Total Maximum Daily Load for Turbidity for Muddy Creek and the Yadkin River in North Carolina

[*Assessment Units* 12-94-(0.5)c, 12-(80.7), 12-(86.7)]

Final Report
November 2011

Yadkin-Pee Dee River Basin

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TMDL Summary Sheet

303(d) List Information

State: North Carolina
Counties: Davidson, Davie, Forsyth, Yadkin
Basin: Yadkin-Pee Dee River Basin

Waterbody Name	Assessment Unit (AU):	Class	10 digit HU	Impairment	Miles
Muddy Creek	12-94-(0.5)c	C	0304010113	Turbidity	4.8
Yadkin River	12-(80.7)	WS-IV	0304010110	Turbidity	9.4
Yadkin River	12-(86.7)	WS-IV	0304010115	Turbidity	10

Constituent of Concern: Turbidity
Reason for Listing: Standard Violations

Applicable Water Quality Standard:

The turbidity in the receiving water shall not exceed 50 Nephelometric Turbidity Units (NTU) in streams not designated as trout waters and 10 NTU in stream, lakes or reservoirs designated as trout water; for lakes and reservoirs not designated as trout waters, the turbidity shall not exceed 25 NTU; if turbidity exceeds these levels due to natural background conditions, the existing turbidity level cannot be increased. Compliance with this turbidity standard can be met when land management activities employ Best Management Practices (BMPs) recommended by the Designated Nonpoint Source Agency. BMPs must be in full compliance with all specifications governing the proper design, installation, operation and maintenance of such BMPs.

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 90^{th} and 10^{th} percent flow exceeded (excludes extreme drought (>90^{th} percentile) and floods (<10^{th} 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.

Turbidity is a measure of cloudiness and is reported in Nephelometric Turbidity Units (NTU). Therefore, turbidity is not measured in terms of concentrations and cannot be directly converted into loadings required for developing a load duration curve. For this reason, total suspended solid (TSS) was selected as the measure for this study.

Critical Conditions:
Critical conditions are accounted in the load duration 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 Load	WLA	LA	MOS	TMDL
Total Suspended Sediment (tons/day)					
Muddy Creek	44.3	5.462	16.14	10%	21.6
Yadkin River	361.50	4.014	146.986	10%	151.00

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 90^{th} and 10^{th} percent recurrence interval.
3. Explicit (10%) margin of safety is considered.

Public Notice Date: July 26, 2011
Submittal Date: 10/19/2011
EPA Approval Date: 11/17/2011

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1.0 Introduction

1.1 TMDL Definition

This report presents the development of turbidity TMDLs for two waterbodies (three assessment units) 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 segments of each waterbody are described in Table 1.1.

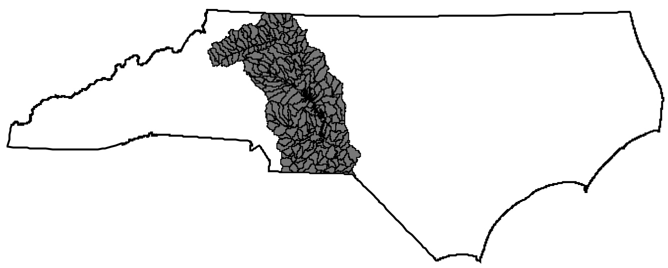

Figure 1.1 Location of the Yadkin River Basin within North Carolina

Table 1.1 Description of turbidity impaired assessment units

Waterbody Name	Description	Assessment Unit (AU):	Class	Miles
Muddy Creek	From SR 2995 to a point 0.8 mile upstream of mouth	12-94-(0.5)c	C	4.8
Yadkin River	From a point 0.3 mile upstream of Bashavia Creek to mouth of Hauser Cr.	12-(80.7)	WS-IV	9.4
Yadkin River	From Davie County water supply intake to a point 0.5 mile upstream of Carters Creek	12-(86.7)	WS-IV	10

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

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 (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.

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

Assimilative Capacity. Estimation of 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 point sources, including NPDES stormwater. Similarly, the load allocation portion of the TMDL accounts for the loads associated with nonpoint sources.

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 is moved off the 303(d) list. Waterbodies remain impaired until compliance with water quality standards is achieved.

1.2 Water Quality Target: North Carolina Standards and Classifications

The North Carolina fresh water quality standard for turbidity (15A NCAC 02B. 0211) states:

> *The turbidity in the receiving water shall not exceed 50 Nephelometric Turbidity Units (NTU) in streams not designated as trout waters and 10 NTU in stream, lakes or reservoirs designated as trout water; for lakes and reservoirs not designated as trout waters, the turbidity shall not exceed 25 NTU; if turbidity exceeds these levels due to natural background conditions, the existing turbidity level cannot be increased. Compliance with this turbidity standard can be met when land management activities employ Best Management Practices (BMPs) recommended by the Designated Nonpoint*

Source Agency. BMPs must be in full compliance with all specifications governing the proper design, installation, operation and maintenance of such BMPs.

1.3 Watershed Description

The impaired waterbodies are located in the Yadkin-Pee Dee River Basin. Watersheds of the impaired waterbodies were delineated using USGS -12 digit HUCs. Location maps for the impaired waterbodies are shown in the following Figures.

Land Cover

The land cover dataset used for this project was created by the NC Center for Geographic Information and Analysis (CGIA) for the upper portion of the Yadkin River Basin, including the entire High Rock Lake watershed. Data are derived from Landsat 5 imagery from 2006 and 2007. The methodology used to create this dataset was based on that used to create the 2001 National Land Cover Database (NLCD). Land cover distribution maps of the watersheds are shown in the following figures, and a comparison is shown in Figure 1.20. A detailed land cover distribution by square miles and percent area are shown for each impaired watershed in Appendix A.

Figure 1.21 shows the land cover distribution adjacent to streams. These data were derived by using GIS to select only land cover grid cells that were intersected by a 1:24000 stream segment.

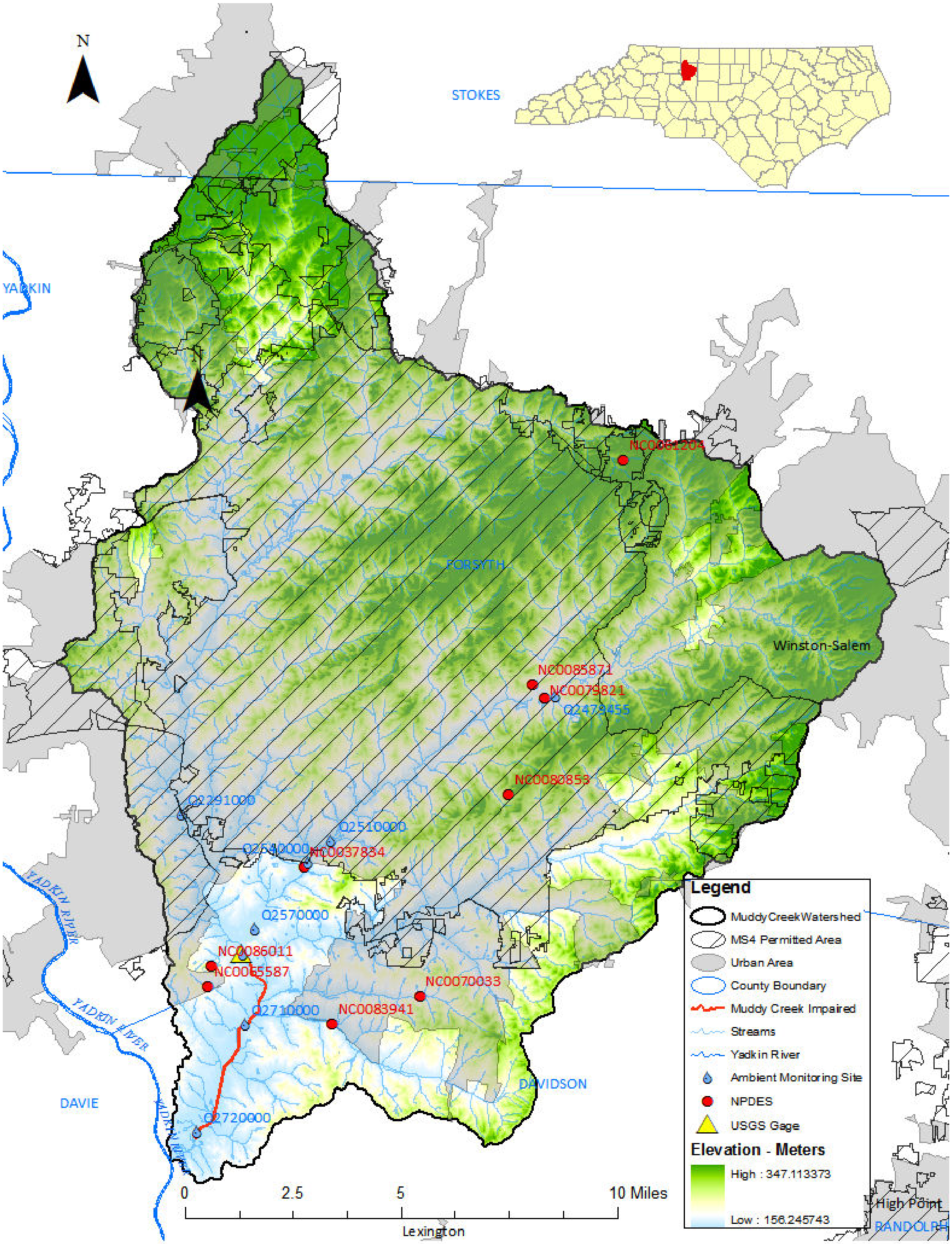

Figure 1.2 Muddy Creek watershed

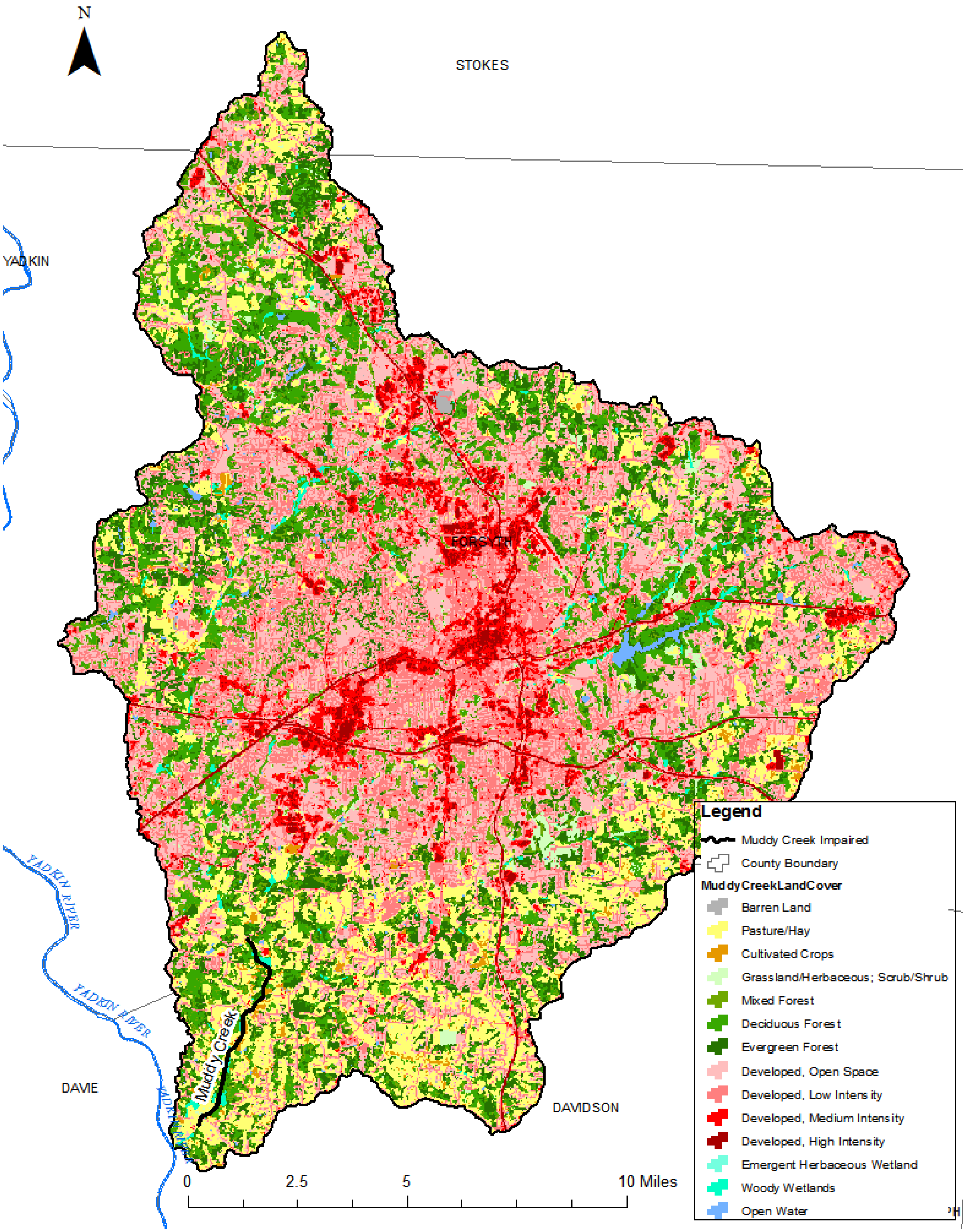

Figure 1.3 Land cover distribution in the Muddy Creek watershed

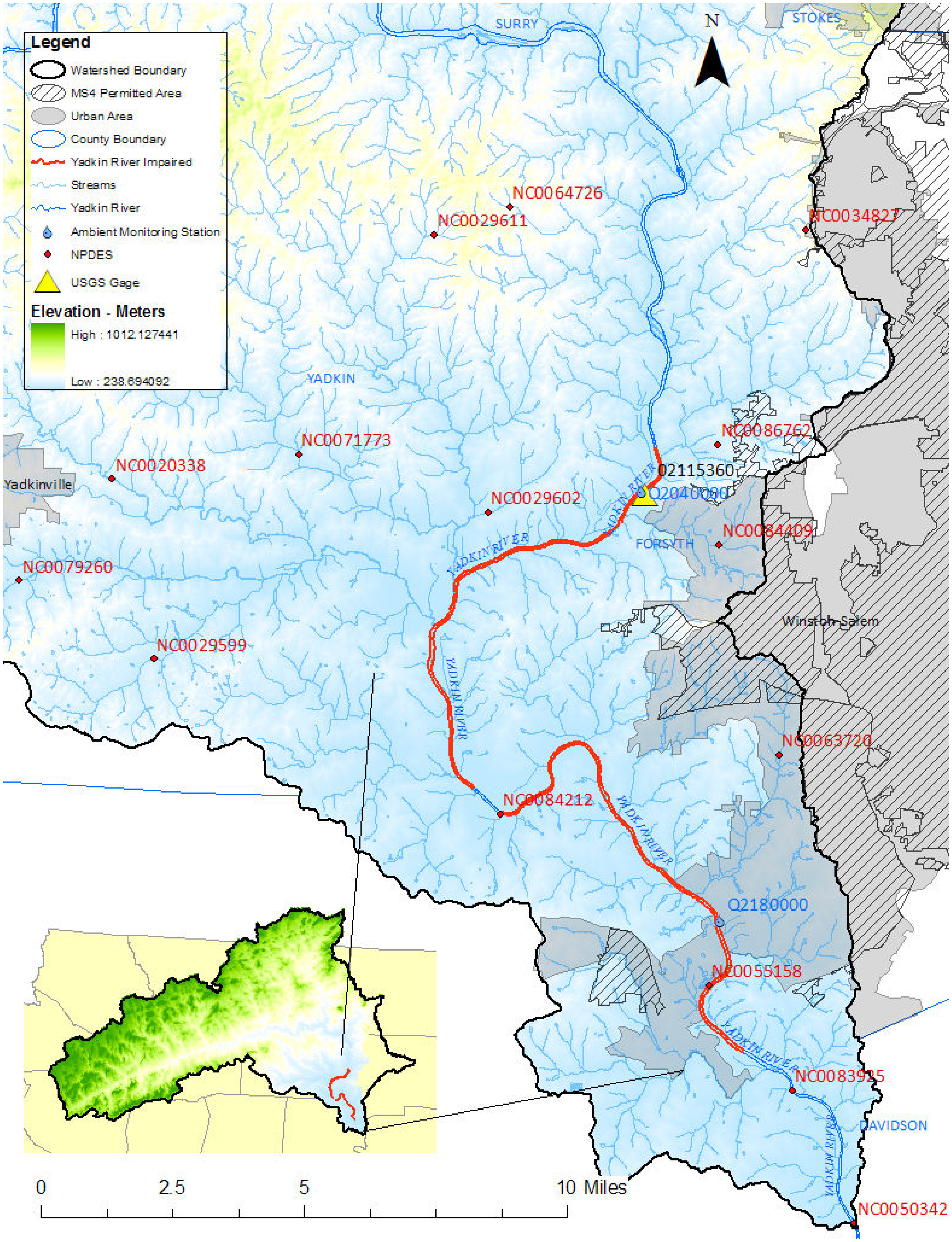

Figure 1.4 Impaired section of the Yadkin River watershed

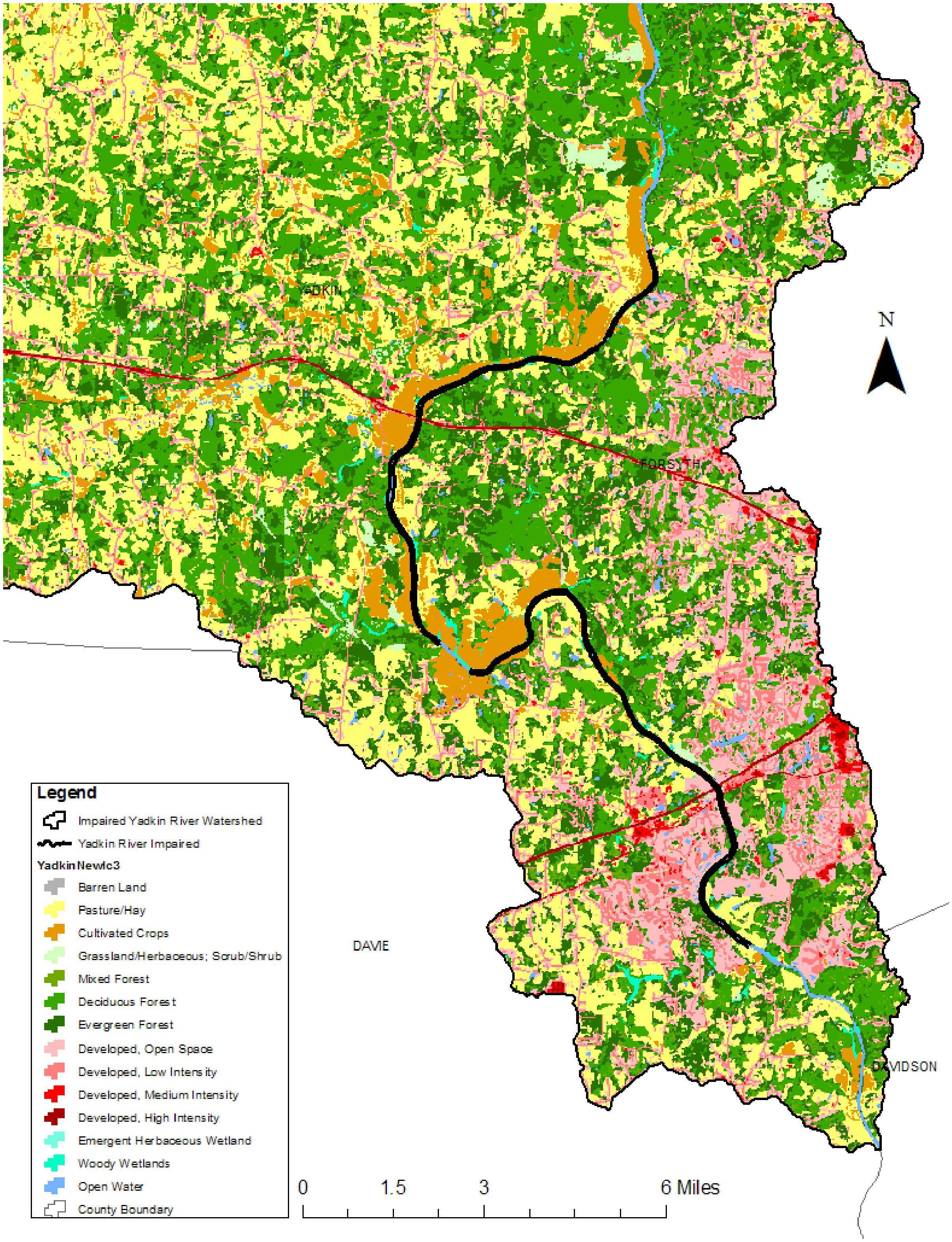

Figure 1.5 Land cover distribution of the Yadkin River Watershed

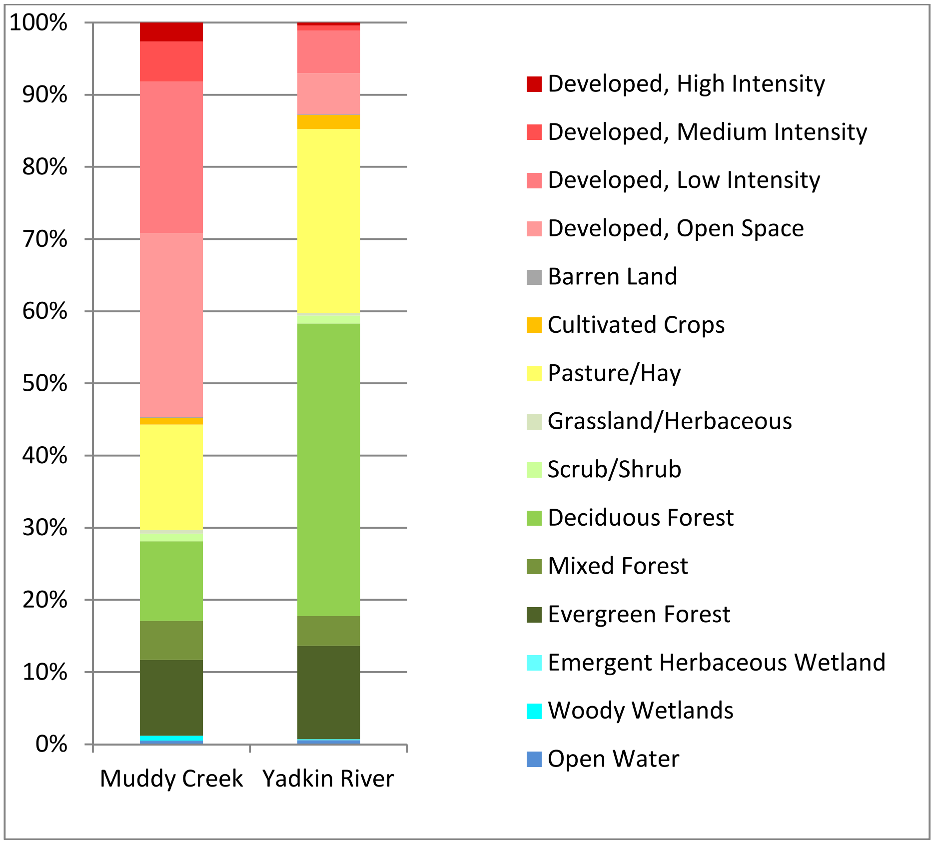

Figure 1.6 Land cover distribution in the impaired watersheds

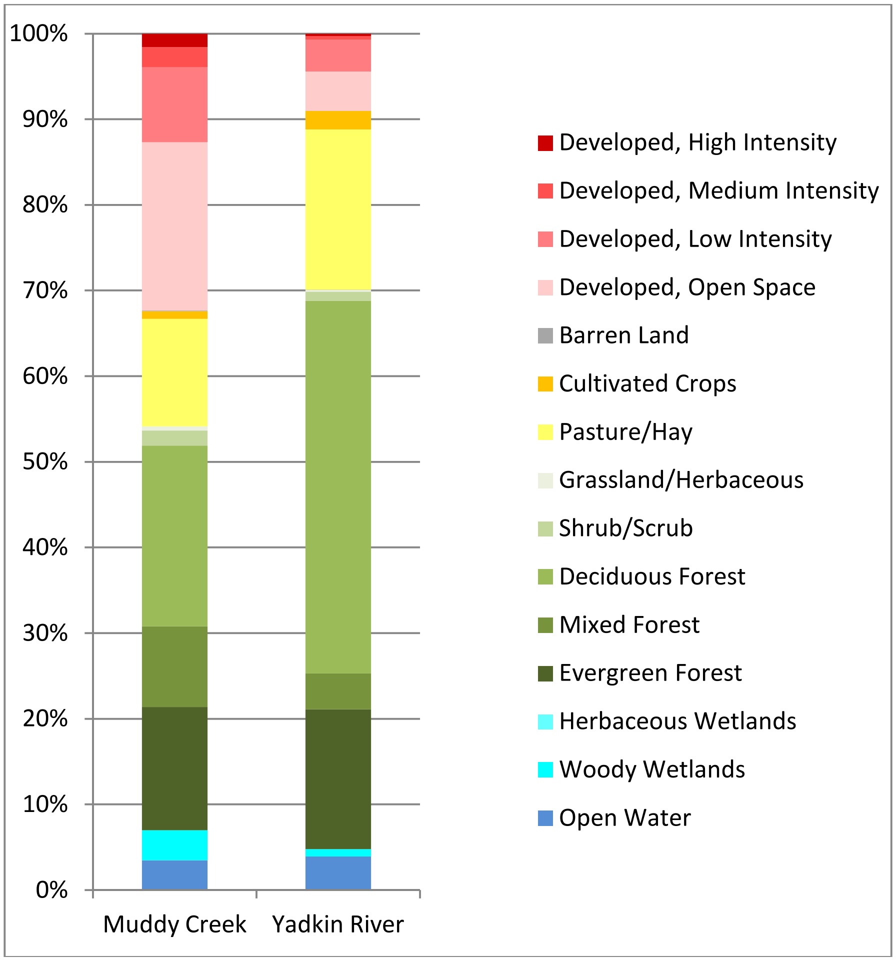

Figure 1.7 Land cover adjacent to streams in the impaired watersheds

1.4 Water Quality Monitoring

Turbidity and total suspended solids (TSS) data collected monthly at DWQ Ambient Monitoring Stations and one Yadkin Pee Dee River Basin Association were used for the TMDLs. The data period used for the TMDLs was from 2000 through 2009. The data used for the 2010 303(d) list assessment are summarized in Table 1.2. Detailed data used in this study is included in Appendix B.

Table 1.2 Summary of 2010 turbidity assessment (data from 2004-2008)

Waterbody	Assessment Unit	Station	Number of Samples	Number Exceeding Standard	Exceeding Percentage
Muddy Creek	12-94-(0.5)c	Q2710000	17	3	17.6
Yadkin River	12-(80.7)	Q2040000	75	10	13.3
Yadkin River	12-(86.7)	Q2180000	60	7	11. 7

2.0 General Source Assessment

Turbidity is a measure of the cloudiness of water. In a waterbody, the cloudiness can be increased due to silt and clay from watershed and stream erosion, organic detritus from streams and wastewater, and phytoplankton growth. In this study, turbidity is measured in Nephelometric Turbidity Units (NTU), which is significantly correlated with total suspended solid (TSS) in this watershed. The relationship between turbidity and TSS is discussed below.

2.1 Nonpoint Sources of Turbidity

Potential sources of turbidity from nonpoint sources are forests, agricultural lands, land disturbance, urban runoff, and stream channel erosion. Surface runoff is the main carrier of sediments from forests and agricultural land. Normally, runoff flowing through undisturbed forest carries insignificant amounts of sediments. Runoff flowing through agricultural land can carry a substantial amount of sediments, depending on erodibility of soils, types of agricultural practices, crop type and density, rainfall intensity, and existence and type of agricultural BMPs.

Urbanization also increases the amount of sediment transported to receiving waters. Impervious urban landscapes like roads, bridges, parking lots, and buildings prevent rainwater from percolating into the ground. In impervious areas, rainwater remains above the land surface, gathers sediments and solid materials, and runs off in large amounts.

2.2 Point Sources of Turbidity

Point sources are distinguished from nonpoint sources in that they discharge directly into streams at discrete points. Point sources of turbidity consist primarily of industries, wastewater treatment plants, and Municipal Separate Storm Sewer Systems (MS4). Municipal storm sewer systems can quickly channel urban runoff from roads and other impervious surfaces. When it leaves the system and empties into a stream, large volumes of quickly flowing runoff erode stream banks, damage streamside vegetation, and widen stream channels. The amount of sediment depends on erodibility of soils, types of surfaces, vegetation, rainfall intensity, and existence and type of BMPs. DWQ implements the Clean Water Act National Pollutant Discharge Elimination System (NPDES) permit program to control water pollution due to point sources. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.

<u>NPDES-Regulated Municipal and Industrial Wastewater Treatment Facilities</u>

Discharges from wastewater treatment facilities may contribute sediment to receiving waters as total suspended solids (TSS) and/or turbidity. Municipal and industrial treatment plants are assigned enforceable TSS limits to protect water quality. Notices of violation and civil penalties are examples of enforcement tools DWQ uses in order to bring non-compliant facilities into compliance.

<u>NPDES Stormwater Permits</u>

Most stormwater permittees are subject to TSS benchmarks. Relatively few permittees are required by the stormwater permits to monitor or address turbidity per se. Generally, permitted facilities are required to develop a stormwater pollution prevention plan, and conduct qualitative and/or quantative monitoring at stormwater outfalls. Monitoring parameters and monitoring frequency are selected for each site, or each industry group, based on DWQ’s assessment of the stormwater runoff pollution risks posed by the particular industrial activities under consideration.

<u>Municipal Separate Storm Sewer System (MS4)</u>

EPA requires NPDES permitted stormwater to be placed in the waste load allocation (WLA) of a TMDL (Wayland, 2002). In 1990, EPA promulgated rules establishing Phase I of the NPDES stormwater program. The Phase I program for Municipal Separate Storm Sewer System (MS4) requires operators of medium and large MS4s, which generally serve populations of 100,000 or greater, to implement a stormwater management program as a means to control polluted discharges from these MS4s. Phase II of the program expanded permit requirements to construction disturbing an acre or more and smaller communities (< 100,000 population) and public entities that own or operate an MS4.

3.0 Muddy Creek

3.1 Source Assessment

Nonpoint Sources

Potential sources of turbidity from nonpoint sources are described in section 2.1

Point Sources

NPDES wastewater and stormwater permittees upstream of an Ambient Monitoring Site that is not impaired (not intersected by the impaired waterbody) are not subject to the TMDL. Permittees that discharge directly to, or upstream of the impairment, yet still downstream of an unimpaired ambient monitoring site are subject to the TMDL and are discussed below.

NPDES Wastewater Permits

There are three facilities that discharge wastewater continuously to Muddy Creek and tributaries under the NPDES program (Table 3.1). In general, facilities are permitted to discharge a monthly average TSS concentration up to 30 mg/L. Locations of dischargers are shown in Figure 1.2.

Table 3.1 NPDES Wastewater Dischargers in the Muddy Creek Watershed

Permit Number	Facility Name	Permit Flow (gpd)	Total Suspended Solids Monthly Average Limit
NC0070033	Quail Run Mobile Home Park	17,000	30 mg/L
NC0083941	Spring Creek WWTP	80,000	30 mg/L
NC0086011	Neilson WTP	48,000,000	30 mg/L

MS4 and Individual Stormwater Permits

The Village of Clemmons (NCS000247), Winston Salem (NCS000410) and the NCDOT (NCS000250) are all MS4 stormwater permittees in the Muddy Creek Watershed.

3.2 Technical Approach

Endpoint for Turbidity

Turbidity is a measure of cloudiness and is reported in NTU. Therefore, turbidity is not measured in terms of concentrations and cannot be directly converted into loadings required for developing a load duration curve. For this reason, TSS was selected as the measure for this study.

In order to determine the relationship between TSS and turbidity in Muddy Creek, a regression equation between the two parameters was developed using the observed data collected from January 2000 through December 2009 at ambient station, Q2600000, on Muddy Creek. The relationship is shown in Equation 3.1. The coefficient of determination (R-Square) between the two parameters was 0.92, showing a strong relationship between the two parameters. The R^2 value is the percentage of the total variation in turbidity that is explained or accounted for by the fitted regression (TSS).

$$y = 1.2741x - 3.7835 \quad R^2 = 0.8947 \tag{3.1}$$

Where Y = TSS in mg/l and X = turbidity in NTU.

The corresponding TSS value at the turbidity standard of 50 NTU is 60 mg/L.

Methodology

The load duration curve method is intended to be a simple method to calculate pollutant reductions. This method was chosen for Muddy Creek because of the availability of long- term data. It is also an efficient method to calculate a percent load reduction from nonpoint sources. The methodology used to develop the load duration curve was based on Cleland (2002). The required load reduction was determined based on water quality monitoring and stream flow data from January 2000 through December 2009.

3.3 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 for the percent of time the flow values were equaled or exceeded. Flows are ranked from lowest, which are exceeded nearly 100 percent of the time, to highest, which are exceeded less than 1 percent of the time. Reliability of the flow duration curve depends on the period of record available at monitoring stations. Accuracy of the curve increases when longer periods of record are used. The flow duration curve, shown in Figure 3.1, was used to determine the seasonality and flow regimes during which the exceedances of the pollutants occurred.

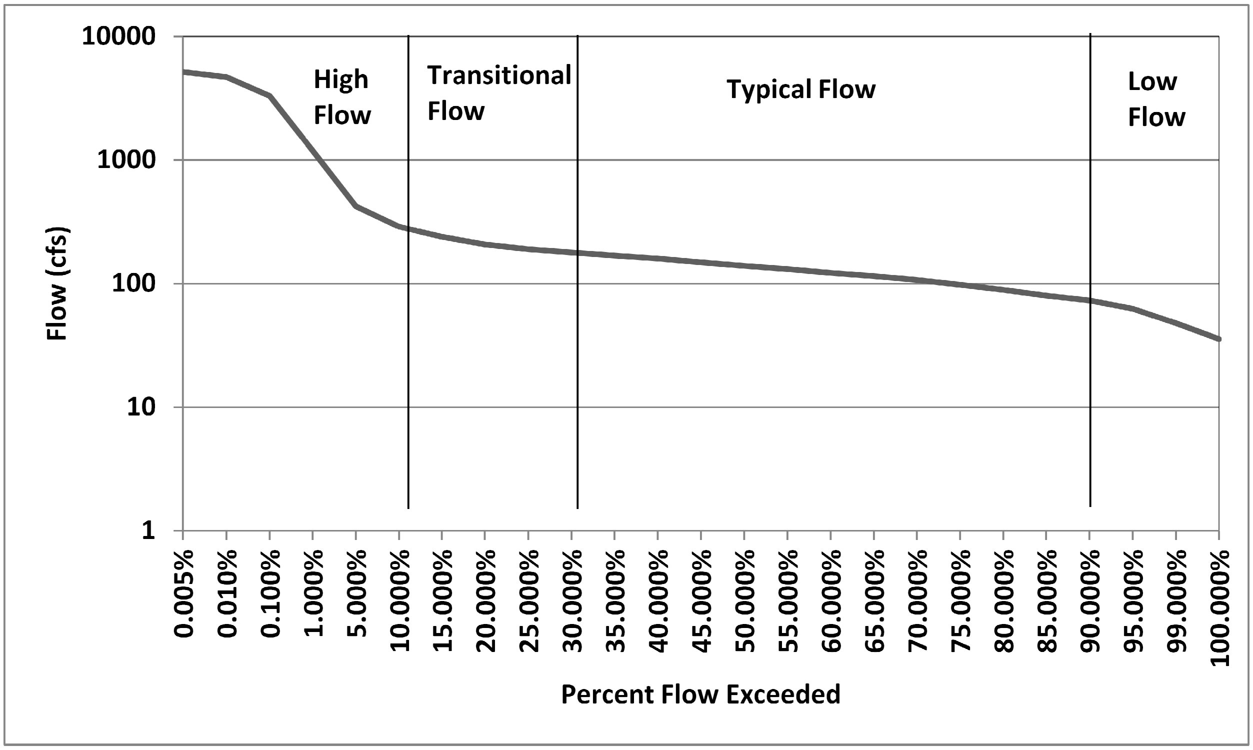

Figure 3.1 Flow Duration Curve for the Muddy Creek at DWQ Station Q2600000

Daily flow data were used from USGS Muddy Creek gauging station 02115860, co-located with the DWQ water quality monitoring station.

3.4 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 shown in Figure 3.2, allowable and existing loads are plotted against the flow recurrence interval. The allowable load is based on the water quality numerical standard, 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. Exceedances that occur 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 non-point sources may cause exceedances during normal flows.

Existing TSS loads to Muddy Creek were determined by multiplying the observed TSS concentration by the flow observed on the date of observation and converting the result to daily loading values. The assimilative capacities of the waterbodies were determined by multiplying the TSS concentration that is equivalent to a turbidity value of 50 NTU by the full range of measured flow values.

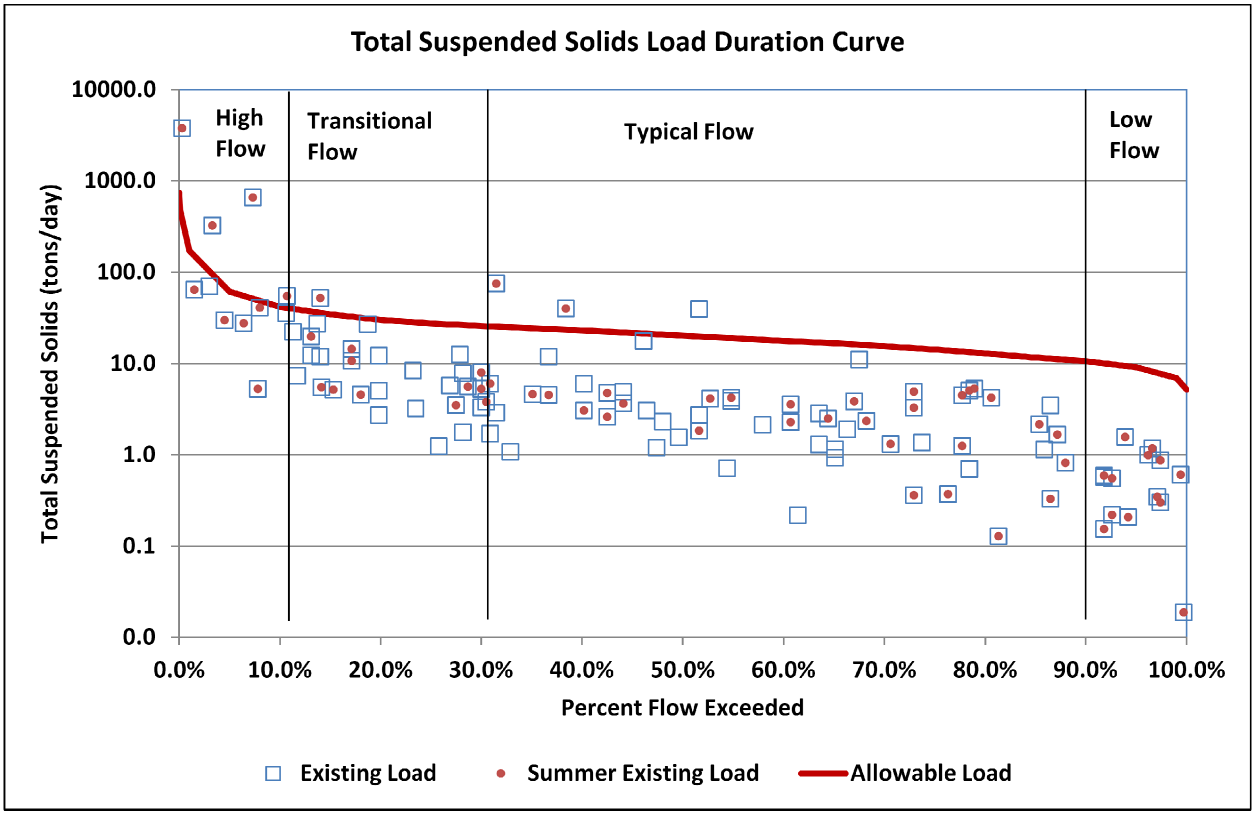

Figure 3.2 Load Duration Curve for Muddy Creek at DWQ station Q2600000

For Muddy Creek, the standard violations occurred during typical to high flow conditions. No exceedances during low-flow conditions suggest that point sources in the watershed may not be a significant source of TSS in this watershed. The higher loads during high and transitional flows suggest that the sources of turbidity could be from storm runoff and/or bank erosion. In addition most of the exceedances occurred during summer when thunderstorms would increase runoff. Stormwater runoff would carry a substantial amount of sediments and solid materials from impermeable as well as permeable land surfaces. Bank erosion may be another result of high and transitional flows. Bank erosion occurs when high volume and velocity runoff exceeds the resistance of the lateral (side) soil material. The loads during high flow period are considered unmanageable and hence are excluded in the TMDL estimation in this study.

3.5 TMDL

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 wasteload allocations (WLAs), nonpoint source load allocations (LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality. This definition can be expressed by equation 3.2.

$$TMDL = \sum WLAs + \sum LAs + MOS \qquad (3.2)$$

The purpose 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 TSS (measure for turbidity), TMDLs are expressed as tons per day. TMDLs represent the maximum one-day load the river can assimilate and maintain the water quality criterion. Load duration curve approach was utilized to estimate the TMDL for TSS. The systematic procedures adopted to estimate TMDLs are described below.

3.5.1 Margin of Safety (MOS)

Conceptually, 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 the TMDL analysis by setting the TMDL target at 10 percent lower than the water quality target for turbidity.

3.6 Target Reduction

To determine the amount of turbidity reduction necessary to comply with the water quality standard, exceedances of the estimated standard (estimated as 60 mg TSS/L) were identified within the 10^{th} to 90^{th} percentile flow recurrence range. Typically the remaining flow recurrence range is not included in the TMDL calculation to allow cases of extreme drought or flood to be excluded.

An exponential curve equation for the data points violating the water quality criterion was estimated. The equation is presented in Equation 3.3.

$$y = 63.197e^{-0.745x} \quad R^2 = 0.2299 \qquad (3.3)$$

Where, Y = TSS (tons/day) and X = Percent Flow Exceeded.

To present the TMDLs as a single value, the existing load was calculated from the exponential curve equation as the average of the load violations occurring between 10% and 90% flow exceedances. 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 exponential curve based on the exceedances are shown in Figure 3.3.

The necessary percent reduction was calculated by taking the difference between the average of the exponential curve load estimates and the average of the allowable load estimates. For example, at each recurrence interval between 10 and 90 (again using recurrence intervals in multiples of 5), the equation of the exponential 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 C.

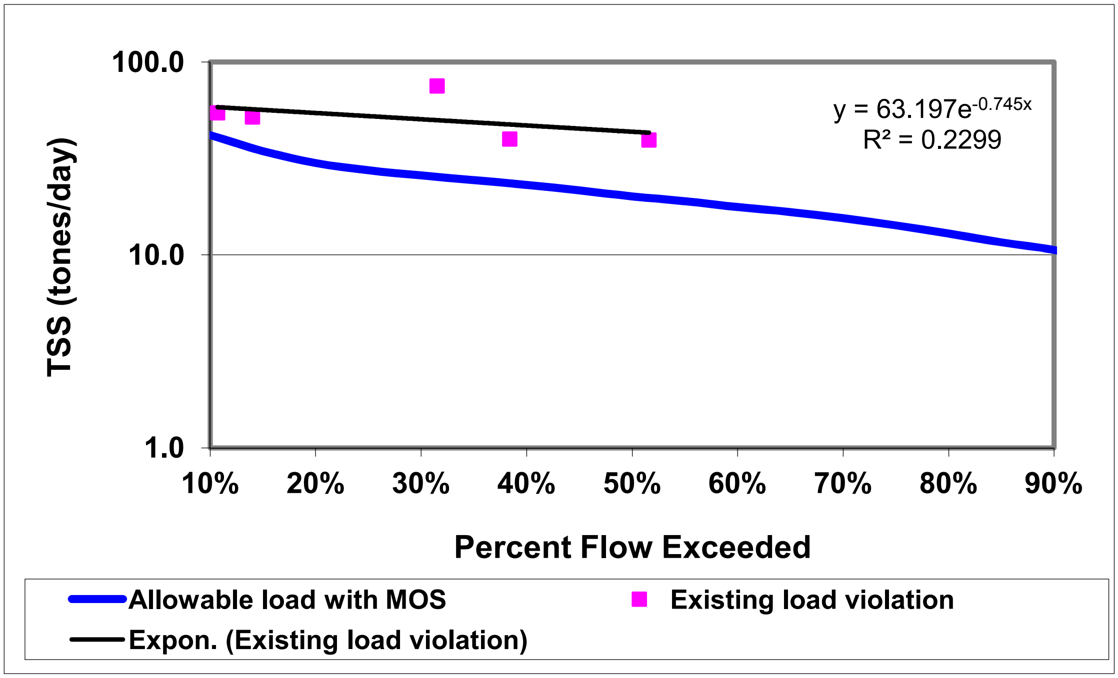

Figure 3.3 Load duration curve allowable TSS load and existing total TSS load violation in Muddy Creek

The exponential line representing the exceeding TSS loads in Figure 3.3 has a lower R-Square value due to presence of an observation that is numerically distant from the rest of the loads.

3.7 TMDL Allocation

3.7.1 Waste Load Allocation (WLA)

Two wastewater treatment plants (WWTP), a water treatment plant, plus the Village of Clemmons, Winston Salem and the NC Department of Transportation hold NPDES permits in the Muddy Creek Watershed. The wastewater load contributions are shown in Table 3.2

Table 3.2 Existing NPDES WW Load Contributions

Facility Name	Permit Number	Flow (gpd)	Permit Limit (monthly max in mg/L)	Load (tons/day)	% of Average Ambient Station Load
Quail Run Mobile Home Park	NC0070033	17,000	30	0.0019	0.004
Spring Creek WWTP	NC0083941	80,000	30	0.0091	0.02
Neilson WTP	NC0086011	48,000,000	30	5.4510	10.92

In order to estimate contributions from the WWTPs, it was assumed that all TSS discharged reaches the ambient station with no settling. Based on facility permit limits of flow and the monthly average permit limits for TSS, the combined WWTP load contributes approximately 11 percent of the average load at DWQ station Q2600000 based on data from years 2000 through 2009. It was concluded that the WWTPs are adequately regulated under existing permits and the waste load allocations in this TMDL were calculated at the existing permit limits.

The NCDOT, Village of Clemmons, and Winston-Salem MS4 permittees were considered significant contributors, and were assigned a percent reduction identical to the nonpoint source reduction. The NCDOT, Village of Clemmons, and Winston-Salem are currently in compliance with their NPDES stormwater permits, and will continue to implement measures required by their permits. Because of the nature of drainage from roads and other impervious areas, data are not available (n/a) to calculate a WLA for the stormwater permittees as a load.

The waste load allocation and required reductions for NPDES permittees in the Muddy Creek watershed are shown in Table 3.3.

Table 3.3 NPDES waste load allocations and required reductions

NPDES Permittee	Permitted Load (tons/day)	WLA (tons/day)	Percent Reduction Required
Quail Run Mobile Home Park	0.0019	0.0019	0%
Spring Creek WWTP	0.0091	0.0091	0%
Neilson WTP	5.4510	5.4510	0%
Village of Clemmons – MS4 Stormwater	N/A	N/A	58%
Winston Salem – MS4 Stormwater	N/A	N/A	58%
NCDOT – MS4 Stormwater	N/A	N/A	58%

3.7.2 Load Allocation (LA)

All TSS loadings from nonpoint sources such as non-MS4 urban land, agriculture land, and forestlands are reported as the LA. The estimated TMDL and allocation of TSS to point and nonpoint sources are presented in Table 3.4. The estimated percent reduction needed from NPDES stormwater and nonpoint sources is 58%, as shown in Table 3.5.

Table 3.4 Estimated TMDL and load allocation for TSS (tons/day) for Muddy Creek

Pollutant	Water Body	Existing Load (tons/day)	WLA	LA	MOS	TMDL
TSS	Muddy Creek	44.3	5.462	16.14	Explicit 10%	21.6

Note: The Margin of safety is included in the TMDL by lowering TSS value calculated at the 50 NTU standard by 10%

Table 3.5 Estimated reduction by source for TSS (tons/day) for Muddy Creek

	NPDES Wastewater WLA	NPDES Stormwater WLA	LA
Existing Load (tons/day)	5.462	N/A	38.8
Allocation (tons/day)	5.462	N/A	16.14
Percent Reduction	0%	58%	58%

3.7.3 Critical Condition and Seasonal Variation

Critical conditions are considered in the load duration 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.

Seasonal variation is considered in the development of the TMDLs, because allocation applies to all seasons. In the load duration curves, the mark inside a square box indicates pollutant load during the summer period.

The exceedances of turbidity occurred during normal to high flow periods. The result shows that wet weather under high-flow period is the critical period for turbidity in Muddy Creek.

4.0 Yadkin River

4.1 Source Assessment

<u>Nonpoint Sources</u>

Potential sources of turbidity from nonpoint sources are described in section 2.1

<u>Point Sources</u>

NPDES wastewater and stormwater permittees upstream of an Ambient Monitoring Site that is not impaired (not intersected by the impaired waterbody) are not subject to the TMDL. Permittees that discharge directly to, or upstream of the impairment, yet still downstream of an unimpaired ambient monitoring site are subject to the TMDL and are discussed below.

<u>NPDES Wastewater Permits</u>

There are 12 facilities that discharge wastewater continuously to the Yadkin River and tributaries under the NPDES program (Table 4.1). In general, facilities are permitted to discharge a monthly average TSS concentration up to 30 mg/L. Locations of dischargers are shown in Figure 1.4.

Table 4.1 NPDES Wastewater Dischargers in the Yadkin River Watershed

Permit Number	Facility Name	Permit Flow (gpd)	Total Suspended Solids Monthly Average Limit
NC0029599	Courtney Elementary School WWTP	5,000	30 mg/L
NC0029602	Forbush Elementary School WWTP	6,000	30 mg/L
NC0029611	East Bend Elementary School WWTP	7,000	30 mg/L
NC0031160	Pilot Mountain State Park WWTP	10,000	30 mg/L
NC0034827	Old Richmond Elementary School	6,400	30 mg/L
NC0055158	Bermuda Run WWTP	193,000	30 mg/L
NC0061204	Scarlett Acres MHP WWTP	20,000	30 mg/L
NC0063720	Forest Ridge WWTP	33,000	30 mg/L
NC0064726	East Bend Industrial Park WWTP	10,000	30 mg/L
NC0084212	Sparks Road WTP	No Permit Limit	30 mg/L
NC0084409	Wellesley Place WWTP	60,000	30 mg/L
NC0086762	Northwest WTP	35,000,000	30 mg/L

MS4 and Individual Stormwater Permits

Lewisville (NCS000494) and the NCDOT (NCS000250) are MS4 stormwater permittees in the TMDL portion of the Yadkin River Watershed.

4.2 Technical Approach

Endpoint for Turbidity

Turbidity is a measure of cloudiness and is reported in NTU. Therefore, turbidity is not measured in terms of concentrations and cannot be directly converted into loadings required for developing a load duration curve. For this reason, TSS was selected as the measure for this study.

In order to determine the relationship between TSS and turbidity in the Yadkin River, a regression equation between the two parameters was developed using the observed data collected from January 2000 through December 2009 at ambient station, Q2040000, on the Yadkin River. The relationship is shown in Equation 4.1. The coefficient of determination (R-Square) between the two parameters was 0.88, showing a strong relationship between the two parameters. The R^2 value is the percentage of the total variation in turbidity that is explained or accounted for by the fitted regression (TSS).

$$y = 0.0019x^2 + 0.3773x + 12.931 \quad R^2 = 0.8842 \qquad (4.1)$$

Where Y = TSS in mg/l and X = turbidity in NTU.

The corresponding TSS value at the turbidity standard of 50 NTU is 37 mg/L.

<u>Methodology</u>

The load duration curve method is intended to be a simple method to calculate pollutant reductions. This method was chosen for the Yadkin River because of the availability of long-term data. It is also an efficient method to calculate a percent load reduction from nonpoint sources. The methodology used to develop the load duration curve was based on Cleland (2002).The required load reduction was determined based on water quality monitoring and stream flow data from February 2000 through December 2009.

4.3 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 for the percent of time the flow values were equaled or exceeded. Flows are ranked from lowest, which are exceeded nearly 100 percent of the time, to highest, which are exceeded less than 1 percent of the time. Reliability of the flow duration curve depends on the period of record available at monitoring stations. Accuracy of the curve increases when longer periods of record are used. The flow duration curve, shown in Figure 4.1, was used to determine the seasonality and flow regimes during which the exceedances of the pollutants occurred.

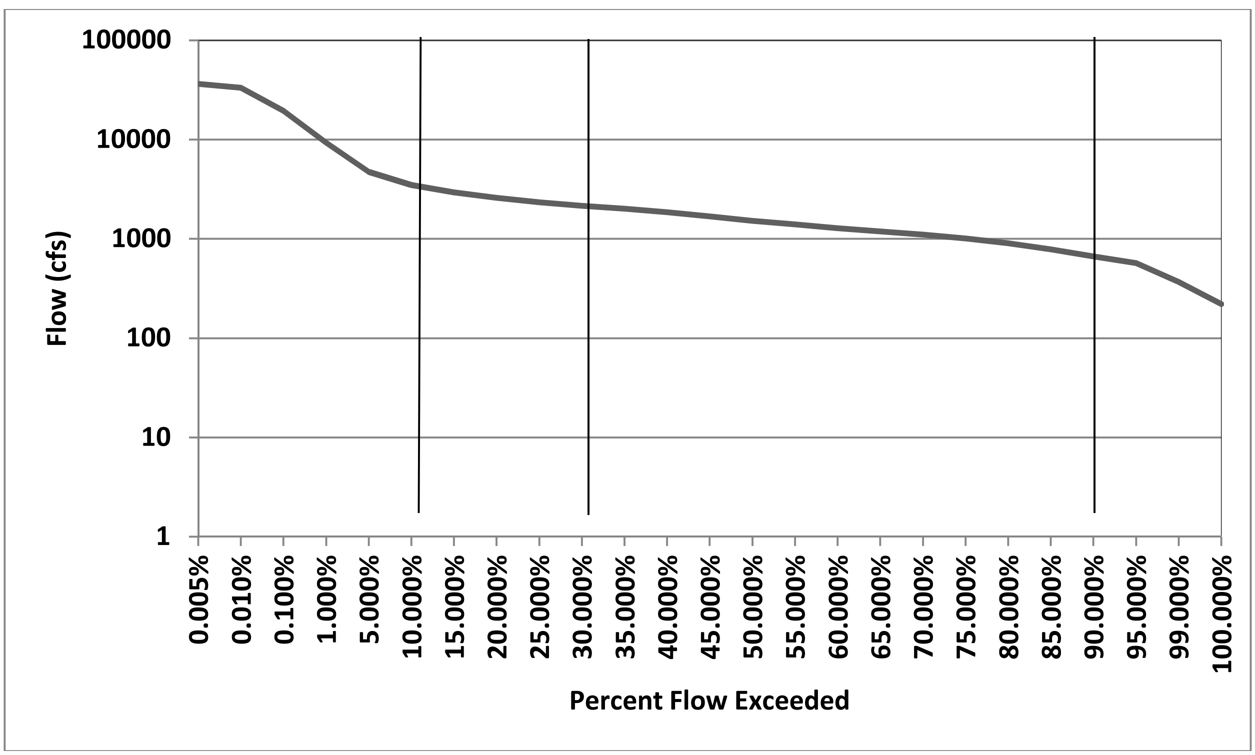

Figure 4.1 Flow Duration Curve for the Yadkin River at DWQ Station Q2040000

Daily flow data were used from USGS Yadkin River gauging station 02115360, co-located with the DWQ water quality monitoring station.

4.4 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 shown in Figure 4.2, allowable and existing loads are plotted against the flow recurrence interval. The allowable load is based on the water quality numerical standard, 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. Exceedances that occur 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 non-point sources may cause exceedances during normal flows.

Existing TSS loads to the Yadkin River were determined by multiplying the observed TSS concentration by the flow observed on the date of observation and converting the result to daily loading values. The assimilative capacities of the waterbodies were determined by multiplying the TSS concentration that is equivalent to a turbidity value of 50 NTU by the full range of measured flow values.

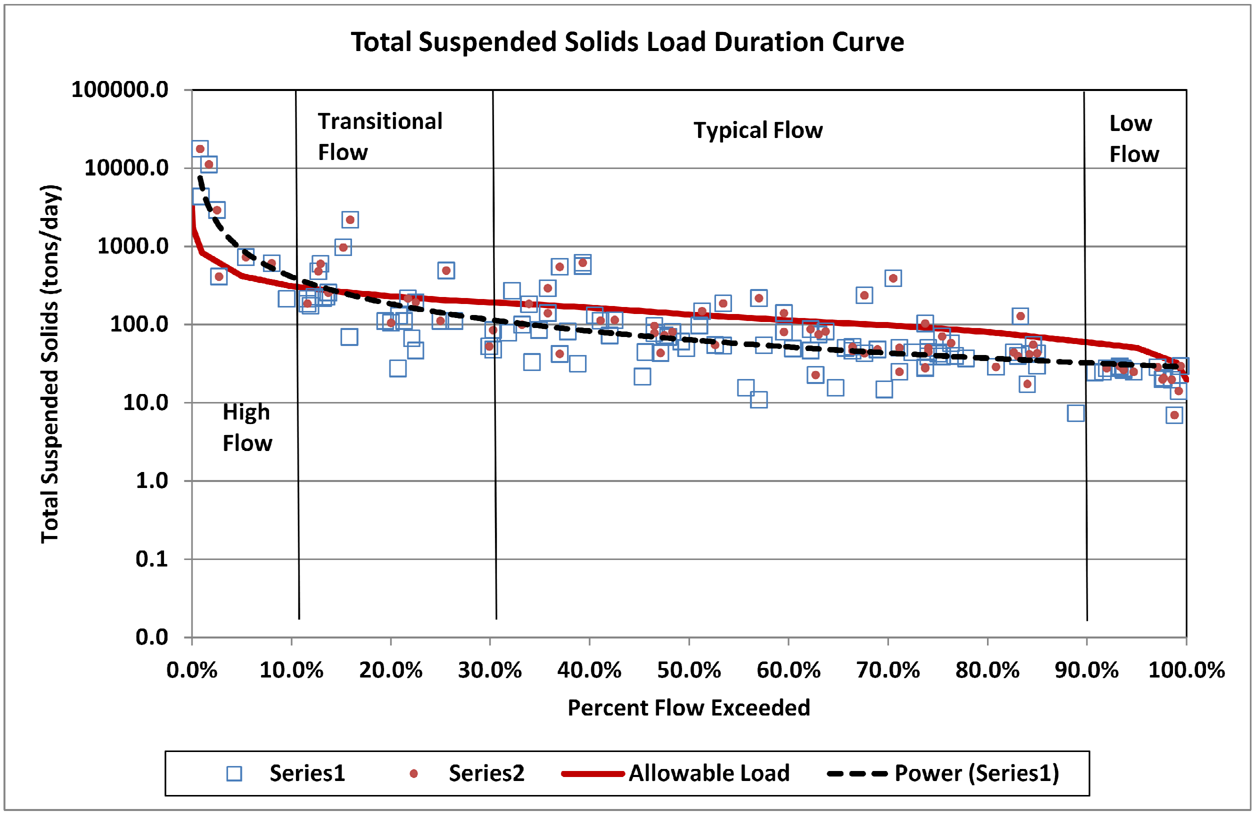

Figure 4.2 Load Duration Curve for the Yadkin River at DWQ station Q2040000

For the Yadkin River, the standard violations occurred mostly during typical to high flow conditions. Few exceedances during low-flow conditions suggest that point sources in the watershed may not be a significant source of TSS in this watershed. The higher loads during high and transitional flows suggest that the sources of turbidity could be from storm runoff and/or bank erosion. In addition most of the exceedances occurred during summer when thunderstorms would increase runoff. Stormwater runoff would carry a substantial amount of sediments and solid materials from impermeable as well as permeable land surfaces. Bank erosion may be another result of high and transitional flows. Bank erosion occurs when high volume and velocity runoff exceeds the resistance of the lateral (side) soil material. The loads during high flow period are considered unmanageable and hence are excluded in the TMDL estimation in this study.

4.5 TMDL

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 wasteload allocations (WLAs), nonpoint source load allocations (LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality. This definition can be expressed by equation 4.2.

$$TMDL = \sum WLAs + \sum LAs + MOS \tag{4.2}$$

The purpose 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 TSS (measure for turbidity), TMDLs are expressed as tons per day. TMDLs represent the maximum one-day load the river can assimilate and maintain the water quality criterion. Load duration curve approach was utilized to estimate the TMDL for TSS. The systematic procedures adopted to estimate TMDLs are described below.

4.5.1 Margin of Safety (MOS)

Conceptually, 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 the TMDL analysis by setting the TMDL target at 10 percent lower than the water quality target for turbidity.

4.6 Target Reduction

To determine the amount of turbidity reduction necessary to comply with the water quality standard, exceedances of the standard (estimated as 37 mg TSS/L) were identified within the 10^{th} to 90^{th} percentile flow recurrence range. Typically the remaining flow recurrence range is not included in the TMDL calculation to allow cases of extreme drought or flood to be excluded.

An power curve equation for the data points violating the water quality criterion was estimated. The equation is presented in Equation 4.3.

$$y = 125.94x^{-0.983} \quad R^2 = 0.606 \tag{4.3}$$

Where, Y = TSS (tons/day) 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 between 10% and 90% flow exceedances. 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 exponential curve based on the exceedances are shown in Figure 4.3.

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 90 (again using recurrence intervals in multiples 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 C.

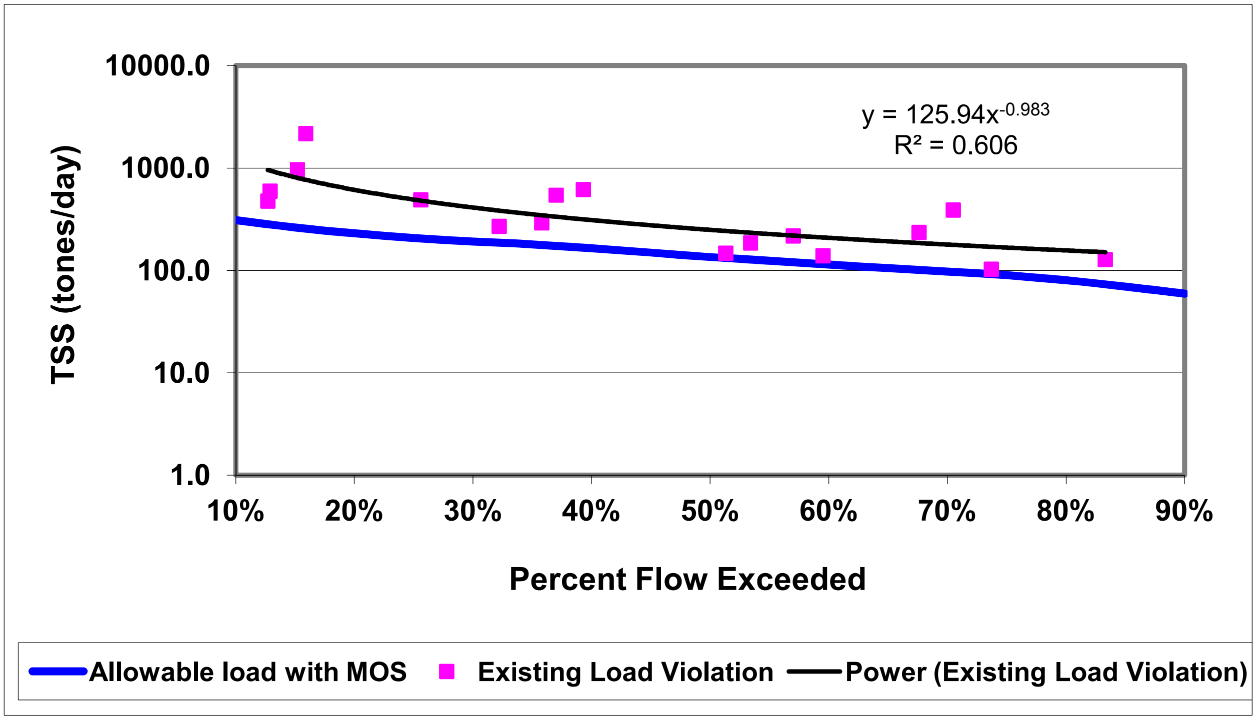

Figure 4.3 Load duration curve allowable TSS load and existing total TSS load violation in the Yadkin River

4.7 TMDL Allocation

4.7.1 Waste Load Allocation (WLA)

Twelve wastewater treatment plants (WWTP) plus the Town of Lewisville, and the NC Department of Transportation hold NPDES permits in the TMDL portion of the Yadkin River Watershed. The wastewater load contributions are shown in Table 4.2.

Table 4.2 Existing NPDES WW Load Contributions

Facility Name	Permit Number	Flow (gpd)	Permit Limit (monthly max in mg/L)	Load (tons/day)	% of Average Ambient Station Load
Courtney Elementary School WWTP	NC0029599	5,000	30	0.0006	0.0002
Forbush Elementary School WWTP	NC0029602	6,000	30	0.0007	0.0002
East Bend Elementary School WWTP	NC0029611	7,000	30	0.0008	0.0002

Facility Name	Permit Number	Flow (gpd)	Permit Limit (monthly max in mg/L)	Load (tons/day)	% of Average Ambient Station Load
Pilot Mountain State Park WWTP	NC0031160	10,000	30	0.0011	0.0003
Old Richmond Elementary School	NC0034827	6,400	30	0.0007	0.0002
Bermuda Run WWTP	NC0055158	193,000	30	0.0219	0.0061
Scarlett Acres MHP WWTP	NC0061204	20,000	30	0.0023	0.0006
Forest Ridge WWTP	NC0063720	33,000	30	0.0037	0.0010
East Bend Industrial Park WWTP	NC0064726	10,000	30	0.0011	0.0003
Sparks Road WTP	NC0084212	No Permit Limit	30	N/A	N/A
Wellesley Place WWTP	NC0084409	60,000	30	0.0068	0.0019
Northwest WTP	NC0086762	35,000,000	30	3.9747	1.0995

The Sparks Road WTP does not have a flow limit, therefore a load will not be calculated for this facility. In order to estimate contributions from the WWTPs, it was assumed that all TSS discharged reaches the ambient station with no settling. Based on facility permit limits of flow and the monthly average permit limits for TSS, the combined WWTP load contributes approximate 1% of the average load at DWQ station Q2040000 based on data from years 2000 through 2009. It appears that these WWTPs do not present a significant load to the Yadkin River. Therefore it was concluded that the WWTPs are adequately regulated under existing permits and the waste load allocations in this TMDL were calculated at the existing permit limits.

The NCDOT and Lewisville MS4 permittees were considered significant contributors, and were assigned a percent reduction identical to the nonpoint source reduction. The NCDOT and Lewisville are currently in compliance with their NPDES stormwater permits, and will continue to implement measures required by their permits. Because of the nature of drainage from roads and other impervious areas, data are not available (n/a) to calculate a WLA for the stormwater permittees as a load.

The waste load allocation and required reductions for NPDES permittees in the Yadkin River watershed are shown in Table 4.3.

Table 4.3 NPDES waste load allocations and required reductions

NPDES Permittee	Permitted Load (tons/day)	WLA (tons/day)	Percent Reduction Required
Courtney Elementary School WWTP	0.0006	0.0006	0%
Forbush Elementary School WWTP	0.0007	0.0007	0%

NPDES Permittee	Permitted Load (tons/day)	WLA (tons/day)	Percent Reduction Required
East Bend Elementary School WWTP	0.0008	0.0008	0%
Pilot Mountain State Park WWTP	0.0011	0.0011	0%
Old Richmond Elementary School	0.0007	0.0007	0%
Bermuda Run WWTP	0.0219	0.0219	0%
Scarlett Acres MHP WWTP	0.0023	0.0023	0%
Forest Ridge WWTP	0.0037	0.0037	0%
East Bend Industrial Park WWTP	0.0011	0.0011	0%
Sparks Road WTP	N/A	N/A	N/A
Wellesley Place WWTP	0.0068	0.0068	0%
Northwest WTP	3.9747	3.9747	0%
Lewisville - MS4 Stormwater	N/A	N/A	59%
NCDOT – MS4 Stormwater	N/A	N/A	59%

4.7.2 Load Allocation (LA)

All TSS loadings from nonpoint sources such as non-MS4 urban land, agriculture land, and forestlands are reported as the LA. The estimated contributions of TSS from the nonpoint sources are presented in Table 4.4. The estimated percent reduction needed from nonpoint sources is 59%, as shown in Table 4.5.

Table 4.4 Estimated TMDL and load allocation for TSS (tons/day) for the Yadkin River

Pollutant	Water Body	Existing Load (tons/day)	WLA	LA	MOS	TMDL
TSS	Yadkin River	361.50	4.014	146.986	Explicit 10%	151.00

Note: The Margin of safety is included in the TMDL by lowering TSS value calculated at the 50 NTU standard by 10%

Table 4.5 Estimated reduction by source for TSS (tons/day) for the Yadkin River

	NPDES Wastewater WLA	NPDES Stormwater WLA	LA
Existing Load (tons/day)	4.014	N/A	357.489
Allocation (tons/day)	4.014	N/A	146.986
Percent Reduction	0%	59%	59%

4.7.3 Critical Condition and Seasonal Variation

Critical conditions are considered in the load duration 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.

Seasonal variation is considered in the development of the TMDLs, because allocation applies to all seasons. In the load duration curves, the mark inside a square box indicates pollutant load during the summer period.

The exceedances of turbidity occurred during normal to high flow periods. The result shows that wet weather under high-flow period is the critical period for turbidity in the Yadkin River.

5.0 Summary and Future Implementation

This report presents the development of the Total Maximum Daily Loads (TMDL) for two waterbodies 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 curve load estimates and the average of the allowable load estimates. The summary of the results is as follows:

- Muddy Creek: A 52% reduction in nonpoint source and NPDES stormwater contributions of TSS is required in order to meet the water quality standard.

- Yadkin River: A 59% reduction in nonpoint source and NPDES stormwater contributions of TSS is required in order to meet the water quality standard. This reduction may be achieved in part through the reductions required for South Deep Creek.

5.1 TMDL Implementation

This section is intended to provide some initial guidance for implementing this TMDL. In order for these waterbodies to meet water quality standards, reductions from both point and nonpoint sources are needed. Under the jurisdiction of the Clean Water Act, as it relates to the development and executions of Total Maximum Daily Loads, reductions in turbidity needed from non-regulated nonpoint sources such as agriculture and silviculture can only be expected to be implemented on a voluntary basis. Reductions in turbidity from permitted MS4 entities will be achieved through incremental measures required through their permitting, with strategies adapted to best reduce pollutant loads to the receiving watershed to the maximum extent practicable. The efficacy of all measures will be determined at the ambient monitoring stations relied upon by the NC DWQ to determine use support status of the waters of the state, which may include more data in the future.

Nonpoint sources: Agricultural land comprises of 16 and 27 percent of the Muddy Creek and Yadkin River watersheds, respectively, based on 2007 land cover data. "Developed, Open Space" properties occupy 26 and 6 percent of the Muddy Creek and Yadkin River watersheds, respectively, based on 2007 land cover data. Reductions in turbidity from these and other rural nonpoint sources are needed to attain water quality standards in Muddy Creek and the Yadkin River. Reduction of turbidity will result from reduced overland flow and stormwater runoff, and improved land management. Landowners, stakeholder groups, local governments, and agencies are encouraged to utilize all available funding sources for water quality improvement projects within the watershed. The following programs provide technical and financial resources for reducing nonpoint source pollution:

- North Carolina Soil and Water Conservation Division
- The Natural Resources Conservation Service
- Clean Water Act Section 319 Nonpoint Source Pollution Control Grant (not available to NC MS4 communities to address turbidity or total suspended solids reductions following the initiation of this TMDL)
- North Carolina Clean Water Management Trust Fund
- 205(j) Water Quality Management Planning Grant

Point Sources: MS4 stormwater permittees identified in this TMDL and entities in the TMDL areas designated as MS4s in the future will be required to establish water quality recovery programs (WQRP), as described in their permits. The WQRP is a requirement under the stormwater permit when the entity is subject to an approved TMDL. The WQRP is designed by the entity and submitted to DWQ for approval. The program will outline ways to incrementally reduce turbidity. Example activities include ordinance enhancements, installing rain barrels, redevelopment with green infrastructure, or stormwater retrofits.

MS4 stormwater permittees are considered in compliance with this TMDL if they meet the conditions of their MS4 stormwater permit, which includes complying with their WQRP.MS4s alone are not responsible for attaining water quality standards at the ambient monitoring stations; we expect this attainment to be achieved through reduction from MS4s along with agriculture operations and other nonpoint source contributors to the high turbidity levels in these waters.

6.0 Public Participation

This TMDL was public noticed through the DWQ Modeling and TMDL unit website, through the Modeling and TMDL unit listserv, through the DWQ events calendar, and through the Water Resources Research Institute (WRRI) listserv of North Carolina State University. The announcement is provided in Appendix D. The TMDL was also available from DWQ's website at http://portal.ncdenr.org/web/wq/ps/mtu/tmdl/tmdls during the comment period. The public comment period lasted from July 26 – August 25, 2011. NCDWQ received comments from seven entities. A summary of their comments and DWQ's response is provided in Appendix E.

7.0 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.

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).

Wayland, R. November 22, 2002. Memorandum from Rober Wayland of the U. S. Environmental Protection Agency to Water Division Directors. Subject: Establishing TMDL Waste Load Allocation for stormwater sources and NPDES permit requirements based on those allocations.

Appendix A: Land Cover Data in Square Miles and Percent Area for the Impaired Watersheds

Description	Muddy Creek		Yadkin River	
Barren Land	0.3	0%	1.6	0%
Cultivated Crops	2.3	1%	37.8	2%
Deciduous Forest	28.2	11%	798.2	41%
Developed, High Intensity	6.7	3%	7.7	0%
Developed, Low Intensity	53.5	21%	116.3	6%
Developed, Medium Intensity	14.2	6%	14.2	1%
Developed, Open Space	65.2	26%	112.5	6%
Emergent Herbaceous Wetland	0.0	0%	0.0	0%
Evergreen Forest	26.8	10%	255.1	13%
Grassland/Herbaceous	1.2	0%	7.6	0%
Mixed Forest	13.8	5%	81.5	4%
Open Water	1.4	1%	11.1	1%
Pasture/Hay	37.3	15%	501.7	25%
Scrub/Shrub	2.7	1%	21.1	1%
Woody Wetlands	1.7	1%	2.3	0%
Total SQMI	**256**		**1969**	

Appendix B. Water Quality Data Used for TMDL Development

Muddy Creek DWQ Station Q2600000 and USGS station 02115860									
Sample Date	Flow (cfs)	TSS (mg/L)	Turbidity (NTU)	TSS Load (tons/day)	Sample Date	Flow (cfs)	TSS (mg/L)	Turbidity (NTU)	TSS Load (tons/day)
01/03/2000	115	3.00	4.30	0.93	11/28/2005	136	108.00	45.00	39.51
02/01/2000	151	12.00	15.00	4.87	12/19/2005	213	47.18	40.00	27.03
03/01/2000	132	2.00	4.60	0.71	01/18/2006	248	40.81	35.00	27.23
04/06/2000	223	24.00	19.00	14.40	02/23/2006	159	14.00	15.00	5.99
05/01/2000	177	8.00	9.00	3.81	04/25/2006	159	7.17	8.60	3.07
06/13/2000	93	18.00	12.00	4.50	05/11/2006	131	12.00	8.50	4.23
07/05/2000	92	20.42	19.00	5.05	06/28/2006	892	26.79	24.00	64.29
08/09/2000	88	17.88	17.00	4.23	08/03/2006	96	1.44	4.10	0.37
09/06/2000	181	11.51	12.00	5.60	08/23/2006	102	12.00	12.00	3.29
10/12/2000	78	1.57	4.20	0.33	09/28/2006	106	4.63	6.60	1.32
11/14/2000	92	2.84	5.20	0.70	10/26/2006	113	0.00	2.80	0.00
12/20/2000	117	4.12	6.20	1.30	11/20/2006	266	10.23	11.00	7.32
01/24/2001	126	6.28	7.90	2.13	12/19/2006	131	11.00	8.30	3.88
02/20/2001	117	9.00	11.00	2.83	01/25/2007	185	11.51	12.00	5.73
04/30/2001	102	1.31	4.00	0.36	02/26/2007	207	22.00	27.00	12.25
05/30/2001	102	18.00	15.00	4.94	03/28/2007	175	6.15	7.80	2.90
06/27/2001	110	7.94	9.20	2.35	04/30/2007	154	6.28	7.90	2.60
07/25/2001	59	6.28	7.90	1.00	05/22/2007	121	11.00	7.30	3.58
08/27/2001	76	4.00	4.60	0.82	06/26/2007	280	72.66	60.00	54.73
09/25/2001	162	91.77	75.00	39.99	07/11/2007	151	8.96	10.00	3.64
10/11/2001	63	-0.22	2.80	-0.04	08/07/2007	65	1.19	3.90	0.21
11/15/2001	71	3.00	16.00	0.57	09/24/2007	55	2.33	4.80	0.35
12/10/2001	78	16.60	16.00	3.48	10/23/2007	54	2.08	4.60	0.30
01/07/2002	111	36.99	32.00	11.04	11/05/2007	79	5.39	7.20	1.15
02/26/2002	101	5.00	3.90	1.36	12/10/2007	76	0.00	2.20	0.00
03/27/2002	147	44.63	38.00	17.65	01/30/2008	113	6.28	7.90	1.91
04/22/2002	112	12.78	13.00	3.85	02/27/2008	146	7.80	9.50	3.06
05/23/2002	80	10.00	8.90	2.15	03/25/2008	115	3.73	5.90	1.16
06/17/2002	57	7.68	9.00	1.18	04/16/2008	136	5.01	6.90	1.83
07/10/2002	45	5.01	6.90	0.61	05/29/2008	116	8.00	7.20	2.50
08/19/2002	54	6.00	7.70	0.87	06/23/2008	245	79.03	65.00	52.09
09/10/2002	42	0.17	3.10	0.02	07/28/2008	77	8.07	9.30	1.67
10/02/2002	87	0.55	3.40	0.13	08/27/2008	2580	546.00	310.00	3789.35
11/25/2002	140	4.12	6.20	1.55	09/25/2008	69	2.97	5.30	0.55
12/16/2002	255	17.88	17.00	12.26	10/23/2008	71	0.80	3.60	0.15
01/28/2003	120	0.68	3.50	0.22	12/01/2008	281	47.18	40.00	35.66
02/11/2003	143	6.00	6.40	2.31	12/18/2008	183	25.52	23.00	12.56
03/03/2003	270	30.62	27.00	22.24	01/20/2009	136	7.43	8.80	2.72
04/15/2003	459	24.25	22.00	29.94	02/19/2009	195	16.00	20.00	8.39
06/11/2003	366	28.07	25.00	27.64	03/26/2009	178	6.92	8.40	3.31
07/01/2003	243	8.45	9.60	5.52	05/05/2009	323	47.18	40.00	40.99
08/04/2003	528	230.00	180.00	326.67	06/04/2009	254	29.00	25.00	19.81
09/03/2003	235	8.19	9.40	5.18	06/29/2009	93	5.01	6.90	1.25
10/01/2003	184	7.05	8.50	3.49	07/22/2009	91	21.70	20.00	5.31
11/25/2003	207	9.00	9.10	5.01	08/25/2009	66	8.80	6.40	1.56
12/29/2003	188	2.46	4.90	1.24	09/21/2009	71	3.10	5.40	0.59
01/27/2004	172	2.33	4.80	1.08	10/21/2009	69	1.19	3.90	0.22
02/11/2004	245	18.00	22.00	11.86	11/30/2009	144	3.10	5.40	1.20
03/10/2004	176	3.61	5.80	1.71	12/10/2009	566	45.91	39.00	69.89
04/22/2004	176	12.78	13.00	6.05					
05/10/2004	175	160.00	100.00	75.32					
06/30/2004	165	10.23	11.00	4.54					
07/20/2004	168	10.23	11.00	4.62					
08/30/2004	121	7.00	5.10	2.28					
09/14/2004	326	6.03	7.70	5.29					
10/06/2004	178	16.60	16.00	7.95					
11/23/2004	165	26.79	24.00	11.89					
12/01/2004	194	6.15	7.80	3.21					
01/04/2005	182	3.61	5.80	1.77					
02/14/2005	182	16.00	8.60	7.83					
03/09/2005	207	4.88	6.80	2.72					
04/19/2005	217	7.81	9.10	4.56					
05/05/2005	178	11.00	6.20	5.27					
06/23/2005	154	11.51	12.00	4.77					
07/21/2005	223	17.88	17.00	10.72					
08/09/2005	338	728.00	500.00	661.91					
10/18/2005	134	11.51	12.00	4.15					

Yadkin River DWQ Station Q2040000 and USGS station 02115360									
Sample Date	Flow (cfs)	TSS (mg/L)	Turbidity (NTU)	TSS Load (tons/day)	Sample Date	Flow (cfs)	TSS (mg/L)	Turbidity (NTU)	TSS Load (tons/day)
01/06/2000	1180	15.75	7.2	49.98	07/13/2005	3880	58.00	60	605.36
02/09/2000	1350	3.00	5.5	10.89	07/27/2005	1820	23.00	24	112.60
03/08/2000	1110	5.00	6.5	14.93	08/09/2005	2870	282.14	290	2178.19
04/05/2000	3170	70.00	50	596.91	08/25/2005	1630	22.00	19	96.46
05/04/2000	1610	10.00	11	43.31	09/22/2005	1050	10.00	7.1	28.25
06/05/2000	1250	26.00	21	87.43	10/17/2005	1460	14.00	14	54.98
07/11/2000	806	8.00	15	17.35	10/25/2005	1240	6.80	3	22.68
08/14/2000	794	26.00	37	55.53	11/21/2005	1250	13.81	2.3	46.43
09/07/2000	1140	77.00	75	236.13	11/28/2005	1380	4.20	2.7	15.59
10/02/2000	838	19.45	16	43.85	01/05/2006	2560	4.00	25	27.55
11/01/2000	645	14.39	3.8	24.97	01/17/2006	3290	24.00	23	212.40
12/04/2000	689	4.00	14	7.41	02/01/2006	2160	8.20	6.5	47.65
01/02/2001	784	14.12	3.1	29.78	02/16/2006	1910	6.20	3.8	31.85
02/05/2001	948	14.51	4.1	37.00	03/02/2006	1680	4.80	3.6	21.69
04/30/2001	1040	18.00	9	50.36	03/15/2006	1540	12.00	5.9	49.71
05/23/2001	1970	102.99	140	545.79	03/30/2006	1200	4.80	4.7	15.49
06/07/2001	1350	60.00	36	217.89	04/06/2006	1140	14.00	6.3	42.93
07/10/2001	1100	131.98	170	390.53	04/27/2006	2060	33.00	21	182.87
08/27/2001	785	20.34	18	42.95	05/18/2006	1300	23.00	19	80.43
09/05/2001	984	22.00	12	58.23	06/01/2006	1050	9.80	8.3	27.68
10/02/2001	615	17.73	12	29.34	06/15/2006	1010	26.00	32	70.64
11/01/2001	606	16.89	10	27.54	06/26/2006	2510	32.00	8.2	216.06
12/11/2001	1890	110.00	100	559.25	07/17/2006	1300	40.00	95	139.88
01/28/2002	1840	26.45	31	130.93	07/27/2006	1440	48.00	31	185.93
02/26/2002	1020	15.54	6.7	42.65	08/07/2006	891	12.00	13	28.76
03/27/2002	2100	48.00	55	271.15	08/22/2006	1040	16.00	16	44.76
04/22/2002	1230	22.61	23	74.82	10/03/2006	1090	8.50	10	24.92
05/23/2002	801	19.45	16	41.92	10/26/2006	1170	14.75	4.7	46.41
06/17/2002	481	22.00	16	28.47	11/20/2006	3550	22.15	22	211.53
07/10/2002	396	18.59	14	19.80	12/20/2006	1440	13.92	2.6	53.94
08/19/2002	453	16.40	8.8	19.98	01/16/2007	2270	18.16	13	110.87
09/10/2002	324	34.00	2.5	29.63	03/21/2007	3260	19.89	17	174.46
10/02/2002	829	17.73	12	39.54	05/03/2007	1600	16.89	10	72.71
11/25/2002	1590	16.23	8.4	69.44	05/29/2007	1170	16.52	9.1	52.00
12/16/2002	3140	26.00	26	219.61	07/05/2007	1120	16.00	20	48.20
01/28/2003	1280	14.31	3.6	49.29	07/19/2007	1050	36.55	50	103.22
02/11/2003	1550	14.47	4	60.34	08/28/2007	636	16.15	8.2	27.63
03/03/2003	3110	27.00	25	225.88	09/13/2007	380	6.80	8.1	6.95
04/15/2003	6130	24.99	28	412.00	10/31/2007	1090	17.31	11	50.76
06/11/2003	4570	59.00	38	725.30	11/26/2007	659	13.77	2.2	24.41
07/01/2003	3300	20.79	19	184.51	01/02/2008	1790	15.00	19	72.23
08/04/2003	7300	567.47	450	11143.33	01/15/2008	1040	14.04	2.9	39.28
09/04/2003	10900	600.00	450	17592.60	02/27/2008	1340	15.14	5.7	54.59
10/13/2003	2160	14.63	4.4	84.99	03/25/2008	1660	10.00	8.6	44.65
11/18/2003	1950	15.54	6.7	81.54	04/14/2008	1580	19.00	16	80.75
12/02/2003	2490	10.00	8.1	66.98	05/12/2008	1490	37.00	55	148.30
01/28/2004	2110	13.81	2.3	78.38	06/09/2008	604	16.23	8.4	26.38
02/18/2004	2640	15.62	6.9	110.96	07/08/2008	823	58.00	130	128.40
03/22/2004	2050	6.00	10	33.09	08/06/2008	352	15.00	26	14.20
04/20/2004	2340	17.73	12	111.62	09/25/2008	446	17.31	11	20.77
06/01/2004	1770	24.03	26	114.39	10/08/2008	579	15.9895	7.8	24.90
06/22/2004	2310	79.00	75	490.90	11/20/2008	1010	14.4314	3.9	39.21
07/29/2004	1890	121.94	160	619.95	12/03/2008	973	15.1433	5.7	39.64
08/25/2004	1630	17.73	12	77.75	01/12/2009	3230	26	32	225.91
09/30/2004	6350	170.00	100	2903.86	02/05/2009	1070	15.4235	6.4	44.39
10/28/2004	2080	17.73	12	99.22	03/10/2009	1500	24	24	96.84
11/30/2004	2550	19.02	15	130.45	04/21/2009	2470	29	14	192.68
12/14/2004	2880	9.00	11	69.72	05/13/2009	2010	54	45	291.97
02/02/2005	2530	16.36	8.7	111.32	06/10/2009	3180	56	38	479.04
02/23/2005	2030	15.58	6.8	85.10	07/28/2009	1220	25	22	82.05
03/10/2005	2470	7.00	3.1	46.51	08/05/2009	1540	46	45	190.56
03/29/2005	10100	160.00	240	4347.04	10/01/2009	2190	49	35	288.66
04/25/2005	2600	15.00	14	104.91	10/26/2009	1230	6.8	7.2	22.50
05/05/2005	2170	9.00	5.3	52.54	11/04/2009	2100	17	19	96.03
05/10/2005	1970	8.00	4.6	42.39					
06/02/2005	2010	26.00	16	140.58					
06/16/2005	3080	31.00	45	256.84					
07/06/2005	2930	123.00	250	969.45					

Appendix C. Load Reduction Estimations

Estimation of Load Reduction Required for TSS for Muddy Creek at Station Q4120000.

% Flow Exceedance	Allowable Load (tons/day	Estimated Exceeding Load (tons/day)
10.00%	41.86	58.66
15.00%	34.58	56.52
20.00%	29.97	54.45
25.00%	27.50	52.46
30.00%	25.85	50.54
35.00%	24.40	48.69
40.00%	23.11	46.91
45.00%	21.61	45.20
50.00%	20.15	43.54
55.00%	19.01	41.95
60.00%	17.74	40.42
65.00%	16.71	38.94
70.00%	15.51	37.52
75.00%	14.25	36.14
80.00%	12.93	34.82
85.00%	11.64	33.55
90.00%	10.62	32.32
Average	**21.61**	**44.27**
Load Reduction Needed = 51%		

Estimation of Load Reduction Required for TSS for the Yadkin River at DWQ Station Q2040000

% Flow Exceedance	Allowable Load (tons/day	Estimated Exceeding Load (tons/day)
10.00%	308.92	1211.05
15.00%	261.87	812.95
20.00%	229.91	612.70
25.00%	206.83	492.03
30.00%	191.74	411.30
35.00%	179.32	353.46
40.00%	164.22	309.98
45.00%	149.13	276.09
50.00%	134.93	248.93
55.00%	124.28	226.67
60.00%	113.63	208.09
65.00%	105.64	192.34
70.00%	97.65	178.83
75.00%	89.66	167.10
80.00%	80.28	156.83
85.00%	69.52	147.76
90.00%	59.36	139.68
Average	**150.99**	**361.52**
Load Reduction Needed = 58%		

Appendix D: Public Notification of TMDL for Yadkin River Basin Turbidity TMDLS

NCDENR

North Carolina Department of Environment and Natural Resources

Division of Water Quality

Beverly Eaves Perdue
Governor

Coleen H. Sullins
Director

July 26, 2011
North Carolina Department of Environment and Natural Resources
Division of Water Quality

DRAFT Total Maximum Daily Load for Turbidity for *Abbotts Creek, Ararat River, Hunting Creek, Muddy Creek, Second Creek, South Deep Creek, South Yadkin River, Third Creek and the Yadkin River,* in the Yadkin River Basin, North Carolina

Now Available for Public Comment

This draft TMDL report was prepared as a requirement of the Federal Water Pollution Control Act, Section 303(d). Interested parties are invited to comment on the draft TMDL report by August 25, 2011. Comments concerning the report should be directed to Andy Painter at andy.painter@ncdenr.gov or write to:

Andy Painter
NC Division of Water Quality
Planning Section
1617 Mail Service Center
Raleigh, NC 27699

The draft TMDL can be downloaded from the following website:
http://portal.ncdenr.org/web/wq/ps/mtu/tmdl/tmdls#Draft

Appendix E: Public Comments

2011 Yadkin River Basin Turbidity TMDLs
Public Comment Response Summary

The comments received for this TMDL were based on the public comment version which included assessment units for Muddy Creek and the Yadkin River. These two waterbodies were not included in the final TMDL presented here in order to allow time to meet with and explain the TMDL process to the MS4 permittees that would be impacted by these TMDLs. However, the comments received regarding Muddy Creek and the Yadkin River were left in the response summary and are addressed below.

Comments were received from:

- Piedmont Triad Regional Council (PTRC)
- Town of Lewisville
- Salisbury-Rowan Utilities
- Winston-Salem
- Village of Clemmons
- North Carolina Department of Transportation (NCDOT)
- North Carolina Conservation Network

1) PTRC:

This turbidity TMDL is for nine large watersheds, yet only identifies four (4) entities total that are responsible for reducing total suspended solids (TSS) loading to receiving waters. The waste load allocations (WLAs) identified in this TMDL may be able to restore receiving waters to conditions where they can meet the turbidity water quality standard if applied broadly across all sectors, however the ability of four entities to achieve this goal is doubtful, especially when considering the land uses and other likely sources of TSS in these nine watersheds. How does NC DWQ or the US EPA realistically expect these entities to be able to restore supportive water quality conditions when they occupy a small area of these watersheds and represent a fraction of the total mass of TSS loaded to receiving waters?

Response: Each TMDL has a Load Allocation, Wasteload Allocation and Margin of Safety. The TMDL Load Allocations show the reductions needed from nonpoint sources. The TMDL does not suggest that the wasteload allocations alone will achieve water quality standard attainment. Reductions for the identified jurisdictions are identical to the reductions for nonpoint sources.

2) PTRC , Town of Lewisville, Winston-Salem, Village of Clemmons:

The commenters mentioned that the Village of Clemmons and the Town of Lewisville have only been NPDES Phase II communities since 2005, and Winston-Salem since 2001. The commenters suggested that the DWQ acknowledge new stormwater ordinances and development regulations in this time period and the impacts of these requirements on the receiving streams have not had time to be assessed. Further, the need for additional expenses to mitigate stormwater sources of water quality pollutants is not readily apparent.

Response: The data used in the TMDL was from years 2000-2009. Implementation of the TMDL will not necessarily incur additional significant costs to the affected NPDES permit holders. The DWQ Stormwater Permitting Unit will consider recent improvements and determine further permit requirements in the next permit renewal.

3) PTRC , Town of Lewisville, Village of Clemmons:

The fiscal year has almost completed its first quarter, and the stormwater and public works budgets are final through June 2012. What will be the Implementation Timeline NC DWQ expects of entities given WLAs?

We are very concerned about the ramifications of these TMDL to growth in the Yadkin River basin. With these communities requiring greater on-site controls for TSS management, and non-permitted communities and rural areas not having these restrictions, there is a high potential to promote sprawl around urbanized areas, which will only add to the non-point source pollutant burden in these watersheds. This is of particular concern in Forsyth County around the communities of Winston-Salem, Clemmons, and Lewisville. How does NC DWQ intend to prevent these impacts to water quality?

Response: The implementation timeline will depend on your water quality recovery plan that you will submit as required under your stormwater permit. We expect the fulfillment of your water quality recovery plan to take several permit cycles. Because this TMDL can be implemented along with various existing permit requirements, and it only requires reductions in the named TMDL subwatersheds, it is not expected to trigger sprawl outside of MS4 jurisdictions.

4) PTRC, Town of Lewisville, Winston-Salem:

The commenters acknowledged that a TMDL Load Allocation has no regulatory authority to require a reduction from nonpoint sources. However, the commenters requested a clearer representation of the presence of animal and forestry operations and communities enrolled in cost-share programs to manage runoff. The commenters also requested greater acknowledgement that rural land uses are contributing to the impairment.

Response: General sources of nonpoint source pollution are described in section 2.1. The TMDL shows land cover for each watershed as well as land cover adjacent to streams for each watershed, including the distribution of agricultural lands (pasture/hay and crop). Further source assessment, including how land is managed, will be useful for TMDL implementation. Reductions in both point and nonpoint sources of turbidity are needed to meet water quality standards as stated in section 12. Reductions for the identified jurisdictions are identical to the reductions for nonpoint sources.

5) PTRC, Town of Lewisville:

All communities are willing to collect data to more precisely pinpoint the sources of TSS loading to receiving waters. The Village of Clemmons, the Town of Lewisville, and the City of Winston-Salem are all willing to collect and analyze water quality data within their jurisdictions, fill out QAPPs to ensure that their practices and methods meet NC DWQ and US EPA Office Of Water standards, and be audited by a third party to ensure quality control in the data. They are happy to do this in-house, or to work with an approved third party laboratory to collect and analyze the data. However, they are only willing to do this if this data will be used by NC DWQ in determining use support decision making. So long as the Division insists that only its staff is capable of adequately collecting and analyzing water quality data for regulatory and policy determination, it is not an effective use of funds for local governments to enrich the datasets for these impaired waters.

Response: The jurisdictions are encouraged to conduct additional monitoring to gain further knowledge of the watersheds' pollution sources. In addition, DWQ indeed uses data from various outside sources; municipalities interested in collecting data to be used for use support assessment should contact DWQ. Please review this website on data sources and how to submit data http://portal.ncdenr.org/web/wq/ps/mtu/assessment#4.

6) PTRC, Town of Lewisville, Winston-Salem:

The regression analyses correlating wet weather events to TSS violations makes a very poor argument on Muddy Creek (R^2 = 0.23). Has NC DWQ considered other sources of TSS that could be contributing to elevated levels? Of the five data analyzed to develop the WLA, one (20%) was collected under dry weather conditions, and the regression analysis does not strongly support a causative relationship between wet weather events and elevated TSS levels. This all suggests another possible source of TSS that remains undiscussed in the TMDL. How can NC DWQ expect local governments to make investments to reduce TSS loadings with BMPs when they cannot show with confidence that the TSS loadings are due to wet weather events? The ramifications are too great to make these investments without more confidence that they will improve water quality conditions.

Response: This is not a correlation between wet weather and TSS. The equation of this line was used to determine the target reduction as describe in section 6.6. Figure 6.2 shows that no exceedances occurred during low flow events. The R^2 of 0.23 for Muddy Creek refers to strength of the linear relationship between the calculated existing load exceedances in Figure 6.3. This response also addresses similar comments for the Yadkin River.

7) PTRC and Winston-Salem:

In response to a Biological Integrity TMDL on Salem Creek, the City of Winston-Salem has invested significant resources in retrofits and restoration projects to mitigate stormwater runoff to this tributary to Muddy Creek. They have also invested in several regional BMPs in this watershed, and required new, more intensive BMPs for new development. Does this TMDL consider the benefits of the efforts on Salem Creek to reduce turbidity levels in Muddy Creek? It is not referenced in the text of the TMDL. With water quality monitoring analyzed for this TMDL ceasing in 2009, there has not been enough time to judge the impacts of these practices to downstream water quality, nor is there evidence that the potentially significant impacts of these investments on Salem Creek may be having in addressing turbidity levels downstream in Muddy Creek

Response: The Salem Creek TMDL targeted Fecal Coliform. If the retrofits to reduce fecal coliform were targeted at stormwater, and also achieved a reduction in turbidity, this can be reflected in your water quality recovery program for your stormwater permit and count towards compliance with this TMDL.

8) PTRC:

The Town of Lewisville mainly lies on two tributaries of the large Yadkin River watershed (as identified in this TMDL). There is one water quality monitoring station upstream of these tributaries (Q2040000). The next water quality monitoring station lies approximately seven miles downstream. How was the WLA for the Town determined with this indirectly sampled data?

Response: Ambient station Q2040000 was used to develop the TMDL for both impaired segments of the Yadkin River for several reasons. One reason is that it is co-located with a USGS gage, which is ideal to develop the load duration curve. Second, the correlation of Turbidity vs. TSS for the lower ambient monitoring site, Q2180000, has an R^2 of 0.579, which is less than the TSS vs turbidity R^2 value of 0.88 for the ambient station (Q2040000) used in the TMDL. Finally, the turbidity data comparison between the two stations show that the data is comparable with median NTU values for Q2040000 and Q2180000 at 16 and 18 respectively for years 2000-2009. The change in reductions between the two stations would likely be insignificant, and uncertainty would be higher due to estimating flow and using the lower TSS vs NTU correlation from site Q2180000.

9) PTRC, Town of Lewisville:

The NC DWQ acknowledges that actions on the Yadkin River may be unnecessary if water quality conditions on the South Yadkin River improve. It appears to be the most prudent use of resources to provide support and time to the communities within the South Yadkin River watershed to address the turbidity issues in that watershed before resources and funds and perhaps unnecessarily spent in the Yadkin River watershed. <u>Is there a timeline of implementation and monitoring that will reflect this management strategy?</u>

Response: Perhaps the commenters are referring to South Deep Creek. Reductions in South Deep Creek alone are not expected to attain the turbidity standard in the Yadkin River. Your water quality recovery program can reflect your implementation and monitoring timeline.

10) Town of Lewisville:

At current the Town of Lewisville employs one full time person to manage all storm water related requirements and activities, and funds the storm water budget out of the general fund. Although there is no consideration given to fiscal impacts, the time and monetary investments associated with implementing a plan or program that may or may not be able to reach the required reductions set forth in the TMDL report are unreasonable and not seen as being efficient and effective use of tax dollars.

Response: Reductions required in the TMDL for NPDES stormwater permittees will be implemented through the stormwater permit, in the form of a water quality recovery program submitted to DWQ by each permittee. This plan will outline how each permittee will improve water quality. Implementation of the TMDL will not necessarily incur additional significant costs to the affected NPDES permit holders. An implementation section has been added to the TMDL to clarify responsibilities of MS4 permittees.

11) Town of Lewisville:

The Town does not disagree that there is an elevated amount of turbidity within the Yadkin River, although there still is no evidence proving the Town has contributed to this condition nor the ability to obtain the required reduction. Therefore, the Town feels the TMDL needs to delayed and restructured before implementation.

Response: Your water quality recovery program will describe how the Town will implement the TMDL. The monitoring you propose (see Comment 5) can assist with source identification and tracking of reductions.

12) Salisbury-Rowan Utilities:

- Table 7.1 (pg 55) & Table 7.2 (pg 60) Second Creek WWTP permitted capacity is 30,000 gpd.
- Pg 55 – Methodology subheading refers to Hunting Creek rather than Second Creek.
- Table 7.5 appears to be labeled Table 7.6 (pg 61)

Response: Thank you. We have made these corrections in the text.

13) Winston-Salem:

Overall, with the pollutants of concern in the watershed being nutrients and turbidity and given the nature of nutrient bound sediments, the draft TMDL's for turbidity should be developed jointly with the High Rock Lake TMDL efforts as they are so interdependent. This should take place with the formation of a Technical Advisory Committee or Stake holder process.

Response: These TMDLs were developed to address localized turbidity impairments in the High Rock Lake watershed. A separate analysis will be conducted to determine how to address the turbidity impairment in High Rock Lake. Winston-Salem is represented on the High Rock Lake nutrient TAC.

14) Winston-Salem:

On page 50 figure 6.3 shows TSS load exceedances within the 10% to 50% range approximately. We assume that there was a fair amount of extrapolation in estimating the required load reductions outside this interval. Is this appropriate in determining the load reduction?

Response: This TMDL approach estimates TSS reduction for any flow exceeded between 10% and 90%. Therefore, we developed Figure 6.3 to show the relationship between percent flow exceeded and daily TSS load to estimate an averaged TSS reduction for the flow exceedance between 10% to 90%. Any method used would require some percent reduction in turbidity. Implementation of this TMDL will involve adaptive management, with the ultimate measure of success attainment of the standard instream.

15) Village of Clemmons:

The Village of Clemmons represents only 6 square miles (2%) of the watershed within Muddy Creek. Land disturbance from agriculture and County development has to be a primary contributor to turbidity problems in Muddy Creek. No allowance has been made for natural, agricultural, and/or County development contributions to the problem and no provision has been proposed to remedy the contributions from these sources.

Response: The Load Allocation reported in the TMDL sets a limit, or "allowance," for turbidity originating from nonpoint sources. An implementation plan is not included in this TMDL. Local governments and other stakeholders are encouraged to design and carry out implementation plans. The monitoring proposed in Comment 5 could assist with source identification and tracking of reductions. Your water quality recovery program can describe how you will differentiate contributions from the Village of Clemmons from other sources.

16) Village of Clemmons:

We are aware of existing and former sand dredging operations located on Muddy Creek within and upstream of the impaired reach. These operations may have caused the reported turbidity violations and should be researched and evaluated for their potential contribution to turbidity problems.

Response: Sand dredging operations are not permitted to exceed the turbidity standard of 50 NTU in Muddy Creek. Sand dredging operations are permitted under general permit NCG520000. Please call the DWQ Winston-Salem Regional Office at 336-771-5000 if you observe a sand dredging operation causing excess turbidity in Muddy Creek.

17) Village of Clemmons:

> Muddy Creek is aptly named! Natural clay from the watershed soils is at least a major cause of turbidity problems. Long before the existence of Clemmons or any other modern development in the area, the stream had a reputation for turbidity. There are references to the stream being called "Muddy Creek" that date back to at least 1880, see: (http://dc.lib.unc.edu/cdm4/item_viewer.php?CISOROOT=/ncmaps&CISOPTR=1323&CISOBOX=1&REC=3)

Response: DWQ acknowledges that some soil types can make it more difficult to control erosion and turbidity. However Muddy Creek has met the turbidity standard in previous years. Muddy Creek was just added to the 303d list in 2010.

18) Village of Clemmons -

> With so many other likely contributors (natural conditions, agriculture, silviculture, sand dredging, transportation, County development, etc.) to turbidity problems in Muddy Creek, it is not appropriate to single out the Village of Clemmons as a primary polluter. Clemmons' contribution to the problem, while arguably present to some degree, has not been conclusively demonstrated or quantified and it is inappropriate to assign any quantitative responsibility without clear justification.

Response: It is currently difficult to quantify a justifiable load from stormwater outfalls within each municipality without monitoring those outfalls. However, MS4 permittees cannot be ignored when addressing a turbidity impairment, especially during wet weather events. The Village has not been "singled out." Nonpoint sources outside your jurisdiction have been assigned a load allocation. The monitoring proposed in Comment 5 could assist with source identification and tracking of reductions. Your water quality recovery program can describe how you will differentiate contributions from the Village of Clemmons from other sources.

19) Part 1 – NCDOT:

In the Source Assessment section for each of the nine named waterbodies in the report, the following paragraph is included for Point Sources:

Point Sources

NPDES wastewater and stormwater permittees upstream of the impairment that discharge above a water quality station that is not impaired for turbidity are not considered to be contributing to the impairment. They are not subject to the TMDL. Permittees considered to be contributing to the impairment are discussed below.

For each of the nine named waterbodies, the paragraph above implies that there exists a portion(s) of each watershed that is not subject to the TMDL from a point source discharge perspective. However, the portion(s) of each watershed not subject to the TMDL is not identified in the report. Since stream reaches and not water quality stations are the features that are labeled impaired in the 303(d) List, terms "impaired water quality stations" and "not impaired water quality stations" are undefined. Therefore, we interpret a *water quality station that is not impaired* as any instream point not falling within the twelve assessment units (AUs) described in Table 1.1 of the report.

Response: NPDES discharges not subject to the TMDLs are identified in the report by the description in the text (as repeated above). Water quality stations refer to Ambient Monitoring Sites as shown in the watershed maps in section 1.3 of the report. We have changed the term "water quality station" to "ambient monitoring site" in the text. Therefore an ambient monitoring site that is not impaired is shown on the watershed maps not falling within the 12 assessment units described in table 1.1 (also shown in red on the watershed maps in section 1.3). We would be happy to assist you with identifying areas of interest to you that are subject to the TMDL.

Part 2 - Comment Continued from 19 – Part 1

Under this interpretation, point source outfalls, by definition, fall into one of two categories: 1) those outfalls that directly discharge into an impaired reach, or 2) those outfalls that discharge upstream of an impaired reach (obviously, point source outfalls that discharge hydrologically downstream of an impaired reach never contribute pollutant loads to the impaired reach and, thus, could never contribute to the impairment). Hence, we interpret the paragraph above to mean that any NCDOT outfall that does not directly discharge into one of the twelve impaired AUs is an outfall above a water quality station that is not impaired for turbidity and, thus, not contributing to the impairment. If this interpretation is not DWQ's intent for how the TMDL regulated area is to be defined, then please include a map delineating the portion of the watershed considered to be contributing to the impairment and differentiate that area from those portions of the watershed not contributing to the impairment from a point source perspective. NCDOT considers this to be critically important information, especially given that we operate NPDES permitted outfalls that discharge upstream, downstream, and directly into the twelve impaired AUs.

Response: The paragraph above has been revised for clarification in the text as follows: "NPDES wastewater and stormwater permittees upstream of an Ambient Monitoring Site that is not impaired (not intersected by the impaired waterbody) are not subject to the TMDL. Permittees that discharge directly to, or upstream of the impairment, yet still downstream of an unimpaired ambient monitoring site are subject to the TMDL and are discussed below."

20) NCDOT:

For each of the nine named impaired waterbodies, NCDOT's wasteload allocation has been deemed not available, or "N/A", due to a purported lack of data to calculate existing and allowable TSS loadings from NCDOT roads and facilities. Despite the lack of data, the report claims that NCDOT is considered a "significant contributor", presumably based on professional judgment, but this is not stated in the report. Given that no supporting information is provided in support of this judgment call and given that NCDOT is in compliance with its NPDES permit as noted in the report, we believe the decision to label NCDOT as a significant contributor was made in an arbitrary fashion and, thus, not appropriate to include in this TMDL report. Since no supporting data is provided, we respectfully request that NCDOT not be labeled a significant contributor. Given NCDOT's strong compliance record with its NPDES permit, the basis for the implied percent load reduction requirements for NCDOT within each of the nine watersheds is not clear.

Response: DWQ is open to new ideas or methods to calculate wasteload allocations for DOT stormwater in TMDLs. It is possible for a permittee to be in compliance with its current permit, yet need to make further reductions to achieve water quality standards instream.

21) Part 1 – NCDOT:

Each of the nine TMDLs is based on a Load Duration Curve methodology using TSS as a surrogate for turbidity. A relatively long period of record (~10 years) for both flow and water quality monitoring was used in the analysis. DWQ represented existing TSS loading over the flow spectrum by fitting a curve represented by a dashed line through the monitored load points. For each of the nine watersheds, the existing load curve was below the allowable load, even with a margin of safety applied. Since the dashed existing load curve did not indicate a load reduction was necessary, DWQ used a variation of the Load Duration Curve methodology to recalculate the "existing load" by fitting a curve through a much smaller dataset that only included load points falling above the allowable curve. NCDOT has several concerns about this variation on the use of the Load Duration Curve methodology which are described using the Hunting Creek TMDL as an example, but the comments generally apply to each of the nine TMDLs. First, compared to the approximately 85 monitored load points falling between the 10th and 90th percentile flows, only three monitored data points were used as the basis for characterizing the "existing load" for Hunting Creek. In this case, only 3.5% of the available water quality data was used, which as a point of reference, is far less than DWQ's policy of indicating impairment by more than 10% of the data above the standard.

Response: The dashed line in the load duration curve figures represents the best fit for the entire data set. As shown in Table 1.2 in the text, 11 to 14 percent of the data has exceeded the turbidity standard. This is why the majority of the dashed lines in the load duration curve figures are below the allowable load line. The load duration curve methodology uses only the points exceeding the allowable load to provide a formula to estimate the exceeding load at a variety of flow ranges. This also enables data points that fall in ranges of extreme flow or drought conditions to be excluded from the TMDL calculation.

Part 2 – Continued from above

standard. Second, using such a small fraction of the available water quality data calls into question whether seasonality was adequately considered. In the case of Hunter Creek, Figure 5.2 suggests that only three samples, all collected during the summer, were used as the basis for calculating the load reduction requirement.

Response: Seasonality is included in the TMDL by using a long term 10 years of data for the TMDLs. This allows for a variety of flow conditions and seasonal variation to be captured in the data.

Part-3 Continued from above

Finally, and most importantly, NCDOT is concerned about the use of "manufactured" load exceedances in TMDL calculations and the subsequent regulations. The Hunting Creek load reduction calculation is based on an average of seventeen manufactured load exceedances labeled "Estimated Exceeding Load" in *Appendix C* and inappropriately labeled "Existing Load" in the *TMDL Allocation Summary* on page ii. We do not believe the labeling of these calculated load exceedances as "existing load" is appropriate because of the inherit bias in the methodology towards inflated loading estimates. By way of illustration, *Appendix C* reports the "existing load" of Hunting Creek at the 30th percentile flow to be 26.71 tons/day, whereas the numerous monitored loads on and immediately surrounding the 30th percentile flow suggest a measured existing load of around 5 tons/day. In summary, DWQ's methodology of recalculating existing loads based only on a small subset of the data results in inflated load estimates across the flow spectrum that are many times higher than the majority of the actual monitored loads.

Response: The equation from the best-fit line from the exceeding loads is used to calculated load exceedances across multiple flow ranges that are not represented by actual data points. This is a good method to estimate or model reductions needed across multiple flow ranges. An alternative method would be to take the TSS value from the highest exceeding point between the 90th and 10th percentile flow exceedance range and reduce it to the TSS standard. Any method used would require some percent reduction in turbidity. Implementation of this TMDL will involve adaptive management, with the ultimate measure of success attainment of the standard instream.

Part 4 – Continued from above

In addition, the existing load violation curves appear to only apply between certain flows; for example, Figure 5.3 implies that the existing load violation curve for Hunting Creek only applies between approximately the 20th and 50th percentile flow regimes. However, the data presented in *Appendix C* apply from the 10th to the 90th percentile flows. Each figure in the report depicting an existing load violation curve should be consistent in its extent with the load reduction calculations shown in *Appendix C*.

Response: The load duration curve methodology uses only the points exceeding the allowable load to provide a formula, in this case 20th to 50th percentile, to estimate the exceeding load at a flow ranges from 10th to the 90th percentile.

22) NCDOT:

There is a discrepancy between the load reduction percentages reported to be required for Muddy Creek presented in *Appendix C* (51%) and Table 6.3 (58%). Please clarify.

Response: The 51% reduction shown in Appendix C is the overall reduction needed based on the TMDL of 21.6 tons/day TSS. However, because NPDES WW discharges are not required to make a reduction, the reductions shown in the TMDL text are based on that of the load allocation only which does not include the wasteload allocation of 5.462 tons/day TSS.

23) NCDOT:

For each of the nine named waterbodies, a regression equation is presented describing the relationship between TSS and turbidity. The associated coefficient of determination (R-square) is cited as justification for using TSS as a surrogate for turbidity and the basis of the TMDL calculations. Given the importance of this justification to the validity of the TMDL calculation, we recommend that a plot showing the data and the regression relationship be presented along with the sample count.

Response: The turbidity and TSS data used in the TMDL can be found in Appendix B.

24) Part 1 NCDOT:

South Yadkin River – two separate AUs along the South Yadkin River appear to be each subject to a TMDL allocation equal to 25.4 tons TSS/day. This allocation seems to be calculated at a point along the upstream-most AU, 12-108-(14.5). However, the allocations conflict with three other TMDLs presented in the report. The TMDL calculations for the two South Yadkin River AUs were based on flow and water quality data collected near DWQ station Q3460000 located along AU 12-108-(14.5). Downstream of this AU is a reach of the South Yadkin River that is not impaired for turbidity, but downstream of this non-impaired reach is AU 12-108-(19.5)b which was assigned a TMDL allocation of 25.4 tons TSS/day. Since AUs 12-108-(14.5) and 12-108-(19.5)b each have an allowable loading of 25.4 tons TSS/day, NCDOT interprets the two TMDLs to mean that no additional TSS loading is allowable within the large intervening drainage area between the two AUs. Between station Q3460000 (TMDL calculation point along AU 12-108-(14.5)) and the downstream-most point along AU 12-108-(19.5)b is the large intervening drainage area in question.

Response: The South Yadkin River watershed is a large drainage area (906 sqmi) and contains other impaired streams included in this TMDL. Each stream received a unique TMDL. Reductions achieved from the impaired streams upstream of the South Yadkin River impairment will also count as reductions for the South Yadkin River TMDL. There is a 3.25 mile stretch of the South Yadkin River that is currently not impaired located between Aus 12-108-(14.5) and 12-108-(19.5)b. Two small unnamed tributaries flow in from the northeast to the South Yadkin River in this stretch; this approximately 7.75 square mile area is not a large intervening drainage area. This 3.5 mile stretch is *within the watershed draining to the impaired waters, and not above an unimpaired Ambient Monitoring Site, thus is subject to the TMDL.*

Part 2 – Continued from above

This drainage area is primarily composed of the TMDL watersheds of Hunting Creek, Third Creek, and Second Creek which have a combined TMDL loading of 21.2 tons TSS/day (11.2, 6.9, and 3.1 tons TSS/day, respectively). The allocation of 21.2 tons TSS/day to these three intervening drainage areas appears to be in conflict with the 25.4 tons TSS/day allocated to AU 12-108-(19.5)b and the 25.4 tons TSS/day allocated to AU 12-108-(14.5). Illustrated on Figure 1.14, DWQ ambient monitoring station Q3970000 appears to be located along AU 12-108-(19.5)b. Data for station Q3970000 is not presented in the report. Given the allocation conflict discussed above and the presence of station Q3970000, a separate TMDL calculation for AU 12-108-(19.5)b seems appropriate. Alternatively, DWQ could choose to not calculate a TMDL for AU 12-108-(19.5)b and move this AU from Category 5 to 4b of the Integrated Report citing that the TMDLs for AU 12-108-(14.5), as well as for Hunting Creek, Third Creek, and Second Creek are expected to result in attainment of the turbidity standard.

Response: The South Yadkin River watershed is a large drainage area (906 sqmi) and contains other impaired streams included in this TMDL. Each stream received a unique TMDL. Reductions achieved from the impaired streams upstream of the South Yadkin River impairment will also count as reductions for the South Yadkin River TMDL. Ambient monitoring station Q3970000 was not used to calculate the TMDL for the lower impaired section (12-108-(19.5)b because there is no flow gage located with that station. Second, the correlation of Turbidity vs. TSS has an R^2 of 0.552, which is less than the TSS vs NTU R^2 value of 0.88 for the upstream ambient station (Q3460000) used in the TMDL. Finally, the turbidity data comparison between the two stations shows that the data is comparable with median NTU values for Q3460000 and Q3970000 both at 22 for years 2000-2009. The change in reductions between the two stations would likely be insignificant, and uncertainty would be high due to estimating flow and using the lower TSS vs NTU correlation from site Q3970000.

25) NCDOT :

Yadkin River – similar to the South Yadkin River comments presented above, a TMDL allocation conflict also exists for the Yadkin River between AUs 12-(80.7) and 12-(86.7) which are separated by a reach of the Yadkin River that is not impaired for turbidity. AU 12-(80.7) and AU 12-(86.7) have each been assigned a TMDL allocation of 151.0 tons TSS/day. Again, NCDOT interprets the two Yadkin River TMDLs to mean that no additional loading is allowed between AUs 12-(80.7) and 12-(86.7). However, between the TMDL calculation point at station Q2040000 and AU12-(86.7) is the intervening drainage area of South Deep Creek which has been allocated a TMDL allowable load of 8.50 tons TSS/day. Since these TMDLs conflict with each other, DWQ should consider recalculating the TMDL for AU 12-(86.7) using data from station Q2180000 illustrated in Figure 1.18, or move AU 12-(86.7) from Category 5 to 4b as similarly discussed for the South Yadkin River situation.

Response: Ambient station Q2040000 was used to develop the TMDL for both impaired segments of the Yadkin River for several reasons. One reason is that it is co-located with a USGS gage used to develop the load duration curve. Second, the correlation of Turbidity vs. TSS for the lower ambient monitoring site, Q2180000, has an R^2 of 0.579, which is less than the TSS vs NTU R^2 value of 0.88 for the ambient station (Q2040000) used in the TMDL. Finally, the turbidity data comparison between the two stations show that the data is comparable with median NTU values for Q2040000 and Q2180000 at 16 and 18 respectively for years 2000-2009. The change in reductions between the two stations would likely be insignificant, and uncertainty would be high due to estimating flow and using the lower TSS vs NTU correlation from site Q2180000. Reductions achieved through the South Deep Creek TMDL will count towards reductions in both assessment units of the Yadkin River TMDL.

26) NCDOT :

Ararat River – similar to the South Yadkin River and Yadkin River situations discussed above, the Ararat River has two AUs, 12-72-(4.5)b and 12-72-(18), which appear to have each been allocated an allowable loading of 13.0 tons TSS/day based on a TMDL calculation point located along the upstream-most AU, 12-72-(4.5)b. Again, a large intervening drainage area contributes flow and presumably TSS loading between the TMDL calculation point at station Q1780000 and AU 12-72-(18), but this additional loading is not reflected in the TMDL for 12-72-(18). This conflicts with the wasteload allocation for the Pilot Mountain WWTP (NC0026646) and presumably with the allocation for the water treatment plant as well. Since Figure 1.4 indicates that DWQ ambient station Q1950000 is located along AU 12-72-(18), it is recommended that the TMDL for this AU be recalculated using data from this station in order to avoid the allocation conflicts.

Response: DWQ did not use data from ambient station Q1950000 because data collection at this station was discontinued in 2006.

27) North Carolina Conservation Network:

> *Exclusion of high flows*. The draft TMDL excludes loads in the highest flow periods as 'unmanageable' (p.29, 36, 43, 50, 58, 65, 73, 81, 89). It is true that many jurisdictions do not require development to manage or treat volumes beyond the 1 year, 24 hour storm. However, these unmanaged flows are not unmanageable; they just demand a different implementation strategy than DWQ has traditionally used. Specifically, high flows can be controlled through design standards for new and retrofitted development that protect the original hydrograph. The fact that the TMDLs consistently found that average loads exceeded the allowable load during high flows (for example, Abbotts Creek, p.29) indicates the need to develop allocations and strategies specifically targeting high flows.

Response: The highest 10% flows were excluded from the TMDL calculation to address extreme flows and this has been the general practice for most TMDLS developed using the LDC method so far. As the commenter suggested, if high flows are commonly occurring in an area a different implementation strategy can be employed to address these high flows. It should be noted that the load duration flow interval serves as an indicator of the hydrologic condition. Even though implementation is not a required element of the TMDL, the use of duration curve zones (e.g., high flow, moist, mid-range, dry, and low flow) presented in the TMDL provide useful information to direct potential implementation actions that most effectively address water quality concerns for various flow conditions.

28) North Carolina Conservation Network:

> *Lack of implementation plan*. The draft TMDL lacks an implementation plan, instead suggesting vaguely that stakeholders in the watershed should consider existing grant and incentive programs that have to date failed to prevent or cure impairment. That omission is a serious problem. We understand that there is a different between a TMDL model and an implementation plan; our argument is that the state cannot choose a non-arbitrary approach to calculating a TMDL and assigning load reductions without some minimal discussion of the approaches that will be relied upon in the implementation plan. For example, to the extent that volume control is a low cost way to reduce in-stream erosion (and therefore total loadings), the formula used to attribute the total load needs to include volume. So, the draft TMDL should outline the regulatory options the state envisions will be used to achieve the allocated reductions.

Response: An implementation section has been added to the TMDL explaining how the TMDL will be implemented through NPDES stormwater permits. Addressing nonpoint sources of turbidity beyond regulatory authority requires the will and cooperation among the community to voluntarily adjust land management practices and to use incentive programs listed in Section 12.1 of the report. An implementation plan, although very useful, is not required in a TMDL.

29) North Carolina Conservation Network:

Omission of MS4s and total volume. Perhaps because it does not address total volume, the draft TMDL does not describe the contribution of or assign volume reductions (as a wasteload allocation) to municipal separate storm sewer systems (MS4s) in the watershed. The discussion of point sources of turbidity acknowledges that "large volumes of quickly flowing runoff erode stream banks, damage streamside vegetation, and widen stream channels," and affirms that MS4s are point sources (p.25). However, the draft TMDL does not take account of the in-stream erosion caused by excess volumes of water. Doing so might require a different approach to attributing loading, expanding the formula at the heart of the calculation to account for the in-stream erosion associated with different volumes of discharge, apart from the TSS load carried by those volumes. Another way of saying this is that each point discharge is carrying a load of suspended sediment, and also a load of kinetic energy, and the combination causes turbidity; as written, the draft TMDL only takes into account the TSS, and not the kinetic energy, in attributing loadings to different sources. That matters, because control of volumes may be a low-cost strategy to reduce downstream turbidity, or at least to prevent it from becoming worse. We recommend that the TMDL be revised to incorporate total volumes, and to assign wasteload allocations to upstream MS4s in the form of total volume reductions.

Response: DWQ agrees high volume and resulting stream bank erosion is likely to contribute a significant portion of turbidity and that using volume as a surrogate parameter would be useful for turbidity TMDLs. DWQ is open to discussing the use of flow, or other innovative approaches for future TMDLs.

30) North Carolina Conservation Network:

Cumulative contributions to impairment. The draft TMDL states, for each of the nine waterbodies, that "permittees …that discharges above a water quality station that is not impaired for turbidity are not considered to be contributing to the impairment [further downstream]." (p.26, 33, 40, 47, 54, 62, 69, 77, 85). While that makes some sense for pollutants where impairment is purely a function of cumulative concentration, it is not a reasonable assumption where the downstream impairment is related nonlinearly to concentration, or is a function of a variable that is not appropriately expressed as a concentration. Both of those conditions are true for turbidity from in-stream erosion: overbank flooding may make it worse in non-linear increments; and the erosion is a function of total kinetic energy, not a concentration. To appropriately account for turbidity in impaired segments, the TMDL should incorporate the volume contributions of upstream MS4s, even above stations that are not impaired for turbidity.

Response: DWQ agrees that volume from upstream locations will contribute to stream bank erosion in the impaired sections. However this TMDL is not intended to address flow. The paragraph mentioned above has been changed in the text in response to comment 19-Part 2. DWQ is open to discussing the use of flow, or other innovative approaches for future TMDLs.

31) North Carolina Conservation Network:

Omission of construction stormwater. The draft TMDL omits another critical category of point source discharges that contribute to turbidity impairment: runoff from construction sites. Again, the draft acknowledges that NPDES stormwater permits are point source discharges, and presumably therefore should be addressed by the TMDL under 40 CFR 130.2(i). However, the draft TMDL does not discuss how runoff from construction sites has contributed to the observed impairment in any of the nine river or stream segments, and does not appear to take this runoff into account in assigning load reductions. It seems likely that, at any given time, a significant share of the impairment in the watershed is a product of temporary land-disturbing activities. Indeed, the draft TMDL says as much: "violations of the turbidity standard did not occur during low flows when continuous dischargers' contributions would be greatest" (Abbott Creek p.32); "higher loads during high and transitional flows suggest the sources of turbidity could be from storm runoff and/or bank erosion" (Ararat River, p. 36); other segments include similar comments. Construction stormwater should receive a wasteload allocation for a reduction in loadings. In keeping with North Carolina's water quality standards for turbidity, in watersheds that are impaired for turbidity (>50 NTUs), the TMDL should acknowledge that the NCG 010000 can authorize *no* increase in turbidity, and therefore no loading.

In this connection, it is worth noting that the state water quality standard for turbidity, which unfortunately includes ambiguous language about the relationship between best management practices (BMPs) and turbidity, does not obviate the need to address construction stormwater in the TMDL. The state water quality standard includes the sentence, "[c]ompliance with this turbidity standard can be met when land management activities employ BMPs recommended by the Designated Nonpoint Source Agency", 15 NCAC 02B .0211. In different contexts, DWQ has maintained that this is either a hopeful prediction (one who complies with BMPs will usually avoid violating the turbidity standard) or an assurance (if a discharger complies with BMPs, DWQ will not enforce against any turbidity violations that occur). Either way, it is not a statement of scientific fact; experience has confirmed repeatedly that BMPs are not sufficient to prevent actual turbidity violations. Science must drive the TMDL process, and so the TMDL must into account the actual contribution of construction stormwater to the impairment of the nine waterbodies.

Response: DWQ believes that a TMDL is not the best tool to address stormwater from construction sites due to the relative short time period in which sites are actually under construction and vulnerable to erosion. DWQ does not require on-site monitoring of stormwater runoff for construction sites and the uncertainty would be very high to estimate a load from construction sites with varying BMPs if DWQ were to base loading on construction stormwater runoff studies alone.