Fecal Coliform Total Maximum Daily Load for the Irwin, McAlpine, Little Sugar and Sugar Creek Watersheds, Mecklenburg County

Final
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Catawba River Basin

Prepared by:

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303(D) LIST INFORMATION

Basin	Catawba				
303(d) Listed Waters	Name of Stream	Description	Class	Index #	Miles
	Irwin Creek	From source to Sugar Creek	C	11-137-1	11.8
	Sugar Creek	From SR1156 Mecklenburg, to Hwy 51	C	11-137b	11.9
	Sugar Creek	From NC Hwy 51 to NC/SC state line	C	11-137c	1.2
	Little Sugar Creek	From source to Archdale Rd	C	11-137-8a	11.8
	Little Sugar Creek	From Archdale Rd to NC 51	C	11-137-8b	5.3
	Little Sugar Creek	From NC 51 to state line	C	11-137-8c	3.6
	McAlpine Creek	From source to SR 3356 (Sardis Rd)	C	11-137-9a	8.3
	McAlpine Creek	From SR 3356 to NC 51	C	11-137-9b	6.3
	McAlpine Creek	From NC 51 to NC 521	C	11-137-9c	4.7
	McAlpine Creek	From NC Hwy 521 to NC/SC state line	C	11-137-9d	1.1
8 Digit Cataloging Unit(s)	03050103				
Area of Impairment	69.3 stream miles				
WQS Violated	Fecal coliform bacteria				
Pollutant of Concern	Fecal coliform bacteria				
Sources of Impairment	Point and nonpoint				

PUBLIC NOTICE INFORMATION

Form(s) of Public Notification	A stakeholders group consisting of environmental groups, local utilities, and area residents was formed at the onset of the TMDL. This group met several times during TMDL development and reviewed the TMDL before formal public notice. Notification of the public review draft was accomplished through the internet and by fliers mailed to the basinwide mailing list for Mecklenburg County and the City of Charlotte. The public comment period for the TMDL was open from April 30, 2001 until May 31, 2001.
Did notification contain specific mention of TMDL proposal?	Yes
Were comments received from the public?	No
Was a responsiveness summary prepared?	N/A

TMDL INFORMATION

Critical conditions	Site-specific critical conditions occurred during periods of low stream flow coinciding with high fecal coliform loads from both the SSOs and the WWTPs
Seasonality	All seasons addressed
Development tools	Watershed model, BASINS Versions

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Supporting documents	"Fecal Coliform Total Maximum Daily Load for the Irwin, McAlpine, Little Sugar, and Sugar Creek Watersheds, Mecklenburg County" and references listed in report
TMDL(s)	Waterbody — TMDL (cfu/100mL)
	Sugar Creek — $8.4x10^{12}$ Little Sugar Creek — $9.4x10^{12}$ McAlpine Creek downstream of Sardis Road — $1.1x10^{13}$ McAlpine Creek upstream of Sardis Road — $6.8x10^{12}$
Loadings	*Sugar Creek watershed:* Point sources $7.4x10^{12}$ col/100mL (63% reduction) Nonpoint sources $8.9x10^{11}$ col/100mL (58% reduction) *Little Sugar Creek watershed:* Point sources $6.7x10^{12}$ col/100mL (43% reduction) Nonpoint sources $2.6x10^{12}$ col/100mL (19% reduction) *McAlpine Creek watershed (downstream):* Point sources $7.8x10^{12}$ col/100mL (70% reduction) Nonpoint sources $3.2x10^{12}$ col/100mL (28% reduction) *McAlpine Creek watershed (upstream):* Point sources $7.8x10^{12}$ col/100mL (32% reduction) Nonpoint sources $5.9x10^{11}$ col/100mL (68% reduction)
Margin of Safety	Implicit

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1 INTRODUCTION

North Carolina's 2000 303(d) list was approved by EPA Region IV on May 15th, 2001. The 2000 list identified ten stream segments, totaling 66.0 miles, in the Sugar, Little Sugar, and McAlpine Creek watersheds, as impaired due to elevated fecal coliform concentrations. The objective of this study is to develop a fecal coliform TMDL using a watershed approach for Irwin, Sugar, Little Sugar, and McAlpine Creeks. This TMDL encompasses all the stream segments listed in the 2000 303(d) list for these watersheds.

Table 1. Impaired stream segments listed in NC's draft 2000 303(d) list as Partially Supporting due to fecal coliform contamination.

Stream	Use Support Index No.	Location	Impaired Stream Miles
Irwin Creek	11-137-1	From source to Sugar Creek	11.8
Little Sugar Creek	11-137-8a	From source to Archdale Rd	11.8
Little Sugar Creek	11-137-8b	From Archdale Rd to NC 51	5.3
Little Sugar Creek	11-137-8c	From NC 51 to state line	3.6
McAlpine Creek	11-137-9a	From source to SR 3356, (Sardis Rd)	8.3
McAlpine Creek	11-137-9b	From SR 3356 to NC 51	6.3
McAlpine Creek	11-137-9c	From NC 51 to NC 521	4.7
McAlpine Creek	11-137-9d	From NC Hwy 521 to NC/SC stateline	1.1
Sugar Creek	11-137b	From SR 1156 Mecklenburg, to HWY 51	11.9
Sugar Creek	11-137c	From Hwy 51 to NC/SC border	1.2

In response to the high level of interest in this TMDL from local government officials and concerned citizens, a stakeholder group was formed in 1999. The stakeholder group, lead by the Mecklenburg County Department of Environmental Protection (MCDEP) and the NC Division of Water Quality (DWQ), took a very active role in every stage of the TMDL development process. MCDEP has a well developed and respected water quality management program and was able to take the lead role in both the source assessment and model development.

1.1 Background

Section 303(d) of the Clean Water Act (CWA) requires states to develop a list of waters not meeting water quality standards or which have impaired uses. This list, referred to as the 303(d) list, is submitted biennially to the U.S. Environmental Protection Agency (EPA) for review. The 303(d) process requires that a Total Maximum Daily Load (TMDL) be developed for each of the waters appearing on Part I of the 303(d) list. The objective of a TMDL is to allocate allowable pollutant loads to known sources so that actions may be taken to restore the water to its intended uses (EPA 1991). Generally, the primary components of a TMDL, as identified by EPA (1991, 2000) and the Federal Advisory Committee (FACA 1998), are as follows:

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

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

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

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

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

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

Section 303(d) of the CWA and the Water Quality Planning and Management regulation (USEPA 2000a) require EPA to review all TMDLs for approval or disapproval. Once EPA approves a TMDL, the waterbody may be moved to Part III of the 303(d) list. Waterbodies remain on Part III of the list until compliance with water quality standards is achieved. Where conditions are not appropriate for the development of a TMDL, management strategies may still result in the restoration of water quality.

The goal of the TMDL program is to restore uses to water bodies. Thus the implementation of bacterial controls will be necessary to restore uses in these creeks. Although an implementation plan is not included in this TMDL, reduction strategies are needed. The involvement of local governments and agencies will be needed in order to develop implementation plans. The MCDEP and affected groups began developing the implementation plan during public review of the TMDL.

1.2 Watershed Description

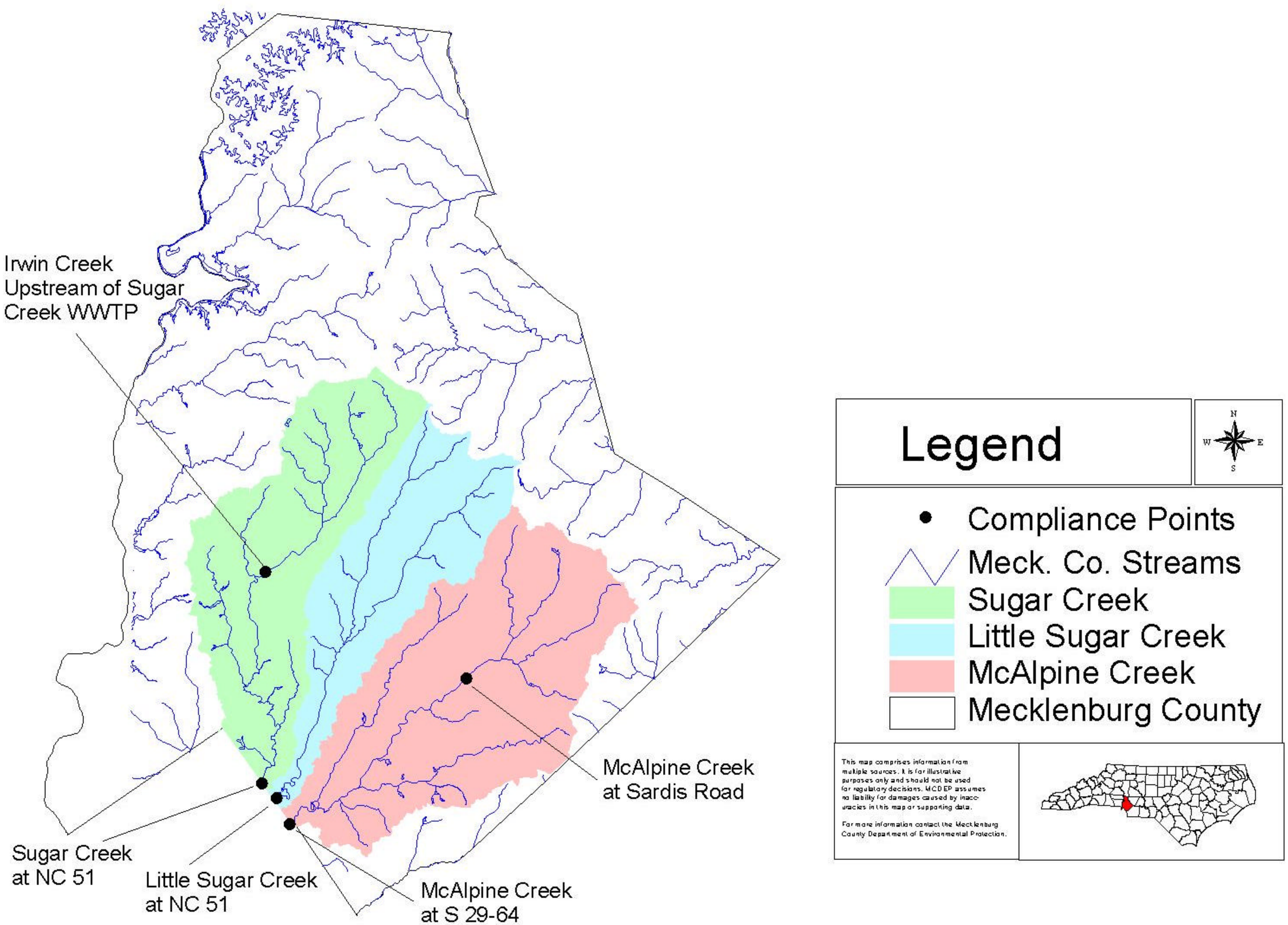
The Sugar, Little Sugar and McAlpine Creek watersheds are all located within Mecklenburg County, North Carolina. The headwaters of each watershed originates in Mecklenburg County and all three creeks flow into the State of South Carolina. In South Carolina, Little Sugar and McAlpine Creeks are tributary to Sugar Creek. Figure 1 shows the location of the three TMDL watersheds within Mecklenburg County.

Each compliance point utilized for this TMDL is associated with ambient monitoring that occurs in the watersheds. Water quality and quantity data is collected at multiple locations within these three watersheds by different agencies. For the purposes of assessing TMDL compliance the DWQ stations were used. There are five DWQ ambient monitoring stations within the Sugar, Little Sugar, and McAlpine Creek watersheds. These locations are noted on Figure 1. Other monitoring is discussed below.

1.3 Water Quality Monitoring Programs

The MCDEP, DWQ, Charlotte Mecklenburg Utilities (CMU), USGS, and South Carolina Department of Health and Environmental Control (DHEC) collect ambient data in the Sugar, Little Sugar, and McAlpine Creek watersheds at regular intervals. However, CMU analyses do not include fecal coliform bacteria. DWQ maintains five ambient monitoring locations in the Sugar, Little Sugar, and

Figure 1: Location of TMDL Watersheds Within Mecklenburg County



McAlpine Creek watersheds. MCDEP maintains over 15 monitoring locations and DHEC maintains three within North Carolina. A list of USGS flow gauges, DWQ ambient stations, and data summaries is presented in Appendix 1.

1.4 Water Quality Target

All TMDLs include the establishment of in-stream numeric endpoints, or targets, used to evaluate the attainment of water quality goals and designated use criteria. The target represents the restoration objective to be achieved by implementation of load reductions specified by the TMDL. For the TMDLs presented in this document, the fecal coliform 30-day geometric mean of 200 c.f.u./100 mL is applicable, as referenced in NC's water quality standard for fecal coliform in Class C waters (15A NCAC 2B .0211 (3)(e)).

Secondary recreation is the designated use being addressed in this TMDL. Secondary recreation is defined in NC's standards (15A NCAC 2B .0202 (57)) as including "wading, boating, other uses not involving human body contact with water, and activities involving human body contact with water where such activities take place on an infrequent, unorganized, or incidental basis." MCDEP officials believe that the streams addressed in this document are used for secondary recreation by the local residents predominantly during warm temperature, non-storm conditions. High stream flow activities such as white water kayaking are not known to take place on a frequent and organized basis in these predominantly urban streams. Hence, MCDEP and DWQ have focused the source assessment and TMDL allocation on those sources and conditions, which represent the highest risk to human health during the times of highest recreational use by the public.

For calibration purposes fecal coliform contributions delivered to the streams via stormwater runoff from unidentified sources were estimated and included in the model. However, loadings from unidentified, stormwater delivered sources were not included as part of the target evaluation and no load allocation was assigned to these sources which could not be identified.

Four compliance points have been established for these TMDLs, representing every DWQ ambient monitoring station location in the affected watersheds. Compliance points are physical locations within a watershed that are used to monitor water quality conditions and assess progress on the TMDL.

2 SOURCE ASSESSMENT

In an urban setting such as Mecklenburg County, potential sources of fecal coliform in a water body are numerous and often time transient. For the purpose of this report, the sources of fecal coliform have been divided into two broad categories; point sources and non-point sources. Point sources can be defined as sources, either constant or time transient, which occur at a fixed location in a watershed. Non-point sources are generally accepted to be diffuse sources not entering a water body at a specific location. Examples of point sources are wastewater treatment plants (WWTP) and documented sanitary sewer overflows. Examples of non-point sources are stormwater runoff, dry weather flow from storm drains and groundwater.

The source assessment presented in this document represents the best estimation of the sources of fecal coliform in the TMDL watersheds at this time. Additional investigation into the sources and distribution of sources of fecal coliform is critical to achieving the water quality target. Therefore, it is expected that, in the future, the source assessment will be modified to reflect additional data. Specifically, seasonal changes and the variation between watersheds needs to be better understood. Specific investigations and program enhancements are presented in the Implementation Strategy (Appendix 1).

2.1 Point Source Assessment

All documented point source dischargers were included in the source assessment. Actual discharge values for fecal coliform concentration and effluent flow rate were used throughout the TMDL. In the absence of direct measurements, permit limit values were used. This was critical for model calibration because National Pollutant Discharge Elimination System (NPDES) Permitted dischargers contribute the vast majority of flow in the TMDL watersheds during dry periods. Furthermore, it was assumed that discharges recorded during 1999 are typical and effectively estimate future conditions. However, many of the discharges recorded during 1999 were well below permit limits and increases in discharges are likely.

2.1.1. NPDES Permitted Dischargers

Tables 2, 3 and 4 present the breakdown of permitted NPDES point source dischargers in the Little Sugar Creek, McAlpine Creek and Sugar Creek Watersheds respectively. Figure 2 is a map of the TMDL Watersheds showing the locations of the permitted point source dischargers. Appendix 3 presents the daily flow rates and fecal coliform loadings for the McAlpine Creek WWTP, Sugar Creek WWTP and Irwin Creek WWTP.

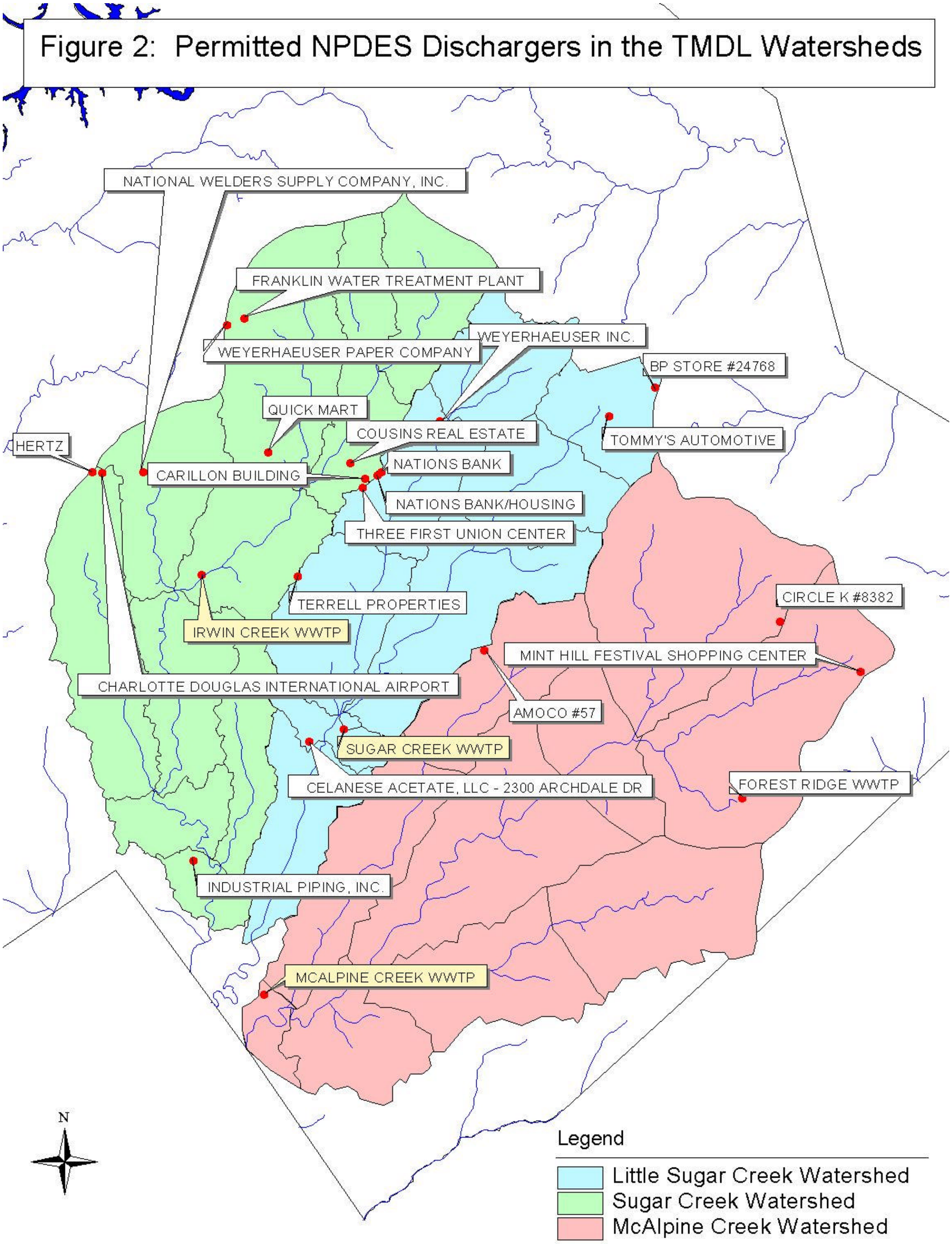


Figure 2: Permitted NPDES Dischargers in the TMDL Watersheds
NATIONAL WELDERS SUPPLY COMPANY, INC.
FRANKLIN WATER TREATMENT PLANT
WEYERHAEUSER INC.
WEYERHAEUSER PAPER COMPANY
BP STORE #24768
QUICK MART
COUSINS REAL ESTATE
TOMMY'S AUTOMOTIVE
HERTZ
NATIONS BANK
CARILLON BUILDING
NATIONS BANK/HOUSING
THREE FIRST UNION CENTER
TERRELL PROPERTIES
CIRCLE K #8382
IRWIN CREEK WWTP
MINT HILL FESTIVAL SHOPPING CENTER
CHARLOTTE DOUGLAS INTERNATIONAL AIRPORT
AMOCO #57
SUGAR CREEK WWTP
CELANESE ACETATE, LLC - 2300 ARCHDALE DR
FOREST RIDGE WWTP
INDUSTRIAL PIPING, INC.
MCALPINE CREEK WWTP
N
Legend
Little Sugar Creek Watershed
Sugar Creek Watershed
McAlpine Creek Watershed

Table 2: NPDES Permitted Dischargers in Little Sugar Creek Watershed

Facility ID	Address	Sub-Watershed ID	NPDES ID	Flow Rate (cfs)	Fecal Coliform Loading (cfu/hour)
Nations Bank	525 N Tryon St	003	NCG510398	0*	-
Nations Bank Housing	401 N Tryon St	003	NCG510277	0.003* (none)	
Three First Union Center	301 S Tryon St	003	NC0086207	0.008* (0.029 mgd)	-
Weyerhaeuser Inc.	201 E 28th St	003	NC0084298	0.0072 (0.0072 mgd)	-
BP Store #24768	7214 The Plaza	006	NCG510242	0	-
Tommy's Automotive	6000 The Plaza	006	NCG510387	0*	-
Celanese Acetate	2300 Archdale Dr	008	NC0084301	0.1152	-
Sugar Creek WWTP	5301 Closeburn Rd	008	NC0024937	Daily* (20 mgd)	Daily* (200/100 ml mo ave 400/100 ml weekly ave.)

Note: * indicates measured values
cfs = cubic feet per second (ft^3/sec)
permit limits shown in parentheses

Table 3: NPDES Permitted Dischargers in McAlpine Creek Watershed

Facility ID	Address	Sub-Watershed ID	NPDES ID	Flow Rate (cfs)	Fecal Coliform Loading (cfu/hour)
Circle K #8382	9201 Lawyers Road	001	NCG510200	0.0001* (none)	-
Forest Ridge WWTP	1076 Kalewood Dr	002	NC0029181	0.138* (0.15 mgd)	4.2E+05* (200/100 ml mo ave 400/100 ml daily max)
Mint Hill Festival Shopping Center	6908 Matthews-Minthill Road	007	NC0063789	0.031* (0.035 mgd)	3.4E+05* (200/100 ml mo ave 400/100 ml daily max)
Amoco #57	4475 Randolph Road	003	NC0085286	0.0144 (0.0144 mgd)	
McAlpine Creek WWTP	12701 Lancaster Hwy	006	NC0024970	Daily* (48 mgd)	**Daily*** (200/100 ml mo ave 400/100 ml weekly ave.)

Note: * indicates measured values
permit limits shown in parentheses

Table 4: NPDES Permitted Dischargers in Sugar Creek Watershed

Facility ID	Address	Sub-Watershed ID	NPDES ID	Flow Rate (cfs)	Fecal Coliform Loading (cfu/hour)
Carillon Building	227 W Trade St	003	NC0085731	0.003* (0.0316 mgd)	-
Cousins Real Estate	800 W Trade St	003	NC0086517	0.05 (0.05 mgd)	-
Franklin Water Treatment Plant	5200 Brookshire Blvd	004	NC0084549	1.36 (none)	-
Quick Mart	2501 Freedom Drive	004	NCG510284	0	-
Weyerhaeuser Paper Company	5419 Hovis Road	004	NC0084298	0.0072 (0.0072 mgd)	-
Irwin Creek WWTP	4000 Westmont	005	NC0024945	Daily* (15 mgd)	Daily* (200/100 ml mo ave 400/100 ml weekly ave.)
Terrell Properties	3000 South Blvd	005	NC0085391	0.0007* (0.004 mgd)	-
Industrial Piping, Inc	800 Culp Rd	006	NC0056669	0.003*	1.2E+05* (200/100 ml mo ave 400/100 ml daily max)
National Welders Supply Company, Inc.	5305 Old Dowd Road	010	NC0079758	0.0143 (0.0143 mgd)	-
Charlotte Douglas International Airport	5501 Josh Birmingham Pky	011	NC0083887	0.01* (none)	-
Hertz	6521 Old Dowd Road	011	NC0084000	0*	-

Note: * indicates measured values
permit limits shown in parentheses

2.1.2 Sanitary Sewer Overflows

Charlotte Mecklenburg Utilities (CMU) sanitary sewers serve all of the Sugar Creek, Little Sugar Creek and McAlpine Creek Watersheds. However, there are three private NPDES facilities with permit limits for fecal coliform in the TMDL watersheds (Tables 2 and 3). Data is not available for un-permitted overflows from the collection systems of these three private facilities. CMU maintains the Sanitary Sewer Overflow Database (SSO Database) system, which is a computerized database of all un-permitted discharges from their collection system. The database includes the location, date and time the discharge started and stopped, whether or not the discharge reached a surface water body, estimated discharge volume and additional data not pertinent to this report. Using this information, all documented un-permitted discharges from CMU's collection system were geocoded using a GIS system. The resulting GIS coverage was then subdivided by sub-watershed for inclusion in the water quality model. A fecal coliform concentration in sewage of 6.4 x 10^6 cfu/100 ml was used to calculate loading values (Center for Watershed Protection, 1999). It is important to note that the SSO Database system may not accurately document the start of an unpermitted discharge because the start time recorded is the moment CMU is first contacted about the discharge (Gallaher, 2001). Processed SSO Database system data for each of the TMDL watersheds is included with this report in Appendix 4. Note, complete SSO Database system data was only available from July, 1998 through June, 2000. Figure 3 depicts the location of each CMU overflow included in this study.

2.2 Non-Point Source Assessment

Non-point sources of fecal coliform are generally attributed to stormwater runoff, however, for the purpose of this report, widely distributed point sources were included in the non-point source category. Examples of widely distributed point sources are failing septic systems and dry weather flow from storm drains. Additionally, impacts from sanitary sewer exfiltration and wildlife were investigated.

2.2.1 Stormwater Runoff

Typically, assessment of the contribution of stormwater runoff is based upon estimations of wildlife, agricultural operations and typical accumulation rates on built up (urban) areas. However, for this report, build-up and wash off rates for each land-use in the TMDL watersheds were calculated from local in-stream stormwater samples collected by the United States Geological Survey (USGS) from December 1993 to September 1997 (Bales et. Al, 1999). The in-stream samples were collected seasonally (four sampling events per year) from relatively uniform land-uses. Each TMDL land-use was paired with a sample site draining a similar land-use as presented in Bales et. Al., 1999 (Note: calculations were based upon raw data obtained from USGS and summarized in Bales (et. Al., 1999)). Table 5 presents the build-up and maximum accumulation levels used in this study.

Table 5: Rate of Accumulation and Maximum Storage of Fecal Coliform by Land-Use

TMDL Land-Use	Dominant Land-Use from Bales et. Al., 1999	Rate of Accumulation of Fecal Coliform (count per acre per day)	Maximum Storage of Fecal Coliform (count per acre)
Heavy Residential/ Institutional	Institutional & High Density Residential	9.04×10^{9}	1.9×10^{10}
Light Residential	Woods/Brush & Low Density Residential	6.86×10^{9}	1.44×10^{10}
Heavy Industrial	Heavy Industrial	2.68×10^{9}	5.63×10^{9}
Heavy Commercial	Heavy Industrial	2.68×10^{9}	5.63×10^{9}
Light Commercial/ Light Industrial	Light Industrial & Light Commercial	3.2×10^{10}	6.72×10^{10}
Woods/Brush	Woods/Brush & Very Low Density Residential	5.48×10^{9}	1.15×10^{10}

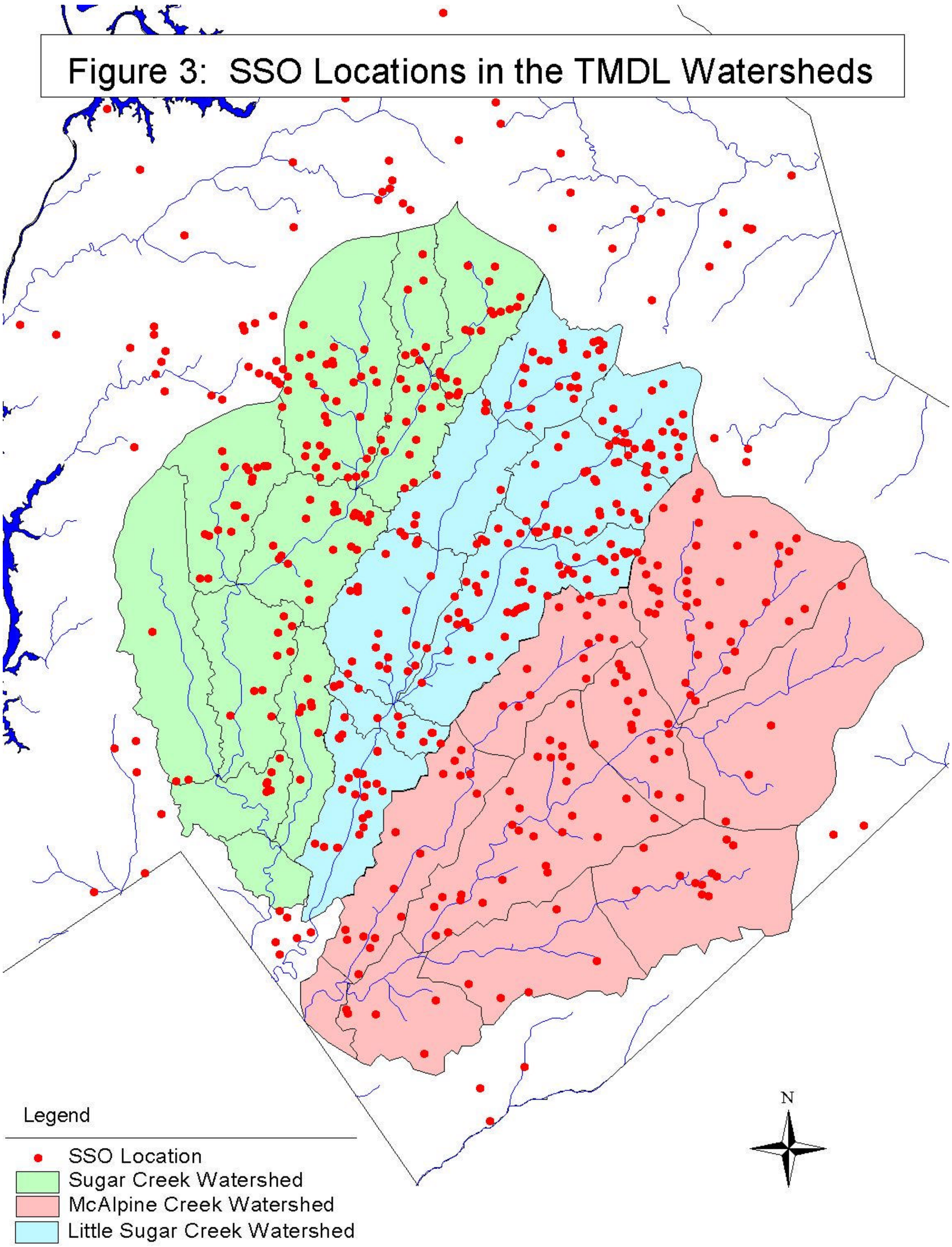


Figure 3: SSO Locations in the TMDL Watersheds
Legend
SSO Location
Sugar Creek Watershed
McAlpine Creek Watershed
Little Sugar Creek Watershed
N

2.2.2 Failing Septic Systems

Failing septic systems have been cited in many TMDLs as a significant contributor of fecal coliform to water bodies (Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Watershed Management Section, 2000). Previous studies have used failure rate values ranging from 4% to 50% of all septic systems. The Mecklenburg County Health Department has estimated the local septic system failure rate to be 1%, (Daniel, 2000). The Health Department cited the following reasons for this estimate (Daniel, 2000):

- In general, Mecklenburg County soils are highly conducive to septic system operation;
- Areas where soil types are not conducive to septic system operation have been excluded from septic system use and existing systems in these areas have been targeted for integration to the CMU sanitary sewer system; and,
- Mecklenburg County has been a leader in enacting septic system regulation in North Carolina, which has prevented the installation of sub-standard systems.

Many stakeholders, including Charlotte Mecklenburg Utilities, have questioned the validity of a 1% failure rate for septic systems. Personal observations and anecdotal evidence appear to indicate a much higher value. However, no documentation of a local investigation to establish a more accurate or reproducible value exists. Because of the lack of direct evidence to refute the 1% value cited by the Health Department, that value has been adopted for the TMDLs presented in this document. Discussion of additional investigation into the failure rate of septic systems in Mecklenburg County will be presented in the Implementation Strategy (Appendix 1).

No direct accounting of the number of septic systems in use in the TMDL watersheds was available. Estimates of the possible number of septic systems were completed through analysis of Mecklenburg County Finance Department data. Essentially, a listing of all built upon parcels of land meeting the following criteria was provided:

- Parcels receiving water bills but no sewer bills. It was inferred that these parcels are likely to be using a septic system. Residences and businesses using small package systems not operated by CMU were omitted from the list; and,
- Parcels receiving no water bills or sewer bills but that were built upon. It was inferred that these parcels are likely to be using a septic system. Residences and businesses using small package systems not operated by CMU were omitted from the list.

The pared down list meeting the above criteria was then geocoded using a GIS system and subdivided by TMDL sub-watershed. An estimated 2.8 individuals were served by each septic system (Daniel, 2000), an estimated flow rate per person of 70 gallons per individual per day (Horsely and Witten, 1996) and an estimated fecal coliform concentration of 10,000 c.f.u./100 ml (Horsely and Whitten, 1996) were used to calculate the loading and flow rates. Tables 6, 7 and 8 present the septic system information used in the water quality model by sub-watershed in the Sugar Creek, Little Sugar Creek and McAlpine Creek Watersheds respectively.

Table 6: Septic System Loading and Flow for Sugar Creek Watershed

Sub-Watershed	Number of Septic Systems	Individuals per System	Individuals Served	Failure Rate (%)	FC Concentration in effluent (c.f.u./100 ml)	FC Load (cfu/hour)	Flow (cfs)
001	717	2.8	2007.6	1	10000	2.2E+07	0.0022
002	392	2.8	1097.6	1	10000	1.2E+07	0.0012
003	325	2.8	910	1	10000	1.0E+07	0.0010
004	1117	2.8	3127.6	1	10000	3.4E+06	0.0034
005	426	2.8	1192.8	1	10000	1.3E+06	0.0013
006	43	2.8	120.4	1	10000	1.3E+06	0.0001
007	172	2.8	481.6	1	10000	5.3E+06	0.0005
008	26	2.8	72.8	1	10000	8.0E+05	0.0001
009	520	2.8	1456	1	10000	1.6E+07	0.0016
010	426	2.8	1192.8	1	10000	1.3E+07	0.0013
011	169	2.8	473.2	1	10000	5.2E+06	0.0005

Table 7: Septic System Loading and Flow for Little Sugar Creek Watershed

Sub-Watershed	Number of Septic Systems	Individuals per System	Individuals Served	Failure Rate (%)	FC Concentration in effluent (c.f.u./100 ml)	FC Load (cfu/hour)	Flow (cfs)
001	381	2.8	1066.8	1	10000	1.1E+07	0.0012
002	313	2.8	876.4	1	10000	9.6E+06	0.0009
003	545	2.8	1526	1	10000	1.6E+07	0.0017
004	480	2.8	1344	1	10000	1.4E+07	0.0015
005	388	2.8	1086.4	1	10000	1.1E+07	0.0012
006	271	2.8	758.8	1	10000	8.3E+06	0.0008
009	105	2.8	294	1	10000	3.2E+06	0.0003
008	64	2.8	179.2	1	10000	1.9E+06	0.0002

Table 8: Septic System Loading and Flow for Little Sugar Creek Watershed

Sub-Watershed	Number of Septic Systems	Individuals per System	Individuals Served	Failure Rate (%)	FC Concentration in effluent (c.f.u./100 ml)	FC Load (cfu/hour)	Flow (cfs)
003	168	2.8	470.4	1	10000	1.2E+08	0.0005
006	709	2.8	1985.2	1	10000	5.2E+08	0.0021
007	344	2.8	963.2	1	10000	2.5E+08	0.0010
008	809	2.8	2265.2	1	10000	6.0E+08	0.0025
009	255	2.8	714	1	10000	1.8E+08	0.0008
010	263	2.8	736.4	1	10000	1.9E+08	0.0008
012	373	2.8	1044.4	1	10000	2.7E+08	0.0011
013	786	2.8	2200.8	1	10000	5.8E+08	0.0024

2.2.3 Dry Weather Flow from Storm Drains

Dry weather flow from storm drains has been the subject of multiple investigations in Mecklenburg County. Initially, an accounting of the storm drain outfalls for the City of Charlotte, which comprises most of the TMDL watersheds, was completed in 1991 (Ogden Environmental & Engineering Services, 1991). This study included the production of a system-wide outfall coverage for use with GIS systems. Additionally, 500 screening points were selected for a field investigation to document the presence of dry weather flow. Of the 500 sites visited, 201 (40.2 %) were found to have dry weather flow. Follow-up activities were completed by the MCDEP from December 1995 to October 1997 at 231 of the outfalls identified as having the potential for dry weather flow pollution (MCDEP, 1998). The follow-up study did not include an assessment of fecal coliform. In order to assess the fecal coliform loading from the storm drain system for the TMDLs, an additional study was completed by MCDEP from June 2000 to October 2000. For the TMDL study, 168 outfalls were randomly selected from the GIS outfall coverage produced in 1991 for screening of flow and fecal coliform. For the TMDL study, dry weather flow was defined as flow occurring after a minimum of 72 hours without rain. Of the 168 outfalls visited during the TMDL study 165 were located and 33 (19.6%) were found to have dry weather flow. Possible reasons for the reduction in dry weather flow from the 1991 study (40.2 %) to the 2000 study (19.6 %) are ongoing investigation of dry weather sources of pollution and different definitions of dry weather flow. Figure 4 shows the locations of the outfalls evaluated during the TMDL study and the distribution of the outfalls for the entire storm drain system. Based upon the data collected from the 33 outfalls that had dry weather flow, a flow rate of 0.0146 cfs and a fecal coliform loading rate of 22,925,015 c.f.u./hour were calculated. Results of the TMDL study are presented in Appendix 5. Note in Appendix 5, that some outfalls have dry weather flow but no flow rate or fecal coliform concentration. These outfalls were inaccessible for sample collection or flow measurement, however dry weather flow was observed. For development of the TMDL, it was assumed that the results of the TMDL study were representative of the entire storm drain system in the TMDL watersheds. Using a GIS system and the system-wide outfall coverage, the total number of outfalls in each of the sub-watersheds in the TMDL watersheds was determined. Overall flow and fecal coliform loading rates were then calculated for each sub-watershed using the total number of outfalls per sub-watershed and the results of TMDL study. Tables 9, 10 and 11 present the results of the TMDL study for the Sugar Creek, Little Sugar Creek and McAlpine Creek watersheds respectively.

Table 9: Dry Weather Flow and Fecal Coliform Loading for Sugar Creek

Sub-Watershed ID	# of Outfalls	# Outfalls w/Dry Weather Flow	Dry Weather FC Loading (cfu/hour)	Dry Weather Flow-Rate (cfs)
001	48	9.3	2.1×10^9	0.1359
002	10	1.9	4.4×10^7	0.0283
003	72	14.0	3.2×10^8	0.2038
004	134	26.0	5.9×10^8	0.3793
005	91	17.7	4.0×10^8	0.2576
006	0	0.0	0	0.0000
007	57	11.1	2.5×10^8	0.1614
008	13	2.5	5.7×10^7	0.0368
009	50	9.7	2.2×10^8	0.1415
010	64	12.4	2.8×10^8	0.1812
011	4	0.8	1.7×10^7	0.0113

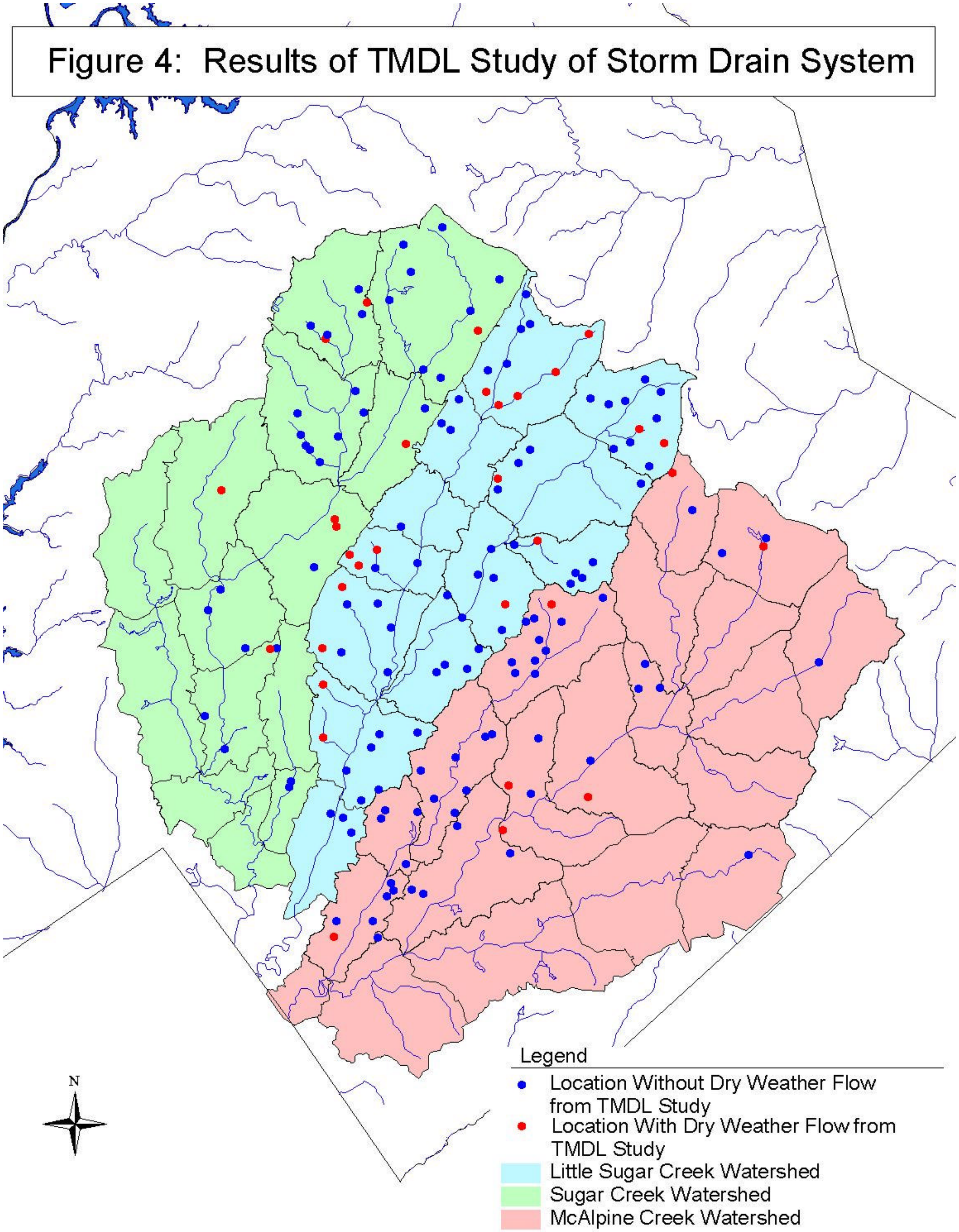


Figure 4: Results of TMDL Study of Storm Drain System
N
Legend
Location Without Dry Weather Flow from TMDL Study
Location With Dry Weather Flow from TMDL Study
Little Sugar Creek Watershed
Sugar Creek Watershed
McAlpine Creek Watershed

Table 10: Dry Weather Flow and Fecal Coliform Loading for Little Sugar Creek

Sub-Watershed ID	# of Outfalls	# Outfalls w/Dry Weather Flow	Dry Weather FC Loading (cfu/hour)	Dry Weather Flow Rate (cfs)
001	105	20.5	4.4×10^8	1.5312
002	146	28.5	6.1×10^8	2.1291
003	125	24.4	5.2×10^8	1.8228
004	202	39.4	8.5×10^8	2.9457
005	147	28.7	6.1×10^7	2.1436
006	120	23.4	5.0×10^8	1.7499
009	96	18.7	4.0×10^8	1.3999
008	38	7.4	1.6×10^8	0.5541

Table 11: Dry Weather Flow and Fecal Coliform Loading for McAlpine Creek

Sub-Watershed ID	# of Outfalls	# Outfalls w/Dry Weather Flow	Dry Weather FC Loading (cfu/hour)	Dry Weather Flow-Rate (cfs)
001	226	44.3	1.0×10^9	0.6460
002	2	0.4	8.9×10^6	0.0057
003	13	2.5	5.8×10^7	0.0372
006	1	0.2	4.5×10^6	0.0029
007	127	24.9	5.7×10^8	0.3630
008	6	1.2	2.6×10^7	0.0171
009	103	20.2	4.6×10^8	0.2944
010	132	25.9	5.9×10^8	0.3773
012	32	6.3	1.4×10^8	0.0915
013	157	30.8	7.0×10^8	0.4487

2.2.4 Wildlife

Typically, for TMDL purposes, wildlife are accounted for in the calculation of build-up and wash-off rates, which are then incorporated into a water quality model. For the purpose of this report, build-up and wash-off rates were developed from direct sampling by land-use and therefore, no direct assessment of wildlife contributions to fecal coliform concentration in stormwater runoff was conducted. Excluding the contribution of wildlife to build-up and wash-off rates, the only remaining pathway of inputting fecal coliform contributions from wildlife to a water body is through direct application. Examples of wildlife meeting this criterion in the TMDL watersheds, which are largely urban, are geese (*Branta canadensis*), ducks (*Anas platyrhynchos*) and beavers (*Castor canadensis*). Estimates of the population of these species were provided by the Mecklenburg County Park and Recreation Department using anecdotal knowledge of the species and informal surveys (Seriff, 2001). All species counts were assumed to be adults. No significant populations of livestock exist in these watersheds and were excluded from the study. Table 12 presents population estimates by TMDL watershed for geese, ducks and beavers.

Table 12: Wildlife Population Estimates by TMDL Watershed

Species	Percentage of time in direct contact with creeks	Fecal Production Rate (count/animal/day)	Sugar Creek (total population)	Little Sugar Creek (total population)	McAlpine Creek (total population)
Geese	0%	4.9×10^{10}	40	150	200
Ducks	10%	2.43×10^{9}	20	50	100
Beaver	25%	2.5×10^{8}	0	0	10

Fecal production rates obtained from Tetra Tech, Inc. (2001).
Percentage of time in direct contact with active water obtained from Serriff (2001).

To determine the total fecal coliform loading from wildlife, a total load for each TMDL sub-watershed was determined using species population, fecal production rates and typical species behavior. For the purposes of this study, fecal coliform contributions from wildlife will occur through direct application; therefore, wildlife contact must occur with a moving stream or a pond or wetland, which flows directly to a stream. Ducks and beavers spend a significant percentage of their time in direct contact with moving water; however, their fecal production rates are very low. Geese have the highest fecal production rate; however, they have minimal direct contact with the TMDL creeks, which are typically narrow, shallow and have a wide tree overhang, which is unsuitable habitat for geese. However, geese are frequently in direct contact with ponds and wetlands, which are often times hydraulically connected to the TMDL creeks during the wet winter months and disconnected during the dryer summer months. For the purposes of this study, 1%, 10% and 25% of the fecal coliform load from geese, ducks and beavers respectively was input to the creek. Tables 13, 14 and 15 present the fecal coliform loading for the Sugar Creek, Little Sugar Creek and McAlpine Creek Watersheds respectively.

Table 13: Fecal Coliform Loading from Wildlife for Sugar Creek

Sub-Watershed ID	FC Loading from Geese (cfu/hour)	FC loading from Ducks (cfu/hour)	FC Loading from Beavers (cfu/hour)	Total Wildlife FC Load (cfu/hour)	Notes
009	8.17 E+08	2.03E+08	0	1.02E+09	Geese Not Contributing in Summer Months

Table 14: Fecal Coliform Loading from Wildlife for Little Sugar Creek

Sub-Watershed ID	FC Loading from Geese (cfu/hour)	FC loading from Ducks (cfu/hour)	FC Loading from Beavers (cfu/hour)	Total Wildlife FC Load (cfu/hour)	Notes
002	1.53E+09	2.53E+08	0	1.78E+09	Geese contributing year round
008	1.53E+09	2.53E+08	0	1.78E+09	Geese contributing year round

Table 15: Fecal Coliform Loading from Wildlife for McAlpine Creek

Sub-Watershed ID	FC Loading from Geese (cfu/hour)	FC loading from Ducks (cfu/hour)	FC Loading from Beavers (cfu/hour)	Total Wildlife FC Load (cfu/hour)	Notes
012	1.53E+11	3.04E+09	1.04E+08	1.56E+11	Geese contributing year round
008	0	1.01E+09	0	1.01E+09	
001	0	5.06E+08	0	5.06E+08	
002	0	5.06E+08	0	5.06E+08	
010	5.10E+10	1.01E+09	0	5.21E+10	Geese contributing year round
007	0	1.01E+09	0	1.01E+09	
009	8.17E+10	0	0	8.17E+10	Geese not contributing in summer months
003	5.10E+10	0	0	5.10E+10	Geese contributing year round
013	2.04E+10	1.01E+09	0	2.14E+10	Geese contributing year round
006	5.10E+10	2.03E+09	0	5.31E+10	Geese contributing year round

2.2.5 Exfiltration from Sanitary Sewer Pipes

In the North Carolina Piedmont Physiographic Province, groundwater flows to the creek except during runoff events. This provides the possibility for surface water impact from groundwater during times of moderate to low flow. A previously unstudied possible source of fecal coliform in Mecklenburg County surface waters is the leaking or exfiltration of untreated sewage from sanitary sewer pipes to groundwater, which may then flow to surface water. In an effort to investigate this possible source, 18 shallow groundwater monitoring wells were installed at 9 locations throughout Mecklenburg County (MCDEP, 2000(a)). The sites were selected by CMU and MCDEP to represent all line sizes, construction material and construction techniques present in the CMU collection system. At each of the 9 sites a minimum of 1 well was installed between the sewer line and the creek and 1 well was installed upgradient of the sewer line. One groundwater sample was collected and groundwater elevations calculated at each of the 18 monitoring wells weekly from November 13, 2000 to December 27, 2000 (MCDEP, 2000(b)). At 5 of the sites the sewer line was below the water table, therefore making exfiltration highly unlikely. None of the samples collected at these 5 sites contained measurable concentrations of fecal coliform in either the upgradient or downgradient well. At the remaining 4 sites, the sewer line was above the water table, making exfiltration from the sewer pipe hydraulically possible. At these sites fecal coliform was detected in 3 out of 4 downgradient wells. None of the samples collected from the upgradient wells at these 4 sites contained measurable concentrations of fecal coliform. Measured concentrations in the downgradient wells at these sites ranged from a minimum of <10 c.f.u./100 ml to a maximum of 1700 c.f.u./100 ml. In order to establish a representative groundwater concentration for use in the water quality models, an average of all sampling data was calculated. This resulted in an average fecal coliform concentration in groundwater of 58 c.f.u./100 ml, which was input to the water quality model as a constant groundwater concentration. The fecal coliform sampling data and analysis is included as Appendix 6. It is important to note that failing septic systems may discharge to groundwater, which may also flow to surface water, however discharges from failing septic systems have been assessed as a separate source (See Section 2.2.2 above). It is important to note that the investigation of exfiltration from sanitary sewer pipes was extremely limited. It is likely that the conclusions presented in this document will be modified as additional data becomes available.

3 MODELING APPROACH AND RESULTS

Water quality modeling is an integral part of any TMDL developed for an environmental pollutant. Establishing the relationship between in-stream water quality and source loadings with a water quality model is a critical component of TMDL development. Similarly, water quality models have the ability to support regulatory decisions and the development of implementation strategies.

3.1 Model Framework Selection

In response to the expected increase in water quality modeling due to the TMDL process, the United States Environmental Protection Agency (USEPA) developed a document entitled "Compendium of Tools for Watershed Assessment and TMDL Development" (Shoemaker et. Al., 1997). This document was intended to serve as a guide to model selection, however it does not endorse the use of a particular model for any pollutant or setting. Model selection is left up to the organization developing a TMDL and often the most important selection criterion is familiarity. Because of the lack of firm guidance, the Technical Subcommittee of the TMDL Stakeholders Group developed a model selection process whereby each model under consideration was carefully assessed based on fixed criteria. Likewise, future modeling considerations were taken into account such that experience and similar aspects could be built upon for future modeling projects. The remainder of this section discusses the rational for model selection.

For the purpose of the TMDL, the top six ranked models in each category in Shoemaker et. Al. (1997) were selected for evaluation. The models included the following:

Simple Models:

1. Simple Method
2. Watershed Management Model

Moderately Complex Models:

3. SLAMM
4. P8-UCM

Complex Models:

5. NPSM/HSPF
6. SWMM

The following criteria were used to compare the models:

- ? Ease of Use;
- ? Defensibility (and/or acceptability);
- ? Accuracy;
- ? Available Sources;
- ? Baseflow/Stormflow;
- ? User Interface;
- ? Tools;
- ? Support;
- ? Data Requirements;
- ? Dynamic (or Steady State);
- ? Other notable points.

Using these criteria a model selection matrix was prepared and is included with this document as Appendix 7.

With the exception of P8-UCM, all of the models reviewed were capable of modeling fecal coliform in surface water. An important factor to be considered was the ability of the model to accurately represent baseflow conditions. Accurate baseflow simulation was important because the TMDL includes dry weather conditions. Additionally, the model needed to be able to accurately simulate both point and non-point sources of fecal coliform. Furthermore, the time transient quality of point sources, such as WWTP effluent and SSOs, warranted the use of a continuous simulation model.

Based upon the aforementioned criteria, NPSM/HSPF was selected for use in preparation of the Fecal Coliform TMDLs for the Sugar Creek, Little Sugar Creek and McAlpine Creek watersheds. HSPF is a spatially distributed, lumped parameter, continuous simulation model used to model water quality conditions in watersheds and river basins. HSPF calculates non-point source loadings of selected pollutants for specified land use categories in a watershed; represents subsequent pollutant runoff response to hydrologic influences, such as precipitation; simulates point sources as constant or variable flow and load; and simulates flow and pollutant routing through a stream network.

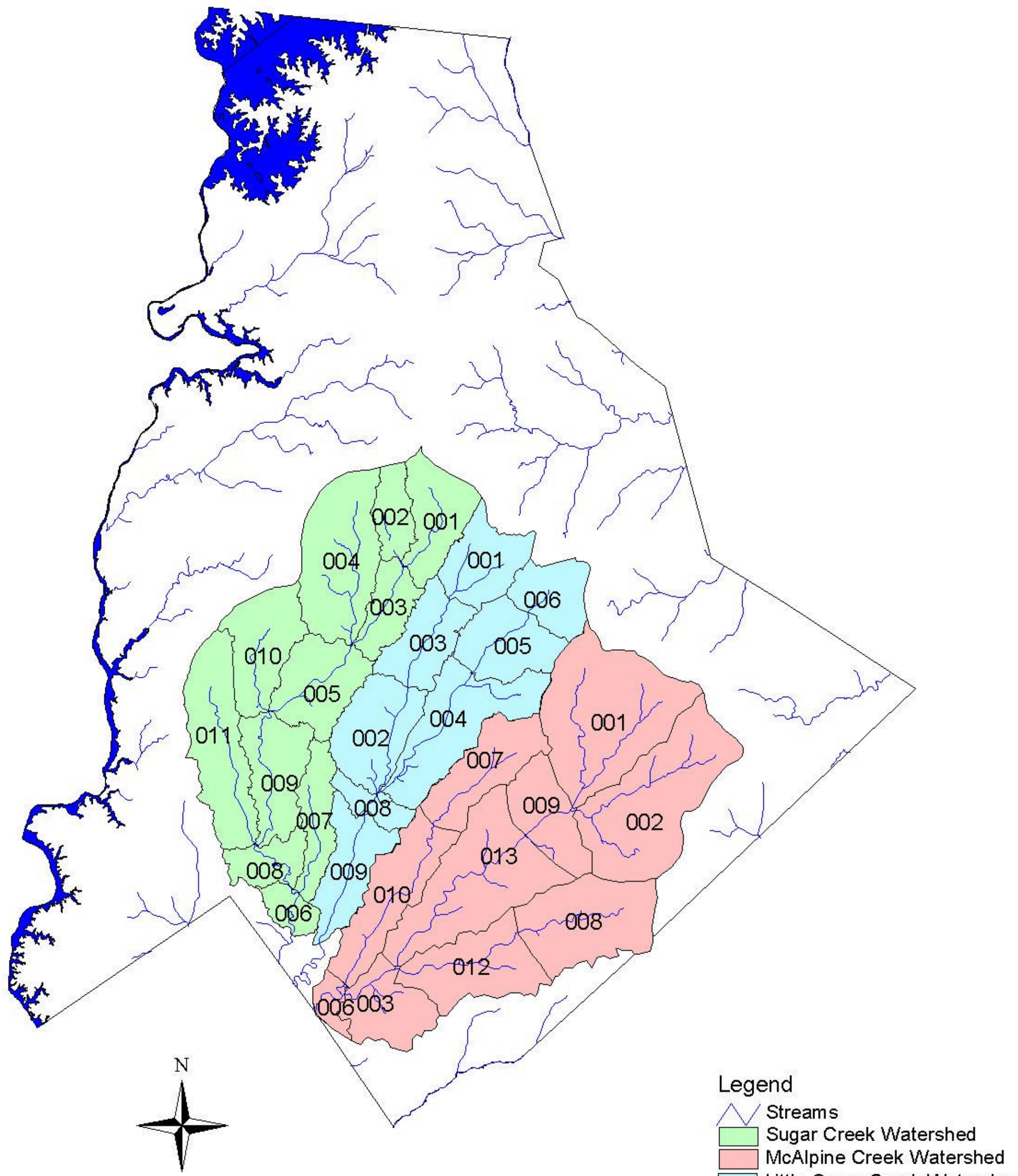
3.2 Model Setup

Figures 5 shows the sub-watershed delineations for the Sugar Creek, Little Sugar Creek and McAlpine Creek Watersheds. Sub-watershed delineation was based upon factors such as the presence of USGS gaging station, presence of a water quality monitoring site, presence of a NCDENR compliance point, confluence of major stream segments and presence of major point source dischargers. Sub-watershed delineation, stream cross section geometry, slope and length were determined using Mecklenburg County's version of the Watershed Information System, which is a GIS based application that allows the manipulation of digital elevation data for modeling applications. Locally developed land use data (based upon individual land parcels) was simplified and used for model preparation. Table 16 shows the land uses used in the TMDL models along with percent imperviousness. Percent imperviousness by TMDL land-use was determined by intersecting the TMDL land-use GIS coverage with an impervious surface GIS coverage. Appendix 2 presents the distribution of land use by sub watershed for the Sugar Creek, Little Sugar Creek and McAlpine Creek watershed respectively. Also included in Appendix 2 are maps showing the distribution of land use in the Sugar Creek, Little Sugar Creek and McAlpine Creek Watersheds. With the exception of rainfall, all weather data was adopted from the Charlotte Douglas International Airport (WBAN 13881). Rainfall data was adopted from USGS rainfall gages located in each watershed. USGS station numbers 351331080525945, 351553080562645 and 02146600 were used for the Sugar Creek, Little Sugar Creek and McAlpine Creek Watersheds respectively.

Table 16. Percent Impervious by Land-Use for TMDL Water Quality Models

Land Use in TMDL Models	Percent Impervious
Heavy Commercial	77.2
Heavy Industrial	38.5
Light Commercial/Light Industrial	49.2
Woods/Brush	7.4
Heavy Residential	32.5
Light Residential	19.6

Figure 5: Sub-Watershed Deliniations for the TMDL Watersheds



3.3 Fecal Coliform Source Representation

Both point and non-point sources of fecal coliform are represented in the water quality model. Certain non-point source categories are not associated with land loading processes and are represented as direct, in-stream source contributions in the model. These include failing septic systems, dry weather flow from the storm drain system, wildlife in streams and sanitary sewer overflows. Land loading non-point sources are represented as indirect contributions to the stream through build-up and wash-off processes (see Section 2.2.1 above). The following sections describe the assumptions used for the various sources described in Section 2.0.

3.3.1 NPDES Discharges

There are 8, 5 and 11 NPDES point source dischargers in the Little Sugar, McAlpine and Sugar Creek Watersheds respectively. With the exception of the CMU WWTPs, all NPDES dischargers were represented in the model as constant (do not vary with time) sources of both flow and fecal coliform. CMU WWTPs were represented as variable sources in the model with a flow and fecal coliform loading rate for each day during the simulation period. CMU's self-monitoring data was used to calculate the loading and flow values. The data used to prepare the CMU WWTP variable source input files is included as Appendix 3.

3.3.2 Sanitary Sewer Overflows

Sanitary sewer overflows were represented in the water quality models as time variable point sources. The geocoded sanitary sewer overflow data from CMU's SSO database was transformed into an hourly loading file appropriate for NPSM/HSPF. In other words, an individual loading value was developed for each hour an overflow occurred in each sub-watershed. The loading values were calculated as described in Section 2.1.2.

3.3.3 Urban Development

Fecal coliform loading from urban areas was represented in the model as both pervious and impervious surfaces. Typically, urban loading rates are adjusted as a primary calibration parameter in the water quality model. However, for the water quality models developed for the TMDL watersheds discussed in this report, loading values were determined through local focused land-use sampling. Therefore, it was assumed that the values calculated were representative of both pervious and impervious urban loading in Mecklenburg County and were not altered in the model to better fit observed data. The values used in the model are presented in Section 2.2.1 above.

3.3.4 Dry Weather Flow

Fecal coliform loading values from dry weather flow were input to the water quality models as continuous point sources by sub-watershed. The fecal coliform loading rates are presented in Section 2.2.3 above.

3.3.5 Failing Septic Systems

Fecal coliform loading values from failing septic systems were input to the water quality models as continuous point sources by sub-watershed. The fecal coliform loading rates are presented in Section 2.2.2 above.

3.3.6 Wildlife

Fecal coliform loading values from wildlife is represented in water quality simulations as described in section 2.2.4 above. Approximate counts of each wildlife species by sub-watershed were used to determine the fecal loading rates. The loading rates were input to the model as continuous point sources by sub-watershed.

3.3.7 Exfiltration from Sanitary Sewer Pipes

Fecal coliform loading rates contributed by exfiltration from sanitary sewer pipes were input to the water quality models as a constant groundwater concentration of 58 c.f.u./100 ml (see Section 2.2.5 above)

3.4 Model Calibration

Calibration of a dynamic loading model involves both hydrologic and water quality components. The model must be calibrated to accurately represent hydrologic response in the watershed before reasonable water quality simulations can be performed. The hydrologic calibration involves comparison of simulated stream-flows to observed stream-flow data from stream gaging stations in the watershed. Simulated stream-flows are generated by the model using both meteorological data and the physical characteristics of the watershed. Typically, certain model parameters are altered until a reasonable match is developed between simulated and observed stream flow. Similar techniques are used to calibrate the water quality portion of the model.

A complete stream-flow data set for the Sugar Creek, Little Sugar Creek and McAlpine Creek Watersheds was only available from July 1998 – June 2000. In order to obtain the best possible hydrologic calibration and representation of pollutant loads, all model simulations were limited to this time frame. Although the data set was limited to July 1998 – June 2000, all model runs were started on January 01, 1998 to allow the model to stabilize.

All model inputs, calibration and validation information, and full model results are discussed in the full modeling report, which is presented in Appendix 8. A condensed presentation of the hydrologic calibration data is included as Tables 17, 18, 19, 20 and 21 for the Sugar Creek, Irwin Creek, Little Sugar Creek, McAlpine Creek Downstream of Sardis Road and McAlpine Creek Upstream of Sardis Road respectively. Much of the difference presented in Tables 17, 18, 19, 20 and 21 may be attributable to the use of a single rain gage in each of the TMDL watersheds. Although the rain gages used were located in each TMDL watershed, a significant variation in rainfall distribution has been reported within each watershed (Sarver et. al., 1999). Figures 6, 7, 8, 9 and 10 are plots of the hydrology calibration for Sugar Creek, Irwin Creek, Little Sugar Creek, McAlpine Creek Downstream of Sardis Road and McAlpine Creek Upstream of Sardis Road respectively. Figures 11, 12, 13, 14 and 15 are plots of the water quality calibration for Sugar Creek, Irwin Creek, Little Sugar Creek, McAlpine Creek Downstream of Sardis Road and McAlpine Creek Upstream of Sardis Road respectively.

Table 17: Basic Hydrology Calibration Data for Sugar Creek

Parameter	Goal	Observed	Simulated	Difference
Total of Highest 10% of flows	15%	8730	9930	12.1%
Total of Lowest 50% of flows	10%	5597	5515	1.5%
Observed Summer flow volume	30%	4484	4555	1.6%
Observed Fall flow volume	30%	4091	5617	27.2%
Observed Winter flow volume	30%	8959	9180	2.4%
Observed Spring Flow volume	30%	5575	5391	3.4%
Observed Total Volume	10%	23109	24744	6.6%

Note: Goal was adopted from HSPEXP.
Note: Units in cfs

Table 18: Basic Hydrology Calibration Data for Irwin Creek

Parameter	Goal	Observed	Simulated	Difference
Total of Highest 10% of flows	15%	4788	5132	6.7%
Total of Lowest 50% of flows	10%	1961	1770	10.8%
Observed Summer flow volume	30%	2428	2307	5.3%
Observed Fall flow volume	30%	1871	1819	2.8%
Observed Winter flow volume	30%	1809	2288	21%
Observed Spring Flow volume	30%	3862	4206	8.2%
Observed Total Volume	10%	9970	10620	6.1%

Table 19: Basic Hydrology Calibration Data for Little Sugar Creek

Parameter	Goal	Observed	Simulated	Difference
Total of Highest 10% of flows	15%	12187	10634	14.6%
Total of Lowest 50% of flows	10%	6024	6267	3.9%
Observed Summer flow volume	30%	5602	5299	5.7%
Observed Fall flow volume	30%	4548	5676	19.9%
Observed Winter flow volume	30%	9919	10334	4.0%
Observed Spring Flow volume	30%	5584	6010	7.1%
Observed Total Volume	10%	25653	27320	6.1%

Note: Goal was adopted from HSPEXP.
Note: Units in cfs

Figure 6: Sugar Creek Hydrology Calibration

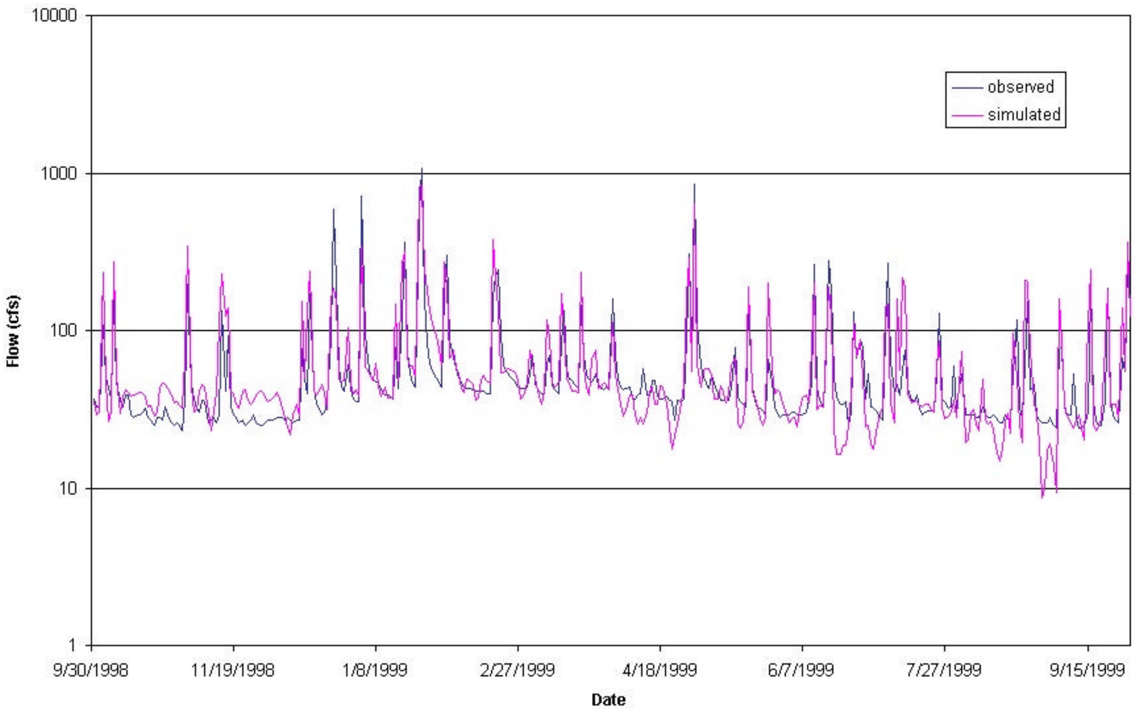


Figure 7: Irwin Creek Hydrology Calibration

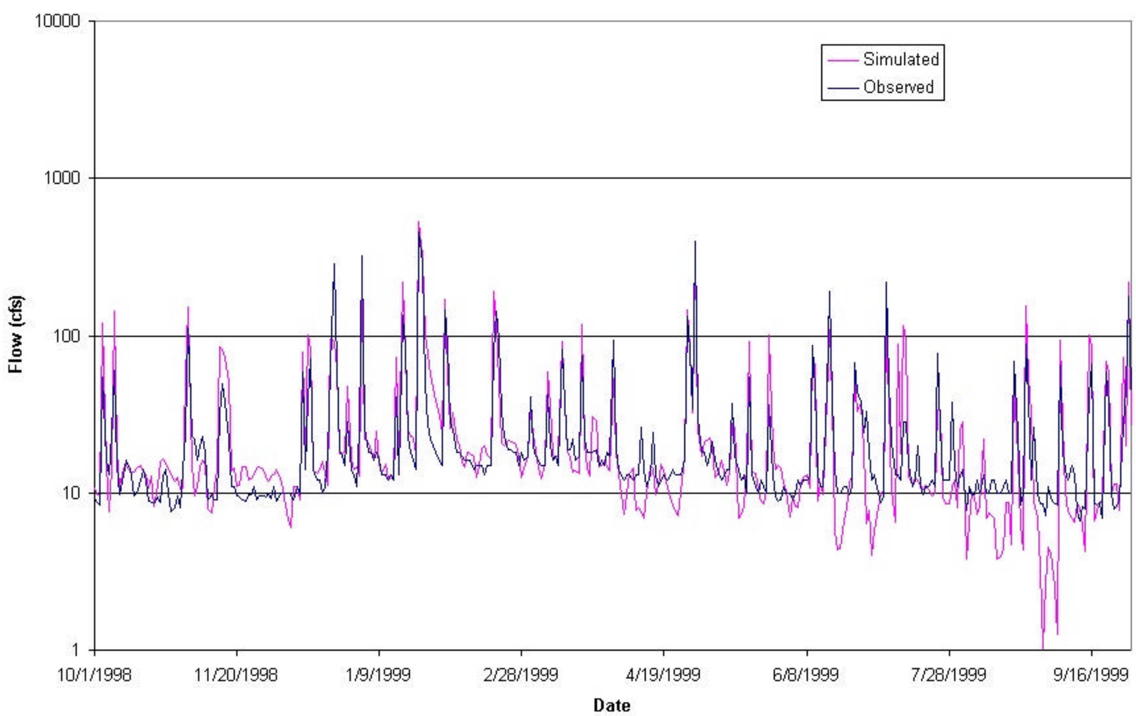


Figure 8: Little Sugar Creek Hydrology Calibration

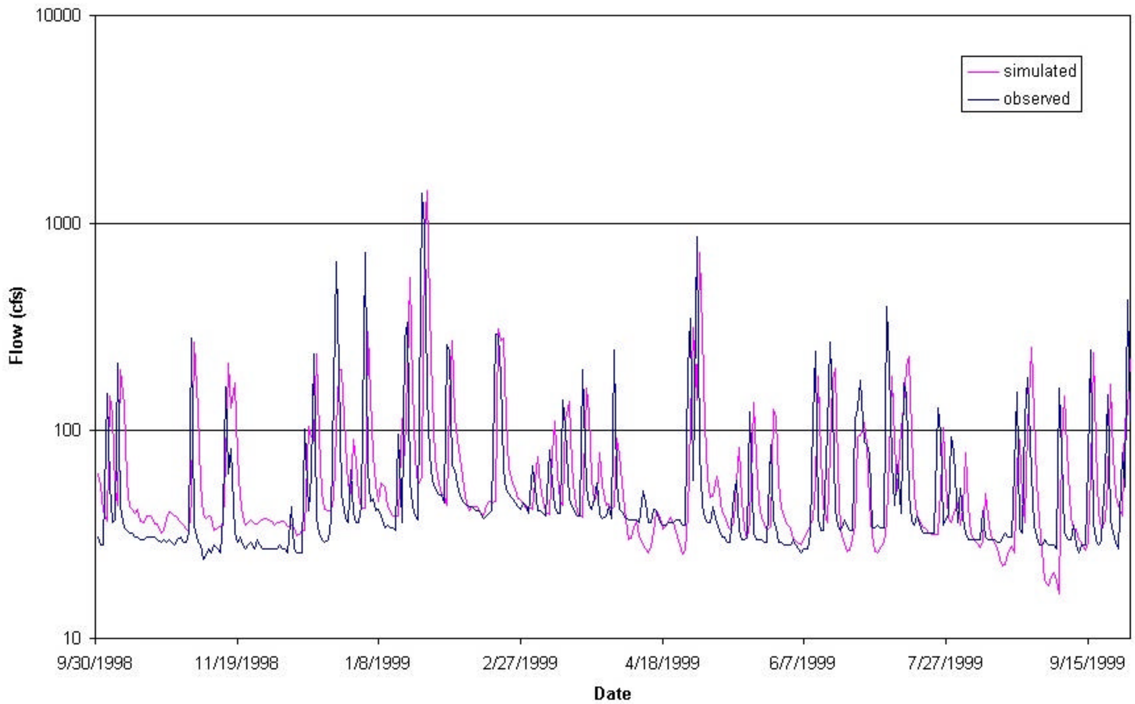


Figure 9: McAlpine Creek Downstream of Sardis Road Hydrology Calibration

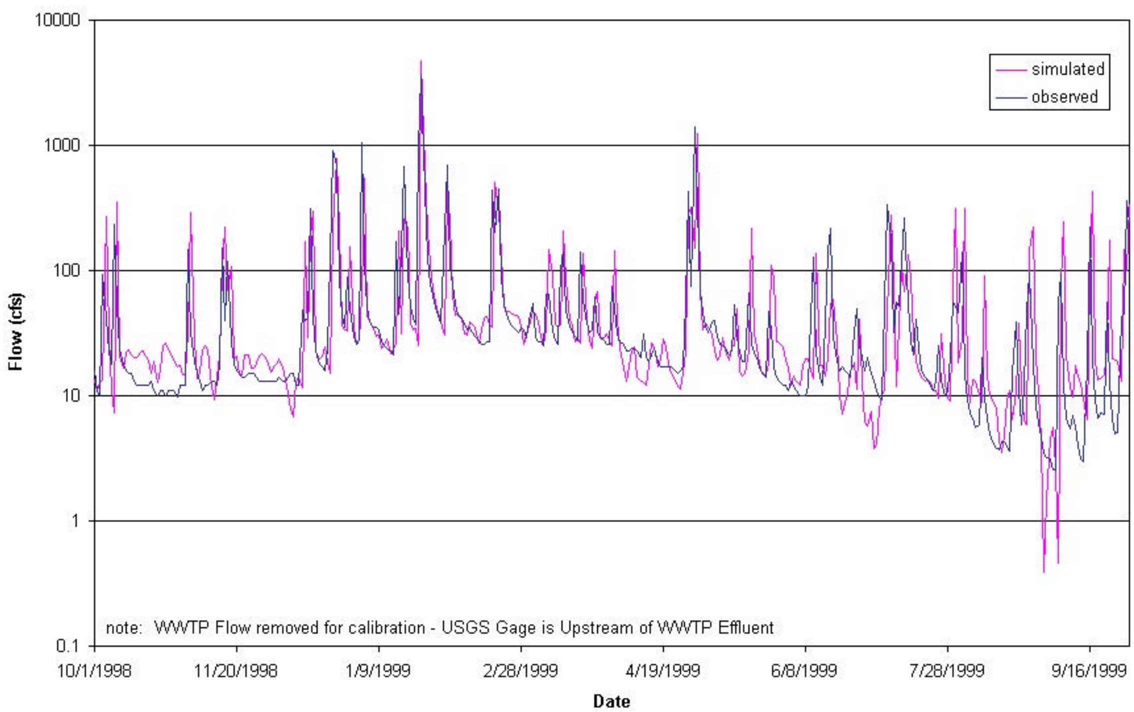


Figure 10: McAlpine Creek Upstream of Sardis Road Hydrology Calibration

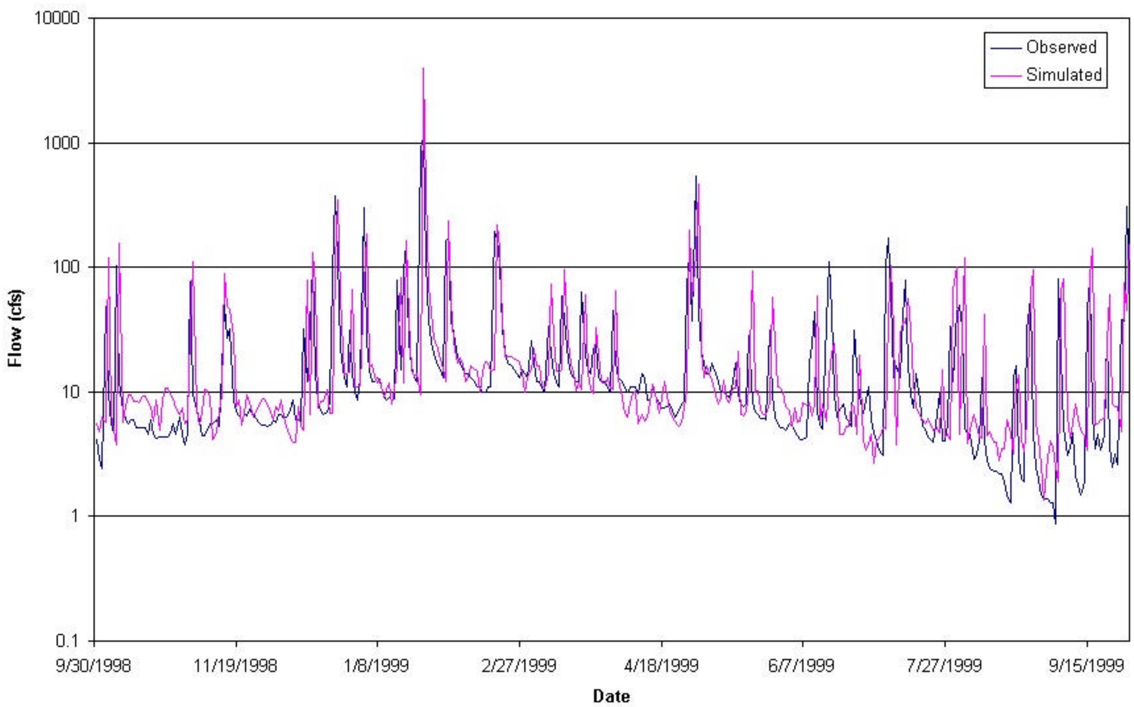


Figure 11: Water Quality Calibration for the Sugar Creek Watershed

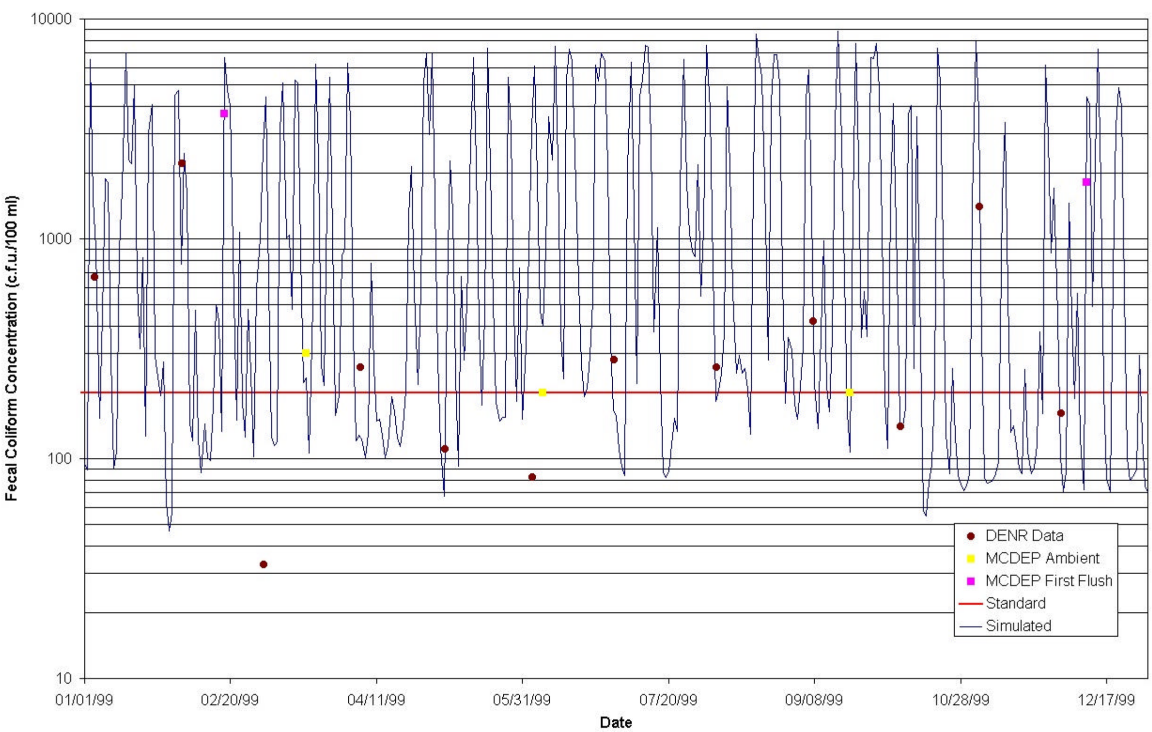


Figure 12: Water Quality Calibration for the Irwin Creek Watershed

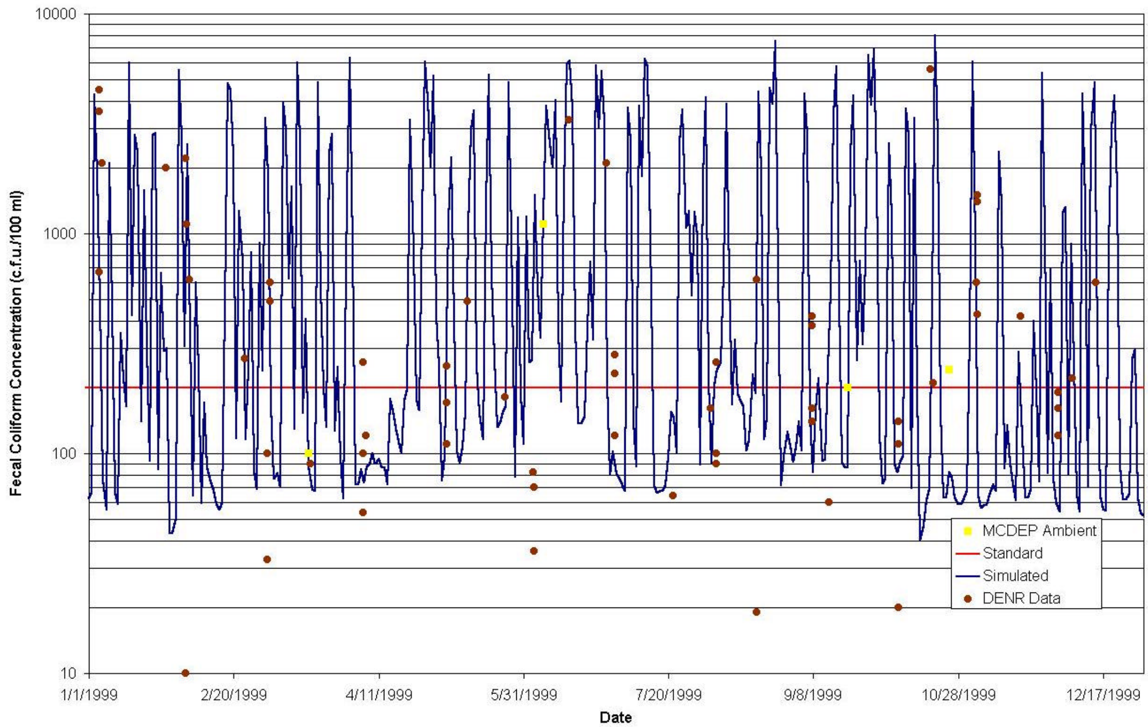


Figure 13: Water Quality Calibration for the Little Sugar Creek Watershed

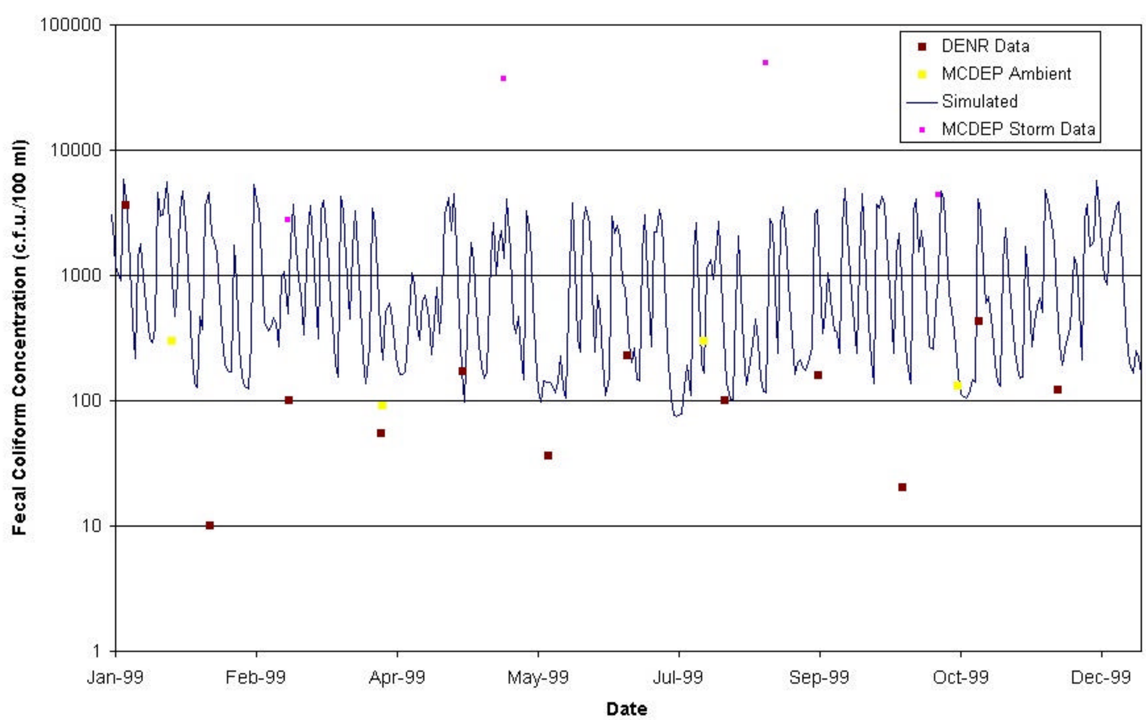


Figure 14: McAlpine Creek Downstream of Sardis Road Water Quality Calibration

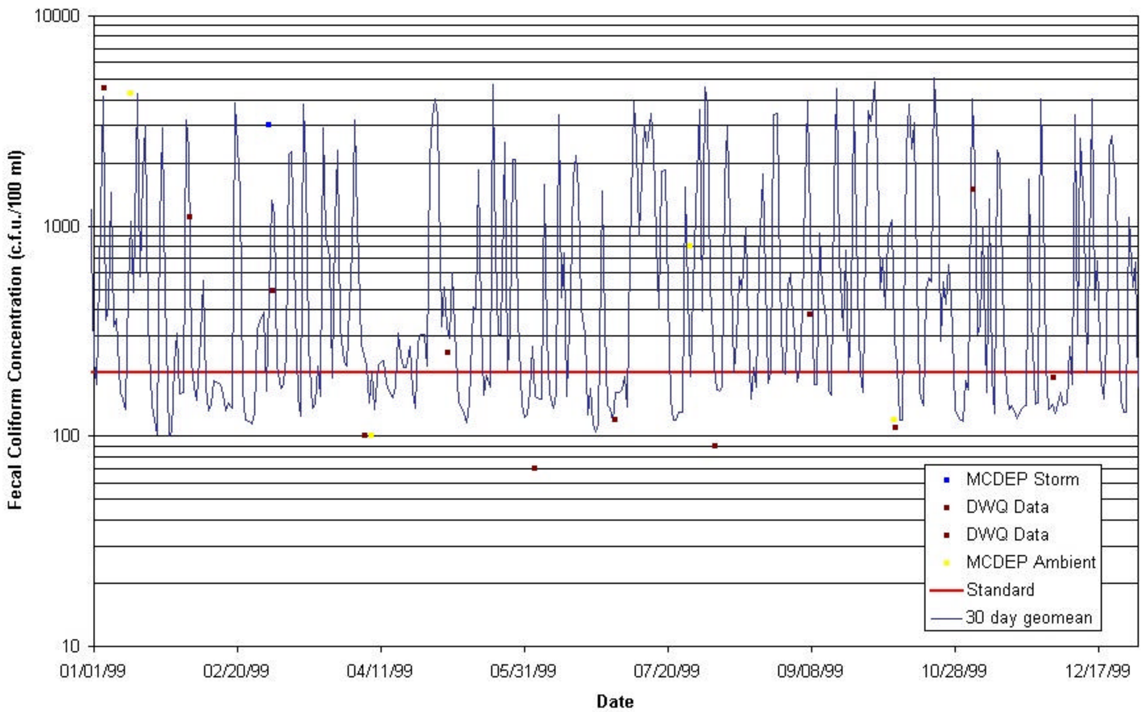


Figure 15: Water Quality Calibration for the McAlpine Creek Watershed Upstream of Sardis Road

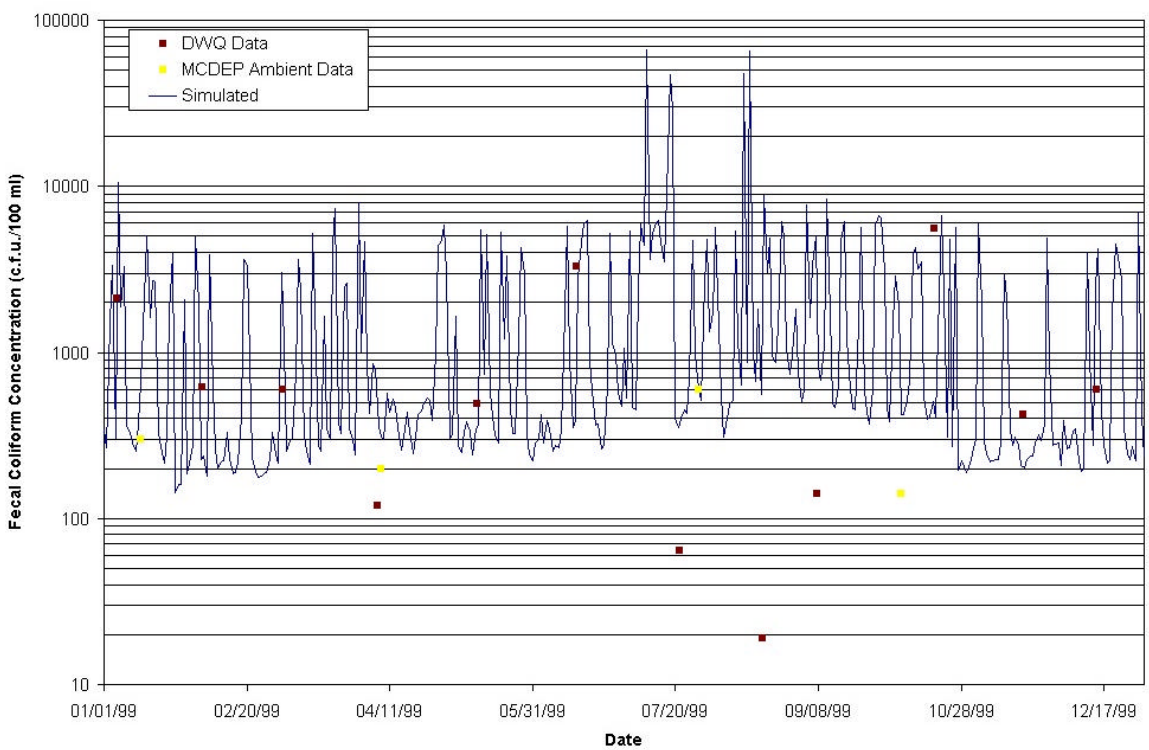


Table 20: Basic Hydrology Calibration Data for McAlpine Creek Downstream of Sardis Road

Parameter	Goal	Observed	Simulated	Difference
Total of Highest 10% of flows	15%	17086	16864	1.3%
Total of Lowest 50% of flows	10%	2366	2603	9.1%
Observed Summer flow volume	30%	3027	3329	9.0%
Observed Fall flow volume	30%	2978	4242	29.8%
Observed Winter flow volume	30%	2936	4213	30.3%
Observed Spring Flow volume	30%	4810	4847	0.7%
Observed Total Volume	10%	25692	26365	2.6%

Note: Goal was adopted from HSPEXP.
Note: Units in cfs

Table 21: Basic Hydrology Calibration Data for McAlpine Creek Upstream of Sardis Road

Parameter	Goal	Observed	Simulated	Difference
Total of Highest 10% of flows	15%	4616	5003	7.7%
Total of Lowest 50% of flows	10%	974	1119	13.0%
Observed Summer flow volume	30%	2000	2023	1.2%
Observed Fall flow volume	30%	1341	1462	8.3%
Observed Winter flow volume	30%	1363	1817	25.0%
Observed Spring Flow volume	30%	5512	7739	28.8%
Observed Total Volume	10%	10216	13042	21.7%

Note: Goal was adopted from HSPEXP.
Note: Units in cfs

In order to assess the status of the hydraulic calibration of the models the goals presented in Table 17, 18, 19, 20 and 21 were adopted from HSPEXP (USGS, 1994). Similarly, for water quality calibration, model parameters (primarily the first order decay coefficient) were adjusted until the closest match of simulated and observed concentrations were made. The closeness of the match was evaluated using the sum of the squares of the differences between simulated and observed values.

The models were evaluated by sources outside MCDEP for reasonableness, completeness and basis in reality. As a result of the outside evaluation, improvements to the model were suggested and adopted.

3.5 Critical Conditions

Fecal coliform contributions to Sugar Creek, Little Sugar Creek and McAlpine Creek may be attributed to both point and non-point sources. Critical conditions for waters impaired by non-point sources generally occur during periods of wet weather, whereas those impaired by point sources generally occur during dry periods. Among the categories of non-point sources are sources that continuously discharge directly to the water body. Examples include failing septic systems, dry weather flow from storm drains and wildlife. It is important to note that the TMDLs discussed in this document do not include stormwater runoff as an allocation category.

The critical conditions for fecal coliform impairment in Sugar Creek, Little Sugar Creek and McAlpine Creek are extended periods of dry weather. Typically, these conditions occur during the summer (June through September) when the minimum stream-flow is available for dilution. However, critical conditions may occur at practically any time because of the highly dynamic and time transient quality of both SSO loads and WWTP effluent loads. Therefore, the 30-day geometric mean of the fecal coliform concentrations produced by the water quality models were used to determine the critical conditions (in other words, flow was not the only consideration). It is important to note that the critical low-flow, dry weather conditions occur during periods when there is not washoff of fecal coliform from the land surface.

3.6 MODEL RESULTS

3.6.1 Existing Conditions

Exclusive of stormwater runoff, model results indicate that the primary sources of fecal coliform contamination in the Little Sugar, Sugar and McAlpine Creek Watersheds are point sources and direct input non-point sources (failing septic systems etc.).

3.6.2 Critical Conditions

Results of the year-long water quality simulation of the 30-day geometric mean concentration for existing conditions at the outlet of the Sugar Creek, Irwin Creek, Little Sugar Creek, McAlpine Creek Downstream of Sardis Road and McAlpine Creek Upstream of Sardis Road Watersheds are shown in Figures 16, 17, 18, 19 and 20 respectively. Critical conditions for each watershed occurred during periods of low stream flow coinciding with high fecal coliform loads from both the SSOs and the WWTPs. The date of maximum exceedance, according to the model simulation, is the time period preceding and including the highest simulated exceedance of the 30-day geometric mean standard. Achieving the water quality criteria for this period ensures that water quality criteria will be achieved for the remainder of the modeling period. The highest 30-day geometric mean for each watershed is listed in Table 22.

Table 22: Critical Condition for the Sugar Creek, Irwin Creek, Little Sugar Creek, McAlpine Creek Downstream of Sardis Road and McAlpine Creek Upstream of Sardis Road Watersheds.

Watershed	Date of Predicted Maximum Exceedance	Value of Predicted Maximum Exceedance (30 day geomean FC Concentration [c.f.u./100 ml])
Sugar Creek	06/28/1999	365.24
Irwin Creek	06/28/1999	362.09
Little Sugar Creek	12/21/1999	297.34
McAlpine Creek Downstream of Sardis Road	08/17/1999	284.43
McAlpine Creek Upstream of Sardis Road	09/12/1999	883.20

Figure 16: Existing and TMDL Conditions for the Sugar Creek Watershed

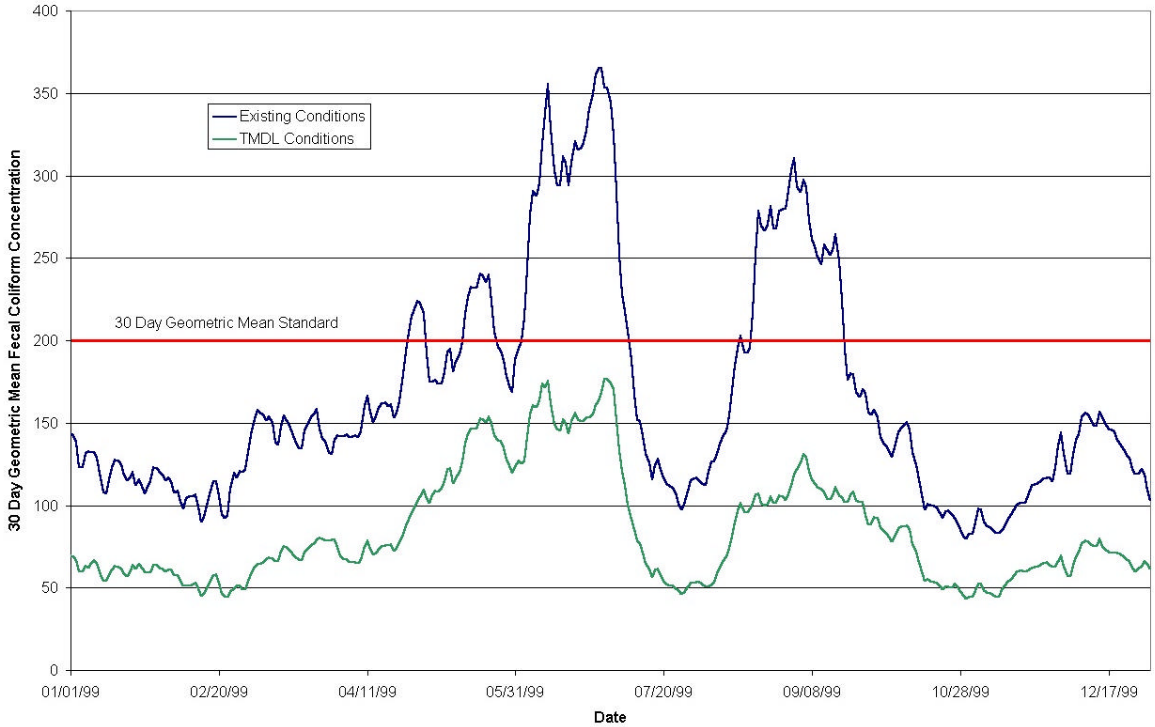


Figure 17: Existing and TMDL Conditions for the Irwin Creek Watershed

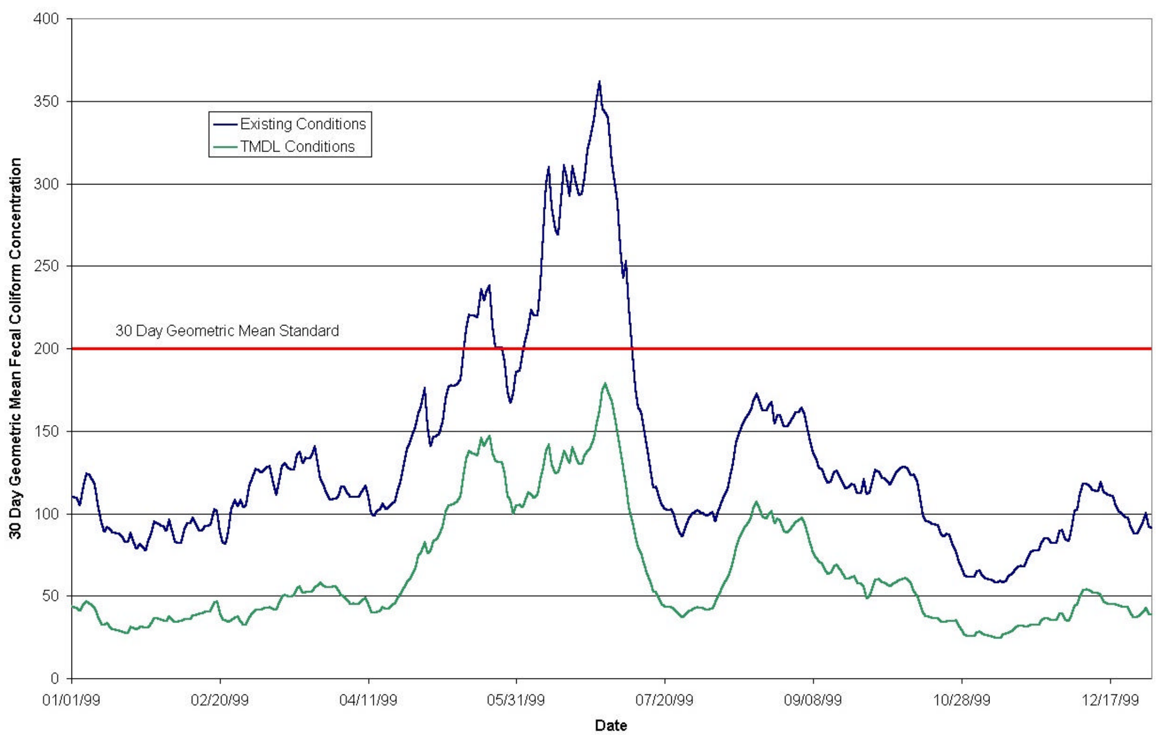


Figure 18: Existing and TMDL Conditions for the Little Sugar Creek Watershed

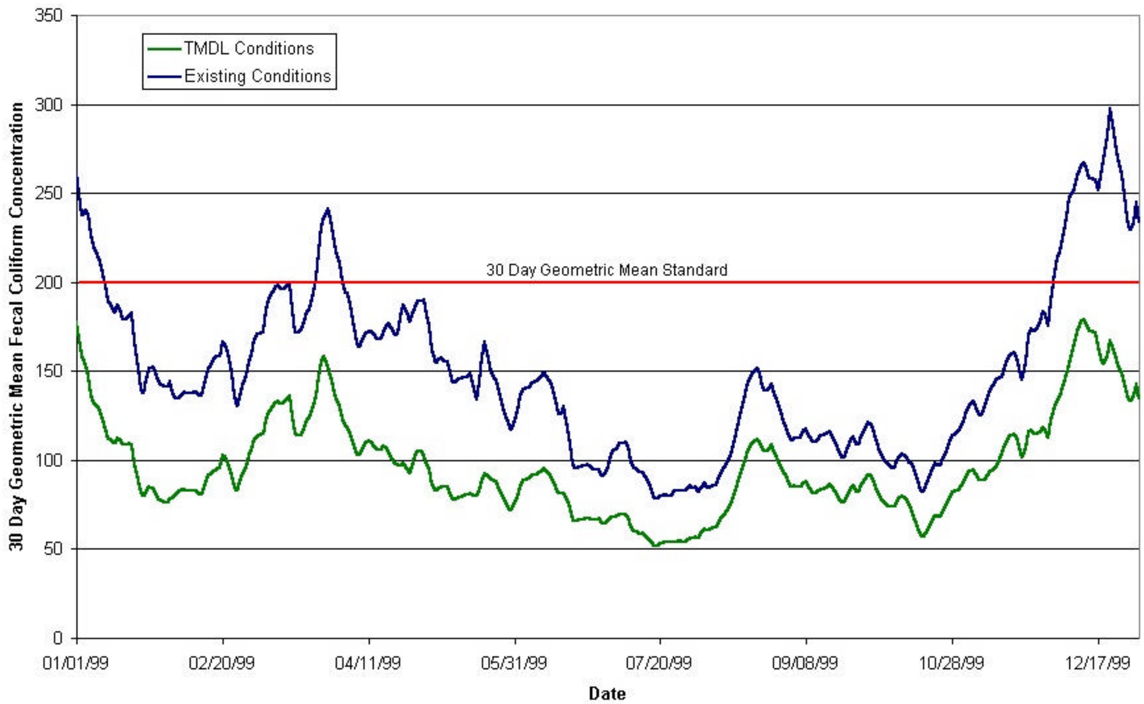
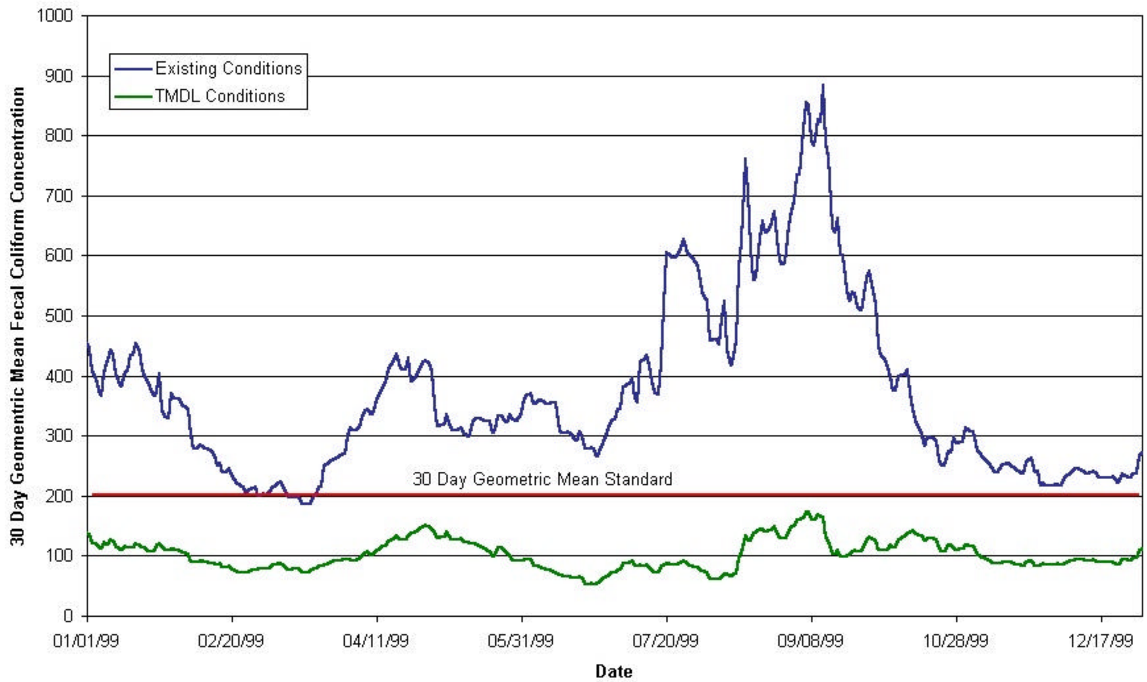


Figure 19: Existing and TMDL Conditions for the McAlpine Creek Watershed Downstream of Sardis Road

Figure 20: Existing and TMDL Conditions for the McAlpine Creek Watershed Upstream of Sardis Road



Tables 23, 24, 25, 26 and 27 present the contribution of each of the source categories to the date of maximum exceedance listed in Table 22. Figures 21, 22, 23, 24 and 25 graphically display the fecal coliform load by source category during these times for the Sugar Creek, Irwin Creek, Little Sugar Creek and McAlpine Creek Downstream of Sardis Road and McAlpine Creek Upstream of Sardis Road Watersheds respectively.

Table 23: Loading Values by Source Category for the Date of Maximum Exceedance in the Sugar Creek Watershed (05/29/1999 – 06/27/1999).

Source Category	**Source Sub-Category**	**FC Load (c.f.u./30 days)**
Point Source	WWTP	3.8×10^{12}
	Sanitary Sewer Overflows	1.6×10^{13}
Non-Point Source	Wildlife	1.5×10^{11}
	Failing Septic Systems	1.0×10^{11}
	Dry Weather Flow from Storm Drain System	1.8×10^{12}
	Sewer Exfiltration	1.0×10^{11}
All Sources		2.0×10^{13}

Table 24: Loading Values by Source Category for the Date of Maximum Exceedance in the Irwin Creek Watershed (05/29/1999 – 06/27/1999).

Source Category	**Source Sub-Category**	**FC Load (c.f.u./30 days)**
Point Source	WWTP	5.6×10^{12}
	Sanitary Sewer Overflows	1.2×10^{13}
Non-Point Source	Wildlife	-
	Failing Septic Systems	1.0×10^{11}
	Dry Weather Flow from Storm Drain System	1.7×10^{12}
	Sewer Exfiltration	1.5×10^{11}
All Sources		1.9×10^{13}

Table 25: Loading Values by Source Category for the Date of Maximum Exceedance in the Little Sugar Creek Watershed (11/21/1999 – 12/20/1999).

Source Category	**Source Sub-Category**	**FC Load (c.f.u./30 days)**
Point Source	WWTP	3.2×10^{12}
	Sanitary Sewer Overflows	8.6×10^{12}
Non-Point Source	Wildlife	1.9×10^{12}
	Failing Septic Systems	3.1×10^{10}
	Dry Weather Flow from Storm Drain System	1.7×10^{11}
	Sewer Exfiltration	3.9×10^{11}
All Sources		1.6×10^{13}

Figure 21: Current and TMDL Fecal Coliform Loading by Source Category for the Sugar Creek Watershed During Critical Condition

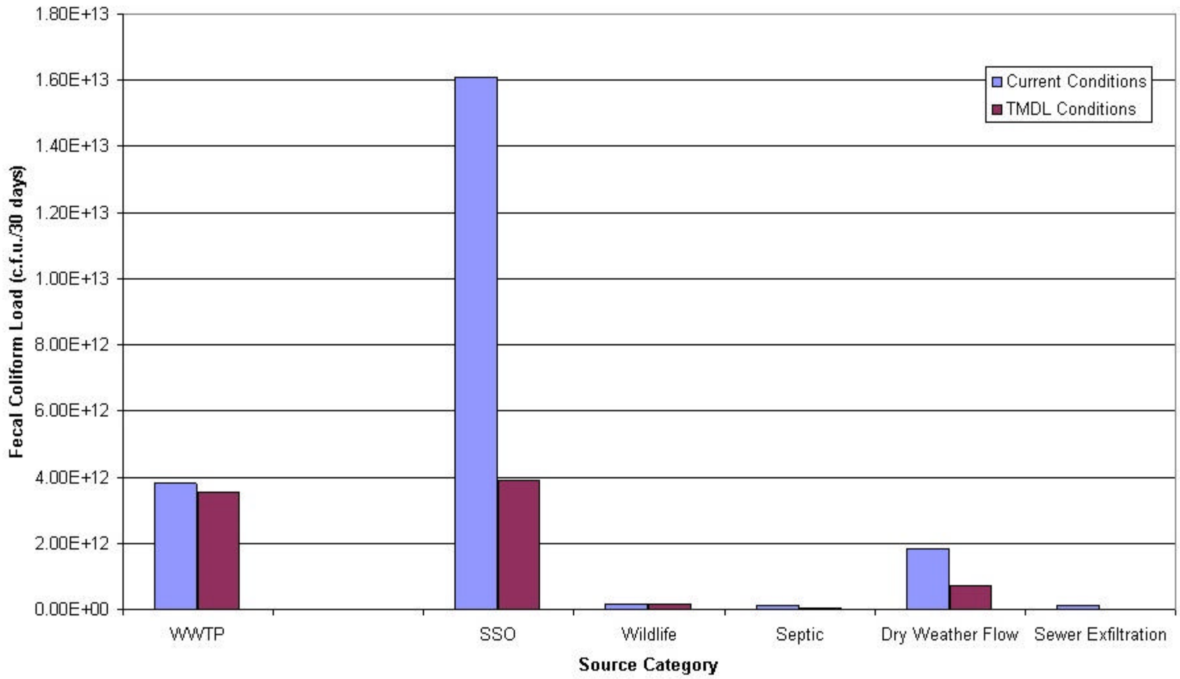


Figure 22: Current and TMDL Fecal Coliform Loading by Source Category for the Irwin Creek Watershed During Critical Condition

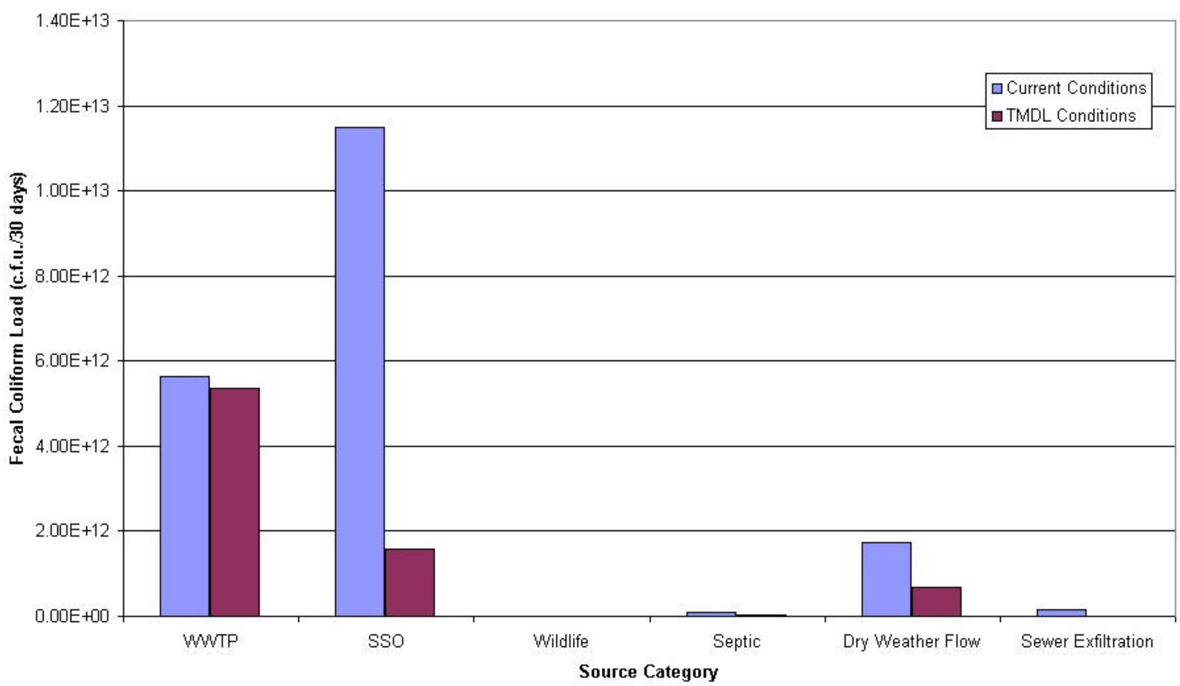


Figure 23: Current and TMDL Fecal Coliform Loading by Source Category for the Little Sugar Creek Watershed During Critical Condition

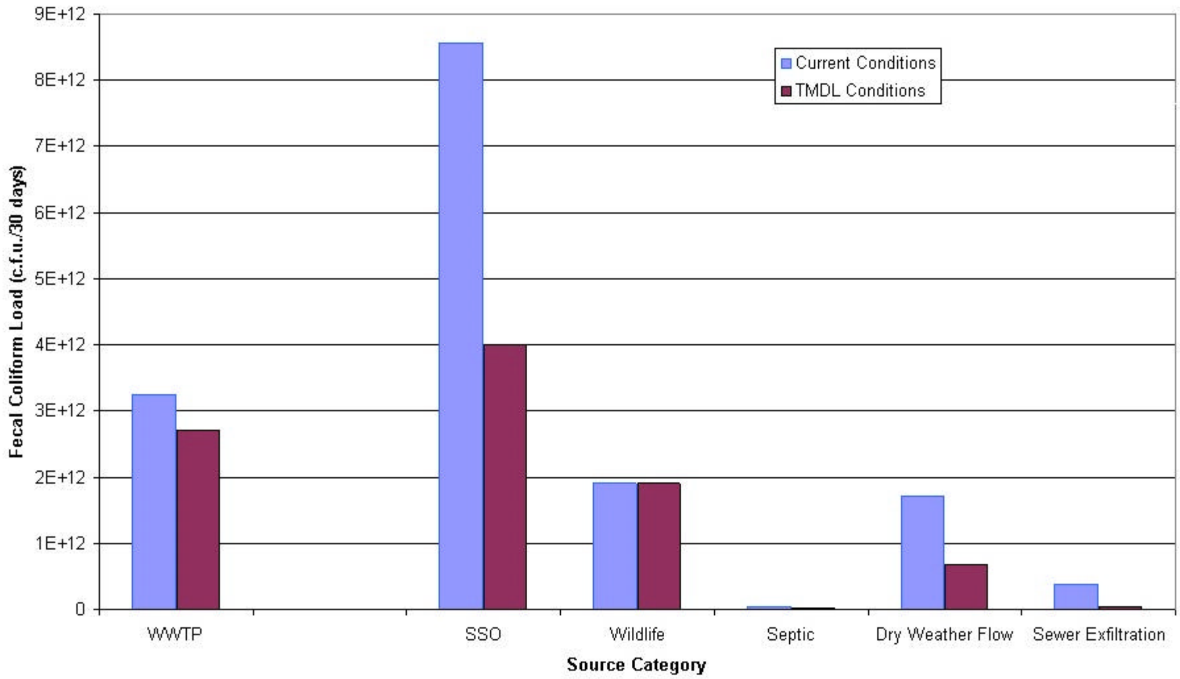


Figure 24: Current and TMDL Fecal Coliform Loading by Source Category for the McAlpine Creek Watershed Downstream of Sardis Road During Critical Condition

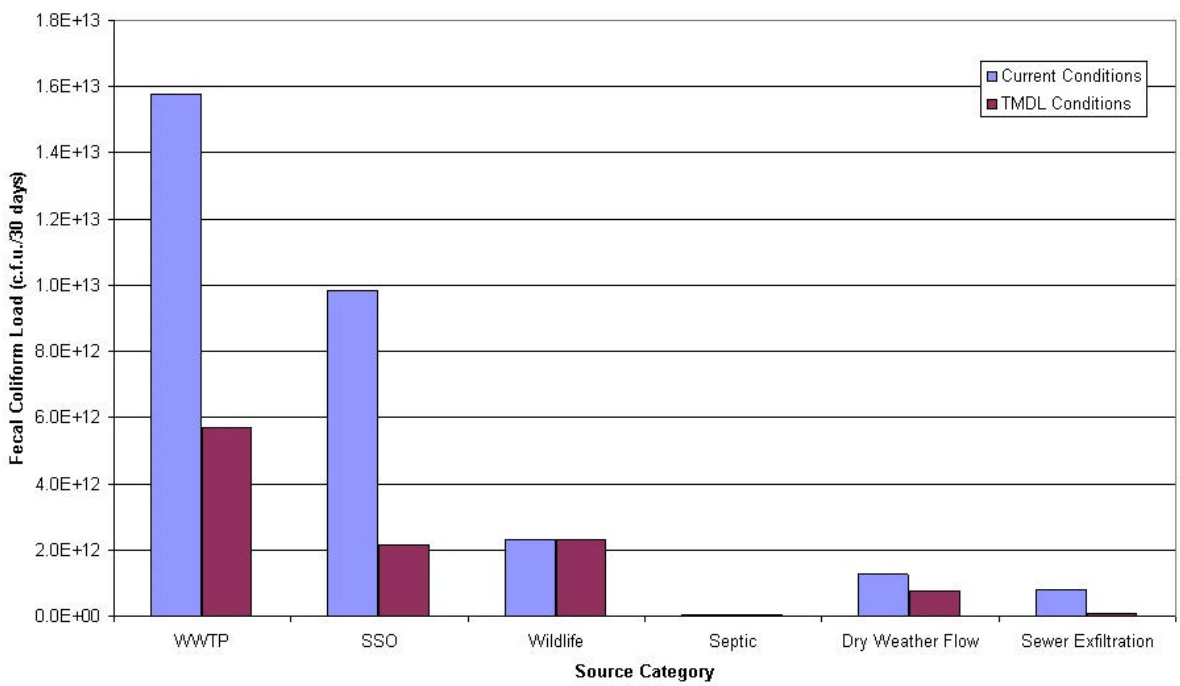


Figure 25: Current and TMDL Fecal Coliform Loading by Source Category for the McAlpine Creek Watershed Upstream of Sardis Road

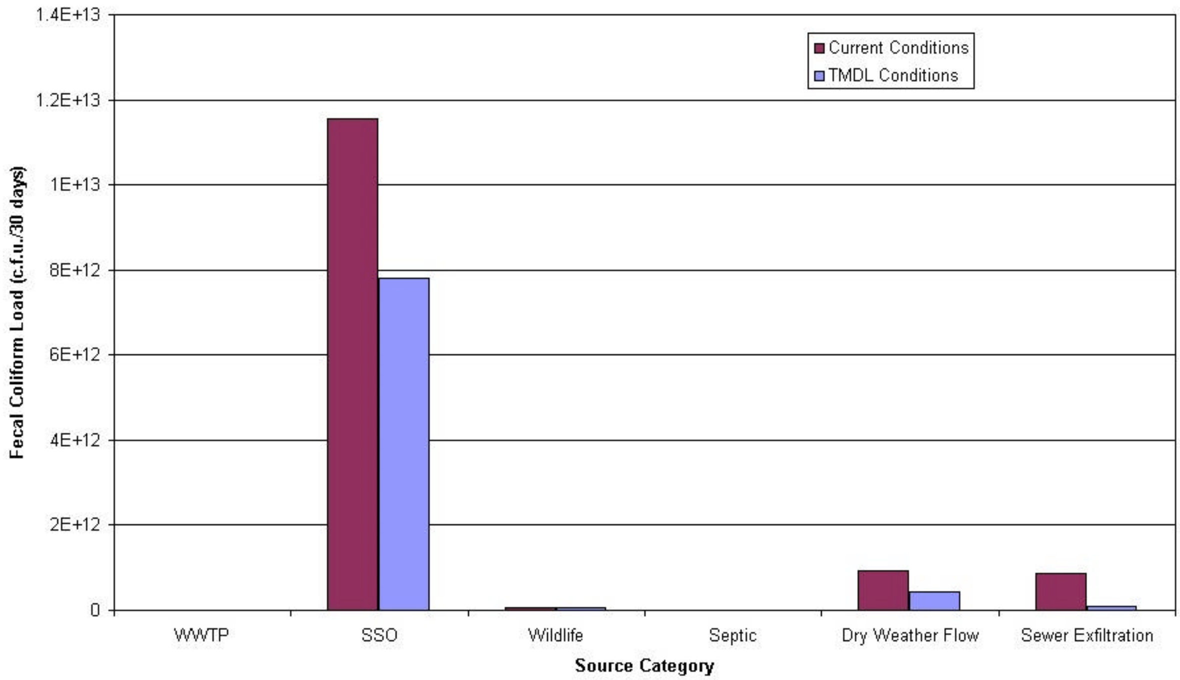


Table 26: Loading Values by Source Category for the Date of Maximum Exceedance in the McAlpine Creek Watershed Downstream of Sardis Road (07/18/1999 – 08/16/1999).

Source Category	**Source Sub-Category**	**FC Load (c.f.u./30 days)**
Point Source	WWTP	1.6×10^{13}
	Sanitary Sewer Overflows	9.8×10^{12}
Non-Point Source	Wildlife	2.3×10^{12}
	Failing Septic Systems	5.7×10^{10}
	Dry Weather Flow from Storm Drain System	1.3×10^{12}
	Sewer Exfiltration	8.0×10^{11}
All Sources		3.2×10^{13}

Table 27: Loading Values by Source Category for the Date of Maximum Exceedance in the McAlpine Creek Watershed Upstream of Sardis Road (07/18/1999 – 08/16/1999).

Source Category	**Source Sub-Category**	**FC Load (c.f.u./30 days)**
Point Source	WWTP	-
	Sanitary Sewer Overflows	1.2×10^{13}
Non-Point Source	Wildlife	6.2×10^{10}
	Failing Septic Systems	4.9×10^{9}
	Dry Weather Flow from Storm Drain System	9.2×10^{11}
	Sewer Exfiltration	8.8×10^{11}
All Sources		1.4×10^{13}

4 ALLOCATION

4.1 Total Maximum Daily Load

The TMDL process quantifies the amount of a pollutant that can be assimilated by a water body, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations [WLAs]), non-point source loads (Load Allocations [LA]), and an appropriate margin of safety (MOS), which takes into account any lack of knowledge concerning the relationship between the effluent limitations and water quality:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR § 130.2 (I) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure. For fecal coliform, TMDLs are expressed as counts per 30 days to be consistent with the water quality standard. Therefore, the TMDL represents the maximum fecal coliform load that can be assimilated by the stream during the critical 30 day period while maintaining the fecal coliform water quality standard of the geometric mean of 200 c.f.u./100 ml over 30 days.

The total maximum daily load of fecal coliform was determined by adding the WLA and LA. The MOS was implicitly included in the TMDL analysis through conservative model inputs and assumptions and does not factor directly in the TMDL equation as shown above. The TMDLs for the Sugar Creek, Irwin Creek, Little Sugar Creek, McAlpine Creek Downstream of Sardis Road and McAlpine Creek Upstream of Sardis Road Watersheds are listed in Table 28. Also included in Table 28 are the number of exceedances of 400 c.f.u./100 ml predicted by the model for calendar year 1999. Note that daily average fecal coliform concentrations were used to produce these counts.

Table 28: TMDLs for the Sugar Creek, Irwin Creek, Little Sugar Creek, McAlpine Creek Downstream of Sardis Road and McAlpine Creek Upstream of Sardis Road Watersheds

Watershed	Predicted Critical Condition	Predicted TMDL (c.f.u./30 days)	Number of exceedances of 400/100 ml during 1999 (% in parentheses)
Sugar Creek	07/01/1999*	8.4×10^{12}	26 (7%)
Irwin Creek	06/30/1999**	7.7×10^{12}	49 (13%)
Little Sugar Creek	12/21/1999	9.4×10^{12}	15 (4%)
McAlpine Creek Downstream of Sardis Road	09/06/1999**	1.1×10^{13}	25 (7%)
McAlpine Creek Upstream of Sardis Road	09/06/1999***	6.8×10^{12}	22 (6%)

*Note: after SSO sources were reduced in the water quality model, the date of maximum exceedance moved from 06/28/1999 to 07/02/1999.

*Note: after SSO sources were reduced in the water quality model, the date of maximum exceedance moved from 06/28/1999 to 07/30/1999.
***Note: after SSO sources were reduced in the water quality model, the date of maximum exceedance moved from 08/17/1999 to 09/06/1999.
****Note: after SSO sources were reduced in the water quality model, the date of maximum exceedance moved from 09/12/1999 to 09/06/1999.

4.2 Waste Load Allocations (Point Sources)

The WLA for the Sugar Creek, Irwin Creek, Little Sugar Creek, McAlpine Creek Downstream of Sardis Road and McAlpine Creek Upstream of Sardis Road Watershed is presented in Tables 29, 30, 31, 32 and 33 respectively. The same information is presented graphically in Figures 21, 22, 23, 24 and 25. In all three watersheds, the sum of the fecal coliform load from point sources vastly outweighs the load from non-point sources during the critical conditions. Therefore, reductions to the point sources would have the greatest impact on the in-stream fecal coliform concentration. The reduction strategy for the point sources is as follows:

NPDES Permitted Dischargers: For calculation of the TMDL, the NPDES permitted dischargers were held to a maximum fecal coliform concentration in their effluent of 1000 c.f.u./100 ml. The original WWTP time variable input files for the model were altered to reflect these changes and then re-input to the model.

Sanitary Sewer Overflows: For calculation of the TMDL, the occurrence of overflows was cut by 33.3 %, 25%, 25% and 33% in the Sugar Creek, Irwin Creek, Little Sugar Creek, McAlpine Creek Downstream of Sardis Road and McAlpine Creek Upstream of Sardis Road respectively.. Additionally, the remaining SSOs were limited to a maximum of 3 hours of flow. The original SSO time variable input files for the model were altered to reflect these changes and then re-input to the model.

Table 29: In Stream Fecal Coliform Load Reductions for the Sugar Creek Watershed (05/30/1999 – 06/28/1999).

Source Category	Source Sub-Category	Original FC Load (c.f.u./30 days)	FC Load after Reduction (c.f.u./30 days)	Reduction
Point Source (WLA)	WWTP	3.8×10^{12}	3.5×10^{12}	7.2 %
	Sanitary Sewer Overflows	1.6×10^{13}	3.9×10^{12}	75.7%
Non-Point Source (LA)	Wildlife	1.5×10^{11}	1.5×10^{11}	0 %
	Failing Septic Systems	1.0×10^{11}	3.8×10^{10}	61.7%
	Dry Weather Flow from Storm Drain System	1.8×10^{12}	7.0×10^{11}	61.7 %
	Sewer Exfiltration	1.0×10^{11}	8.5×10^{9}	91.6 %
All Sources (TMDL)		2.0×10^{13}	8.4×10^{12}	59.2 %

Table 30: In Stream Fecal Coliform Load Reductions for the Irwin Creek Watershed (05/30/1999 – 06/28/1999).

Source Category	**Source Sub-Category**	**Original FC Load (c.f.u./30 days)**	**FC Load after Reduction (c.f.u./30 days)**	**Reduction**
Point Source (WLA)	WWTP	5.6×10^{12}	5.4×10^{12}	3.6 %
	Sanitary Sewer Overflows	1.2×10^{13}	1.6×10^{12}	86.7%
Non-Point Source (LA)	Wildlife	-	-	-
	Failing Septic Systems	1.0×10^{11}	4.0×10^{10}	60.0%
	Dry Weather Flow from Storm Drain System	1.7×10^{12}	6.8×10^{11}	60.0 %
	Sewer Exfiltration	1.5×10^{11}	1.3×10^{10}	91.3 %
All Sources (TMDL)		1.9×10^{13}	7.8×10^{12}	58.9 %

Table 31: In-Stream Fecal Coliform Load Reductions for the Little Sugar Creek Watershed (11/21/1999 – 12/20/1999).

Source Category	**Source Sub-Category**	**Original FC Load (c.f.u./30 days)**	**FC Load after reduction (c.f.u./30 days)**	**Reduction**
Point Source (WLA)	WWTP	3.2×10^{12}	2.7×10^{12}	16.7%
	Sanitary Sewer Overflows	8.6×10^{12}	4.0×10^{12}	53.2 %
Non-Point Source (LA)	Wildlife	1.9×10^{12}	1.9×10^{12}	0 %
	Failing Septic Systems	3.1×10^{10}	1.2×10^{10}	60 %
	Dry Weather Flow from Storm Drain System	1.7×10^{11}	6.8×10^{10}	60 %
	Sewer Exfiltration	3.9×10^{11}	4.4×10^{10}	88.7 %
All Sources (TMDL)		1.6×10^{13}	9.4×10^{12}	40.9 %

Table 32: In-Stream Fecal Coliform Load Reductions for the McAlpine Creek Watershed Downstream of Sardis Road (08/07/1999 – 09/05/1999).

Source Category	**Source Sub-Category**	**Original FC Load (c.f.u./30 days)**	**FC Load after Reduction (c.f.u./30 days)**	**Reduction**
Point Source (WLA)	WWTP	1.6×10^{13}	5.7×10^{12}	64.0 %
	Sanitary Sewer Overflows	9.8×10^{12}	2.1×10^{12}	78.2 %
Non-Point Source (LA)	Wildlife	2.3×10^{12}	2.3×10^{12}	0 %
	Failing Septic Systems	5.7×10^{10}	3.5×10^{10}	38.1%
	Dry Weather Flow from Storm Drain System	1.3×10^{12}	7.7×10^{11}	39.7%
	Sewer Exfiltration	8.0×10^{11}	8.7×10^{10}	89.1 %
All Sources (TMDL)		3.2×10^{13}	1.1×10^{13}	65.8 %

Table 33: In-Stream Fecal Coliform Load Reductions for the McAlpine Creek Watershed Upstream of Sardis Road(08/07/1999 – 09/05/1999).

Source Category	**Source Sub-Category**	**Original FC Load (c.f.u./30 days)**	**FC Load after reduction (c.f.u./30 days)**	**Reduction**
Point Source (WLA)	WWTP	-	-	-
	Sanitary Sewer Overflows	1.2×10^{13}	7.8×10^{12}	32.6 %
Non-Point Source (LA)	Wildlife	6.2×10^{10}	6.2×10^{10}	0 %
	Failing Septic Systems	4.9×10^{9}	2.4×10^{9}	50.7 %
	Dry Weather Flow from Storm Drain System	9.2×10^{11}	4.2×10^{11}	53.8 %
	Sewer Exfiltration	8.8×10^{11}	1.1×10^{11}	87.7 %
All Sources (TMDL)		1.4×10^{13}	6.8×10^{12}	52.1 %

4.3 Load Allocations (Non-Point Sources)

The LA for the Sugar Creek, Irwin Creek, Little Sugar Creek and McAlpine Creek Watershed is presented in Tables 29, 30, 31, 32 and 33 respectively. Modeling results indicate much less impact from non-point sources in the TMDL watersheds than from point sources. Therefore, large reductions in non-point source loads have lesser impact than reductions in point source loads. The reduction strategy for the non-point sources is as follows:

Wildlife: For calculation of the TMDL, no reductions in fecal coliform loading from wildlife were included.

Failing Septic Systems: For calculation of the TMDL, estimated fecal coliform loads from failing septic systems were reduced by 60% in the Sugar Creek, Irwin Creek and Little Sugar Creek Watershed, 40% in the McAlpine Creek Watershed Downstream of Sardis Road and 80% in the McAlpine Creek Watershed Upstream of Sardis Road. The original constant input files for the model were altered to reflect this load reduction.

Dry Weather Flow from Storm Drains: For calculation of the TMDL, estimated fecal coliform loads from dry weather flow from storm drains were reduced by 60% in the Sugar Creek, Irwin Creek and Little Sugar Creek Watersheds, 40% in the McAlpine Creek Watershed Downstream of Sardis Road and 80% in the McAlpine Creek Watershed Upstream of Sardis Road. The original constant input files for the model were altered to reflect this load reduction.

Exfiltration from Sanitary Sewer Pipes: For calculation of the TMDL, estimated groundwater and interflow concentrations in the model were reduced to 5 c.f.u./100 ml.

Tables 34, 35, 36, 37 and 38 present example reduction strategies that were used to calculate the TMDLs in the Sugar Creek, Irwin Creek, Little Sugar Creek, McAlpine Creek downstream of Sardis Road and McAlpine Creek Upstream of Sardis Road respectively. The reductions presented in this table represent calculated reductions based entirely upon the source assessment. It is highly likely that once implementation begins, this matrix will change to reflect additional data. The tables are presented for comparison purposes only.

Table 34: Example Source Reduction Strategy for the Sugar Creek Watershed

Source Category	Original Source Distribution	Example Reduction Scenario	Example Source Distribution
WWTP	No Daily Max	Max 1000 c.f.u./100 ml conc. In effluent	NA
SSOs	86 SSOs; 371 hour duration	33% Reduction and 3 hour duration	57 SSOs; 165 hour duration
Wildlife	40 Geese 20 Ducks	NA	40 Geese 20 Ducks
Septic Sytems	43.3 Failing Septic Systems	60% Reduction	17.3 Failing Septic Systems
Dry Weather Flow	105.4 Outfalls with Dry Weather Flow	60% Reduction	42.2 Outfalls with Dry Weather Flow
Sewer Exfiltration	58 c.f.u./100 ml in Ground Water	5 c.f.u./100 ml in Ground Water	NA

Table 35: Example Source Reduction Strategy for the Irwin Creek Watershed

Source Category	Original Source Distribution	Example Reduction Scenario	Example Source Distribution
WWTP	No Daily Max	Max 1000 c.f.u./100 ml conc. In effluent	NA
SSOs	55 SSOs; 228 hour duration	33% Reduction and 3 hour duration	36 SSOs; 103 hour duration
Wildlife	NA	NA	NA
Septic Systems	29.7 Failing Septic Systems	60% Reduction	11.9 Failing Septic Systems
Dry Weather Flow	68.9 Outfalls with Dry Weather Flow	60% Reduction	27.6 Outfalls with Dry Weather Flow
Sewer Exfiltration	58 c.f.u./100 ml in Ground Water	5 c.f.u./100 ml in Ground Water	NA

Table 36: Example Source Reduction Strategy for the Little Sugar Creek Watershed

Source Category	Original Source Distribution	Example Reduction Scenario	Example Source Distribution
WWTP	No Daily Max	Max 1000 c.f.u./100 ml conc. In effluent	NA
SSOs	93 SSOs; 443 hour duration	25% Reduction and 3 hour duration	69 SSOs; 206 hour duration
Wildlife	150 Geese 50 Ducks	NA	150 Geese 50 Ducks
Septic Systems	25.5 Failing Septic Systems	60% Reduction	10.2 Failing Septic Systems
Dry Weather Flow	191.1 Outfalls with Dry Weather Flow	60% Reduction	76.4 Outfalls with Dry Weather Flow
Sewer Exfiltration	58 c.f.u./100 ml in Ground Water	5 c.f.u./100 ml in Ground Water	NA

Table 37: Example Source Reduction Strategy for the McAlpine Creek Watershed Downstream of Sardis Road

Source Category	Original Source Distribution	Example Reduction Scenario	Example Source Distribution
WWTP	No Daily Max	Max 1000 c.f.u./100 ml conc. In effluent	NA
SSOs	39 SSOs; 195 hour duration	25% Reduction and 3 hour duration	31 SSOs; 93 hour duration
Wildlife	160 Geese 90 Ducks 10 Beavers	NA	160 Geese 90 Ducks 10 Beavers
Septic Sytems	34.5 Failing Septic Systems	40% Reduction	20.7 Failing Septic Systems
Dry Weather Flow	91.7 Outfalls with Dry Weather Flow	40% Reduction	55.02 Outfalls with Dry Weather Flow
Sewer Exfiltration	58 c.f.u./100 ml in Ground Water	5 c.f.u./100 ml in Ground Water	NA

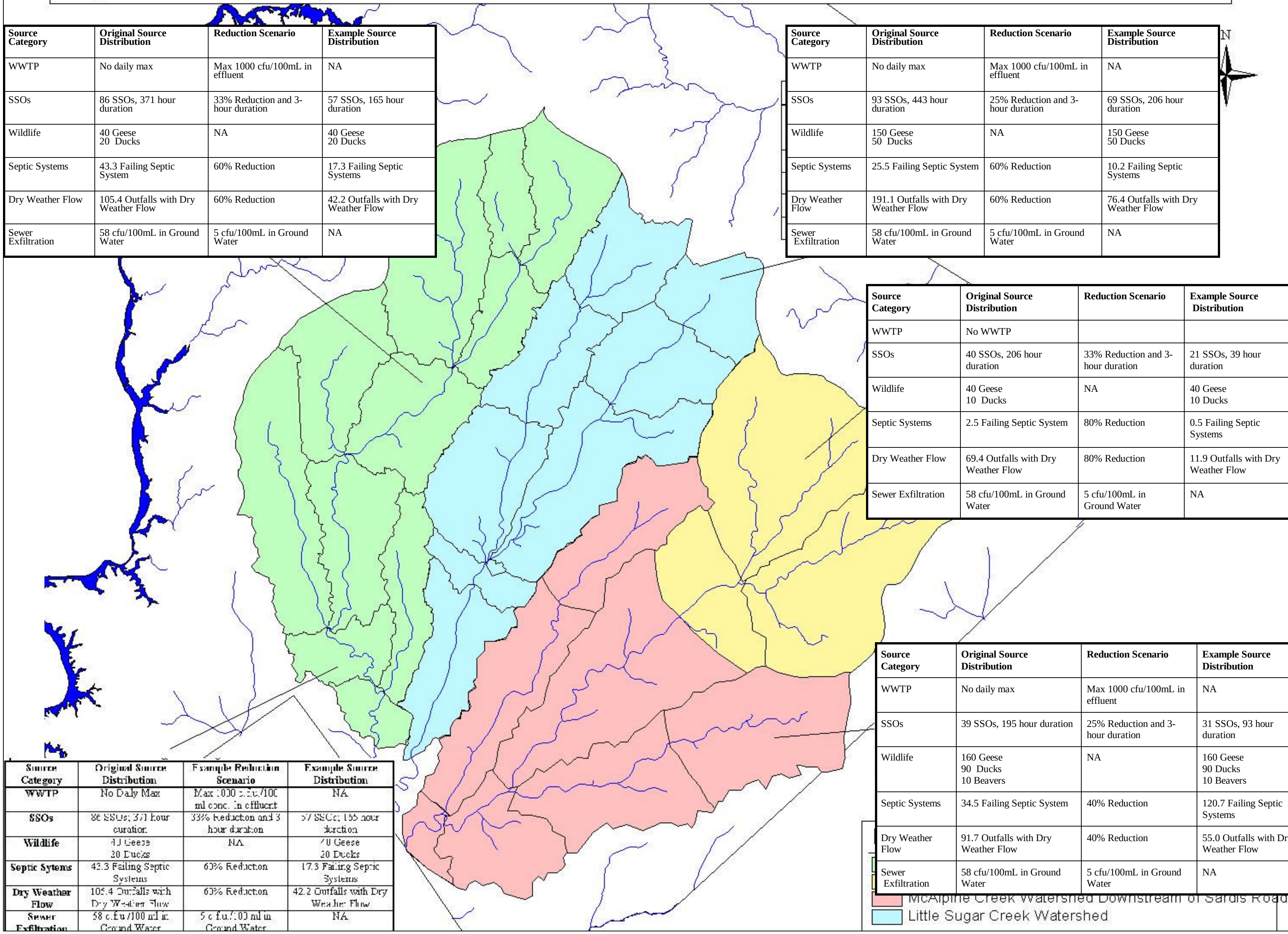
Table 38: Example Source Reduction Strategy for the McAlpine Creek Watershed Upstream of Sardis Road

Source Category	Original Source Distribution	Example Reduction Scenario	Example Source Distribution
WWTP	No WWTP	-	-
SSOs	40 SSOs; 206 hour duration	33% Reduction and 3 hour duration	21 SSOs; 39 hour duration
Wildlife	40 Geese 10 Ducks	NA	40 Geese 10 Ducks
Septic Sytems	2.5 Failing Septic Systems	80% Reduction	0.5 Failing Septic Systems
Dry Weather Flow	64.9 Outfalls with Dry Weather Flow	80% Reduction in Sub-watershed 001 & 002; 85% in 009	11.9 Outfalls with Dry Weather Flow
Sewer Exfiltration	58 c.f.u./100 ml in Ground Water	5 c.f.u./100 ml in Ground Water	NA

The data included in Tables 34, 35, 36, 37 and 38 is presented graphically in Figure 26.

Table 39 presents a matrix of reduction strategies that were evaluate prior to arrival at the strategy discussed above.

Figure 26: Example Source Reduction Strategies for the TMDL Watersheds



Source Category	Original Source Distribution	Reduction Scenario	Example Source Distribution
WWTP	No daily max	Max 1000 cfu/100mL in effluent	NA
SSOs	86 SSOs, 371 hour duration	33% Reduction and 3-hour duration	57 SSOs, 165 hour duration
Wildlife	40 Geese 20 Ducks	NA	40 Geese 20 Ducks
Septic Systems	43.3 Failing Septic System	60% Reduction	17.3 Failing Septic Systems
Dry Weather Flow	105.4 Outfalls with Dry Weather Flow	60% Reduction	42.2 Outfalls with Dry Weather Flow
Sewer Exfiltration	58 cfu/100mL in Ground Water	5 cfu/100mL in Ground Water	NA

Source Category	Original Source Distribution	Reduction Scenario	Example Source Distribution
WWTP	No daily max	Max 1000 cfu/100mL in effluent	NA
SSOs	93 SSOs, 443 hour duration	25% Reduction and 3-hour duration	69 SSOs, 206 hour duration
Wildlife	150 Geese 50 Ducks	NA	150 Geese 50 Ducks
Septic Systems	25.5 Failing Septic System	60% Reduction	10.2 Failing Septic Systems
Dry Weather Flow	191.1 Outfalls with Dry Weather Flow	60% Reduction	76.4 Outfalls with Dry Weather Flow
Sewer Exfiltration	58 cfu/100mL in Ground Water	5 cfu/100mL in Ground Water	NA

Source Category	Original Source Distribution	Reduction Scenario	Example Source Distribution
WWTP	No WWTP		
SSOs	40 SSOs, 206 hour duration	33% Reduction and 3-hour duration	21 SSOs, 39 hour duration
Wildlife	40 Geese 10 Ducks	NA	40 Geese 10 Ducks
Septic Systems	2.5 Failing Septic System	80% Reduction	0.5 Failing Septic Systems
Dry Weather Flow	69.4 Outfalls with Dry Weather Flow	80% Reduction	11.9 Outfalls with Dry Weather Flow
Sewer Exfiltration	58 cfu/100mL in Ground Water	5 cfu/100mL in Ground Water	NA

Source Category	Original Source Distribution	Reduction Scenario	Example Source Distribution
WWTP	No daily max	Max 1000 cfu/100mL in effluent	NA
SSOs	39 SSOs, 195 hour duration	25% Reduction and 3-hour duration	31 SSOs, 93 hour duration
Wildlife	160 Geese 90 Ducks 10 Beavers	NA	160 Geese 90 Ducks 10 Beavers
Septic Systems	34.5 Failing Septic System	40% Reduction	120.7 Failing Septic Systems
Dry Weather Flow	91.7 Outfalls with Dry Weather Flow	40% Reduction	55.0 Outfalls with Dry Weather Flow
Sewer Exfiltration	58 cfu/100mL in Ground Water	5 cfu/100mL in Ground Water	NA

Source Category	Original Source Distribution	Example Reduction Scenario	Example Source Distribution
WWTP	No Daily Max	Max 1000 c.f.u./100 ml conc. in effluent	NA
SSOs	86 SSOs; 371 hour duration	33% Reduction and 3 hour duration	57 SSOs; 165 hour duration
Wildlife	40 Geese 20 Ducks	NA	40 Geese 20 Ducks
Septic Sytems	43.3 Failing Septic Systems	60% Reduction	17.3 Failing Septic Systems
Dry Weather Flow	105.4 Outfalls with Dry Weather Flow	60% Reduction	42.2 Outfalls with Dry Weather Flow
Sewer Exfiltration	58 c.f.u./100 ml in Ground Water	5 c.f.u./100 ml in Ground Water	NA

Table 39: Reduction Strategies Used during the Allocation Process

Strategy	WWTP	SSOs	Wildlife	Septic	Dry Weather Flow	Sewer Exfiltration
1	No Red.	50%, 3 hour Limit	No Red	90%	90%	58 c.f.u/100 ml to 5 c.f.u./100 ml
2	No Red	50%, 3 hour Limit	No Red	90%	90%	58 c.f.u/100 ml to 5 c.f.u./100 ml
3	1000 cfu/100ml daily max	50%, 3 hour Limit	No Red.	90%	90%	58 c.f.u/100 ml to 5 c.f.u./100 ml
4	1000 cfu/100ml daily max	33%, 3 hour Limit	10%	60%	60%	58 c.f.u/100 ml to 5 c.f.u./100 ml
5	1000 cfu/100ml daily max	33%, 3 hour Limit	20%	60%	60%	58 c.f.u/100 ml to 5 c.f.u./100 ml
6	1000 cfu/100ml daily max	25%, 3 hour Limit	10%	60%	60%	58 c.f.u/100 ml to 5 c.f.u./100 ml
7	1000 cfu/100ml daily max	25%, 3 hour Limit	No Red.	60%	60%	58 c.f.u/100 ml to 5 c.f.u./100 ml
8	1500 cfu/100ml daily max	25%, 3 hour Limit	No Red.	40%	40%	58 c.f.u/100 ml to 5 c.f.u./100 ml
9	1000 cfu/100ml daily max	33%, 3 hour Limit	No Red.	80%	80%	58 c.f.u/100 ml to 5 c.f.u./100 ml
10	1000 cfu/100ml daily max	33%, 3 hour Limit	No Red.	60%	60%	58 c.f.u/100 ml to 5 c.f.u./100 ml

Note: All percentages are in reduction (90% indicates 90% reduction not 90% remaining); No Red. = No Reduction

4.4 Seasonal Variation

Seasonal variation is accounted for in the dynamic water quality model by simulations covering a full calendar year.

4.5 Margin of Safety

The MOS is a required component of TMDL development. There are two basic methods for incorporating the MOS: 1) implicitly incorporate the MOS using conservative model assumptions to develop allocations, or 2) explicitly specify a portion of the total TMDL as the MOS and use the remainder for allocations. For Sugar Creek, Little Sugar Creek and McAlpine Creek Fecal Coliform TMDLs, the MOS was both implicitly and explicitly incorporated into the modeling analysis by use of conservative model assumptions and a water quality target of 180 c.f.u./100 ml. This was accomplished by selection of conservative model input parameters and incorporation of the critical period based on the results of a full year simulation. Similarly, the explicit margin of safety was included in an attempt to account for possible inaccuracies in the source assessment.

5 RECOMMENDATIONS

Implementation of the TMDL can be accomplished cooperatively by the Mecklenburg County Department of Environmental Protection, Charlotte Mecklenburg Utilities and Charlotte Mecklenburg Storm Water Services. Local coordination, oversight and reporting for the TMDL should be the responsibility of the Mecklenburg County Department of Environmental Protection. Each of the three programs have currently funded efforts dedicated to reducing fecal coliform levels in Charlotte's streams and these efforts can be augmented to fulfill the requirements of the TMDL Implementation Strategy.

6 PUBLIC PARTICIPATION

The TMDL for Little Sugar, Sugar and McAlpine Creeks was developed from an interactive stakeholder process involving a group of thirteen (13) individuals representing diverse community interests from the following organizations:

Mecklenburg County Department of Environmental Protection - 2 representatives
Charlotte Mecklenburg Utilities - 1 representative
Charlotte Mecklenburg Storm Water Services - 2 representatives
Sierra Club - 1 representative
Catawba River Keeper - 1 representative
N.C. Department of Environment and Natural Resources - 1 representative
S.C. Department of Health and Environmental Control - 1 representative
University of North Carolina at Charlotte - 1 representative
Building Development Commission - 1 representative
Community Resident - 2 representatives

The Mecklenburg County Department of Environmental Protection led the stakeholder process and worked to provide stakeholders with the facts and information necessary to make informed decisions and to ensure that ample opportunities were available for stakeholder input and involvement throughout the process. The stakeholder group met on seven (7) different occasions between December 2, 1999 and April 3, 2001. Stakeholder involvement included input into the development of the source assessment strategy, model selection and field data collection methodology. The stakeholders were also given the opportunity to review and comment on two (2) separate drafts of the TMDL document. Each comment was carefully considered by staff of the Mecklenburg County Department of Environmental Protection and the TMDL was revised accordingly. As a result of this process, the stakeholder group has indicated a high degree of confidence that the TMDL will achieve the desired result of meeting North Carolina's fecal coliform standard for class C waters.

The draft TMDL was publicly noticed on April 30, 2001. Public notice was achieved by posting the TMDL to the DWQ web site, sending a notice to multiple electronic mailing lists, and mailing hardcopies of the notice to interested citizens. Interested citizens were identified using the Planning Branch Catawba River Basin mailing list for Mecklenburg County and the City of Charlotte. A public comment period was through May 31, 2001. Written comments were not received from the public as a result of this review. A copy of the notice is included in Appendix 9.

It is the intent of the Mecklenburg County Department of Environmental Protection to conduct the TMDL implementation phase using continued community involvement and stakeholder input. The stakeholder group will continue to meet to finalize the Implementation Strategy for the TMDL. Community involvement in this process will be expanded by conducting public education and input sessions. Following the completion of the Implementation Strategy, stakeholder involvement will continue to provide oversight throughout the implementation phase of the TMDL.

References

Bales, Jerad D., J. Curtis Weaver and Jerald B. Robinson, 1999, Relation of Land Use to Streamflow and Water Quality at Selected Sites in the City of Charlotte and Mecklenburg County, North Carolina, 1993-98. U.S. Geological Survey Water-Resources Investigations Report 99-4180, Raleigh, North Carolina.

Center for Watershed Protection, 1999, Concentrations, Sources, and Pathways *in* Microbes and Urban Watersheds. Watershed Protection Techniques, v. 3, n. 1, p. 554-565.

Daniel, Sylvia, 2001, Personal Communication, Mecklenburg County Health Department, January 31, 2001.

Gallaher, Bert, 2001, Personal Communication, Charlotte Mecklenburg Utilities, February 6, 2001.

Horsley & Whitten. 1996. Identification and Evaluation of Nutrient and Bacteriological Loadings to Maquoit Bay, Brunswick, and Freeport, Maine. Final Report. Casco Bay Estuary Project, Portland, ME.

Lumb, A.M., McCammon, R.B., and Kittle, J.L., Jr., 1994, Users manual for an expert system (HSPEXP) for calibration of the Hydrologic Simulation Program--Fortran: U.S. Geological Survey Water-Resources Investigations Report 94-4168, 102 p.

Mecklenburg County Department of Environmental Protection, 1998, Completion of Follow-Up Field Screening Activities. Mecklenburg County, North Carolina.

Mecklenburg County Department of Environmental Protection, 2000(a), Well Installation Report. Mecklenburg County, North Carolina.

Mecklenburg County Department of Environmental Protection, 2000(b), Protocol for theSampling of Ground Water Monitoring Wells for the presence of Fecal Coliform Bacteria. Mecklenburg County, North Carolina.

North Carolina Department of Environment and Natural Resources, Division of Water Quality, 2000, 2000 303(d) List (Final Draft), North Carolina Department of Environment and Natural Resources, Division of Water Quality, Raleigh, North Carolina.

Ogden Environmental & Engineering Services, 1991, National Pollutant Discharge Elimination System, Storm Water Discharge Permit Application: Part 1. Prepared for the City of Charlotte, North Carolina. Charlotte, North Carolina.

Ogden Environmental & Engineering Services, 1992, National Pollutant Discharge Elimination System, Storm Water Discharge Permit Application: Part 2. Prepared for the City of Charlotte, North Carolina. Charlotte, North Carolina.

Seriff, Don, 2001, Personal Communication, Mecklenburg County Park and Recreation Department, January 23, 2001.

Sarver, K.M., W.F. Hazell and J.B. Robinson, 1999, Precipitation, Atmospheric Deposition, Streamflow, and Water Quality Data from Selected Sites in the City of Charlotte and

Mecklenburg County, North Carolina, 1997-98. U.S. Geological Survey Open File Report 99-273, Raleigh, North Carolina.

Shoemaker, L., 1997, Compendium of Tools for Watershed Assessment and TMDL Development. EPA 841-B-97-006. U.S. Environmental Protection Agency, Watershed Branch, Assessment and Watershed Protection Division, Office of Wetlands, Oceans, and Watersheds, Washington, D.C.

Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Watershed Management Section, 2000, Total Maximum Daily Load for Fecal Coliform in Sinking Creek, Watauga River Watershed, Tennessee (HUC 06010103). Nashville, Tennessee.

Tetra Tech, Inc., 2001, Fecal Tool User's Guide. Draft report submitted to USEPA. Fairfax, Virginia.

US Environmental Protection Agency (EPA), 1991, Guidance for Water Quality-based Decisions: The TMDL Process. EPA 440/4-91-001. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

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

US Environmental Protection Agency, 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).