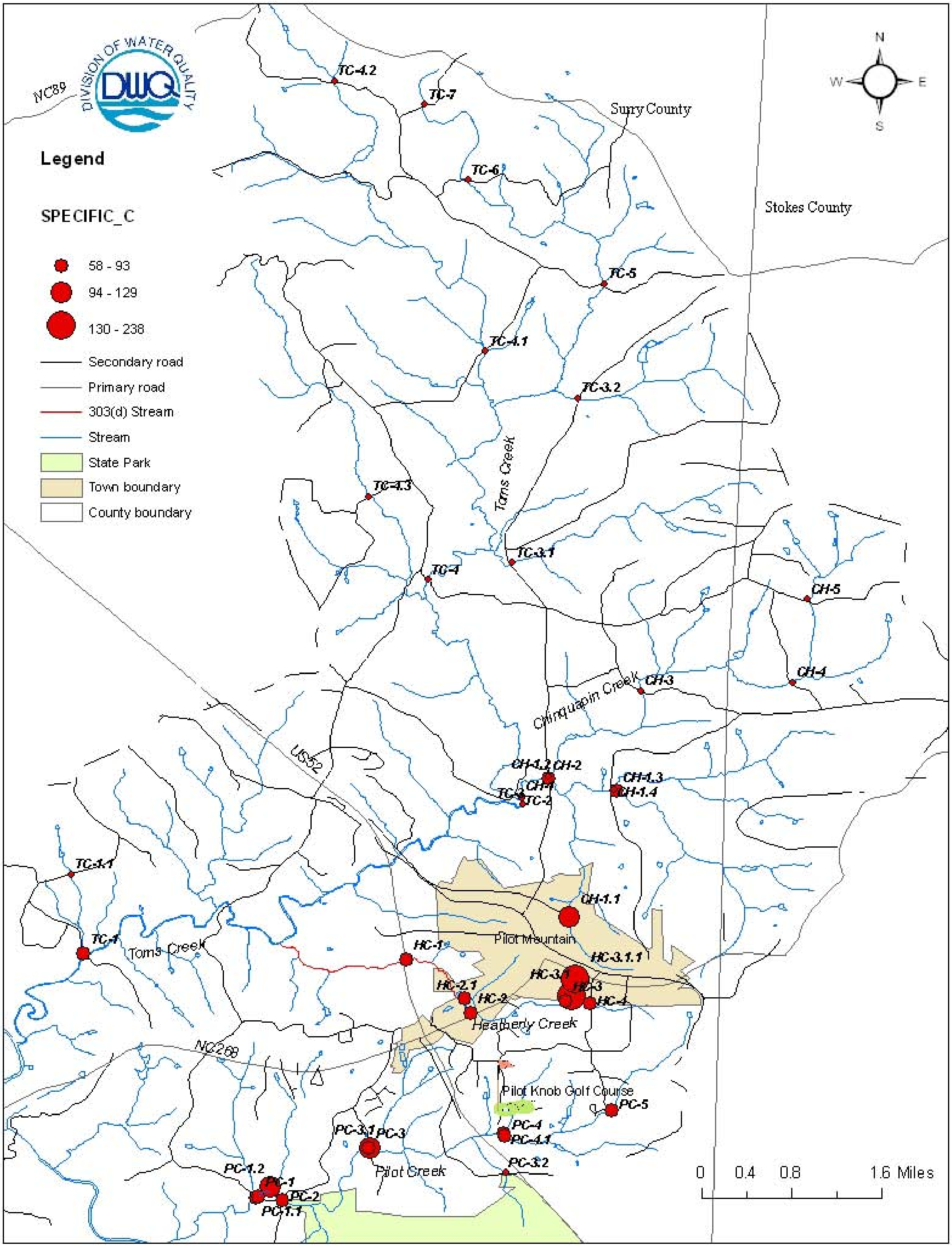


Figure 2. Specific conductance results (uS/cm) from recon in March 2011.

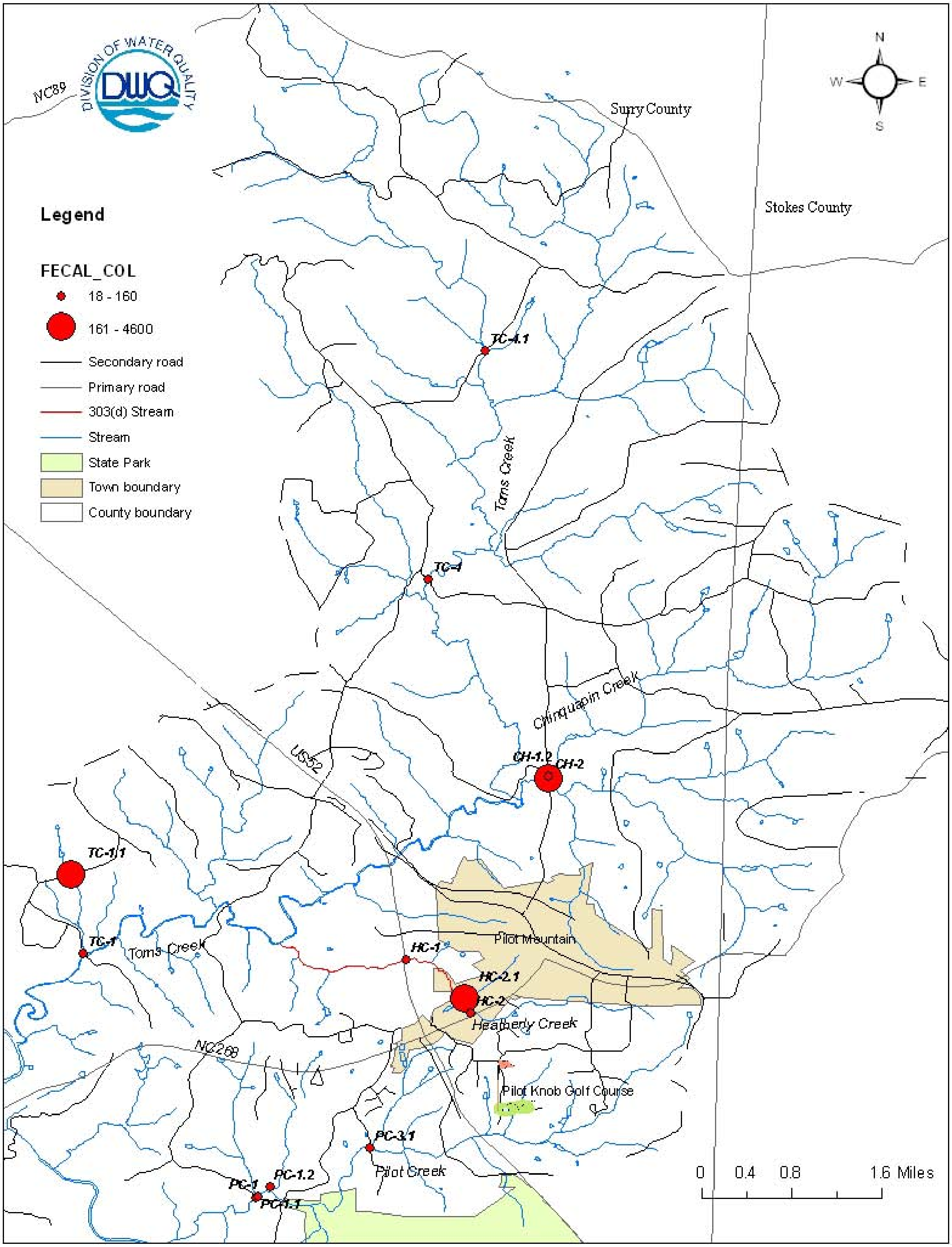


Figure 3. Fecal coliform bacteria results (cols/100 mL) from recon in March 2011.

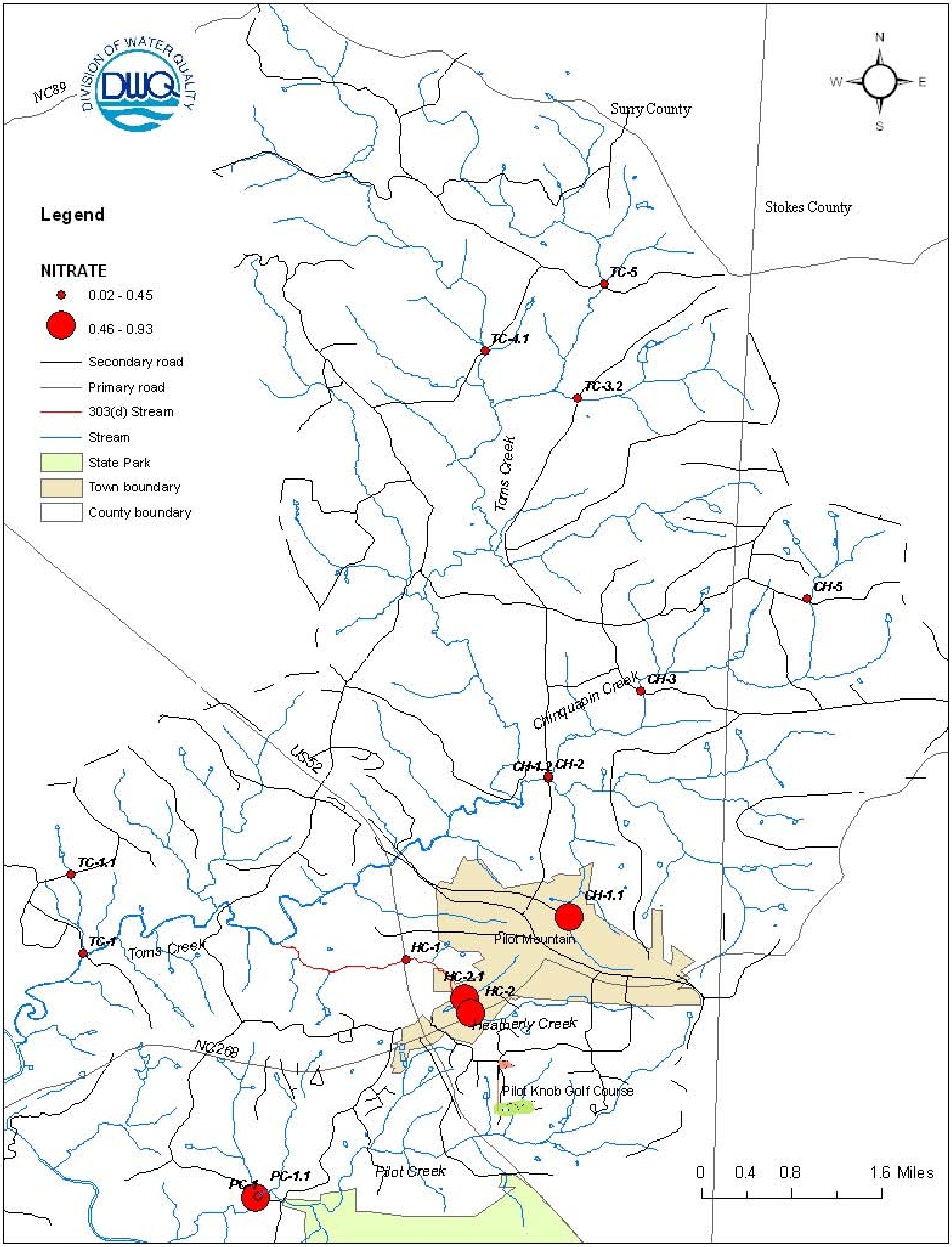


Figure 4. Nitrate-nitrite nitrogen results (mg/L) from recon in March 2011

Photo 1. Construction equipment storage yard on Academy Street along a UT to Heatherly Creek near South Davis Street (HC-3.1). A potential stormwater BMP location. Specific conductance at this tributary location was 238 uS/cm.

Photo 2. UT to Heatherly Creek at WWTP (HC-2.1). Further assessments needs to be conducted within this tributary due to somewhat elevated fecal coliform bacteria and nutrients relative to other locations in Heatherly Creek.

Photo 3. Heatherly Creek at US 52 (HC-1). The stream channel appeared to be over widened at this location. Undercut banks and root mats were exposed.

Photo 4. An upstream segment in Heatherly Creek at Academy Street (HC-4) noting the formation of point bars and depositional areas. Habitat conditions were degraded by sediment at this location and others throughout the planning area.

Photo 5. Pilot Creek at Seven Springs Lane (PC-5) upstream of the golf course noting a lack of riparian vegetation.

Photo 6. UT to Pilot Creek at Boyd Nelson Road (PC-3.1) indicating a degraded riparian zone. Specific conductance was highest of all locations in Pilot Creek drainage at 125 uS/cm.

Photo 7. Chinquapin Creek at SR1830 (CH-1). Note the turbid conditions 40 hours following a storm event of approximately two inches over a less than 24-hour period. Also note the stream bank erosion and coarse material located along the inside bend of the meander. Drainage area at this point is 9.4 square miles.

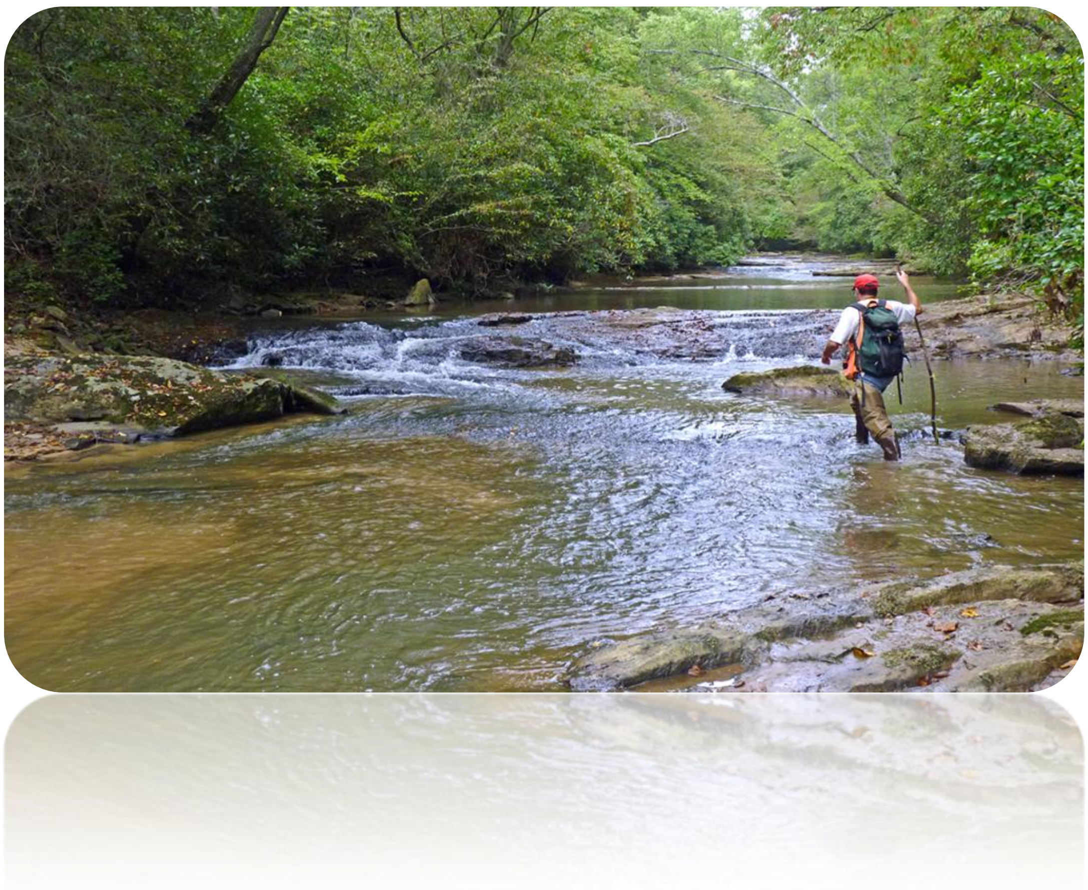

Photo 8. Chinquapin Creek at SR1809 (CH-2). Note the excessive sediment accumulation in the box culvert. The sediment is a likely stressor to habitat functions in Chinquapin Creek and other streams in the planning area.

Photo 9. Upstream view of a UT to Toms Creek at SR1811 (TC-4.1) where a cattle operation is located on both sides of the stream. Note riparian impacts.

Photo 10. UT to Toms Creek at SR1809 where an unknown upstream disturbance caused turbid conditions.

Water Quality Technical Memorandum for the Ararat Pilot Mountain Local Watershed Planning Area

Prepared by North Carolina Division of Water Quality
Watershed Assessment Team
August, 2012



Suggested Citation:

NCDWQ-WAT. 2012. Water Quality Technical Memorandum for the Ararat Pilot Mountain Local Watershed Planning Area. North Carolina Division of Water Quality, Watershed Assessment Team. Raleigh, NC.

Cover Photo: Toms Creek. Courtesy of Hal Bryson, NCEEP

Table of Contents

List of Figures

List of Tables

List of Figures in Appendix
(Field and Lab Data)

List of Exhibits in Appendix

Executive Summary

In January, 2011, the NC Division of Water Quality Watershed Assessment Team (NCDWQ WAT) began an evaluation of water quality within a 50 mi^2 area located in portions of Surry and Stokes County and the Town of Pilot Mountain (14-digit hydrologic unit code 03040101 110 030 and a portion of 03040101 110 050) as part of a Local Watershed Plan managed by the North Carolina Ecosystem Enhancement Program (NCEEP). This project was a re-start of the NCEEP planning process originally launched in 2008 in a 235 mi^2 area in the headwaters of the Yadkin River. The re-started effort is referred to as the Ararat-Pilot Mountain Local Watershed Plan (APM LWP). The overall goals of the APM LWP effort are to identify key local watershed problems and to develop a Project Atlas and a Watershed Management Plan to address the major stressors to water quality, hydrology and habitat within the focus area. The final Project Atlas will include candidate sites for traditional mitigation projects (stream and wetland restoration/enhancement and preservation) as well as urban and agricultural best management practices (BMPs).

Four named streams were included within the planning area including: 1) Toms Creek (38.4 mi^2 drainage area) classified as water supply (WS-II) with a supplemental classification of High Quality Waters (HQW) upstream of the water intake for the Town of Pilot Mountain and is Class C downstream of the Town's intake; 2) Heatherly Creek (2.6 mi^2 drainage area), a tributary to Toms Creek, which is currently on the 2012 Draft 303(d) Impaired Waters List for biological impairment (has been since 2006) and is designated as Class C waters; Chinquapin Creek (9.4 mi^2 drainage area), which is a tributary to Toms Creek with a supplemental classification of High Quality Waters (HQW); and, Pilot Creek (7.4 mi^2) designated as Class C waters. The planning area was divided into 10 subwatersheds (~ 5.0 mi^2 each) to help organize assessment activities and prioritize problem areas.

The water quality evaluation summarized within this report was completed in March, 2012. Specific tasks included: 1) a preliminary field reconnaissance of water quality conditions to prioritize where further monitoring needed to occur; 2) the identification of a mostly undisturbed reference site for comparison purposes; 3) follow-up chemical/physical monitoring to identify sources of water quality problems (including biological impairment of Heatherly Creek) and to locate potential mitigation projects and BMPs; 4) the assessment of benthic (12 sites) and fish (six sites) communities; 5) habitat and channel assessments; and, 6) a nutrient assessment related to the Pilot Knob golf course. This report summarizes the results of all the tasks above except for those related to task 4 (benthic and fish assessments).

The field reconnaissance involved a onetime sampling of 40 locations over a four-day period in March, 2011. The sampling included field measurements (specific conductance, dissolved oxygen, pH and water temperature) for all 40 locations. Nutrient samples (nitrate + nitrite nitrogen, ammonia nitrogen, total Kjeldahl nitrogen and total phosphorus) were collected from 16 locations. Fecal coliform samples were collected from 13 locations. Observations were also noted related to channel and

aquatic habitat conditions. The reconnaissance identified 32 locations for further monitoring.   Eight were recommended for elimination from further consideration.

Follow-up chemistry, fecal coliform sampling and channel/habitat assessments were initiated in June, 2011 and finalized in March, 2012. For the most part, water quality associated with streams draining the Town of Pilot Mountain was found to be more degraded than reference conditions and catchments outside of the Town limits. Some of these problems may be the result of leaking sewer lines. Water quality conditions have apparently improved in Heatherly Creek to the extent that it potentially may be removed from the 2014 impaired waters list. There were a few locations outside the Town limits where water quality remained uncertain because time constraints prevented further monitoring. These sites were recommended for additional monitoring and data collection.

As part of the follow-up monitoring and assessment to help identify where mitigation and BMPs may be needed, nearly six miles of stream channel and habitat conditions were assessed and scored using NCDWQ Biological Assessment Unit's (BAU) Mountain/Piedmont Habitat Assessment Form Revision 7, 3/09 (NCDWQ-BAU, 2011). Habitat conditions were mixed throughout the planning area, ranging from riparian zones that lacked woody vegetation and had extreme bank erosion and sedimentation to those with stable banks and wide, forested riparian zones with a good mix of substrates.

Locations for traditional mitigation projects and BMPs that NCEEP may decide to pursue were identified throughout the planning area. It was recommended that three locations be considered for preservation, nine for riparian restoration and two for storm water BMPs. It was also recommended that an equipment storage facility, within the Town's limits, be contacted by NCDWQ's regional office to conduct an inspection of the site to identify where storm water BMPs may be beneficial

Introduction

In January, 2011, the North Carolina Ecosystem Enhancement Program (NCEEP) re-started a local watershed planning process that originally began in 2008 in a 235 mi^2 area in the headwaters of the Yadkin River. The focus area for the present study consists of 50 mi^2 which lies within the 14-digit hydrologic unit code (HUC) 03040101 110 030 and a portion of 03040101 110 050. This area was further divided into ten subwatersheds, roughly five mi^2 each (Figure 1 below). This restarted effort is referred to as the Ararat-Pilot Mountain Local Watershed Plan (APM LWP). The overall goals of the APM LWP effort are to identify key local watershed problems and to develop a Project Atlas and a Watershed Management Plan to address the major stressors to water quality, hydrology and habitat within the focus area. The final Project Atlas will include candidate sites for traditional mitigation projects (stream and wetland restoration/enhancement and preservation) as well as urban and agricultural best management practices (BMPs).

A Scope of Work (SOW) was developed by personnel from the North Carolina Division of Water Quality Watershed Assessment Team (NCDWQ-WAT) and NCEEP and finalized in August, 2011 (NCDWQ-WAT, 2011a). The SOW outlined and described water quality monitoring and assessment tasks to be completed by NCDWQ-WAT at various stream locations. An estimate of effort and costs was also prepared for budgetary purposes. Standard Operating Procedures (SOPs) for chemical and biological sampling were provided in the SOW.

Tasks outlined in the SOW were based partly on: (1) the goals and objectives identified by stakeholders during a meeting at the Pilot Center in the Town of Pilot Mountain in February, 2011; (2) field reconnaissance (see description in paragraph below) work conducted by NCDWQ-WAT in March, 2011 (NCDWQ-WAT, 2011b); and, (3) previously collected data related to the initial watershed planning process conducted in 2008. A summary of the initial work completed by NCDWQ-WAT and NCEEP is available in hyperlink format in the Reference section (NCDWQ-WAT, 2009).

The field reconnaissance was conducted over a four-day period in March, 2011 (NCDWQ-WAT, 2011b). The purpose was to rapidly assess chemical and physical water quality conditions throughout the planning area at road-accessible locations to help prioritize where further monitoring needed to occur. Field measurements (specific conductance, dissolved oxygen, pH and temperature) were recorded for 40 locations. Nutrient samples (nitrate + nitrite nitrogen, ammonia nitrogen, total Kjeldahl nitrogen and total phosphorus) were collected from 16 locations. Fecal coliform samples were collected from 13 locations. Samples were sent to NCDWQ’s laboratory for analysis.

This document reports on the results of the water quality monitoring and assessments conducted in March, 2011 through March 2012 including reconnaissance data.

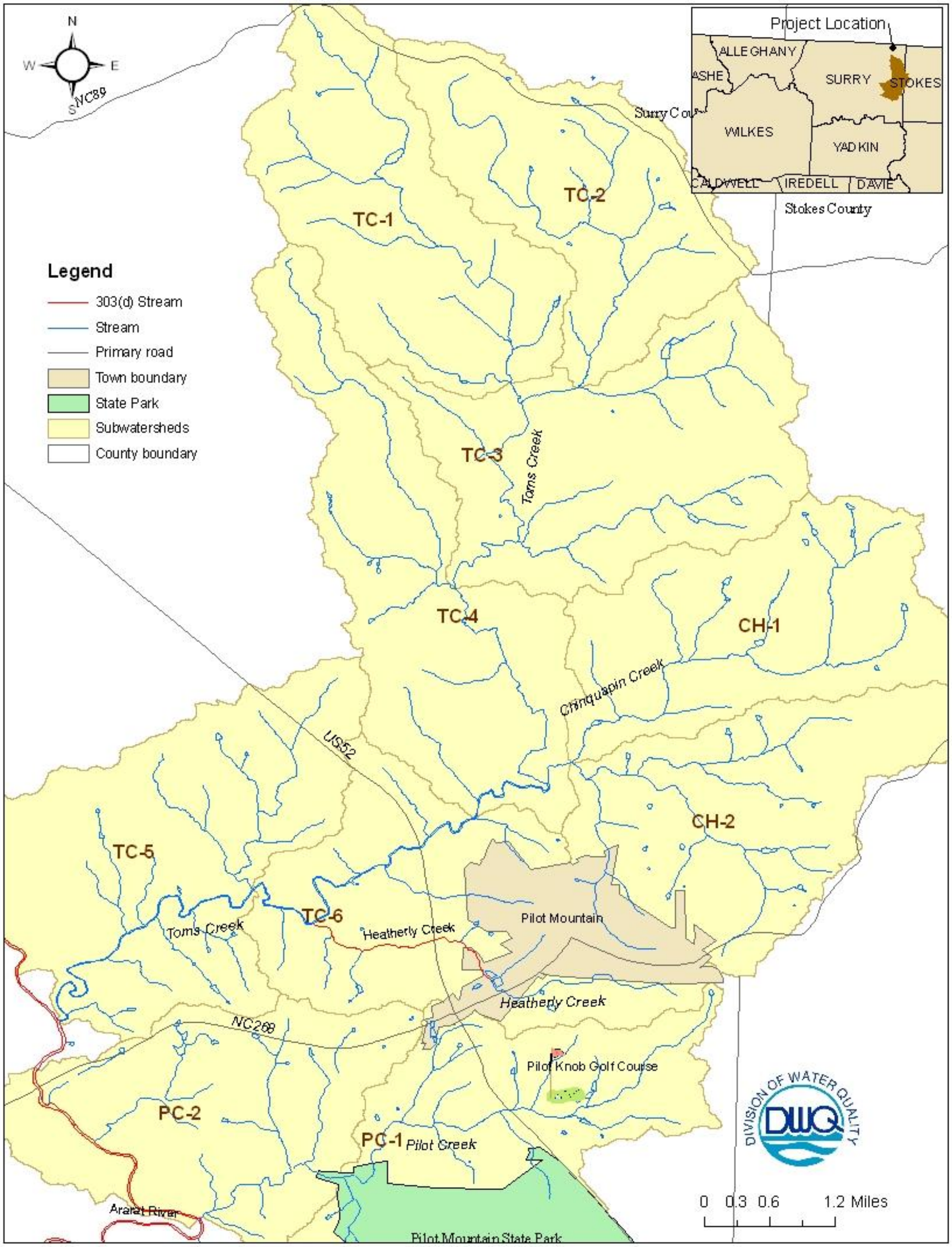


Figure 1. Ararat - Pilot Mountain Local Watershed Planning area.

Methods

Based on the results of the reconnaissance (NCDWQ-WAT, 2011b) and iterative reviews of data collected throughout the monitoring period, 35 locations were selected for further monitoring, including one reference site. Of those, 27 were selected for fecal bacteria and nutrient follow-up sampling (stressor identification/follow-up); nine were selected for habitat/channel assessments, 12 were selected for benthic macroinvertebrate surveys, and six for fish community assessments. Monitoring and assessments at these locations occurred during June, 2011 through March, 2012.

The follow-up locations were selected based on a number of factors listed below.

- Where comparatively higher results for specific conductance or nitrate + nitrite were observed;
- Where fecal coliform bacteria results were greater than 200 cfu/100 mL;
- Where habitat conditions were judged to be degraded;
- Where livestock were observed to have access to the stream channel;
- To compare with existing historical data;
- To assess biological conditions where no previous biological data existed; and,
- To investigate reasons for biological impairment (e.g., Heatherly Creek).

Water quality monitoring and assessment activities outlined in the SOW were organized into the four groups of activities described below. The type of monitoring activities, locations and map codes (corresponding to map Figures) are presented in Table 1.

Physical/Chemical Assessments [27 sites]: The objectives and outcome of this task were to identify water quality problem areas and sources of water quality degradation, and to identify potential sites where best management practices may be needed.

This task involved water quality sampling at several locations (listed in Table 1 and shown in Figure 2 below) based on evidence from the field reconnaissance that suggested a potential upstream problem may exist (e.g., leaking sewer lines, failing septic systems, straight pipes, or livestock waste). The parameters measured included field meter readings (dissolved oxygen, pH, temperature and specific conductance), nutrients (nitrate + nitrite nitrogen, ammonia nitrogen, total Kjeldahl nitrogen, and total phosphorus), chloride and fecal coliform bacteria. Samples were collected in baseflow conditions, defined as no rain within 48 hours prior to sampling. After laboratory results were received, additional sampling occurred at the same location to confirm results or (in some cases) further upstream to pinpoint a source.

Biological Assessments [12 benthic sites; six fish sites]: The objectives and outcome of this task were to determine the status of biological communities and to identify stressors that may be degrading aquatic communities.

Both fish and benthic macroinvertebrate communities were surveyed at various locations (listed in Table 1 and shown in Figure 2 below). Personnel from NCDWQ-WAT and NCEEP surveyed benthic communities. Personnel from the North Carolina Department of Transportation (NCDOT) led the fish surveys with assistance from NCEEP. The benthic and fish reports were submitted to NCEEP as separate technical reports in November, 2011 (NCDWQ-WAT, 2011c and NCDOT, 2011, respectively). Neither the fish nor benthic results will be discussed in this report.

Aquatic Habitat and Channel Assessments [9 sites/reaches]: The objectives and outcome of this task were to conduct visual habitat and channel assessments to build a more complete picture of habitat conditions throughout the planning area, to judge the extent to which bank erosion/sediment may have contributed to habitat degradation and sediment loading, and to identify potential mitigation sites or areas where best management practices may be needed.

Locations for habitat assessments (listed in Table 1 below) were selected based on a number of factors listed below.

- Sites were chosen where benthics were not assessed;
- Where observations made during the reconnaissance indicated that habitat conditions were degraded;
- Where aerial photography indicated a lack of riparian buffers; and,
- In some cases, where follow-up work was planned to investigate sources of degraded water quality as described below in the Stressor Source Identification and Follow-up section.

This task involved walking upstream to observe the channel and riparian area and completing the NCDWQ Biological Assessment Unit's (BAU) Mountain/Piedmont Habitat Assessment Form Revision 7, 3/09 (NCDWQ-BAU, 2011) rating several metrics to obtain a total numerical score of habitat conditions.

Stressor Source Identification and Follow-up [11 sites]: The objectives and outcome of this task were to investigate upstream problem areas as identified by physical/chemical assessments or by other means (e.g., suggested by stakeholders, identified during the course of field assessments or aerial photo review), to determine the sources of elevated fecal coliform bacteria and nutrients, or the reason(s) for degraded biological communities, and to identify potential mitigation sites or areas where best management practices may be needed.

This task involved walking upstream (streamwalks) along the riparian area and in the stream channel to locate problem areas and collect additional samples (fecal coliform, chloride, nutrients and field meter readings) if warranted and to identify problem areas that may help explain water quality and biological community degradation. This effort usually coincided with habitat assessments.

Table 1. Monitoring and assessment objectives, locations and descriptions.

Location	Subwatershed	Map Code	Drainage Area (square miles)	Monitoring Objective	Benthic	Fish	Habitat/Channel Assessments	Physical/Chemical
Chinquapin Creek at SR 1830 Matthews Road	TC-4	CH-1	9.4	Habitat assessment			x	
UT to Chinquapin Creek at Old US 52	CH-2	CH-1.1	0.3	Habitat assessment; Investigate high specific conductance; Bacteria source ID			x	x
UT to Chinquapin Creek at SR 1809 Old Westfield Road		CH-1.2	4.9	Determine status of biological communities; Bacteria source ID	x	x		x
UT to Chinquapin Creek at SR 1837 Carson Road (right branch looking upstream)		CH-1.3	1.7	Habitat assessment; bacteria source ID			x	x
UT to Chinquapin Creek at SR 1837 Carson Road		CH-1.4	2.0	Habitat assessment; bacteria source ID			x	x
Chinquapin Creek at SR 1809 Old Westfield Road	CH-1	CH-2	4.4	Determine status of biological communities	x	x		
Chinquapin Creek at SR 1835 Hills Presby Church Road		CH-3	3.4	Habitat assessment			x	
Chinquapin Creek at SR 1202 Wilson Road		CH-4	1.8	Bacteria and nutrient assessment				x
Heatherly Creek at US 52	TC-6	HC-1	1.6	Determine status of biological communities	x	x		
Heatherly Creek at NC 268		HC-2	0.8	Determine status of biological communities	x			
UT to Heatherly Creek at WWTP on Lynchburg Road		HC-2.1	0.2	Habitat assessment; Bacteria source ID			x	x
Heatherly Creek near South Davis Street		HC-3	0.5	Habitat assessment; Bacteria source ID			x	x
UT to Heatherly Creek near South Davis Street		HC-3.1	0.1	Bacteria and nutrient assessment				x
Pilot Creek at SR 2047 Jim McKinney Road	PC-1	PC-1	6.0	Determine status of biological communities	x	x		
UT to Pilot Creek at SR 2047 Jim McKinney Road		PC-1.1	0.7	Bacteria source ID				x
UT to Pilot Creek at Private Drive off Jim McKinney Road		PC-1.2	0.9	Bacteria and nutrient assessment				x
Pilot Creek at SR 2954 Boyd Nelson Road		PC-3	3.2	Bacteria source ID				x
UT to Pilot Creek upstream of SR 2028 Shoals Road (Reference)		PC-2.1	0.8	Reference site for data comparisons	x	x		x

Location	Subwatershed	Map Code	Drainage Area (square miles)	Monitoring Objective	Benthic	Fish	Habitat/Channel Assessments	Physical/Chemical
UT to Pilot Creek at SR 2954 Boyd Nelson Road	PC-1	PC-3.1	0.5	Habitat assessment; Bacteria source ID; Investigate high specific conductance			x	x
Pilot Creek at Sandtrap Lane		PC-4	1.4	Determine status of biological communities; Nutrient assessment downstream of golf course	x			x
UT to Pilot Creek at Sandtrap Lane		PC-4.1	0.3	Bacteria and nutrient assessment				x
Pilot Creek at Seven Springs Lane		PC-5	0.5	Determine status of biological communities; Nutrient assessment upstream of golf course	x			x
Pilot Creek at Pilot Mtn SP Road upstream of Reference		PC-6	5.3	Bacteria and nutrient assessment				x
UT to Toms Creek at SR 2022 Community Building Road	TC-5	TC-1.1	0.2	Bacteria and nutrient assessment				x
UT to Toms Creek at SR 1815 West Dobson Mill Road		TC-1.2	3.0	Bacteria and nutrient assessment				x
Toms Creek at SR 1830 Matthews Road	TC-4	TC-2	18.3	Determine status of biological communities	x			
Toms Creek at SR 1812 Jessup Grove Church Road		TC-4	16.0	Bacteria source ID				x
UT to Toms Creek at SR 1825 Tom Hunter Road		TC-4.3	1.3	Habitat assessment; Bacteria source ID			x	x
UT to Toms Creek at SR 1812 Jessup Grove Church Road		TC-4.4	2.8	Bacteria and nutrient assessment				x
UT to Toms Creek at SR 1809 Old Westfield Road	TC-3	TC-3.1	1.5	Determine status of biological communities	x			
UT to Toms Creek at SR 1809 Old Westfield Road and Rosa Lee Lane		TC-3.2	1.5	Bacteria and nutrient assessment				x
Toms Creek at SR 1811 Toms Creek Church Road	TC-2	TC-5	3.3	Determine status of biological communities; Bacteria source ID	x	x		x
Toms Creek at SR 1804 Bryan Road		TC-6	1.0	Bacteria and nutrient assessment				x
UT to Toms Creek at SR 1811 Cleo Cain Road	TC-1	TC-4.1	3.6	Determine status of biological communities; Bacteria source ID	x			x
UT to Toms Creek at SR 1806 Toms Creek Church Road		TC-4.5	2.2	Bacteria and nutrient assessment				x

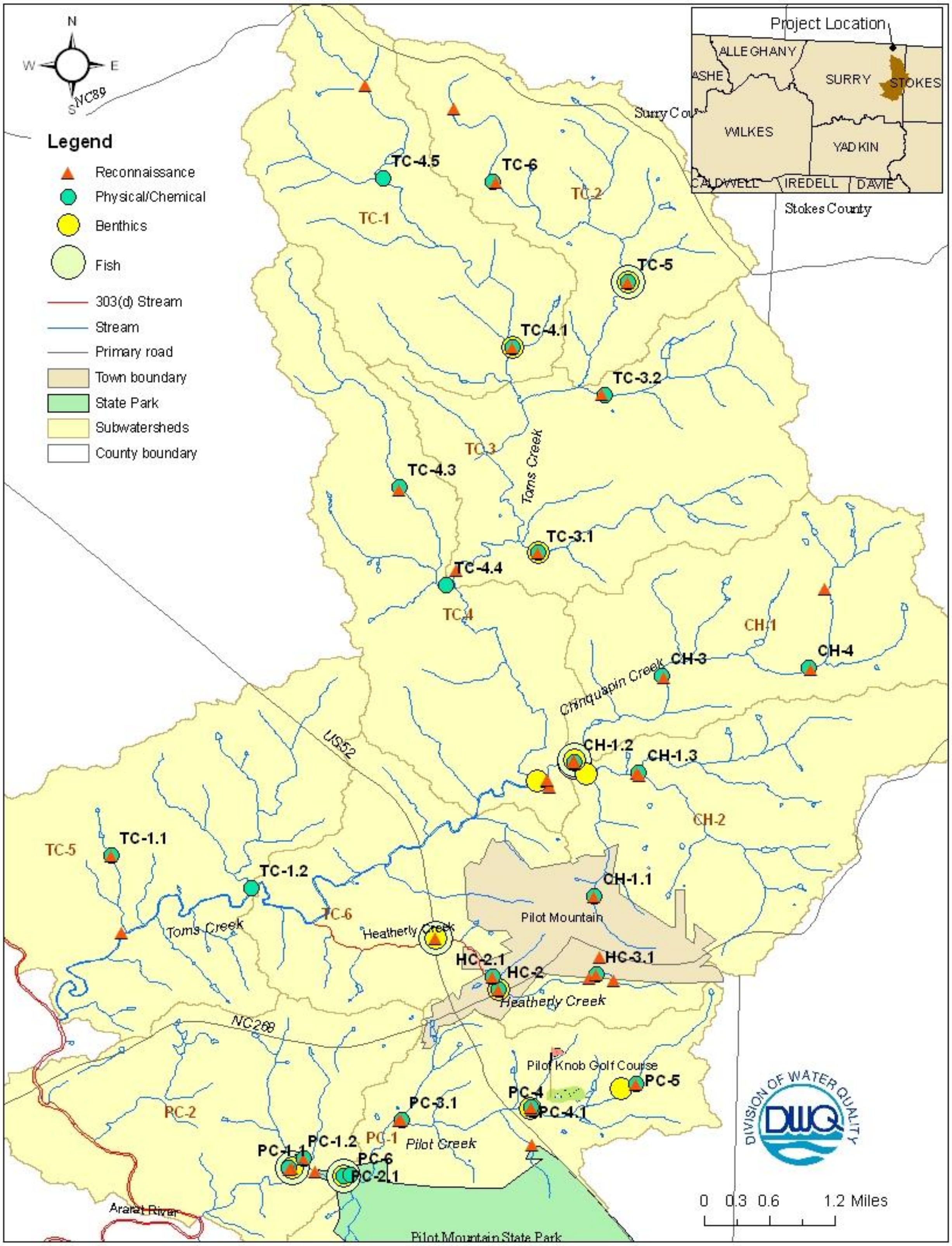


Figure 2. Biological and physical/chemical monitoring locations throughout the planning area.

Descriptions of Subwatersheds.

A general description of each major drainage area, including land-use characteristics, is provided below. Monitoring location map codes are explained in Table 1 above.

Heatherly Creek (in Subwatershed TC-6) has a drainage area of 2.6 mi^2. All of the water quality monitoring and assessments were conducted upstream of US 52, within or downstream of the mostly urban area of the Town of Pilot Mountain. Historically, the Town's wastewater treatment plant (WWTP) discharged treated effluent to Heatherly Creek. This discharge point was moved to the Ararat River in 1996. Heatherly Creek was listed on North Carolina's 303(d) Impaired Waters List for biological impairment in 2006, 2008, 2010 and 2012. Heatherly Creek eventually converges with Toms Creek about 1.0 mile downstream of US 52.

Chinquapin Creek (in Subwatersheds CH-1 and CH-2) drains to Toms Creek (Subwatershed TC-4). Chinquapin Creek (along with Toms Creek) supplies water to the Town of Pilot Mountain and is designated as Water Supply (WS-II) with a supplemental High Quality Waters (HQW) designation. It has a drainage area of 9.4 mi^2 (at the confluence with Toms Creek). The Chinquapin Creek subwatersheds are mostly rural and forested with scattered livestock operations and crop fields of tobacco and corn. Two tributaries (in Subwatershed CH-2) drain urban portions of the Town of Pilot Mountain along Old US 52.

Pilot Creek (in Subwatersheds PC-1 and PC-2) has a drainage area of 7.4 mi^2 and is mostly rural and agricultural, although there are urban/commercial portions along NC 268 and US 52 as well as a golf course (Pilot Knob Park Golf and Swim Club) east of US 52. A mostly forested northern section of Pilot Mountain State Park is drained by Pilot Creek. Pilot Creek converges with the Ararat River about 1.0 mile downstream of SR 2047 (Jim McKinney Road). The reference stream chosen for this project (0.8 square mile drainage area) is a UT to Pilot Creek (PC-2.1) that drains a portion of Pilot Mountain State Park. It is mostly forested but includes a small area of agricultural land.

Toms Creek (in Subwatersheds TC-1, TC- 2, TC-3, TC-4, and TC-5) has a drainage area of 38.4 mi^2 and includes the Chinquapin Creek and Heatherly Creek drainage areas. The Toms Creek drainage area is mostly rural and forested with scattered livestock operations and crop fields of tobacco and corn. Toms Creek is a Water Supply watershed (WS-II) with a supplemental HQW designation upstream of the raw water intake located near Old US 52. Downstream of the intake, Toms Creek is designated Class C.

Results

Physical and Chemical Assessments

This section provides a summary of the water quality data collected during monitoring at each of the locations and the reference site. Only specific conductance, nitrate + nitrite nitrogen (hereafter written as NO_x) and fecal coliform bacteria will be presented in this section since these parameters were most notable and indicative of potential problem areas. The data are presented using two methods: (1) by whisker box plots of individual measurements at each location and parameter using JMP® statistical software version 8.0; and (2) geospatially using ESRI® ArcMap™ version 9.3.1 to plot medians for each location and parameter. Figure 4 below provides an example with explanations of summary statistics. Box plots summarizing the entire field and laboratory data set by monitoring location are provided in the Appendix. Median data displayed geospatially for each location are provided below in Figures 5, 7 and 9. Data from the reference site (labeled and shown as a hashed line in the box plots) are medians based on all analyses or meter readings collected from the reference site (n=4), except for fecal coliform which are presented as the geometric mean (n=4).

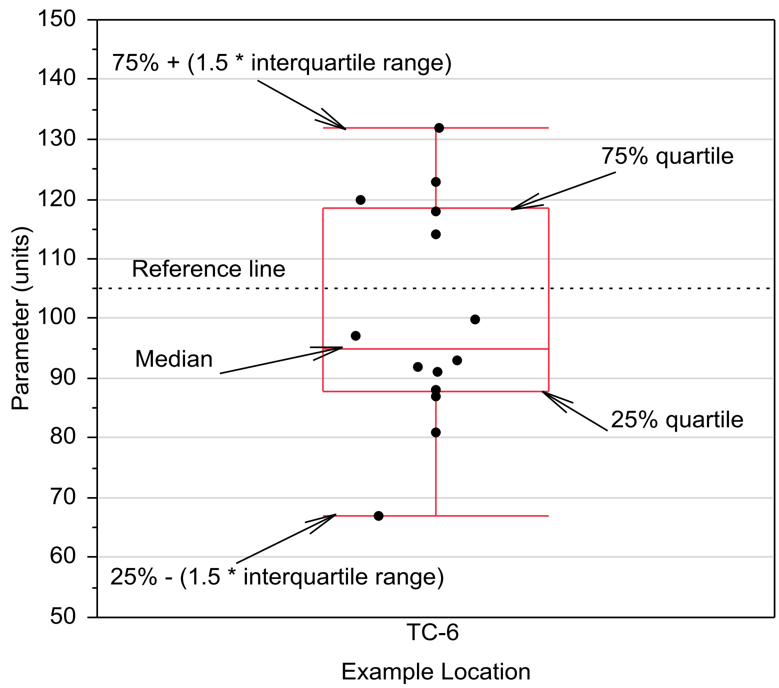


Figure 3. Example whisker box plot with summary statistics. Reference line (value) represents data collected from the UT to Pilot Creek (PC-2.1). The reference line is the median (or geometric mean of fecal coliform), n=4.

Subwatershed Results

Specific Conductance

Specific conductance is a measure of the capacity of water to conduct an electrical current. It is an indirect measure of the presence of dissolved ionic solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron. Conductance increases with increasing amounts of ions. These ions, which come from several sources (e.g., soil, underlying bedrock, decaying organic matter, roads, fertilizers, leaking septic systems and sewer lines and illicit connections/discharges) conduct electricity because they are negatively or positively charged when dissolved in water. There is not a state water quality standard for specific conductance, but it is a good field indicator of where potential problems may exist. The presence of dissolved ionic solids and elevated specific conductance may or may not indicate water pollution.

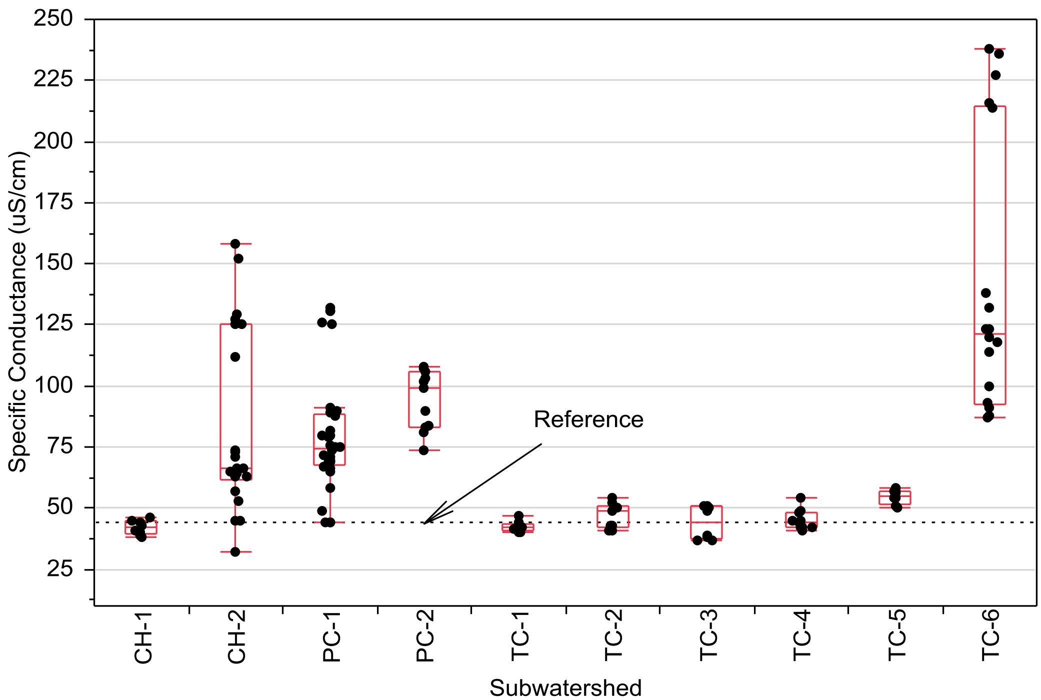


Figure 4. Specific conductance (uS/cm) for select locations.
Reference value (44 uS/cm) is median, n=4.

Specific conductance ranged from a low of 32 uS/cm at 25°C in Subwatershed CH-2 to a high of 238 in Subwatershed TC-6 as shown in Figure 4 above. Subwatersheds with the least amount of variability and with specific conductance similar to the reference value (44 uS/cm) included mostly rural catchments within Subwatersheds TC-1, TC-2, TC-3, TC-4, TC-5 and CH-1. Notable departures from the reference value included Subwatersheds PC-1, PC-2, CH-2 and TC-6.

As shown in Figure 5 below, the highest median values were associated with catchments that drain portions of the Town of Pilot Mountain and Pilot Knob Golf Course in Subwatersheds CH-2, PC-1 and TC-6.

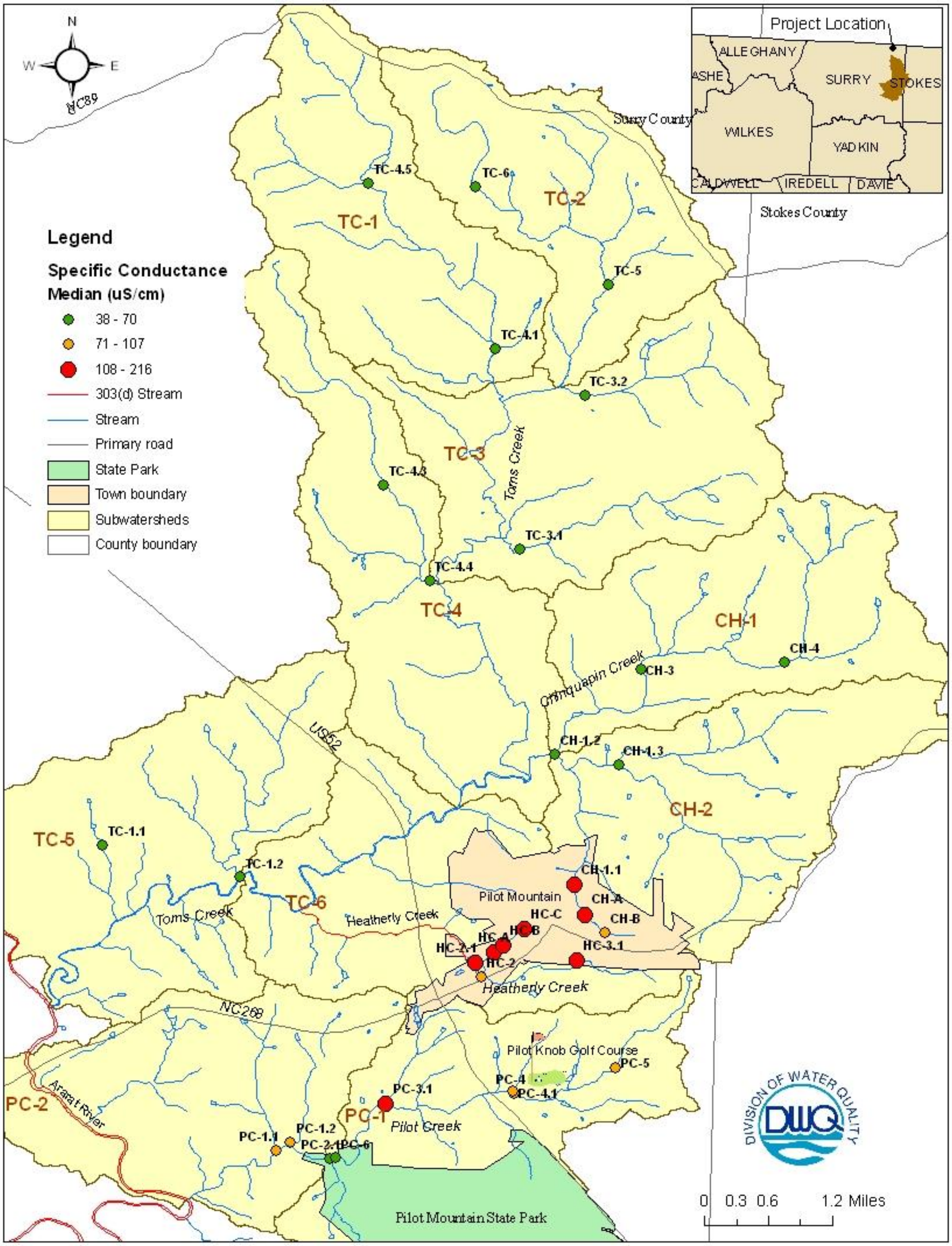


Figure 5. Median specific conductance (uS/cm) for select locations.

Nutrients

Nutrient data (in this case, NO_x) were also collected to help pinpoint where upstream problem areas may exist. Elevated NO_x levels may be related to excess chemical fertilizer use, sewer line or septic tank failures, or degraded buffer zones (lack of high quality riparian buffers at least 50 ft. wide) along streams.

It is difficult to assess problems (or degraded water quality and water quality functions) associated with nutrients in streams because there are no applicable state water quality standards for nutrients, with the exception of that for nitrate nitrogen (10 mg/L), which is not applicable to in-stream biological impacts but rather towards human health. Also, a higher concentration at one location relative to another does not indicate there necessarily is a problem at that location.[1] However, we can compare these data relative to data collected from a reference stream. In theory, some value above the reference value could be evidence of possible water quality impacts or a stream system with degraded water quality functions (for this planning area).

Observations of nutrient response factors such as the amount of biofilm growth on stream substrates (periphyton/algae/bacteria) can also provide evidence of excessive nutrients that otherwise could not be surmised by assessing laboratory data alone.

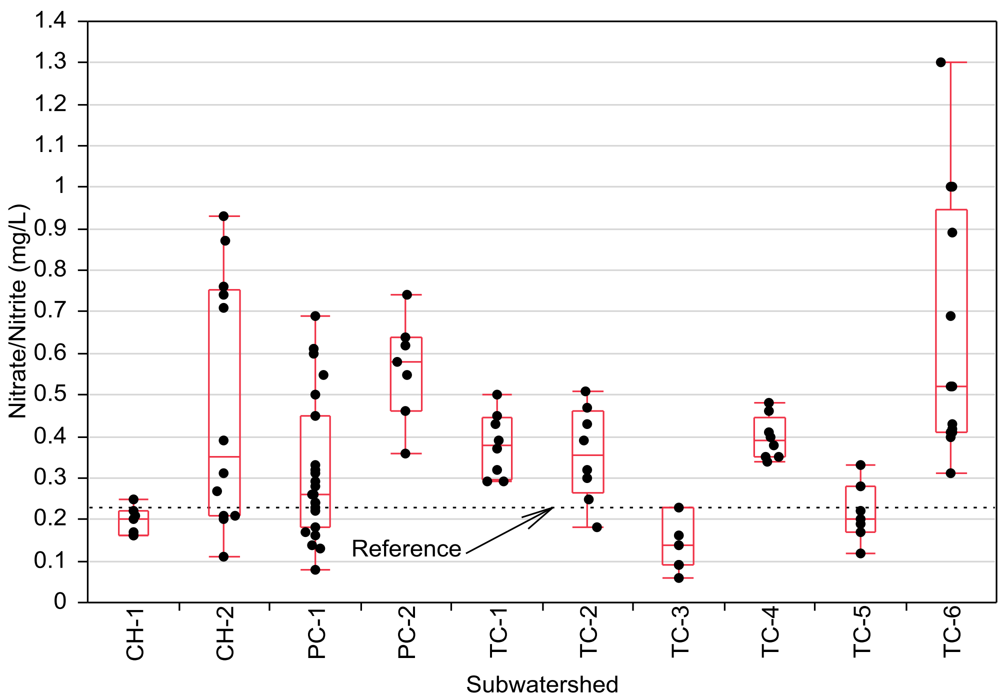


Figure 6. Nitrate + nitrite concentrations (mg/L) for select locations.
Reference value (0.23 mg/L) is median, n=4.

[1]To fully assess nutrient dynamics within a stream ecosystem, it would be necessary to conduct tracer studies that measure nutrient uptake length, which is the average distance traveled by a dissolved nutrient before biotic uptake (Hauer and Lamberti, 2007). Field studies of this type are beyond the scope of this assessment.

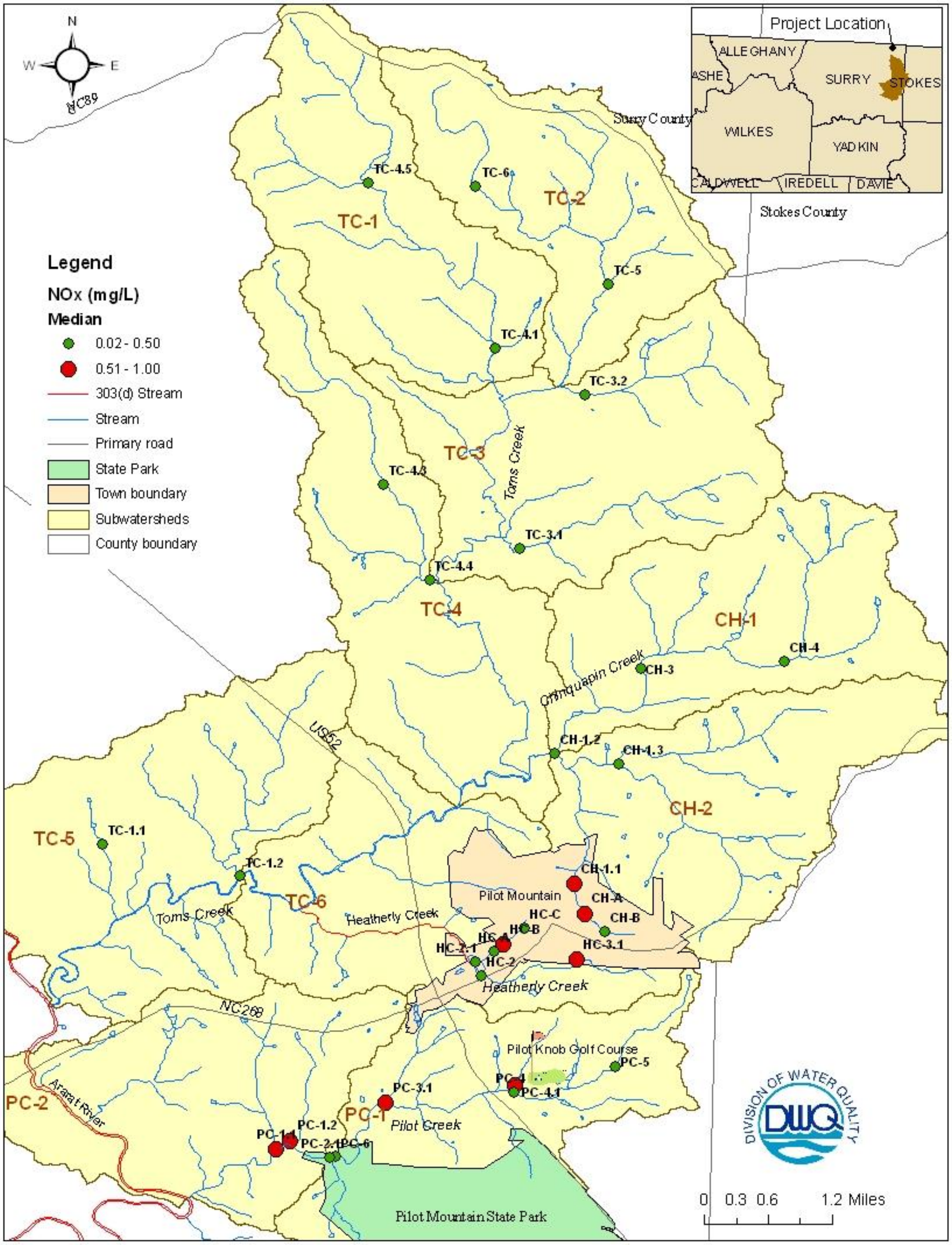


Figure 7. Median nitrate + nitrite concentrations (mg/L) for select locations.

In general, locations with elevated NO_x values correlated with locations where specific conductance was elevated (r = 0.60; see Exhibit 1 in the Appendix). These included catchments draining the Town of Pilot Mountain (Subwatersheds CH-2 and TC-6) and catchments within the Pilot Creek drainage (Subwatershed PC-1) associated with a tributary draining the golf course and tobacco fields and, unexpectedly, two catchments that were mostly forested in Subwatershed PC-2 (Figures 6 and 7 above). The lowest value (0.06 mg/L) was a mostly forested catchment in a tributary to Toms Creek within Subwatershed TC-3.

Fecal coliform bacteria

Fecal coliform bacteria are indicators of pathogenic organisms that potentially may be present (Hauer and Lamberti, 2007). Fecal coliform samples were collected to investigate potential upstream problem areas (i.e., leaking sewer lines, sewer overflows, septic tank failures, livestock access to stream channel). They were not collected to assess if fecal coliform water quality standards were met; this would require a sampling frequency of five consecutive samples (from the same location) within a 30-day period. To meet the standard, the geometric mean of those five samples cannot exceed 200 colony forming units (CFUs)/100 mL nor 400 CFUs/100 mL in more than 20 percent of the samples over a 30-day period. Though the data from this project were not appropriate for determining exceedence of the water quality standard, the 200 CFUs/100 mL or greater counts were used as the threshold level which triggered further upstream monitoring and investigation.

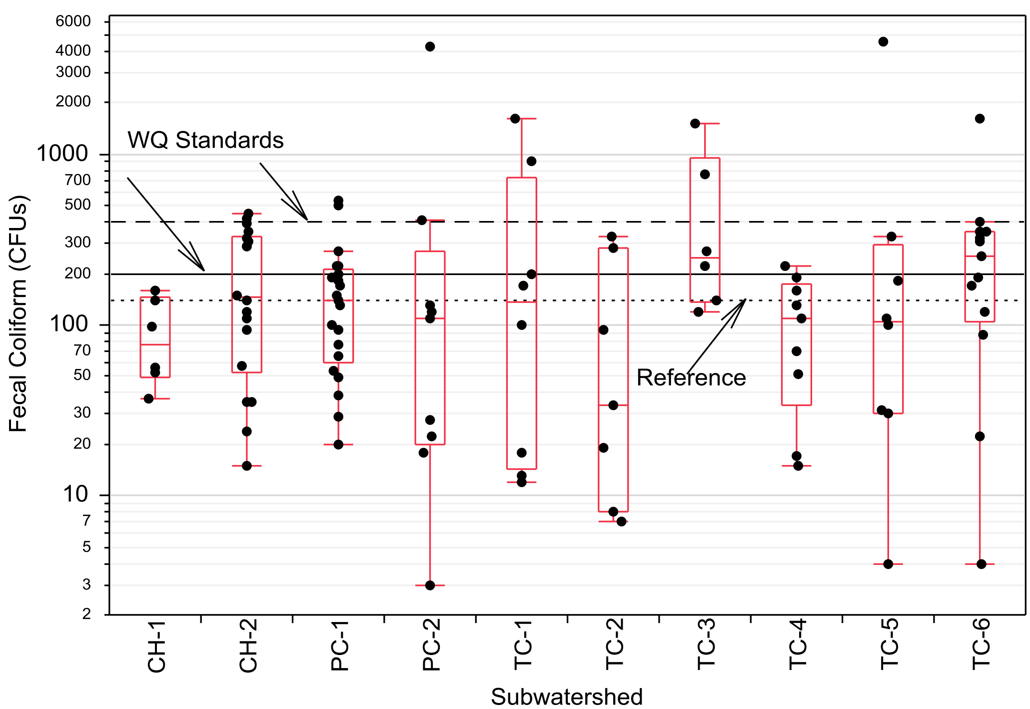


Figure 8. Fecal coliform bacteria for select locations (box plot is log scale).
Reference value (117 CFUs/100 mL) is geometric mean, n=4. Hashed lines at 200 CFUs/100 ml and 400 CFUs/100 mL are NCDWQ water quality standards. The standard requires that five samples be collected within a 30-day period, and that the geometric mean of those five samples cannot exceed 200 CFUs/100 mL or 400 CFUs/100 mL in more than 20 percent of the samples over that 30-day period.

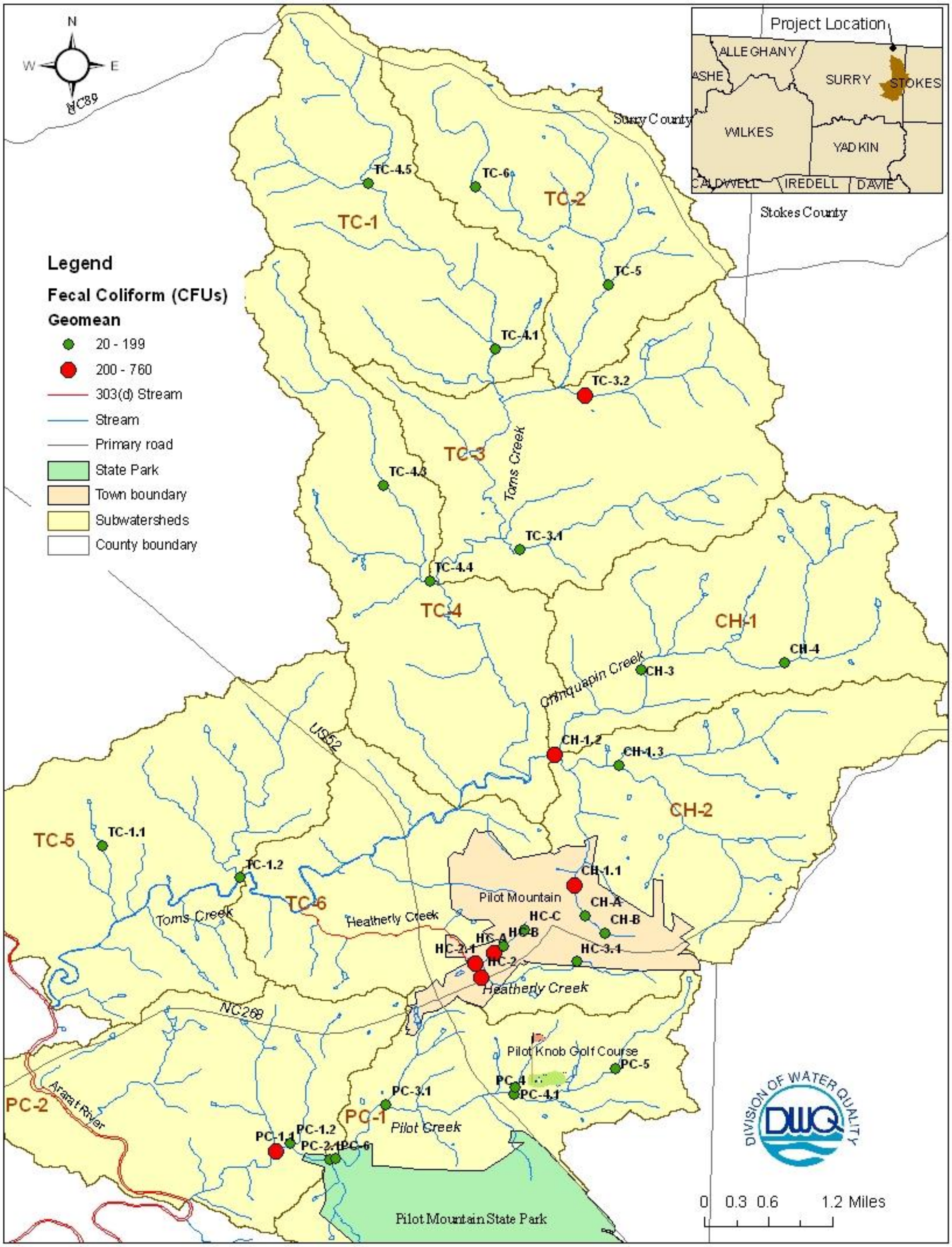


Figure 9. Fecal coliform bacteria (geometric mean) for select locations.

For the most part, fecal counts between subwatersheds were variable with both very high counts and very low counts (Figures 8 and 9 above). The highest and the lowest counts occurred in Subwatersheds PC-2, TC-5 and TC-6, ranging between 4600 to 3 CFUs. All subwatersheds had at least one count above the threshold level of 200 CFUs/100 mL except for Subwatershed CH-1, where all results were below that level. The reference site (geometric mean of four samples) was below the threshold level as well. For the most part, the highest geometric means were observed in catchments associated with the Town of Pilot Mountain in Subwatersheds CH-2 and TC-6 (Figure 9 above). There were two locations (one each in Subwatershed PC-2 and Subwatershed TC-3) outside of the Town's influence where geometric mean levels were above the threshold level (Figure 9 above).

By Drainage Area

This section presents the monitoring and assessment data collected as part of the stressor identification and follow-up work for each major drainage area, part of which involved assessing close to 6.0 miles of stream channel in various locations as described below.

Heatherly Creek Investigations

Two UTs to Heatherly Creek (HC-2.1, UT to Heatherly Creek near the WWTP and HC-3.1, UT to Heatherly Creek near South Davis Street) were selected for further investigations because the data collected during the field reconnaissance in March, 2011 were above the threshold level for fecal coliform and specific conductance was elevated relative to other locations (Figure 10 below). The follow-up investigations were also conducted to help identify sources and causes of biological impairment to Heatherly Creek related to leaking sewer lines, sewer overflows, septic tanks, illicit discharges or other nonpoint source pollution.

UT to Heatherly Creek near WWTP (HC-2.1). Two sampling events in March and June, 2011 in UT to Heatherly Creek near the WWTP (HC-2.1) resulted in elevated bacterial counts. This prompted further sampling In July, 2011 to pinpoint possible sources. Staff walked for approximately 0.5 mile along the sewer line right-of-way which parallels the tributary upstream of the Town of Pilot Mountain's wastewater treatment plant (WWTP) to collect additional samples (Figure 10 below). Follow-up sampling occurred in February and March, 2012 at four tributary locations to confirm results (Figure 10 and Table 2 below). Samples for chloride were also collected during this resampling effort. It was thought that chloride, which is soluble and present in raw sewage, might help indicate leaking sewer lines.

Fecal coliform data (in Table 2 below) show that there may be a sewer line leak or residue from previous sewer overflows near location HC-A. The geometric mean at the nearest downstream location (HC-2.1) was 225 CFUs/100 mL while the geometric mean at HC-A was 760 CFUs/100 mL. Data from the two locations further upstream were much lower and actually less than the reference value, i.e., geometric mean of 117 CFUs/100 mL.

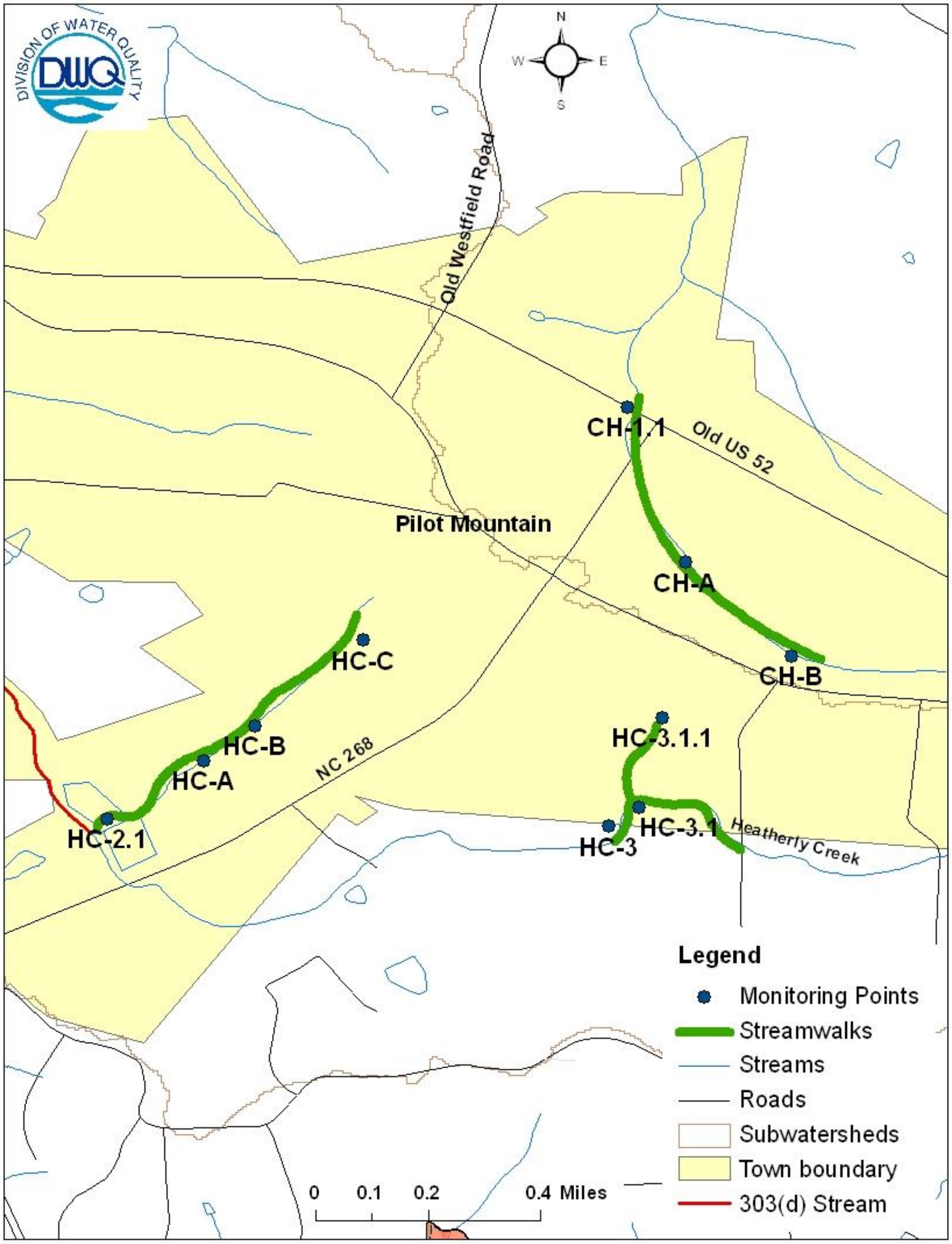


Figure 10. Follow-up assessments within the Town of Pilot Mountain.

Table 2. Water quality data collected from select locations in Heatherly Creek.

Map Code	Fecal Coliform (CFUs)				Specific Conductance (uS/cm)				Chlorides (mg/L)				Nitrate + Nitrite (mg/L)			
	N	Min	Geo Mean	Max	N	Min	Median	Max	N	Min	Median	Max	N	Min	Median	Max
HC-2.1	6	87	225	350	7	93	120	132	3	12	13	19	5	0.41	0.43	0.69
HC-A	2	340	760	1700	2	107	114	120	-	-	-	-	-	-	-	-
HC-B	3	20	83	220	3	119	120	129	3	5	13	14	3	0.51	0.52	0.60
HC-C	3	23	37	60	3	204	214	310	3	23	31	64	3	0.36	0.37	0.39
HC-3	1	93	93	93	2	81	86	92	-	-	-	-	-	-	-	-
HC-3.1	3	4	55	350	5	138	216	238	3	16	16	17	4	0.9	1.0	1.3
PC-2.1 ref	4	54	117	180	4	44	44	49	3	3.8	3.8	4.2	4	0.14	0.23	0.26

Chloride was not a definitive indicator of leaking sewer lines along this tributary. For example, median chloride at the most upstream location (HC-C) was the highest between locations at 31 mg/L but also has the lowest fecal count (geometric mean of 37 CFUs/100 mL). It was not clear why chloride was high at this location. Elevated chloride likely did contribute to specific conductance (r = .68, correlation analysis provided in the Appendix, Exhibit 1).

Habitat conditions were evaluated along the tributary (HC-2.1) and are compared with reference conditions in Table 3 below. The scores represent average conditions between locations HC-A and HC-C in Figure 10 above. Notable findings included the sewer line right-of-way; a wide, mature forested buffer along the right riparian area (facing upstream); and a perched culvert from a storm water detention pond servicing a housing development along the left side of the channel (facing upstream) which was causing scour along the stream bank. The total score for this segment was 74 and the reference total score was 88.

Table 3. Habitat scores recorded for Heatherly Creek.

Habitat Metrics	Habitat Scores		
	UT to Heatherly Ck at WWTP HC-2.1	Heatherly Creek near South Davis St. HC-3	UT to Pilot Ck at SR 2028 PC-2.1 (reference)
Channel modification (5)	4	2	5
In-stream habitat (20)	16	8	16
Bottom substrate (15)	11	8	12
Pool variety (10)	6	6	10
Riffle habitats (16)	10	7	16
Bank stability/vegetation, erosion (7)	5	6	6
Bank stability/vegetation, vegetation (7)	6	5	6
Light penetration (10)	8	7	10
Riparian zone width (10)	8	6	7
Total Habitat (100)	74	55	88

Note: Maximum possible score for each category is shown in parentheses.

UT to Heatherly Creek and Heatherly Creek near South Davis Street (HC-3 and HC-3.1). One mainstem segment of Heatherly Creek near South Davis Street (HC-3) and a small (0.1 mi^2) UT to Heatherly Creek near South Davis Street (HC-3.1) were assessed in August, 2011 to investigate potential sources of pollution that may be contributing to biologic impairment of Heatherly Creek. The investigations were conducted because high specific conductance measurements were observed in the tributary location during the reconnaissance survey. It was possible that pollutants from upstream sources were entering the tributary and Heatherly Creek. Follow-up monitoring was also conducted in the tributary location (HC-3.1) in February and March, 2012, to rule out septic tank or sewer line leaks. Laboratory and field data are summarized in Table 2 above. The mainstem segment (approximately 0.5 mile beginning at HC-3) adjacent to a heavy equipment storage facility (owned by J.R. Lynch and Son) was also assessed by staff (Figure 10 above). Habitat scores are provided in Table 3 above.

In the tributary location (HC-3.1), fecal coliform data were variable with two low counts (4 and 120 CFUs/100 mL) and one high count (350 CFUs/100 mL). NO_x data were less variable but were higher than any other location in the planning area (median 1.0 mg/L). The source of NO_x is unclear although it may be related to a failing septic system (see narrative in next paragraph). The higher NO_x (and chloride) partially explains the elevated specific conductance. Chloride was also high at his location relative to other locations (median = 16 mg/L).

Staff drove to the headwater area of the tributary to West Pine Street to locate the stream origin, observe land use, collect field meter readings and to determine whether the adjacent equipment storage facility was a source of pollutants. The stream emerged from the ground near West Pine Street (HC-3.1.1 in Figure 10 above) where rip rap had been placed. In-stream algae and rust colored iron oxide bacteria were present. Land use upstream of West Pine Street consisted of single family homes and one possible pollution source which appeared to be a lift station for a septic tank. The specific conductance reading was the same here as was recorded at the downstream location (HC-3.1) near South Davis Street (227 uS/cm). The high specific conductance could be related to background conditions (i.e., geology and soil), leaking sewer or water lines or leachate from buried contaminants. In any case, these observations suggested that the equipment storage facility was likely not the source of elevated specific conductance since the reading upstream of the facility was similar to the reading downstream.

Staff walked approximately 300 feet downstream to the rail line where a four-foot-wide by forty-foot-long ephemeral channel with a large head cut approximately eight feet high was discovered. There was no stream flow, but it appeared that during storm events the channel carries storm flow which scours sediments along the way. The head cut will likely continue to move upstream and scour channel sediments with each subsequent storm event. This may be a good location for storm water management practices.

The equipment storage area was bounded on two sides by stream channels; Heatherly Creek along the south side of the facility and the tributary (HC-3.1) along the west side. The stream banks adjacent to the facility along the mainstem and the tributary consisted of fill material close to 20 feet high. The riparian zone along right side of the mainstem (facing upstream) was wide and forested for most of the segment's length. Riffle embeddedness (approximately 50%) was prevalent throughout the segment. All metrics but one scored lower than reference conditions (Table 3 above). The total score for this segment was 55 and the reference total score was 88. Habitat scores were not recorded for the tributary.

No apparent problems were noted relative to storm water runoff from the storage site. NCDWQ regional staff determined that a storm water permit was not required for the facility (personal conversation with Corey Basinger, NCDWQ Regional Office Supervisor). Mr. Basinger suggested that it would be a good idea for staff to conduct an inspection at the site to help the owner of the facility identify where storm water BMPs may be beneficial (though not required).

Chinquapin Creek Investigations

UT to Chinquapin Creek at Old US 52 (CH-1.1). On two occasions, one each in July and August, 2011, staff walked upstream (for approximately 0.3 mile) along UT to Chinquapin Creek at Old US 52 (CH-1.1) near one of the Town of Pilot Mountain's pump stations to pinpoint the source(s) of fecal coliform and collect field measurements (see Figure 11 below). The reason for this investigation was that previous sampling events in June and July, 2011, at the Old US 52 location resulted in elevated bacterial counts and NO_x concentrations. Follow-up monitoring was conducted in February and March, 2012, to confirm previous results. Samples for chloride were also collected during this resampling effort. Data are provided in Table 4 below.

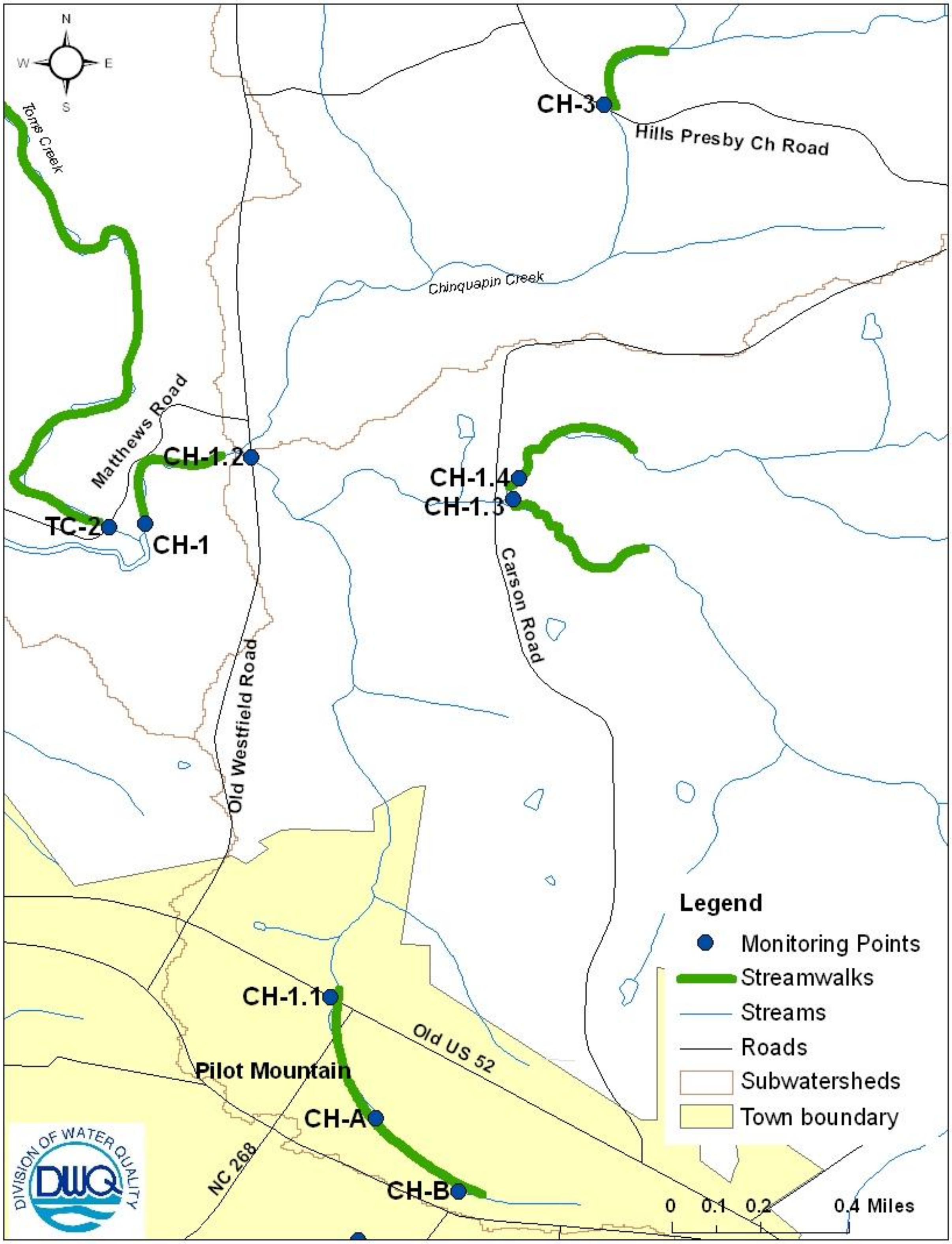


Figure 11. Follow-up investigations along Chinquapin Creek.

Table 4. Water quality data collected from select locations in Chinquapin Creek.

Map Code	Fecal Coliform (CFUs)				Specific Conductance (uS/cm)				Chlorides (mg/L)				Nitrate/Nitrite (mg/L)			
	N	Min	Geo Mean	Max	N	Min	Median	Max	N	Min	Median	Max	N	Min	Median	Max
CH-1.1	6	93	206	450	7	112	127	158	3	12	12	15	5	0.71	0.76	0.93
CH-A	5	23	140	1100	4	114	116	154	3	10	10	13	3	0.70	0.71	0.77
CH-B	3	90	118	140	3	89	91	100	3	5.9	6.1	11	3	0.25	0.27	0.28
PC-2.1 ref	4	54	117	180	4	44	44	49	3	3.8	3.8	4.2	4	0.14	0.23	0.26

The data point to a possible sewer line leak between the Old US 52 location (CH-1.1) and the next upstream location near Depot Street (CH-A). Fecal coliforms at the most upstream location at North Academy Street (CH-B) never exceeded the threshold level of 200 CFUs/100 mL, while, in the next two downstream locations, levels exceeded the threshold level twice at CH-A and three times at CH-1.1. Chloride, specific conductance and NO_x increased in a downstream fashion (Table 4 above).

The pump station was located where the stream crosses North Key Street (NC 268). No leaks or overflows were observed. A sewer line right-of-way parallels the stream along the left of the stream channel (facing upstream) for approximately 3000 feet upstream beginning at the pump station. Habitat conditions were assessed for two separate segments (See Table 5 below). The first segment (CH-1.1) was from Old 52 to North Key Street (NC 268) and the other continued 1100 feet upstream to Depot Street (CH-A). The most notable feature of the first segment was the homogeneous substrate of bedrock. Almost the entire segment consisted of bedrock. The upstream segment had a good mix of substrates and habitat types, but riffles were approximately 40% embedded. The stream had cut a deep channel with streambanks close to four feet high as measured from the stream bed. Riparian zones were forested and wide except for a few locations where housing encroached on the sewer line right-of-way along the left side (facing upstream).

Table 5. Habitat assessment scores recorded for Chinquapin Creek.

Habitat Metrics	Habitat Scores						
	UT to Chinquapin Creek. at Old US 52 CH-1.1	UT to Chinquapin Creek at Key St. CH-A	UT to Chinquapin Creek . at Carson Rd. CH-1.3	UT to Chinquapin Creek . at Carson Rd. CH-1.4	Chinquapin Creek. at Matthews Rd. CH-1	Chinquapin. Creek. at Hills Presby. Church Rd. CH-3	UT to Pilot Creek at SR 2028 Shoals Road PC-1.2 (reference)
Channel modification (5)	5	3	5	5	4	3	5
In-stream habitat (20)	11	16	16	16	12	12	16
Bottom substrate (15)	3	12	12	8	8	12	12
Pool variety (10)	6	6	10	10	8	10	10
Riffle habitats (16)	6	16	16	10	14	3	16
Bank stability/vegetation, erosion (7)	6	6	6	3	0	6	6
Bank stability/vegetation, vegetation (7)	5	7	7	5	7	7	6
Light penetration (10)	7	7	10	8	10	7	10
Riparian zone width (10)	8	8	10	10	8	7	7
Total Habitat (100)	57	81	92	75	71	67	88

Note: Maximum possible score for each category is shown in parentheses.

UTs to Chinquapin Creek at SR 1837 Carson Road (CH-1.3 and 1.4). Fecal coliform monitoring was conducted in UTs to Chinquapin Creek at SR 1837 Carson Road (CH-1.3 and CH-1.4) in June and July, 2011 to investigate possible sources of fecal coliform. This decision was based on monitoring conducted in March, 2011 in UT to Chinquapin Creek at SR 1809 Old Westfield Road (CH-1.2), about 0.6 miles downstream, where bacterial counts were elevated. Since this site was downstream of another Chinquapin Creek tributary (CH-1.1, see discussion above) where fecal counts were also elevated, it was necessary to rule out these two upstream tributaries as potential sources. Follow-up monitoring was conducted in February and March, 2012 at CH-1.3 and CH-1.2 to confirm results. These data are provided in Table 6 below. Site locations are in Figure 11 above.

Table 6. Additional water quality data for Chinquapin Creek.

Map Code	Fecal Coliform (CFUs)				Specific Conductance (uS/cm)				Nitrate/Nitrite (mg/L)			
	N	Min	Geo Mean	Max	N	Min	Median	Max	N	Min	Median	Max
CH-1.2	5	35	220	420	6	57	66	73	4	0.20	0.24	0.39
CH-1.3	5	15	46	290	6	53	64	74	3	0.11	0.21	0.31
CH-1.4	2	120	130	140	3	32	45	45	-	-	-	-
CH-3	3	37	94	160	4	43	45	46	4	0.16	0.19	0.25
PC-2.1 ref	4	54	117	180	4	44	44	49	4	0.14	0.23	0.26

Neither of the tributaries at Carson Road (CH-1.3 and 1.4) were major contributors to elevated fecal bacteria downstream in CH-1.2. The geometric means for both locations were below the trigger level of 200 CFUs/100 mL. The geometric mean for CH-1.4 was actually lower than reference site (see Table 6). Median specific conductance for CH-1.3 (64 uS/cm) was higher than CH-1.4 (45 uS/cm). It is likely that the source of fecal coliform in CH-1.2 was further upstream either from leaking sewer lines from the Town of Pilot Mountain and/or from location(s) between CH-1.2 and CH-1.1.

Habitat conditions were assessed along each tributary to identify sources of sediment and to compare the degree of sedimentation between the two catchments. Habitat data are provided above in Table 5 above and are discussed below.

Approximately 0.5 and 0.4 mile of channel in CH-1.4 and CH-1.3 respectively were assessed by staff (Figure 11 above). In general, habitat conditions were more stable in CH-1.3 with wide forested riparian zones and a good mix of habitat types. The total score very slightly exceeded the reference site score (92 vs. 88) and should be interpreted as essentially the same, as both are very high scores. Bedrock outcroppings were more abundant in this tributary. Stream bank erosion was more prevalent in CH-1.4, along with embedded riffle habitats (total score = 75). Stream bank erosion was the likely source of sediment. Riparian zones were wide and forested here as well. A four-wheel dirt path parallels the stream along the stream banks in a number of locations. Two stream crossings were noted.

Chinquapin Creek at SR 1830 Matthews Road (CH-1). Habitat assessments were conducted in the mainstem of Chinquapin Creek at SR 1830 Matthews Road (CH-1). In March, this location was surveyed as part of the reconnaissance and was subsequently selected for habitat assessments because of extreme channel degradation (incision, high unstable banks and sedimentation). The assessment started at the confluence with Toms Creek and continued upstream in Chinquapin Creek for approximately 0.25 mile (Figure 11 above).

The most notable feature was the extreme bank erosion and deposits of sand/gravel/cobbles along outside meander bends. There was a good mix of habitat types, although riffles were mostly embedded. The total habitat score was 71 (Table 5 above). A horse pasture was located along the north portion of the stream along the left side (facing upstream). This section was not scored, but degraded riparian zones were noted.

Chinquapin Creek at SR 1835 Presbyterian Church Road (CH-3). A Chinquapin Creek mainstem location was assessed at SR 1835 Hills Presbyterian Church Road (CH-3) to determine the status of habitat and riparian conditions (Figure 11 above). Habitat scores are provided in Table 5 above. Follow-up monitoring for fecal coliform, specific conductance and NO_x was conducted in this location during February and March, 2012. These data are provided in Table 6 above and discussed briefly below.

The habitat assessment began at Hills Presbyterian Church Road and ended 0.25 mile upstream. The most notable features along this segment were the mostly bedrock substrates and two small waterfalls. The riparian area along the left side (facing upstream) was pasture with a narrow vegetated strip consisting of grass and shrubs. The condition of the riparian area along the right side was mostly forested. Fences were in place along both sides of the stream. Total habitat score was 67. Downstream of the assessed segment, across Presbyterian Church Road, a large pasture area with degraded riparian zones was noted. Fecal coliform, specific conductance and NO_x data (Table 6 above) were very similar to the data collected from the reference site and indicated no obvious water quality degradation.

<u>Pilot Creek Investigations</u>

UT to Pilot Creek at SR 2954 Boyd Nelson Road (PC-3.1). High fecal coliform counts and specific conductance at UT to Pilot Creek at SR 2954 Boyd Nelson Road (PC-3.1) in June, 2011 prompted follow-up monitoring in July and August, 2011 along this tributary to investigate possible upstream septic tanks failures (Table 7 below). Monitoring locations, provided below in Figure 12, included two mainstem locations (PC-3.1 and PC-B) and a tributary (not shown in Figure 12) location (PC-A) that drained an adjacent neighborhood.

Specific conductance was relatively high at each location in July and August. Fecal coliform results were much lower in the July and August (geometric mean = 162 CFUs/100 mL). It was not clear what caused high initial counts. Perhaps it was due to wildlife stirring up stream sediments. Deer tracks were observed throughout the channel on one occasion.

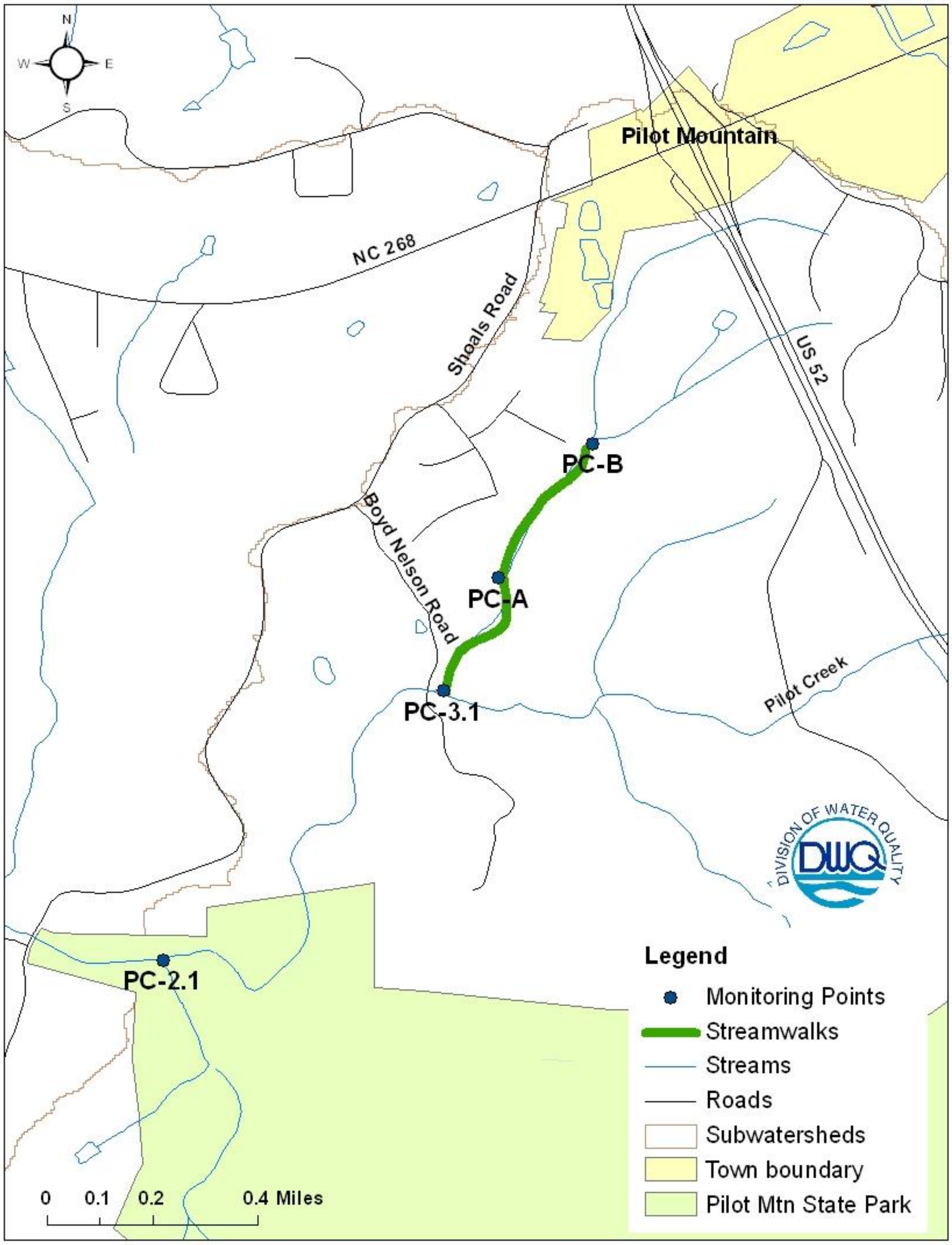


Figure 12. Follow-up assessments in Pilot Creek.

Table 7. Water quality data for a UT to Pilot Creek at SR 2954 Boyd Nelson Road (PC-3.1).

Map Code	Fecal Coliform (CFUs) N	Min	Geo Mean	Max	Specific Conductance (uS/cm) N	Min	Median	Max	Nitrate/Nitrite (mg/L) N	Min	Median	Max
PC-3.1	4	49	162	530	5	125	131	132	1	0.55	0.55	0.55
PC-A	1	110	110	110	1	226	226	226	-	-	-	-
PC-B	2	62	79	100	2	142	143	144	-	-	-	-
PC-2.1 ref	4	54	117	180	4	44	44	49	4	0.14	0.23	0.26

Table 8. Habitat scores recorded for a UT to Pilot Creek (PC-3.1).

Habitat Metrics	Habitat Scores: UT to Pilot Creek at SR 2954 Boyd Nelson Rd. PC-3.1	UT to Pilot Creek at SR 2954 Boyd Nelson Rd. PC-B	UT to Pilot Creek at SR 2028 Shoals Rd. PC-2.1 (reference)
Channel modification (5)	2	5	5
In-stream habitat (20)	11	16	16
Bottom substrate (15)	8	12	12
Pool variety (10)	6	6	10
Riffle habitats (16)	14	16	16
Bank stability/vegetation, erosion (7)	3	6	6
Bank stability/vegetation, vegetation (7)	3	7	6
Light penetration (10)	2	10	10
Riparian zone width (10)	4	10	7
Total Habitat (100)	53	88	88

Note: Maximum possible score for each category is shown in parentheses.

Habitat assessments were also conducted along two segments of the tributary. Scores are provided in Table 8 above. The first segment (PC-3.1) was 1800 feet long and began at the confluence with Pilot Creek. The final segment continued upstream for another 1000 feet ending at PC-B. In general, segment PC-3.1 was more degraded. The stream had likely been channelized and moved to allow for agriculture, a portion of which is currently in tobacco. Bank erosion was evident throughout the reach, and the riparian zone consisted of a narrow vegetated strip. The total habitat score was 53.

The total habitat score for the upstream segment (PC-B) was 88. The channel was mostly undisturbed with a wide forested riparian zone. Some minor bank erosion was evident along with embedded riffles.

Pilot Knob Park Swim and Golf Club. Golf courses are known to use chemical fertilizers to promote turf growth. Monitoring was conducted upstream and downstream of the golf course to determine if the golf course was a source of nutrients. The amount, timing, and frequency of fertilizer applications at this golf course were not researched for this project. UT to Pilot Creek at Sandtrap Lane (PC-4.1) and Heatherly Creek at Sandtrap Lane (PC-4) were two downstream locations and Heatherly Creek at Seven Springs Lane (PC-5) was selected as the upstream location (Figure 13 below). Several single family homes on septic tanks and tobacco fields were located in the catchments. Fecal coliform and chloride data were collected for the tributary location in February and March, 2012 because high levels of fecal coliform (500 CFUs/100 mL) were measured in June, 20ll. A summary of selected data are provided below in Table 9. Median NO_x data are provided in chart format in Figure 14 below.

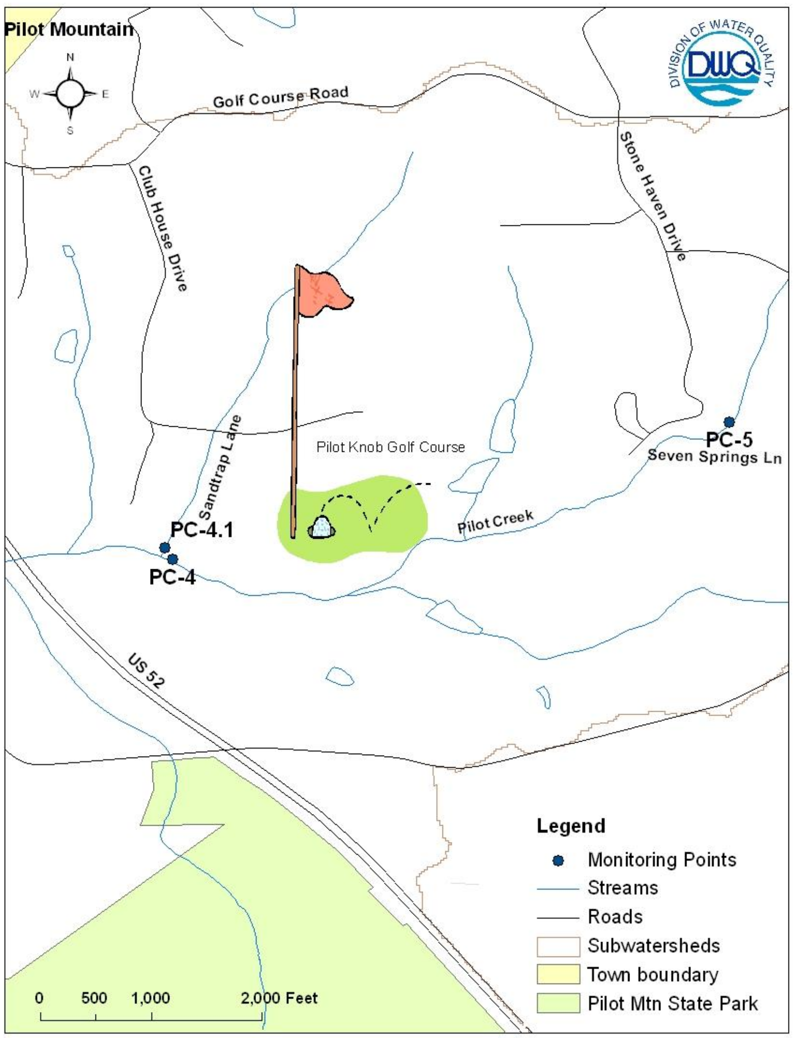


Figure 13. Nutrient assessment at Pilot Knob Park Golf Course.

Table 9. Water quality data upstream/downstream of Pilot Knob Park Golf Course.

Map Code	Fecal Coliform (CFUs)				Specific Conductance (uS/cm)				Chlorides (mg/L)				Nitrate/Nitrite (mg/L)			
	N	Min	Geo Mean	Max	N	Min	Median	Max	N	Min	Median	Max	N	Min	Median	Max
PC-4.1	5	77	157	500	5	74	76	88	2	6	6	6	5	0.45	0.60	0.69
PC-4	3	29	63	220	5	65	71	90	-	-	-	-	5	0.13	0.18	0.29
PC-5	-	-	-	-	6	58	80	89	-	-	-	-	5	0.08	0.23	0.31
PC-2.1 ref	4	54	117	180	4	44	44	49	3	3.8	3.8	4.2	4	0.14	0.23	0.26

In Figure 14 below, median NO_x was higher (0.23 mg/L) in the upstream location in Pilot Creek at Seven Springs Lane (PC-5) than the downstream Pilot Creek location (PC-4) at Sandtrap Lane (0.18 mg/L). This indicates that the mainstem portion of Pilot Creek adjacent to the golf course either is a sink rather than a source of NO_x or that dilution was a factor. Ponds throughout the golf course may be sequestering a portion of NO_x as well.

In the tributary location (PC-4.1), the median NO_x level (0.60 mg/L) was higher than the two mainstem locations and higher than the reference site (Figure 14 below). Based on surface topography, it appeared that only a small portion of the golf course was drained by the tributary and that adjacent tobacco fields and septic tank leach fields may be sources of NO_x to the tributary. Periphyton/algae were observed on bottom substrates of the channel near the confluence with the mainstem.

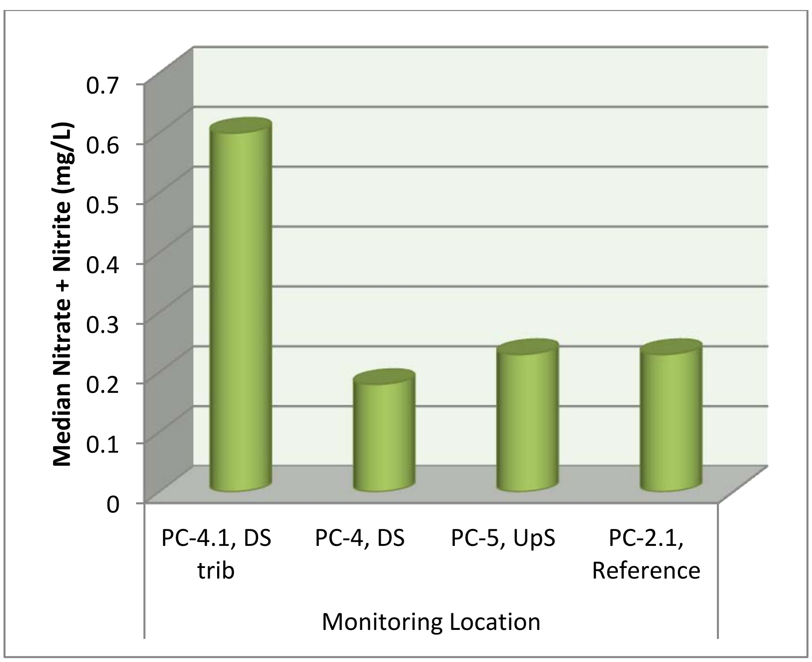


Figure 14. Follow-up monitoring at Pilot Knob Park Golf and Swim Club.

In Table 9 above, the geometric mean for fecal coliform in the tributary location (PC-4.1) was slightly elevated compared with reference conditions (157 vs. 117 CFUs/100 mL) as were median specific conductance (76 vs. 44 uS/cm) and chloride (6.0 vs. 3.8 mg/L). It is likely that several sources are contributing NOx to the tributary (PC-4.1) including septic systems and fertilizers from adjacent crop fields, the golf course and lawns.

Toms Creek Investigations

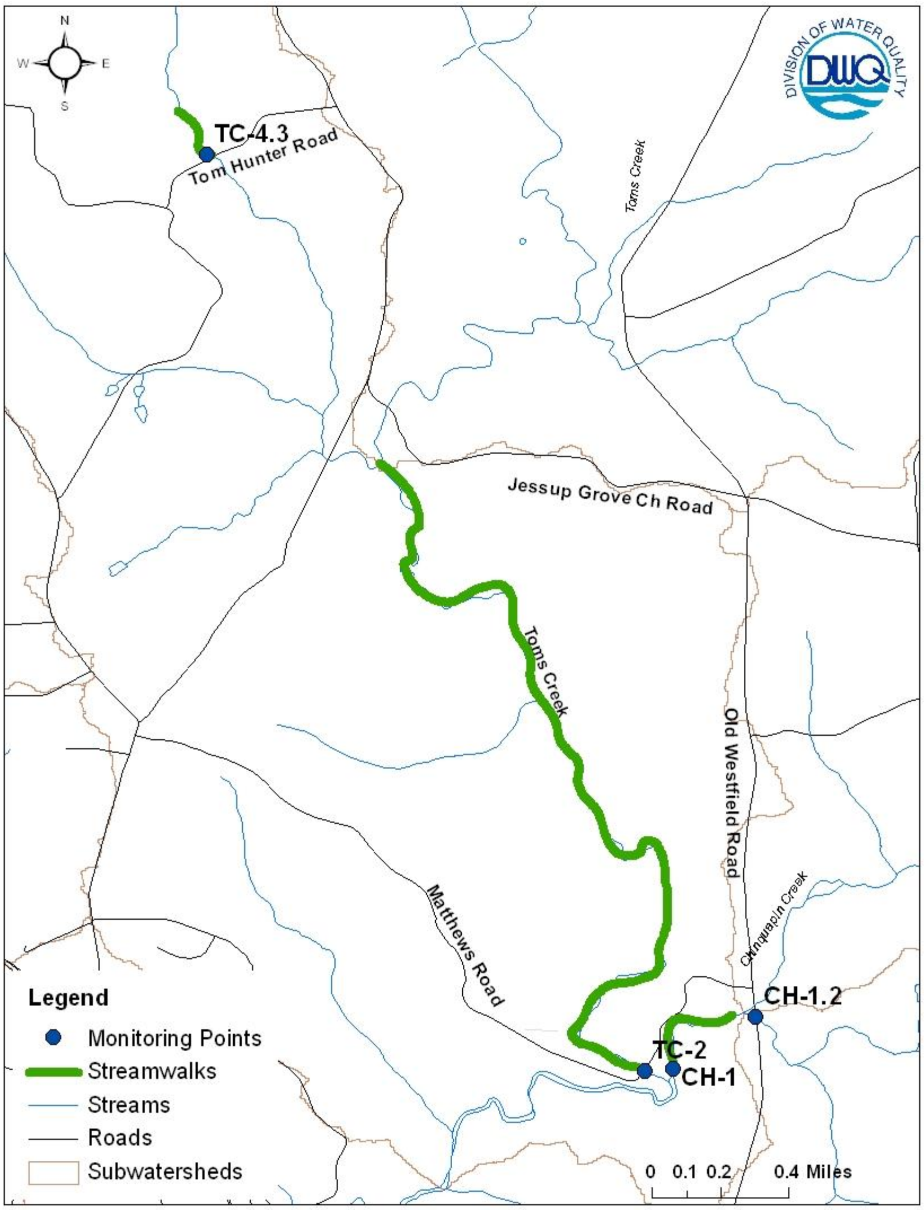


Figure 15. Follow-up assessments in Toms Creek.

Toms Creek at SR 1830 Matthews Road (TC-2). Staff decided more investigation of habitat conditions were warranted at Toms Creek at SR 1830 Matthew Road (TC-2) because the benthic community bioclassification from the June, 2011 sampling event was not as good as expected (NCDWQ-WAT, 2011c). Staff from both NCDWQ-WAT and NCEEP walked nearly 2.5 miles within a segment of Toms Creek between SR 1830 Matthews Road and SR 1812 Jessup Grove Church Road (beginning at point TC-2 in Figure 15 above) in September, 2011, to further assess habitat conditions and water quality conditions.

The most favorable habitat conditions were the wide forested buffer zones along both sides of the stream channel. There were several segments of extreme bank erosion. Areas of poor habitat for benthics (stretches of slow, sluggish flow; straight channel; steep and straight stream banks; and sandy, homogeneous substrate) were also observed. Evidence of nutrient enrichment was also observed (areas of algae and periphyton growth on the sand, bedrock, and rocks). Staff decided that channel and habitat conditions were likely not responsible for the degraded benthic community and requested NCDWQ's Biological Assessment Unit (BAU) to sample the site again.

The site was sampled again in November, 2011 by BAU. An improvement of the biological rating was reported and attributed to collection techniques, seasonality (summer vs. fall/winter) and higher stream levels in November which increased accessibility to root mat habitats.

UT to Toms Creek at SR 1825 Tom Hunter Road (TC-4.3). Fecal coliform at UT to Toms Creek at SR 1825 Tom Hunter Road (TC-4.3) in June, 2011, were close to the threshold level (190 CFUs/100 mL). Therefore, it was decided to include this location for follow-up water quality monitoring in February and March, 2012, to verify these results and to help with the overall functional assessment ratings. These data are provided in Table 10 below. Habitat conditions were also assessed for a 700-foot segment in September, 2011, to help determine the current status of habitat conditions (Figure 15 above) and to identify potential mitigation sites. Habitat scores are provided in Table 11 below.

Fecal coliform, specific conductance and NO_x data (Table 10 below) were very similar to the data collected from the reference site and indicated no obvious water quality degradation. The most notable habitat features in this segment were a good mix of gravel, cobble and boulder substrates and a variety of instream habitats. However, embedded riffles were prevalent and channelization was evident. The total habitat score was 72 (Table 11 below).

Table 10. Water Quality data for a UT to Toms Creek at SR 1825 Tom Hunter Road (TC-4.3).

Map Code	Fecal Coliform (CFUs)				Specific Conductance (uS/cm)				Nitrate/Nitrite (mg/L)			
	N	Min	Geo Mean	Max	N	Min	Median	Max	N	Min	Median	Max
TC-4.3	4	15	66	190	5	42	42	45	4	0.34	0.39	0.48
PC-2.1 ref	4	54	117	180	4	44	44	49	4	0.14	0.23	0.26

Table 11. Habitat assessment scores recorded for a tributary to Toms Creek (TC-4.3).

Habitat Metrics	Habitat Scores	
	UT to Toms Creek at SR 1825 Tom Hunter Road TC-4.3	UT to Pilot Creek at SR 2028 Shoals Rd. PC-2.1 (reference)
Channel modification (5)	3	5
In-stream habitat (20)	12	16
Bottom substrate (15)	8	12
Pool variety (10)	6	10
Riffle habitats (16)	14	16
Bank stability/vegetation, erosion (7)	6	6
Bank stability/vegetation, vegetation (7)	7	6
Light penetration (10)	8	10
Riparian zone width (10)	8	7
Total Habitat (100)	72	88

Note: Maximum possible score for each category is shown in parentheses.

Summary and Conclusions

- Fecal coliform bacteria counts were below the threshold value of 200 CFUs/100 mL for most locations. Instances where counts exceeded the threshold level included those within the Town of Pilot Mountain and along sewer line rights-of-way adjacent to Chinquapin Creek and Heatherly Creek and appeared to reflect the possibility of leaking sewer lines or residue from previous overflows. This is a concern since Chinquapin Creek is a tributary to Toms Creek, which is the water supply for the Town. There were two locations outside of the Town where the threshold level was exceeded. However, time constraints did not allow for further investigations to locate sources. More work needs to be conducted in those areas (see recommendations below).

- The highest NO_x levels were located within the Town limits and tributaries to Pilot Creek. The lowest levels were found in various locations throughout the planning area but most were located within the Toms Creek subwatersheds. Periphyton/algae on benthic substrates were observed in a few locations throughout the study area, suggesting nutrient enrichment.

- While the data set was limited in number and the monitoring was not targeted to follow fertilizer applications, the golf course was not likely a source of nutrients. NO_x in the monitoring site upstream of the golf course was actually higher than the downstream site. Probable reasons for lower concentrations downstream of the golf course include: 1) dilution; 2) NO_x in the ground water discharge to the channel was not significant; 3) nitrogen fixation via assimilation by riparian vegetation and/or periphyton on benthic substrates; 4) NO_x sequestration by the ponds within the golf course; and, 5) nitrogen loss through denitrification. Storm event water quality monitoring upstream/downstream of the golf course at targeted times throughout the year (following fertilizer applications for example), may show an increase in NO_x and other nitrogen species and phosphorus.

- Specific conductance tended to be highest in catchments that drained the Town of Pilot Mountain and tributaries to Pilot Creek.

- Chloride was not a definitive predictor of sewer line leaks (as indicated by fecal coliform, $r = .51$), but did correlate with specific conductance ($r = 0.68$) and NO_x ($r = 0.60$). The data set was limited in number and further monitoring may show a stronger correlation. See Exhibit 1 in the Appendix.

- The benthic report was not discussed above, but the follow-up investigations within the Heatherly Creek drainage area were designed partly with an eye towards identifying causes and sources of biological impairment in Heatherly Creek at US 52 (HC-1). In October, 2011, NCDWQ biologists reported that the benthic community in Heatherly Creek improved sufficiently enough to consider its removal from the 303d list (NCDWQ-WAT, 2011c). Improvement was likely a result of several factors including: 1) the relocation of the Town's wastewater treatment plant discharge in 1996 to the Ararat River; 2) a new rating system that used small stream biocriteria to rate the stream (NCDWQ BAU, 2009); and, 3) a return to more normal flow condition since the previous assessment when drought conditions were apparent (NCDWQ-WAT, 2009). Exhibits 2 through 5 in the Appendix provide United States Geological Survey (USGS) stream discharge data for two streams nearby the planning area (Little Yadkin River at Dalton, NC USGS No. 02114450 and Ararat River at Ararat, NC USGS No. 02113850) that compares discharge data during the 52-week period prior to benthic sampling in 2008 and 2011. Stream discharge returned closer to the median daily statistic (over the 51 and 47 year period of record respectively) in 2010–2011 vs. 2007–2008.

While there was an improvement in the benthic community in the Heatherly Creek at US 52 (HC-1), the community was degraded in comparison with the upstream location in Heatherly Creek at NC 268 (HC-2) and reference conditions in Pilot Creek (PC-2.1) i.e., Good/Fair vs. Good vs. Excellent respectively. And while ascertaining the causes and sources of biological impairment goes beyond the scope and budget of this study, plausible stressors affecting the benthic community in Heatherly Creek include periodic toxicants from sewer line leaks or overflows, toxicants in urban storm water runoff, scouring of habitats and scant habitats. Continued benthic monitoring in Heatherly Creek in subsequent years will help to clarify if water quality continues to improve.

- In general, where habitat was assessed, there were adequate in-stream habitats (rocks, sticks, snags, logs and undercut banks and root mats) and typically a good mix of gravel, cobbles and boulders. However, there were segments where homogeneous substrates of mostly bedrock or sand were observed or where rock and cobble substrates were covered with periphyton. Habitat conditions that drove total scores down and which departed from reference conditions included degraded riparian zones (narrow or lacking riparian buffers**),** a lack of canopy and extreme stream bank erosion. Habitat assessments helped to identify where potential mitigation sites may be needed.

Recommendations

Recommendations for further investigations and locations for potential mitigation sites and BMPs are listed below. Figure 17 below displays the locations that correspond to recommendations listed below.

- The Town of Pilot Mountain should further investigate possible sewer line leaks along sewer right-of-ways for tributaries to Heatherly and Chinquapin Creeks (see Table 12 below).
- The storm water retention pond along the UT to Heatherly Creek near the WWTP should be further assessed to determine if improvements can be made (see Table 12 below).
- The headcut along the rail line near Pine Street and UT to Heatherly Creek near the equipment storage facility owned by J.R. Lynch and Son should be inspected to determine if further scouring can be controlled during storm events (see Table 12 below).

Table 12. Locations and descriptions of problem areas.

Areas of Concern	Latitude	Longitude
Headcut at UT to Heatherly Creek near Pine Street and rail line near HC-3.1.1 (Figure 10).	36.3822	-80.4673
Potential sewer line leak at UT to Heatherly Creek upstream of WWTP near point HC-A (Figure 10).	36.3812	-80.4786
Location where storm water BMP improvement may be needed along UT to Heatherly Creek upstream of WWTP near point HC-B (Figure 10).	36.3833	-80.4768
Potential sewer line leak at UT to Chinquapin Creek downstream of Depot Street near point CH-A (Figure 11).	36.3837	-80.4693
Potential sewer leak at pump station on NC 268 upstream of CH-1.1 (Figure 11).	36.3896	-80.4678

Note: Figures 10 and 11 in parentheses are hyperlinks.

Further monitoring needs to be conducted in the following locations where time constraints prevented follow-up monitoring for sources of fecal coliform.

- Heatherly Creek at NC 268 (HC-2);
- UT to Pilot Creek at SR 2047 Jim McKinney Road (PC-1.1);
- UT to Toms Creek at SR 1809 Old Westfield Road near Rosa Lee Lane (TC-3.2); and,
- UT to Chinquapin Creek at SR 1809 Old Westfield Road (CH-1.2).

NCDWQ's regional office staff needs to schedule a storm water inspection at the equipment storage facility owned by J.R. Lynch and Son to identify potential locations for BMPs (near point HC-3.1, in Figure 16 below).

The following locations may be good segments for preservation (see Figure 16 below).

- The two UTs to Chinquapin Creek at SR 1837 Carson Road (CH-1.3 and 1.4)
- Toms Creek at SR 1830 Matthews Road (TC-2).

The following locations need to be further investigated as candidates for riparian restoration to improve degraded riparian buffers (see Figure 16 below).

- An upstream portion of the mainstem of Chinquapin Creek at SR 1837 (CH-1) along Matthews Road.
- Two segments of the mainstem of Chinquapin Creek on both sides of SR 1835 Hills Presbyterian Church Road (CH-3).
- The UT to Pilot Creek at SR 2954 Boyd Nelson Road (PC-3.1).
- A downstream segment of the mainstem of Pilot Creek at Sandtrap Lane (PC-4) (downstream of the golf course).
- The UT to Toms Creek at SR 1825 Tom Hunter Road (TC-4.3).
- Both upstream and downstream segments of UT to Toms Creek at SR 1811 Cleo Cain Road (TC-4.1).
- Toms Creek at SR 1811 Toms Creek Church Road (TC-5).

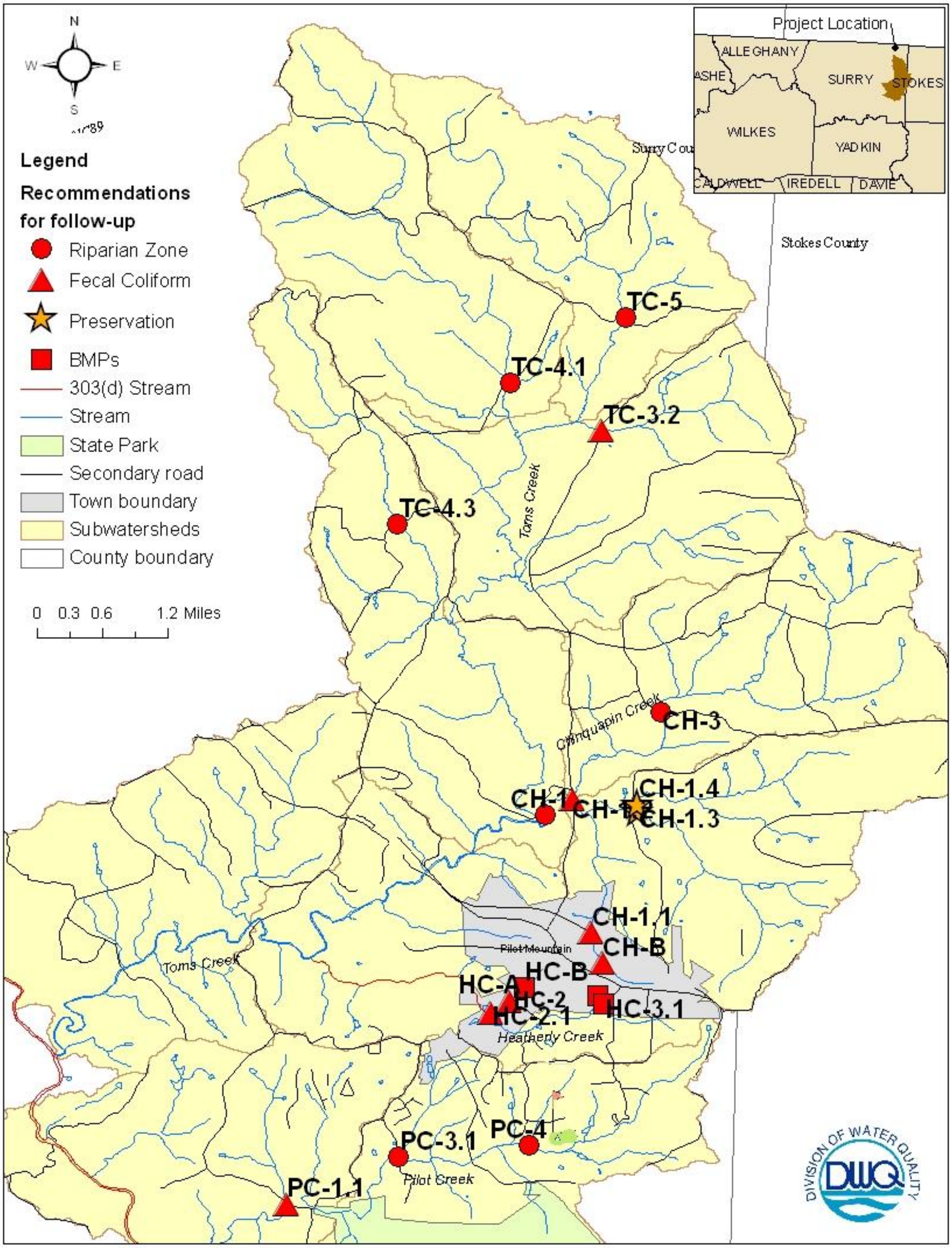


Figure 16. Sites that were recommended for mitigation, BMPs and further investigation.

References

Hauer, F.R., G.A. Lamberti. 2007. Methods in Stream Ecology. Second Edition. Elsevier, Inc. Burlington, MA.

NCDOT. 2011. Summary of Fish Collections in the Toms Creek and Pilot Creek Watersheds, Surry County. North Carolina Department of Transportation. Biological Surveys Group. Memorandum to NCEEP. November.

NCDWQ-BAU, 2009. Small Stream Biocriteria Development. North Carolina Division of Water Quality Environmental Sciences Section May.

NCDWQ-BAU, 2011. Standard Operating Procedures for Collection and Analysis of Benthic Macroinvertebrates. North Carolina Department of Environment and Natural Resources, Division of Water Quality, Environmental Sciences Section, Bioassessment Unit. Version 3, December.

NCDWQ-WAT, 2009. Integrated Analysis Report of Water Quality for the Ararat River Watershed Local Watershed Plan. North Carolina Division of Water Quality, Watershed Assessment Team. Version 3.0, July. Integrated Report

NCDWQ-WAT. 2011a. Scope of Work for the Ararat-Pilot Mountain Local Watershed Plan. North Carolina Division of Water Quality, Watershed Assessment Team. August.

NCDWQ-WAT. 2011b. Field Reconnaissance Report for Ararat-Pilot Mountain Local Watershed Plan Focus Area. April.

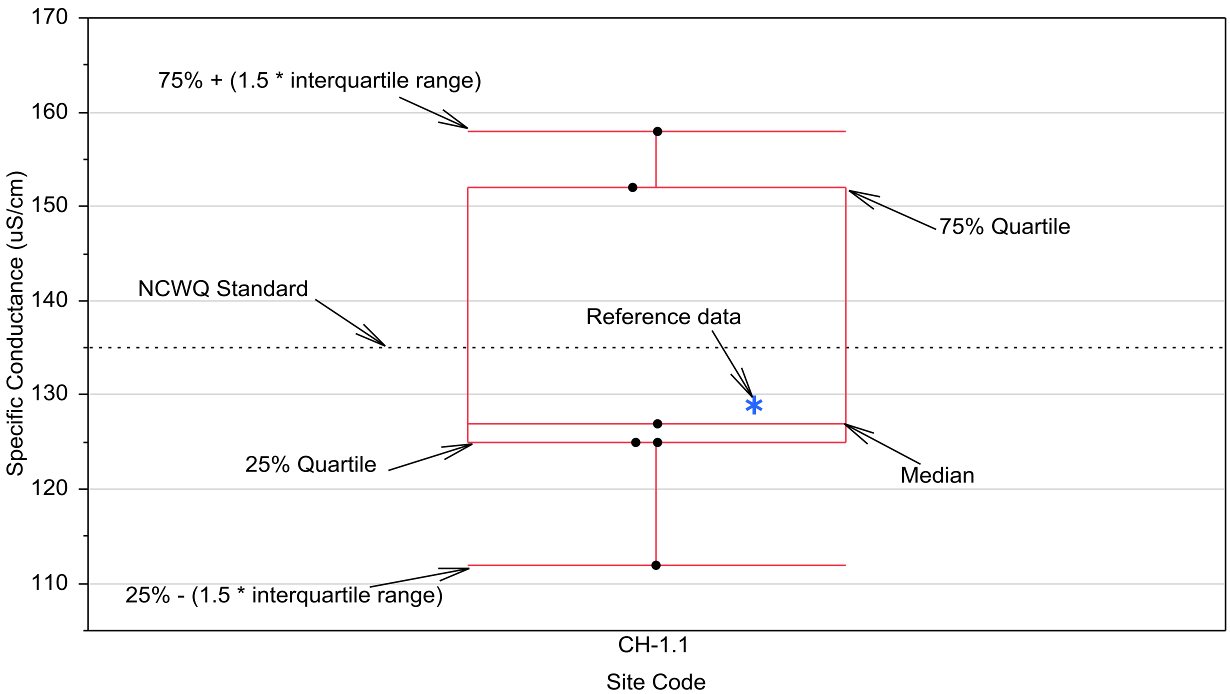
NCDWQ-WAT. 2011c. Benthic Sampling Report for the Ararat-Pilot Mountain Local Watershed Plan. October.

USEPA. 2001. Protocol for Developing Pathogen TMDLs. First Edition. EPA Report Number 841-R-00-002.

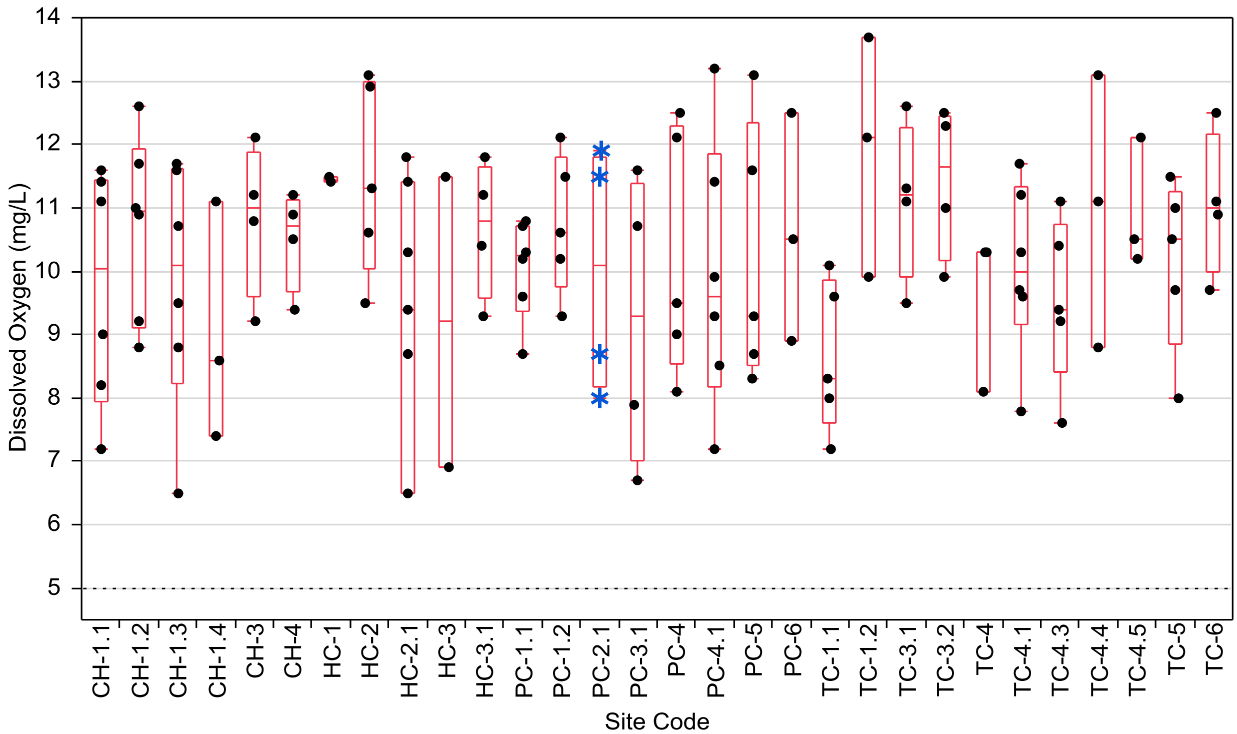
Appendix

Field and Laboratory Data

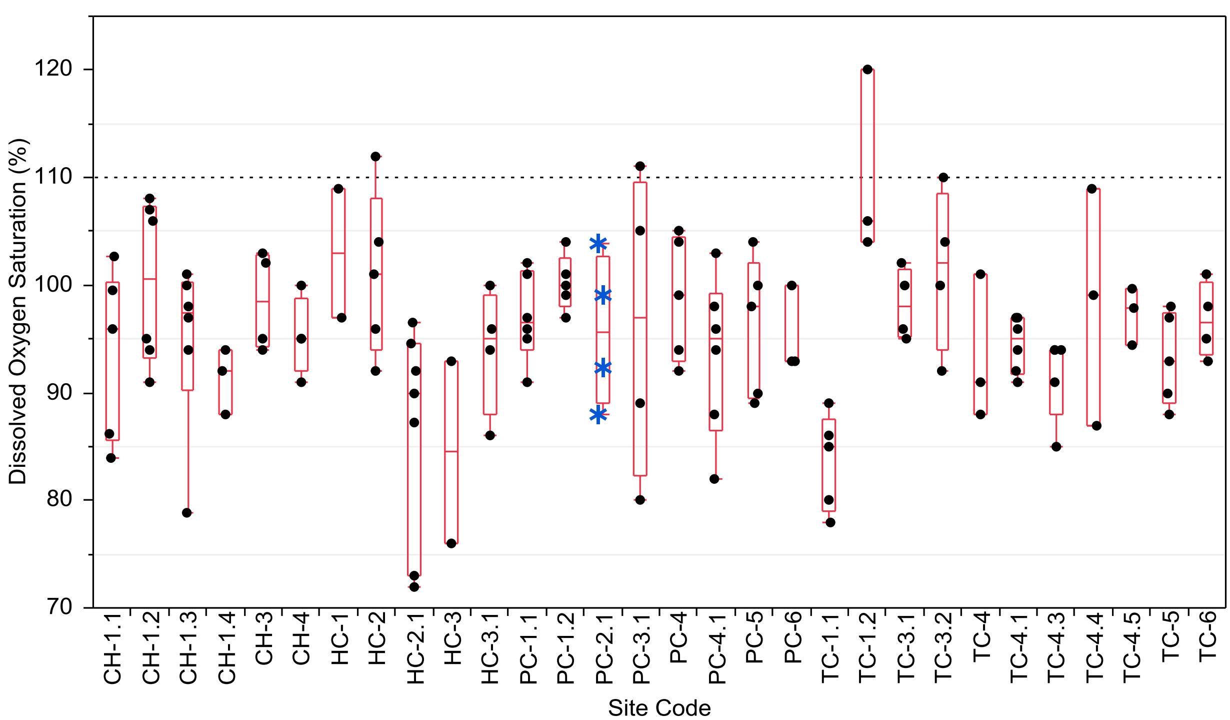
Chemical/physical data collected for selected locations for March, 2011 through March, 2012 are provided below in Box Plots 1 through 12 (black dots). Explanations of box plot lines and whiskers are provided below in Box Plot 1. Blue asterisks in the box plots are data collected from the reference site and are provided for comparison purposes.



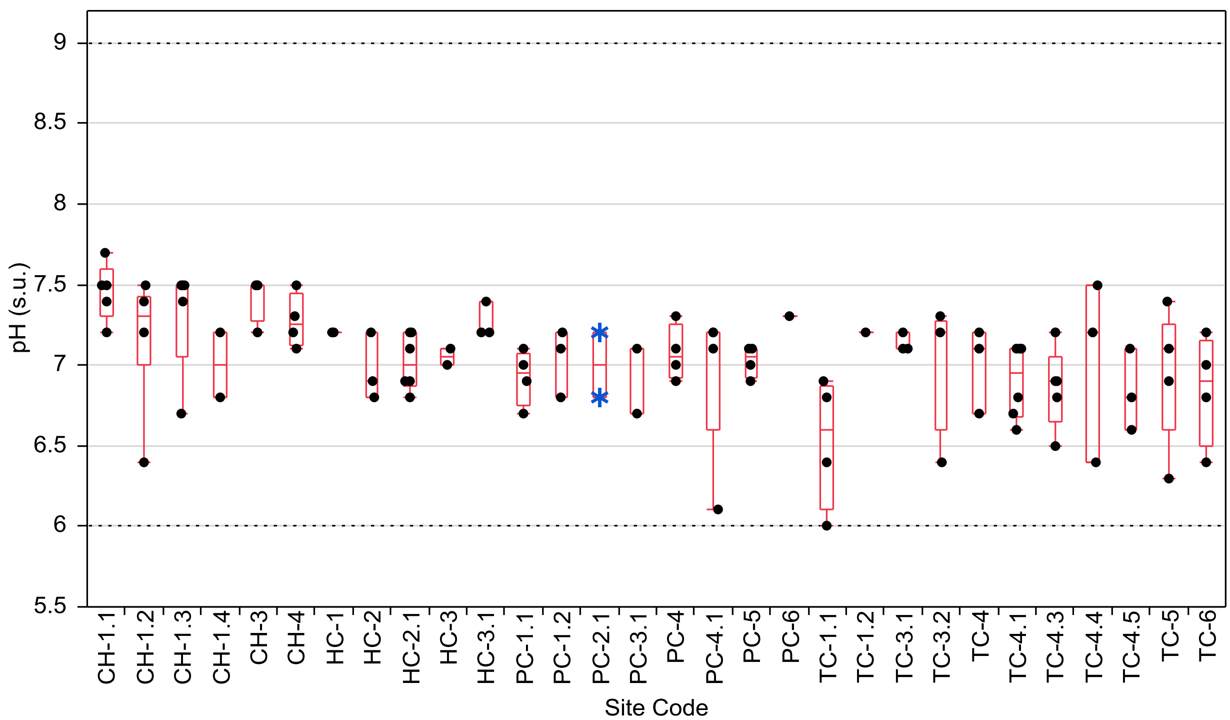
Box Plot 1. Example box plot data and statistics explanation.



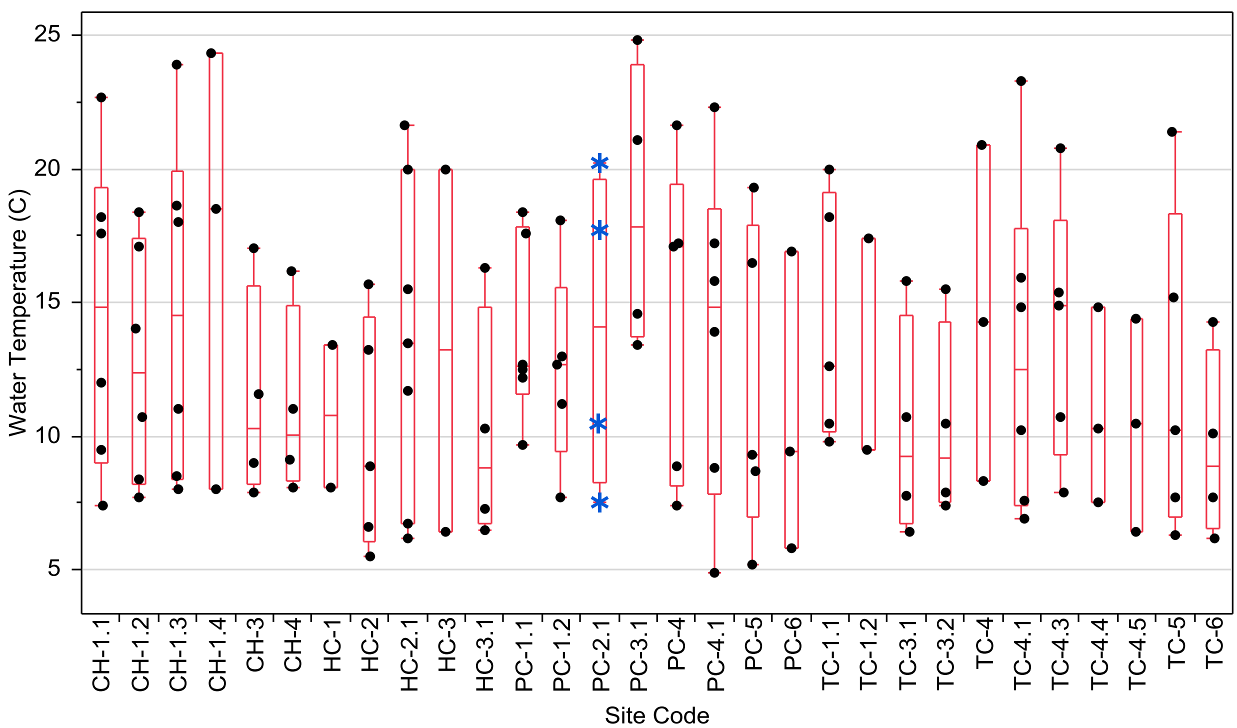
Box Plot 2. Dissolved oxygen concentration (mg/L).
The horizontal hashed line at 5.0 mg/L is the NCWQ Standard.



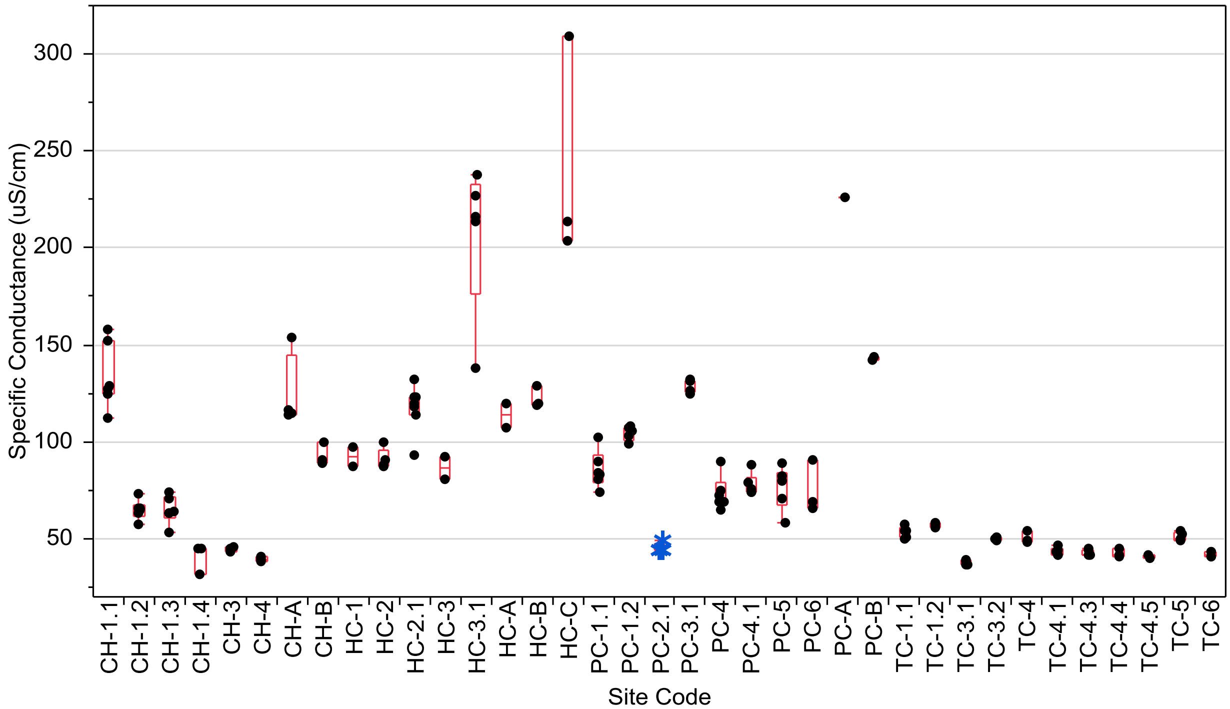
Box Plot 3. Dissolved oxygen (% saturation).
The horizontal hashed line at 110% is the NCWQ Standard.



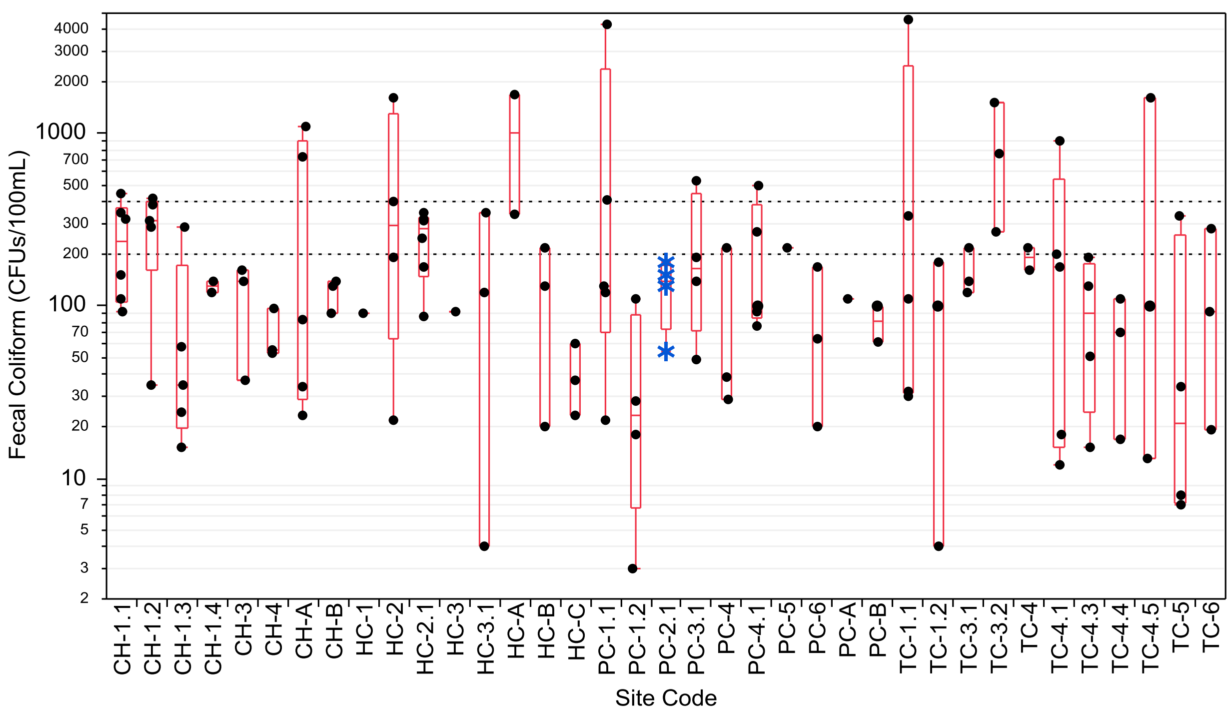
Box Plot 4. pH (s.u.).
The horizontal hashed lines at 6.0 and 9.0 s.u. are the NCWQ Standards.



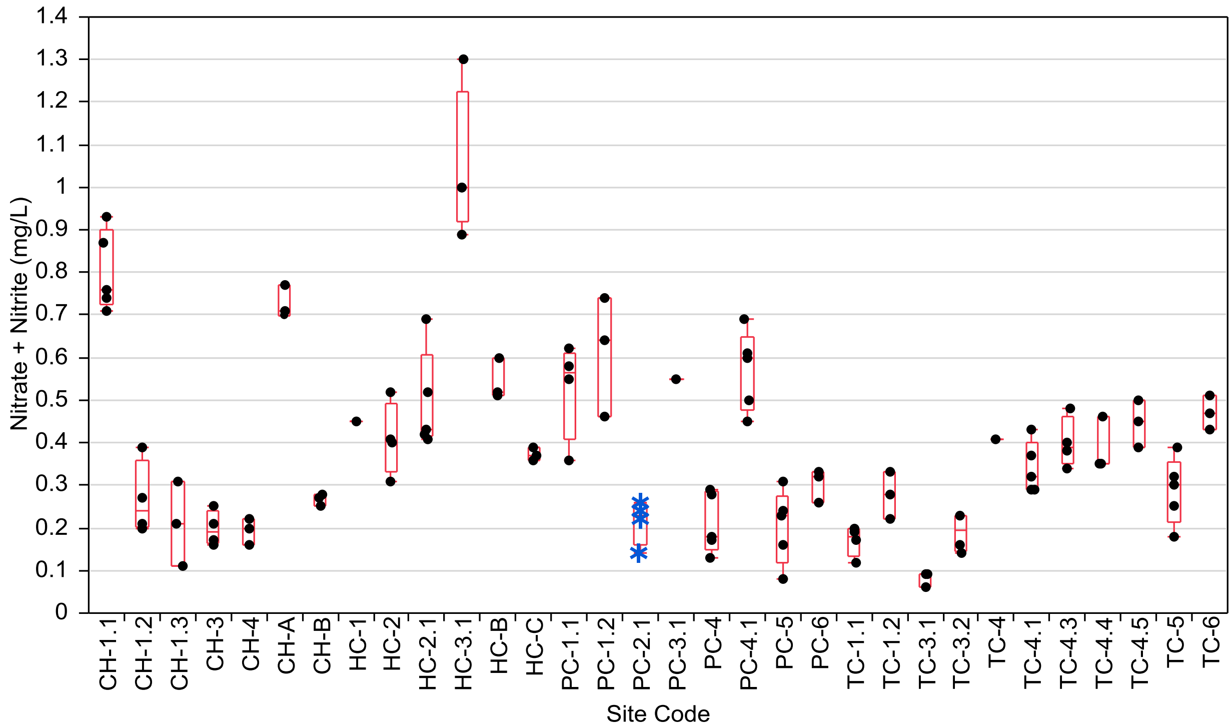
Box Plot 5. Water temperature (degrees C).



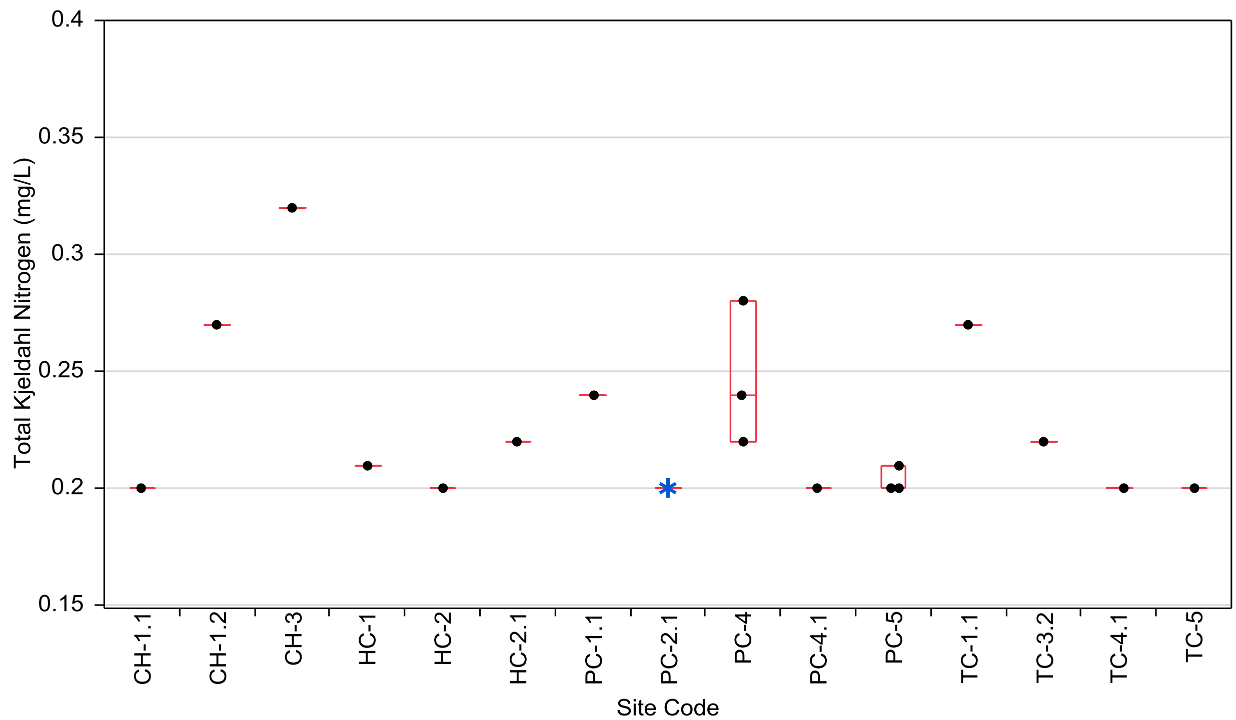
Box Plot 6. Specific conductance (uS/cm).



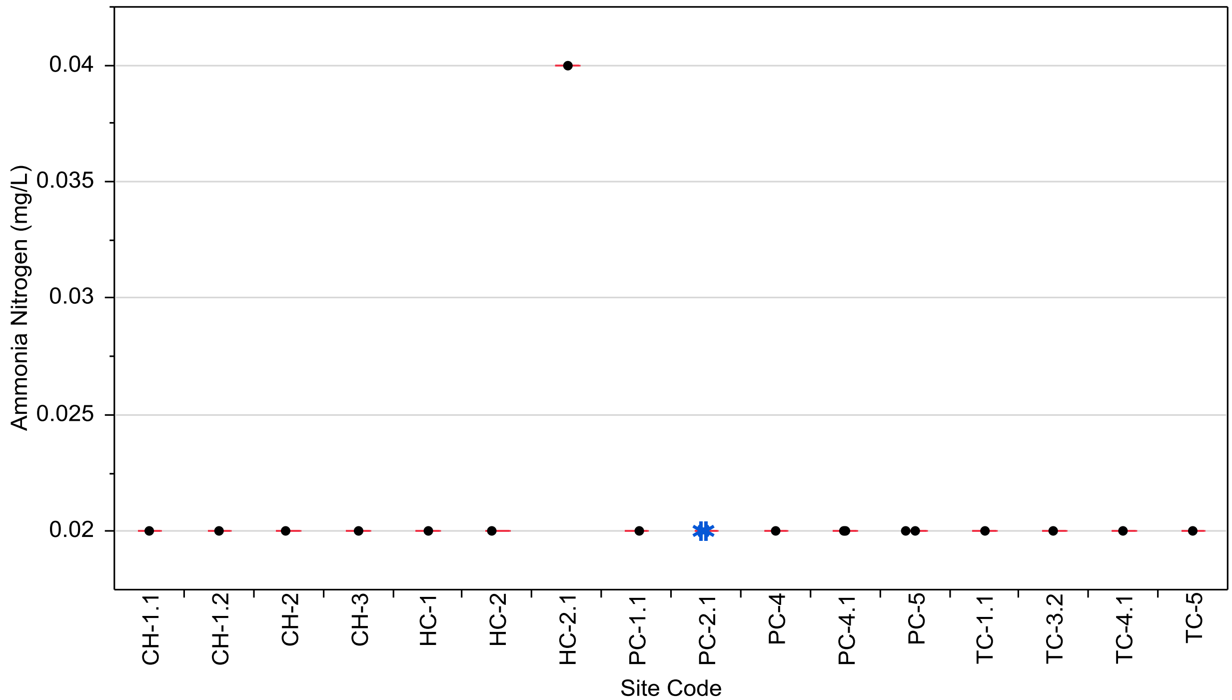
Box Plot 7. Fecal coliform bacteria (CFUs/100 mL) counts.
The two horizontal hashed lines at 200 and 400 CFUs/100 mL are NCWQ Standards. Samples were not collected with intent to assess a NCWQ Standard violation.



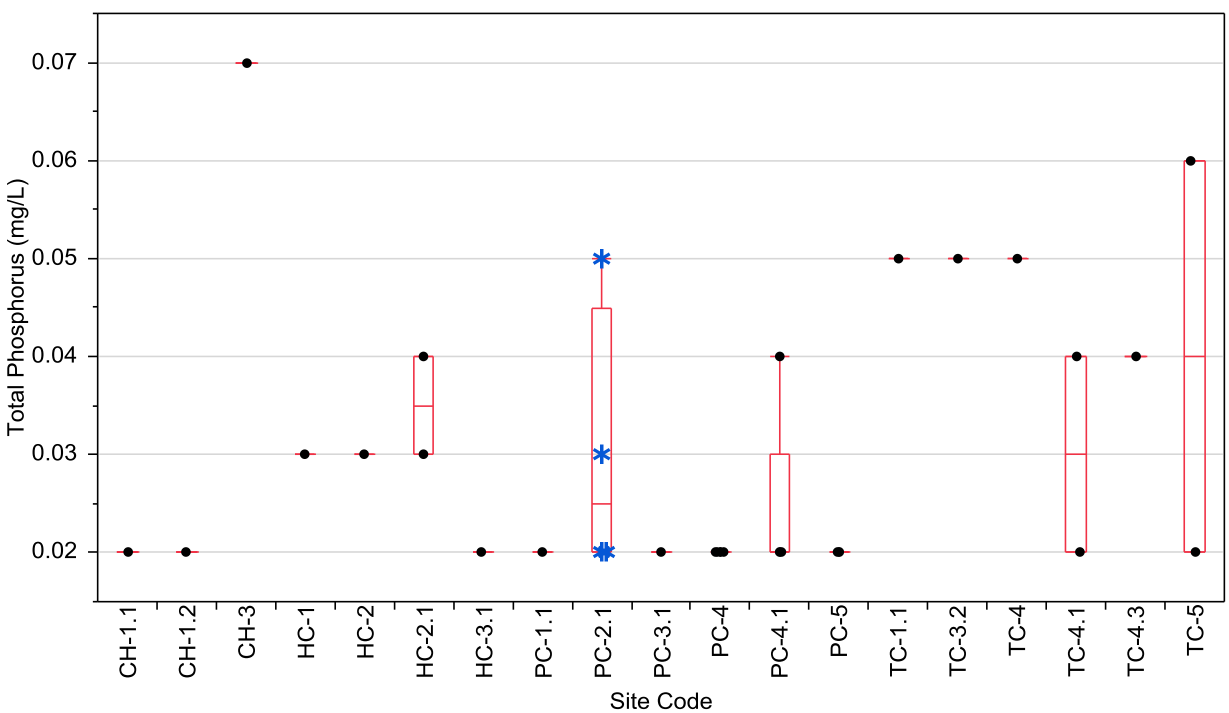
Box Plot 8. Nitrate + nitrite nitrogen (mg/L) concentrations.



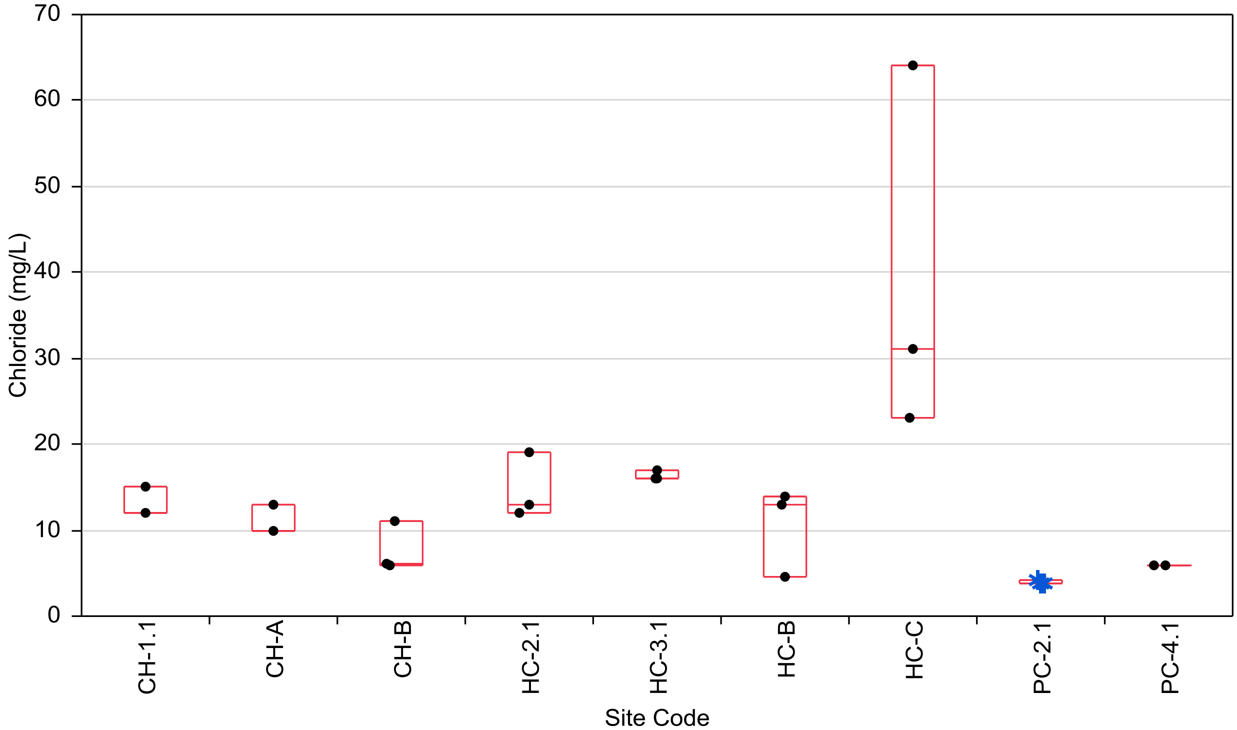
Box Plot 9. Total Kjeldahl nitrogen (mg/L) concentrations.



Box Plot 10. Ammonia nitrogen (mg/L) concentrations.



Box Plot 11. Total phosphorus (mg/L) concentrations.



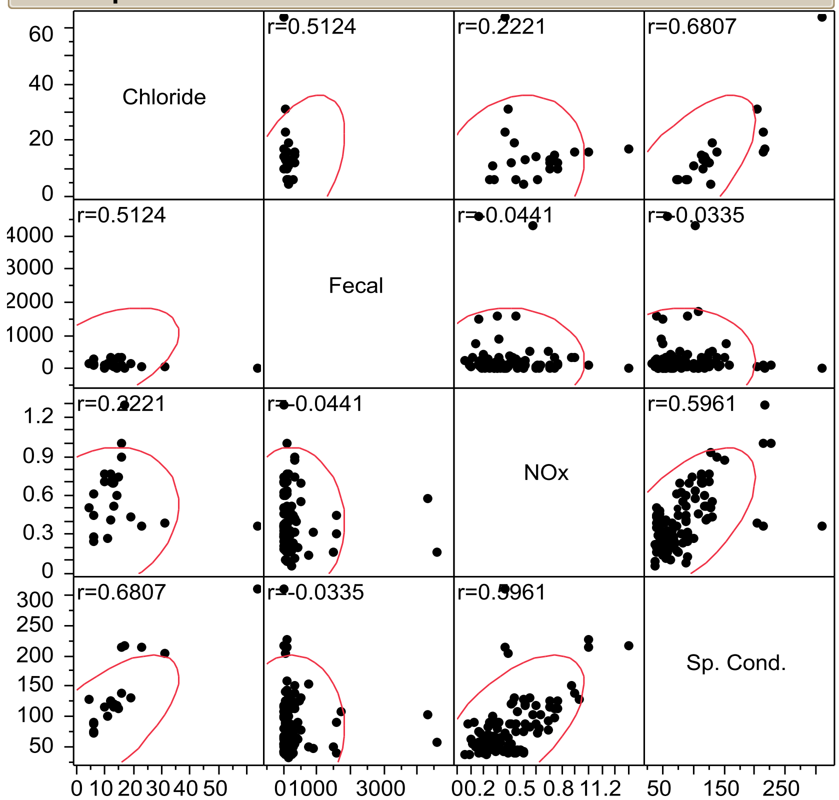
Box Plot 12. Chloride (mg/L) concentrations.

Exhibits

Correlations

	Chloride	Fecal	NOx	Sp. Cond.
Chloride	1.0000	0.5124	0.2221	0.6807
Fecal	0.5124	1.0000	-0.0441	-0.0335
NOx	0.2221	-0.0441	1.0000	0.5961
Sp. Cond.	0.6807	-0.0335	0.5961	1.0000

Scatterplot Matrix



Pairwise Correlations

Variable	by Variable	Correlation	Count	Lower 95%	Upper 95%	Signif Prob
Fecal	Chloride	-0.2546	23	-0.6034	0.1761	0.2411
NOx	Chloride	-0.1028	23	-0.4941	0.3231	0.6407
NOx	Fecal	-0.0513	92	-0.2535	0.1551	0.6271
Sp. Cond.	Chloride	0.8623	23	0.6983	0.9403	<.0001*
Sp. Cond.	Fecal	-0.0320	120	-0.2101	0.1481	0.7284
Sp. Cond.	NOx	0.5940	109	0.4569	0.7035	<.0001*

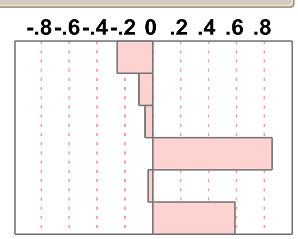


Exhibit 1. Correlation analyses for select data.

Note: Reference data were not included in Exhibit 1 above.

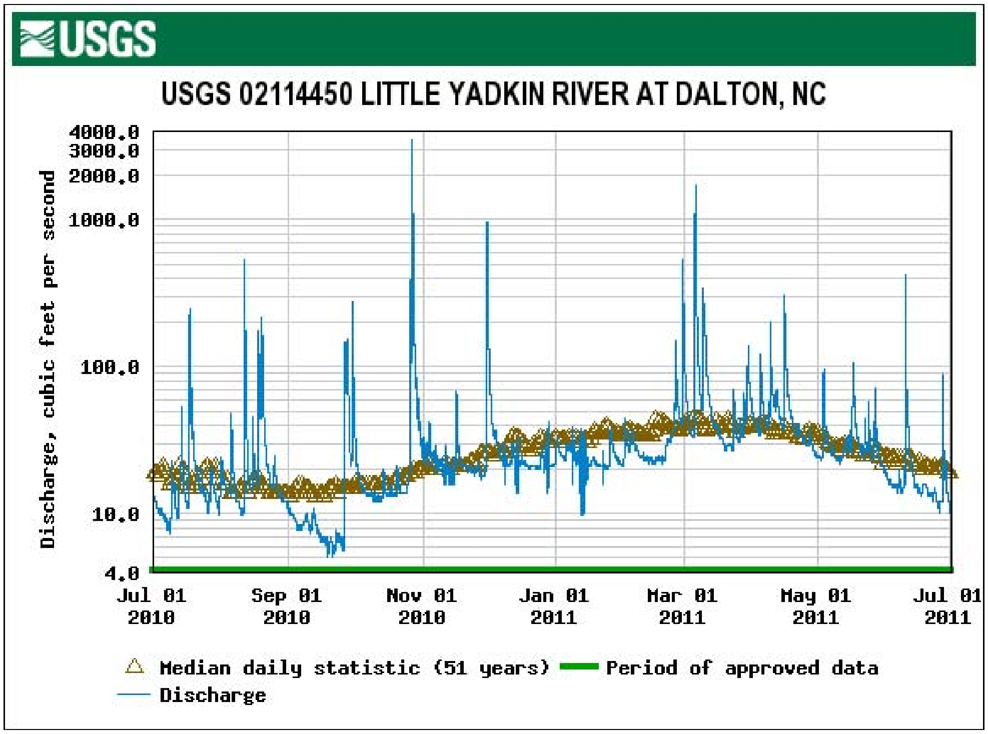


Exhibit 2. Discharge data for Little Yadkin River at Dalton, NC July, 2010 through July, 2011.

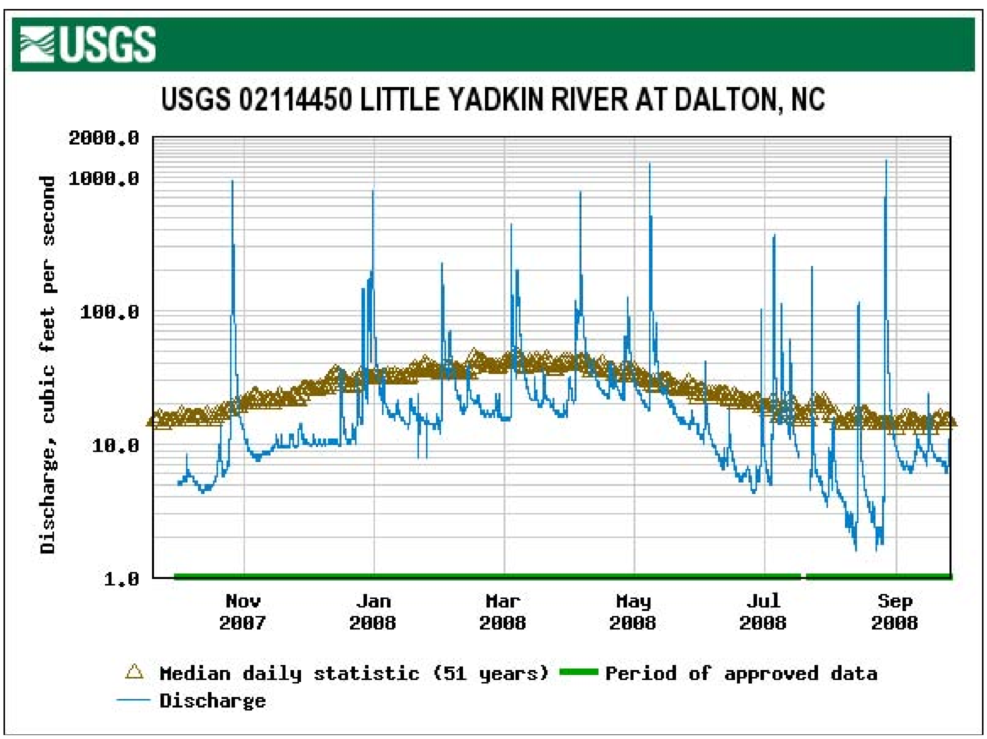


Exhibit 3. Discharge data for Little Yadkin River at Dalton, NC September, 2007 through September, 2008.

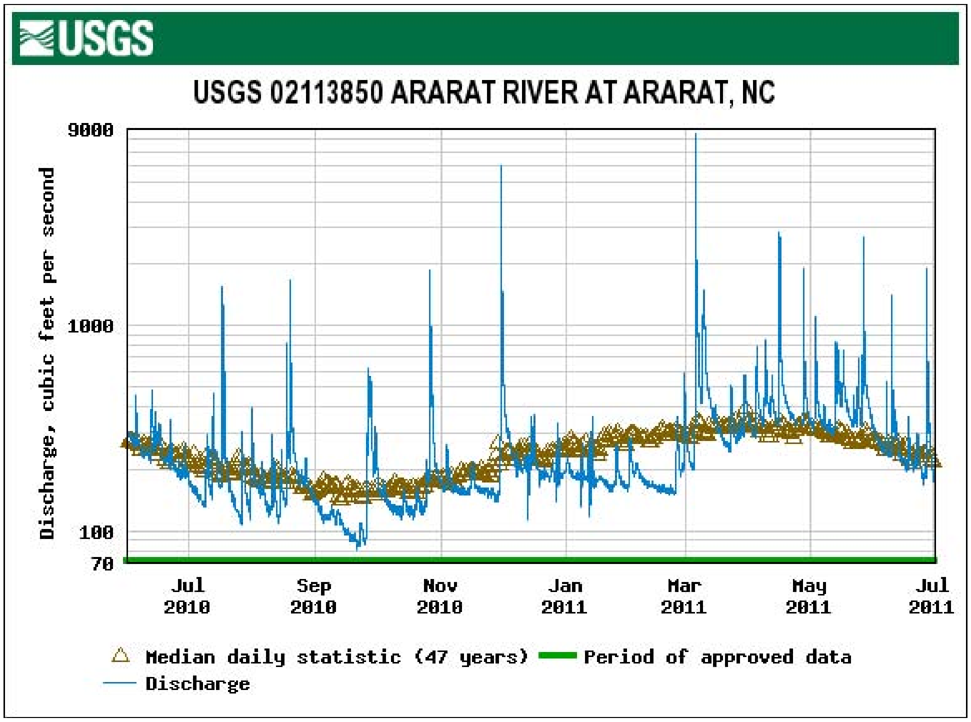


Exhibit 4. Discharge data for Ararat River at Ararat, NC July, 2010 through July, 2011.

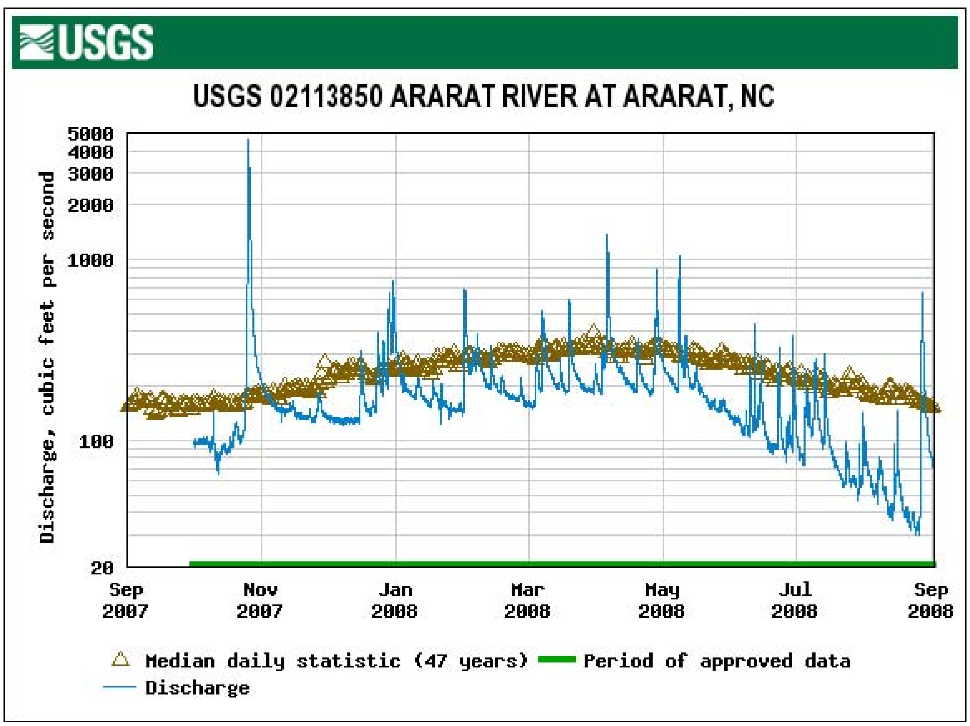


Exhibit 5. Discharge data for Ararat River at Ararat, NC September, 2007 through September, 2008.

APPENDIX B – NC DWQ-BAU Technical Memorandum (Benthos)

Division of Water Quality
Watershed Assessment Team
October 25, 2011

Memorandum

To: Andrea Leslie, EEP
Hal Bryson, EEP

Through: Stratford Kay

From: Cathy Tyndall

Subject: Benthic sampling results for Ararat-Pilot Mountain (APM) Local Watershed Plan
Yadkin River Basin Subbasin 03; HUC 03040101

Background

The North Carolina Ecosystem Enhancement Program (EEP) began a Local Watershed Plan (LWP) in the Ararat River and Upper Yadkin in 2008. This LWP covered an area of approximately 230 square miles and was comprised of nine 14-digit hydrologic units. In support of the LWP, NC DWQ's Biological Assessment Unit (BAU) sampled 14 macroinvertebrate sites in September 2008. The results of this sampling can be found in the BAU memo dated February 4, 2009, Subject: Benthic sampling results for EEP study in Surry County, NC (NCDWQ 2009). In early 2009, this LWP was put on hold.

In early 2011, EEP re-started the LWP effort in the Ararat-Pilot Mountain area. The newly re-started LWP is a smaller focus area within the original LWP and covers 49.7 square miles and is comprised of one 14-digit hydrologic unit (03040101 110 030) and a portion of 03040101 110 050. The re-started LWP area includes the Toms Creek, Chinquapin Creek, Heatherly Creek, and Pilot Creek watersheds. Macroinvertebrate sampling was conducted at 12 sites in May, June, and July 2011 (Table 1 and Figure 1) in support of the re-started LWP. Two of the twelve sites that were sampled in 2011 were sampled in 2008 by BAU. These were Toms Creek at SR 1830 and Heatherly Creek at US 52. Chinquapin Creek was sampled in 2008 and 2011, but at different locations. In 2008, BAU sampled Chinquapin Creek at SR 1830 and the 2011 sampling location was further upstream at SR 1809. The 2008 sampling results for these three sites are depicted in Table 3 with the 2011 results.

The 12 sites that were sampled in 2011 are located in the Northern Inner Piedmont Level IV Ecoregion (Griffith et al 2002). BAU generally considers the Northern Inner Piedmont as an extension of the mountain region due to taxa composition from historical benthic sampling. Bioclassifications based on mountain criteria are more rigorous than piedmont criteria due to the reasoning that mountain streams typically have cooler water temperatures and higher gradients which lead to higher levels of dissolved oxygen and more suitable habitat for macroinvertebrates. Therefore, these sites usually support greater macroinvertebrate diversity and abundance than typical piedmont sites.

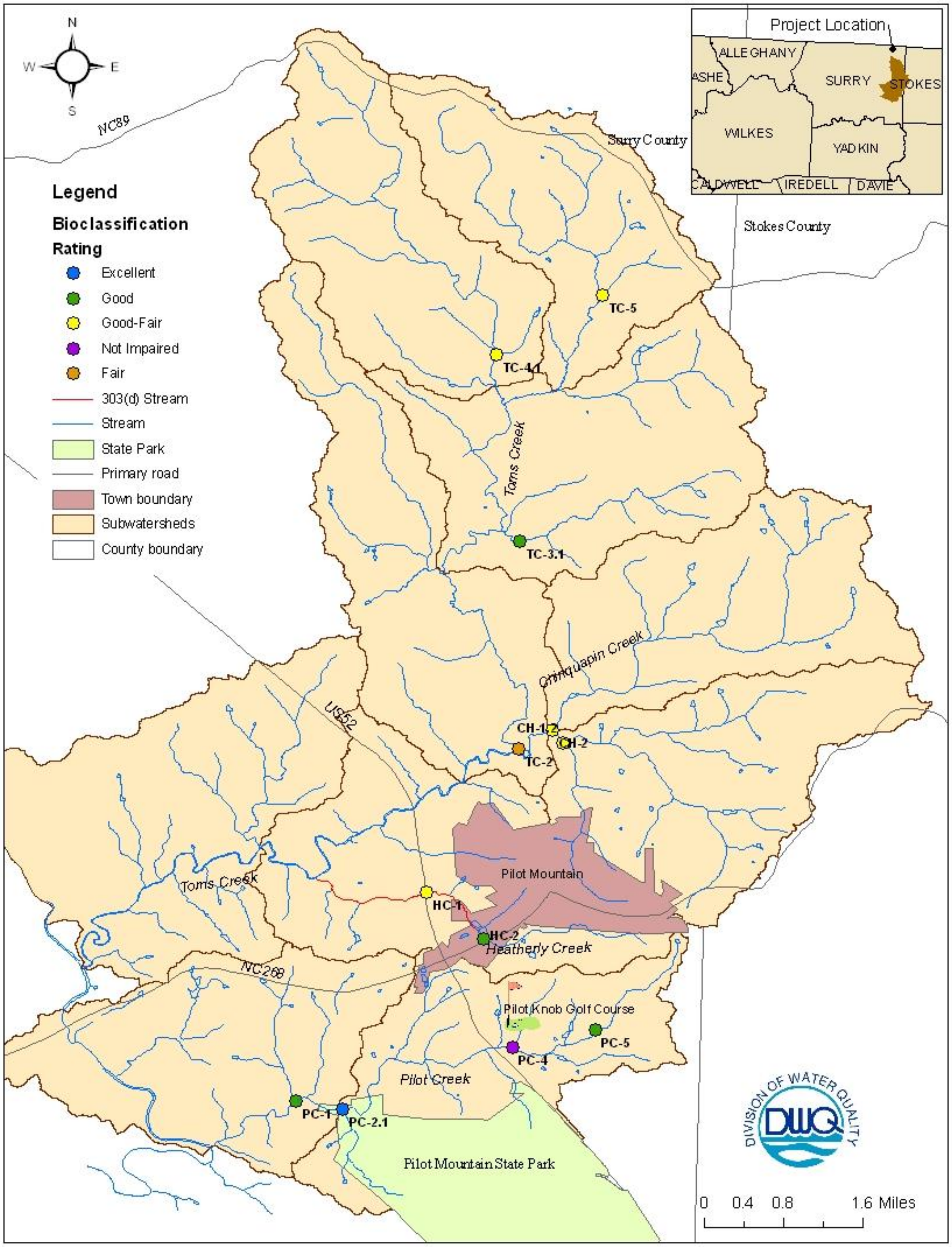


Figure 1. Location of macroinvertebrate sampling locations Ararat Pilot Mountain Local Watershed Plan. May, June July 2011. Surry County.

Table 1. Macroinvertebrate sampling locations Ararat Pilot Mountain Local Watershed Plan, May, June and July 2011. Surry County.

	Toms Cr at SR 1808 Toms Creek Church Rd)	UT Toms Creek at SR 1811 (Cleo Cain Rd)	UT Toms CR at SR 1809 (Old Westfield Rd)	Toms Cr at SR 1830 (Matthews Rd)	Chinquapin Cr at SR 1809 (Old Westfield Rd)	UT Chinquapin Cr at SR 1809 (Old Westfield Rd)
Map number	TC-5	TC-4.1	TC 3.1	TC-2	CH-2	CH 1.2
Sample date	6-27-11	6-27-11	5-26-11	6-27-11	7-18-11	7-18-11
Latitude (º)	36.4724	36.4637	36.4364	36.4068	36.4089	36.4085
Longitude (º)	-80.4633	-80.4787	-80.4753	-80.4763	-80.4705	-80.4705
Drainage area (mi²)	3.3	3.6	1.5	18.3	4.4	4.9
Stream Segment AU	12-72-14-(1)	12-72-14-2	-	12-72-14-(1)	12-72-14-3	-
Stream classification	WS II; HQW	WS II; HQW	WS II; HQW	WS II; HQW	WS II; HQW	WS II; HQW

	Heatherly Cr at NC 268	Heatherly Cr at US 52	Pilot Cr off SR 2144 (Stone Haven Dr)	Pilot Cr at Sand Trap Lane	Pilot Cr at SR 2047 (Shoal Rd)	UT Pilot Cr at Pilot Mtn State Park Rd
Map number	HC-2	HC-1	PC-5	PC-4	PC-1	PC-2.1
Sample date	5-25-11	5-25-11	5-26-11	7-18-11	7-18-11	5-26-11
Latitude (º)	36.3783	36.3852	36.3651	36.3625	36.3546	36.3535
Longitude (º)	-80.4806	-80.4889	-80.4643	-80.4764	-80.5080	-80.5012
Drainage area (mi²)	0.8	1.6	0.5	1.4	6.0	0.8
Stream Segment AU	12-72-14-5a	12-72-14-5b	12-72-16	12-72-16	12-72-16	-
Stream classification	C	C	C	C	C	**C**

Methods

Benthic Macroinvertebrates

Benthic macroinvertebrates were collected using BAU's Qual 4 method. This method is typically used for small streams (streams that have a drainage area of three square miles or less). With the adoption of BAU's small stream criteria in May 2009, small streams that are sampled during the months of April, May and June can be assigned bioclassifications (NCDWQ 2009a). Prior to the adoption of the small stream criteria, small streams could not be assigned a bioclassification and were considered either Not Rated or Not Impaired.

Due to time constraints and to maintain sample consistency, the Qual 4 method was used for all 12 sites, regardless of the watershed size. For the sites with drainage areas greater than three square miles, a bioclassification based on EPT richness was assigned. This was possible since the collection method for Qual 4 samples and EPT samples is the same. A bioclassification was assigned to the small streams using BAU's 2009 small stream criteria except for Pilot Creek at Sand Trap Lane. This site was sampled outside of the small streams bioclassification window and it could not receive a bioclassification using the small streams criteria. It was instead rated with a previous BAU protocol, which rates a small stream as either Not Impaired or Not Rated with EPT richness criteria developed for larger streams. A rating of Not Impaired is given to a site that would get a Good-Fair rating or better. If the site would be Fair or Poor, it is considered Not Rated.

The Qual 4 collection method is comprised of four samples including the collection of one riffle-kick, one bank/root mat sweep, one leaf pack, and visual collections. These collections are used to inventory the aquatic fauna and produce an indication of the relative abundance for each taxon. Organisms are identified to the lowest possible taxon and enumerated as Rare (1-2 specimens, denoted by "R" on taxa tables), Common (3-9 specimens, "C"), or Abundant (≥10 specimens, "A").

Several data analysis summaries (metrics) are calculated from the benthic data to facilitate the detection of physical habitat and/or water quality problems. These metrics are based on a long history of observations and studies that show unstressed streams and rivers have higher invertebrate diversity and a relatively high proportion of intolerant species. Taxa within the three EPT insect orders (Ephemeroptera, Plecoptera and Trichoptera) are generally intolerant of many kinds of pollution. Therefore, higher EPT taxa richness values indicate better water quality. Conversely, polluted streams have lower invertebrate diversity and are dominated by tolerant species.

The diversity of the invertebrate fauna is evaluated using taxa richness (i.e. the total number of distinct taxa present); the tolerance of the stream community is evaluated using a Biotic Index (derived from the general response of each taxon to the presence of stressors). Both tolerance values for individual taxa and the final biotic index values have a range of 0-10 with higher numbers indicating more tolerant taxa and more polluted conditions respectively.

For more information on sampling methods, metrics, and ratings, refer to "*Standard Operating Procedures for Benthic Macroinvertebrates*" (NCDWQ 2006).

Habitat Evaluation
The habitat assessment assigns a numerical score from 1-100 for the reach of stream sampled, based on channel modification, instream habitat, bottom substrate, pool variety, riffle habitats, bank stability and vegetation, light penetration, and width of the riparian zone. More specifically, these habitat evaluations assess the quality and quantity of instream habitat, the quality and quantity of the stream's riparian zone, and also evaluate detrimental impacts on stream habitat such as bank erosion and substrate embeddedness. No criteria have been developed to rate habitat scores, but the higher the score, the better the overall habitat.

Physical-Chemical
Measurements for pH were collected from each site using an Accumet AP61 meter. Data for temperature, dissolved oxygen, and specific conductance were collected using a YSI-85 multimeter for all sites. All measurements were made in accordance with standard operating procedures (NCDWQ 2006a).

Table 2. Summary of habitat and physical-chemical data for benthic sampling sites for the Ararat Pilot Mountain LWP. May, June July 2011. Surry County.

	Toms Cr at SR 1808	UT Toms Creek at SR 1811	UT Toms Cr at SR 1809	Toms Cr at SR 1830	Chinquapin Cr at SR 1809	UT Chinquapin Cr at SR 1809	Heatherly Cr at NC 268	Heatherly Cr at US 52	Pilot Cr off Stone Haven Dr	Pilot Cr at Sand Trap Lane	Pilot Cr at SR 2047	UT Pilot Cr at Pilot Mtn SP Rd
Map number (figure 1)	TC-5	TC-4.1	TC 3.1	TC-2	CH-2	CH 1.2	HC-2	HC-1	PC-5	PC-4	PC-1	PC-2.1
Habitat Scores												
Channel modification (5)	4	4	4	4	4	4	4	3	4	4	4	5
In-stream habitat (20)	8	14	12	8	14	14	14	14	14	12	14	16
Bottom substrate (15)	3	3	6	3	6	6	6	8	6	6	8	12
Pool variety (10)	4	4	8	6	10	10	8	8	8	4	4	10
Riffle habitats (16)	7	3	3	7	7	7	10	7	8	7	16	16
Bank stability/vegetation (14)	8	7	8	10	8	8	8	8	8	6	10	12
Light penetration (10)	10	7	7	10	10	10	10	10	7	2	10	10
Riparian zone width (10)	2	2	4	10	3	0	6	7	5	0	9	7
Total Habitat (100)	46	44	52	58	62	59	66	65	60	41	75	88
Other Habitat												
Average stream width (m)	5	4	2	5	4	3	1.5	3	2	1	3	1.5
Average stream depth (m)	.05	0.2	0.3	0.2	0.2	0.1	.15	0.2	0.1	.05	0.2	.15
Canopy (%)	70	50	50	80	70	70	80	80	75	50	70	80
Substrate (%)												
Bedrock	0	0	0	0	0	0	0	35	5	0	0	5
Boulder	5	0	0	0	10	5	0	0	0	0	20	15
Cobble	5	5	10	5	15	20	10	15	15	20	20	20
Gravel	0	20	20	10	30	25	20	15	30	25	25	25
Sand	85	50	50	75	40	40	65	30	40	45	20	35
Silt	5	25	20	10	5	10	5	5	10	10	15	0
Physicochemical												
Temperature (ºC)	23.1	24.0	24.2	23.8	23.0	23.0	19.3	20.1	21.9	26.0	21.0	18.3
Dissolved oxygen (mg/L)	7.4	7.4	6.8	7.1	6.5	6.6	7.0	6.6	7.4	6.7	7.8	8.4
Specific conductance (µS/cm)	53	43	36	49	74	53	95	100	66	50	60	43
pH	7.0	6.5	--	7.0	7.2	7.0	7.0	6.9	6.8	7.0	6.9	6.9

Table 3. Benthic community summary for Ararat Pilot Mountain LWP May, June July 2011 and June 2008. Surry County.

	Toms Cr at SR 1808	UT Toms Creek at SR 1811	UT Toms Cr at SR 1809	Toms Cr at SR 1830	Toms Cr at SR 1830	Chinquapin Creek at SR 1830[1]	Chinquapin Cr at SR 1809	UT Chinquapin Cr at SR 1809	Heatherly Cr at NC 268	Heatherly Cr at US 52	Heatherly Creek at US 52	Pilot Cr off SR 2144	Pilot Cr at Sand Trap Lane	Pilot Cr at SR 2047	UT Pilot Cr at Pilot Mtn SP Rd
Map # (Figure 1)	TC 5	TC-4.1	TC-3.1	TC-2	NA	NA	CH-2	CH 1.2	HC-2	HC-1	NA	PC-5	PC-4	PC-1	PC-2.1
Sample Date	**6/2011**	**6/2011**	**5/2011**	**6/2011**	**9/2008**	**9/2008**	**7/2011**	**7/2011**	**5/2011**	**5/2011**	**9/2008**	**5/2011**	**7/2011**	**7/2011**	**5/2011**
Sample method	Qual 4	Qual 4	Qual 4	Qual 4	Full Scale	Full scale	Qual 4	Qual 4	Qual 4	Qual 4	Qual 4	Qual 4	Qual 4	Qual 4	Qual 4
Bioclassification	**Good-Fair**	**Good-Fair**	**Good**	**Fair**	**None**	**Good-Fair**	**Good-Fair**	**Good-Fair**	**Good**	**Good-Fair**	**Not Rated**	**Good**	**Not Impaired**	**Good**	**Excellent**
Richness															
Ephemeroptera	11	12	8	7	12	14	12	11	9	6	7	8	15	14	13
Plecoptera	4	5	5	3	3	3	4	3	2	2	1	6	3	5	7
Trichoptera	10	7	3	6	3	4	9	10	4	6	4	11	9	14	10
Total EPT	25	24	16	16	18	21	25	24	15	14	12	25	27	33	30
Odonata	5	5	4	5	8	7	7	3	3	4	1	6	8	3	2
Megaloptera	4	2	2	3	2	2	3	2	1	1	2	1	2	1	0
Coleoptera	1	5	4	5	8	10	6	4	2	2	4	5	6	7	3
Chironomidae	10	11	9	10	13	25	10	5	10	13	8	14	9	11	8
non-Chironomidae Diptera	5	4	4	2	4	5	4	3	5	4	2	6	4	3	6
Oligochaeta	2	2	1	1	1	2	2	2	1	1	3	0	0	0	0
Mollusca	1	1	0	0	2	3	1	1	0	0	1	1	2	1	1
Other taxa	1	2	2	1	3	1	3	0	1	1	1	1	2	0	1
Total taxa richness	54	56	42	43	59	76	61	44	38	40	34	59	60	59	51
Other biological metrics															
EPT abundance	99	113	76	80	79	80	132	99	59	58	61	70	115	152	132
EPT Biotic Index	3.77	3.98	4.42	3.65	4.57	4.94	3.90	3.62	2.90	3.99	5.06	3.42	4.87	3.29	2.22
NCBI	4.34	4.74	4.64	4.41	5.26	5.30	4.62	4.15	4.11	5.21	5.24	4.05	5.27	3.79	2.68

Detailed site descriptions and results

In the Metric and Taxonomic Evaluation discussions for each site, Abundant refers to 10 or greater individuals, Common refers to 3-9 individuals and Rare means that 1-2 individuals were collected. The number in parentheses above the picture corresponds to the map number on Figure 1.

Toms Creek at SR 1808 (Toms Creek Church Rd) (TC-5)

Photo: mid-reach, looking downstream

Visible land use: Forest, residential, fallow fields.
Width (m): 5.0
Drainage Area (mi^2): 3.3
Depth (m): Average: 0.05
Canopy (% cover): 70, deciduous forest
Substrate (%): Boulder (5), rubble (5), gravel (Tr), sand (85), silt (5), bedrock (Tr).
Riparian quality: Right bank not intact <6 meters. Left bank not intact 12-18 meters with breaks.
Instream habitat: Rocks rare, macrophytes rare, sticks/leafpacks common, snags/logs common, undercut banks/ rootmats common.
Habitat Score (out of 100): 46
Dissolved Oxygen (mg/L): 7.4
Specific conductance (µS/cm): 53
Temperature (°C): 23
pH: 7.0
Remarks: Abundant sand. Habitat below SR 1808 supported better fish community; channel width 2 meters, more sinuous,
Bioclassification: Good-Fair

Site Description
This location is the most upstream site sampled for macroinvertebrates on Toms Creek. Sand comprised a high amount of the substrate. The amount of fine silt was not as high at this location as the UT to Toms Creek at SR 1811. Field observations included steep, straight banks, bar development, and water clarity as clear to slightly turbid.

Metrics and Taxonomic Evaluation
This location on Toms Creek received a Good-Fair rating based on EPT richness. Twenty-five EPT taxa were collected and the community was similar to UT Toms Creek at SR 1811. Many of the same taxa were found at both sites. The EPT BI was lower at this site (3.77 versus 3.98), indicating a slightly less tolerant community. *Rhyacophila fuscula*, an intolerant free-living caddisfly, was Abundant at this site but was not collected at the UT Toms Creek at SR 1811. One individual of *Rhyacophila carolina*, another very intolerant caddisfly, was collected here. Other intolerant caddisflies such as *Neophylax oligius* were Common and *Pychnopsyche* were Abundant. Hydropsychid caddisflies (*Hydropsyche betteni*) were Abundant at this site. The beetle diversity was low at this site; only one type of beetle, *Helichus*, was collected. Similar to UT Toms Creek at SR 1811, both intolerant and tolerant taxa were Abundant. The fact that intolerant taxa were Common and Abundant indicates that the water quality is good enough to support intolerant taxa despite the sandy substrate and low habitat score.

UT Toms Creek at SR 1811 (Cleo Cain Rd) (TC-4.1)

Photo: mid-reach, looking upstream

Visible land use: Forest, active pasture, fallow fields, residential.
Width (m): 4.0
Drainage Area (mi^2): 3.6
Depth (m): Average: 0.2
Canopy (% cover): 50, deciduous forest
Substrate (%): Boulder (Tr), rubble (5), gravel (20), sand (50), silt (25).
Riparian quality: Both banks not intact (with breaks) and <6 meters.
Instream habitat: Rocks common, macrophytes rare, sticks/leafpacks common, snags/logs common, undercut banks common, rootmats rare.
Habitat Score (out of 100): 44
Dissolved Oxygen (mg/L): 7.4
Specific conductance (µS/cm): 43
Temperature (°C): 29
pH: 6.5
Remarks: Abundant silt
Bioclassification: Good-Fair

Site Description
This tributary to Toms Creek is located in an agricultural setting with scattered residences. The most obvious habitat concern was the amount of fine silt and sand at this site. The substrate was estimated to be 75% sand and silt. The stream was turbid at time of sampling.

Metrics and Taxonomic Evaluation
This site rated Good-Fair based on the 24 EPT taxa that were collected. The EPT taxa were a mixture of moderately tolerant to intolerant. Abundant mayfly taxa included *Isonychia, Baetis pluto*, and *Maccaffertium modestum*. These are all moderately tolerant. The mayfly *Teloganopsis deficiens*, which is intolerant, was Abundant as were the caddisfly taxa, *Ceratopsyche sparna* and *Neophylax oligius*. The most abundant stonefly was *Perlesta*, a moderately tolerant perlid. Intolerant stoneflies were also collected including *Acroneuria abnormis, Tallaperla, Leuctra*, and *Pteronarcys*. These were all Common or Rare in number. The taxa assemblage was very similar to the headwaters Toms Creek site (Toms Creek at SR 1808). Field notes included that there was a high number of hydropsychid caddisflies which can be an indicator of nutrient enriched conditions. The abundance of the midge, *Tribelos*, which is considered tolerant of enriched conditions further points to enrichment in this tributary. Although there were indicators of nutrient enrichment and a high amount of sand and silt, the water quality was good enough to support some intolerant taxa.

UT Toms Creek at SR 1809 (Old Westfield Rd) (TC-3.1)

Photo: mid-reach, looking upstream

Visible land use: Forest, fallow field, residential.
Width (m): 2.0
Drainage Area (mi^2): 1.5
Depth (m): Average: 0.3
Canopy (% cover): 50, deciduous forest.
Substrate %: Boulder (Tr), rubble (10), gravel (20), sand (50), silt (20).
Riparian quality: Right bank >18 meters with some breaks. Left bank < 6 meters and not intact.
Instream habitat: Rocks common, macrophytes rare, sticks/leafpacks common, snags/logs rare, undercut banks common, rootmats rare.
Habitat Score (out of 100): 52
Dissolved Oxygen (mg/L): 6.8
Specific conductance (µS/cm): 36
Temperature (°C): 24
pH: not documented
Remarks: Small partially breached earthen dam just above site. Eroding clay from the impoundment appears to greatly impact site. Turbid.
Bioclassification: Good

Site Description
This is a small tributary to Toms Creek. A partially breached earthen dam was noted upstream of the sampling reach. At time of sampling, the water was turbid and the bottom was very soft and silty downstream of the impoundment, which suggested that the impoundment created by the dam (or the breaching of the dam) affected the water quality in this small UT.

Metrics and Taxonomic Evaluation
This site received a Good bioclassification based on small stream criteria. Sixteen EPT taxa were collected. The EPT BI was 4.42 and the NCBI was 4.64. The same stonefly and mayfly taxa that were collected at the UT Toms Creek at SR 1811 and the Headwater Toms Creek site at SR 1808 were collected here. The stoneflies included *Perlesta, Acroneuria abnormis, Tallaperla*, and *Leuctra*. An intolerant stonefly, *Isoperla holochlora*, was collected at this site (Rare in abundance) but not in any of the other Toms Creek drainage sites. Five stonefly taxa were collected, a fairly high number for such a small drainage. The mayflies at the three sites included *Isonychia, Teloganopsis deficiens*, and *Eurylophella verisimilis*. However, only three caddisfly taxa were collected here, which is a very low number for caddisfly diversity. All of the caddisflies that were collected were hydropsychids, which are filter feeders, possibly indicating nutrient enriched conditions.

Toms Creek at SR 1830 (Matthews Road) (TC-2)


Photo: mid-reach, looking downstream

Visible land use: Forest, residential, fallow fields.
Width (m): 5.0
Drainage Area (mi^2): 18.3
Depth (m): Average: 0.2
Canopy (%cover): 80, deciduous forest
Substrate %: Boulder (Tr), rubble (5), gravel (10), sand (75), silt (10).
Riparian quality: Riparian zone > 18 meters on both sides and intact.
Instream habitat: Rocks common, macrophytes rare, sticks/leafpacks common, snags/logs common, undercut banks/rootmats common.
Habitat Score (out of 100): 58
Dissolved Oxygen (mg/L): 7.1
Specific conductance (µS/cm): 49
Temperature (°C): 24
pH: 7.0
Remarks: Abundant sand.
Bioclassification: Fair

Site Description
This site is the most downstream location on Toms Creek that was sampled for macroinvertebrates. It has the supplemental classification of WS-II HQW and serves as the water supply for the Town of Pilot Mountain. This location was sampled in 2008 by BAU, but was not rated because it was thought that drought conditions may have adversely affected the benthic community. If a rating had been assigned in 2008, the site would have rated Fair. Similar to other sites sampled in the Toms Creek watershed, sand and silt were estimated to be 85% of the substrate. The habitat received a score of 58, which was the highest habitat score of the four sites sampled in the Toms Creek watershed upstream of Chinquapin Creek. This site scored higher than the other Toms Creek watershed sites for riparian zone width, bank stability, and canopy. The low score was mostly due to the sandy, silty substrate.

Metrics and Taxonomic Evaluation
Based on the number of EPT taxa collected (16), this site received a Fair rating. Sixteen EPT taxa for a stream this large (drainage area = 18.3 square miles) is low. The EPT BI was 3.65 and the NCBI was 4.41. The much smaller upstream sites of upper Toms Creek at SR 1808 (drainage area = 3.3 square miles) and UT Toms Creek at SR 1811 (drainage area = 3.6 square miles) had 25 and 24 EPT taxa, respectively. Sixteen EPT taxa were collected at UT Toms Creek at SR 1809 which has a drainage area of only 1.5 square miles. It would be expected that this lower site would have as many or more EPT taxa in the sample as the upper sites. Toms Creek at SR 1830 did have several intolerant taxa (*Leucrocuta*,

Heptagenia marginalis) that were collected here but not at the other Toms Creek watershed sites. The abundant EPT taxa included the mayflies *Isonychia*, and *Maccaffertium modestum*, the stonefly *Perlesta*, and the caddisflies *Ceratopsyche sparna*, *Neophylax oligius*, and *Cheumatopsyche*. *N. oligius* is intolerant, and *C. sparna* is slightly less intolerant. The intolerant stoneflies, *Acroneuria abnormis* and *Pteronarcys* were common. The low EPT diversity at this site is a concern, although the sample did include some intolerant taxa. Habitat does not appear to be the only cause of the low diversity since the upper sites had sandy, silty substrates. Water quality at this most downstream site on Toms Creek may be adversely affecting the benthic community. Taking into consideration that this site has the supplemental classification of WS-II HQW and that the drainage area is large, the Fair rating should be considered tentative until a Full Scale macroinvertebrate sample can be conducted.

Chinquapin Creek at SR 1809 (Old Westfield Rd) (CH-2)

Photo: mid-reach, looking upstream

Visible land use: Forest, residential, fallow fields, commercial.
Width (m):4.0
Drainage Area (mi^2): 4.4
Depth (m): Average: 0.2
Canopy (% cover): 70, deciduous forest.
Substrate %: Boulder (10), rubble (15), gravel (30), sand (40), silt (5), bedrock (Tr).
Riparian quality: Right bank >18 meters with breaks. Left bank < 6 meters with breaks. Both banks not intact.
Instream habitat: Rocks abundant, macrophytes rare, sticks/leafpacks common, snags/logs common, undercut banks/rootmats common.
Habitat Score (out of 100): 62
Dissolved Oxygen (mg/L): 6.5
Specific conductance (µS/cm): 74
Temperature (°C): 23
pH: 7.2
Remarks: channel filled in with sediment, bar development, exposed bedrock.
Bioclassification: Good-Fair

Site Description

Chinquapin Creek is a tributary to Toms Creek. The amount of sand and silt in the substrate was less than in Toms Creek and overall, the substrate provided better habitat for benthic fauna. However, the specific conductance was slightly higher in Chinquapin Creek (74 µS/cm) than in Toms Creek or any of the UTs to Toms Creek.

Metrics and Taxonomic Evaluation

Twenty-five EPT taxa were collected at this location, yielding a Good-Fair bioclassification. The intolerant mayflies, *Epeorus vitreus*, and *Teloganopsis deficiens* were Abundant. *Epeorus* was not collected at any sites in the Toms Creek watershed. The intolerant stoneflies, *Acroneuria abnormis* and *Eccoptura xanthenes* were Abundant. In addition, the intolerant caddisflies, *Neophylax oligius* and *Chimarra* were Abundant. The benthic community was comprised of intolerant and moderately tolerant taxa.

UT Chinquapin Creek at SR 1809 (Old Westfield Rd) (CH 1.2)

Photo: mid-reach, looking downstream

Visible land use: Forest, residential, fallow fields, commercial.
Width (m): 3.0
Drainage Area (mi^2): 4.9
Depth (m): Average: 0.1
Canopy (% cover): 70, deciduous forest.
Substrate %: Boulder (5), rubble (20), gravel (25), sand (40), silt (10).
Riparian quality: Both riparian zones < 6 meters not intact.
Instream habitat: Rocks abundant, macrophytes rare, sticks/leafpacks common, snags/logs common, undercut banks/rootmats common.
Habitat Score (out of 100): 59
Dissolved Oxygen (mg/L): 6.6
Specific conductance (µS/cm): 53
Temperature (°C): 23
pH: 7.0
Remarks: channel filled in with sediment, bar development, steep, straight banks.
Bioclassification: Good-Fair

Site Description

The drainage area of the UT Chinquapin Creek and Chinquapin Creek are similar, as were the habitat scores. Field notes included that the channel was filled in with sediment, bar development, and steep, straight banks. The specific conductance (53 µS/cm) was less than in Chinquapin Creek (74 µS/cm).

Metrics and Taxonomic Evaluation

Twenty-four EPT taxa were collected and a Good-Fair rating was assigned to this UT to Chinquapin Creek. The EPT BI (3.62) and the NCBI (4.15) were slightly lower at this site than at the Chinquapin Creek site, indicating a slightly less tolerant benthic community. Many of the same taxa were present, but there were some differences such as *Isonychia*, a moderately tolerant mayfly that feeds by filtering food particles, was Abundant in the UT Chinquapin site and was not collected in the Chinquapin site. The intolerant mayfly, *Epeorus vitreus*, was Abundant at both locations as were the intolerant caddisflies, *Neophylax oligious* and *Chimarra*, The stonefly taxa that were collected in Chinquapin Creek and UT Chinquapin Creek were similar.

Heatherly Creek at NC 268 (HC-2)

Photo: mid-reach, looking upstream

Visible land use: Forest, residential, commercial.
Width (m): 1.5
Drainage Area (mi^2): 0.8
Depth (m): Average: 0.15
Canopy (% cover): 80, deciduous forest.
Substrate %: Boulder (Tr), rubble (10), gravel (20), sand (65), silt (5).
Riparian quality: Right riparian zone >18 meters and intact. Left riparian not intact and 6-12 meters.
Instream habitat: Rocks common, macrophytes rare, sticks common, leafpacks rare, snags/logs common, undercut banks/rootmats abundant.
Habitat Score (out of 100): 66
Dissolved Oxygen (mg/L):7.0
Specific conductance (µS/cm): 95
Temperature (°C): 19
pH: 7.0
Remarks: Abundant sand.
Bioclassification: Good

Site Description

Heatherly Creek is an urban stream, with its headwaters originating in the Town of Pilot Mountain. Urban influences such as storm water runoff could affect the specific conductance, which was noticeably higher in Heatherly Creek than in any of the other watersheds. Similar to the other streams in this area, sand and silt were in high amounts in the substrate. Steep, straight banks and bar development were noted in the field as was the scarcity of leaf packs. A higher amount of impervious surfaces in the watershed could affect the occurrence of steep banks, bar development, and scarcity of leaf packs.

Metrics and Taxonomic Evaluation

This small Heatherly Creek site (drainage area = 0.8 square miles) received a Good Bioclassification based on small stream criteria for mountain streams. Fifteen EPT taxa were collected and the EPT BI was the second lowest of the 12 sites after the comparison site. It was observed that hydropsychid caddisflies were scarce at this site while midges (*Tvetenia bavarica, Thienemannimyia gr*.) and baetid mayflies (*Baetis pluto*) were Abundant. The intolerant caddisfly, *Neophylax oligius*, was Abundant. The sample was a mixture of intolerant and moderately tolerant taxa. Although many of the intolerant taxa were Rare in number, their occurrence at all in such a small stream produced a Good rating.

Heatherly Creek at US 52 (HC-1)

Photo: mid-reach, looking upstream

Visible land use: Forest, highway, railroad tracks.
Width (m): 3
Drainage Area (mi^2): 1.6
Depth (m): Average: 0.2
Canopy (% cover): 80, deciduous forest.
Substrate %: Boulder (Tr), rubble (15), gravel (15), sand (30), silt (5), bedrock (35).
Riparian quality: Right riparian zone >18 meters and intact. Left riparian 12-18 meters and not intact .
Instream habitat: Rocks abundant, macrophytes rare, sticks common, leafpacks rare, snags/logs rare, undercut banks common, rootmats abundant.
Habitat Score (out of 100): 65
Dissolved Oxygen (mg/L):6.6
Specific conductance (µS/cm): 100
Temperature (°C): 20
pH: 6.9
Remarks: Railroad tracks run parallel to left bank.
Bioclassification: Good-Fair

Site Description

The drainage area doubles at this location to 1.6 square miles from 0.8 square miles at the NC 268 site on Heatherly Creek. Railroad tracks parallel the stream. There was less sand and silt at this location and a good amount of bedrock.

Metrics and Taxonomic Evaluation

Heatherly Creek at NC 52 has a history of a severely impacted benthic community and poor water quality. This site has been sampled by BAU dating back to 1987. In 1987 and 1994, this site received a Poor Bioclassification. In 1987, only two EPT taxa were collected and in 1994, none were collected. In the years 2001, 2004, 2006, and 2008 it was Not Rated, due to the small size of the drainage area. In 1996, the Town of Pilot Mountain relocated their wastewater treatment plant discharge to the Ararat River. In 2001, the number of EPT taxa increased to 11 and has remained fairly stable (11 in 2004, 17 in 2006, and 12 in 2008) (NCDWQ 2009).

In 2011, 14 EPT were collected at this site. The bioclassification was Good-Fair based on small stream criteria for mountain streams. The benthic sample was a mixture of mostly moderately tolerant taxa with some intolerant taxa. The EPT BI increased from 2.90 at NC 268 to 3.99 at US 52 and the NC BI increased from 4.11 to 5.21. The increase in these metric shows that there is more tolerant benthic community at the downstream US 52 site. The midge, *Chironomus*, was Abundant at US 52 but was not collected at NC 268. *Chironomus* are usually associated with sediments and can occur in heavily polluted conditions or in relatively clean water (Epler 2001). Larvae that are subjected to environmental pollutants may display deformities of the mentum (Lenat 1993). Fifteen of the twenty *Chironomus* specimens were mounted for deformity analysis, but no deformities were observed, possibly indicating low dissolved oxygen conditions rather than toxicants. It is noteworthy that this was the only site of the 12 sampled where *Chironomus* were Abundant and that no Chironomus were collected upstream at NC 268.

Although the Heatherly Creek benthic community declined from the site NC 268 site to the US 52 site in 2011, a comparison of the 2008 US 52 sample with the 2001 sample shows some improvement. In 2008, the EPT BI was 5.06 and the NC BI was 5.24. Both of these metrics declined for the 2011 sample, indicating a less tolerant macroinvertebrate community in 2011 than in 2008.

Pilot Creek off SR 2144 (Stone Haven Drive) (PC-5)

Photo: mid-reach, looking downstream

Visible land use: Forest and residential.
Width (m): 1.5
Drainage Area (mi^2): 0.5
Depth (m): Average: 0.1
Canopy (% cover): 75, deciduous forest
Substrate (%): Boulder (Tr), rubble (15), gravel (30), sand (40), silt (10), bedrock (5).
Riparian quality: Right bank >18 meters and intact. Left bank <6 meters and not intact.
Instream habitat: Rocks abundant, macrophytes rare, sticks/leafpacks common, snags/logs common, undercut banks rare, rootmats common.
Habitat Score (out of 100): 60
Dissolved Oxygen (mg/L): 7.4
Specific conductance (µS/cm): 66
Temperature (°C): 22
pH: 6.8
Remarks: above golf course abundant sand, silt .
Bioclassification: Good

Site Description
This small site on Pilot Creek was chosen because it is located above the Pilot Knob golf course and could be compared to the site below the golf course. It was noted in the field that there was a large amount of sand and silt in the substrate, even at this furthest upstream location on Pilot Creek. Riffles were shallow and short and root mats were isolated from the water.

Metrics and Taxonomic Evaluation
This small site rated Good based on small stream criteria. Twenty-five EPT taxa were collected. The EPT BI was 3.42 and the NCBI was 4.05. Six different stonefly taxa were collected including *Eccoptura xanthenes*, *Perlesta*, *Tallaperla*, *Amphinemura*, *Leuctra*, and *Isoperla holochlora*. Eight mayfly taxa were collected including the intolerant taxa *Paraleptophlebia* and *Habrophleboides*. This is the only site where *Habrophleboides* was collected. The intolerant caddisfly, *Dolophilodes*, was Abundant. Other intolerant caddisfly taxa collected included *Diplectrona modesta*, *Glossosoma*, and *Pycnopsyche gentilis*. Twenty-five EPT is a high number of taxa for a 0.5 square mile drainage area.

Pilot Creek at Sand Trap Lane (PC-4)

Photo: mid-reach, looking downstream

Visible land use: Forest, agriculture.
Width (m): 1.0
Drainage Area (mi^2): 1.4
Depth (m): Average: 0.1
Canopy (% cover): 50, deciduous trees, shrubs
Substrate (%): Boulder (Tr), rubble (20), gravel (25), sand (45), silt (10), bedrock (Tr).
Riparian quality: Both banks <6 meters and not intact.
Instream habitat: Rocks common, macrophytes rare, sticks/leafpacks common, snags/logs rare, undercut banks/ rootmats common.
Habitat Score (out of 100): 41
Dissolved Oxygen (mg/L): 6.7
Specific conductance (µS/cm): 50
Temperature (°C): 26
pH: 7.0
Remarks: below golf course, appears nutrient enriched, lots of algae and periphyton.
Bioclassification: Not Impaired

Site Description

This site is located below the golf course and is adjacent to tobacco fields. It was observed that this site appeared to be more nutrient enriched than the upper site at Stone Haven Drive by the amount of algae and periphyton that covered the rocks in the stream substrate. The site is also more open with less canopy, allowing for warmer water temperatures and increased algae growth.

Metrics and Taxonomic Evaluation

This site was rated as Not Impaired, since it was sampled in July and the small stream criteria could not be used to determine a rating. Not Impaired means that the site would have rated at least Good-Fair, using criteria for larger streams. This site had 27 EPT taxa, which is slightly more than the 25 EPT taxa collected above the golf course. However, the EPT BI increased from 3.42 at the Pilot Creek site above the golf course to 4.87 below the golf course and the NC BI increased from 4.05 to 5.27, meaning that this site supports a much more tolerant macroinvertebrate community than the upper site that is located above the golf course. This site had the highest EPT BI and NCBI, indicating the most tolerant benthic community of all 12 sites. The mayfly, *Caenis*, which is tolerant and is found in depositional zones and areas with silt, was Abundant. *Baetis intercalaris,* a tolerant and ubiquitous mayfly was also Abundant, but was not collected at the upstream Pilot Creek location. The increase in number or the new appearance of taxa such as *Caenis*, *B. intercalaris*, *Hydropsyche betteni*, and *Cheumatopsyche* all corroborate with the increase in water temperature and increased algae and periphyton on the substrate that this site is showing signs of nutrient enrichment.

Pilot Creek at SR 2047 (Shoal Road) (PC-1)

Photo: mid-reach, looking downstream

Visible land use: Forest.
Width (m): 3.0
Drainage Area (mi^2): 6.0
Depth (m): Average: 0.2
Canopy (% cover): 70, deciduous trees, shrubs
Substrate (%): Boulder (20), rubble (20), gravel (25), sand (20), silt (15).
Riparian quality: Left and right banks >18 meters. Right bank intact. Left bank not intact.
Instream habitat: Rocks abundant, macrophytes common, sticks/leafpacks common, snags/logs rare, undercut banks/ rootmats rare.
Habitat Score (out of 100): 75
Dissolved Oxygen (mg/L): 7.8
Specific conductance (µS/cm): 60
Temperature (°C): 21
pH: 6.9
Remarks: Abundant silt on rocks and roots.
Bioclassification: Good

Site Description

This location on Pilot Creek is below the confluence with the UT Pilot Creek (small stream reference site). At the time of sampling it was turbid and there was a high amount of silt on the substrate rocks and root mats. Sand and Silt were estimated to be 35% of the total substrate. Local stakeholders stated that a road project may be part of the silt problem, but also stated that the stream showed impacts from erosion prior to the road project. More silt was noted at this Pilot Creek site than in the UT Pilot Creek.

Metrics and Taxonomic Evaluation

This site received a Good bioclassification. Thirty-three EPT taxa were collected, the highest number of EPT taxa collected at the 12 sites. The EPT BI (3.29) was the third lowest, after the reference site (UT Pilot Creek at State Park Road) and the upper Heatherly Creek site at US 268. The NCBI (3.79) was the second lowest after the reference site. Fourteen different caddisfly taxa were collected, which is the highest number of the 12 sites. This was the only site where the caddisfly *Ceratopsyche morosa* was collected. The intolerant mayflies, *Leucrocuta* and *Epeorus vitreus* were Abundant. Although silt was abundant, *Neophylax oligius*, an intolerant caddisfly that attaches its retreat to rocks was Abundant.

UT Pilot Creek off gated SP Road (PC-2.1)

Photo: mid-reach, looking upstream

Visible land use: Forest
Width (m): 1.5
Drainage Area (mi^2): 0.8
Depth (m): Average: .15
Canopy (% cover): 80, deciduous forest
Substrate (%): Boulder (15), rubble (20), gravel (25), sand (35), silt (0), bedrock (5).
Riparian quality: Right bank >18 meters and intact. Left bank not intact (gravel road parallel to stream) riparian width 12-18 meters.
Instream habitat: Rocks abundant, macrophytes rare, sticks common, leafpacks abundant, snags/logs rare, undercut banks/ rootmats rare.
Habitat Score (out of 100): 78
Dissolved Oxygen (mg/L): 8.4
Specific conductance (µS/cm): 43
Temperature (°C): 18
pH: 6.9
Remarks: abundant sand.
Bioclassification: Excellent

Site Description
This site was sampled to serve as a reference site for the small streams (drainage area less than 3 square miles). This UT to Pilot Creek originates within and flows mostly through Pilot Mountain State Park and has a mostly forested watershed.

Metrics and Taxonomic Evaluation
This was the only site that received an Excellent bioclassification. Thirty EPT taxa were collected and the EPT BI (2.22) and the NCBI (2.68) were the lowest of all 12 sites, indicating that this site had the most intolerant benthic fauna. Seven stonefly taxa were collected at this site, the most at any of the 12 sites. This was the only site where the intolerant mayfly, *Paraleptophlebia* was Abundant and the only site where another intolerant mayfly *Habrophlebia vibrans*, was collected. This is also one of two locations where the intolerant caddisfly *Dolophilodes* was Abundant. Two genera of the intolerant caddisfly *Neophylax* were collected (*N. oligius* and *N. mitchelli*) as well as *Rhyacophila fuscula* and *R. carolina*.

Table 4. Grouping of 2011 macroinvertebrate sites based on Bioclassification

	Bioclassification	EPT BI	NC BI
Excellent Bioclassification			
UT Pilot Creek off gated State Park Road	Excellent	2.22	2.68
Good Bioclassification			
Pilot Creek at SR 2047 (Shoal Road)	Good	3.29	3.79
Pilot Creek off SR 2144 (Stone Haven Road)	Good	3.42	4.05
Heatherly Creek at NC 268	Good	2.90	4.11
UT Toms Creek at SR 1809	Good	4.42	4.64
Good-Fair Bioclassification/Not Impaired			
Toms Creek at SR 1808	Good-Fair	3.77	4.34
Chinquapin Creek at SR 1809	Good-Fair	3.90	4.62
UT Chinquapin Creek at SR 1809	Good-Fair	3.62	4.15
UT Toms Creek at SR 1811	Good-Fair	3.98	4.74
Heatherly Creek at US 52	Good-Fair	3.99	5.21
Pilot Creek at Sand Trap Lane	Not Impaired	4.87	5.27
Fair Bioclassification			
Toms Creek at SR 1830	Fair	3.65	4.41

Conclusions

Toms Creek watershed
Overall, sites in the Toms Creek watershed upstream of Chinquapin Creek had the lowest habitat scores than the other three watersheds (Heatherly, Chinquapin, Pilot Creek). The Toms Creek drainage upstream of Chinquapin Creek has more sand and silt in the substrate than the other watersheds. The substrate scores along with poor riffles and narrow riparian zones contributed to the overall low habitat scores.

Toms Creek is classified as WS II, HQW and it serves as the water supply for the Town of Pilot Mountain. The lower site at SR 1830 rated Fair due to the low number of EPT taxa collected. The sample did contain some intolerant taxa, so it is difficult to say whether it is habitat or water quality or the combination of both that is stressing the benthic community. It may be a combination of both poor habitat and water quality issues related to nutrient enrichment. The macroinvertebrate community composition of the samples from the upper sites at SR 1808 and the UT at SR 1811 did indicate nutrient enrichment and a

2.5 mile stream walk upstream from SR 1830 revealed abundant periphyton growth on rocks and the sandy substrate. In addition, areas of slow water movement and poor habitat (steep banks, straight channel, no edge habitat, and silty bottom) were noted. Typically, it is expected that the taxa richness and diversity increase as the watershed size of a stream increases, but this was not the case in Toms Creek. As demonstrated by the benthic communities, the water quality in Toms Creek declines in a downstream progression.

Chinquapin Creek watershed
Benthic sampling in 2011 in Chinquapin Creek and the UT Chinquapin Creek indicated Good-Fair benthic community conditions. The 2008 sample in Chinquapin Creek at SR 1830 also rated Good-Fair. Overall, the stream quality in the Chinquapin Creek watershed can be characterized as Good-Fair.

Based on 2011 sampling, the specific conductivity is slightly elevated in Chinquapin Creek prior to the confluence with the UT.

Heatherly Creek watershed
Heatherly Creek is currently 303d listed from NC 268 to Toms Creek for biological integrity (benthos) based on a 1994 Fair rating (NCDWQ 2010). The US 52 site rated Good-Fair in 2011 using small stream criteria and shows improvement since the relocation of the Town of Pilot Mountain's wastewater treatment discharge in 1996. However, there are still concerns in Heatherly Creek with the elevated specific conductivity and the benthic community at US 52 which is more tolerant than the upstream location on Heatherly Creek. Benthic sampling in 2011 suggested that the water quality in Heatherly Creek declined from the upstream site at NC 268 to the downstream site at US 52. The NC 268 site on Heatherly Creek had the second highest EPT BI after the reference site on UT Pilot Creek.

Pilot Creek
The UT Pilot Creek site at State Park Road, which was sampled as a reference site for the small streams (streams that have a drainage area of three square miles or less), was clearly the most intolerant (highest quality) benthic community of the 12 sites sampled, although it was evident that this small system carried a large amount of sand. Comparing this reference site to the other five small sites in the study clearly shows that this site supports a much more intolerant benthic fauna. The watershed for this small UT is mostly forested.

Water quality decreases in Pilot Creek from the site above the golf course to the site below the golf course. The Pilot Creek site below the golf course at Sand Trap Lane is clearly showing signs of stress, possibly from the golf course and/or agriculture. The high EPT taxa number, high EPT BI, high NCBI, fairly low number of midge taxa, and absence of oligochaetes is an atypical benthic faunal composition and is an indication of nutrient enrichment. Pilot Creek appears to recovers after the golf course site and rated Good at SR 2047. Input from UT Pilot Creek just upstream of the SR 2047 site may help the water quality and benthic community at the SR 2047 site.

Recommendations for further study

1. It is recommended that Toms Creek at SR 1830 be re-sampled with the Full Scale sampling method to determine if the tentative 2011 Fair rating that was determined based on EPT taxa richness remains valid.

2. Although the Pilot Creek site at Shoal Road had the third highest EPT BI and rated Good, there was a large amount of sand and silt covering the substrate and root mats. The source of sand/silt needs to be investigated.

3. In addition, further investigation is recommended to determine whether the golf course and/or agriculture are contributing to nutrient enrichment in Pilot Creek.

4. Pending basinwide planning review of Heatherly Creek, it may be necessary to re-sample the NC 52 site to determine if the section of Heatherly Creek (NC 268 to Toms Creek) that is currently on the 303d list for biological integrity can be removed. If any additional sampling is conducted in Heatherly Creek at NC 52, it should be done April through June when small stream criteria can be used to assign a rating.

References

Epler, John H. 2001. Identification Manual for the larval Chironomidae (Diptera) of North and South Carolina. A guide to the taxonomy of the midges of the southeastern United States including Florida. Special Publication SJ2001-SP13.

Griffith, G.E., Omernik, J.M., Comstock, J.A. Schafale, M.P., McNab, W.H., Lenat, D.R., MacPherson, T.F., Glover, J.B. and Shelburne, V.B. 2002. Ecoregions of North Carolina and South Carolina. (color poster with map, descriptive text, summary tables and photographs): Reston, VA, U.S. Geological Survey (map scale 1:1,500,000

Lenat, David R. 1993. Using mentum deformities of *Chironomus* larvae to evaluate the effects of toxicity and organic loading in streams. Journal North American Benthological Society 12(3): 265-269.

NCDWQ. 2006. Standard Operating Procedures for Benthic Macroinvertebrates. NC Division of Water Quality – Biological Assessment Unit. July 26. 2006. See: http://www.esb.enr.state.nc.us/BAUwww/benthossop.pdf

NCDWQ. 2006a. Intensive Survey Unit – Standard Operating Procedures Manual: Physical and Chemical Monitoring. Version 1.3. December 2006. NC Division of Water Quality, Environmental Sciences Section. See: http://www.esb.enr.state.nc.us/documents/PHYSICAL-CHEMICAL%20SOP.pdf

NCDWQ 2009. Benthic sampling results for EEP study in Surry County, NC. September 2008 (Yadkin River Basin, Subbasin 03; HUC 03040101.

NCDWQ. 2009a. Small Streams Biocriteria Development. NC Division of Water Quality. May 29, 2009. See: http://portal.ncdenr.org/c/document_library/get_file?uuid=2d54ad23-0345-4d6e-82fd-04005f48eaa7&groupId=38364

NCDWQ. 2010 North Carolina Water Quality Assessment and Impaired List (2006 Integrated 305(b) and 303(d) Report) Final. Planning Section, Division of Water Quality. http://h2o.enr.state.nc.us/tmdl/General_303d.htm

Appendix 1. List of Taxa for Ararat Pilot Mountain LWP, June, July August 2011.

		TOMS CR SR 1808	UT TOMS CREEK SR 1811	UT TOMS CR SR 1809	TOMS CR SR 1830	CHINQUAPIN CR SR 1809	UT CHINQUAPIN CR SR 1809	HEATHERLY CR NC 268	HEATHERLY CR US 52	PILOT CR OFF STONE HAVEN DR	PILOT CR SAND TRAP LN	PILOT CR SR 2047	UT PILOT CR PILOT MTN SP RD
	Ephemeroptera												
Baetidae	ACENTRELLA NADINEAE												R
	ACENTRELLA SPP		R									R	
	BAETIS FLAVISTRIGA					R					R	R	R
	BAETIS INTERCALARIS	C	R	C	C	A	R	R	A		A	A	
	BAETIS PLUTO	C	A	R		R		A	A	R	R	R	A
	BAETIS TRICAUDATUS							C	C				R
	CENTROPTILUM SPP		R								C		
	PLAUDITUS DUBIUS GR				R	R					R	C	
	PROCLOEON APPALACHIA									R			
	PROCLOEON SPP						R	R					
	PSEUDOCLOEON PROPINQUUM	R						R			C		
Caenidae	BRACHYCERCUS SPP	R											
	CAENIS SPP	C	C			R				R	A		
Ephemerellidae	EPHEMERELLA DOROTHEA							R					R
	EURYLOPHELLA VERISIMILIS	R	R	R			R	C	R				R
	TELAGONOPSIS DEFICIENS	C	A	C		A	C			R	C	C	
Ephemeridae	HEXAGENIA SPP	R	R		R								
Heptageniidae	EPEORUS DISPAR										R		
	EPEORUS VITREUS					A	A					A	A
	HEPTAGENIA MARGINALIS				C								
	LEUCROCUTA SPP				C	C	C				R	A	C
	MACCAFFERTIUM ITHACA		R				R					R	
	MACCAFFERTIUM MODESTUM	A	A	A	A	A	A			A	A	A	
	MACCAFFERTIUM PUDICUM							A	A				A
	STENACRON INTERPUNCTATUM					R	R		R		C	C	

		TOMS CR SR 1808	UT TOMS CREEK SR 1811	UT TOMS CR SR 1809	TOMS CR SR 1830	CHINQUAPIN CR SR 1809	UT CHINQUAPIN CR SR 1809	HEATHERLY CR NC 268	HEATHERLY CR US 52	PILOT CR OFF STONE HAVEN DR	PILOT CR SAND TRAP LN	PILOT CR SR 2047	UT PILOT CR PILOT MTN SP RD
	STENACRON PALLIDUM			R		C	R	C			R	C	R
Isonychiidae	ISONYCHIA SPP	A	A	A	A		A			R	A	A	R
Leptohyphidae	TRICORYTHODES SPP					R					R		
Leptophlebiidae	HABROPHLEBIA VIBRANS												R
	HABROPHLEBIODES SPP									C			
	PARALEPTOPHLEBIA SPP	R	R	R						C		C	A
	Plecoptera												
Leuctridae	LEUCTRA SPP	R	C	R		R				R	R	R	R
Nemouridae	AMPHINEMURA SPP								R	C			C
Peltoperlidae	TALLAPERLA SPP	C	R	R						R		C	C
Perlidae	ACRONEURIA ABNORMIS	C	C	C	C	A	C				C	A	A
	ECCOPTURA XANTHENES					A	C	R		C	C	R	C
	PERLESTA SPP	A	A	A	A	C	A	A	R	A		A	A
Perlodidae	ISOPERLA HOLOCHLORA			R						R			A
Pteronarcyidae	PTERONARCYS SPP		R		C								
	Trichoptera												
Glossosomatidae	GLOSSOSOMA SPP					R				R		R	R
Hydropsychidae	CERATOPSYCHE MOROSA											R	
	CERATOPSYCHE SPARNA	C	A	A	A	A	C		R	R	C	A	A
	CHEUMATOPSYCHE SPP	C	A	A	A	A	A		A	C	A	A	C
	DIPLECTRONA MODESTA							R		R			
	HYDROPSYCHE BETTENI	A	A	A		A	R	R	C	C	A	C	R
Leptoceridae	OECETIS NOCTURNA						R						
	TRIAENODES IGNITUS		R		R	C	C			R	A	C	
Limnephilidae	PYCNOPSYCHE GENTILIS									R			
	PYCNOPSYCHE LEPIDA GR	R											
	PYCNOPSYCHE SPP	A	C		R	R	R	C	R	C		R	
Philopotamidae	CHIMARRA SPP	C	R			A	A			C	A	A	R

		TOMS CR SR 1808	UT TOMS CREEK SR 1811	UT TOMS CR SR 1809	TOMS CR SR 1830	CHINQUAPIN CR SR 1809	UT CHINQUAPIN CR SR 1809	HEATHERLY CR NC 268	HEATHERLY CR US 52	PILOT CR OFF STONE HAVEN DR	PILOT CR SAND TRAP LN	PILOT CR SR 2047	UT PILOT CR PILOT MTN SP RD
	DOLOPHILODES SPP								C	A	R	C	A
Polycentropodidae	POLYCENTROPUS SPP						R				R		
Psychomyiidae	LYPE DIVERSA										R		
	PSYCHOMYIA SPP						R					R	
Rhyacophilidae	RHYACOPHILA CAROLINA	R										R	R
	RHYACOPHILA FUSCULA	A			R	R						C	C
Uenoidae	NEOPHYLAX MITCHELLI	R										R	R
	NEOPHYLAX OLIGIUS	C	A		A	A	A	A	C	C	C	A	A
	Odonata												
Aeshnidae	BOYERIA SPP									R			
	BOYERIA VINOSA	C	C	R	R	C			R		C	C	
Calopterygidae	CALOPTERYX SPP	R	R		R	R		R	C	C	C		R
Coenagrionidae	ARGIA SPP		A			C			R	R	C		
Cordulegasteridae	CORDULEGASTER SPP					R				R	C		
Gomphidae	GOMPHUS SPP	R	C		C						C		
	HAGENIUS BREVISTYLUS			R									
	LANTHUS SPP			C			R	R	R	R		R	R
	OPHIOGOMPHUS SPP	A	A	C	R		R				A	R	
	PROGOMPHUS OBSCURUS					R					R		
	STYLOGOMPHUS ALBISTYLUS					C							
	STYLURUS SPP									R			
Macromiidae	MACROMIA SPP	R			R	R	R	R					
	MACROMIIDAE										R		
	Hemiptera												
Gerridae	GERRIDAE					R					R		
	Megaloptera												
Corydalidae	CORYDALUS CORNUTUS	R	C	R	C	R	C		R		C		
	NIGRONIA FASCIATUS	R								R			

		TOMS CR SR 1808	UT TOMS CREEK SR 1811	UT TOMS CR SR 1809	TOMS CR SR 1830	CHINQUAPIN CR SR 1809	UT CHINQUAPIN CR SR 1809	HEATHERLY CR NC 268	HEATHERLY CR US 52	PILOT CR OFF STONE HAVEN DR	PILOT CR SAND TRAP LN	PILOT CR SR 2047	UT PILOT CR PILOT MTN SP RD
	NIGRONIA SERRICORNIS	R		R	R	A	C	C			R	C	
Sialidae	SIALIS SPP	R	C		R	R							
	Coleoptera												
Dryopidae	HELICHUS SPP	C	A	C	C	R	R	R	R	R	C	C	R
Elmidae	ANCYRONYX VARIEGATUS					C							
	MACRONYCHUS GLABRATUS		C		R	R	C			R	C	C	
	OPTIOSERVUS OVALIS		C		R						R	R	
	PROMORESIA ELEGANS				R								
	PROMORESIA SPP											R	
	STENELMIS SPP		R	R		R				R	R	C	R
Gyrinidae	GYRINUS SPP		C	R	R	R	R						
Hydrophilidae	LACCOBIUS SPP										R		
Psephenidae	PSEPHENUS HERRICKI					C	R	C	R	C	C	A	C
Ptilodactylidae	ANCHYTARSUS BICOLOR			R						R		C	
	Chironomidae												
Chironomidae	ABLABESMYIA MALLOCHI										R		
	BRILLIA SPP	R		R				R	R	R		R	
	CARDIOCLADIUS SPP								R			R	
	CHIRONOMUS SPP		R		R				A	R			
	CLADOTANYTARSUS SP A												R
	CORYNONEURA SPP	R							R				
	CRICOTOPUS BICINCTUS					C					C	R	
	CRYPTOCHIRONOMUS SPP									R			
	CRYPTOTENDIPES SPP									R			
	DEMICRYPTOCHIRONOMUS SP C						R						
	DIAMESA SPP												C
	DICROTENDIPES NEOMODESTUS								R				
	EUKIEFFERIELLA CLARIPENNIS GR							C					

		TOMS CR SR 1808	UT TOMS CREEK SR 1811	UT TOMS CR SR 1809	TOMS CR SR 1830	CHINQUAPIN CR SR 1809	UT CHINQUAPIN CR SR 1809	HEATHERLY CR NC 268	HEATHERLY CR US 52	PILOT CR OFF STONE HAVEN DR	PILOT CR SAND TRAP LN	PILOT CR SR 2047	UT PILOT CR PILOT MTN SP RD
	EUKIEFFERIELLA DEVONICA GR				R								
	MICROTENDIPES RYDALENSIS GR					R							
	MICROTENDIPES SPP		R		R		C						
	NANOCLADIUS DOWNESI	R	C										
	NANOCLADIUS SPP									R		R	
	PAGASTIA ORTHOGONIA	R											
	PARAMETRIOCNEMUS SPP	C	C	R		R		C	C	C		A	C
	PARATENDIPES SPP									R			
	PENTANEURA INCONSPICUA			R							R		
	PHAENOPSECTRA OBEDIENS GR				C	C			A				
	POLYPEDILUM AVICEPS		R	R	R			C		C	R	R	C
	POLYPEDILUM FALLAX/SP A						A					C	
	POLYPEDILUM FLAVUM					C	C		R				
	POLYPEDILUM ILLINOENSE GR	C	C	C	C	R		C	C	C	R		
	POLYPEDILUM SCALAENUM GR										C	R	R
	PROCLADIUS SPP								R				
	RHEOCRICOTOPUS ROBACKI			R	C					R		R	
	RHEOTANYTARSUS SPP	C	A	R	R	C		R	R	R	C		
	STENOCHIRONOMUS SPP		R										
	TANYTARSUS SP A										C		
	TANYTARSUS SPP											R	
	THIENEMANIELLA SPP	R						R					
	THIENEMANIELLA XENA					C							
	THIENEMANNIMYIA GR	R	C	C		R	C	A	C	C	C	A	R
	TRIBELOS SPP		A							C			R
	TVETENIA BAVARICA GR	C	A		R	R		A	R	R			
	TVETENIA VITRACIES			R	R								A
	ZAVRELIMYIA SPP							R					

		TOMS CR SR 1808	UT TOMS CREEK SR 1811	UT TOMS CR SR 1809	TOMS CR SR 1830	CHINQUAPIN CR SR 1809	UT CHINQUAPIN CR SR 1809	HEATHERLY CR NC 268	HEATHERLY CR US 52	PILOT CR OFF STONE HAVEN DR	PILOT CR SAND TRAP LN	PILOT CR SR 2047	UT PILOT CR PILOT MTN SP RD
	non-Chironomidae Diptera												
Ceratopogonidae	PALPOMYIA COMPLEX			R				R		C	R		C
Dixidae	DIXA SPP	R	C	C				C	C	A			A
	DIXELLA INDIANA					R	R						
Simuliidae	SIMULIUM SPP	A	A	C	R	A	C	A	A	R	A	A	C
Tipulidae	ANTOCHA SPP				R	R			R		C	R	
	DICRANOTA SPP	R		R				C		C			R
	HEXATOMA SPP	R	C				R			R	C	R	R
	TIPULA SPP	R				C							
	TIPULIDAE		C					C	A	A			R
	Oligochaeta												
Megadrile	MEGADRILE OLIGOCHAETE		R				R		R				
Naididae	NAIDIDAE					R							
	NAIS SPP	R		R	C	C	R	C					
Tubificidae	AULODRILUS PLURISETA		C										
	TUBIFICIDAE	R											
	Crustacea												
Cambaridae	CAMBARIDAE	C	R	C	C	C		A	C	R	C		C
	Gastropoda												
Ancylidae	FERRISSIA SPP					R							
Physidae	PHYSA SPP										C		
Pleuroceridae	ELIMIA SPP	R	R				C			R	C	A	A
	Other												
Hydracarina	HYDRACARINA		R	R		R							

Additional Benthic Sampling Results
November 2011
Andrea Leslie, NC EEP

The NC Division of Water Quality sampled three sites in the Ararat-Pilot Mountain study area in November, 2011. Two sites were on Toms Creek, one at Matthews Rd (SR 1830), which was previously sampled in June 2011, and the other at Jessup Grove Church Rd (SR 1812), which is several miles upstream. UT to Toms Creek, a major tributary between the two sites, was also sampled just off Jessup Grove Church Rd.

Location information on these sites is in Table 1. Table 2 provides information on habitat and physical/chemical data at the sites, and Table 3 provides the benthic community summary. A taxa list is provided in Table 4.

Table 1. Macroinvertebrate sampling locations in the Ararat-Pilot Mountain study area, November 2011.

Stream	UT Toms Creek	Toms Creek	Toms Creek
Site Location	off Jessup Grove Church Rd/SR 1812	Jessup Grove Church Rd/SR 1812	Matthews Rd/SR 1830
Latitude (º)	36.4321	36.4343	36.4068
Longitude (º)	-80.4876	-80.4863	-80.4763
Drainage area (mi^2)	2.5	16.0	18.0
Stream Segment AU	-	12-72-14-(1)	12-72-14-(1)

Table 2. Summary of habitat and physical/chemical data for benthic sampling sites in the Ararat-Pilot Mountain study area, November 2011.

Stream	UT Toms Creek	Toms Creek	Toms Creek
Site Location	off SR 1812	SR 1812	SR 1830
Habitat Scores			
Channel modification (5)	5	4	5
In-stream habitat (20)	14	16	14
Bottom substrate (15)	15	13	5
Pool variety (10)	8	8	8
Riffle habitats (16)	10	7	8
Bank stability/vegetation (14)	5	11	7
Light penetration (10)	10	10	10
Riparian zone width (10)	10	7	10
Total Habitat (100)	77	76	67
Other Habitat			
Average stream width (m)	4	7	8
Average stream depth (m)	0.2	0.5	0.5
Canopy (%)	65	70	60
Substrate (%)			
Boulder	10	15	15
Cobble	25	20	25
Gravel	20	15	15
Sand	35	40	30
Silt	10	10	10
Bedrock	0	0	5
Physicochemical			
Temperature (ºC)	7.5	6.7	9.5
Dissolved oxygen (mg/L)	11.0	13.2	9.7
Specific conductance (µmhos/cm)	47	52	49
pH	6.6	6.5	6.7

Table 3. Benthic community summary for sampling sites in the Ararat-Pilot Mountain study area, November 2011.

Stream	UT Toms Creek	Toms Creek	Toms Creek
Site Location	off SR 1812	SR 1812	SR 1830
Collection date	2-Nov-11	2-Nov-11	1-Nov-11
Sample method	Qual 4	Full Scale	Full Scale
Criteria	Fall/ Mountain	Fall/ Mountain	Fall/ Mountain
Richness			
Ephemeroptera	7	12	12
Plecoptera	5	4	6
Trichoptera	4	10	14
Total EPT	16	27	32
Seasonal EPT	--	*4*	*5*
Corrected EPT	--	*23*	*27*
Odonata	3	6	6
Megaloptera	1	3	3
Coleoptera	2	0	8
Chironomidae	2	11	9
non-Chironomidae Diptera	3	5	4
Oligochaeta	0	4	2
Mollusca	2	2	2
Other taxa	1	4	2
Total taxa richness	30	62	68
Other biological metrics			
EPT abundance	60	122	124
EPT Biotic Index	4.10	3.66	3.80
NCBI	4.58	4.19	4.57
Seasonal Correction	--	*0.40*	*0.40*
Corrected NCBI	--	*4.59*	*4.97*
Bioclassification	Not Impaired	Good-Fair	Good-Fair

Table 4. Taxa list for benthic sampling sites in the Ararat-Pilot Mountain study area, November 2011 (page 1 of 3).

			UT Toms Cr off SR 1812 Surry County 02 Nov 2011	Toms Creek SR 1812 Surry County 02 Nov 2011	Toms Creek SR 1830 Surry County 01 Nov 2011
Ephemeroptera	Baetidae	*Acentrella turbida*		C	
		Baetis flavistriga			R
		Baetis intercalaris	R	A	C
		Baetis pluto	C	C	C
		Centroptilum spp			R
		Plauditus dubius gr	R	C	
	Baetiscidae	*Baetisca carolina*		C	C
	Caenidae	*Caenis spp*			R
	Ephemerellidae	*Ephemerellidae*			C
	Ephemeridae	*Hexagenia spp*		R	R
	Heptageniidae	*Heptagenia marginalis*		R	
		Leucrocuta spp	R	R	R
		Maccaffertium modestum	A	A	A
		Stenacron interpunctatum		R	
		Stenacron pallidum	C	A	A
	Isonychiidae	*Isonychia spp*	A	A	A
Plecoptera	Capniidae	*Allocapnia spp*	A	A	A
	Perlidae	*Acroneuria abnormis*	C	C	A
		Acroneuria spp	R		
		Beloneuria spp	R		
	Perlodidae	*Clioperla clio*		R	C
		Cultus decisus complex		A	C
		Perlodidae	R		R
	Taeniopterygidae	*Taenioptery x spp*		R	R
Trichoptera	Hydropsychidae	*Ceratopsyche bronta*		R	
		Ceratopsyche sparna	R	A	C
		Cheumatopsyche spp	A	A	A
		Diplectrona modesta			R
		Hydropsyche betteni		C	C
		Hydropsyche spp			R
	Leptoceridae	*Ceraclea spp. (cf. neffi)*	R	A	A
		Triaenodes ignitus		R	C
		Triaenodes perna/helo			R
	Limnephilidae	*Hydatophylax argus*	C	C	C
	Philopotamidae	*Chimarra spp*		R	A
		Dolophilodes spp			R

Table 4, continued (page 2 of 3).

			UT Toms Cr off SR 1812 Surry County 02 Nov 2011	Toms Creek SR 1812 Surry County 02 Nov 2011	Toms Creek SR 1830 Surry County 01 Nov 2011
	Phryganeidae	*Oligostomis pardalis*		R	
	Psychomyiidae	*Lype diversa*			R
		Psychomyia flavida			R
	Rhyacophilidae	*Rhyacophila fuscula*		R	R
Odonata	Aeshnidae	*Boyeria vinosa*		C	C
	Calopterygidae	*Calopteryx spp*	C	C	C
	Gomphidae	*Gomphus spp*	C	C	R
		Ophiogomphus spp		R	C
		Stylurus spp		R	R
	Macromiidae	*Didymops transversa*	R		
		Macromia spp		C	A
Hemiptera	Corixidae	*Corixidae*		C	A
Megaloptera	Corydalidae	*Corydalus cornutus*		C	A
		Nigronia serricornis	R	C	A
	Sialidae	*Sialis spp*		R	R
Coleoptera	Dryopidae	*Helichus basalis*			C
		Helichus fastigiatus	R		
	Dytiscidae	*Neoporus spp*	R		R
	Elmidae	*Ancyronyx variegatus*			C
		Dubiraphia spp			C
		Macronychus glabratus			C
		Microcylloepus pusillus			R
		Promoresia tardella			R
	Gyrinidae	*Dineutus spp*			R

Table 4, continued (page 3 of 3).

			UT Toms Cr off SR 1812 Surry County 02 Nov 2011	Toms Creek SR 1812 Surry County 02 Nov 2011	Toms Creek SR 1830 Surry County 01 Nov 2011
Chironomidae	Chironomidae	*Ablabesmyia mallochi*			R
		Cricotopus bicinctus		R	
		Cricotopus infuscatus gr		R	
		Diplocladius cultriger	R	R	
		Eukiefferiella claripennis gr		R	R
		Nanocladius downesi		C	R
		Orthocladius dorenus			R
		Orthocladius obumbratus gr	R	C	C
		Orthocladius rivicola		R	
		Orthocladius spp		R	
		Polypedilum fallax/sp A			R
		Polypedilum illinoense gr			R
		Stictochironomus spp		R	
		Stilocladius clinopecten			R
		Tribelos jucundum		C	
		Tvetenia bavarica gr		R	R
non-Chironomidae Diptera	Dixidae	*Dixella indiana*	R		
	Rhagionidae	*Atherix spp*	R	A	C
	Simuliidae	*Simulium spp*		A	C
	Tabanidae	*Chrysops spp*			R
	Tipulidae	*Antocha spp*		C	
		Dicranota spp		R	
		Tipula spp	C	A	A
Oligochaeta	Lumbriculidae	*Lumbriculidae*		R	
	Megadrile	*Megadrile oligochaete*		R	
	Naididae	*Naididae*		R	
		Nais behningi		R	R
	Tubificidae	*Tubificidae*			C
Crustacea	Cambaridae	*Cambaridae*	R	C	
		Cambarus spp			C
Gastropoda	Ancylidae	*Laevapex fuscus*		C	R
	Physidae	*Physa spp*	R		R
	Pleuroceridae	*Elimia spp*	R	A	
Other	Glossiphoniidae	*Placobdella parasitica*		R	
	Hydracarina	*Hydracarina*		R	

APPENDIX C – NC DOT Biological Surveys Group Report

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

BEVERLY EAVES PERDUE
GOVERNOR

EUGENE A. CONTI, JR.
SECRETARY

November 18, 2011

Memorandum To: Andrea Leslie, Ecosystem Enhancement Program

From: Neil Medlin, Biological Surveys Group
Natural Environment Section/PDEA

Subject: Summary of Fish Collections in the Toms Creek and Pilot Creek Watersheds, Surry County.

As part of the watershed assessment for the Toms Creek watershed, the NC Ecosystem Enhancement Program (EEP) requested the assistance of Biological Surveys Group (BSG) of North Carolina Department of Transportation (NCDOT) in the collection of fish community data within the watershed. The Pilot Creek watershed was also included in the study. The collaboration resulted in fish populations being sampled at six (6) locations throughout the watersheds in June 2011. The description of these locations along with the catchment drainage areas at each site are outlined in Table 1 below and shown on the Figure 1 map. UT Pilot Creek was selected as a reference location for the other small stream sampled (Heatherly Creek) due to its catchment being mostly forested. The North Carolina Division of Water Quality (NCDWQ) collects fish community data at the most downstream crossing on Toms Creek (SR 2024) as part of their basin assessment program. That information is included in the tables and text of this report for a general comparison to the fish community data collected during this study. A brief summary by NCDWQ of their data is attached as Appendix 1.

Table 1. Fish Community Sampling Locations in the Toms Creek and Pilot Creek Watersheds, Surry County, June 2011.

Map Number	Stream	Location	Drainage Area (mi^2)
1	Heatherly Creek	US 52	1.6
2	UT Pilot Creek	Denny Farm Rd	0.8
3	Pilot Creek	SR 2048	6.0
4	Toms Creek	SR 1808	3.3
5	Chinquapin Creek	SR 1809	4.4
6	UT Chinquapin Creek	SR 1809	4.9
7	Toms Creek	SR 2024	37.7

MAILING ADDRESS:
NC DEPARTMENT OF TRANSPORTATION
PROJECT DEVELOPMENT AND ENVIRONMENTAL ANALYSIS
NATURAL ENVIRONMENT SECTION
1548 MAIL SERVICE CENTER
RALEIGH NC 27699-1548

TELEPHONE: 919-707-6000
FAX: 919-250-4224

WEBSITE: WWW.NCDOT.ORG/DOH/PRECONSTRUCT/PE/

LOCATION:
CENTURY CENTER, BUILDING B
1020 BIRCH RIDGE DRIVE
RALEIGH NC 27610

Methods

The fish communities were surveyed using BSG's typical fish collection protocols as described below. The primary deviation from the protocols was the lack of active and passive seining due to the shallow water and low flow conditions found throughout both watersheds during the survey month.

Typical fish surveys employ a variety of collection techniques.

Seining: This is generally defined as actively pulling a seine through the water. The technique is most often used in pool or deeper run areas.

Passive Seining: The seine is stationary, held in place by two (2) biologists. Fish can be driven into the seine by kicking/disturbing the substrate and water column from upstream to downstream to the seine, or using the backpack electrofishing unit(s) to shock from upstream to downstream to the seine. When the electrofishing unit(s) is (are) used, at least one biologist with a dip net should accompany the biologist(s) with the electrofishing unit(s) to collect any fish that do not drift into the seine. Passive seining is typically used in areas of high water velocity such as riffles or fast runs.

Backpack Electrofishing: Traditional backpack electrofishing consists of a biologist operating the electrofishing unit to stun the fish accompanied by another biologist using a dip net to collect the stunned fish. Multiple electrofisher/dip net teams may be used on streams with an average width of great than four (4) meters to maximize sampling efficiency. This collection technique is employed in areas of slow to moderate stream flow. Habitat such as woody debris (snags and logs), rocks, and root mats and undercut banks along stream edges are generally sampled using backpack electrofishing units.

Fish collected from all techniques are temporarily held in five (5) gallon buckets until they can be identified and recorded. Voucher specimens for any questionable identifications should be preserved in 10 % formalin solution and returned to the lab for positive identification. All field data and species present are recorded on data sheets developed by the North Carolina Wildlife Resources Commission (NCWRC). The final product of the survey is a list of fish species collected at a site and the total number of individuals of each species.

The area covered during surveys may vary depending upon the purpose of the survey and the size of the stream. All habitat types (root mats and undercut banks, woody debris, and rocks) and flow regimes (fast-riffles, moderate-runs, and slow-pools) found in a stream are sampled. A minimum of five (5) sampling passes are made for each of the habitat types and flow regimes. If any new fish species are collected during the last pass, two (2) additional passes are made for that habitat type or flow regime.

In addition to the fish community data, habitat evaluations were conducted at each of the six (6) collection sites using the NCDWQ habitat evaluation forms. The habitat forms were completed by EEP/NCDWQ personnel as part of benthic macroinvertebrate surveys conducted during the May – July 2011 time period. Physical water quality measurements were also taken in the field at the time of the fish surveys using Accumet and YSI hand held meters. Physical water chemistry measurements (pH, dissolved oxygen, specific conductance, and temperature) were taken by EEP personnel participating in the fish surveys.

The fish data collected during this study was generally evaluated using the criteria outlined in the NCDWQ Standard Operating Procedures Manual for their fish community data (http://portal.ncdenr.org/web/wq/ess/bau). NCDWQ uses a total of 12 metrics (No. of species, No. individuals, No. darter species, No. sunfish, bass, trout, No. sucker species, No. intolerant species, % tolerant individuals, % omnivorous + herbivorous individuals, % insectivorous individuals, % piscivorous individuals, % of diseased individuals, and % of species with multiple age classes) as part of its Index of Biotic Integrity (NCIBI). While all 12 of the NCIBI metrics were considered during the evaluation of the data, only those metrics that appeared to have a discernable correlation to habitat or water quality parameters are discussed.

Results

Heatherly Creek at US 52

This site had the largest portion of its watershed located in an urbanized area as it drains parts of the Town of Pilot Mountain. Runoff from this area may have contributed to Heatherly Creek having the highest percentage of tolerant individual fish (21%) of any of the six (6) locations sampled in this study (Table 2). However, it should be noted that the 21% value is still within the range that would receive the highest score for the NCIBI metric for tolerant individuals. The tolerant fish species collected at this site were the creek chub (*Semotilus atromaculatus*), white sucker (*Catostomus commersoni*), and redbreast sunfish (*Lepomis auritus*).

The lowest number of individual fish (134) of the study was collected from Heatherly Creek and this low number of fish resulted in the site have the lowest Catch Per Unit Effort (CPUE) recorded for the study at 12 fish/100 shocking seconds. This CPUE value was the only for the six (6) study sites that was lower than the CPUE value at NCDWQ site (21 fish/100 shocking seconds). Site conditions observed at the time of the fish sampling included low water levels and limited flow. These low water conditions may have contributed to the low number of fish utilizing the sampling reach and the low CPUE value. In spite of the differences in comparison to the other study sites, the fish community in Heatherly Creek at US 52 was similar in species composition to the fish communities at the rest of the study sites and included the intolerant highback chub (*Hybopsis hypsinotus*) that was collected at all six (6) sites.

UT Pilot Creek at Denny Farm Road

This location was chosen to serve as a small stream reference site. UT Pilot Creek is primarily contained within Pilot Mountain State Park and its watershed is mostly forested.

The habitat evaluation supported the reference location status for this site with the highest score (88) recorded for any site in the study (Table 3). The sampling reach for UT Pilot Creek was located approximately one quarter stream mile above the sampling reach for Pilot Creek. Although UT Pilot Creek had the smallest watershed of the study (0.8 mi^2), the second highest number of species (14) and the third highest CPUE value (49 fish/100 shocking seconds) were recorded at the site. UT Pilot Creek also had the lowest percentage of omnivorous plus herbivorous individuals (13%) recorded at any of the study sites. This percentage was also lower than the value (24%) recorded at the NCDWQ fish community site on Toms Creek.

Somewhat surprising was the collection of three (3) species of tolerant fish at the site, leading to the second highest percentage of tolerant individuals (13%) at any of the study sites. The tolerant species collected from UT Pilot Creek were the creek chub (*Semotilus atromaculatus*), white sucker (*Catostomus commersoni*), and green sunfish (*Lepomis cyanellus*). By comparison, a total of five (5) tolerant fish species were collected at the NCDWQ site that included the three (3) tolerant species collected from UT Pilot Creek plus the satinfin shiner (*Cyprinella analostana*) and redbreast sunfish (*Lepomis auritus*).

<u>Pilot Creek at SR 2048</u>
Pilot Creek at the sampling location had the largest watershed (6.0 mi^2) of all EEP/NCDOT study sites, and thus as would generally be expected, the highest number of individual fish (869) and the most species (16) of any of the sites in this study. The CPUE of 57 fish/shocking second was the second highest for the study. The high productivity for Pilot Creek at SR 2048 may be aided by nutrient input from nonpoint source runoff from the stream's drainage area above the site. The most prominent evidence of slightly elevated nutrient levels in the stream is the % of omnivorous + herbivorous individuals value of 49%. This value is at the upper range for a middle score for this metric according to NCDWQ NCIBI criteria.

Both of the intolerant species of fish (highback chub, *Hybopsis hypsinotus*, and piedmont darter, *Percina crassa*) collected during this study and at the NCDWQ site, were documented at the Pilot Creek location. Offsetting the collection of the two (2) intolerant fish species was the collection of three (3) tolerant fish species (satinfin shiner, *Cyprinella analostana*, white sucker, *Catostomus commersoni*, and redbreast sunfish, *Lepomis auritus*).

The habitat score of 75 (Table 3) for Pilot Creek at SR 2048 was the second highest of the six (6) locations included in this fish community study. The habitat evaluation was conducted at the time of the macroinvertebrate study and the area evaluated was above the SR 2048 crossing within the Pilot Mountain State Park boundary. This immediate area is completely forested. The fish sampling reach extended from approximately 200 meters above the road crossing to roughly 100 meters below the road. Due to dramatic differences in stream habitat characteristics, a separate habitat evaluation was completed for the portion of the fish sampling reach below SR 2048. While there was an increase in score for pool variety from four (4) points upstream to 10 downstream, there were significant decreases in scores for riffle habitat (16 points upstream to 7 downstream), bank stability and vegetation (10 points upstream to 6 downstream), light penetration (10 points upstream to 2 downstream), and riparian vegetation zone width (9 points upstream to 0 points downstream). The overall habitat score decrease to a total of 50 downstream of the road.

The more prominent deep water habitat below the road crossing was evidenced by the majority of white sucker (*Catostomus commersoni*) and sunfish individuals being collected downstream of the crossing. The lack of shading contributing to increased algal growths on the rocky substrate apparently influenced the collection of most of the central stoneroller (*Campostoma anomalum*) individuals from the downstream reach as well.

Toms Creek at SR 1808

Toms Creek at this location had the second highest number of individual fish collected at any of the six (6) study sites, but had the highest CPUE of any site with 83 fish/100 shocking seconds. This CPUE value was four (4) times higher than the CPUE value (21 fish/100 shocking seconds) observed downstream at the NCDWQ sampling location. Productivity in Toms Creek at SR 1808 was possibly aided by slight nutrient enrichment as indicated by the somewhat elevated percentage of omnivorous + herbivorous individuals (38%). This percentage value would have received a mid-level score according to NCDWQ NCIBI criteria for the metric.

In contrast to the large number of fish collected and high CPUE value for Toms Creek at SR 1808, the lowest numbers for fish species (11) and habitat score (46) of the study were recorded at this location. The lack of habitat available instream habitat and shifting sand substrate may have contributed to the low number of fish species collected at the site.

Chinquapin Creek at SR 1809

In comparison to the other five (5) sites included in this study and the NCDWQ site, the fish community documented at this site may best be described as “average”. The numbers of fish species (14) and individuals collected (297) were in the mid-range of those recorded for the study sites. The percentage of omnivorous + herbivorous individuals (23%) and the CPUE value of 28 fish/100 shocking seconds were similar to the 24% omnivorous + herbivorous individuals and 21 fish/100 shocking seconds recorded at the NCDWQ site on Toms Creek. Both of the intolerant fish species (highback chub, *Hybopsis hypsinotus*, and piedmont darter, *Percina crassa*) found during this study and at the NCDWQ site were also collected in Chinquapin Creek.

UT Chinquapin Creek at SR 1809

This site on UT Chinquapin Creek and the site on Chinquapin Creek are immediately adjacent to each other. The sampling reaches on UT Chinquapin and Chinquapin Creeks started roughly 25 meters from the confluence of the two streams and the habitat scores were very similar with a value of 62 assigned to Chinquapin Creek and a value of 59 assigned to UT Chinquapin Creek. As might be expected, the fish communities were similar as well including the two (2) intolerant species collected during the study, the highback chub (*Hybopsis hypsinotus*) and piedmont darter (*Percina crassa*). Other similarities between UT Chinquapin and Chinquapin Creek included the number of fish species, 13 and 14, respectively, number of individuals, 274 and 297, respectively, and CPUE, 27 fish/100 shocking seconds and 28 fish/100 shocking seconds, respectively.

Toms Creek at SR 2024 (NCDWQ)

The watershed for this sampling location includes all of the collection sites for this study except for UT Pilot Creek and Pilot Creek. At 37.7 mi^2, the watershed at the NCDWQ site was far larger than for any of the sites sampled during the EEP/NCDOT study. As would be expected due to the larger watershed size, the number of fish species (22) and number of individuals (935) also exceeded those values for the six (6) EEP/NCDOT study sites. Although the 935 individuals was slightly more than the EEP/NCDOT study high of 869 individuals from Pilot Creek, the CPUE of 21 fish/100 shocking seconds was far lower than the CPUE of 57 fish/100 shocking seconds at the Pilot Creek site. In fact, NCDWQ site CPUE was less than all of the EEP/NCDOT sites with the exception of the 12 fish/100 shocking seconds value recorded from Heatherly Creek.

All of the species of fish collected during the EEP/NCDOT study were also collected at the Toms Creek NCDWQ site with the exception of white crappie (*Pomoxis annularis*). This species was represented by a single individual at the UT Chinquapin site.

Although only the 2011 fish community data and summary are included as part of this report, NCDWQ also collected fish community data from the SR 2024 location in 2001 and 2006. The fish community was rated as Excellent according to NCIBI criteria for all three (3) years. The consistent Excellent rating at this suggests that any stressors to the fish communities in the upper portions of the Toms Creek watershed are alleviated by the time the stream reaches the NCDWQ sampling location.

Summary

Fish communities were sampled at six (6) locations in the Toms Creek and Pilot Creek watersheds. The main source of potential impacts to the aquatic communities of these locations appeared to be nonpoint source runoff. Runoff may have contributed to the moderate nutrient enrichment indicated by the elevated percentage of omnivorous and herbivorous individuals collected at the Toms Creek and Pilot Creek sampling locations. A benthic macroinvertebrate study was conducted by NCDWQ/EEP staff during roughly the same time frame as the fish study and included all the sites at which fish were collected. The bioclassifications based on the macroinvertebrate data were Good-Fair at four (4) of the sites, Good at another site, and Excellent at the UT Pilot Creek reference site. While there are no classification/rating criteria associated with the NCDOT fish collection protocols, the overall fish community information collected during this study is similar to the macroinvertebrate data in suggesting generally “middle of the road” or better fish communities at the sampling locations.

NCDWQ has a long term fish community sampling location on Toms Creek at SR 2024. This site is the most downstream road crossing of Toms Creek and is well downstream of all the fish sampling locations included in this study. The Excellent NCIBI rating given to the site for the fish community samples collected in 2001, 2006, and 2011 suggests that any local impacts to the fish communities in the upper portions of the Toms Creek watershed are mitigated by the time the stream reaches the SR 2024 road crossing.

Figure 1. Fish monitoring sites in the Toms and Pilot Creek watersheds.

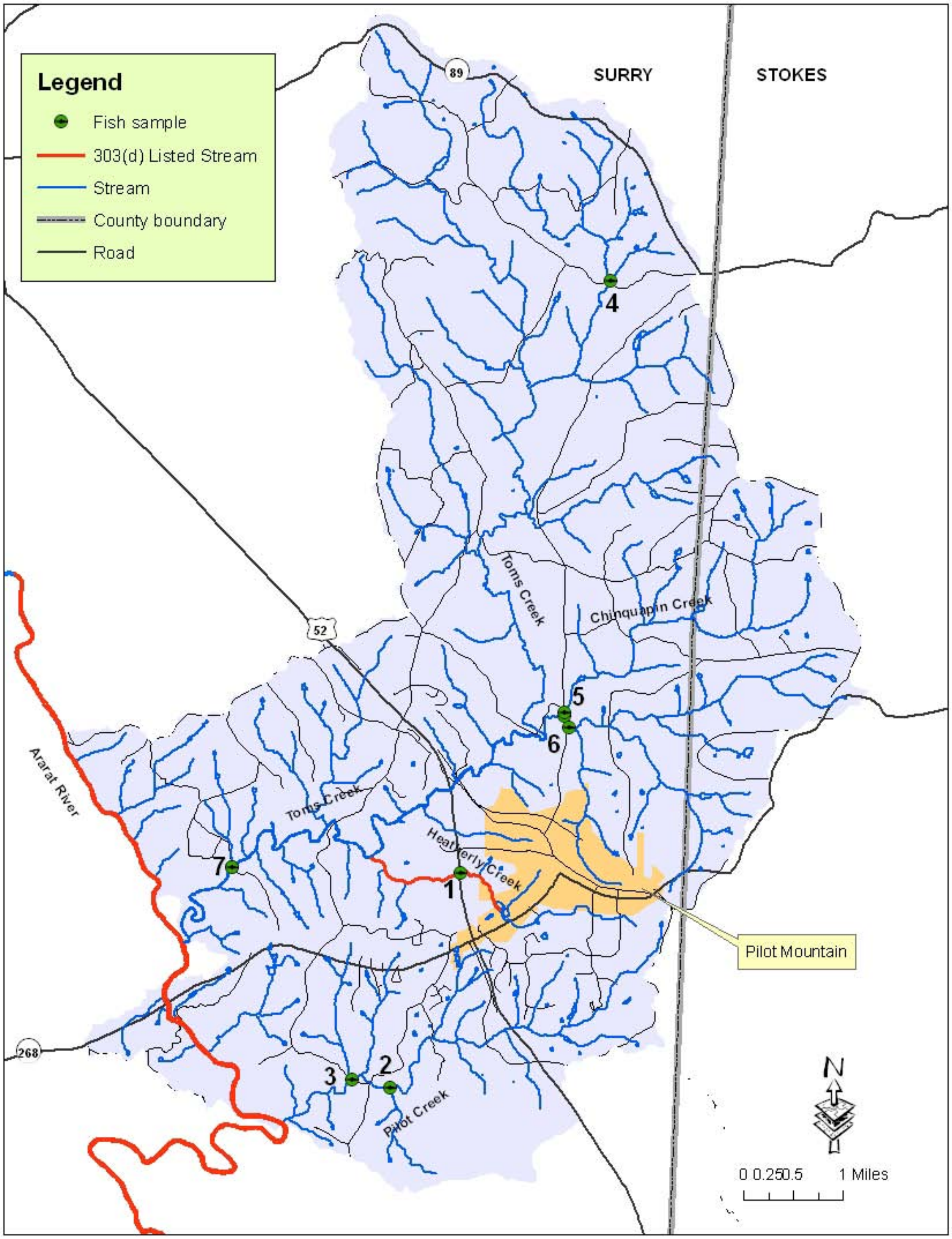


Table 2. Fish Species and Summary Information for Toms Creek and Pilot Creek Watersheds, Surry County, June 2011.

Common Name	**Species Name**	Heatherly Creek	UT Pilot Creek	Pilot Creek	Toms Creek	Chinquapin Creek	UT Chinquapin Creek	Toms Creek*
Central stoneroller	*Campostoma anomalum*	3		47				3
Rosyside dace	*Clinostomus funduloides*	27	30	13	109	54	28	8
Highback chub	*Hybopsis hypsinotus*	2	3	45	17	2	20	87
Bluehead chub	*Nocomis leptocephalus*	23	15	301	197	60	74	202
Satinfin shiner	*Cyprinella analostana*			3				2
Redlip shiner	*Notropis chiliticus*	31	65	262	109	75	61	312
Spottail shiner	*Notropis hudsonius*							6
Sandbar shiner	*Notropis scepticus*							7
Mountain redbelly dace	*Chrosomus oreas*	8	3	52	37		2	2
Creek chub	*Semotilus atromaculatus*	14	17		38	3	3	3
Northern hogsucker	*Hypentelium nigricans*							1
White sucker	*Catostomus commersoni*	9	2	24	6	7	13	13
Brassy jumprock	*Scartomyzon sp. cf. lachneri*			1				3
Margined madtom	*Noturus insignis*		2	12		6	6	38
Flat bullhead	*Ameiurus platycephalus*							3
Redbreast sunfish	*Lepomis auritus*	5		11	4	6		23
Green sunfish	*Lepomis cyanellus*		6			1		9
Bluegill	*Lepomis macrochirus*		5	3	3	1	1	9
Warmouth/Green hybrid	*Lepomis sp.*		1					
Largemouth bass	*Micropterus salmoides*	1	5	10		1		2
White crappie	*Pomoxis annularis*						1	
Carolina fantail darter	*Etheostoma brevispinum*	8	2	32	65	13	23	80
Tessellated darter	*Etheostoma olmstedi*	3	3	50	55	65	40	102
Piedmont darter	*Percina crassa*			3		3	2	20

	Heatherly Creek	UT Pilot Creek	Pilot Creek	Toms Creek	Chinquapin Creek	UT Chinquapin Creek	Toms Creek*
No. Species	12	14	16	11	14	13	22
No. Individuals	134	159	869	640	297	274	935
No. Intolerant species	1	1	2	1	2	2	2
% Tolerant individuals	21%	16%	4%	8%	6%	6%	6%
% Omnivorous + herbivorous individuals	32%	13%	49%	38%	23%	32%	24%
Shocking seconds	1076	328	1524	771	1048	1026	4451
CPUE (No. Individuals/100 shocking seconds)	12	49	57	83	28	27	21

*** NCDWQ NCIBI collection**

Table 3. NCDWQ Habitat Scores and Physical Water Chemistry Measurements for Toms Creek and Pilot Creek Watersheds, Surry County, May[1], June[2], July[3] 2011. (Habitat Evaluation Results Below Road Crossing)

	Heatherly[1] Creek	UT Pilot[1] Creek	Pilot[3] Creek	Toms[2] Creek	Chinquapin[3] Creek	UT Chinquapin[3] Creek	Toms[3] Creek*
Parameter (Max. Score)							
Channel Modification (5)	3	5	4 (4)	4	4	4	5
Instream Habitat (20)	14	16	14 (13)	8	14	14	18
Bottom Substrate (15)	8	12	8 (8)	3	6	6	11
Pool Variety (10)	8	10	4 (10)	4	10	10	10
Riffle Habitat (16)	7	16	16 (7)	7	7	7	10
Bank Stability and Veg. (14)	8	12	10 (6)	8	8	8	13
Light Penetration (10)	10	10	10 (2)	10	10	10	9
Riparian Veg. Zone Width (10)	7	7	9 (0)	2	3	0	10
Total Score	**65**	**88**	**75 (50)**	**46**	**62**	**59**	**86**
Substrate Composition (~ %)							
Bedrock	35	5	0	Trace	Trace	0	NA
Boulder	Trace	15	20	5	10	5	NA
Cobble	15	20	20	5	15	20	NA
Gravel	15	35	25	Trace	30	25	NA
Sand	30	35	20	85	40	40	NA
Silt	5	0	15	5	5	10	NA
Water Chemistry Parameters (June 2011)							
Temperature (^{o}C)	20.8	21.2	20.9	21.7	21.5	22.6	20.6
Dissolved Oxygen (mg/l)	5.5	7.3	6.4	6.4	6.8	5.6	8.1
Specific Conductance (µS/cm)	93	39	66	54	53	69	67
pH (s.u.)	6.7	6.9	6.9	6.7	6.9	6.9	6.5

*NCDWQ NCIBI Collection

Appendix 1. Summary for Toms Creek, NCIBI Collection, Surry County, June 21, 2011.

FISH COMMUNITY SAMPLE

Waterbody	Location	Date	Station ID	Bioclassification
TOMS CR	**SR 2024**	**06/21/11**	**QF57**	**Excellent**

County	Subbasin	8 digit HUC	Latitude	Longitude	AU Number	Level IV Ecoregion
SURRY	2	03040101	36.3860715	-80.5298551	12-72-14-(4)	Northern Inner Piedmont

Stream Classification	Drainage Area (mi^2)	Elevation (ft)	Stream Width (m)	Average Depth (m)	Reference Site
C	37.7	880	13	0.4	No

	Forested/Wetland	Rural Residential	Agriculture	Other (describe)
Visible Landuse (%)	80	5	15 (tobacco field)	0

Upstream NPDES Dischargers (> 1MGD or < 1MGD and within 1 mile)	NPDES Number	Volume (MGD)
None	---	---

Water Quality Parameters

Temperature (°C)	20.6
Dissolved Oxygen (mg/L)	8.1
Specific Conductance (µS/cm)	67
pH (s.u.)	6.5

Water Clarity: Very slightly turbid

Habitat Assessment Scores (max)

Channel Modification (5)	5
Instream Habitat (20)	18
Bottom Substrate (15)	11
Pool Variety (10)	10
Riffle Habitat (16)	10
Erosion (7)	6
Bank Vegetation (7)	7
Light Penetration (10)	9
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	**86**

Site Photograph

Substrate: Cobble, sand, silt, bedrock shelves

Sample Date	Sample ID	Species Total	NCIBI	Bioclassification
6/21/2011	2011-47	22	56	Excellent
6/19/2006	2006-83	22	58	Excellent
6/21/2001	2001-70	23	56	Excellent

Most Abundant Species, 2011: Redlip Shiner (33%)

Exotic Species: Central Stoneroller, Mountain Redbelly Dace, Northern Hog Sucker, Green Sunfish

Species Change Since Last Cycle: **Gains** -- first collection ever for Mountain Redbelly Dace. **Lost** -- Spotted Bass. All species gained or lost were represented by 1 or 2 fish/species.

Data Analysis

Watershed -- drains eastern Surry County, including the Town of Pilot Mountain, and a small portion of western Stokes County; one NPDES permitted discharger located ~ 4.5 mi. upstream (NC0068365, water treatment plant, Q_w = unlimited); tributary to the Ararat River. **Habitats** -- no substantial changes since 2001 in the moderately high quality instream and riparian habitats (total habitat score range 73-86); riffles, chutes, and pools; wide riparian zones with a Rhododendron-lined and forested bluff on the right. **Water Quality** -- specific conductance typical for a rural Piedmont stream, stable, and ranging from 61-67 µS/cm; temperature, dissolved oxygen, and pH stable and typical of this area. **2011** -- total number of fish collected was greater than in 2006 (935 vs.834, respectively); Redlip Shiner and Bluehead Chub accounted for 55% of all the fish collected. **2001-2011** -- an abundant, trophically balanced, and diverse fish community; 27 species are known from the site, including 3 intolerant species (Thicklip Chub, Highback Chub, and Piedmont Darter), 3 species of darters, 4 species of suckers, and 5 nonindigenous species; dominant species in each cycle have been Redlip Shiner and Bluehead Chub; total number of fish collected has been steadily increasing, but the catch per unit effort has been stable, ranging from 19.1-21.1 fish/100 seconds shocking time; community has consistently rated Excellent being sampled during the same week over the past 10 years. **Recommendation** -- continue basinwide monitoring of this site in 2016.

APPENDIX D – Wildlands Engineering Technical Memorandum

TECHNICAL MEMORANDUM 1

Review of Existing GIS Data Sets, GIS-Based Riparian Buffer Assessment, and GIS-Based Project Prioritization

Ararat-Pilot Mountain Local Watershed Plan
Surry and Stokes County, North Carolina

Yadkin River Basin
HUC 03040101

Prepared for:

NC Department of Environment and Natural Resources
Ecosystem Enhancement Program
1652 Mail Service Center
Raleigh, NC 27699-1652

Prepared by:

Wildlands Engineering, Inc.
5605 Chapel Hill Road, Suite 122
Raleigh, NC 27607
Phone – 919-851-9986
Jeff Keaton
JKeaton@wildlandseng.com

(August 2012)

Ararat-Pilot Mountain Local Watershed Plan

Technical Memorandum 1: Review of Existing GIS Data Sets, GIS-Based Riparian Buffer Assessment, and GIS-Based Project Prioritization

Prepared For:
North Carolina Ecosystem Enhancement Program (EEP)

Submitted By:
Wildlands Engineering, Inc.

August 2012

Wildlands Engineering, Inc. (WEI) is assisting the North Carolina Ecosystem Enhancement Program (EEP) in developing a local watershed plan (LWP) within the Ararat River watershed within the Upper Yadkin River Basin (HUC 03040101). This LWP originally began in the spring of 2008, covering a much larger study area, but was put on hold in early 2009. After deciding to restart the LWP in late 2010, EEP chose the Tom's Creek watershed (HUC 03040101110030) and the adjacent Pilot Creek watershed (a portion of the lower Ararat River HUC 0304010111050) as the focus area of the planning effort. The 50-square mile Ararat-Pilot Mountain LWP focus area also includes Heatherly Creek and Chinquapin Creek, tributaries to Toms Creek, and the Town of Pilot Mountain (see Figure 1). A section of Heatherly Creek from NC 268 to its confluence with Tom's Creek is listed as "impaired" on the 2012 North Carolina 303(d) list for ecological/biological impairment. Tom's Creek is fully supporting its designated uses (NCDWQ, 2012).

WEI is performing multiple tasks to support the refocused LWP effort. The first three of these tasks have been completed. These include:

- Review of Existing GIS Data Sets (Task 1)
- GIS-Based Riparian Buffer Assessment (Task 2)
- Updated GIS Analysis and GIS-Based Project Prioritization (Task 3).

The work to complete these tasks and the work products are described in this technical memorandum (TM).

Review of Existing GIS Datasets (Task 1)
WEI reviewed existing GIS datasets provided by EEP and developed a project GIS database to support additional work throughout the LWP process. The database includes datasets compiled or created during the first phase of the LWP (2008 to 2009). WEI also obtained additional updated GIS layers to add to the information included in the database. These layers included 2010 aerial photos from Surry and Stokes Counties, parcel data from Surry and Stokes Counties, and 2010 leaf-on aerial photos from the Natural Resources Conservation Service (NRCS). Future layers created for other tasks in the LWP effort will be added to the database as they are created. Appendix A is a table showing all of the GIS datasets used or created during completion of the work described in this technical memorandum. Existing datasets used during (or new datasets created for) the tasks described in this TM are summarized in Appendix A.

GIS-Based Riparian Buffer Assessment (Task 2)
WEI developed a riparian buffer width GIS dataset for the study area using the 2010 aerial photography. The buffer assessment was conducted on streams included in the 1:24K hydrography dataset obtained from the North Carolina Center for Geographic Information and Analysis (CGIA). WEI used the aerial photos to estimate the width of the woody riparian buffer along both banks of all streams included in the 1:24K hydrography layer within the study area (not including ponds). The buffer widths of all reaches were then grouped into five categories:

- No buffer on either side
- Minimal buffer on both sides (<30 feet)
- Adequate buffer (>30 feet) on one side
- Adequate buffer (>30 feet) both sides
- Excellent (>100 feet) buffer both sides.

The width of the riparian buffers was based on the the width of woody vegetation along the stream banks visible in the aerial photography. For the purposes of this assessment, woody vegetation included forests, plantations with existing timber stands, early successional zones, and shrub/scrub areas.

During the assessment, reaches were broken at the following locations:

- Confluences with tributaries or receiving streams
- Road crossings
- Locations where the buffer width changes for more than 100 feet
- Locations where streams are impounded for more than 100 feet (e.g. large ponds).

The result of the assessment is a new GIS layer (Buffer Centerline shapefiles delivered to EEP on August 18, 2011) of reaches broken as described above and attributed with the buffer width category classification. Buffer width can be easily displayed for visual review by color-coding the reaches based on their buffer width category (Figure 2). The results of the buffer width assessment are summarized by subwatershed and displayed in Table 1. The buffer width GIS layer was used as a key dataset in the completion of Task 3, described below. See Appendix A for information on GIS datasets used for or created during completion of this task.

Table 1. Buffer Width Assessment Results by Subwatershed

Reach	No Buffer		Minimal Buffer		One Side Adequate Buffer		Adequate Buffer		Excellent Buffer	
	Length (ft)	% of Total	Length (ft)	% of Total	Length (ft)	% of Total	Length (ft)	% of Total	Length (ft)	% of Total
CH-1	2,111	4.0%	12,260.4	23.3%	11,707.9	22.3%	6,282.5	11.9%	20,240.2	38.5%
CH-2	4,917	6.9%	7,079.9	10.0%	13,577.4	19.2%	16,212.7	22.9%	29,035.0	41.0%
PC-1	8,359	12.1%	4,118.7	6.0%	9,634.8	14.0%	9,674.1	14.0%	37,096.2	53.9%
PC-2	2,099	3.3%	5,453.0	8.6%	16,782.4	26.4%	5,748.2	9.0%	33,550.4	52.7%
TC-1	8,158	13.5%	6,834.1	11.3%	9,363.8	15.5%	5,792.9	9.6%	30,339.0	50.2%
TC-2	385	0.8%	4,047.1	8.1%	11,249.1	22.5%	8,218.7	16.4%	26,198.2	52.3%
TC-3	3,970	5.9%	6,528.8	9.7%	18,880.4	28.2%	7,020.2	10.5%	30,576.5	45.7%
TC-4	2,896	4.6%	6,143.1	9.7%	10,579.3	16.7%	7,333.3	11.6%	36,316.6	57.4%
TC-5	3,086	2.8%	6,456.6	5.8%	23,674.4	21.1%	15,282.0	13.7%	63,445.5	56.7%
TC-6	3,475	5.5%	5,606.5	8.9%	16,745.5	26.7%	12,198.0	19.5%	24,651.1	39.3%
Total	39,456	5.9%	64,528.2	9.6%	142,195.0	21.2%	93,762.5	14.0%	331,448.7	49.4%

CH = Chinquapin Creek; PC = Pilot Creek, and TC = Tom's Creek; Note: Heatherly Creek is part of subwatershed TC-6.

Updated GIS Analysis and GIS-Based Project Prioritization (Task 3)

WEI used the GIS data assembled for the LWP (Appendix A) to assess the condition of stream and wetlands within the focus area and identify and prioritize potential stream and wetland restoration projects. The first step in this process was to work with EEP to establish the parameters that would be used for the assessment and prioritization. The parameters selected were focused on identifying and prioritizing projects that would most likely result in a group of potential projects that would help meet EEP's mitigation needs within the Upper Yadkin basin. However, the prioritization process was also designed so that smaller projects that might be viable for local resource agencies or conservation organizations would not be screened out. EEP and WEI solicited input on these project screening/ranking criteria from the Ararat-Pilot Mountain LWP stakeholder team in the spring of 2012.

Stream Project Prioritization

WEI performed the GIS-based stream assessment on all of the streams included in the 1:24K hydrography layer within the LWP focus area. The process was performed in a step-wise manner following the order in which the parameters are described below.

1. Drainage Area – Streams that have a drainage area of larger than 10 square miles are typically not considered good projects by EEP and were removed from further evaluation. The drainage areas of remaining streams were categorized as follows:
   - 0 to 1.9 square miles (high priority)
   - 2 to 5 square miles (medium priority)
   - >5 square miles and <10 square miles (low priority).

2. Riparian Buffer Quality – The new riparian buffer layer created during Task 2 for this LWP described above was used to screen out additional sites that have an "excellent" or "adequate" buffer on both sides. According to the classifications in the existing buffer layer, the remaining streams were categorized as:
   - No buffer (high priority)
   - Adequate buffer on one side (medium priority)
   - Minimal buffer (low priority).
3. Project Length – Length was calculated for the remaining stream reaches that were not screened out based on items 1 and 2 above. Reaches were then placed into one of three categories:
   - >/= 4,000 LF (high priority)
   - 2,000 to 3,999 LF (medium priority)
   - <2,000 LF (low priority).

4. Landowner Density – A land parcel GIS layer was obtained from each county and used to determine the number of parcels along each remaining reach. Any reach of stream with less than 750 feet of length per landowner (e.g. 4 landowners per 3,000 LF) was eliminated from further evaluation. The remaining streams were then categorized as follows:
   - On average 3,000 LF or more per landowner (high priority)
   - On average 2,000 to 2,999 LF per landowner (medium priority)
   - On average less than 2,000 LF per landowner (low priority).

5. Livestock Access – WEI attempted to determine if remaining streams are used to water livestock. This analysis was done by reviewing the 2010 aerial photos from Surry and Stokes Counties for signs of livestock. Based on this analysis, the remaining stream reaches were categorized as follows:
   - Obvious signs of livestock access such as visible livestock or signs of livestock near streams (high priority)
   - Livestock access is unknown due to uncertainty about the presence of livestock or possible restrictions such as fencing or buffers to stream access (medium priority)

- No indication of livestock access for residential areas, fields used for row crops, etc. (low priority).

6. Qualitative Assessment of Channelization – The degree to which remaining streams appear to have been channelized was determined. This assessment was made through review of the 2010 aerial photography and topography obtained from Surry and Stokes Counties (see Appendix A). Streams were categorized as follows:
    - Obvious channelization (high priority)
    - A portion of the reach has been channelized or channelization is uncertain (medium priority)
    - Channelization is not apparent (low priority).

A seventh parameter, Subwatershed Functional Assessment, was considered for inclusion in the prioritization protocol. This parameter consisted of an overall rating of each subwatershed developed from multiple criteria gathered during the LWP Phase II work (watershed assessment and monitoring) - such as percent impervious cover, water quality monitoring data, bioclassifications based on benthic sampling, percent forest cover and indicators of stream sedimentation. EEP determined that the subwatershed functional assessment scores were pertinent to the identification of major stressors and sources, but would not help to significantly differentiate the project screening/ranking scores. The results of the subwatershed functional assessment will be presented and discussed in EEP's *Watershed Assessment Report*.

All stream reaches that remained at the end of the evaluation of the above six parameters were included in the final database of potential projects (delivered to EEP on June 29, 2012). Reaches were grouped into potential projects based on proximity to one another. Reaches that were direct tributaries to another reach in the database, that were on the same parcel as another reach, or that were separated by less than 500 feet from another reach were grouped together as potential projects. All potential projects were included in the final database regardless of total length. However, based on EEP implementation guidelines, potential projects less than 2,000 feet in length were noted as "Small Projects" and projects less than 500 feet in length will not be included in EEP planning documents.

A score was assigned to each potential project for each of the six parameters. For each potential project, any parameter rated as high priority received three points, any parameter rated as medium priority received two points, and a parameter rated low priority received one point. Each potential stream project in the database was given an additional point if there was a potential wetland restoration or enhancement site adjacent to it and another additional point if it was upstream of the drinking water intake for the Town of Pilot Mountain. Weightings were then assigned to each parameter so that certain parameters would have a greater influence on the final scores and thus the prioritization of potential projects. The weighting system was built into a spreadsheet database so that the influence of any parameter could be adjusted by watershed stakeholders based on their specific interests and priorities. EEP determined the final weightings in order to prioritize the projects that were most suitable for meeting program mitigation requirements. The final EEP weightings are included in Table 2.

Table 2. Stream Assessment Parameter Weightings

Metric	Weighting
Riparian Buffer Quality Rating	1.5
Drainage Area Rating	1

Metric	Weighting
Length Rating	2
Landowner Density Rating	1
Livestock Access Rating	2
Qualitative Channelization Assessment Rating	1

Once the projects in the database were scored and parameter weightings were adjusted, the total score for each potential project was computed. The total scores ranged from a high of 22 down to 10. A frequency distribution plot of each total score versus the number of projects with that score (Appendix B) was used to determine break points to put total scores into tiers of high, medium, and low priority projects for EEP. Based on the frequency distribution, the tiers were assigned as follows:

- 15 to 22 = High Priority
- 13 to 14 = Medium Priority
- 10 to 12 = Low Priority.

The High Priority tier includes 56 potential projects, including 13 less than 500 feet in length and 25 greater than or equal to 2,000 feet in length. The Medium Priority tier includes 71 projects, 22 of which are less than 500 feet in length and 10 of which are greater than or equal to 2,000 feet in length. The remaining 30 sites comprise the Low Priority tier, including 11 sites less than 500 feet and only 2 sites greater than 2,000 feet in length). The 43 high priority sites (not including those less than 500 feet in length) will be described and mapped in a document called the *Project Atlas*. The complete potential project database (delivered to EEP on June 29, 2012) is included in Appendix C and Figure 3 provides a map of all 56 high priority sites.

Wetland Project Prioritization

WEI identified and prioritized potential wetland projects in a similar manner that streams were prioritized using four parameters developed by WEI and EEP.

The following approach was used on all areas of hydric soils within the focus area. To serve as the basis for this analysis, a hydric soils GIS layer was compiled for the focus area from the NRCS national hydric soils list (NRCS, 2012) and the SSURGO soils GIS layer (see Appendix A for data references).

1. Hydric soil rating – Sites that have hydric soils according to the SSURGO GIS layer were evaluated for consideration as wetland projects. To begin, each soil type was rated based on the likelihood that hydric soil indicators would be observed in the field because it is not uncommon for some types of soils to be hydric at some locations and non-hydric at others. This rating was developed by WEI to differentiate the likelihood that soils on the list are actually hydric at a specific site based on professional judgment and knowledge of specific soil types. A-rated soils are those that are most often determined to be hydric in the field (e.g. Wehadkee). B-rated soils are soils that are often, but sometimes not, determined to be hydric based on field assessments (e.g. Chewacla). C-rated are those that are included on hydric soils lists but are often determined to be non-hydric in the field. There are no hydric soils in the study area that WEI rated as C soils. Soils were categorized as follows:
    - A rated hydric soil (high priority)
    - B rated hydric soil (medium priority).

2. Vegetation – Sites with hydric soils were then evaluated to determine the degree of vegetative cover as viewed on the 2010 aerial photos. Less vegetative cover indicates a wetland site that is more in need of restoration or enhancement. Sites or portions of sites that are fully forested were removed from further evaluation. Remaining sites were categorized as follows:
    - No vegetation other than grass or crops (high priority)
    - Less than 25% of the site is covered with trees in sporadic groves or along stream channels (medium priority)
    - More than 25% of the site is covered with trees (low priority).

3. Signs of drainage or hydrologic alteration – The 2010 aerial photographs were used to identify signs of hydrologic alteration to wetland sites including drainage ditches, channelized streams, or indications of tile drainage. This information was used to categorize potential wetland sites as follows:
    - Obvious signs of hydrologic alteration (high priority)
    - Limited or potential hydrologic alteration (medium priority)
    - No signs of hydrologic alteration (low priority).

4. Size of potential project – The size of the potential wetland site was determined and categorized as follows:
    - Greater than 5 acres (high priority)
    - 2 to 5 acres (medium priority)
    - Less than 2 acres (low priority).

All remaining wetland areas that were not eliminated due to forest cover were included in the final wetland site database (delivered to EEP on June 29, 2012). The final scoring of the potential wetland sites was similar to the final scoring for the stream sites. A score was assigned to each potential wetland site for each of the four parameters described above. For each site, any parameter rated as high priority received three points, any parameter rated as medium priority received two points, and parameter rated low priority received one point. Each wetland site in the database was given an additional point if there was a potential stream restoration or enhancement site adjacent to it. Weightings were then assigned to each parameter as was done in the stream prioritization. EEP determined the final weightings which are included in Table 3.

Table 3. Wetland Assessment Parameter Weightings

Metric	Weighting
Hydric Soil Rating	1
Vegetation Rating	1
Drainage Rating	1
Size Classification	2

Once the wetland sites in the database were scored and parameter weightings were adjusted, the total score for each potential site was computed. The total scores ranged from 8 to 16 points. A frequency distribution plot of each total score versus the number of projects with that score (Appendix B) was used to determine break points to put total scores into tiers of high, medium, and low priority projects for EEP. Based on the frequency distribution, the tiers were determined to be:

- 13 to 16 = High Priority

- 11 to 12 = Medium Priority
- 8 to 10 = Low Priority.

The High Priority tier includes nine potential wetland sites, the Medium Priority tier includes 11 sites, and the remaining three sites were rated as Low Priority. The nine high priority sites will be described and mapped in a document called the *Project Atlas*. The complete potential project database is included in Appendix C and Figure 3 shows the high priority wetland sites mapped with the high priority stream sites.

BMP Project Prioritization

Urban stormwater best management practice (BMP) opportunities were investigated within the town limits of the Town of Pilot Mountain. To begin the process of identifying potential BMP sites, aerial photos were reviewed in order to locate open spaces in highly impervious watersheds. A GIS layer of the Town's storm drainage infrastructure was reviewed with the aerial photos to identify stormwater outfalls from developed watersheds where BMPs could potentially be sited (see Appendix A for GIS data references). The potential BMP sites were then visited to verify the stormwater drainage mapping and assess the implementation feasibility at the site. Twenty newly identified sites and ten sites identified during a previous stormwater study (Michael Baker Corporation, 2009) were then evaluated based on the following criteria.

1. Watershed characteristics – Extensive research has shown that water quality and aquatic habitat are increasingly impacted as impervious cover in a watershed increases (Schueler et al., 2009). Size of drainage area also plays a key role in the amount of pollutants that would be removed from runoff by a BMP to receiving streams and downstream waters. The amount of pollutants removed by a BMP will generally increase with drainage area and the degree of imperviousness within that drainage area. These characteristics were used to categorize the potential BMP sites as follows:

    - Drainage area greater than eight acres and impervious cover greater than 25% (high priority)
    - Drainage area less than eight acres and impervious cover greater than 25% (medium priority)
    - Impervious cover less than 25% (low priority)
      Note: According to Schueler's Reformulated Impervious Cover Model (2009), 25% impervious cover is the generalized threshold between watersheds that are "impacted" and watersheds that are "non-supporting." According to this model, watersheds with less than 10% impervious cover are "sensitive" (or not impacted).

2. Implementation feasibility – It must be feasible to construct and maintain BMP facilities in order to implement the projects. Issues with site access, required drainage reconstruction, space, required tree removal, excessive grading or other requirements can drive up costs, and many other issues can affect successful implementation. This metric was evaluated as follows, based on BMP site visits conducted in May 2012:

    - Highly feasible – No apparent major issues with access or constructability, stormwater infrastructure in place, limited utility conflicts, suitable topography, and no other foreseeable drawbacks (high priority)
    - Potentially feasible – Some potential problems with access, tree removal, constructability, utilities, or topography; drainage infrastructure would need to be altered or constructed; and/or other potential issues have been identified (medium priority)

- Low feasibility – Space or access appears limited, major construction obstacles identified, significant utility conflicts apparent, and/or other unforeseen circumstances (e.g. available space is being utilized for other purposes) exist that would hinder successful implementation (low priority).

3. Landowner classification – Landowner acceptance of a potential project is required for project success. Sites on public lands have a much greater likelihood of landowner buy-in. The metric was categorized as follows:

    - Public landowner (high priority)
    - One commercial, industrial, or residential landowner (medium priority)
    - Multiple private landowners (low priority).

Sites that were rated as "Low Feasibility" for parameter 2 above were removed from further consideration. All remaining BMP sites were included in the final BMP site database (delivered to EEP on June 29, 2012). The final scoring of the potential BMP sites was similar to the final scoring for the stream and wetland sites. A score was assigned to each potential BMP site for each of the three parameters described above. For each site, any parameter rated as high priority received three points, any parameter rated as medium priority received two points, and any parameter rated low priority received one point. The parameters were not weighted. The final tiers of prioritization were determined to be:

- High priority (8 points),
- Medium priority (7 points), or
- Low priority (less than 7 points).

The high priority tier includes eight sites, the medium priority tier includes 15 sites, and the low priority tier includes six sites. The nine high priority sites will be mapped in detail in the *Project Atlas*. The complete potential project database is included in Appendix C and the high priority sites are shown on Figure 4.

A preliminary analysis was conducted to determine which type of potential BMP would be appropriate for each site. The types of BMPs considered include:

Wet Detention Basins -- These facilities are designed to detain stormwater to attenuate flooding and allow time for solids to settle out of the water column. Wet ponds also allow for biological uptake of some pollutants, primarily by plants installed around the perimeter of the basin. This type of BMP offers high pollutant removal efficiencies and is useful in treating stormwater from large drainage areas (>10 acres).

Stormwater Wetlands -- These facilities are similar to wet detention basins but provide additional stormwater treatment. These facilities are effective at removing a variety of pollutants and are more efficient at removing certain types of pollutants than wet detention basins. However, a high water table or soils with very low permeability are required for proper function of these systems.

Bioretention -- These stormwater treatment cells are often small and are may be designed to look like part of the developed landscaping. Bioretention cells, or "rain gardens," function best when treating small, highly impervious drainage areas such as parking lots. In addition to stormwater treatment, they also provide limited peak flow attenuation to reduce flooding. They perform well in areas where groundwater is several feet below the ground surface.

The results of the preliminary analysis indicate that stormwater wetlands would be appropriate for seven of the top eight high priority BMP sites and a bioretention cell would be appropriate for the other. Depending on water table depth, a dry detention pond might be better suited to some of the sites. Preliminary BMP types for each site evaluated are included in Appendix C.

Conclusions

Based on the GIS-based assessments described above, there appear to be abundant opportunities for stream restoration and enhancement in the LWP focus area. Opportunities for wetland restoration are much more limited due to a general lack of hydric soils in the area. However, viable wetland restoration sites, most adjacent to potential stream restoration projects, have been identified. Opportunities for implementation of stormwater best management practices (BMPs) were also identified within the municipal limits of the Town of Pilot Mountain. The potential BMP sites that were rated "High Priority" will be modeled by WEI to determine which potential facilities would be most effective at removing pollutants. The modeling results will be used for the final prioritization of the BMP sites. The final stream, wetland, and BMP sites will be documented in the Project Atlas. The *Project Atlas* will be used by EEP implementation staff to identify and pursue mitigation projects within the 14-digit HUC.

References

Michael Baker Corporation, 2009. Town of Pilot Mountain Stormwater Drainage Study.

Natural Resources Conservation Service (NRCS), 2012. National Hydric Soils List. Accessed July 24, 2012 at: http://soils.usda.gov/use/hydric/

North Carolina Division of Water Quality (NCDWQ), 2012. North Carolina Draft 2012 303(d) Lists. Accessed June 27 at: http://portal.ncdenr.org/c/document_library/get_file?uuid=2dbffc77-1c7b-4979-9b60-4cd2a06094af&groupId=38364

Schueler, TR, Fraley-McNeal, L, and Cappiella, K, 2009. Is Impervious Cover Still Important? Review of Recent Research. *Journal of Hydrologic Engineering, 14(4), 309-315.*

Figures

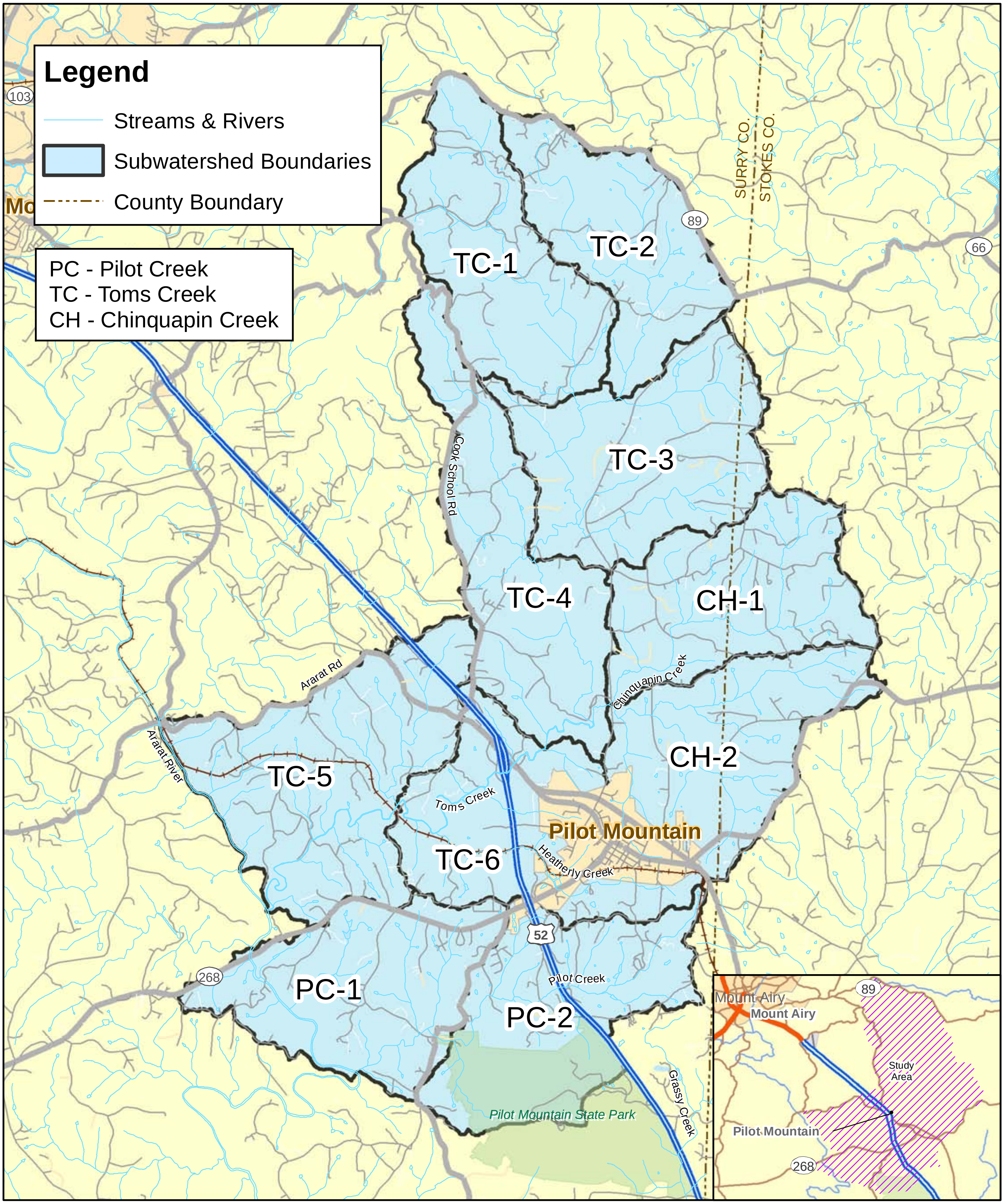


Figure 1: Study Area
Ararat - Pilot Mountain
Local Watershed Plan

WILDLANDS ENGINEERING

Stokes & Surry Counties, NC

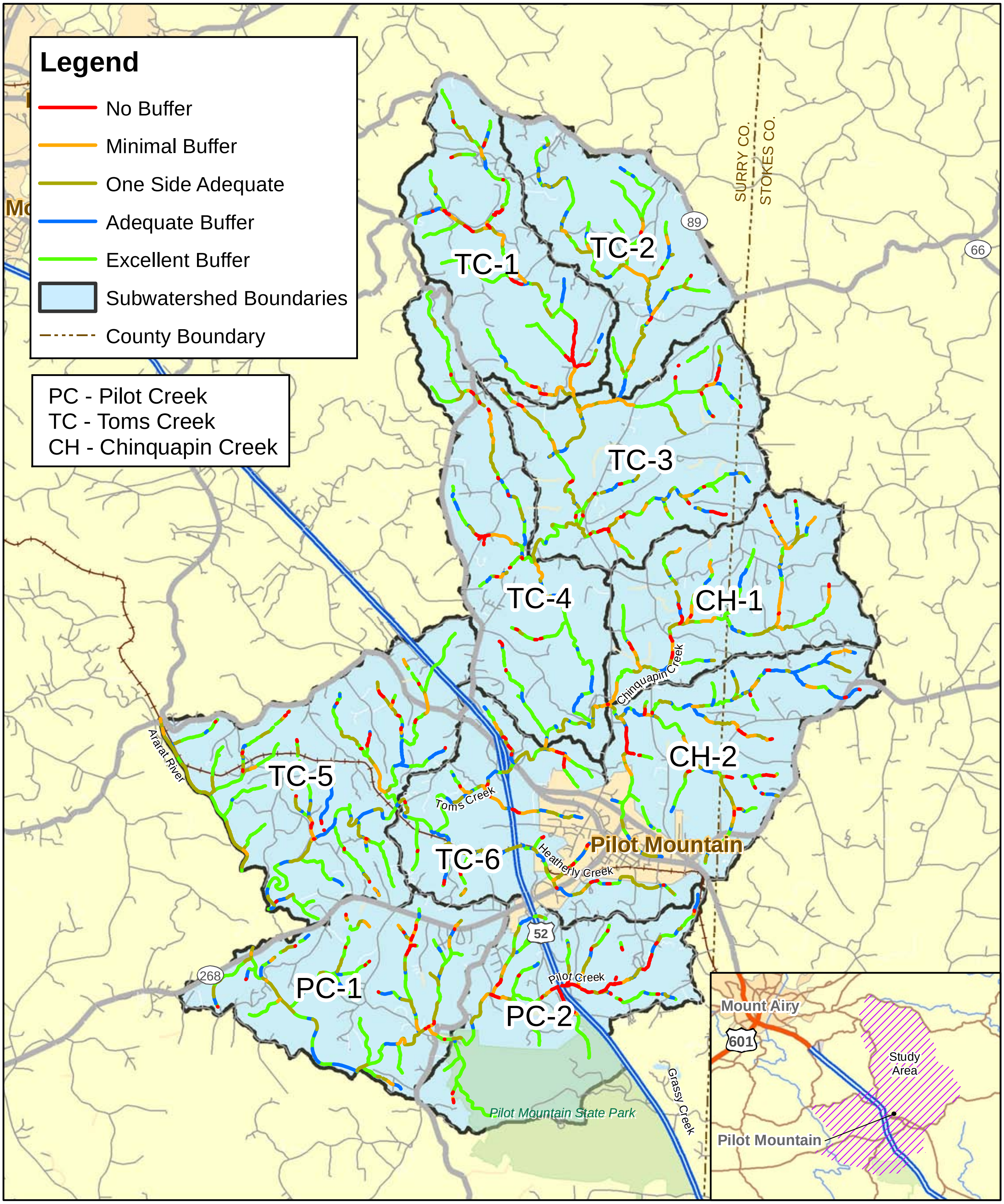


Figure 2: Stream Buffer Assessment
Ararat - Pilot Mountain
Local Watershed Plan

WILDLANDS ENGINEERING

Stokes & Surry Counties, NC

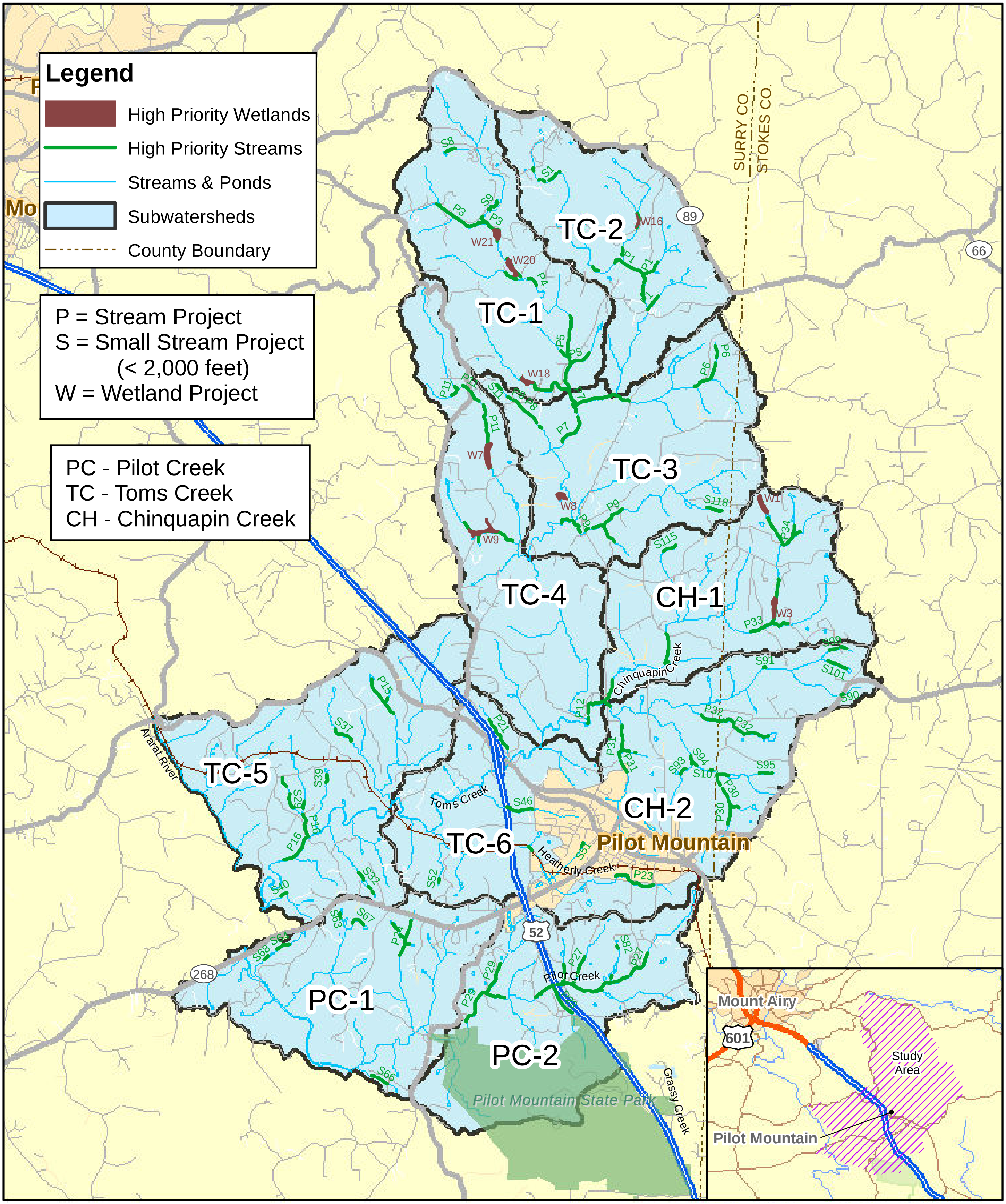


Figure 3: High Priority Stream and Wetland Restoration Sites
Ararat - Pilot Mountain Local Watershed Plan

Stokes & Surry Counties, NC

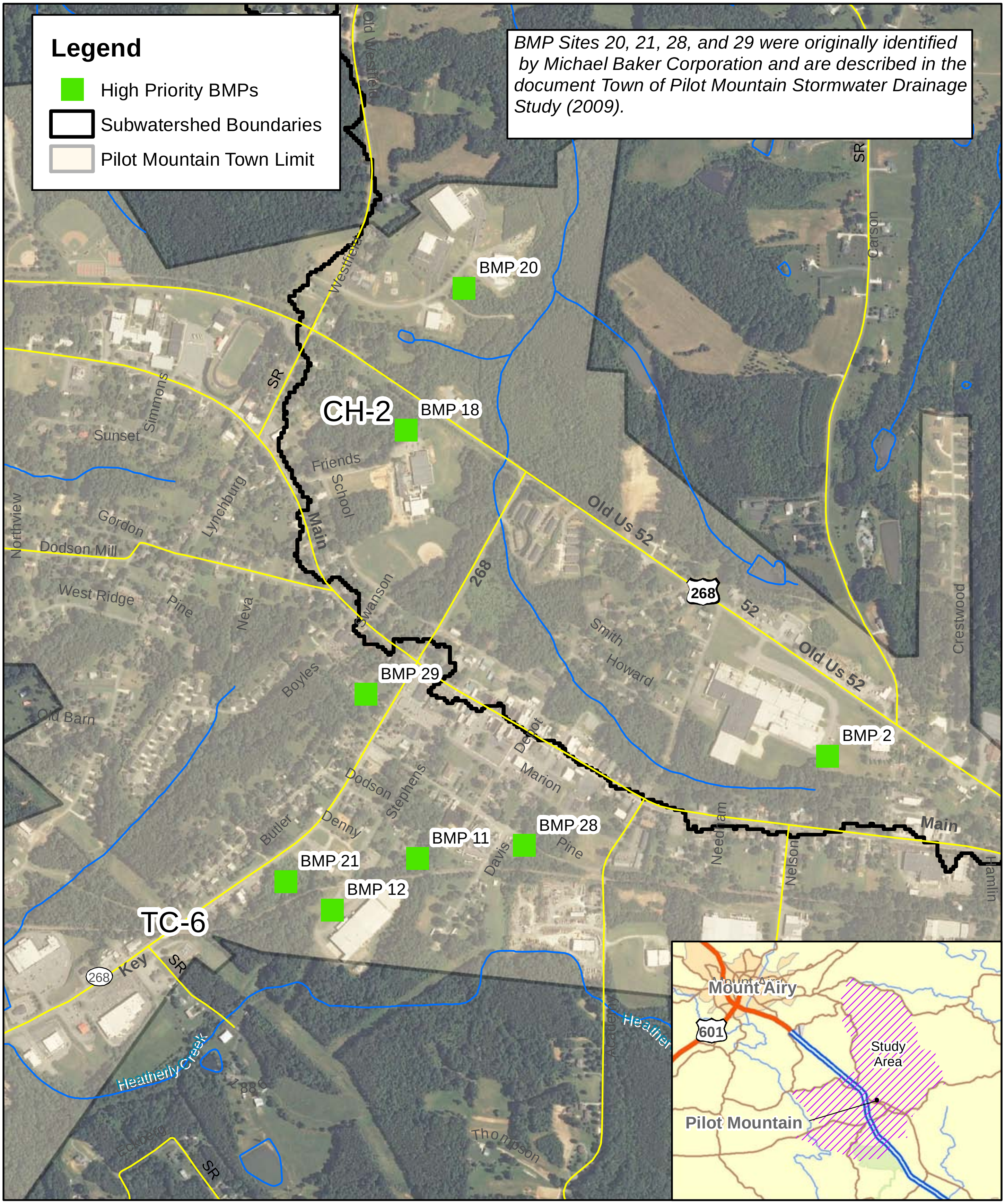


Figure 4: High Priority BMP Sites
Ararat - Pilot Mountain
Local Watershed Plan

WILDLANDS ENGINEERING

Stokes & Surry Counties, NC

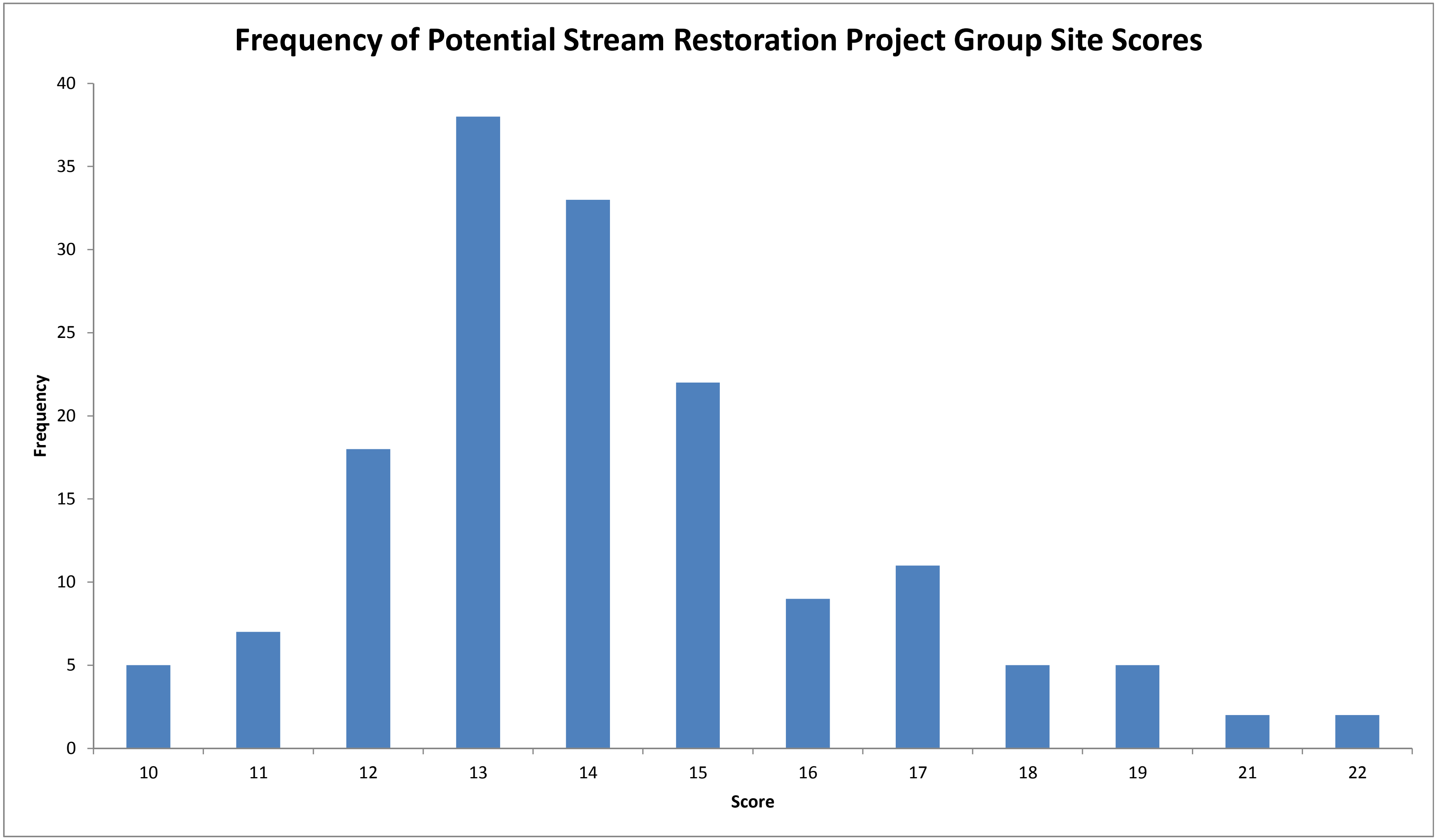
Appendix A: GIS Database for Technical Memorandum 1

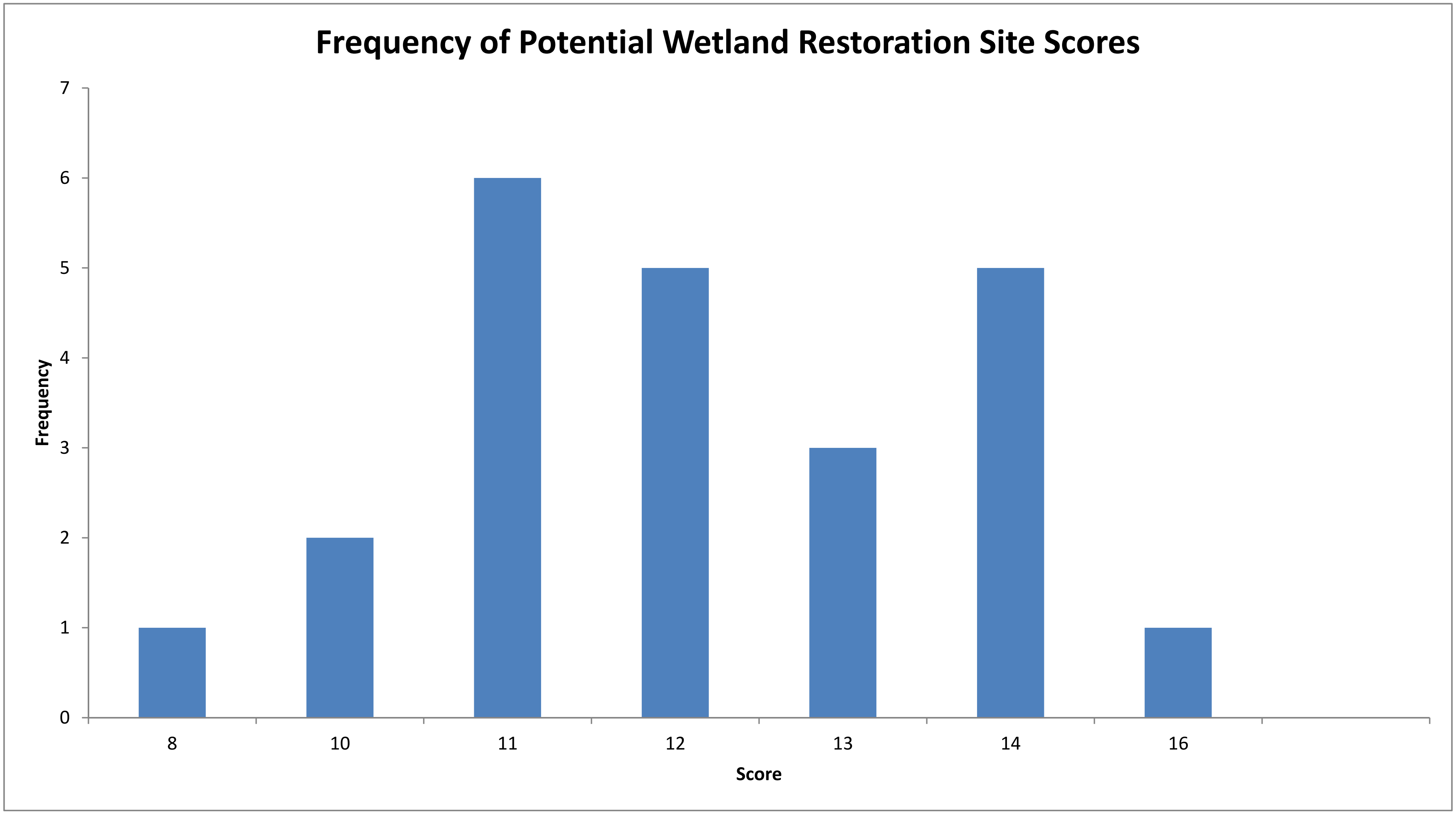
GIS Database for Technical Memorandum 1

Data Set	Source	Description
2010 NC Orthoimagery for Surry County	Surry County Tax Department	High-resolution, leaf-off aerials of entire county
2010 NC Orthoimagery for Stokes County	Stokes County Mapping/GIS Department	High-resolution, leaf-off aerials of entire county
Land Parcels for Surry County	Surry County Tax Department	Land parcel data including landowner information
Land Parcels for Stokes County	Stokes County Mapping/GIS Department	Land parcel data including landowner information
2010 Leaf-On Aerial Photos for Surry and Stokes Counties	Natural Resources Conservation Service	High-resolution, leaf-on aerials of entire county
1:24K Hydrography Dataset	NC Center for Geographic Information and Analysis	Streams and rivers at 1:24,000 scale
SSURGO Soils	Natural Resources Conservation Service	Soil Survey Geographic Database
Municipal Limits	Street Maps USA	Municipal Boundaries
County Boundaries	NC Center for Geographic Information and Analysis	County Boundaries Of North Carolina
Roads and Streets	Street Maps USA	Streets and Roads
State Park Boundaries	NC Dept. of Administration, State Property Office	State Owned Land Boundaries
Subwatershed Boundaries	NCEEP	Subwatershed Boundaries in our work area
Buffer Centerline	Wildlands Engineering, Inc.	Riparian buffers categorized bu width for streams included in 1:24K hydrography dataset
High Priority Streams	Wildlands Engineering, Inc.	Potnetial stream projects in focus area rated as "High Priority"

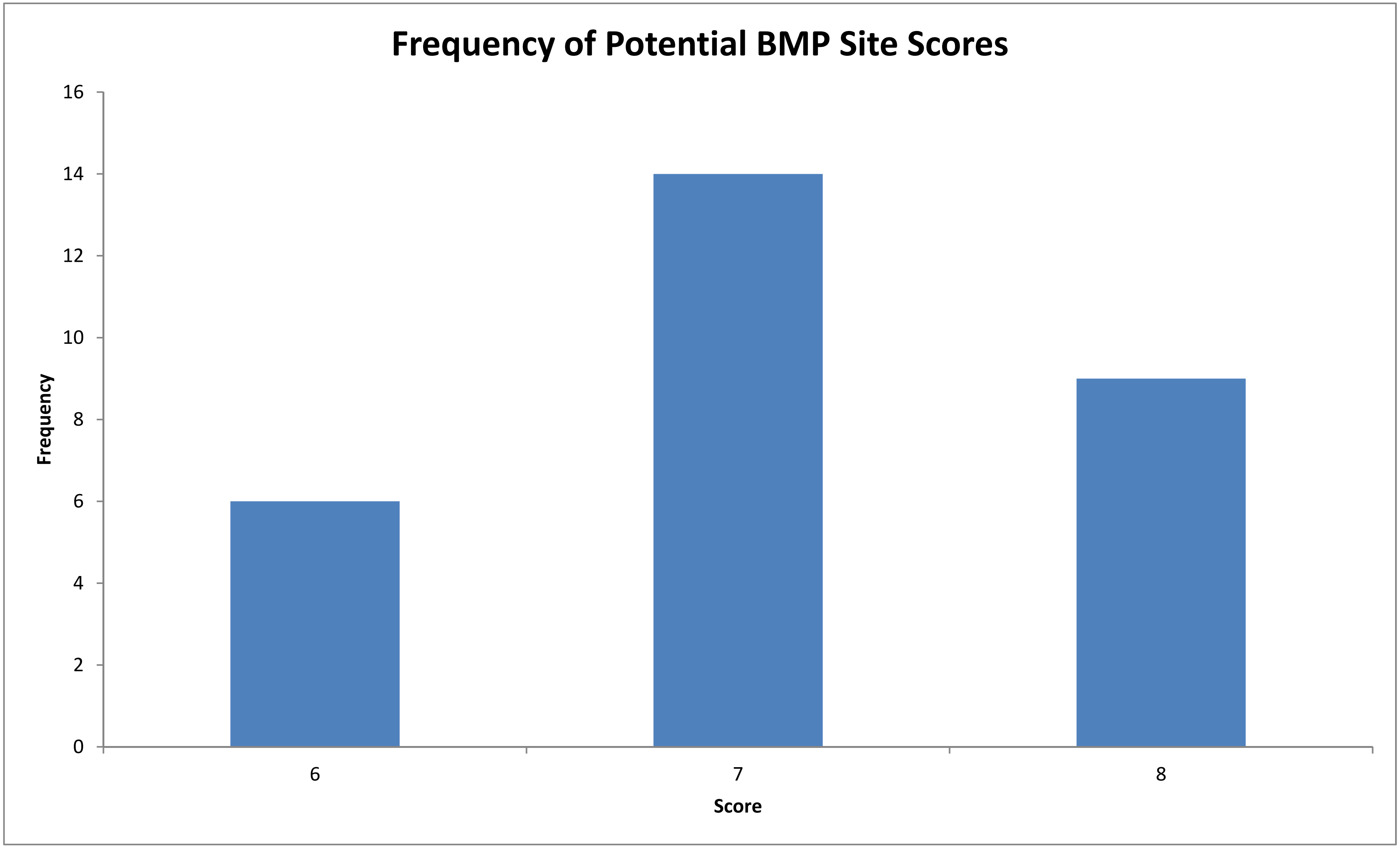
Data Set	Source	Description
High Priority Wetlands	Wildlands Engineering, Inc.	Potnetial wetland projects in focus area rated as "High Priority"
High Priority BMP Sites	Wildlands Engineering, Inc.	Potnetial BMP projects in focus area rated as "High Priority"
Added Streams	Wildlands Engineering, Inc.	Streams that weren't shown on 1:24K Hydrography Set (Mainly Drained Ponds)
Impervious Cover for BMP Watersheds	Wildlands Engineering, Inc.	Impervious Ground Cover
Drainage Lines Split	Michael Baker Corparation	Stormwater Infrastructure- Pipes
Drainage Structures	Michael Baker Corparation	Stormwater Infrastructure- Structures
Michael Baker BMP Sites	Wildlands Engineering, inc.	BMP's From Michael Baker Stormwater Study
High Priority BMP Sites	Wildlands Engineering, inc.	Potential BMP sites rated as "High Priority"
Surry County Topography	Surry County Tax Department	Contour Lines in Surry County
Stokes County Topography	Stokes County Mapping/GIS Department	Contour Lines in Stokes County

Appendix B: Frequency Distribution Plots for Potential Project Sites


Frequency of Potential Stream Restoration Project Group Site Scores
Frequency
0
5
10
15
20
25
30
35
40
10
11
12
13
14
15
16
17
18
19
21
22
Score



Frequency of Potential Wetland Restoration Site Scores
Frequency
Score
0
1
2
3
4
5
6
7
8
10
11
12
13
14
16


Frequency of Potential BMP Site Scores
16
14
12
10
8
6
4
2
0
Frequency
6
7
8
Score

Appendix C: Potential Project Database

Potential Stream Project Database
Ararat-Pilot Mountain Local Watershed Plan

Project Group	Sub-watershed	Project Group Length (LF)	Small Site?	Riparian Buffer Quality Rating	Drainage Area Rating	Length Rating	Landowner Density Rating	Livestock Access Rating	Qual. Channelization Assessment Rating	Subwatershed Functional Assess. Rating	Wetland Adjacent?	Upstream of Water Supply	Score	Rating
Project_32	CH-2	4528.9	No	2	3	3	1	3	2	3		Y	22	High
Project_11	TC-4	5982.0	No	2	3	3	1	3	1	1	Y	Y	22	High
Project_5	TC-1	10444.4	No	2	2	3	1	3	1	2	Y	Y	21	High
Project_10	TC-4	3902.1	No	2	3	2	1	3	2	1	Y	Y	21	High
Project_34	CH-1	4318.3	No	2	3	3	1	1	2	3	Y	Y	19	High
Project_31	CH-2	3355.9	No	2	3	2	3	2	1	3		Y	19	High
Project_24	PC-2	3363.9	No	2	3	2	3	2	2	1			19	High
Project_1	TC-2	5973.6	No	2	2	3	1	2	1	1	Y	Y	19	High
Project_6	TC-3	2794.1	No	2	3	2	1	3	1	2		Y	19	High
Project_33	CH-1	4928.6	No	2	3	3	1	1	1	3	Y	Y	18	High
Project_3	TC-1	5485.1	No	2	2	3	1	1	2	2	Y	Y	18	High
Project_15	TC-5	2906.9	No	2	3	2	1	2	2	1		Y	18	High
Project_21	TC-6	2124.2	No	2	3	2	3	1	2	3		Y	18	High
Small_118	TC-3	936.7	Yes	3	1	1	3	2	2	2		Y	18	High
Small_95	CH-2	775.4	Yes	2	3	1	1	3	1	3		Y	17	High
Small_66	PC-2	880.7	Yes	2	3	1	3	2	2	1			17	High
Small_8	TC-1	592.8	Yes	2	3	1	1	3	1	2		Y	17	High
Project_8	TC-3	2271.6	No	2	3	2	1	2	1	2		Y	17	High
Small_46	TC-6	1605.8	Yes	2	3	1	3	2	1	3		Y	17	High
Project_27	PC-1	9677.6	No	2	3	3	1	1	2	2			17	High
Small_90	CH-2	107.7	Yes	3	3	1	3	1	1	3		Y	17	High

Project Group	Sub-watershed	Project Group Length (LF)	Small Site?	Riparian Buffer Quality Rating	Drainage Area Rating	Length Rating	Landowner Density Rating	Livestock Access Rating	Qual. Channelization Assessment Rating	Subwatershed Functional Assess. Rating	Wetland Adjacent?	Upstream of Water Supply	Score	Rating
Small_91	CH-2	147.9	Yes	3	3	1	3	1	1	3		Y	17	High
Small_82	PC-1	140.0	Yes	3	3	1	3	1	2	2			17	High
Small_52	TC-6	229.2	Yes	3	3	1	3	1	1	1		Y	17	High
Small_9	TC-1	950.1	Yes	3	3	1	3	1	1	2		Y	17	High
Project_36	CH-1	2010.6	No	2	2	2	3	1	1	3		Y	16	High
Small_101	CH-2	1199.9	Yes	2	3	1	3	1	2	3		Y	16	High
Project_30	CH-2	3780.4	No	2	3	2	2	1	1	3		Y	16	High
Project_29	PC-1	5328.5	No	2	2	3	1	1	1	2	Y		16	High
Project_4	TC-1	2868.1	No	2	2	2	1	1	2	2	Y	Y	16	High
Project_9	TC-3	5564.1	No	2	2	3	1	1	1	2		Y	16	High
Project_12	TC-4	3733.6	No	2	2	2	1	2	1	1		Y	16	High
Small_60	TC-6	311.4	Yes	2	3	1	3	1	2	3		Y	16	High
Small_68	PC-2	318.2	Yes	1	3	1	3	2	2	1			16	High
Small_115	CH-1	896.6	Yes	2	3	1	3	1	1	3		Y	15	High
Small_107	CH-2	149.2	Yes	2	3	1	3	1	1	3		Y	15	High
Small_93	CH-2	460.1	Yes	2	3	1	3	1	1	3		Y	15	High
Small_94	CH-2	811.2	Yes	2	3	1	3	1	1	3		Y	15	High
Small_64	PC-2	830.4	Yes	2	3	1	3	1	2	1			15	High
Small_63	PC-2	315.8	Yes	2	3	1	1	2	2	1			15	High
Small_67	PC-2	910.6	Yes	2	3	1	1	2	2	1			15	High
Small_1	TC-2	1047.1	Yes	2	3	1	3	1	1	1		Y	15	High
Small_4	TC-2	934.7	Yes	2	3	1	3	1	1	1		Y	15	High
Small_11	TC-3	396.6	Yes	2	3	1	3	1	1	2		Y	15	High
Project_7	TC-3	7197.4	No	2	1	3	1	1	1	2		Y	15	High
Small_29	TC-5	1947.3	Yes	2	3	1	2	1	2	1		Y	15	High
Small_37	TC-5	1159.4	Yes	2	3	1	3	1	1	1		Y	15	High

Project Group	Sub-watershed	Project Group Length (LF)	Small Site?	Riparian Buffer Quality Rating	Drainage Area Rating	Length Rating	Landowner Density Rating	Livestock Access Rating	Qual. Channelization Assessment Rating	Subwatershed Functional Assess. Rating	Wetland Adjacent?	Upstream of Water Supply	Score	Rating
Small_39	TC-5	487.1	Yes	2	3	1	3	1	1	1		Y	15	High
Small_40	TC-5	403.7	Yes	2	3	1	3	1	1	1		Y	15	High
Small_32	TC-5	853.3	Yes	2	3	1	1	2	1	1		Y	15	High
Project_16	TC-5	3543.9	No	2	1	2	1	2	1	1		Y	15	High
Project_23	TC-6	2500.4	No	2	3	2	1	1	1	3		Y	15	High
Small_99	CH-2	912.0	Yes	1	3	1	3	1	2	3		Y	15	High
Project_28	PC-1	3147.5	No	3	2	2	1	1	1	2			15	High
Small_51	TC-6	205.1	Yes	1	3	1	3	1	2	3		Y	15	High
Small_119	TC-2	446.7	Yes	2	3	1	1	2	1	1		Y	15	High
Small_111	CH-1	1356.5	Yes	2	3	1	1	1	2	3		Y	14	Medium
Project_35	CH-1	3228.1	No	2	2	2	1	1	1	3		Y	14	Medium
Project_37	CH-1	3046.8	No	2	2	2	1	1	1	3		Y	14	Medium
Small_103	CH-2	345.8	Yes	2	3	1	1	1	2	3		Y	14	Medium
Small_104	CH-2	142.9	Yes	2	3	1	1	1	2	3		Y	14	Medium
Small_105	CH-2	651.5	Yes	2	2	1	3	1	1	3		Y	14	Medium
Small_106	CH-2	365.5	Yes	2	3	1	1	1	2	3		Y	14	Medium
Small_108	CH-2	144.8	Yes	2	3	1	1	1	2	3		Y	14	Medium
Small_96	CH-2	1771.7	Yes	2	3	1	1	1	1	3	Y	Y	14	Medium
Small_98	CH-2	1012.7	Yes	2	2	1	3	1	1	3		Y	14	Medium
Small_84	PC-1	458.7	Yes	2	3	1	3	1	1	2			14	Medium
Small_85	PC-1	171.5	Yes	2	3	1	3	1	1	2			14	Medium
Small_88	PC-1	499.5	Yes	2	3	1	3	1	1	2			14	Medium

Project Group	Sub-watershed	Project Group Length (LF)	Small Site?	Riparian Buffer Quality Rating	Drainage Area Rating	Length Rating	Landowner Density Rating	Livestock Access Rating	Qual. Channelization Assessment Rating	Subwatershed Functional Assess. Rating	Wetland Adjacent?	Upstream of Water Supply	Score	Rating
Small_62	PC-2	646.5	Yes	2	3	1	3	1	1	1			14	Medium
Small_70	PC-2	759.5	Yes	2	3	1	3	1	1	1			14	Medium
Small_75	PC-2	460.1	Yes	2	3	1	3	1	1	1			14	Medium
Project_25	PC-2	7052.9	No	2	1	3	1	1	1	1			14	Medium
Small_7	TC-1	1107.4	Yes	2	3	1	1	1	1	2	Y	Y	14	Medium
Project_2	TC-2	3571.1	No	2	2	2	1	1	1	1		Y	14	Medium
Small_10	TC-3	1255.4	Yes	2	3	1	1	1	1	2	Y	Y	14	Medium
Small_17	TC-3	809.8	Yes	2	1	1	1	2	1	2	Y	Y	14	Medium
Small_19	TC-4	746.1	Yes	2	3	1	1	1	2	1		Y	14	Medium
Small_21	TC-4	499.0	Yes	2	3	1	1	1	2	1		Y	14	Medium
Small_28	TC-5	526.1	Yes	2	3	1	1	1	2	1		Y	14	Medium
Small_33	TC-5	369.7	Yes	2	3	1	1	1	2	1		Y	14	Medium
Small_54	TC-6	475.2	Yes	2	3	1	1	1	2	3		Y	14	Medium
Small_59	TC-6	308.3	Yes	2	3	1	1	1	1	3	Y	Y	14	Medium
Project_13	TC-6	2632.0	No	2	1	2	2	1	1	3		Y	14	Medium
Small_110	CH-1	640.4	Yes	1	3	1	3	1	1	3		Y	14	Medium
Small_35	TC-5	445.4	Yes	1	3	1	3	1	1	1		Y	14	Medium
Small_36	TC-5	1353.3	Yes	1	3	1	3	1	1	1		Y	14	Medium
Project_22	TC-6	2783.3	No	1	3	2	1	1	1	3		Y	14	Medium
Small_120	TC-3	307.5	Yes	2	1	1	3	1	2	2		Y	14	Medium
Small_113	CH-1	785.2	Yes	2	3	1	1	1	1	3		Y	13	Medium
Small_116	CH-1	412.5	Yes	2	3	1	1	1	1	3		Y	13	Medium
Small_117	CH-1	165.6	Yes	2	3	1	1	1	1	3		Y	13	Medium
Small_109	CH-1	1101.1	Yes	2	3	1	1	1	1	3		Y	13	Medium

Project Group	Sub-watershed	Project Group Length (LF)	Small Site?	Riparian Buffer Quality Rating	Drainage Area Rating	Length Rating	Landowner Density Rating	Livestock Access Rating	Qual. Channelization Assessment Rating	Subwatershed Functional Assess. Rating	Wetland Adjacent?	Upstream of Water Supply	Score	Rating
Small_102	CH-2	821.2	Yes	2	3	1	1	1	1	3		Y	13	Medium
Small_89	CH-2	1251.6	Yes	2	2	1	1	1	2	3		Y	13	Medium
Small_92	CH-2	1057.4	Yes	2	3	1	1	1	1	3		Y	13	Medium
Small_79	PC-1	473.8	Yes	2	2	1	3	1	1	2			13	Medium
Small_83	PC-1	232.5	Yes	2	3	1	1	1	2	2			13	Medium
Small_65	PC-2	625.1	Yes	2	3	1	1	1	2	1			13	Medium
Small_6	TC-1	1512.2	Yes	2	3	1	1	1	1	2		Y	13	Medium
Small_2	TC-2	794.0	Yes	2	3	1	1	1	1	1		Y	13	Medium
Small_3	TC-2	1382.7	Yes	2	3	1	1	1	1	1		Y	13	Medium
Project_14	TC-3	2852.8	No	2	1	2	1	1	1	2		Y	13	Medium
Small_24	TC-4	513.2	Yes	2	3	1	1	1	1	1		Y	13	Medium
Small_25	TC-4	182.3	Yes	2	3	1	1	1	1	1		Y	13	Medium
Small_26	TC-4	684.8	Yes	2	3	1	1	1	1	1		Y	13	Medium
Small_30	TC-5	316.1	Yes	2	3	1	1	1	1	1		Y	13	Medium
Small_31	TC-5	1030.7	Yes	2	3	1	1	1	1	1		Y	13	Medium
Small_34	TC-5	1595.6	Yes	2	3	1	1	1	1	1		Y	13	Medium
Small_41	TC-5	500.9	Yes	2	3	1	1	1	1	1		Y	13	Medium
Small_42	TC-5	455.0	Yes	2	1	1	3	1	1	1		Y	13	Medium
Small_43	TC-5	662.0	Yes	2	1	1	3	1	1	1		Y	13	Medium
Project_17	TC-5	2625.7	No	2	1	2	1	1	1	1		Y	13	Medium
Project_19	TC-5	3440.9	No	2	1	2	1	1	1	1		Y	13	Medium
Project_20	TC-5	3456.0	No	2	1	2	1	1	1	1		Y	13	Medium
Small_44	TC-6	1540.8	Yes	2	1	1	3	1	1	3		Y	13	Medium
Small_47	TC-6	899.2	Yes	2	3	1	1	1	1	3		Y	13	Medium
Small_48	TC-6	577.6	Yes	2	3	1	1	1	1	3		Y	13	Medium
Small_49	TC-6	1344.2	Yes	2	3	1	1	1	1	3		Y	13	Medium
Small_50	TC-6	1233.9	Yes	2	3	1	1	1	1	3		Y	13	Medium

Project Group	Sub-watershed	Project Group Length (LF)	Small Site?	Riparian Buffer Quality Rating	Drainage Area Rating	Length Rating	Landowner Density Rating	Livestock Access Rating	Qual. Channelization Assessment Rating	Subwatershed Functional Assess. Rating	Wetland Adjacent?	Upstream of Water Supply	Score	Rating
Small_55	TC-6	1220.8	Yes	2	3	1	1	1	1	3		Y	13	Medium
Small_56	TC-6	1975.5	Yes	2	2	1	1	1	2	3		Y	13	Medium
Small_57	TC-6	1186.3	Yes	2	3	1	1	1	1	3		Y	13	Medium
Small_58	TC-6	587.0	Yes	2	3	1	1	1	1	3		Y	13	Medium
Small_61	TC-6	281.9	Yes	2	3	1	1	1	1	3		Y	13	Medium
Small_112	CH-1	928.2	Yes	1	2	1	3	1	1	3		Y	13	Medium
Small_22	TC-4	321.1	Yes	3	1	1	1	1	1	1		Y	13	Medium
Small_78	PC-1	330.7	Yes	2	3	1	1	1	1	2			12	Low
Small_80	PC-1	212.6	Yes	2	3	1	1	1	1	2			12	Low
Small_81	PC-1	497.2	Yes	2	3	1	1	1	1	2			12	Low
Small_86	PC-1	78.4	Yes	2	3	1	1	1	1	2			12	Low
Small_87	PC-1	150.1	Yes	2	3	1	1	1	1	2			12	Low
Small_71	PC-2	1195.1	Yes	2	3	1	1	1	1	1			12	Low
Small_73	PC-2	383.7	Yes	2	3	1	1	1	1	1			12	Low
Small_74	PC-2	174.6	Yes	2	3	1	1	1	1	1			12	Low
Small_76	PC-2	901.2	Yes	2	3	1	1	1	1	1			12	Low
Project_26	PC-2	2890.1	No	2	1	2	1	1	1	1			12	Low
Small_13	TC-3	1409.9	Yes	2	1	1	1	1	1	2	Y	Y	12	Low
Small_20	TC-4	212.1	Yes	2	2	1	1	1	1	1		Y	12	Low
Small_114	CH-1	594.2	Yes	1	3	1	1	1	1	3		Y	12	Low
Small_100	CH-2	714.7	Yes	1	3	1	1	1	1	3		Y	12	Low
Small_97	CH-2	565.0	Yes	1	3	1	1	1	1	3		Y	12	Low
Small_5	TC-2	511.3	Yes	1	3	1	1	1	1	1		Y	12	Low
Small_12	TC-3	831.1	Yes	1	3	1	1	1	1	2		Y	12	Low
Project_18	TC-5	2752.2	No	1	1	2	1	1	1	1		Y	12	Low
Small_14	TC-3	763.7	Yes	2	1	1	1	1	1	2		Y	11	Low
Small_16	TC-3	717.1	Yes	2	1	1	1	1	1	2		Y	11	Low

Project Group	Sub-watershed	Project Group Length (LF)	Small Site?	Riparian Buffer Quality Rating	Drainage Area Rating	Length Rating	Landowner Density Rating	Livestock Access Rating	Qual. Channelization Assessment Rating	Subwatershed Functional Assess. Rating	Wetland Adjacent?	Upstream of Water Supply	Score	Rating
Small_23	TC-4	912.4	Yes	2	1	1	1	1	1	1		Y	11	Low
Small_27	TC-4	383.7	Yes	2	1	1	1	1	1	1		Y	11	Low
Small_38	TC-5	1204.6	Yes	2	1	1	1	1	1	1		Y	11	Low
Small_45	TC-6	376.6	Yes	2	1	1	1	1	1	3		Y	11	Low
Small_53	TC-6	927.0	Yes	2	1	1	1	1	1	3		Y	11	Low
Small_69	PC-2	880.6	Yes	2	1	1	1	1	1	1			10	Low
Small_72	PC-2	677.8	Yes	2	1	1	1	1	1	1			10	Low
Small_77	PC-2	727.2	Yes	2	1	1	1	1	1	1			10	Low
Small_15	TC-3	431.0	Yes	1	1	1	1	1	1	2		Y	10	Low
Small_18	TC-4	779.7	Yes	1	1	1	1	1	1	1		Y	10	Low

Potential Wetland Site Database
Ararat-Pilot Mountain Local Watershed Plan

Sub-watershed	ID	Area (Ac)	Unit Symbol	Hydric Soil Rating	Vegetation Rating	Drainage Rating	Size Classification	Sub-watershed Functional Assess. Rating	Adjacent Stream Project Group	Score	Rating
TC-3	8	5.1	ArA	3	3	3	3	2	Y	16	High
CH-1	3	7.2	CsA	3	2	2	3	3	Y	14	High
TC-4	7	11.8	ArA	3	2	2	3	1	Y	14	High
TC-4	9	11.5	ArA	3	3	1	3	1	Y	14	High
TC-1	20	7.5	ArA	3	2	2	3	2	Y	14	High
TC-1	21	5.6	ArA	3	2	2	3	2	Y	14	High
TC-2	16	2.6	ArA	3	3	2	2	1	Y	13	High
TC-1	18	4.6	ArA	3	3	2	2	2	Y	13	High
CH-1	1	7.3	BeA	2	2	2	3	3	Y	13	High
TC-5	12	2.0	ArA	3	3	1	2	1	Y	12	Medium
TC-4	13	2.3	ArA	3	3	1	2	1	Y	12	Medium
TC-2	17	3.0	ArA	3	3	1	2	1	Y	12	Medium
TC-1	19	2.9	BaC	2	3	2	2	2	Y	12	Medium
TC-1	23	3.7	BaC	2	3	2	2	2	Y	12	Medium
PC-1	10	1.7	ArA	3	3	2	1	2	Y	11	Medium
CH-1	2	3.6	BaB	2	3	1	2	3	Y	11	Medium
CH-2	4	4.3	BaB	2	3	1	2	3	Y	11	Medium
TC-3	6	2.1	ArA	3	2	1	2	2	Y	11	Medium
TC-3	14	3.4	ArA	3	2	1	2	2	Y	11	Medium
TC-1	22	2.5	BaC	2	3	1	2	2	Y	11	Medium
TC-6	11	0.8	ArA	3	3	1	1	3	Y	10	Low
TC-3	15	1.1	ArA	3	3	1	1	2	Y	10	Low
CH-2	5	1.4	BaB	2	3	1	1	3		8	Low

Potential Stormwater BMP Database
Ararat-Pilot Mountain Local Watershed Plan

BMP Site	BMP Type	Impervious Area (ac)	Drainage Area (ac)	% Impervious	Landowner	Watershed Characteristics	Feasibility Rating	Landowner Rating	Score	Rating
BMP 2	Stormwater Wetland	2.9	8.2	35.7%	Bank	3	3	2	8	High
BMP 11	Stormwater Wetland	7.6	15.3	49.8%	Industrial	3	3	2	8	High
BMP 12	Stormwater Wetland	3.7	11.2	33.1%	Industrial	3	3	2	8	High
BMP 18	Bioretnetion	0.7	1.0	71.2%	Public (County School)	2	3	3	8	High
BMP 20	Stormwater Wetland	2.5	9.2	27.4%	Ccommercial	3	3	2	8	High
BMP 21	Stormwater Wetland	2.7	8.5	31.6%	Commercial	3	3	2	8	High
BMP 28	Stormwater Wetland	6.0	9.5	62.9%	Industrial	3	3	2	8	High
BMP 29	Stormwater Wetland	3.6	8.1	44.2%	Private	3	3	2	8	High
BMP 30	Wet Pond/Stormwater Wetland	4.0	14.9	26.5%	Private	3	2	2	7	Medium
BMP 26	Bioretention	1.7	8.7	19.3%	Private	2	3	2	7	Medium
BMP 22	Bioretention/ Stormwater Wetland	0.6	13.0	4.6%	Public	1	3	3	7	Medium
BMP 1	Bioretention	0.2	0.6	36.1%	Private	2	3	2	7	Medium
BMP 25	Bioretention	1.1	1.3	82.7%	Commercial	2	3	2	7	Medium
BMP 8	Bioretention	0.3	0.5	65.4%	Private	2	3	2	7	Medium
BMP 9	Bioretention	1.0	2.6	38.7%	Private	2	3	2	7	Medium
BMP 13	Bioretention	1.2	3.5	33.3%	Industrial	2	3	2	7	Medium
BMP 15	Bioretention	0.4	0.4	91.1%	Commercial	2	3	2	7	Medium
BMP 16	Stormwater Wetland	5.9	12.2	47.9%	Private	3	2	2	7	Medium
BMP 19	Stormwater Wetland	3.0	4.1	73.8%	Public (County School)	2	2	3	7	Medium
BMP 23	Bioretention	0.9	1.4	66.2%	Church	2	3	2	7	Medium
BMP 24	Bioretention	2.7	5.7	48.5%	Private	2	3	2	7	Medium
BMP 25	Bioretention	1.1	1.5	74.8%	Commercial	2	3	2	7	Medium
BMP 27	Stormwater Wetland	3.3	11.0	30.1%	Private	3	2	2	7	Medium

BMP Site	BMP Type	Impervious Area (ac)	Drainage Area (ac)	% Impervious	Landowner	Watershed Characteristics	Feasibility Rating	Landowner Rating	Score	Rating
BMP 3	Bioretention	0.3	0.5	57.6%	Public (Town)	1	2	3	6	Low
BMP 4	Bioretention	0.8	4.6	17.6%	Private	1	3	2	6	Low
BMP 7	Bioretention	3.2	4.3	75.3%	Church	2	2	2	6	Low
BMP 10	Bioretention	0.6	0.7	84.1%	Industrial	2	2	2	6	Low
BMP 14	Bioretention	0.3	0.6	47.7%	Commercial	2	2	2	6	Low
BMP 17	Bioretention	0.4	0.7	59.6%	Private (Appt Buildings)	2	2	2	6	Low