Total Maximum Daily Load for Fecal Coliform for Elk Creek in North Carolina

Final Report

February 2008

Yadkin-Pee Dee River Basin

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TMDL Summary Sheet

303(d) List Information

State: North Carolina
Counties: Wilkes
Basin: Yadkin- Pee Dee River Basin

Waterbody Name	Description	Assessment Unit (AU):	Class	Subbasin	Impairment	Miles
Elk Creek	From Dugger Creek to Yadkin River	12-24-(10)	B, ORW	03-07-01	Fecal Coliform	9.1

Constituents of Concern: Fecal Coliform Bacteria
Reason for Listing: Standard Violations

Applicable Water Quality Standard for Class B Waters:

- Fecal coliform shall not exceed a geometric mean of 200/100 ml (membrane filter count) based upon at least five consecutive samples examined during any 30 day period, nor exceed 400/100 ml in more than 20 percent of the samples examined during such period.

TMDL Development

Analysis/Modeling:
Load duration curves are based on cumulative frequency distribution of flow conditions in the watershed. Allowable loads are average loads over the recurrence interval between the 95th and 10th percent flow exceeded (excludes extreme drought (>95th percentile) and floods (<10th percentile). Percent reductions are expressed as the average value between existing loads (typically calculated using an equation to fit a curve through actual water quality violations) and the allowable load at each percent flow exceeded.

Critical Conditions:
Critical conditions are accounted in the load curve analysis by using an extended period of stream flow and water quality data, and by examining at what flow (percent flow exceeded) the existing load violations occur.

Seasonal Variation:
Seasonal variation in hydrology, climatic conditions, and watershed activities are represented through the use of a continuous flow gage and the use of all readily available water quality data collected in the watershed.

TMDL Allocation Summary

Pollutants/Watershed	Existing Exceeding Load	WLA	LA	MOS	TMDL
Fecal Coliform (colony forming units (cfu)/day)					
Elk Creek	1.08E+12	0	5.58E+11	6.20E+10	6.20E+11

Notes:
WLA = Wasteload Allocation, LA = Load Allocation, MOS = Margin of Safety.

1. LA = TMDL – WLA – MOS.
2. TMDL represents the average allowable load between the 95th and 10th percent recurrence interval.
3. Explicit (10%) and implicit Margins of Safety are considered.
4. Overall reduction is based on the instantaneous standard of 400 cfu/100ml and is assumed to be more stringent than the geometric mean standard.

Contributing Municipalities: NONE

Public Notice Date: 12/17/2007 – 1/31/2008
Submittal Date: 2/04/2008
Establishment Date: 2/20/2008
EPA Lead on TMDL (EPA or Blank):
DOT a Significant Contribution (Yes or Blank):
Endangered Species (Yes or Blank):
TMDL Considers Point Source, Nonpoint Source, or Both: both

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1.0 Introduction

1.1 TMDL Definition

This report presents the development of a Fecal Coliform Total Maximum Daily Load (TMDL) for Elk Creek in the Yadkin-Pee Dee River Basin (Figure 1.1) in North Carolina. As identified by the North Carolina Division of Water Quality (DWQ), the impaired segment of the waterbody is described in Table 1.1.

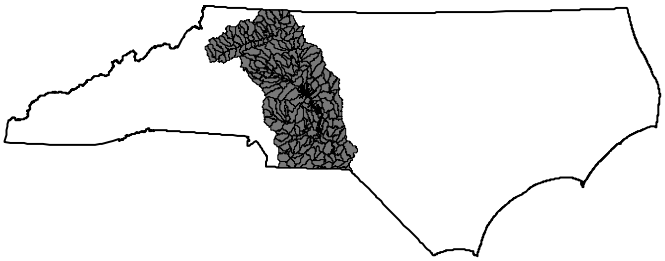

Figure 1.1. Location of Yadkin River Basin within North Carolina.

Table 1.1. Description of Impaired Segments for Elk Creek.

Waterbody Name	Description	Assessment Unit (AU):	Class	Subbasin	Impairment	Miles
Elk Creek	From Dugger Creek to Yadkin River	12-24-(10)	B[1], ORW	03-07-01	Fecal Coliform	9.1

[1] Class B waters are freshwaters protected for primary recreation, which includes swimming on a frequent or organized basis and all Class C uses. Class C waters are protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife.

Section 303(d) of the Clean Water Act (CWA) requires States to develop a list of water bodies that do not meet water quality standards or have impaired uses. The list, referred to as the 303(d) list, is submitted biennially to the U.S. Environment Protection Agency (USEPA) for review. The 303(d) process requires that a Total Maximum Daily Load (TMDL) be developed for each of the waters appearing on Category 5 of the 303(d) list.

1.2 TMDL Components

The objective of a TMDL is to allocate allowable pollutant loads to known sources so that actions may be taken to restore the water to its intended uses (USEPA, 1991). Generally, the primary components of a TMDL, as identified by USEPA (1991, 2000) and the Federal Advisory Committee (FACA) (USEPA, 1998) are as follows:

Target identification or selection of pollutant(s) and end-point(s) for consideration. The pollutant and end-point are generally associated with measurable water quality related characteristics that indicate compliance with water quality standards. North Carolina indicates known pollutants on the 303(d) list.

Source assessment. All sources that contribute to the impairment should be identified and loads quantified, where sufficient data exist.

Assimilative Capacity. Estimation or level of pollutant reduction needed to achieve water quality goal. The level of pollution should be characterized for the water body, highlighting how current conditions deviate from the target end-point. Generally, this component is identified through water quality modeling.

Allocation of Pollutant Loads. Allocating pollutant control responsibility to the sources of impairment. The waste load allocation portion of the TMDL accounts for the loads associated with existing and future point sources. Similarly, the load allocation portion of the TMDL accounts for the loads associated with existing and future nonpoint sources, storm water, and natural background.

Margin of Safety. The margin of safety addresses uncertainties associated with pollutant loads, modeling techniques, and data collection. Per EPA (2000a), the margin of safety may be expressed explicitly as unallocated assimilative capacity or implicitly due to conservative assumptions.

Seasonal Variation. The TMDL should consider seasonal variation in the pollutant loads and end-point. Variability can arise due to stream flows, temperatures, and exceptional events (e.g., droughts, hurricanes).

Critical Conditions. Critical conditions indicate the combination of environmental factors that result in just meeting the water quality criterion and have an acceptably low frequency of occurrence.

Section 303(d) of the CWA requires EPA to review all TMDLs for approval. Once EPA approves a TMDL, the water body may be moved to Category 4a of the 303(d) list. Water bodies remain on Category 4a of the list until compliance with water quality standards is achieved.

1.3 Water Quality Target: North Carolina Standards and Classifications

1.3.1 Water Quality Standard for Fecal Coliform

The North Carolina fresh water quality standard for Class B waters for fecal Coliform (15A NCAC 02B. 0219) states:

> *The following water quality standards apply to surface waters that are for primary recreation, including frequent or organized swimming and are classified as Class B*

waters. Water quality standards applicable to Class C waters as described in Rule .0211 of this Section also apply to Class B waters.

Organisms of coliform group: fecal coliforms not to exceed geometric mean of 200/100 ml (MF count) based on at least five consecutive samples examined during any 30-day period and not to exceed 400/100 ml in more than 20 percent of the samples examined during such period.

The North Carolina fresh water quality standard for Class C waters for fecal Coliform (15a NCAC 02B .0211) states:

Organisms of the coliform group: fecal coliforms shall not exceed a geometric mean of 200/100ml (MF count) based upon at least five consecutive samples examined during any 30 day period, nor exceed 400/100ml in more than 20 percent of the samples examined during such period; violations of the fecal coliform standard are expected during rainfall events and, in some cases, this violation is expected to be caused by uncontrollable nonpoint source pollution; all coliform concentrations are to be analyzed using the membrane filter technique unless high turbidity or other adverse conditions necessitate the tube dilution method; in case of controversy over results, the MPN 5-tube dilution technique shall be used as the reference method.

1.3.2 Outstanding Resource Water Classification

Elk Creek is designated as an Outstanding Resource Water (ORW). Special protection measures that apply to North Carolina ORWs are set forth in 15A NCAC 2B.0225. At a minimum, no new discharges or expansions are permitted, and a 30-foot vegetated buffer or stormwater controls for new developments are required. In some circumstances, the unique characteristics of the waters and resources that are to be protected require that a specialized (or customized) ORW management strategy be developed.

1.4 Watershed Description

The watershed area was delineated by using the USGS 14-digit hydrologic units. Elk Creek is located in the Yadkin-Pee Dee River Basin. The Elk Creek watershed is located within Watauga and Wilkes Counties, as shown in Figure 1.2. The watershed is located within hydrologic unit 03040101010050.

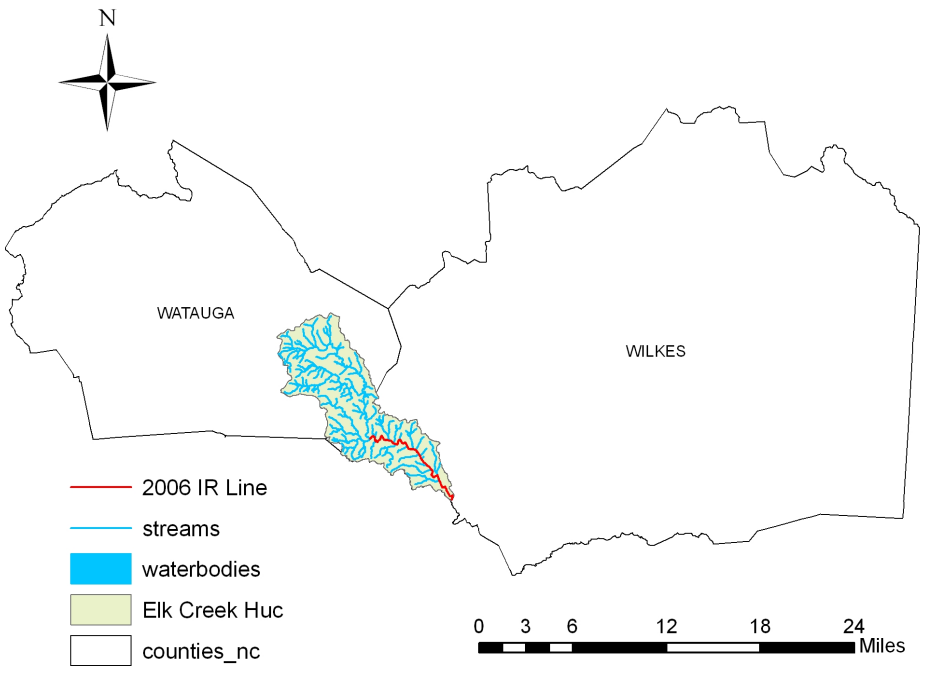

Figure 1.2. Elk Creek Watershed and Surrounding Area.

Population is measured in census blocks, which do not usually coincide with watershed boundaries. Therefore, population information is grouped by county, as seen in Table 1.2. The population totals in each county for 2000 and 2006 are given, as well as percent change in these values. The percent change statistic gives an estimate on the rate of growth in each county.

Table 1.2. Population Information for Relevant Counties.

County	Persons per square mile, 2000[1]	2000 Population	2006 Population Estimate	Population, percent change, April 1, 2000 to July 1, 2006[2]
Wilkes	86.7	65,632	67,310	2.6%
Watauga	136.4	42,695	42,700	0.0%

1. North Carolina average persons per square mile = 165.2
2. North Carolina average population percent change 4/1/00 – 7/1/06 = 10.1%

Wilkes - http://quickfacts.census.gov/qfd/states/37/37193.html
Watauga - http://quickfacts.census.gov/qfd/states/37/37189.html

Land Use/Land Cover

The land use/land cover characteristics of the watershed were determined using the 2001 National Land Cover Database (http://www.mrlc.gov/mrlc2k_nlcd.asp). Table 1.3 shows the area in acres for each of these categories. Land use and land cover information is also provided graphically in Figure 1.3.

Table 1.3. Land Use Acreages and their Percent Compositions in the Elk Creek Watershed.

Land Use	Area (acres)	Area (percent)
Deciduous Forest	27,606.83	85.24%
Pasture/Hay	1,526.71	4.71%
Evergreen Forest	1,115.06	3.44%
Developed, Open Space	884.22	2.73%
Mixed Forest	751.90	2.32%
Shrub/Scrub	336.70	1.04%
Grassland/Herbaceous	88.51	0.27%
Woody Wetlands	30.69	0.09%
Cultivated Crops	21.79	0.07%
Developed, Low/Medium Intensity	11.12	0.03%
Barren Land (Rock/Sand/Clay)	9.79	0.03%
Open Water	2.89	0.01%
Total	32,386	100%

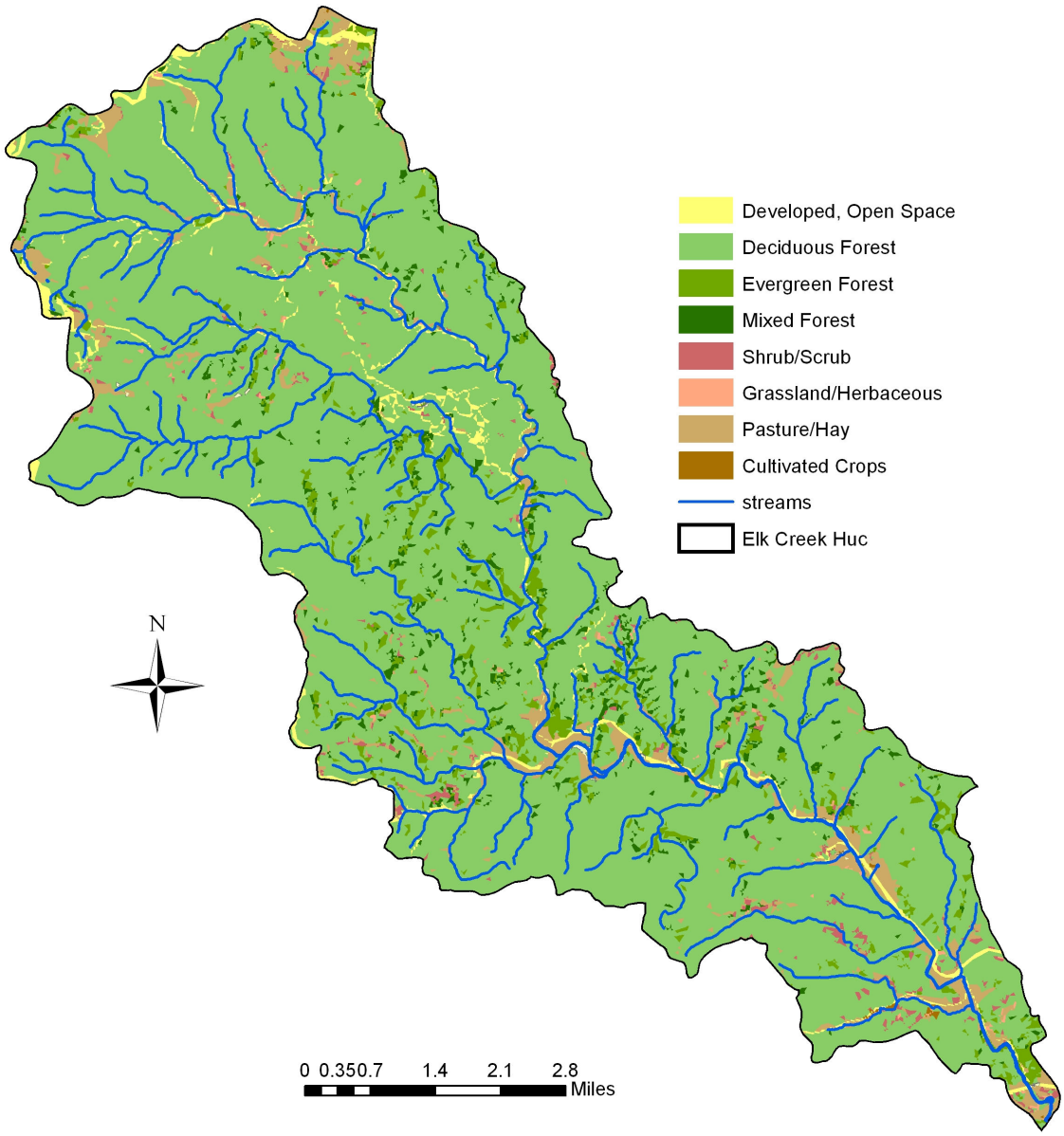

Figure 1.3. Land Use and Land Cover distribution in the Elk Creek Watershed.

1.5 Water Quality Monitoring

1.5.1 Fecal Coliform Monitoring in Elk Creek

The DWQ has one monitoring station on Elk Creek: Q0220000 at Elk Creek at NC268 in Elkville. The location of this station is shown in Figure 1.4. There are numerous qualifiers on the sampling data, which can be found in Appendix Table A.1. The most common qualifier (Q) refers to the exceedance of holding times of the water quality samples that were collected. Holding time refers to holding samples on ice from the time of collection until the samples can be analyzed in the laboratory. Holding samples on ice slows the metabolism of the organisms

resulting in no appreciable growth. DWQ used all the data collected, including those data that exceeded holding times, in the development of the TMDL. The actual concentration is expected to be at least as high as the value reported.

In addition to the normal monthly samples, ten additional samples were taken at this station in June (5 samples) and July (5 samples) of 2002 to determine if fecal coliform concentrations exceeded the geometric mean portion of the standard (*fecal coliforms not to exceed geometric mean of 200cfu/100 ml based on at least five consecutive samples examined during any 30-day period*). These sampling points are highlighted in Appendix Table A.1. A more detailed accounting of sampling can be found in Table 1.4.

Table 1.4. Elk Creek Sampling

Station	Sampling Period	Number of Samples Collected	Approximate Sampling Frequency	Number of Samples Exceeding Standard (400 colony forming units (cfu)/100 ml)	June 2002 Geomean[1]	July 2002 Geomean[1]
Q0220000	Jan. 1997 – Sept. 2006	121	monthly	17 (14%)	408 cfu/100 ml	455 cfu/100 ml

1. Geomean is calculated when there are five consecutive samples examined during any 30-day period.

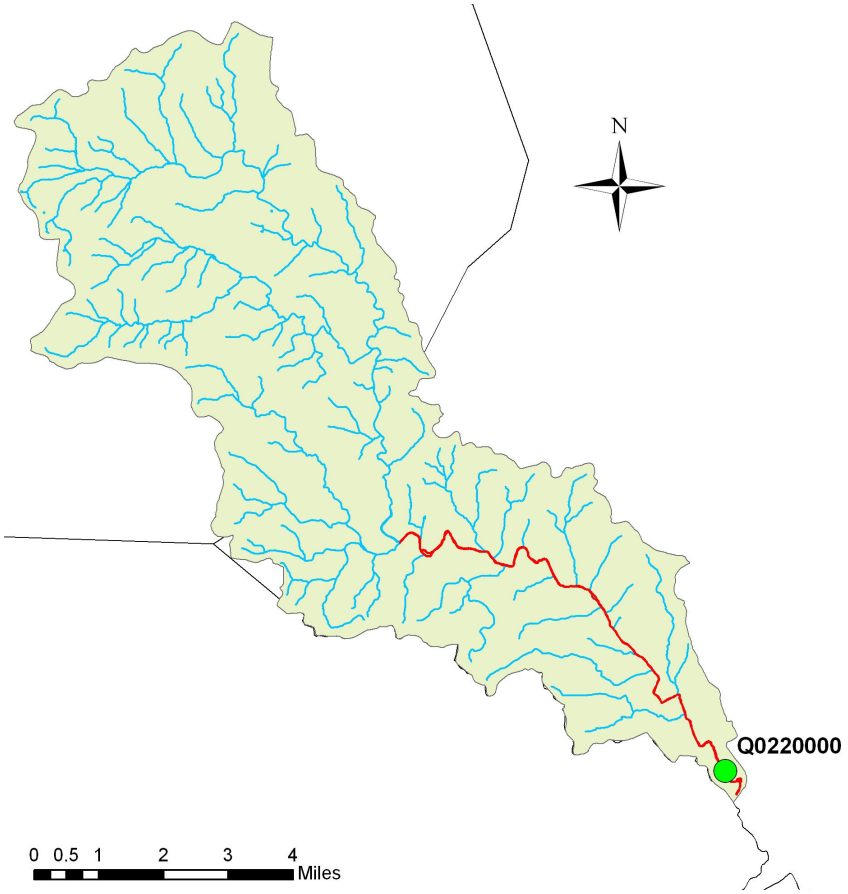

Figure 1.4. Water Quality Monitoring Station in the Elk Creek Watershed.

2.0 Source Assessment

A source assessment is used to identify and characterize the known and suspected sources of fecal coliforms in the watershed. This section outlines general sources of fecal coliform. Sources specific to the Elk Creek watershed are discussed in Section 3.1.

2.1 General Sources of Fecal Coliform

Both point sources and nonpoint sources may contribute fecal coliform to water bodies. However, in Elk Creek, there are no point sources. Potential nonpoint sources of fecal coliform loading are discussed below.

2.1.1 Nonpoint Sources of Fecal Coliform

Fecal coliform from nonpoint sources include those sources that cannot be identified as entering the water body at a specific location. Nonpoint source pollution can include both urban and agricultural sources and human and non-human sources (Table 2.1). Nonpoint sources of fecal coliform include wildlife, livestock (land application of agricultural manure and grazing), urban development (stormwater runoff, including sources from domestic animals), failing septic systems, and sewer line systems (illicit connections, leaky sewer lines and sewer system overflows).

Table 2.1. Potential Source of Fecal Coliform Bacteria in Urban and Rural Watersheds. (Source: Center for Watershed Protection, 1999)

Source Origin	Type	Source
Human Sources	Sewered watershed	Combined sewer overflows
		Sanitary sewer overflows
		Illegal sanitary connections to storm drains
		Illegal disposal to storm drains
	Non-sewered watershed	Failing septic systems
		Poorly operated package plant
		Landfills
		Marinas
Non-human Sources	Domestic animals and urban wildlife	Dogs, cats, rats, raccoons, pigeons, gulls, ducks, geese
	Livestock and rural wildlife	Cattle, horse, poultry, beaver, muskrats, deer, waterfowl
	Others	Hobby farms

Land use can contribute to fecal coliform runoff. Agricultural land alongside a stream would contribute fecal coliform from livestock and manure applications. In addition, when cattle have direct access to streams, feces may be deposited directly into a stream.

Runoff from urban surface is also a potentially significant source of fecal coliform loadings. Urban lands may contribute fecal coliform from pets such as dog and cats. In a study conducted by Hyer et al., 2001, the bacterial loads due to dog waste accounted for nearly 10 percent of the total bacterial load in three creeks of Virginia: Accotink Creek, Blacks Run, and Christians Creek. Furthermore, wildlife feces in runoff may be a frequent source of fecal coliform loading where forest dominates the streamside.

Fecal coliform can originate from various urban sources. These sources include pet waste, runoff through stormwater, sewers, illicit discharges/connections of sanitary waste, leaky sewer systems, and sewer system overflows.

Fecal coliform contamination can be profound when sewer pipes are clogged or flooded by stormwater. Infiltration of rainfall can enter the sewer system through cracks and leaks in pipes. This additional flow volume, in combination with the existing sewer flow, can exceed the capacity of the system resulting in a sanitary-sewer-overflow (SSO).

3.0 Elk Creek Impairment

3.1 Source Assessment

3.1.1 NPDES Wastewater Permits

There are no facilities that discharge wastewater to the polluted portion of Elk Creek and its tributaries.

3.1.2 NPDES Stormwater Permits

The only stormwater permit in the Elk Creek watershed is held by the North Carolina Department of Transportation (NC DOT), whose NPDES Phase I permit applies statewide. At the time of development of this TMDL, it does not appear that NC DOT is a significant contributor of fecal coliform in this watershed. NC DOT is allowed to continue to discharge in accordance with its approved NPDES stormwater permit (NCS000250). NC DOT will continue to implement measures required by the permit, including illicit discharge detection and elimination, post-construction controls, management of hydraulic encroachments, sediment and erosion control, stormwater pollution prevention for industrial facilities, research, and education programs. The finding that NCDOT is not a significant contributor of fecal coliform loads may be subject to change over time if watershed conditions significantly change.

3.1.3 Livestock Populations

The North Carolina Department of Agriculture (NCDA) regularly performs an agricultural census for each county of the state. This census includes estimated livestock populations in each county, as shown in Table 3.1 for the counties that contain the Elk Creek watershed.

DWQ requested information specific to the Elk Creek watershed from both Watauga and Wilkes Soil & Water Conservation Districts. DWQ received a completed questionnaire from the Wilkes Soil & Water Conservation District. The questionnaire is provided in Appendix B.

As shown in Table 3.1, a very small percentage of cattle and beef cows in Wilkes County are actually in the Elk Creek watershed. However, even though the percentage is small, 75% of the cattle in the Elk Creek watershed have direct access to Elk Creek (Appendix B).

The Wilkes Soil & Water Conservation District also estimates that 80% of horses in the watershed have direct access to streams in the watershed. In addition, manure from various livestock is applied to agricultural lands in the watershed.

Table 3.1. Estimated Livestock population in Watauga and Wilkes Counties.

Livestock	Date data is valid from	Watauga[1]	Wilkes[1]	Estimated livestock in Wilkes County portion of Elk Creek Watershed[2]
Cattle All	Jan 1, 2007	10,200	32,000	480 (1.5%)
Beef Cows	Jan 1, 2007	3,600	15,100	151 (1%)
Milk Cows	Jan 1, 2007	No data	1,300	0%
Broilers Produced	2006	No data	91,700,000	0%
Chickens, excluding broilers	Dec. 1, 2006	No data	1,050,000	0%

1. Source: Wilkes: http://www.ncagr.com/stats/codata/wilkes.htm
   Watauga: http://www.ncagr.com/stats/codata/watauga.htm
2. Estimated by Wilkes Soil & Water Conservation District (see Appendix B).

3.1.4 Septic Tanks

Septic tanks and cesspools can contribute to the nonpoint sources of fecal coliform found in Elk Creek. The Wilkes Soil & Water Conservation District estimates the septic system failure rate to be 25% in Wilkes County (see Appendix B). More information is provided in Table 3.2.

Table 3.2. Estimated housing units using septic systems in 1990 in Wilkes and Watauga Counties.

County	Number of Housing Units (1990)	Number of Septic Tank or Cesspool Systems	Percentage of Housing Units with Septic Tank or Cesspool Systems
Wilkes	24,960	20,467	82%
Watauga	19,538	11,582	59%

Source for Septic Tank and Cesspool System data:
http://factfinder.census.gov/servlet/QTTable?_bm=y&-context=qt&-qr_name=DEC_1990_STF3_DP5&-ds_name=DEC_1990_STF3_&-CONTEXT=qt&-tree_id=101&-all_geo_types=N&-redoLog=true&-_caller=geoselect&-geo_id=05000US37189&-geo_id=05000US37193&-search_results=01000US&-format=&-_lang=enSource for Housing Unit data:

3.2 Technical Approach

Based on the above information, nonpoint sources contribute fecal coliform to Elk Creek. Because of the size of Elk Creek, the amount of fecal coliform data, and the type of flow data available, a load duration approach has been adopted for this study. This approach determines impaired loads under different flow conditions – high flow, transition flow, typical flow, and low flow – to identify source types, specify assimilative capacity of a stream, and to estimate magnitude of load reduction required to meet the water quality standard. The methodology used to develop a load duration curve was based on Cleland (2002).

3.2.1 Endpoint for Fecal Coliform

The TMDL objectives require the instream fecal coliform concentrations to meet both the instantaneous standard of 400 cfu/100ml and the geometric mean standard of 200 cfu/100ml. Data is not collected in Elk Creek often enough to evaluate the geometric mean standard using the load duration curve approach, therefore only the instantaneous standard is used as the endpoint for the fecal coliform TMDL in the creek. An analysis of the effectiveness of the reduction on meeting the geometric mean standard is provided below in Section 3.3.3.

3.2.2 Flow Duration Curve

Development of a flow duration curve is the first step of the load duration approach. A flow duration curve employs a cumulative frequency distribution of measured daily stream flow over the period of record. The curve relates flow values measured at the monitoring station to the percent of time the flow values were equaled or exceeded. Flows are ranked from lowest, which exceed nearly 100 percent of the time, to highest, which exceed less than 1 percent of the time.

Reliability of the flow duration curve depends on the period of record available at monitoring stations. Predictability of the curve increases when longer periods of record are used. There is daily flow data available for Elk Creek from USGS Gaging Station #02111180 (see Appendix A, Figure A.1), Elk Creek at Elkville, which is in the same location that ambient monitoring data is collected. Flow statistics as generated by the curves from the estimated flow data are presented in Table 3.3.

Table 3.3. Flow Statistics for estimated Elk Creek at ambient station Q0220000

High Flow ($<10^{th}$ Percentile)	Transitional Flow (Between 10^{th} and 30^{th} Percentile)	Typical Flow (Between 30^{th} and 90^{th} Percentile)	Low Flow ($>90^{th}$ Percentile)
150 – 2950 cfs	88 – 150 cfs	21 – 88 cfs	7 – 21 cfs

The flow duration curve, shown in Figure 3.2, was used to determine the seasonality and flow regimes during which the exceedances of the pollutants occurred. It was also used to determine maximum daily pollutant load based on the flow duration and applicable standard. The applications of the flow duration curve for Elk Creek are discussed in the following paragraphs.

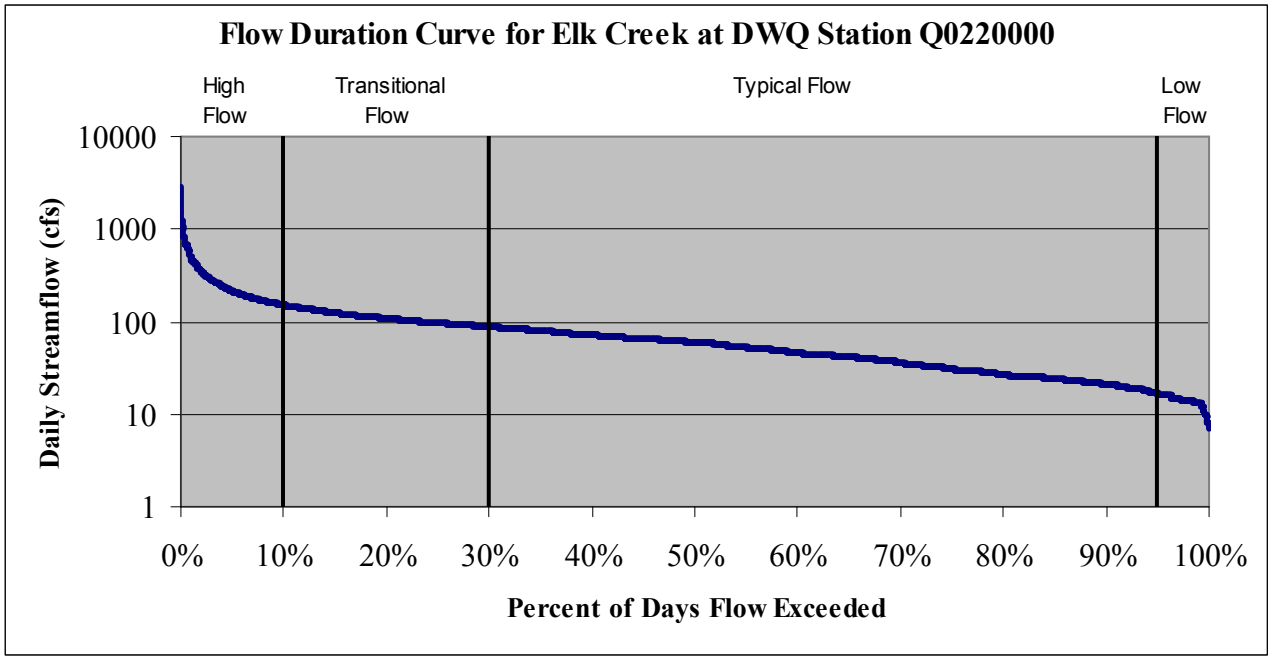

Figure 3.2. Flow Duration Curve for Elk Creek at Station Q0220000.

3.2.3 Load Duration Curve

A load duration curve is developed by multiplying the flow values along the flow duration curve by the pollutant concentrations and the appropriate conversion factors. As seen in Figure 3.3, allowable and existing loads are plotted against the flow recurrence interval. The allowable load assumes a fecal coliform concentration of 360 cfu/100ml and is based on the water quality numerical criteria, margin of safety, and flow duration curve. The target line is represented by the line drawn through the allowable load data points and hence, it determines the assimilative capacity of a stream or river under different flow conditions. Any values above the line are exceeded loads and the values below the line are acceptable loads. Therefore, a load duration curve can help define the flow regime during which exceedances occur.

The following paragraphs discuss procedures to estimate endpoints for fecal coliform in Elk Creek in order to identify assimilative capacity of the river in each flow condition and to identify the flow regime during which exceedances occur.

The fecal coliform assessment also used the load duration curve approach to determine existing load and assimilative capacity. As stated in Section 3.2.1, analysis was performed for the instantaneous standard of 400 cfu/100ml to determine the most conservative measure of impairment. Figure 3.3 presents the calculated loads and the TMDL target loadings for fecal coliform.

In Elk Creek, the criteria violations seem to have occurred at all ranges of flows, suggesting that contamination due to fecal coliform occurred during both wet and dry weather conditions.

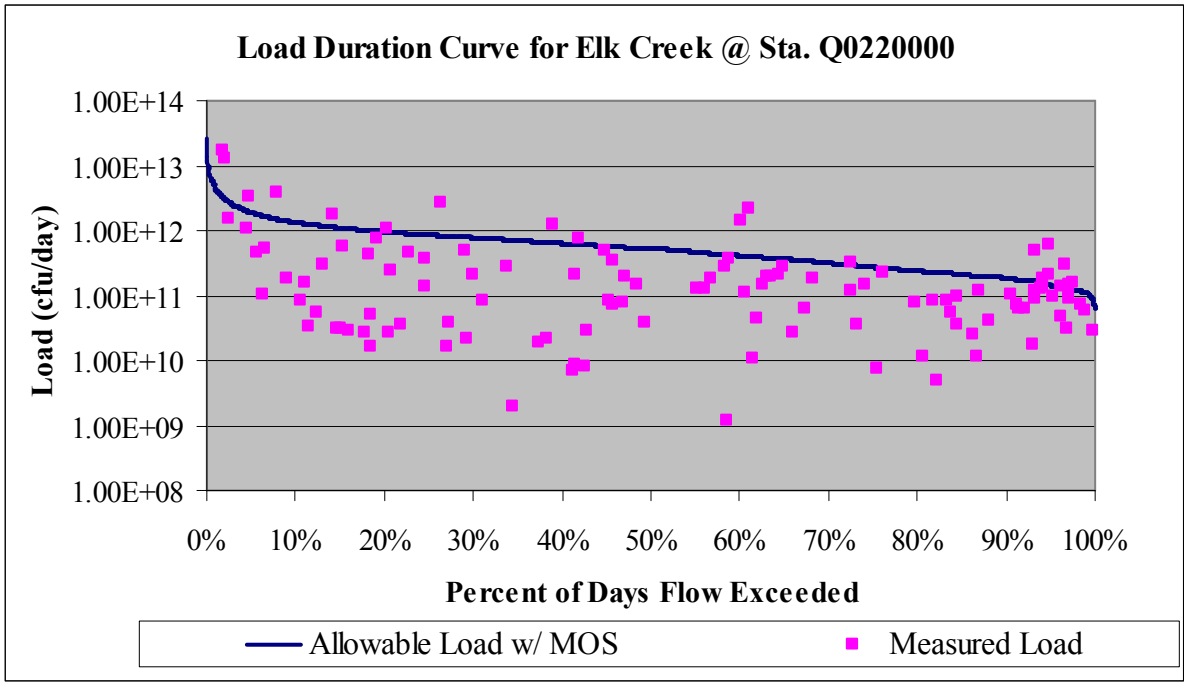

Figure 3.3. Fecal coliform load duration curve for Elk Creek at station Q0220000, from January 1997 through September 2006.

3.3 Total Maximum Daily Load (TMDL)

Section 3.2 described the processes and rationale to identify the endpoints, assimilative capacity, potential sources, and target loadings for fecal coliform bacteria in the Elk Creek watershed. These efforts formed the basis for the TMDL process. The following sections describe the key components required by the TMDL guidelines to set the final TMDL allocation for the watershed.

Total Maximum Daily Load (TMDL) can be defined as the total amount of pollutant that can be assimilated by the receiving water body while achieving water quality standards. A TMDL can be expressed as the sum of all point source allocations (WLAs), nonpoint source allocations (LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluence limitations and water quality. This definition can be expressed by equation 3.1:

$$TMDL = \sum WLAs + \sum LAs + MOS \qquad (3.1)$$

The objective of the TMDL is to estimate allowable pollutant loads and to allocate those loads in order to implement control measures and to achieve water quality standards. The Code of Federal Regulations (40 CFR § 130.2 (1)) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For fecal coliform contamination, TMDLs are expressed as counts, or colony forming units (cfu), per 100 milliliters. TMDLs represent the maximum one-day load the stream can assimilate and maintain the water quality criterion. A

load duration curve approach was utilized to estimate the TMDL for fecal coliform. The systematic procedures adopted to estimate TMDLs are described below.

3.3.1 Margin of Safety (MOS)

The MOS is included in the TMDL estimation to account for the uncertainty in the simulated relationship between the pollutants and the water quality standard. In this study, the MOS was explicitly included in following TMDL analysis by setting the TMDL target at 10 percent lower than the water quality target for fecal coliform. The water quality standard and the target can be seen in Table 3.4.

Table 3.4. Water Quality Standard and Explicit Margin of Safety.

Standard for Fecal Coliform	400 cfu/100 ml
Target with 10% MOS	360 cfu/100 ml

3.3.2 Target Reduction

The load reduction needed to meet the instantaneous fecal coliform standard was estimated with the observed data that exceeded the applicable water quality standard (400 cfu/100 ml) within the 10^{th} to 95^{th} percentile flow recurrence range.

A power curve equation for the data points violating the water quality criterion was estimated. The equation is presented in Equation 3.2.

$$Y = 4.13E11 * X^{-0.939} \quad R^2 = 0.47 \qquad (3.2)$$

Where, Y = fecal coliform (cfu/100ml) and X = Percent Flow Exceeded.

To present the TMDLs as a single value, the existing load was calculated from the power curve equation as the average of the load violations occurring when the flow exceeded at a frequency greater than 10 percent and less than 95 percent. Additionally, the average load was calculated by using percent flow exceedances in multiples of 5 percent. The allowable loadings for each exceedance were calculated from the TMDL target value, which includes the 10 percent MOS. The target curve based on the allowable load and the power curve based on the exceedances are shown in Figure 3.4.

The necessary percent reduction was calculated by taking the difference between the average of the power curve load estimates and the average of the allowable load estimates. For example, at each recurrence interval between 10 and 95 (again using recurrence intervals in multiple of 5), the equation of the power curve was used to estimate the existing load. The allowable load was then calculated in a similar fashion by substituting the allowable load curve. The estimated

values are given in Appendix Table A.2. The derivation of TMDL components is provided in Appendix Table A.3.

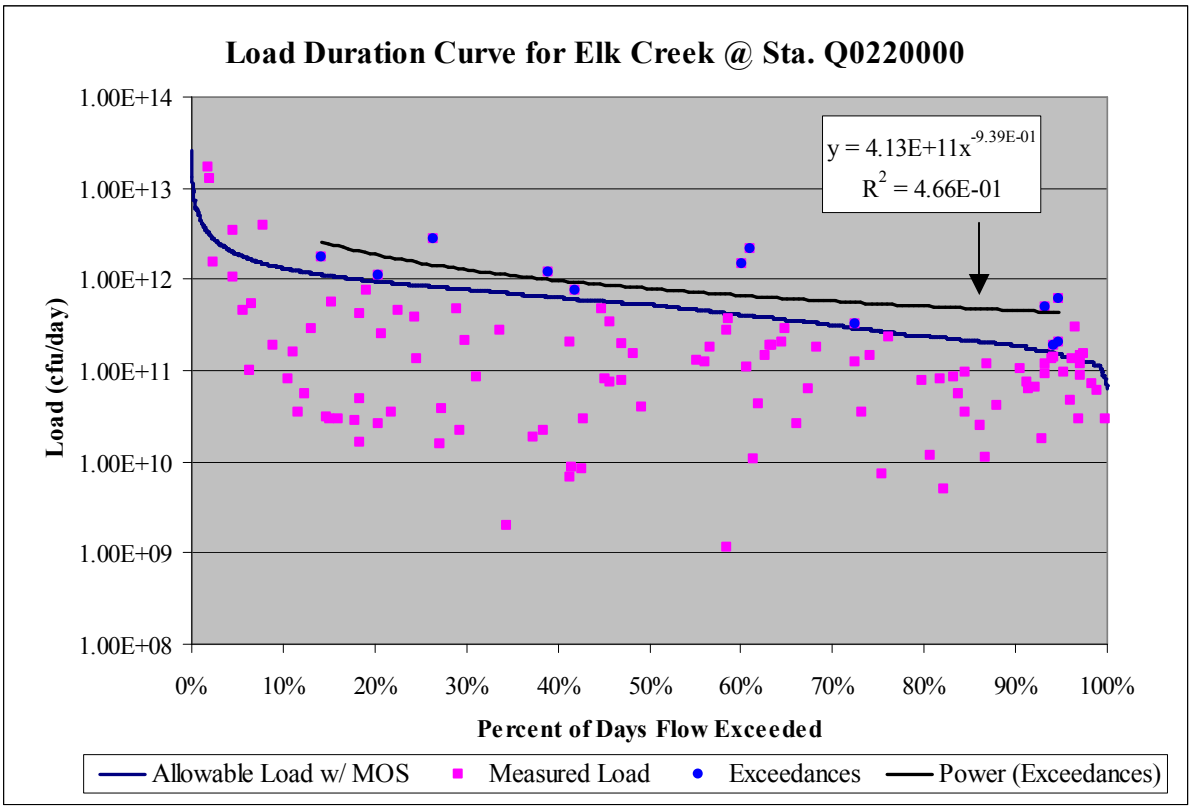

Figure 3.4. Load Duration Curve with Allowable and Estimated Exceeding Loads of Fecal Coliform in Elk Creek at station Q0220000.

3.3.3 TMDL Allocation

As identified by the above load duration curve method, a significant reduction of fecal coliform is required in Elk Creek. A summary of reductions required is provided in Table 3.5 (also, see Appendix Table A.2).

Table 3.5. Reduction required for Fecal Coliform.

Pollutant	Target with MOS	Estimated Exceeding Load	Allowable Load (TMDL-MOS)	Average Reduction Required
Fecal Coliform (cfu/day)	<360 cfu/100ml	1.08E+12	5.58E+11	48.4%

As mentioned above in Section 3.2.1, the TMDL objectives require the instream fecal coliform concentrations to meet both the instantaneous standard of 400 cfu/100ml and the geometric mean standard of 200 cfu/100ml. This analysis used the instantaneous standard as the endpoint for the fecal coliform TMDL in the creek. To verify that the required reduction will also meet the

geometric mean standard, the reduction was applied to those fecal coliform concentrations measured during the sampling to calculate the geometric mean (shown in Appendix Table A.1) and a new geometric mean was calculated. The results of this analysis are shown in Table 3.6 and indicate that the required reduction will meet the geometric mean portion of the fecal coliform standard.

Table 3.6. Verification of geometric mean portion of fecal coliform standard.

Sampling Period	Measured Geometric Mean	Geometric Mean with Reduction
June 2002	408	147
July 2002	455	154

3.3.3.1. Waste Load Allocation (WLA)

The waste load allocation for fecal coliform is 0 cfu/day.

3.3.3.2. Load Allocation (LA)

All fecal coliform loadings from nonpoint sources such as non-MS4 urban land, agriculture land, and forestlands are reported as LAs. In Elk Creek watershed, there are only nonpoint sources contributing fecal coliform to the creek. The estimated contributions of fecal coliform from the nonpoint sources are presented in Table 3.7. The estimated percent reduction from nonpoint sources is 48%, as shown in Table 3.8.

Table 3.7. Estimated TMDL and Load Allocation for Fecal Coliform for the Elk Creek Watershed.

Pollutant	Existing Load	WLA	LA	MOS	TMDL[1]
Fecal Coliform (cfu/day)	1.08E+12	0	5.58E+11	6.20E+10	6.20E+11

1. TMDL = WLA + LA + MOS

Table 3.8. Estimated Percent Reduction by Source for Fecal Coliform (shown in cfu/day) for the Elk Creek Watershed.

	WLA	LA
Existing Load (cfu/day)	0	1.08E+12
Load Allocation (cfu/day)	0	5.58E+11
Percent Reduction	0%	48.4%

3.3.4 Critical Condition and Seasonal Variation

Critical conditions are considered in the load curve analysis by using an extended period of stream flow and water quality data, and by examining the flows (percent flow exceeded) where the existing loads exceed the target line.

Seasonal variation is considered in the development of the TMDLs, because allocation applies to all seasons. According to the load duration curve (Figure 3.3), the existing load violation for fecal coliform occurred at all flow conditions throughout the year (Figure 3.4). Therefore, both dry and wet weathers are critical for fecal coliform.

4.0 Summary and Future Consideration

This report presents the development of the Fecal Coliform Total Maximum Daily Load (TMDL) for Elk Creek in the Yadkin Pee-Dee River Basin.

Available water quality data were reviewed to determine the critical periods and the sources that lead to exceedances of the standard. The necessary percent reduction to meet the TMDL requirement was then calculated by taking a difference between the average of the power curve load estimates and the average of the allowable load estimates. The summary of the results is as follows:

- About 48 percent reduction in nonpoint source contributions of fecal coliform is required in order to meet the water quality standard in Elk Creek. Nonpoint sources are responsible for the exceedance of fecal coliform standards.

4.1 Stream Monitoring

Stream monitoring should continue on a monthly interval at the existing ambient monitoring stations. The continued monitoring of fecal coliform will allow for the evaluation of progress towards the goal of reaching water quality standards by comparing the instream data to the TMDL target. In addition, the schedule for stream monitoring should be reviewed and revised to eliminate or reduce holding time violations and include evaluation of the geometric mean portion of the standard (i.e. periodically collect five samples in 30 days to calculate geometric mean).

4.2 Implementation Plan

Reductions for fecal coliform should be sought through controlling animal access to streams, identification and repair of failing septic systems, and targeting storm-driven sources.

The TMDL analysis was performed using the best data available to specify the fecal coliform reduction necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications in the watershed. A detailed implementation plan is not included in this TMDL. Local stakeholder groups, governments, and agencies are encouraged to develop a more specific implementation plan.

5.0 Public Participation

A draft of the TMDL was publicly noticed through various means. The TMDL was public noticed in the relevant counties through a local newspaper (Wilkes Journal-Patriot on December 19, 2007, see Appendix C). The TMDL was also public noticed on December 18, 2007 through the North Carolina Water Resources Research Institute email list-serve (see Appendix C).

Finally, the TMDL was available on DWQ's website (http://h2o.enr.state.nc.us/tmdl/) during the comment period. The public comment period lasted until January 31, 2008.

DWQ received no public comments on the Elk Creek TMDL.

6.0 References

Cleland, B.R. 2002. TMDL Development from the "Bottom Up" – Part II: Using load duration curves to connect the pieces. Proceedings from the WEF National TMDL Science and Policy 2002 Conference.

Hyer, Kenneth, Doughlas Moyer, and Trisha Baldwin. 2001. Bacteria Source Tracking to Improve TMDL Development in Bacteria. U.S. Geological Survey, WRD, 1730 East Parham Rd., Richmond, VA 23228. In va.water.usgs.gov/GLOBAL/posters/BST.pdf.

North Carolina Department of Agriculture (NCDA):
Wilkes: http://www.ncagr.com/stats/codata/wilkes.htm
Watauga: http://www.ncagr.com/stats/codata/watauga.htm

U.S. Environmental Protection Agency (USEPA). 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. Assessment and Watershed Protection Division, Washington, DC.

U.S. Environmental Protection Agency (USEPA) 1998. Draft Final TMDL Federal Advisory Committee Report. U.S. Environmental Protection Agency, Federal Advisory Committee (FACA). Draft final TMDL Federal Advisory Committee Report. 4/28/98.

U.S. Environmental Protection Agency (USEPA) 2000. Revisions to the Water Quality Planning and Management Regulation and Revisions to the National Pollutant Discharge Elimination System Program in Support of Revisions to the Water Quality Planning and management Regulation; Final Rule. Fed. Reg. 65:43586-43670 (July 13, 2000).

U.S. Census Bureau:
Wilkes - http://quickfacts.census.gov/qfd/states/37/37193.html
Watauga - http://quickfacts.census.gov/qfd/states/37/37189.html

U.S. Census Bureau:
http://factfinder.census.gov/servlet/QTTable?_bm=y&-context=qt&-qr_name=DEC_1990_STF3_DP5&-ds_name=DEC_1990_STF3_&-CONTEXT=qt&-tree_id=101&-all_geo_types=N&-redoLog=true&-_caller=geoselect&-geo_id=05000US37189&-geo_id=05000US37193&-search_results=01000US&-format=&-_lang=enSource for Housing Unit data:

APPENDIX A: Elk Creek Data

Table A.1. Water Quality Data for Elk Creek at Station Q0220000 (highlighted rows indicate data was collected for 5/30 testing).

Date	Instream Fecal Coliform Concentration (cfu/100mL)	Remark[1]
01/16/97	10	K
02/18/97	10	K
03/11/97	10	K
04/08/97	10	K
05/08/97	10	K
06/10/97	140	
07/09/97	130	
08/11/97	100	
09/10/97	220	
10/09/97	18	
11/13/97	45	
12/15/97	10	K
01/12/98	10	K
02/12/98	10	K
03/19/98	91	
04/30/98	23	
05/18/98	90	
06/11/98	190	
07/15/98	140	
08/10/98	280	
09/15/98	140	
10/21/98	45	
11/18/98	76	
12/10/98	160	
01/11/99	10	K
02/08/99	27	
03/23/99	10	K
04/27/99	150	
06/10/99	120	
07/08/99	100	
08/05/99	20	J
09/07/99	60	J
10/14/99	150	J
11/04/99	100	J
12/14/99	630	L
02/07/00	27	
03/23/00	45	

Date	Instream Fecal Coliform Concentration (cfu/100mL)	Remark[1]	
04/11/02	41	Q1	
05/14/02	1300	Q1	
6/4/2002	300		Geometric Mean = 408
6/11/2002	200		
6/13/2002	250		
6/18/2002	500		
6/20/2002	1500		
07/09/02	240	B4,Q1	
7/9/2002	320		Geometric Mean = 455
7/17/2002	346		
7/18/2002	400		
7/24/2002	1050		
7/25/2002	420		
08/01/02	210	Q1,B4	
09/09/02	140	Q1	
10/01/02	180	Q1	
11/14/02	17	B5,Q1	
12/09/02	12	Q1	
01/15/03	5	Q1	
02/04/03	670	Q1	
03/12/03	7	Q1	
04/24/03	48	Q1	
05/19/03	150	Q1	
06/04/03	930	Q1	
07/09/03	120	Q1	
08/12/03	190	Q1	
09/25/03	100	Q1	
10/30/03	50	Q1	
11/12/03	52	Q1	
12/01/03	18	Q1	
01/14/04	4	Q1	
03/15/04	18	Q1	
04/19/04	14	Q1	
05/13/04	440	B4,Q1	
06/22/04	1500	Q1	
07/26/04	200	Q1	
08/26/04	310	B4,Q1	

Date	Instream Fecal Coliform Concentration (cfu/100mL)	Remark[1]
04/12/00	100	
05/09/00	230	
06/12/00	210	
07/19/00	150	
08/15/00	340	A
09/12/00	240	
10/10/00	450	A
11/08/00	800	
12/27/00	82	
01/09/01	190	
02/08/01	130	
04/23/01	400	
05/07/01	130	B1,J2,Q
06/12/01	200	B1,Q
07/12/01	140	B1,Q
08/14/01	2000	Q
09/06/01	310	Q
10/09/01	120	B4,Q
11/07/01	39	Q
12/11/01	560	Q
01/10/02	8	Q1
02/20/02	40	Q1
03/07/02	1	B2,Q1

Date	Instream Fecal Coliform Concentration (cfu/100mL)	Remark[1]
09/27/04	160	Q1
10/28/04	410	Q1,B4
11/03/04	220	B4,Q1
12/14/04	6	Q1
02/01/05	17	Q1
03/03/05	57	Q1
03/31/05	22	Q1
04/20/05	95	Q1
06/01/05	300	B4,Q1
06/29/05	180	Q1
07/14/05	280	B4,Q1
08/02/05	120	Q1
08/31/05	1200	Q1
11/01/05	67	Q1
11/30/05	200	Q1
02/01/06	1	Q1
03/22/06	5	Q1
05/02/06	47	Q1
6/1/2006	190	Q1
6/27/2006	1900	Q1
7/13/2006	190	Q1
8/10/2006	90	Q1
9/12/2006	180	Q1

1. Fecal Coliform Remark Codes:
   - A Value reported is the mean (average) of two or more determinations. This code is to be used if the results of two or more discrete and separate samples are averaged. These samples shall have been processed and analyzed independently (e.g. field duplicates, different dilutions of the same sample).
   - B1 Countable membranes with less than 20 colonies. Reported value is estimated or is a total of the counts on all filters reported per 100 ml.
   - B4 Filters have counts of both >60 or 80 and <20. Reported value is a total of the counts from all countable filters reported per 100 ml.
   - B5 Too many colonies were present; too numerous to count (TNTC), the numeric value represents the maximum number of counts typically accepted on a filter membrane (60 for fecal and 80 for total), multiplied by 100 and then divided by the smallest filtration volume analyzed. This number is reported as a greater than value.
   - J Estimated value; value may not be accurate.
   - J2 Estimated value; value may not be accurate. The reported value failed to meet the established quality control criteria for either precision or accuracy.
   - K Actual value is known to be less than value given
   - L Actual value is known to be greater than value given
   - Q Holding time exceeded.
   - Q1 Holding time exceeded. Holding time exceeded prior to receipt by lab.

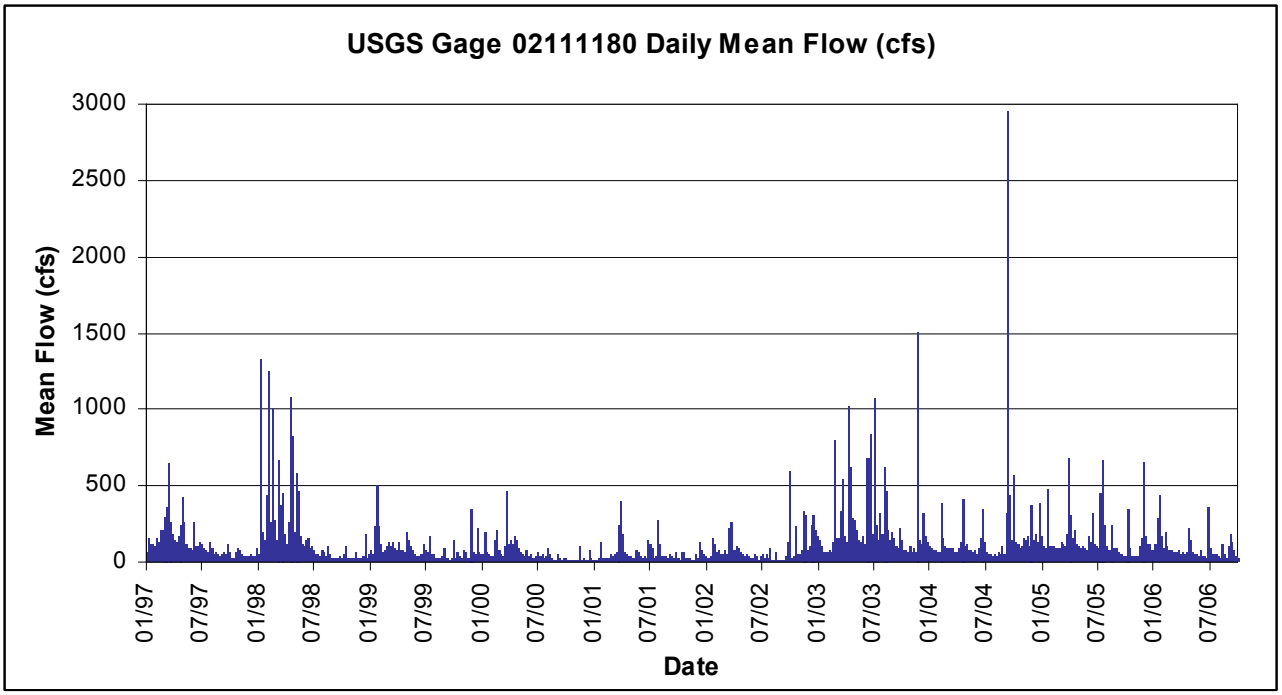

Figure A.1. Daily average flow (cfs) measured at USGS Gage 02111180.

Table A.2. Estimation of Load Reduction Required in Fecal Coliform for Elk Creek at Station Q0220000.

% Flow Exceeded	Flow (cfs)	Estimated Exceedance Load (cfu/day)	TMDL not including MOS (cfu/day)
10%	150.0	3.59E+12	1.32E+12
15%	124.0	2.45E+12	1.09E+12
20%	109.0	1.87E+12	9.60E+11
25%	97.0	1.52E+12	8.54E+11
30%	88.0	1.28E+12	7.75E+11
35%	80.0	1.11E+12	7.05E+11
40%	71.0	9.76E+11	6.25E+11
45%	65.0	8.74E+11	5.72E+11
50%	60.0	7.92E+11	5.28E+11
55%	53.0	7.24E+11	4.67E+11
60%	46.0	6.67E+11	4.05E+11
65%	41.0	6.19E+11	3.61E+11
70%	36.0	5.77E+11	3.17E+11
75%	31.0	5.41E+11	2.73E+11
80%	27.0	5.09E+11	2.38E+11
85%	24.0	4.81E+11	2.11E+11
90%	21.0	4.56E+11	1.85E+11
95%	16.9	4.33E+11	1.49E+11
	Average	1.08E+12	5.58E+11
		Avg. Reduction Required	**48.4%**

Table A.3. Derivation of TMDL Components

% Flow Exceeded	MOS	WLA	LA	TMDL (including MOS)
10.0%	1.47E+11	0	1.32E+12	1.47E+12
15.0%	1.21E+11	0	1.09E+12	1.21E+12
20.0%	1.07E+11	0	9.60E+11	1.07E+12
25.0%	9.49E+10	0	8.54E+11	9.49E+11
30.0%	8.61E+10	0	7.75E+11	8.61E+11
35.0%	7.83E+10	0	7.05E+11	7.83E+11
40.0%	6.95E+10	0	6.25E+11	6.95E+11
45.0%	6.36E+10	0	5.72E+11	6.36E+11
50.0%	5.87E+10	0	5.28E+11	5.87E+11
55.0%	5.19E+10	0	4.67E+11	5.19E+11
60.0%	4.50E+10	0	4.05E+11	4.50E+11
65.0%	4.01E+10	0	3.61E+11	4.01E+11
70.0%	3.52E+10	0	3.17E+11	3.52E+11
75.0%	3.03E+10	0	2.73E+11	3.03E+11
80.0%	2.64E+10	0	2.38E+11	2.64E+11
85.0%	2.35E+10	0	2.11E+11	2.35E+11
90.0%	2.06E+10	0	1.85E+11	2.06E+11
95.0%	1.66E+10	0	1.49E+11	1.66E+11
Average	**6.20E+10**	**0**	**5.58E+11**	**6.20E+11**

APPENDIX B. Wilkes Soil & Water Conservation District Questionnaire

TMDL QUESTIONAIRE –Wilkes County (Elk Creek Watershed)

Estimated Livestock Population

The North Carolina Department of Agriculture (NCDA) regularly performs an agricultural census for each county of the state. Can you estimate what percentage of the county population is found within the Elk Creek watershed? Please enter any available estimates in the table below.

Livestock	Date data is valid from	Wilkes	% in Elk Creek watershed
Cattle All	Jan 1, 2007	32,000	1.5%
Beef Cows	Jan 1, 2007	15,100	1%
Milk Cows	Jan 1, 2007	1,300	0%
Broilers Produced	2006	91,700,000	0%
Chickens, excluding broilers	Dec. 1, 2006	1,050,000	0%
Source: Wilkes: http://www.ncagr.com/stats/codata/wilkes.htm			

Stream Access

1. Do beef cattle have access to streams? Yes or No (circle correct answer)
    a. Could you approximate the percentage beef cattle having stream access within the watershed? __**75%**_____
2. Do horses have access to streams? Yes or No (circle correct answer)
    a. Could you approximate the percentage horses having stream access within the watershed? ___**80%**_____
3. Are hogs confined or do they have limited stream access? _____N/A_____
4. Percent of beef cows with access to forested areas __30%_____
5. Do you have any estimate on the deer population? ___35_____ per square mile

Manure Application

6. Is manure from beef cattle, dairy cattle, swine, poultry, sheep, or horses collected and applied to agricultural lands? Yes or No (circle correct answer)

Manure occurs in the field. Chicken litter from other areas of Wilkes Co. is most likely applied to the majority of the fields, at unknown application rates.

7. If answer to #6 is yes, can you approximate the percentage of livestock manure that is collected and applied to agricultural land? Example: 30 percent swine, 100 percent dairy cattle, and 100 percent poultry are collected and applied.

Animal Type	Percent Collected and applied
Beef Cattle	
Dairy Cattle	
Swine	
Poultry	
Sheep	
Horses	

8. Is manure imported into the county? Yes or No (circle correct answer)

9. Are there any confined poultry operations? Yes or No (circle correct answer)

   a. How do they manage their poultry litter?

   b. Where (and how, and when) do they land apply?

      Land application of chicken litter probably occurs. It most likely originates from other areas of Wilkes.

   c. If so, is data available to calculate the loading rates? Yes or No (circle correct answer)

      What are the rates if known? _____

10. Dairy cattle are assumed to be confined 40 percent of the time and grazing 60 percent. Dairy cattle are assumed not to have access to streams. Is this a correct assumption? Yes or No (circle correct answer)

N/A

   a. How is the liquid residual from cleaning barns after milking disposed of?

   b. It could be assumed that the majority of the operation's parlor waste is collected with the waste system. If this is a significant amount available for runoff, please indicate.

Septic System Contribution

11. What do you estimate the septic system failure rate in your county to be? __25%_____ EPA assumes 20 percent.

APPENDIX C. Public Notification of TMDL for Fecal Coliform for Elk Creek

Subject: [wrri-news] PUBLIC NOTICE: Elk Creek TMDL for Fecal Coliform
From: "Kelly Porter" <kaporter@gw.fis.ncsu.edu>
Date: Tue, 18 Dec 2007 12:42:32 -0500
To: <wrri-news@lists.ncsu.edu>

PUBLIC NOTICE: Elk Creek TMDL for Fecal Coliform

Now Available Upon Request –
Total Maximum Daily Load (TMDL) for Fecal Coliform for Elk Creek (Yadkin-Pee Dee River Basin) in North Carolina is now available upon request from the North Carolina Division of Water Quality. This TMDL study was prepared as a requirement of the Federal Water Pollution Control Act, Section 303(d). The study identifies the sources of the pollutants, determines allowable loads to surface waters, and suggests fecal coliform allocations for Elk Creek.

TO OBTAIN A FREE COPY OF THE TMDL REPORT:
Please contact Ms. Linda Chavis (919) 733-5083, extension 558 or write to:
Ms. Linda Chavis
Water Quality Planning Section
1617 Mail Service Center
Raleigh, NC 27699

Interested parties are invited to comment on the draft TMDL study by January 31, 2008. Comments concerning the report should be directed to Pam Behm at the above address. The draft TMDL is also located on the following website: http://h2o.enr.state.nc.us/tmdl.

Publisher's Affidavit

State of North Carolina, Wilkes County.

Personally appeared before me the Undersigned JULIUS C. HUBBARD, JR. and/or JOHN W. HUBBARD Co-Publishers of WILKES JOURNAL-PATRIOT, a public newspaper of general circulation, printed and published in North Wilkesboro, in the county aforesaid who, being duly sworn, upon his oath, sayeth that the notice of which the attached is a true copy, was duly published in said paper for 1 insertions successively, the first of which publication was on the 19th day of December 20 07 and the last on the _____ day of _____ 20_____.

Publication Fee $ 12.60

John W. Hubbard
Co-Publisher of Wilkes Journal-Patriot

Subscribed and sworn to before me January 3rd 20 08

Nicole Eller
Notary Public

My Commission expires My Commission Expires 10-03-2009

NICOLE ELLER
Notary Public
WILKES COUNTY, NC

PUBLIC NOTICE
State of North Carolina
Division of Water Quality
Availability of the Total Maximum Daily Load (TMDL) for Fecal Coliform for Elk Creek in North Carolina.
Copies of the TMDL are available may be obtained by calling Linda Chavis at 919-733-5083, ext. 558 or on the internet at http://h2o.enr.state.nc.us/tmdl. Written comments regarding this TMDL will be accepted until January 31, 2008. Please mail comments to NCDWQ Planning Section, Attn: Pam Behm, 1617 Mail Service Center, Raleigh, NC 27699.
12-19-1t(W)