Total Maximum Daily Loads for Turbidity and Fecal Coliform for East Fork Deep River, North Carolina

[Waterbody ID 17-2-(0.3) and
Waterbody ID 17-2-(0.7)]

Final Report

February 2004

(Approved March 2004)

Cape Fear River Basin

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SUMMARY SHEET

Total Maximum Daily Load (TMDL)

1. 303(d) Listed Waterbody Information

State: North Carolina

County: Guilford

Major River Basin: Cape Fear River Basin

Watershed: East Fork Deep River – in Deep River Watershed HUC 03030003

Impaired Waterbody (2000 303(d) List):

Waterbody Name - (ID)	Water Quality Classification	Impairment	Length (mi)
East Fork Deep River - 17-2-(0.3)	WS-IV - Aquatic life and secondary contact recreation	Fecal Coliform	6.5
East Fork Deep River - 17-2-(0.3)	WS-IV - Aquatic life and secondary contact recreation	Turbidity	6.5
East Fork Deep River - 17-2-(0.7)	WS-IV CA - Aquatic life and secondary contact recreation	Turbidity	0.6

Constituent(s) of Concern: Fecal Coliform Bacteria, Turbidity

Designated Uses: Biological integrity, propagation of aquatic life, and recreation.

Applicable Water Quality Standards for Class C Waters:

Fecal coliforms shall not exceed a geometric mean of 200/100ml (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.

Turbidity: not to exceed 50 NTU

2. TMDL Development

Analysis/Modeling:

Load duration curves 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 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 for in the load curve analysis by determining the average difference between the existing load violation trend line and the allowable load line. This approach was chosen because existing load violations occur at all flow levels.

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.

3. Allocation Watershed/Stream Reach

Pollutant	Existing	WLA[1]	LA	MOS[2]	TMDL	Reduction Required
TSS (lb/day) [3]	2,564.6	77.9	895.4	Explicit 10%	973.3	62%
Fecal coliform (counts/day)	$7.3x10^{11}$	$9.2x10^{10}$	$8.8x10^{10}$	Explicit 10%	$1.8x10^{11}$	75%

Notes:

WLA = wasteload allocation, LA = load allocation, MOS = margin of safety

1. WLA = TMDL – LA - MOS; where TMDL is the average allowable load between the 95th

and 10th percent flow exceeded.

2. Margin of safety (MOS) equivalent to 10 percent of the target concentration for fecal coliform and turbidity.

3. Turbidity is not a concentration and, as a measure, cannot be directly converted into loadings required for the TMDL. Total suspended solids (TSS) was therefore selected as the surrogate measure for turbidity and used to develop the TMDL target and limits (USEPA 1999).

4. Public Notice Date: 12/10/2003

5. Submittal Date: 2/13/2004

6. Establishment Date: 3/4/2004

7. Endangered Species (yes or blank):

8. EPA Lead on TMDL (EPA or blank):

9. TMDL Considers Point Source, Nonpoint Source, or both: both

1 Introduction

This report presents the development of Total Maximum Daily Loads (TMDLs) for fecal coliform and turbidity impairments of the East Fork Deep River. The East Fork of the Deep River near Greensboro, North Carolina has been placed on the North Carolina 2002 list of impaired waters (the 303(d) list) and requires estimation of a Total Maximum Daily Load for turbidity and fecal coliform in order to meet the water quality standards specified for WS-IV and WS-IV CA waters. The East Fork Deep River is a headwater tributary to the Deep River and is located entirely within Guilford County, North Carolina (Figure 1) and drains an area of approximately 14.8 square miles.

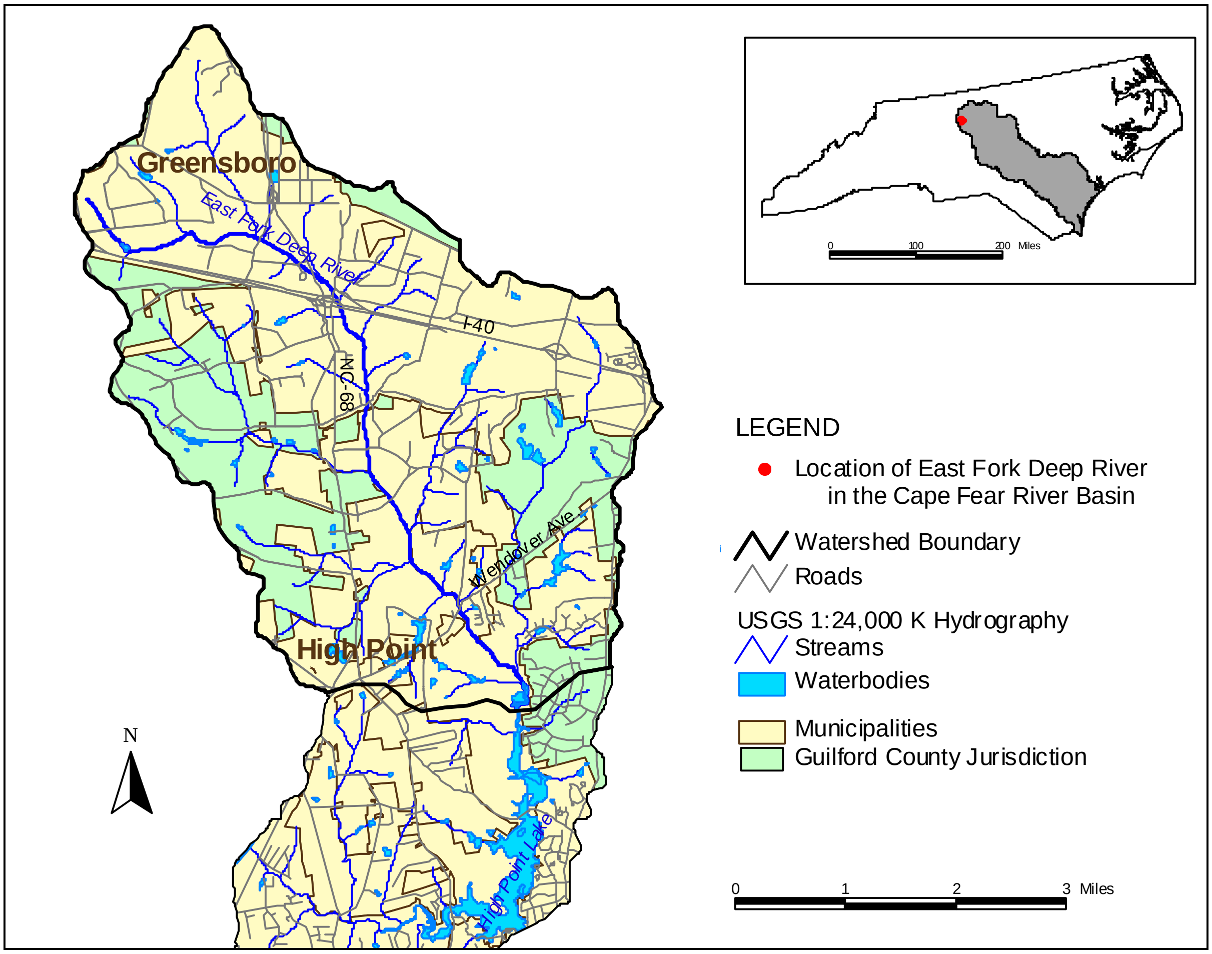

Figure 1. Location of East Fork Deep River

1.1 PROBLEM DEFINITION

Section 303(d) of the Clean Water Act (CWA) requires states to develop a list of waters not meeting water quality standards or which have impaired uses. This list, referred to as the 303(d) list, is submitted biennially to the U.S. Environmental Protection Agency (EPA) for review. Development of a TMDL requires an assessment of the assimilative capacity of the stream, assessment of the sources within the watershed contributing to the total instream load, and a recommendation of the reductions required from each source.

1.1.1 TMDL Components

The 303(d) process requires that a Total Maximum Daily Load (TMDL) be developed for each of the waters appearing on Part I of the 303(d) list. The objective of a TMDL is to estimate allowable pollutant loads and allocate 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 EPA (1991, 2000) and the Federal Advisory Committee (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.

Reduction target. Estimation of the level of pollutant reduction needed to achieve water quality goal. The level of pollution should be characterized for the waterbody, 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 wasteload 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 non-point sources, stormwater, and natural background.

Margin of Safety. The margin of safety addresses uncertainties associated with pollutant loads, modeling techniques, and data collection. Per EPA (2000), 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 and the Water Quality Planning and Management regulation (USEPA, 2000) require EPA to review all TMDLs for approval or disapproval. Once EPA approves a TMDL, then the waterbody may be moved to Category 4a of the Integrated Report. Waterbodies remain in Category 4a until compliance with water quality standards is achieved. Where conditions are not appropriate for the development of a TMDL, management strategies may still result in the restoration of water quality.

1.1.2 East Fork Deep River Turbidity and Fecal Coliform Impairments

The State of North Carolina has identified the segment within the East Fork Deep River watershed as being impaired by fecal coliform and turbidity. The listings are contained in the *North Carolina Water Quality Assessment and Impaired Waters List (2002 Integrated 305(b) and 303(d) Report).* The East Fork of the Deep River near Greensboro, North Carolina has been placed on the North Carolina 2002 list of impaired waters (the 303(d) list) and requires estimation of a Total Maximum Daily Load for turbidity and fecal coliform in order to meet the water quality standards specified for a WS-IV water. The segments of East Fork considered to be impaired due to turbidity [Waterbody ID 17-2-(0.3) and 17-2-(0.7)] extend 7.1 miles from the headwaters down to the inlet for High Point Lake (Figure 2). The fecal coliform impairment extends for 6.5 miles from the headwaters to a point 0.4 miles downstream of SR-1541 [Waterbody ID 17-2-(0.3)].

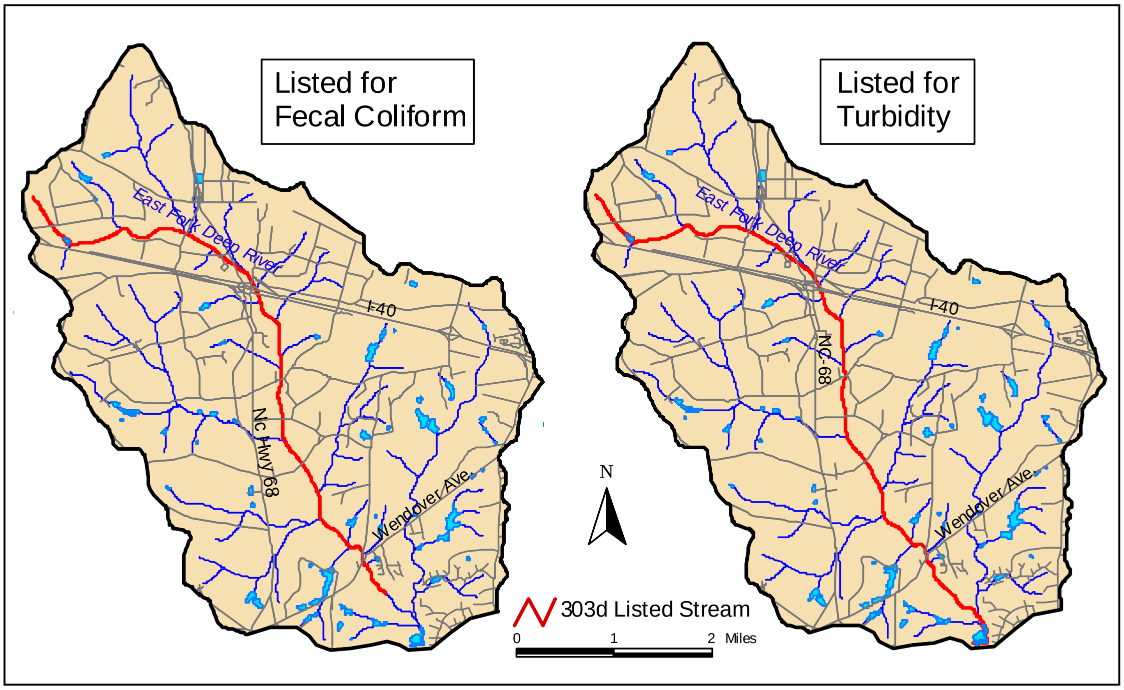

Figure 2. Extent of Fecal Coliform and Turbidity Listed Segments

The East Fork Deep River has a designated use classification of WS-IV which is intended to protect drinking water supplies. This designation also encompasses the more general Class C requirements that protect aquatic life and secondary contact recreation (NCDENR, 2003). The North Carolina fresh water quality standard for fecal coliform in Class C waters (T15A:02B.0211) states:

> Organisms of the coliform group: fecal coliforms 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; 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 will be used as the reference method.

The North Carolina water quality standard for turbidity is stated as follows:

> The turbidity in the receiving water shall not exceed 50 Nephelometric Turbidity Units (NTU) in streams not designated as trout waters.

1.2 WATERSHED DESCRIPTION

The East Fork Deep River is located entirely within Guilford County, North Carolina (Figure 1). The East Fork extends 7.1 miles from its headwaters in western Greensboro to its entrance into High Point reservoir and includes approximately 18 miles of mainstem and tributary stream reaches. The river drains approximately 14.8 square miles of land, including sections of the cities of Greensboro and High Point.

1.2.1 Landuse Distribution in the East Fork Deep River Watershed

The Multi-Resolution Landuse Classification (EPA, 2000) dataset was used to determine the landuse distribution within the watershed. This dataset was developed using satellite data collected during the period from 1992 – 1993. As shown in Table 1, agricultural and forested areas dominate the landuse. However, significant development has occurred in the watershed in recent years and resulted in conversion of large rural parcels into residential and commercial areas. In Figure 3, the 1995 Greensboro planimetric data and a recent High Point buildings coverage overlays the MRLC landuse, providing a more accurate view of the development in the watershed. Informal windshield surveys in the watershed indicate that urbanization has continued since the Greensboro and High Point data were collected.

Conversion of rural areas to urban landuses, including highways, can be a significant source of sediment during the construction phase. In addition, the higher imperviousness of the new landuse increases urban runoff volumes and results in erosion of surface soils and stream channels. The conversion of rural landuses will shift the nonpoint source contribution of fecal coliform from agricultural activities such as cattle grazing and manure application to urban sources such as fecal waste from household pets, sanitary-sewer overflows (SSOs), and leaking sewer lines.

The population density within the watershed grew from 166 people per square mile to about 340 people per square mile between 1990 and 2000 (U.S. Census, 1990 and 2000). As residential and commercial areas grew, the High Point and Greensboro municipal boundaries were expanded, new sewer lines were added, and septic systems were phased out. It is likely that a majority of the households now have sewer service; a review of the 1995 Guilford County Atlas shows that the entire watershed lies within either the existing or proposed sewer service areas.

Table 1. East Fork Watershed MRLC Landuse Acreage and Percent Composition

Landuse	Barren	Agriculture	Pasture	Forest	Urban	Water/ Wetland	Total
Area (ac)	13	3,507	682	4014	1158	0	9,479
Area (%)	0.1	37.0	7.2	42.4	12.2	1.1	100

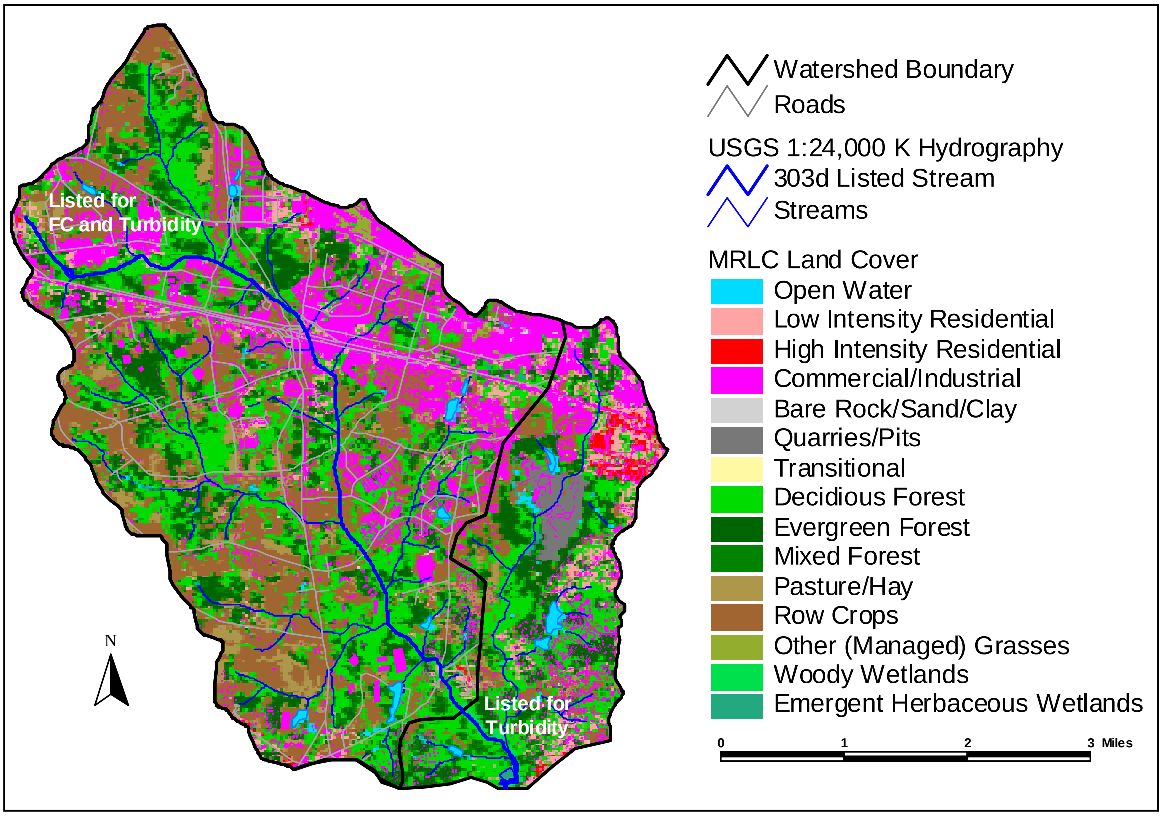

Figure 3. East Fork Deep River MRLC Landuse Overlaid with Greensboro and High Point Planimetric Data

1.3 WATER QUALITY MONITORING

Water quality monitoring performed by NCDENR for turbidity and fecal coliform have shown occasional excursions above the water quality standard. Additional fecal coliform monitoring data, collected by the Piedmont-Triad Council of Governments (PTCOG), further supports the decision to list the East Fork Deep River for fecal coliform impairment.

1.3.1 NCDENR Monitoring

Water quality monitoring for the East Fork was performed by NCDENR at Station B424000 near Wendover Avenue (Figure 4). Regular monitoring was performed for the period from 1/23/1997 through 9/18/2001. These data were collected approximately monthly and include observations for fecal coliform, turbidity, total residue, specific conductance, and total suspended solids. Additional intensive fecal coliform monitoring was performed during the period from 4/4/2002 through 5/16/2002 to assess the impairment status with regards to the standards specification requiring five samples per 30-day period. Table 2 presents a summary of the fecal coliform and turbidity data collected. It should be noted that the exceedance count does not consider the requirement that five samples must be taken within a 30-day period.

Table 2. Summary of NCDENR Water Quality Monitoring for Turbidity and Fecal Coliform Impairment

Parameter	Period	Number of Samples	Number greater than standard
Turbidity	1/97 – 9/02	63	7 [a]
Fecal coliform	1/97 – 9/02	57	9 [b]
Fecal coliform	4/02 – 5/02	10	2 [b]
Fecal coliform	4/02 – 5/02	4	2 [c]

[a] Turbidity measurements > 50 NTU
[b] Instantaneous fecal coliform measurements > 400 cfu/100 mL
[c] 30-day Geometric mean of fecal coliform measurements > 200 cfu/100 mL

1.3.2 PTCOG Fecal Monitoring Data

The Piedmont Triad Council of Governments (PTCOG) also undertook monitoring from 4/9/01 through 1/16/03 in the East Fork watershed to assess fecal coliform impairment and to identify potential sources. A summary of the monitoring efforts and conclusions are presented in *Identification of Fecal Coliform Bacteria Sources for North Carolina 303(d) Listed Waters in Greensboro and High Point* (PTCOG, 2003). A formal Quality Assurance Program Plan, included with the report, was submitted to NCDENR to provide the quality-control documentation required for the data to be accepted as "certified." Fecal coliform data were collected at five primary and twenty-one secondary watershed stations (Figure 4). A summary of the data collected in the East Fork watershed as part of the PTCOG study is presented in Table 3. It should be noted that the exceedance count includes all data collected and does not consider the requirement that five samples must be taken within a 30-day period.

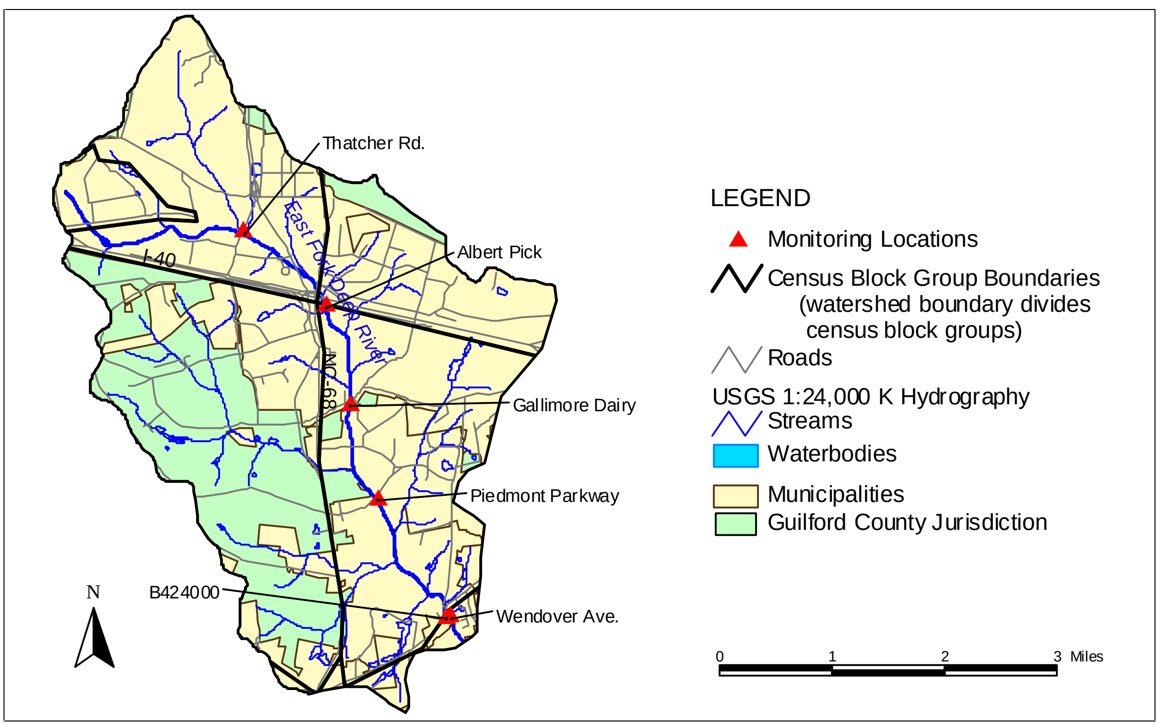

Figure 4. NCDENR and PTCOG Monitoring Locations

Table 3. Summary of PTCOG Fecal Coliform Monitoring Data

Station	Number of Samples	Number Greater Than Standard [a]
Thatcher Road - Primary Station	36	6
Thatcher Road - All Stations	9	8
Albert Pick - Primary Station	39	14
Albert Pick - All Stations	32	22
Gallimore Dairy - Primary Station	34	14
Gallimore Dairy - All Stations	24	13
Piedmont Parkway - Primary Station	30	6
Wendover Avenue - Primary Station	35	5

[a] Instantaneous fecal coliform measurements > 400 cfu/100 mL

Data collected at the PTCOG water quality monitoring stations during 2002 show an increase in fecal coliform concentrations during storm events (Figure 5). However, occasional exceedances during typical and low flow periods indicate that intermittent, direct contributions of fecal coliform are likely to contribute to instream impairment. Analysis of the data shows a high correlation between fecal coliform concentrations at each station. This result is not surprising as the flow from each segment contributes to the total flow in the downstream reach. It does, however, show that the fecal coliform concentration in each reach is highly dependent on the upstream contributions and also shows that problems in the headwaters (e.g., Albert Pick, Gallimore Dairy) may contribute to elevated levels in all the reaches.

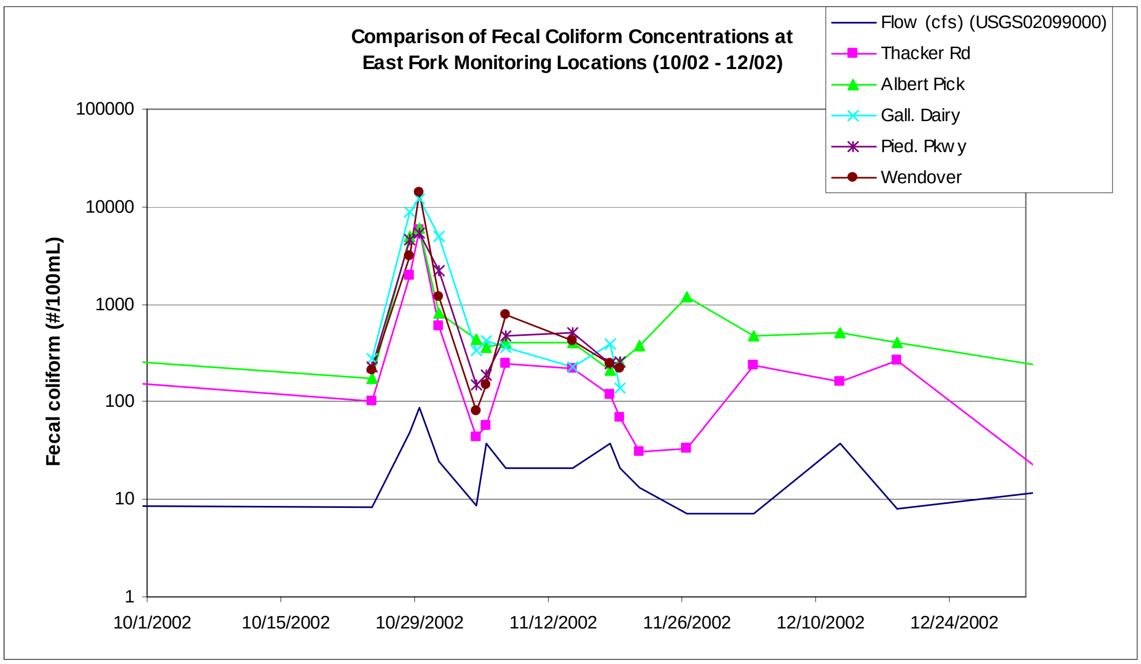

Figure 5. PTCOG High Flow Period Fecal Coliform Monitoring Data (10/1/02 – 12/31/02)

2 Source Assessment

A critical step in developing a useful and defensible TMDL is the assessment of potential sources. A watershed-wide review was performed to assess sources that potentially contribute to high turbidity and fecal coliform loading. This review included data from the National Pollutant Discharge Elimination System, septic use and public sewer boundaries, and landuse/landcover information. Geographical information systems and digital orthophotos were used to gain an understanding of the sources within the watershed. Discussion with local jurisdictions and field personnel were also used to identify and quantify potential sources. A study by the Piedmont Triad Council of Governments was recently completed, which aided significantly in the understanding of the potential sources in the watershed.

2.1 General Sources of Turbidity

2.1.1 Nonpoint Sources of Turbidity

Both point and nonpoint sources may contribute to turbidity in waterbodies. Potential sources of turbidity include silt and clay from watershed and stream erosion, organic components from detritus, and algal matter. In rural areas, runoff can transport significant loads of sediment from natural sources and agricultural activities. Construction activities in developing areas and stormwater runoff from urban areas are also significant contributors of sediment washoff. A landuse map of the East Fork Deep River watershed is presented in Figure 3. In the early 1990's when the landuse data was developed, the predominant landuses were forest and agriculture, 42 percent and 37 percent respectively. In recent years much of the rural area has been converted to urban residential and commercial landuses.

Rural Sources

Turbidity loading from rural sources is primarily due to erosion of soil from forest and agricultural areas. Although forest runoff in general produces little to no sediment load, forest-disturbing activities such as tree harvesting, site preparation, and reforesting can have high loading rates. A review of active harvesting may provide information on the extent of the contributions from this landuse.

Nonpoint source contamination from agriculture originates primarily from storm event runoff. A number of factors influence the extent of erosion including erodability of the soils, types of agricultural practices, crop type, rainfall, and the existence and type of agricultural BMPs.

Urban Runoff and Stream Channel Erosion

Significant development has been occurring in the East Fork watershed. This usually results in a decrease in low-flow volumes and an increase in high-flow volumes. These changes are caused by the shift of landuse in the watershed from pervious land such as forest to more impervious areas such as roads, driveways, and parking lots. As imperviousness increases, there is less opportunity for infiltration into the soil layer causing reduced groundwater recharge and resulting baseflow volumes. Highly impervious areas also reduce the time of concentration and increase peak flow and velocity. A large fraction of the rainfall during a storm event is infiltrated in the soil in naturally vegetated areas. As the impervious area increases, rainfall events produce high intensity, short duration runoff events which increase the potential for erosion and are capable of transporting higher amounts of sediment from the watershed to the stream.

The increase in peak flow and velocity results in an increase in bank failure, which is frequently a more important source of total sediment in urban streams than sediment from upland areas. Bank erosion is, however, difficult to quantify on a watershed scale. During a high-volume storm, discharge increases and the stream becomes deeper as it fills its banks. When the water level in the stream is at the top of the bank, the flow is termed *bankfull discharge*. Streams have tremendous erosive power at this stage, and flows that form new channels are often associated with discharges greater than bankfull. In undisturbed watersheds, flows in excess of bankfull spill over into the floodplain, and high-energy flows are dissipated over a larger area. As a result, velocity, shear stress, and erosive power decline dramatically.

In more urbanized watersheds, stream incision often prevents access to the floodplain, and streams are unable to dissipate their energy during high-flow events. Stream bank failure is common in urban systems where stream hydrographs have been altered due to an increase in impervious cover. Removal of riparian trees during development exacerbates the problem by decreasing stability provided by root systems.

Construction

According to the Greensboro Sediment and Erosion Control department, construction is the major source of sediment in the watershed (Cook, 2003). Land clearing and site preparation for the development of residential buildings, commercial areas, roads, and highways increase the erosion potential of soils. Vegetative cover is lost and the soil surface is often disturbed allowing for greater exposure to rainfall and greater chance of rill and gully erosion. Soil loss rates from construction sites can be many times higher than natural sites when erosion controls are not required or correctly maintained.

2.1.2 Point Source Turbidity Contributions

Urban stormwater runoff can contribute significant amounts of turbidity to the East Fork. However, much of this runoff is regulated in compliance with the NPDES Storm Water Phase I and Phase II progam (EPA, 2000). This rule applies to a unit of government such as a city or county, which owns or operates a municipal separate storm sewer system (MS4). The MS4 is required to obtain a National Point Source Discharge Elimination System (NPDES) permit for their stormwater discharges to surface waters. As such, stormwater runoff from areas within an MS4 is considered a point source. The City of Greensboro, City of High Point, and Guilford County fall under the NPDES stormwater rules and therefore maintain a stormwater management programs. There are no continuous point sources in the watershed with NPDES permit limits for turbidity or TSS.

2.2 General Sources of Fecal Coliform

Both point and nonpoint sources may contribute fecal coliform to the waterbodies. Potential sources of fecal coliform loading are numerous and often occur in combination. In rural areas, runoff can transport significant loads of fecal coliform from agricultural activities. Septic systems, illicit discharges, and broken sewer pipes can be potential sources in urban areas.

Potential sources of fecal coliform loading in the watershed were identified based on an evaluation of current landuse/cover, septic system/sewer use, and SSO data. The source assessment was used as the basis of development of the model and ultimate analysis of the TMDL allocations.

2.2.1 Nonpoint Source Fecal Coliform Contributions

Research was performed to assess the most probable nonpoint sources of fecal coliform. Information on sources was gathered from GIS information, census data, and personal communication with local and state officials. The principal sources investigated were sewer overflows, landuse distribution, septic systems, sewer pipe defects, and the populations of wildlife and domestic animals.

Landuse Contributions

Runoff from landuses in the watershed can be a significant contributor to fecal coliform loadings to streams. Stormwater runoff carries wildlife and domestic animal feces into surface water. Agricultural land near streams contributes fecal coliform from livestock and the land application of manure. Runoff from urban surface is also a potentially significant source of fecal coliform loadings.

A landuse map of the East Fork Deep River watershed is presented in Figure 3. In the early 1990s when the landuse data was developed, the predominant landuses were forest and agriculture, 42 percent and 37 percent respectively. In recent years much of the rural area has been converted to urban land such as residential and commercial landuses. The Greensboro and High Point planimetric data is overlayed with the landuse data in Figure 3 to show more recent development.

From inspection of the landuse figure, it is apparent that forest dominates the streamside contribution to the system. Forest surrounds the downstream portion of the East Fork, especially from Piedmont Parkway to the outlet. In this portion of the watershed, wildlife feces in runoff may be a frequent cause of fecal coliform loading. Row crop landuses and some pasture also exist alongside streams in the watershed. These landuses contribute fecal coliform from livestock and manure application. Residential areas are dispersed throughout the watershed, but several housing developments exist near the stream between Piedmont Parkway and Wendover Avenue. These developments probably contribute some fecal coliform from family pets.

According to the monitoring data, fecal coliform exceedances in the East Fork Deep River occurred most often during high flow events. Where fecal coliform is not directly attributed to SSOs, it is likely that a combination of urban runoff and animal populations has caused the fecal coliform exceedances.

Septic Systems

Septic tanks were considered a potential source of fecal coliform to the streams during low flow events. The 1990 census and digitized Greensboro sewer lines were used to assess the remaining number of septic tanks in the watershed[1]. The census block groups divide the watershed into four portions defined by the intersection of Interstate 40 and State Highway 68: Northwest, Southwest, Northeast, and Southeast. Table 4 summarizes the population densities and housing units served by either septic systems or sewer service in each of the four quadrants.

Table 4. 1990 and 2000 Census Data for Sewage Disposal by Housing Unit (HU) and Population Density for the East Fork Deep River

	Sewer 1990 (HU/mi^2)	Septic 1990 (HU/mi^2)	Population Density 1990 (persons/mi^2)	Population Density 2000 (persons/mi^2)
Northwest	<6	6-256	64-166	134
Southwest	6	45	141	301
Northeast	160	13	275	378
Southeast	90	38	224	339

A large percentage of the Northwest portion had the lowest density of housing units using septic tanks in 1990. The recent Greensboro sewer lines extend throughout this area, suggesting that most residential areas are using the sewer system or are in the process of converting. In the City of Greensboro, residents are required to switch from septic to sewer systems within 5 years of the sewer line extension. Houses with defective septic tanks may be required to connect immediately, while elderly or low-income residents may be given more time to connect (Peacock, 2003). However, in one census block group in the Northwest portion, a reported value of 256 septic tanks per square mile was given. It is likely that this high number actually reflects the more rural parts of the census block group and not the small section in this watershed.

[1] The 2000 Census did not collect information on sewage disposal.

The Eastern portions of the watershed have the highest population density. The majority of housing units were connected to the sewer system in 1990, and more households have probably converted from septic to sewer disposal over the last decade. Therefore, septic tanks are an unlikely source in the Eastern half of the watershed.

The Southwest portion of the watershed had the highest septic-tank density of 45 housing units per square mile. About one half of the census block group is within the East Fork watershed. This area includes recent expansion of High Point as well as the 1995 proposed sewer service area of Guilford County (Guilford County, 1995). The High Point buildings coverage shows that development remains widely dispersed and that most houses may continue to use septic tanks. If these septic tanks were contributing fecal coliform to the East Fork, low flow exceedances would occur frequently. Instead, low flow exceedances are infrequent, which suggests that septic tanks are not causing high fecal coliform concentrations.

Given the low number of septic tanks in the county (U.S. Census, 1990) and the locations relative to the East Fork Deep River watershed, septic tanks were not considered primary sources in the loading analysis. Septic tank contributions of fecal coliform were considered negligible in comparison to other nonpoint sources.

Sewer Overflows

Fecal coliform may enter surface water when sewer pipes are clogged, damaged, 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). Figure 6 shows the locations of known SSOs affecting surface water in Greensboro between 1998 and 2003 (Phlegar, 2003). Most SSOs reported for Greensboro were blockages or damage that are not likely to reoccur. The Albert Pick Lift Station is the only reoccurring SSO, and eight out of the thirteen overflows were due to high rain events. Within the City of High Point, no known SSOs or other sewer problems have occurred in the East Fork watershed within the last 3 years (Hepler, 2003).

The Albert Pick Lift Station SSOs are likely sources of high flow fecal coliform exceedances. This lift station is located near the East Fork main stem upstream of the Gallimore Dairy Road monitoring site. These SSOs were likely to contribute to high flow exceedances at the Gallimore Dairy Road site.

A sewer-line force-main break in 2001 may explain some of the four normal flow and three low flow fecal coliform exceedances. At Gallimore Dairy Road, exceedances from June through October 2001 were probably caused by the sewer break South of Albert Pick Road (Patrick, 2003). Construction equipment on I-40 damaged the sewer force main during the summer of 2001, and the sewer was not repaired until October 2001.

The SSOs do not directly explain the remaining normal and low-flow exceedances. Most of these exceedances originated at the Albert Pick Road site, and a few exceedances originated at the Thatcher Road site. Clogged sewer pipes have been reported in these areas, and clogged pipes may have contributed to these exceedances.

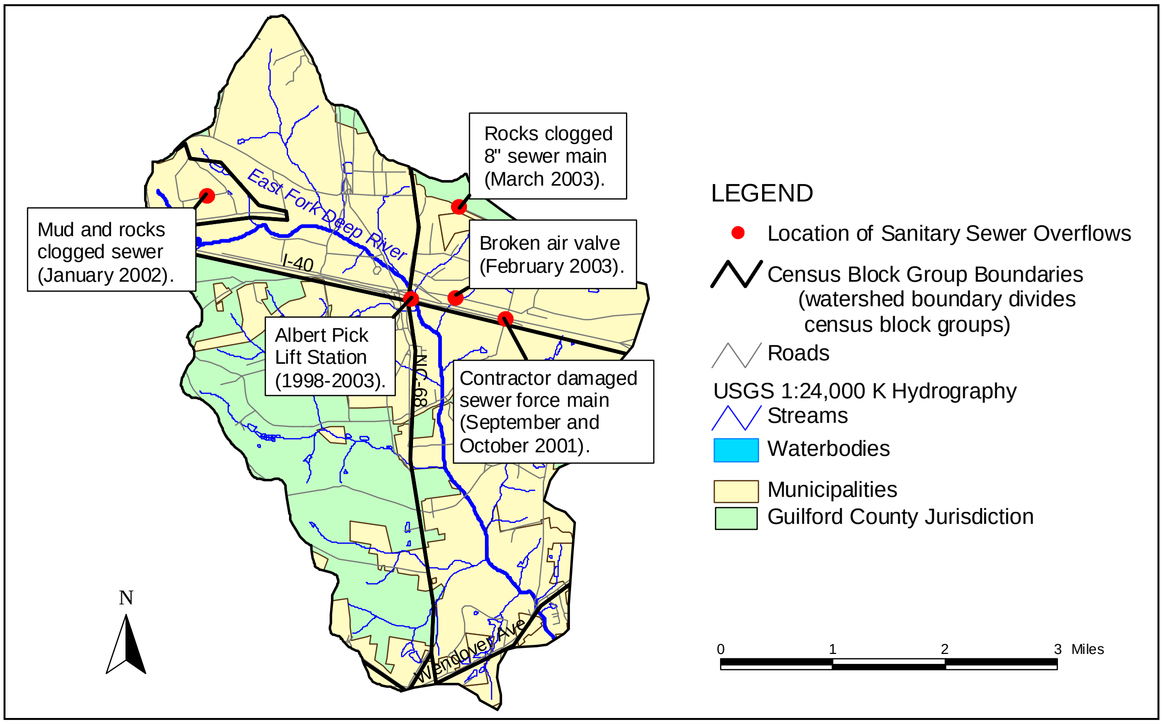

Figure 6. Location, Description, and Date of Sanitary Sewer Overflows (SSOs) and Census Block Boundaries

Sewer Defects

Defects in sewer pipes, including cracked and corroded pipes, allow sewage to leak into surface water. Sewer pipe leaks are a likely cause of low flow fecal coliform exceedances as they contribute high loads during periods where there is a minimal amount of stream flow to dilute their contribution. Other potential sources like illicit discharges and septic tanks are not as likely because the exceedances would reflect a continuous load.

In its July 2003 report on fecal coliform sources, PTCOG did not find any known sewer defects in the East Fork watershed. One exception was a sewer break in the Gallimore Dairy watershed that was reported as an SSO and repaired. The Albert Pick and Gallimore Dairy subwatersheds were chosen to conduct an updated assessment of sewer defects since these subwatersheds experience the most fecal coliform exceedances. Charles Pegram of the City of Greensboro reported that no recent surveys had been conducted in these subwatersheds and that he was not aware of any sewer leaks (Pegram, 2003). The occasional, low flow exceedances are probably caused by unknown sewer leaks.

2.2.2 Point Source Fecal Coliform Contributions

As mentioned in Section 2.1.2, the City of Greensboro, City of High Point, and Guilford County are required to implement programs under the Phase II Stormwater Rule (Greensboro is also a Phase I city). As such, loadings of fecal coliform from stormwater runoff are considered to be point source discharges for the purpose of the TMDL. There are no NPDES continuous point source discharges permitted to discharge fecal coliform in the watershed.

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3 Technical Approach

Given the results of the initial data analysis and time and budget constraints, an approach focusing on the magnitude of water quality standard exceedances and potential sources contributing to the stream during the exceedances was used. This approach used a flow-duration curve analysis to determine the flow conditions under which impairment occurs. In addition, the approach was used to identify source types, specify the assimilative capacity of the stream, and estimate the magnitude of load reduction required to meet the water quality standards. The potential sources determined from the load-duration curve were inventoried and assessed for their relative contributions to allocate reductions among sources. The results of this assessment were used to derive the allocations required by the TMDL.

This section describes the process used to specify the endpoints and calculate the existing loading and assimilative capacity. The determination of the TMDL reductions and loads are presented in Section 4.

3.1 TMDL ENDPOINTS

3.1.1 Endpoint for Turbidity TMDL

Turbidity is a measure of the scattering of light as it passes through water and is reported in Nephelometric Turbidity Units (NTU). This turbidity may come from a variety of components including suspended sediment, organic matter, and microorganisms in the water column. Waters with high turbidity can affect aquatic life processes, disinfection processes for drinking water supplies, and aesthetics. However, turbidity is not a concentration and, as a measure, cannot be directly converted into loadings required for the TMDL. For this reason, available water quality data was evaluated in order to identify a surrogate measure, which could be used as a predictor of turbidity. NCDENR data for total residue, total filterable residue, and total suspended solids (TSS) were processed and compared with turbidity measurements collected on the same day. Of these measures, TSS was most highly correlated with turbidity and was a significant explanatory variable ($p<0.001$). TSS was therefore selected as the surrogate measure for turbidity and used to develop the TMDL target and limits (USEPA 1999).

A regression of TSS on turbidity was used to estimate the median TSS at the turbidity standard of 50 NTU. The regression used natural log transformations of TSS and Turbidity monitoring data from 1997 through 2002. Median TSS at 50 NTU will occur between 16 and 34 mg/L in 95% of samples. The estimated median TSS for the turbidity standard is 23 mg/L TSS. The regression results are shown in Figure 7.

3.1.2 Endpoints for Fecal Coliform TMDL

The achievement of the TMDL objectives require the instream concentrations to meet both the instantaneous standard of 400 cfu/100 mL and the geometric mean standard of 200 cfu/100 mL. Both standards are considered to be the endpoints for the determination of the fecal coliform TMDL for the East Fork Deep River.

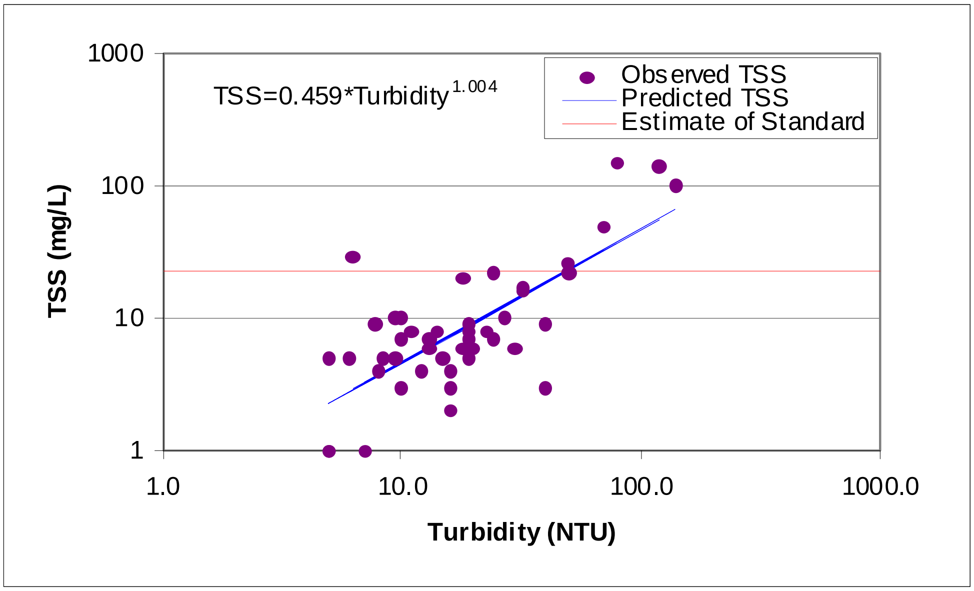

Figure 7. Regression of TSS (mg/L) on Turbidity (NTU) R^2=0.54, p<0.001

3.2 Flow-Duration Curves for Turbidity and Fecal Coliform

The analysis of pollutant levels in conjunction with water quality standards and measured flow is a useful tool for assessing critical conditions, as well as existing and target loads. The Flow-Duration Curve Method (Stiles 2002, Cleland 2002) was used for both TSS and fecal coliform. This method plots flow and observed data to analyze the flow conditions under which impairment occurs and water quality deviates from the standard. The method was used to determine the seasonality and flow regimes during which the exceedances occur and to determine maximum daily load based on the flow duration and applicable standard.

A flow-duration curve analysis was performed to identify the flow regimes during which exceedances of the water quality standards occur. This method determines the relative ranking of a given flow based on the percent of time that historic flows exceed that value. Daily gaging data for the period from 1/1929 through 12/2002 at USGS Station 02099000 was used to establish the historic flow regimes and define ranges for the high, transitional, typical, and low flow conditions. Flow statistics for the gage are presented in Table 5.

Table 5. Flow Statistics for USGS Gage 02099000 (E. Fork Deep at Wendover Ave.)

Flow Parameter	Value (cfs)
Mean	17.4
Min	0.6
Max	1670.0
High flow range	26.0 – 1,670.0
Transitional flow range	12.0 – 26.0
Typical flow range	4.7 – 12.0
Low flow range	0.6 – 4.7

Once the relative rankings were calculated for flow, monitoring data were matched by date to compare observed water quality to the flow regime during which it was collected. As is seen in Figure 8, this type of analysis can help define the flow regime during which exceedances occur and also pinpoint the source of the impairment. Exceedances that occur only during low-flow events are likely caused by continuous or point source discharges, which are generally diluted during storm events. Exceedances that occur during high-flow events are generally driven by storm-event runoff. A mixture of point and nonpoint sources may cause exceedances during normal flows.

Review of Figure 8 indicates that the turbidity impairment occurs during high-flow events and is likely caused by storm runoff. The majority of exceedances of the water quality standard occur during high flow events. These exceedances also tend to occur during the summer (April through October). This type of behavior is consistent with high sediment loadings resulting from nonpoint source summer, storm event runoff. Streambank erosion may be a contributing factor for high values in the 0-10% interval (Cleland, 2002). Figure 9 presents the flow duration curve for TSS and compares the monitoring data to the surrogate target value of 23 mg/L.

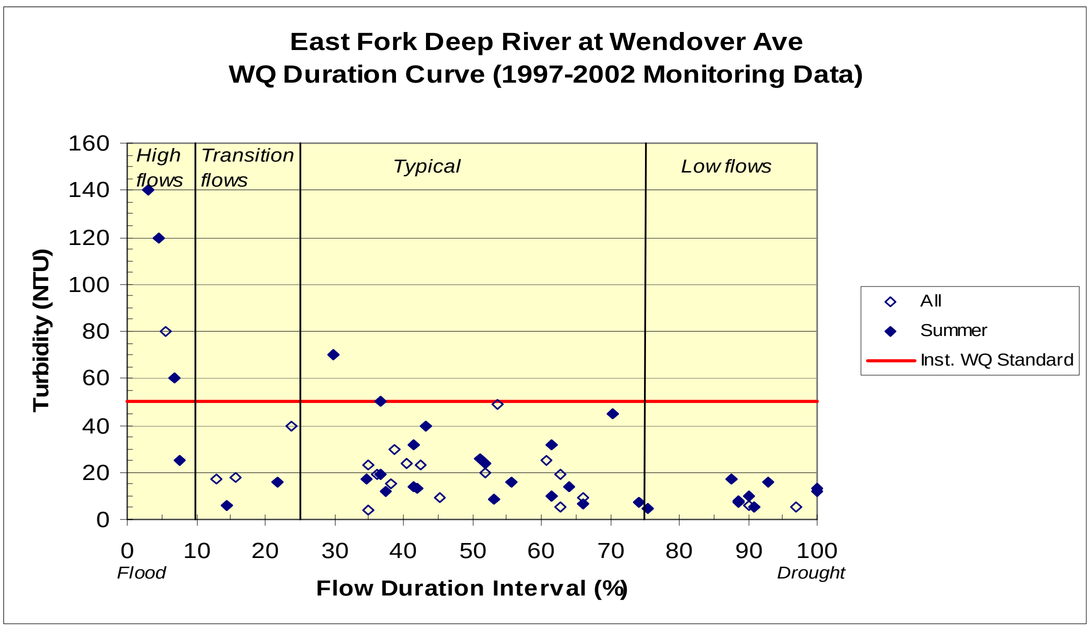

Figure 8. Turbidity Flow-Duration Curve at NCDENR Station B424000

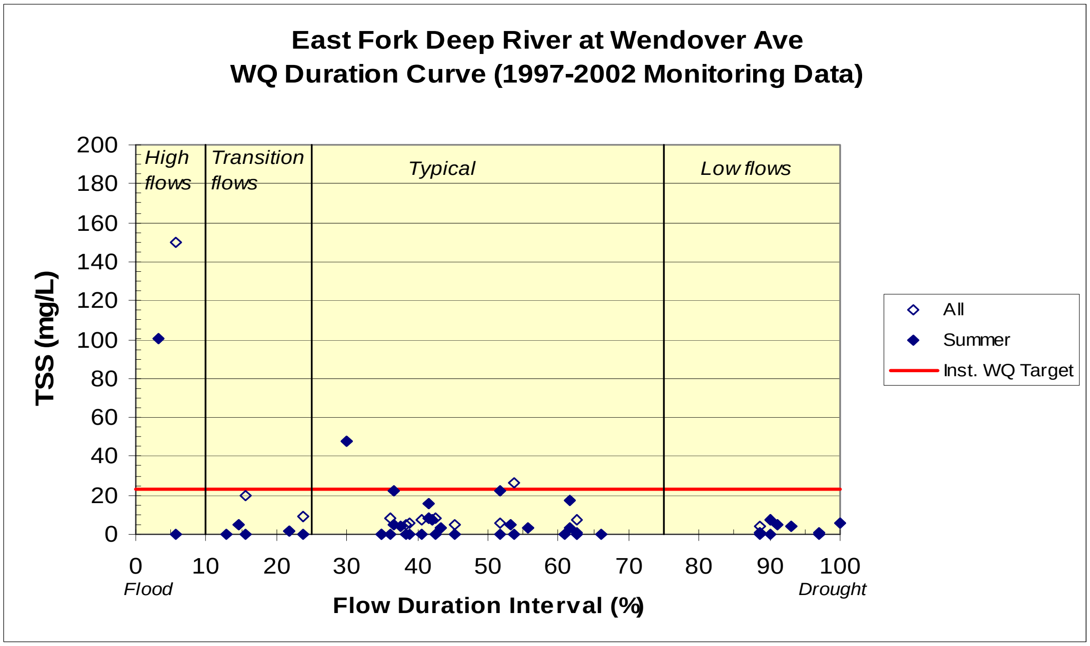

Figure 9. TSS Flow-Duration Curve at NCDENR Station B424000

Figure 10 shows exceedances of the instantaneous-fecal-coliform water quality standard (400 cfu/100 mL) during high-flow and typical-flow regimes, indicating contributions from moderate and high-flow-storm events as well as some intermittent discharges. Fecal coliform concentrations are expressed as number of colony forming units and may be written as "#/100 mL" or "cfu/100 mL."

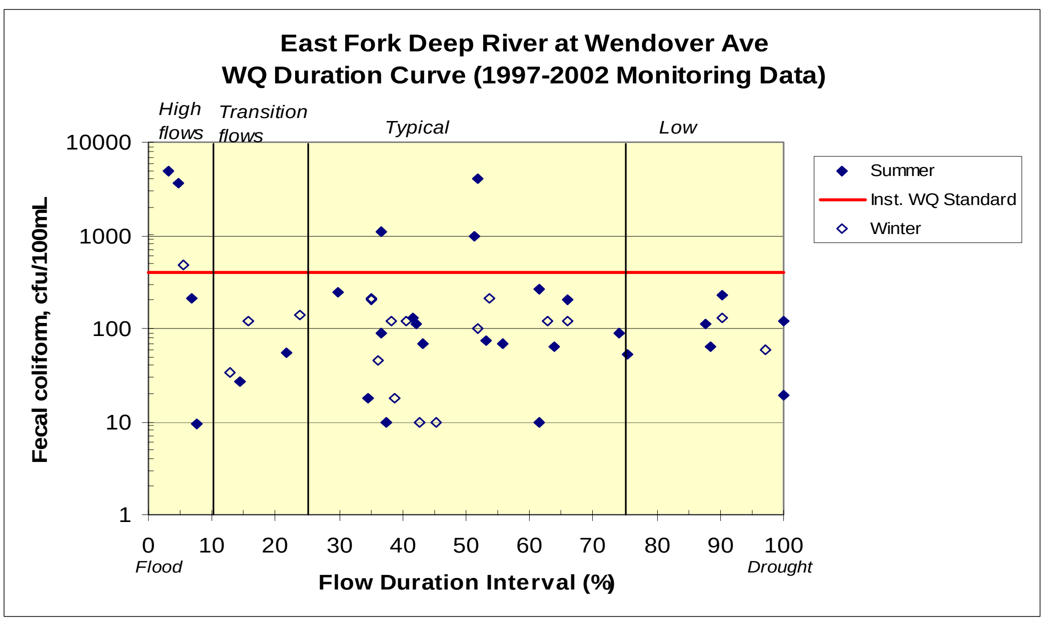

Figure 10. Fecal Coliform Flow-Duration Curve at NCDENR Station B424000

Figure 11 presents the flow-duration analysis for the primary PTCOG monitoring locations. The PTCOG monitoring data provide four additional sample sites upstream of the NCDENR station at Wendover Ave. This higher resolution indicates that while many exceedances occur during high and transition-flow events, fecal coliform also exceeds the instantaneous standard during typical and low flows. The PTCOG data suggest that both storm-event runoff and low-flow sources, such as illicit discharges, septic systems, or broken sewer lines, contribute to high fecal coliform loading in the East Fork Deep River.

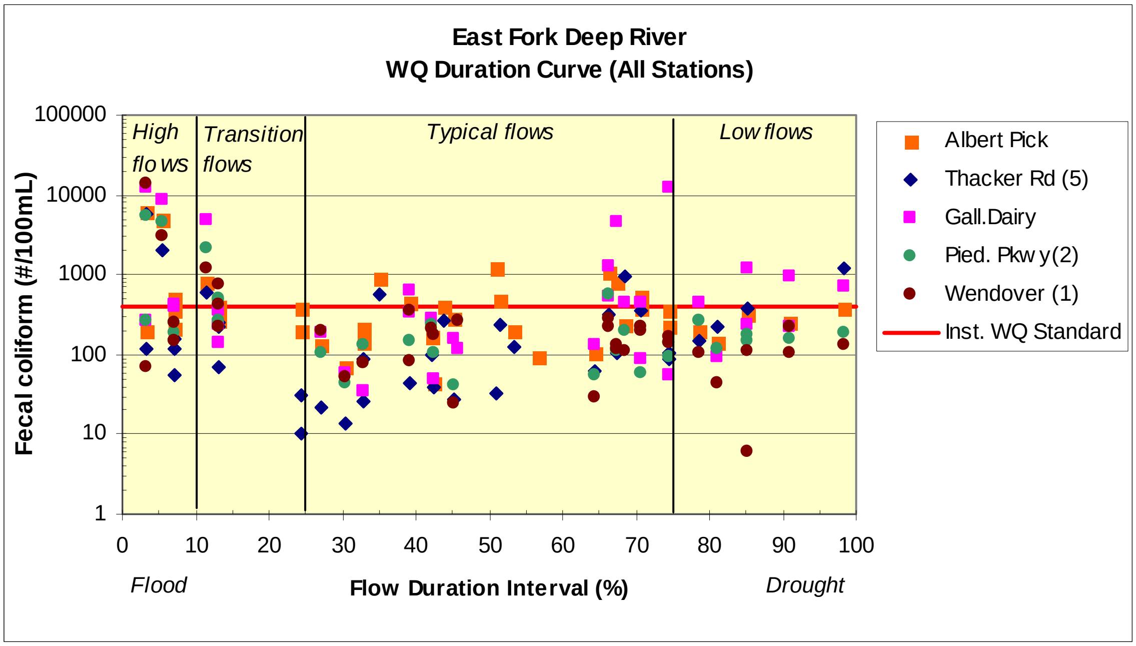

Figure 11. Flow-Duration Curve For PTCOG Fecal Coliform Data

3.3 Assimilative Capacity

3.3.1 Determination of Existing TSS Load and Assimilative Capacity

The TSS assessment used the Flow-Duration Curve approach presented to NCDENR by Bruce Cleland. This approach uses a flow-duration curve analysis to determine the flow conditions under which impairment occurs. In addition, the approach is used to identify source types, specify the assimilative capacity of the stream, and estimate the magnitude of load reduction required to meet the water quality standards. The potential sources determined from the load-duration curve were inventoried and are discussed in Section 4.

As discussed in Section 3.1.1, TSS was selected as a suitable surrogate for determining turbidity impairment. Existing TSS loading to the East Fork was determined by multiplying the observed TSS data by the flow observed on the date of the observation and converting the result to a daily loading value. The assimilative capacity of the stream was determined by multiplying the TSS concentration equivalent to a turbidity value of 50 NTU (23 mg TSS/L) by the full range of measured flow values. Figure 12 presents the calculated loads based on the NCDENR monitoring data and the TMDL target loading. As discussed in Section 2, the assimilative capacity of the East Fork is exceeded primarily during high-flow events although the frequency of exceedance is fairly low.

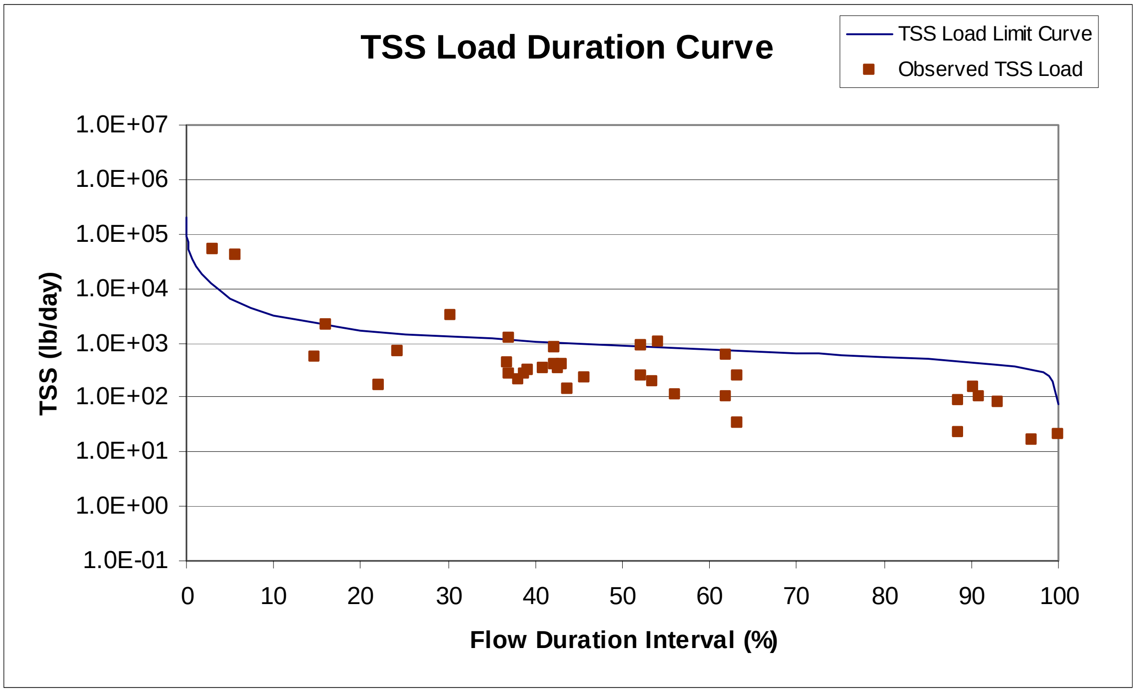

Figure 12. Load-Duration Curve for TSS

3.3.2 Determination of Existing Fecal Coliform Load and Assimilative Capacity

The fecal coliform assessment also uses the Flow-Duration Curve approach for determination of the existing load and assimilative capacity. The analysis was performed for both the instantaneous and geometric mean standard to determine the most conservative measure of impairment. Figure 13 and Figure 14 present the results of the instantaneous and geometric mean load-duration analyses based on DENR and PTCOG data collected at Wendover Avenue. The average of the five flow observations corresponding to the five fecal coliform sample dates was used as the flow for each geometric mean load. As described in Section 3.2, many of the exceedances of the instantaneous standard occur during high-flow events with occasional elevated levels during lower flows. This response is not seen as frequently for the geometric mean analysis, supporting the conclusion that intermittent direct contributions are the cause of the low-flow exceedances.

The load-duration curves developed in this section provide guidance in the determination of the pollutant sources that are likely the primary contributors to elevated levels of fecal coliform. For example, elevated fecal coliform levels that occur only during typical and high flow events are not likely to be caused by failing septic systems. Nonpoint sources and sporadic sources such as sanitary sewer overflows would likely be the main focus of the inventory in this case.

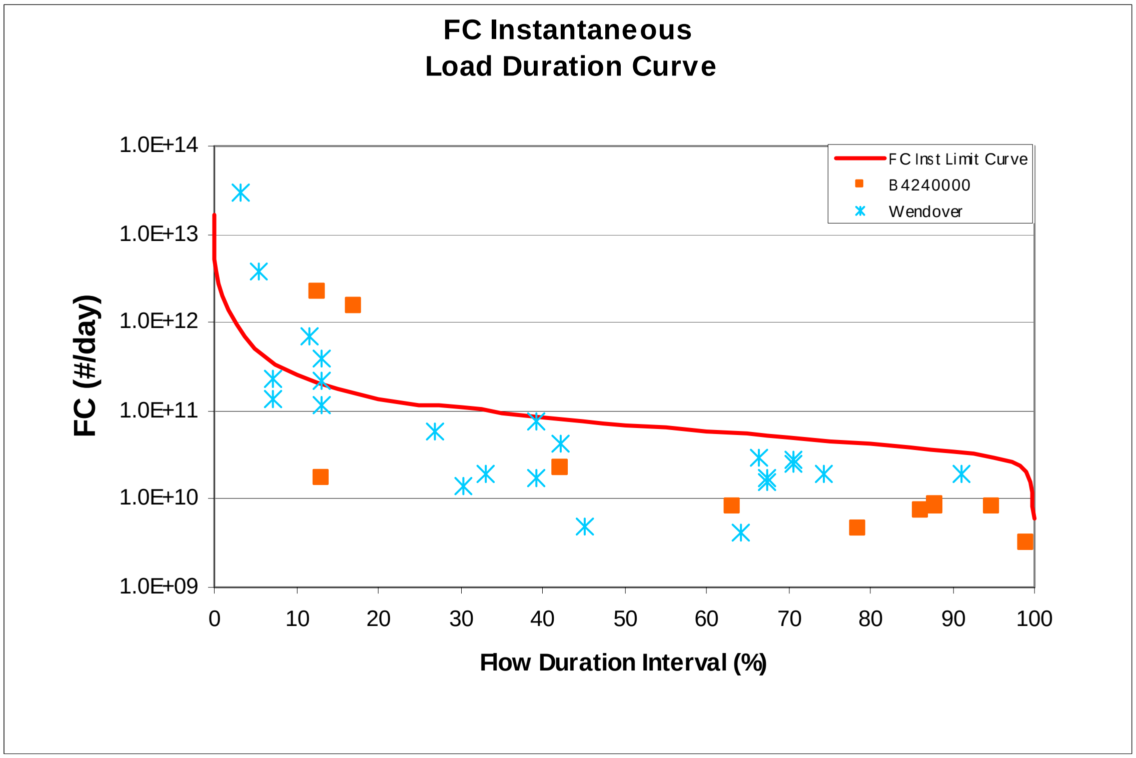

Figure 13. Instantaneous Fecal Coliform Load-Duration Curves

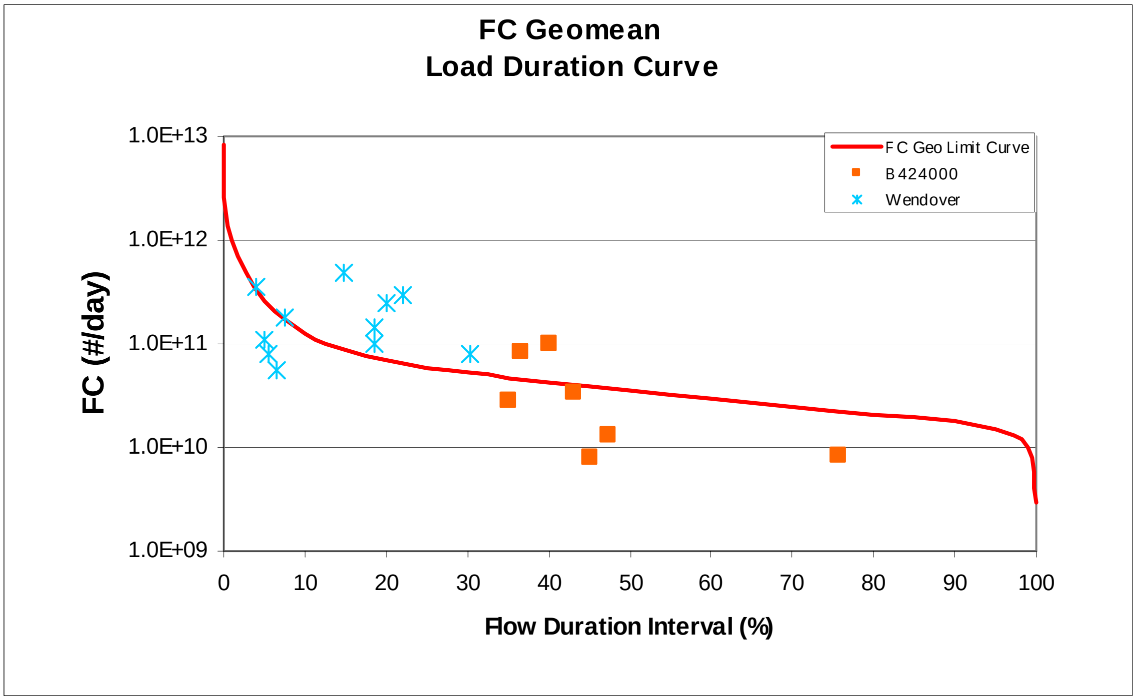

Figure 14. Geometric Mean Fecal Coliform Load-Duration Curves

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4 TMDL Development

Sections 1 through 3 described the processes and rationale required to identify the endpoints, critical conditions, potential sources, and target loadings for each pollutant. These efforts formed the basis for the TMDL process. This section describes the key components required by the TMDL guidelines and synthesizes the project efforts to set the final TMDL allocations.

4.1 TMDL Definition

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality criteria (in this case a target for warm water aquatic habitat). TMDLs can be expressed in terms of mass per time or by other appropriate measures such as concentration. TMDLs are comprised of the sum of individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

$$\text{TMDL} = \Sigma\text{WLAs} + \Sigma\text{LAs} + \text{MOS}$$

4.2 TMDL Endpoints

TMDL endpoints represent the instream water quality targets used in quantifying TMDLs and their individual components. As discussed in Section 3, turbidity as a measure is not applicable to the estimation of loading to a stream. TSS was selected as a surrogate measure for turbidity. Based on the regression analysis, a TSS limit of 23 mg/L was determined to be equivalent to a turbidity measure of 50 NTU.

There are two endpoints that will be used to determine the fecal coliform TMDL, as specified in the North Carolina water quality standards. Both the instantaneous limit of 400 cfu/100 mL and the geometric mean of 200 cfu/100 mL were considered.

4.3 Critical Conditions

Based on the load-duration curves, the greatest frequency of exceedances for both turbidity and fecal coliform occur during the summer period. Elevated turbidity occurs during high-flow events. Fecal coliform impairment also occurs during high-flow events with occasional exceedances during typical flows. The Load-Duration-Curve approach addresses the load reductions required during all flow regimes. However, the majority of exceedances occurred during storm events, so these were the primary targets for the load reductions.

4.4 Seasonal Variations

Seasonal variation is considered in the development of the TMDLs because the allocation applies to all seasons. As noted in the critical conditions section, the majority of the exceedances occur during the summer months.

4.5 MARGIN OF SAFETY (MOS)

There are two methods for incorporating a MOS in the analysis: 1) by implicitly incorporating the MOS using conservative model assumptions to develop allocations; or 2) by explicitly specifying a portion of the TMDLs as the MOS and using the remainder for allocations. For the purposes of this analysis, an explicit 10 percent margin of safety was specified.

4.6 TMDL CURVES

The load-duration curves presented in Section 3.3 provide the basis for the reductions required to meet the TMDL targets. Allowable load curves were calculated with the water quality standards and a 10% MOS. Based on guidance from EPA Region 4, data collected during extreme drought conditions (>95th percentile) and floods (<10th percentile) were excluded from the reduction analysis. For the TSS and fecal coliform geomean reductions, flow-duration and loading curves were generated from historical monitoring data. These curves combine flow and observed concentrations to show the flow conditions under which the water quality standards are exceeded. An existing loading curve could not be estimated from the instantaneous fecal coliform data; therefore, the geometric mean of the exceedances was used as an estimate of the existing load.

4.6.1 TMDL Curve for Turbidity

The results of the analysis described in Section 3 were used to develop flow-duration and loading curves based on historical monitoring data. Exceedances of the estimated standard (23 mg TSS/L) were identified within the 10th to 95th percentile flow recurrence range. The natural log of exceedances was regressed on the natural log of the flow interval, and this regression curve was used to estimate the existing loading at every 5th percentile flow recurrence. Allowable loading was calculated at every 5th percentile flow recurrence based on the TMDL target value, which includes the 10 percent MOS. For the estimates within the 10th to 95th percentile flow recurrence range, the average of the two sets of loading estimates was calculated and the percent that the existing load exceeded the target was determined.

The target curve based on the TMDL limit and the MOS, and the regression curve based on exceedances are shown in Figure 15. The average existing and target loadings were estimated at every fifth flow interval. These results as well as the average values are presented in Appendix B. To meet the water quality standard and account for the margin of safety, a 62 percent reduction is required.

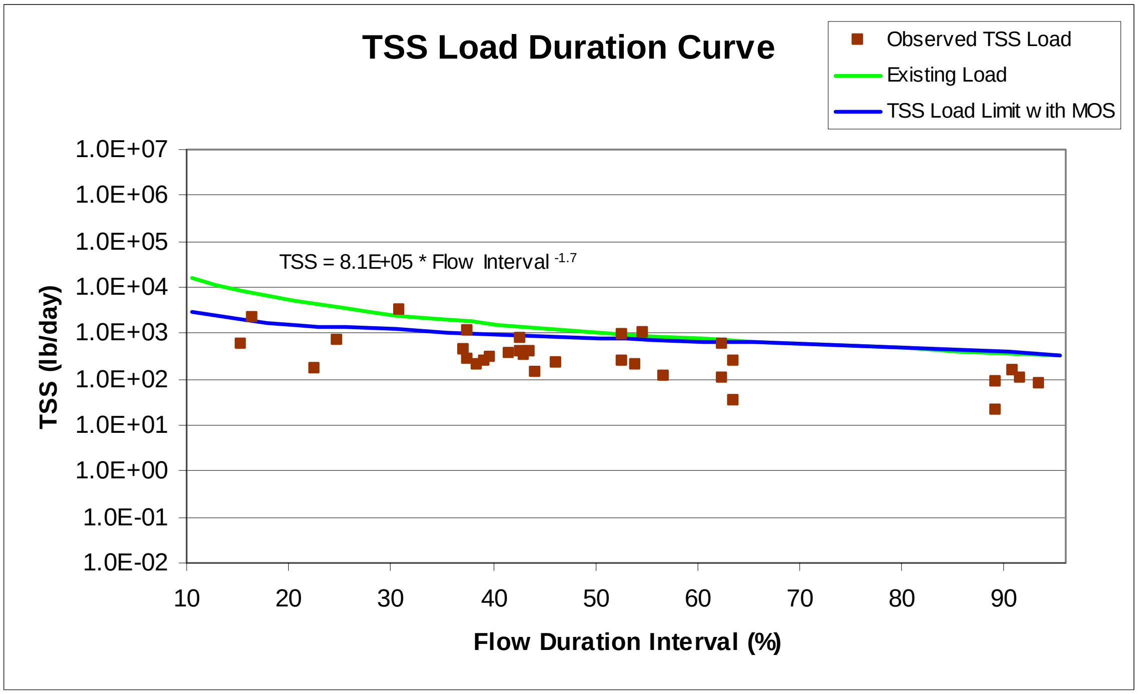

Figure 15. TMDL Curve Based on TSS Surrogate Standard for Turbidity

4.6.2 TMDL Curves for Fecal Coliform

The reductions for the instantaneous and geomean fecal coliform standard were estimated with the observed data that exceeded the applicable water quality standard within the 10th to 95th percentile flow recurrence range. For the instantaneous standard, a valid regression curve for existing loading could not be estimated from the observed data. Therefore, the geomean of the exceedances was used as an estimate of the existing load. The allowable loads for each exceedance were calculated based on the TMDL target value, which includes the 10 percent MOS. The target curve based on the allowable loads and the exceedances used for the existing load are shown in Figure 16. The geomeans of the exceedances and the allowable loads were used to calculate the percent that the existing load exceeded the target.

The reductions for the fecal coliform geomean were estimated by regressing the natural log of exceedances on the natural log of the flow interval. At every 5th percentile flow recurrence, the existing loads were calculated from the regression equation, and the allowable loadings were calculated from the TMDL target value, which includes the 10 percent MOS. The target curve based on the allowable loadings, and the regression curve based on the exceedances are shown in Figure 17. Within the 10th to 95th percentile flow recurrence range, the average of the two sets of loading estimates was calculated and the percent that the existing load exceeded the target was determined.

The loading estimates as well as the average values are presented in Appendix B. To meet the water quality standard and account for the 10 percent margin of safety, a 75 percent reduction in fecal coliform is required to meet the instantaneous limit (target load divided by existing load), and 63 percent reduction is required to meet the geometric mean target.

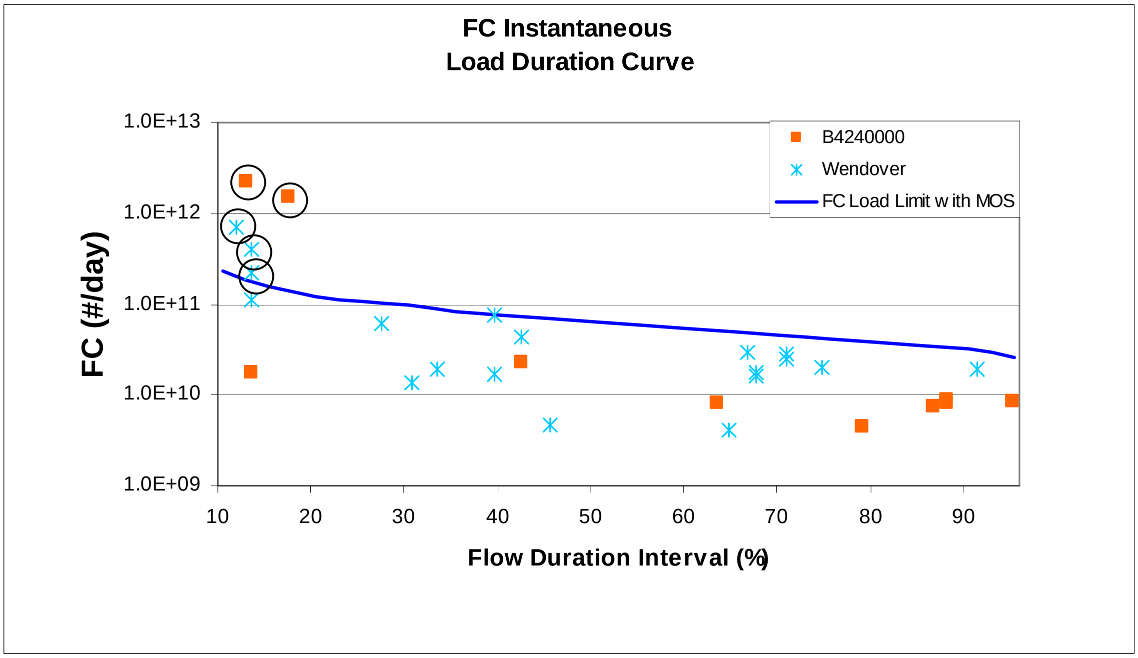

Figure 16. TMDL Curve Based on Instantaneous Fecal Coliform Standard, Exceedances Circled

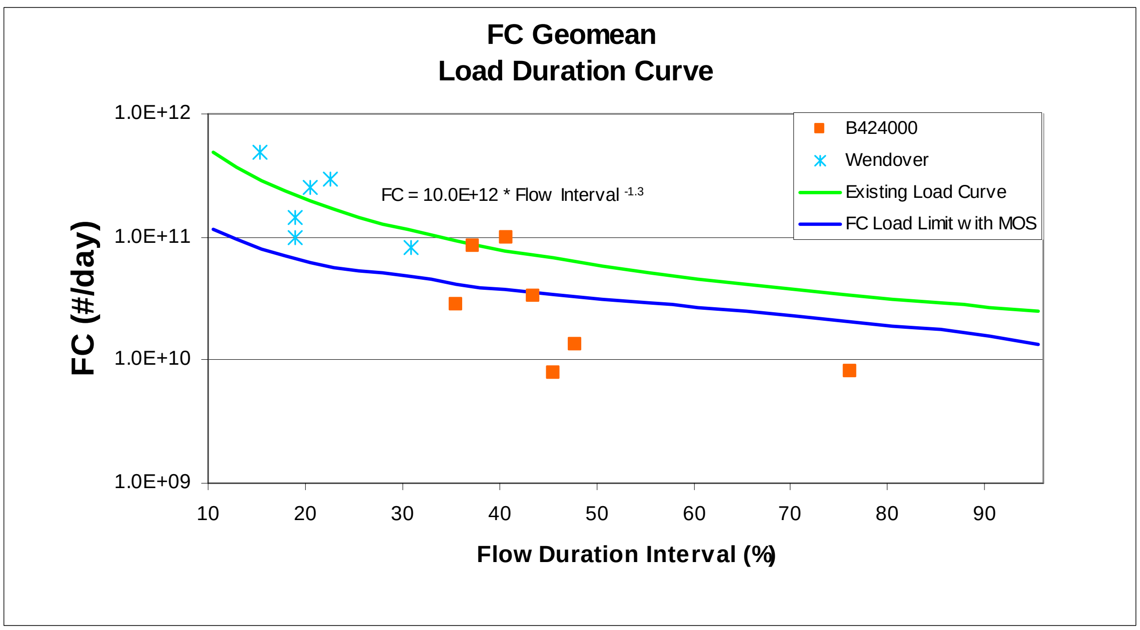

Figure 17. TMDL Curve Based on Geometric Mean Fecal Coliform Standard

4.7 TMDL SUMMARY

The load-duration curves for the existing and target conditions were evaluated to determine the reductions needed to meet the TMDL endpoints. To achieve the specified TMDL targets, significant reductions were required. These are summarized in Table 6.

Table 6. TMDL Reductions for TSS and Fecal Coliform

Pollutant	Target	Existing Load (lb/day)	Target Load (lb/day)	Reduction Required
TSS	<21 mg/L	2,564.6	973.3	62%
Fecal coliform (Instantaneous Limit)	<360 cfu/100 mL	7.3×10^{11}	1.8×10^{11}	75%
Fecal coliform (Geometric Mean Limit)	<180 cfu/100 mL	1.02×10^{11}	3.8×10^{10}	63%

The instantaneous standard is more restrictive than the geometric mean standard based on the percent reduction required. The higher reduction requirement will be selected to provide an added margin of safety to the TMDL.

The TSS and fecal coliform geometric mean reductions were used to develop the total TMDL loadings. Further analysis was required to determine the breakdown between point source (WLA) and nonpoint source (LA) loadings that meet the TMDL objectives. Based on the EPA guidance in regards to the Phase II Rule, urban stormwater runoff from an MS4 is considered as a WLA component.

The entire East Fork Deep River watershed falls within the Phase II boundaries. Therefore, all TSS and fecal loadings from urban landuses are assigned to the WLA component. Loadings from agricultural and forested areas are considered as nonpoint sources and are reported as LAs. The distribution of the urban and rural landuses, 12 percent and 88 percent respectively, was determined from the MRLC landuse coverage discussed in Section 2. In addition, the relative loading rates between the urban and rural landuse types was determined based on analysis of fecal coliform and TSS runoff data collected by USGS and summarized in the report *Relation of Land Use to Streamflow and Water Quality at Selected Sites in the City of Charlotte and Mecklenburg County, North Carolina, 1993-98* (USGS, 1999). Water quality data was collected at nine sites which drained relatively homogeneous landuses in order to estimate the pollutant yields from each (See Appendix B). Average sediment and fecal coliform concentrations were calculated by combining the estimates for the urban and rural watersheds. In addition, an estimate of SSO and sewer break fecal coliform contributions was calculated based on available monitoring data and literature values. The urban rate estimate for fecal coliform was increased to represent these non-runoff associated contributions that were seen to be a significant source of the stream impairment in the East Fork Deep River. The relative percent contributions of TSS and fecal coliform were combined with the landuse distribution to estimate the overall relative loading ratios for urban (MS4) and rural (non MS4) areas (Table 7). More information on these calculations is provided in the Appendix. It is important to note that these estimates are based on data from the early 1990's and are heavily weighted towards the rural landuses.

Table 7. Relative Pollutant Contributions Rates

Pollutant	Urban (% of Load)	Rural (% of Load)
TSS	8	92
Fecal coliform	51	49

The assimilative capacity determined in Section 3.3 was split based on the relative contributions presented in Table 7 to determine the WLA and LA components. The results of these calculations are summarized in Table 8.

Table 8. East Fork Deep River TMDL Components

Pollutant	Existing	WLA	LA	MOS	TMDL
TSS (lb/day)	2,564.6	77.9	895.4	Explicit 10%	973.3
Fecal coliform (counts/day)	7.3×10^{11}	9.2×10^{10}	8.8×10^{10}	Explicit 10%	1.8×10^{11}

While these estimates help provide understanding of the relative loads, they are not definitive and should be viewed in light of the limited data available to quantify the actual contributions from each individual source. For example, the available land cover data is outdated and fails to represent current land use. The primary focus of efforts to minimize future impairment should focus on the percent reductions required and control of sources identified in the Source Assessment and discussed in the Implementation and Future Efforts sections.

5 Report Summary

This report presents the development of Total Maximum Daily Loads (TMDLs) for fecal coliform and turbidity impairments of the East Fork Deep River. The East Fork of the Deep River near Greensboro, North Carolina was placed on the North Carolina 2002 list of impaired waters (the 303(d) list) for turbidity and fecal coliform. Available water quality data were reviewed to determine the frequency of exceedances. The flow-duration curve method was applied to determine the critical periods and the sources that lead to exceedances of the standard.

The potential sources determined from the load-duration curve were inventoried, and an assessment of their relative contributions was used to allocate reductions among sources. Analysis of the turbidity and total suspended solids monitoring data indicate that nonpoint sources, primarily development and associated land disturbing activities, are the primary cause of the turbidity impairment. A review of fecal coliform data indicates that storm event and intermittent point source contributions, such as sewer-pipe breaks and SSOs, are the cause of the fecal coliform impairment. These results were used to derive the allocations required by the TMDL.

6 TMDL Implementation Plan

Reductions for fecal coliform should be sought through identification and repair of aging sewer infrastructure as well as targeting other storm-driven sources. Enforcement of stormwater BMP requirements for construction sites, additional education related to farming practices and other land disturbing activities, and additional urban stormwater controls for sediment are potential management options for improving turbidity levels in East Fork Deep River.

For turbidity, much of the impairment is likely due to erosion from landuses during conversion from rural to urban uses. While stormwater controls are typically required during development activites, significant loadings can occur due to initial periods of land disturbance before controls are in place or during high rainfall periods during which the controls are inadequate. Additional turbidity impairment may be due to runoff from agricultural areas and from erosion of soils due to increased imperviousness in urbanizing areas.

The TMDL analysis was performed using the best data available to specify the fecal coliform and total suspended solids reductions 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. The involvement of local governments and agencies will be needed in order to develop an implementation plan.

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7 Stream Monitoring

Monitoring will continue on a monthly interval at the ambient monitoring site in the East Fork Deep River watershed. The continued monitoring of fecal coliform, turbidity, and total suspended solids will allow for the evaluation of progress towards the goal of achieving water quality standards and intended best uses.

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8 Future Efforts

MS4 jurisdictions within the East Fork watershed are Guilford County, the City of Greensboro, and the City of High Point. Guilford County submitted its Phase II MS4 permit application in 2003. The county has been operating an erosion control program since 1974, and its development ordinance requires that construction sites use erosion and sediment-control BMPs. Guilford County began enforcing watershed protection in 1984. According to its permit application and current development ordinance, the county will continue to enforce the use of stormwater BMPs in water supply watersheds and improve the monitoring of these BMPs (Guilford County, 2003).

The City of Greensboro submitted its Phase I MS4 permit application in 1994, renewed the Phase I permit in 1999, and submitted its Phase II permit application in June 2003. The city requires erosion and sediment controls and NPDES good-housekeeping measures at construction sites (City of Greensboro, 2003). All new high-density developments are required to treat stormwater runoff with wet detention ponds, bioretention cells, stormwater wetlands, or sandfilters, following the state BMP guidelines. All new low-density developments are required to treat stormwater runoff with land-disturbance buffers or structural BMPs. The city has also conducted an educational campaign and recently completed an inventory of all existing stormwater infrastructure (Small, 2003).

The City of High Point submitted its Phase II MS4 permit in March 2003. The city requires erosion control plans for any land-disturbing activity greater than 1 acre (City of High Point, 2003). The city began requiring stormwater controls in 1993 (Boone, 2003). The city requires a watershed development plan for any lot greater than 20,000 square feet (City of High Point, 2003).

All three jurisdictions enforce state water-supply-watershed development regulations to High Point City Lake. The majority of the East Fork drains the General Watershed Overlay District, while the downstream portions of the watershed include High Point City Lake's Watershed Critical Area.

Fecal coliform impairments appear to be driven mostly by storm events. The contributions during these events may include runoff from agricultural areas, urban stormwater washoff, and SSO events. Additional impairments occurred more infrequently during lower flow events and are most likely caused by sewer blockages or leaks. Review of the PTCOG study (2003) provides significant insight into specific areas within the watershed which appear to warrant further investigation.

Other potential mechanisms for reduction of both pollutants include local regulations or ordinances related to zoning, landuse, or storm water runoff controls. Local governments can provide funding assistance through general revenues, bond issuance, special taxes, utility fees, and impact fees. Additional mechanisms may employ concurrent education and outreach, training, technology transfer, and technical assistance with incentive-based pollutant management measures. The State and local governments will take the primary lead in the TMDL implementation.

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9 Public Participation

A draft of the TMDL was publicly noticed through various means, including notification in the local newspapers, *Greensboro News and Record* and *High Point Enterprise* on December 10, 2003. DWQ electronically distributed the draft TMDL and public comment information to known interested parties. The TMDL was also available from the Division of Water Quality's website at http://h2o.enr.state.nc.us/tmdl/ during the comment period. A public meeting was held on December 19, 2003 to present the TMDL and answer questions. In addition to DWQ staff, 4 people attended. The public comment period ended on January 13, 2004. No comments were received.

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10 Further Information

Further information concerning North Carolina's TMDL program can be found on the Internet at the Division of Water Quality website**:**

http://h2o.enr.state.nc.us/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the DWQ Modeling/TMDL Unit:

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12 Appendices

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Appendix A Water Quality Sampling Data

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Table 9. NCDENR Monitoring Data for Station B4240000 near Wendover Ave. (1997-2002)

Date	Flow (cfs)	Flow Regime	Turbidity (NTU)	TSS (mg/L)	Fecal Coliform (#/100mL)
10/23/1997	9.0	37.5	12	4	10
11/19/1997	8.8	38.3	15	5	120
12/17/1997	7.7	45.3	9.3	5	10
1/26/1998	13.0	23.8	40	9	140
2/23/1998	47.0	5.6	80	150	490
3/16/1998	9.2	36.2	19	8	45
4/22/1998	11.0	29.9	70	48	250
5/20/1998	8.2	42.1	13	7	110
6/17/1998	8.3	41.6	32	16	130
7/16/1998	19.0	14.5	6	5	27
8/18/1998	5.9	61.6	32	17	260
9/9/1998	9.1	36.6	50	22	1100
10/7/1998	3.6	90.2	10	7	230
11/5/1998	2.8	97.0	5	1	60
12/15/1998	6.7	53.7	49	26	210
1/19/1999	18.0	15.7	18	20	120
3/17/1999	8.1	42.6	23	8	10
5/26/1999	5.9	61.6	10	3	10
6/15/1999	6.9	51.8	24	22	4100
7/27/1999	3.7	88.5	7	1	64
8/31/1999	8.0	43.3	40	3	70
9/30/1999	89.0	3.1	140	100	5000
10/28/1999	6.5	55.7	16	3	70
11/23/1999	5.8	62.7	5	1	
12/28/1999	5.8	62.7	19	7	120
2/23/2000	8.7	38.8	30	6	18
3/30/2000	8.4	40.5	24	7	120
4/26/2000	9.1	36.6	19	5	90
5/30/2000	8.3	41.6	14	8	
6/28/2000	14.0	21.7	16	2	54

Date	Flow (cfs)	Flow Regime	Turbidity (NTU)	TSS (mg/L)	Fecal Coliform (#/100mL)
7/27/2000	7.0	51.2	26		990
8/16/2000	3.8	87.6	17		110
9/26/2000	58.0	4.6	120		3700
10/30/2000	5.7	64.0	14		63
11/29/2000	9.4	35.0	23		210
12/21/2000	9.4	35.0	3.7		200
1/16/2001	5.5	66.0	9.2		120
4/3/2001	39.0	6.8	60		210
5/22/2001	6.8	53.1	8.3	5	73
6/25/2001	8.5				940
7/17/2001	4.8	74.1	7.4		88
8/23/2001	3.5	91.0	5	5	
9/17/2001	5.5	66.0	6.3		200
10/4/2001	4.7	75.4	4.3		53
11/20/2001	3.7	88.5	8	4	
12/20/2001	6.0	60.8	25		
1/17/2002	3.6	90.2	6.2		130
2/13/2002	6.9	51.8	20	6	100
3/26/2002	21.0	12.9	17		34
4/25/2002	5.1	70.3	45		
5/20/2002	3.3	93.0	16	4	
6/24/2002	1.1	100.0	12		19
7/15/2002	9.5	34.6	17		18
8/8/2002	0.6	100.0	13	6	120
9/18/2002	34.0	7.7	25		9.3

Note: Does not include turbidity or fecal coliform data on dates where gage data was unavailable.

Table 10. PTCOG Fecal Coliform Monitoring Data 2001-2003

Date	Flow (cfs) (USGS02099000)	Flow Regime	Previous Rainfall (Hours)	Thatcher Rd.	Albert Pick Rd.	Gallimore Dairy Rd.	Piedmont Parkway	Wendover Ave.
4/9/2001	11	30.4%	144	14	70	58	43	51
4/11/2001	10	33.0%	192	26	143	35	130	80
4/23/2001	7.8	45.1%	120	27	277	160	42	25
4/24/2001	12	27.0%	144	22	130	185	104	204
5/3/2001	5.7	64.3%	360	62	106	130	54	30
5/4/2001	5.4	67.3%	384	105	790		112	120
5/8/2001	4.8	74.4%	480	105	347	56	92	168
5/9/2001	5.1	70.6%	504	350	523	88	58	227
6/6/2001	81	3.4%	72	120	200	270	270	68
6/12/2001	4.5	78.6%	72	148	197	460	260	102
6/18/2001	5.3	68.6%	72	930	240	440	196	110
6/21/2001	4	85.2%	144	380	320	1200	152	108
7/17/2001	4.8	74.4%	72	88	228	12320	137	142
8/20/2001	5.1	70.6%			370	460		203
8/23/2001	3.5	91.0%				980		228
8/27/2001	5.4	67.3%				4600		134
9/12/2001	8.7	39.2%				620		350
9/17/2001	5.5	66.3%				540		218
10/30/2001	4	85.2%				239	176	6
11/1/2001	3.8	87.8%						
11/28/2001	4.3	81.1%	96	226	140	92	120	45
1/9/2002	7.7	45.7%				115	272	264
1/14/2002	4	85.2%						
3/5/2002	8.2	42.6%	48	38	44	48	104	182
5/8/2002	3.5	91.0%	24		248	220	160	104
5/29/2002	1.8	99.5%	96					
6/3/2002	5.5	66.3%	48	310	1100	1260	550	287
6/6/2002	7.7	45.7%	72					
7/9/2002	2.5	98.3%	36	1200	380	700	185	130
7/15/2002	9.5	35.1%	72	580	876			

Date	Flow (cfs) (USGS02099000)	Flow Regime	Previous Rainfall (Hours)	Thatcher Rd.	Albert Pick Rd.	Gallimore Dairy Rd.	Piedmont Parkway	Wendover Ave.
10/24/2002	8.3	42.1%	72	100	171	280	230	210
10/28/2002	49	5.5%	48	2000	4900	8700	4600	3100
10/29/2002	86	3.2%	24	5900	6000	12000	5400	13800
10/31/2002	24	11.5%	24	600	800	5000	2200	1200
11/4/2002	8.7	39.2%	48	44	440	340	150	81
11/5/2002	37	7.2%	72	56	360	425	188	152
11/7/2002	21	13.2%	24	250	400	365	480	773
11/14/2002	21	13.2%	36	220	400	230	510	430
11/18/2002	38	7.1%	24	118	210	390	250	250
11/19/2002	21	13.2%	36	68	260	138	260	220
11/21/2002	13	24.3%	48	31	370			
11/26/2002	7.1	50.9%	96	33	1180			
12/3/2002	7	51.6%	24	240	480			
12/12/2002	38	7.1%	48	162	510			
12/18/2002	8	43.7%	24	270	400			
1/6/2003	13	24.3%	24	10	204			
1/7/2003	10	33.0%	48	88	210			
1/13/2003	6.8	53.5%	144	128	200			
1/16/2003	6.4	56.8%			92			

Appendix B Load Reduction Calculations

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Table 11. Estimation of Load Reduction for Turbidity (lb/day TSS)

Flow Interval	Target Load	Existing Load
10	2,903.1	16,366.6
15	2,009.8	8,171.3
20	1,563.2	4,991.8
25	1,339.9	3,405.9
30	1,228.2	2,492.2
35	1,060.7	1,913.8
40	960.2	1,522.5
45	870.9	1,244.3
50	792.8	1,038.8
55	736.9	882.3
60	669.9	760.1
65	625.3	662.7
70	569.4	583.7
75	524.8	518.6
80	480.1	464.4
85	446.6	418.5
90	402.0	379.5
95	335.0	345.9
Average	**973.3**	2,564.6

Table 12. Estimation of Load Reduction (#/day) based on Fecal Coliform Instantaneous Standard

Flow Interval	Target Load	Existing Load
12.6	2.2E+12	1.9E+11
17.1	1.5E+12	1.5E+11
11.5	7.0E+11	2.1E+11
13.2	4.0E+11	1.8E+11
13.2	2.2E+11	1.8E+11
Geomean	**1.8E+11**	**7.3E+11**

Table 13. Estimation of Load Reduction (#/day) based on Fecal Coliform Geometric Mean Standard

Flow Interval	Target Load	Existing Load
10	1.1E+11	4.8E+11
15	7.9E+10	2.8E+11
20	6.2E+10	1.9E+11
25	5.3E+10	1.5E+11
30	4.8E+10	1.1E+11
35	4.2E+10	9.3E+10
40	3.8E+10	7.8E+10
45	3.4E+10	6.7E+10
50	3.1E+10	5.8E+10
55	2.9E+10	5.2E+10
60	2.6E+10	4.6E+10
65	2.5E+10	4.1E+10
70	2.2E+10	3.8E+10
75	2.1E+10	3.4E+10
80	1.9E+10	3.1E+10
85	1.8E+10	2.9E+10
90	1.6E+10	2.7E+10
95	1.3E+10	2.5E+10
Average	**3.8E+10**	**1.02E+11**

Table 14. Estimates of TSS and Fecal Coliform Runoff Loading Rates for Urban and Rural Lands (USGS, 1999)

Landuse Type	TSS Conc. (ton/mi^2/yr)	FC Conc. (mg/L)[1]
Mixed forest/pasture/ low density residential	2400	15
Mixed forest, pasture, medium- and low-density residential	2100	20
Mixed forest, pasture, medium- and low-density residential	564	24.5
Average Rural	**1688.0**	**19.8**
Industrial	122	27.5
Industrial	300	14.6
Medium-density residential	225	29
Medium-density residential	77	26.5
High-density residential	1000	15
Developing	4700	13
Average Urban	**1070.7**	**20.9**

[1] Loading estimates not developed by USGS for coliform

Table 15. Estimates of Direct Fecal Coliform Contribution from Urban Sources

Typical SSO and Sewer Effluent Concentration (#/100mL)	Estimated Percent of Storm Event Contribution	Additional Contribution to Urban Fecal Loading Rate (#/100mL)
10,000[1]	0.675[2]	67.5

[1] Source: (EPA, 2001)
[2] Based on reported SSO overflows

Table 16. Relative Urban and Rural TSS Areal Loading

Landuse	Landuse Distribution	Relative TSS Rate	TSS Loading Ratio
Rural	87.8%	1688	92.0%
Urban	12.2%	1070	8.0%

Notes:
1-TSS data collected at nine urban and rural sites were analyzed to estimate average sediment concentrations in stormwater runoff. The relative percent contributions of TSS were multiplied by the landuse distribution and normalized to estimate the relative loading ratio for urban (MS4) and rural (non MS4) areas.
2-Land use data is from the early 1990's and may not represent current conditions.

Table 17. Relative Urban and Rural FC Areal Loading

Landuse	Landuse Distribution	Relative FC Rate	FC Loading Ratio
Rural	87.8%	19.8	48.9%
Urban	12.2%	88.4	51.1%

Notes:
1-Fecal coliform data collected at nine urban and rural sites were analyzed to estimate average fecal coliform concentrations in stormwater runoff. The urban rate estimate was increased based on available SSO and sewer break monitoring and literature to represent the non-runoff associated contributions (20.9 plus 67.5). The relative percent contributions of fecal coliform were multiplied by the landuse distribution and normalized to estimate the relative loading ratio for urban (MS4) and rural (non MS4) areas.
2- Land use data is from the early 1990's and may not represent current conditions.

Appendix C Affidavits of Publication for Public Notice

News & Record

Published by
News & Record, Inc.
Greensboro, North Carolina

North Carolina, Guilford County **Affidavit of Publication** 12/9/2003

Before the undersigned, a Notary Public of said County and State, duly commissioned, qualified and authorized by law to administer oaths, personally appeared the Publisher's Representative who being first duly sworn, deposed and says:

1. That he/she is the Publisher's Representative of the Greensboro News & Record, Inc. a corporation, engaged in the publicati of newspapers known as "News & Record", published, issued and entered as second class mail in the City of Greensboro in sa County and State.

2. That he/she is authorized to make this affidavit and sworn statement; that the notice or other legal advertisement, a copy of which is attached hereto, was published in the News & Record on the dates listed below.

3. That the said newspaper (or newspapers) in which such notice, paper, document, or legal advertisement was published was, the time of each and every such publication, a newspaper meeting all of the requirements and qualifications of Section 1-597 of t General Statutes of North Carolina and was a qualified newspaper within the meaning of Section 1-597 of the General Statutes c North Carolina.

Publisher's Representative Donna Battaglia

Sworn to and subscribed before me, this 16th day of December, 2003.

Valerie McNeil
Notary Public

My commission expires: August 23, 2005

VALERIE McNEIL
NOTARY PUBLIC
GUILFORD COUNTY, NC

Name	Ad #	Date	Edition	Class	PO	Ad Copy
NC DENR DIV OF WATER QUALITY	6184088	12/15/03	News & Record	400	TMDL E FORK	Public Notice/State o

Ad # 6184588 Date 12/08/2003 Time 2:24 PM

Public Notice
State of North Carolina
Division of Water Quality

Availability of the Fecal Coliform and Turbidity Total Maximum Daily Load (TMDL) for East Fork Deep River

Copies of the TMDL may be obtained by calling J. Todd Kennedy at (919) 733-5083, ext. 514 or on the internet at http://h2o.enr.state.nc.us/tmdl. A public meeting to discuss the TMDL will be held on December 19 at 10 AM at the following address: PIEDMONT ENVIRONMENTAL CENTER 1220 Penny Road, High Point, NC 27265. Written comments regarding this TMDL will be accepted until January 13, 2004. Please mail comments to NCDWQ Planning Branch, attn: J. Todd Kennedy, 1617 Mail Service Center, Raleigh, NC 27699.

Ad shown is not actual print size

NORTH CAROLINA
GUILFORD COUNTY

AFFIDAVIT OF PUBLICATION

Before the undersigned, a Notary Public of said County and State, duly commissioned, qualified, and authorized by law to administer oaths, personally appeared Carol F. Elliott, who being first duly sworn, deposes and says: that she is Advertising billing Manager of THE HIGH POINT ENTERPRISE, INC. engaged in the publication of a newspaper known as THE HIGH POINT ENTERPRISE, published, issued, and entered as second class mail in the City of High Point in said County and State; that (she) is authorized to make this affidavit and sworn statement; that the notice or other legal advertisement, a true copy of which is attached hereto, was published in The High Point Enterprise on the following dates:

December 10, 2003

and that the said newspaper in which such notice, paper, document, or legal advertisement was published was, at the time of each and every such publication, a newspaper meeting all the requirements and qualifications of Section 1-597 of the General Statutes of North Carolina and was a qualified newspaper within the meaning of Section 1-597 of the General Statutes of North Carolina.

This 9 day of February, 20 04

Carol F. Elliott

Sworn to and subscribed before me, this 9 day of February, 20 04

Ketta E. Edwards

Notary Public

My Commission expires

My Commission Expires 1-15-2006

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