South Carolina
Department of Health and Environmental Control

Total Maximum Daily Load Development for Dorchester Creek and Sawmill Branch: Stations CSTL-013 and CSTL-043 Fecal Coliform Bacteria

March 4, 2003

Bureau of Water

Prepared by Wayne Harden

DHEC

PROMOTE PROTECT PROSPER

South Carolina Department of Health and Environmental Control

Abstract

Sawmill Branch and Dorchester Creek (03050202-030-020) in Dorchester, Berkeley, and Charleston Counties, South Carolina, are small streams that are impaired for primary contact recreational uses by fecal coliform bacteria. Sawmill Branch flows into Dorchester Creek, which is a tributary to the Ashley River. The Sawmill watershed (19.9 km^2) is mostly forested, with one fourth of the land in urbanized and much of the rest wetland. The Dorchester Creek watershed (25.9 km^2), however, is mostly urbanized with most the remainder forest land or wetland. During the 1996-2000 assessment period, 32 % (CSTL-013) and 46% (CSTL-043) of samples exceeded the water quality standard of 400 counts/100ml.

This TMDL was based on a mass-balance method whereby the load from each source was estimated and summed for the TMDL. The principal source of fecal coliform loading to the stream was estimated to be runoff from urbanized land. Failing septic systems and other potential sources were small. The total maximum daily loads for these two streams for fecal coliform bacteria were determined to be $1.3 x 10^{10}$ and $3.1 x 10^{10}$ cfu /day, respectively. A reduction of approximately 96 % in the current load to Sawmill Branch and 93 % to Dorchester Creek would be required to meet this TMDL.

Table of Contents

Tables and Figures

Dorchester Creek & Sawmill Branch
(HUC 03050202-030-020)

1.0 INTRODUCTION:

1.1 Background

Levels of fecal coliform bacteria can be elevated in water bodies as the result of both point and nonpoint sources of pollution. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for water bodies that are not meeting designated uses under technology-based pollution controls. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in stream water quality conditions so that states can establish water quality-based controls to reduce pollution and restore and maintain the quality of water resources (USEPA 1991).

1.2 Watershed Description

Dorchester Creek and Sawmill Branch are the lower and upper sections, respectively, of a small creek in Dorchester, Berkeley, and Charleston Counties, SC that drains into the Ashley River near Summerville (Figure 1). The drainage areas of concern for these TMDLs are that part of watershed 03050202-030-020 upstream of CSTL-043 (Sawmill Branch) and upstream of CSTL-013 (Dorchester Creek). All references to the Dorchester Creek watershed in this TMDL refer specifically to the area draining to CSTL-013 and downstream of CSTL-043. Sawmill Branch has a drainage area of 19.9 km^2 (7.7 mi^2); Dorchester Creek has a drainage area of 25.9 km^2 (10 mi^2).

The land uses (Table 1 and Figure 2) in the Sawmill and Dorchester watersheds are predominantly forested (56% and 34% respectively) and urban (25% and 49%) (MRLC data). The urban land use is scattered throughout most of the two sub-watersheds, except for the upper part of Sawmill. This region is being urbanized rapidly due to its proximity to Charleston and the location of I-26 through the Sawmill watershed. There is no significant agricultural activity in these watersheds.

Most of the channel of Sawmill and Dorchester has been widened, deepened, and straightened, isolating the stream from its floodplain wetlands that help remove pollutants from stormwater. In the mid 1990's a 319-funded project was carried out in Summerville to restore a wetland adjacent to Sawmill Branch. A 9.5- acre wetland was restored so that stormwater passed through the wetland prior to flowing into the branch.

1.3 Water Quality Standard

Sawmill Branch is designated as Class Freshwater. Waters of this class are described as follows:

> >Freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and

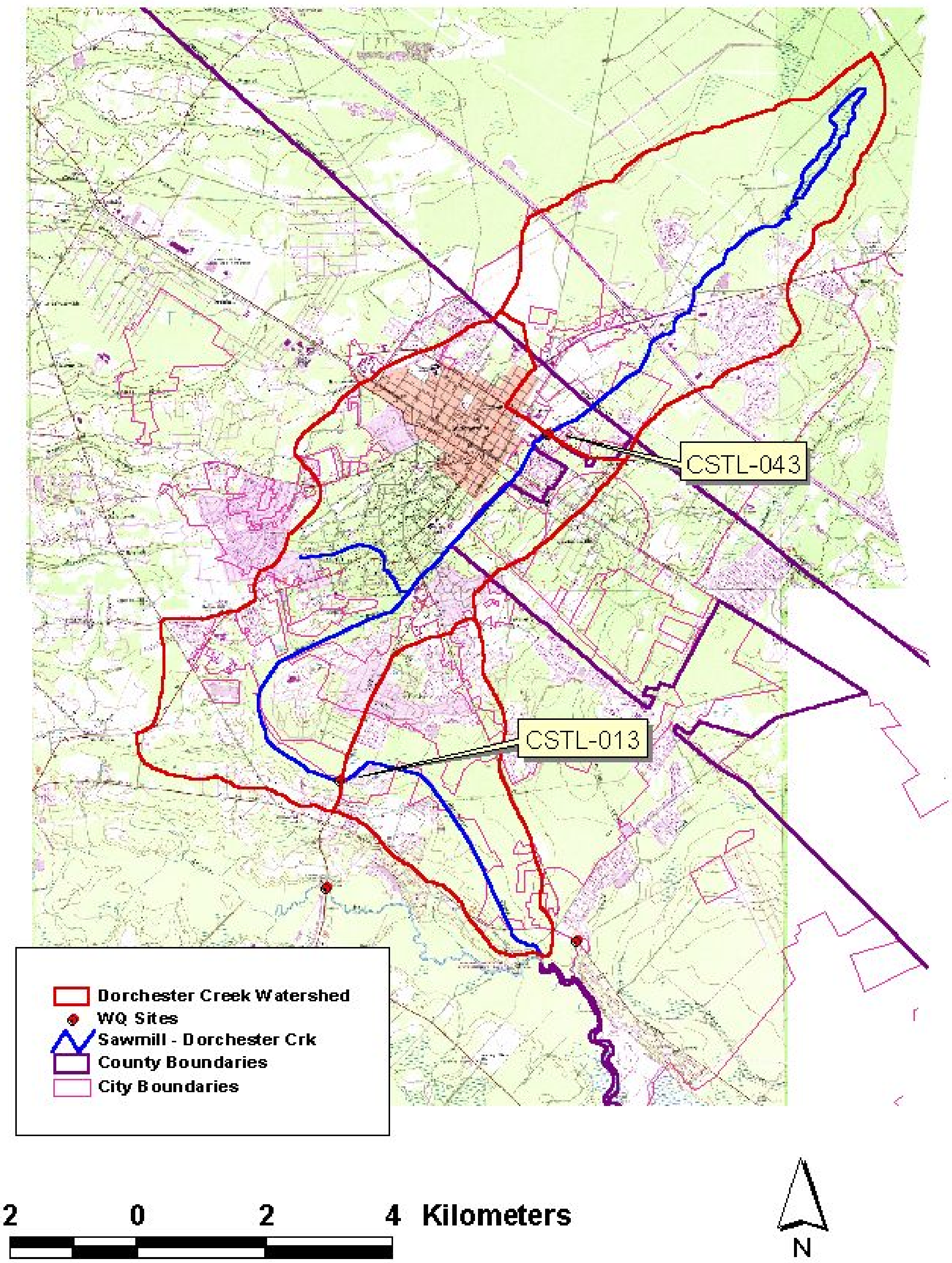


Figure 1. Map of the Sawmill Branch and Dorchester Creek Watershed, Dorchester, Berkeley, and Charleston Counties, showing sewer lines.

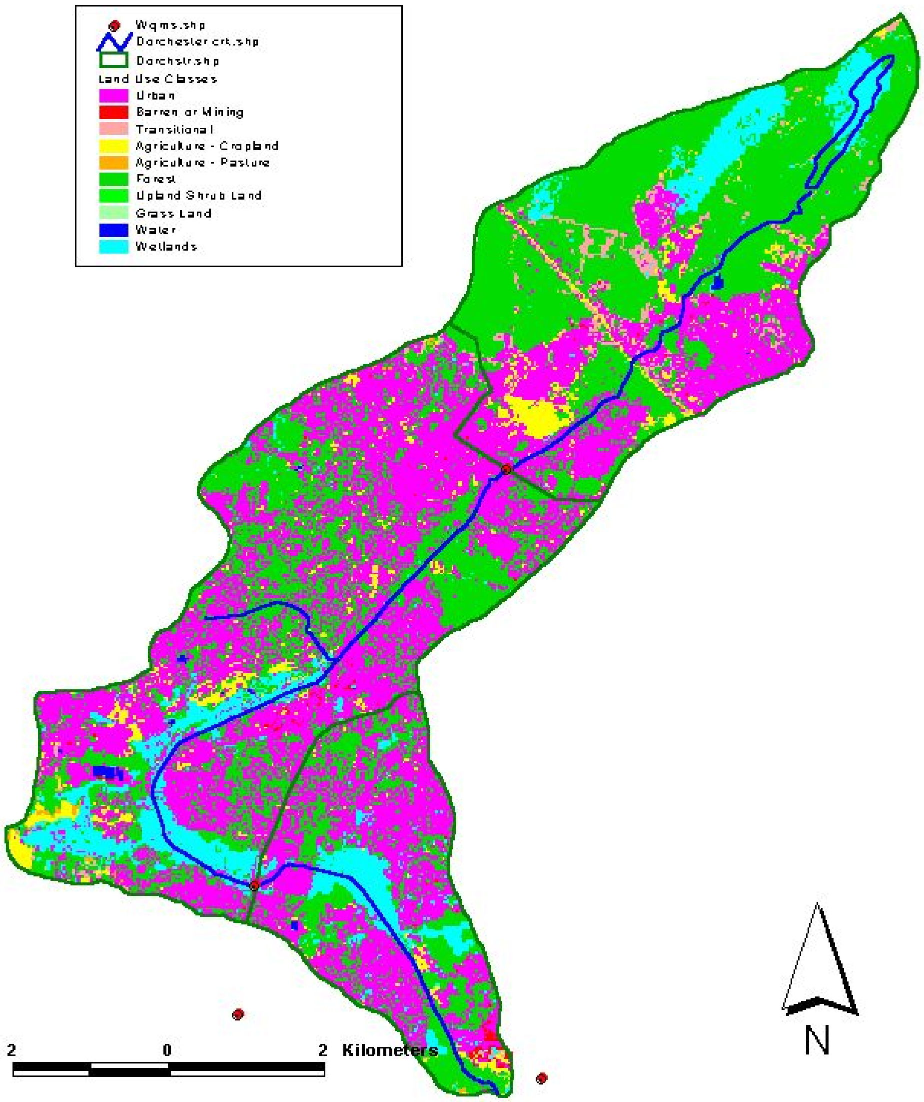


Figure 2. Land use in the Sawmill Branch – Dorchester Creek Watershed.

the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses.= (R.61-68)

Dorchester Creek is designated Class SA. Waters of this class are described as follows:

>are tidal saltwaters suitable for primary and secondary contact recreation, crabbing, and fishing, except harvesting of clams, mussels, or oysters for market purposes or human consumption and uses listed in Class SB. Also suitable for the survival and propagation of a balanced indigenous aquatic community of marine fauna and flora. = (R.61-68)

South Carolina=s standard for fecal coliform in Freshwater and SA waters is:

>Not to exceed a geometric mean of 200/100 ml, based on five consecutive samples during any 30 day period; nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml.= (R.61-68)

Table 1. Sawmill Branch and Dorchester Creek Watersheds Land Use.

Sub-watershed => Land Use Class		**Sawmill Branch above CSTL-043 (hectares and %)**			**Dorchester Creek above CSTL-013 (hectares and %)**	
Urban		498.6	25.1%		1278.8	49.4%
Transitional - Barren		98.0	4.9%		20.6	0.8%
Forest		1106.9	55.6%		871.5	33.7%
Pasture		0.5	0.0%		8.0	0.3%
Cropland		54.2	2.7%		23.0	0.9%
Wetlands		170.4	8.6%		218.1	8.4%
Other		61.5	3.1%		166.6	6.4%
Total		1990.0	100.0%		2586.5	100.0%

2.0 WATER QUALITY ASSESSMENT

The water quality assessment for the 2002 South Carolina 303(d) list used 1996 to 2000 data to identify Sawmill Branch and Dorchester Creek as impaired. Both streams were first included on the 1998 303(d) list. Waters in which no more than 10% of the samples collected over a five year period are greater than 400 cfu / 100 ml of fecal coliform bacteria are considered to comply with the South Carolina water quality standard for fecal coliform bacteria. Waters with more than 10 percent of samples greater than 400 cfu / 100 ml are considered impaired and are placed on South

Carolina=s 303(d) List for fecal coliform bacteria. SCDHEC has ambient monitoring stations, CSTL-043 on Sawmill Branch and CSTL-013, on Dorchester Creek. Aquatic life uses are supported at both stations, however neither supports recreational uses due to violations of the 400/100 ml fecal coliform criterion. During the assessment period (1996-2000), 32 % of the CSTL-013 samples and 46 % of the CSTL-043 samples did not meet the fecal coliform criterion. Fecal coliform data for both water quality stations are in Appendix A.

3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

Fecal coliform bacteria enter surface waters from both point and nonpoint sources. Poorly treated municipal sewage has been a major source of fecal coliform, but with improved treatment and enforcement is not usually the case not now. All point sources must have a NPDES permit. Holders of South Carolina NPDES permits that discharge sanitary wastewater must meet the state standard for fecal coliform at the end of pipe.

Nonpoint sources are diffuse sources that have multiple routes of entry into surface waters. Some sources are related to land use activities that accumulate fecal coliform on the land surface, which then runs off during storm events. Other sources are more or less continuous. Potential nonpoint sources of fecal coliform bacteria are: wildlife, land application of manure, grazing animals, failing septic systems, urban storm runoff, and leaking or overflowing sewer collection systems**.**

3.1 Point Sources in the Sawmill Branch and Dorchester Creek Watersheds

There are no point sources in the Sawmill Branch or Dorchester Creek watersheds.

3.2 Nonpoint Sources in Sawmill Branch and Dorchester Creek Watersheds

3.2.1 Wildlife

Wildlife (mammals and birds) contribute a background level of fecal coliform bacteria to surface waters. Wastes from wildlife are carried into nearby streams by runoff during rainfall. In this area white-tail deer are the predominant large animal and generally assumed to be main contributor of fecal coliform bacteria. The SC Department of Natural Resources (Charles Ruth, DNR Deer Project Supervisor, personal communication, 2000) has estimated a density between 30 and 45 deer/mi^2 for this area. For this TMDL the fecal coliform bacteria load from wildlife is included in background.

3.2.2 Failing Septic Systems

The number of houses within the Dorchester Creek and Sawmill Branch watersheds that have septic systems or otherwise not sewered was determined by GIS from the 1990 census data (Appendix B). The average household was assumed to consist of 2.4 persons. Loading of fecal coliform bacteria to the streams was calculated from an average waste flow per person of 70 gal/capita/day (Horsley and Witten, 1996), a wastewater concentration of 10^4 cfu/100ml (Horsley and Witten, 1996), and a septic system failure rate of 20 % (Schueler, 1999). All wastewater was assumed to reach the streams. The census also includes the category of ‘other’ which may include privies and straight pipes. Failing septic systems are estimated to be a minor contributor of fecal coliform bacteria (Sawmill: < 1% and Dorchester: < 1%).

3.2.3 Urban Storm Runoff

Urbanized or developed land typically generates an increased loading for pollutants relative to forest and other undeveloped land uses. Dogs, cats, and other pets are the primary source of fecal coliform deposited on the urban landscape. Storm runoff washes some of this fecal material into streams directly or through the storm sewers. This source is estimated by the >simple method= of Schueler (1987) using a concentration for fecal coliform from the literature (USEPA, 2001). This source is the largest contributor to the load going into Sawmill Branch and Dorchester Creek, accounting for 97% and 98%, respectively, of the existing load. However, an analysis of precipitation and fecal coliform concentrations in Sawmill Branch and Dorchester Creek showed no correlation between the two. Therefore failing septic systems and/or leaking and overflowing sanitary sewers may be more significant than urban runoff in causing impairment of these two stream segments.

3.2.4 Leaking or Overflowing Sanitary Sewers

Most of these watersheds are sewered and sewer lines are adjacent to the creeks along most of their length. A cursory examination of the Sanitary Sewer Overflow database indicates that there have been overflows in the area. For this TMDL an average daily input to the creek of 100 gal of wastewater with a fecal coliform concentration of 3×10^6 cfu /100 ml was assumed. This level would make leaking or overflowing sewers the third most important fecal coliform source. The closeness of sewer lines to the stream channels would tend to reduce attenuation of the fecal coliform bacteria from any leaks or overflows.

4.0 METHODS

The small size of these two watersheds and the lack of flow data on Dorchester Creek or any nearby stream of similar size, necessitated the use of a non-modeling approach for these TMDLs. For these TMDLs we chose to use a mass-balance approach. Estimates of the various source inputs was summed up and would ideally be comparable to the load estimated for the creek from the flow and the mean concentration. However limited water quality and flow data may make this unlikely. Appendix B contains the spreadsheets that actually calculate these loads.

The probable sources of fecal coliform bacteria in Sawmill Branch – Dorchester Creek were determined to be wildlife, failing septic systems, urban storm runoff, and leaking or overflowing sanitary sewers. Fecal coliform from wildlife are considered as background for these TMDLs and was estimated by multiplying the flow by 30 cfu/100ml, which was determined to be the average fecal coliform concentration for waters in South Carolina draining forested drainages.

The input of fecal coliform from failing septic systems was estimated from the number of houses reported as having septic wastewater treatment in the 1990 census. For this drainage area 20 % (middle of range cited in Schueler, 1999) of septic systems was assumed to have failed and the load was estimated based on literature values for wastewater flow and concentration of fecal coliform.

Urban storm runoff was estimated using the Schueler simple method of calculating a load from urban land (Appendix C). This method uses precipitation and impervious area to estimate the runoff. A concentration of 1300 cfu/100 ml for urban runoff was used; this value is on the lower end of the range in the Protocol for Developing Pathogen TMDLs (EPA, 2001). Fecal coliform concentrations have exceeded the standard on Sawmill Branch and Dorchester Creek but the means of all values are 573 cfu/100ml and 758 cfu/100ml respectively so that a low concentration for runoff seemed appropriate.

There was no available local data for leaking and overflowing sanitary sewers. A minimal daily flow of 100 gal was estimated for these sources. A middle range concentration of $3 x 10^6$ cfu/100ml for raw sewage from the protocol (EPA, 1999) was chosen for this potential source.

These estimates were based on the average flow during the warm season (May – October) the critical period. This average flow was based on a map of South Carolina with runoff isolines, that was developed by Terry Borders (1980) and a correction using the ratio of warm season precipitation to annual precipitation for Summerville, SC.

5.0 TMDL Development

This TMDL was developed using a mass balance approach as suggested in the USEPA (2001) Protocol for Developing Pathogen TMDLs. The small size of the watershed, the lack of flow data, and the limited number of potential sources make this approach preferable. The estimated loads were added up to calculate the existing loads to the creeks. For the TMDL the average warm weather flow was multiplied by the target fecal coliform concentration (190 cfu/100ml). The average warm weather flow for Sawmill Branch and Dorchester Creek, which is not gauged, was calculated from the relationship determined by Borders (1980).

5.1 Critical Conditions

Novotny & Olem (1994) found statistically lower fecal coliform counts in cold weather urban runoff samples than in warmer weather urban runoff. To substantiate this, winter and summer fecal coliform values were compared at ambient water quality monitoring stations in the Piedmont Region in South Carolina impacted by nonpoint sources. This analysis reveals similar or higher values in the summer than the winter. Therefore, the warm season (May-October), which is also the most likely time for contact recreation, is considered critical conditions. This can be explained by the nature of storm events in the summer versus the winter. Thunderstorms are typical in the summer months. This pattern of rainfall allows for the accumulation and washing off of fecal coliforms into the streams resulting in spikes of fecal coliform concentrations. In the winter, long slow rain events are more typical. This pattern of rainfall does not allow for the high build-up of coliform that characterizes the summer. Rather, coliform bacteria are washed into the stream at a more even rate. This, coupled with the increased winter flows that provide more dilution, results in lower fecal coliform concentrations.

5.2 Margin of Safety

There are two basic methods for incorporating the margin of safety or MOS (USEPA 1991): 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; use the remainder for allocations.

The MOS for this TMDL is an explicit 25 cfu/ 100 ml; that is the difference between the standard and the target concentration of 175 cfu/ 100 ml. By setting the target based on the geometric mean of 200 counts/ 100 ml we have some assurance that the stream can meet the criterion >not more than 10% of samples exceed 400/100 ml=. A review of water quality data in South Carolina by SCDHEC (unpublished data) showed that over 75% of waters having a fecal coliform concentration less than 175 cfu/ 100ml also meet the 10% less than 400 cfu/ 100ml criterion.

5.3 Seasonal Variability

The discussion of critical conditions indicated that the warm weather months tend to have higher fecal coliform concentrations. Basing this TMDL on the warm weather months will also protect the stream during the cold weather months when base flows tend to be higher and fecal coliform concentrations in runoff lower.

5.4 Existing Load

The existing loads in Sawmill Branch and Dorchester Creek are the sum of the point sources, nonpoint sources, and background (Table 2). Stormwater runoff from built-up areas is the predominant component of the existing load based on the limited data available for this assessment.

6.0 TOTAL MAXIMUM DAILY LOAD

A total maximum daily load (TMDL) for a given pollutant and water body is comprised of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is represented by the equation:

TMDL = 3 WLAs + 3 LAs + MOS

Table 2. Existing load estimates for Sawmill Branch and Dorchester Creek

Source		Load (cfu/day)		Percent-age
Sawmill Branch				
Failing Septic Systems		1.32E+09		0.3%
Stormwater - Built-up		4.15E+11		97.0%
Leaking/Overflowing Sewers		1.14E+10		2.7%
Background		2.00E+08		0.0%
Total		4.28E+11		100.0%
Dorchester Creek				
Failing Septic Systems		6.09E+09		0.7%
Stormwater - Built-up		8.57E+11		98.0%
Leaking/Overflowing Sewers		1.14E+10		1.3%
Background		4.60E+08		0.1%
Total		8.75E+11		100.0%

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while still achieving water quality standards. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established and thereby provide the basis to establish water quality-based controls.

For most pollutants, TMDLs are expressed as a mass load (e.g., kilograms per day). For bacteria, however, TMDLs are expressed in terms of organism counts (or resulting concentration), in accordance with 40 CFR 130.2(l).

6.1 Waste Load Allocations

There are no point source dischargers to Sawmill Branch, Dorchester Creek, or their tributaries. The waste load allocation for these streams is zero.

6.2 Load Allocations

Load allocations were calculated from the warm season mean flow and the target concentration (Appendix B Calculation of TMDL and Target Loading). The method of estimation of warm season mean flow is found in Appendix B Calculation of Runoff. The load allocation for Sawmill Branch is $1.16\,x\,10^{10}$ cfu/day and for Dorchester Creek is $2.68\,x\,10^{10}$ cfu/day.

6.3 Margin of Safety

The margins of safety are $1.66\,x\,10^{9}$ and $3.84\,x\,10^{9}$ cfu/day for Sawmill Branch and Dorchester Creek, respectively. The MOS values are simply the loads associated with concentration of the MOS (25 cfu/ 100ml)**.**

6.4 TMDL

TMDL = 3WLA + 3LA + MOS

Sawmill Branch:

TMDL = 0 + $1.16\,x\,10^{10}$ cfu/day + $1.66\,x\,10^{9}$ cfu/day.

TMDL = $1.32\,x\,10^{10}$ cfu/day

Target Loading = $1.16\,x\,10^{10}$ cfu/day

Dorchester Creek:

TMDL = 0 + $2.68\,x\,10^{10}$ cfu/day + $3.84\,x\,10^{9}$ cfu/day.

TMDL = $3.06\,x\,10^{10}$ cfu/day

Target Loading = $2.68\,x\,10^{10}$ cfu/day

The target loading value is the load to the creek that it can safely receive and meet the water quality standard. It is simply the TMDL minus the MOS. The target loading for Dorchester Creek requires a theoretical reduction of 96 % from the current load of $2.6\,x\,10^{11}$ cfu/day. The target loading for Sawmill Branch also calls for a theoretical reduction of 93 % from the estimated current loading of $3.94\,x\,10^{11}$ cfu/day.

7.0 REFERENCES

Borders, Terry. 1980. Map of South Carolina showing runoff isolines. SCDHEC.

Horsley & Witten, Inc. 1996. Identification and Evaluation of Nutrient and Bacterial Loadings to Maquoit Bay, Brunswick, and Freeport, Maine. Casco Bay Estuary Project, Portland, ME

Novotny, V. and H. Olem. 1994. Water Quality Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold, New York.

SCDHEC. 1999. Watershed Water Quality Assessment: Santee River Basin. Technical Report No. 012-99.

SCDHEC. 1998. Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina.

Schueler, T. R. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Publ. No. 87703. Metropolitan Washington Council of Governments, Washington, DC.

Schueler, T. R. 1999. Microbes and Urban Watersheds: Concentrations, Sources, and Pathways. Watershed Protection Techniques 3(1): 554-565.

United States Environmental Protection Agency (USEPA). 1983. Final Report of the Nationwide Urban Runoff Program, Vol 1. Water Planning Division, US Environmental Protection Agency, Washington, DC.

United States Environmental Protection Agency (USEPA). 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. Office of Water, EPA 440/4-91-001.

United States Environmental Protection Agency (USEPA). 2001. Protocol for Developing Pathogen TMDLs. First Edition. Office of Water, EPA 841-R-00-002.

APPENDIX A Fecal Coliform Data for Sawmill Branch & Dorchester Creek

Sawmill Branch at US-78

CSTL-043		
Date	Time	FC (cfu/100ml)
2-May-88	1206	240
15-Jun-88	949	1210
8-Jul-88	937	35
31-Aug-88	939	1384
21-Sep-88	1052	244
10-Oct-88	956	500
2-May-89	1230	250
30-Jun-89	1115	4750
31-Jul-89	1340	312
24-Aug-89	1132	240
14-Sep-89	1050	160
15-May-90	1135	300
17-Aug-90	1331	240
3-Oct-90	930	16
6-Dec-90	1140	470
2-May-91	935	450
13-Jun-91	1055	112
12-Jul-91	1120	240
19-Aug-91	945	308
4-Sep-91	930	800
1-Oct-91	925	252
20-May-93	925	350
1-Jun-93	954	170
12-Jul-93	850	1100
18-Aug-93	1254	650
16-Sep-93	844	490
25-Oct-93	1326	540
26-May-94	845	660
9-Jun-94	909	410
18-Jul-94	908	5500
2-Aug-94	1016	860
7-Sep-94	919	720
7-Oct-94	845	620
15-May-95	1051	110
8-Jun-95	830	1000
20-Jul-95	957	500
28-Aug-95	925	1200
25-Sep-95	947	1660
20-Jun-96	815	800
23-Jul-96	905	410
14-Aug-96	850	1200
24-Sep-96	1204	120
31-Oct-96	945	100
12-May-97	1015	360
9-Jun-97	1025	490
8-Jul-97	1040	770
19-Aug-97	1010	90
8-Sep-97	1035	55
23-Oct-97	1140	1040
23-Apr-98	1020	3200
26-May-98	1040	520
25-Jun-98	1425	220
20-Jul-98	1035	1200
6-Aug-98	945	1200
28-Sep-98	1040	380
6-Oct-98	930	900
5/11/00		30
6/20/00		1
7/20/00		12
8/17/00		320
9/7/00		320
10/25/00		20

Dorchester Creek at SC-642

CSTL-013

Date	Time	FC (cfu/100ml)
8-Jul-88	1032	112
31-Aug-88	903	1640
21-Sep-88	1014	3176
10-Oct-88	1324	160
2-May-89	1255	1790
31-Jul-89	1031	2400
23-Aug-89	1328	240
15-May-90	1053	68
14-Jun-90	1135	240
17-Aug-90	1012	240

3-Oct-90	1030	360
6-Dec-90	1230	100
2-May-91	1010	650
13-Jun-91	1135	450
12-Jul-91	1200	210
19-Aug-91	1010	240
4-Sep-91	1010	580
1-Oct-91	1020	356
13-May-92	1136	200
19-Jun-92	1214	270
30-Jul-92	1303	220
17-Aug-92	1315	240
11-Sep-92	1324	1700
22-Oct-92	1201	220
2-Nov-92	1355	68
10-Dec-92	1232	240
14-Jan-93	1256	240
2-Feb-93	1231	70
9-Mar-93	1148	128
7-Apr-93	1159	590
20-May-93	1409	120
1-Jun-93	1340	160
12-Jul-93	1250	68
18-Aug-93	937	590
16-Sep-93	1240	300
25-Oct-93	958	100
9-Nov-93	1239	540
28-Dec-93	1130	15
12-Jan-94	1236	2600
2-Feb-94	1137	1340
21-Apr-94	850	20
26-May-94	1202	19
8-Jun-94	925	192
18-Jul-94	1209	3200
2-Aug-94	1327	600
7-Sep-94	1419	80
7-Oct-94	1148	1900
21-Nov-94	858	380
28-Dec-94	1217	460
19-Jan-95	1016	340
21-Feb-95	1300	280
16-Mar-95	1043	220
5-Apr-95	1452	20
15-May-95	1320	48
8-Jun-95	1113	196
20-Jul-95	1308	152
28-Aug-95	1206	2350
25-Sep-95	1242	2020
21-Nov-95	1216	192
11-Jan-96	1457	76
2-May-96	1232	380
20-Jun-96	1300	590
23-Jul-96	1325	84
14-Aug-96	1145	600
26-Sep-96	1120	194
31-Oct-96	1357	56
7-Nov-96	925	208
2-Dec-96	914	2000
23-Jan-97	1045	48
11-Feb-97	1155	68
13-Mar-97	924	28
1-Apr-97	1200	40
12-May-97	945	310
9-Jun-97	955	475
8-Jul-97	1005	590
19-Aug-97	935	460
8-Sep-97	1015	138
4-Nov-97	1045	360
2-Dec-97	940	130
6-Jan-98	1055	420
19-Feb-98	1050	560
3-Mar-98	1000	240
23-Apr-98	950	2600
4-May-98	1445	2500
1-Jun-98	1110	80
7-Jul-98	1045	360
4-Aug-98	930	4400
1-Oct-98	1025	5000
4-Nov-98	1130	350
1-Dec-98	1015	150
21-Jan-99		300
25-Feb-99		180
17-Mar-99		200
4-Aug-99		170
2-Sep-99		280
19-Oct-99		650
16-Nov-99		88
2-Dec-99		200
18-Jan-00		140
17-Feb-00		380
20-Mar-00		0
6-Apr-00		280
31-May-00		130
8-Jun-00		250

5-Jul-00		0
1-Aug-00		600
21-Sep-00		1000
23-Oct-00		480
4-Dec-00		260

Appendix B Calculations

Calculation of Existing Load

Load Calculations for the Dorchester Creek at CSTL-043 & Sawmill Branch at CSTL-013 (HUC 03050202-030-020)
February 27, 2003
Existing Loading | **Decay Rate: 0.5 (cfu/day)**

Sources:	**Type**	**it #**		**Flow**		**Conc**		**Load**	**Method**	**Load at**
				(cfs)	**(L/day)**	**(cfu/**		**(cfu**	**of calc**	**Sampling**
						100ml)		**/day)**	**Loading**	**Station**
										(cfu/day)
Sawmill Branch										
Failing Septic Systems	NPS	N/A		0.00542	1.3E+04	1.E+04		1.32E+09	% of septic systems	
Stormwater - Built-up	NPS	N/A		NA	NA	NA		4.15E+11	Schueler's Simple	
Leak/O-flowing Sewers				0.00015	3.8E+02	3.0E+06		1.14E+10	Estimated	
Background	NPS			2.72328	6.7E+06	30		2.00E+08	Conc x Flow	
Total								4.28E+11		2.58E+11
Dorchester Creek										
Failing Septic Systems	NPS			0.02491	6.1E+04	1.E+04		6.09E+09	% of septic systems	
Stormwater - Built-up	NPS			NA	NA	NA		8.57E+11	Schueler's Simple	
Leak/O-flowing Sewers				0.00015	3.8E+02	3.0E+06		1.14E+10	Estimated	
Background	NPS			6.26567	1.5E+07	30		4.60E+08	Conc x Flow	
Total								8.75E+11	Flow x Conc	3.91E+11
Total Loading (cfu/day)					**3.9E+11**					

Calculation of TMDL and Target Loading

Allocations				Flow (cfs)	(L/sec)	Conc (cfu/ 100ml)		Load (cfu /day)	Percent Reduction (cfu/day)
Load Allocations									
Sawmill Branch				2.72	77.0	175		1.16E+10	
Dorchester Creek				6.27	177.5	175		2.68E+10	
Wasteload Allocations									
Sawmill Branch				0	0.0	200		0.00E+00	
Dorchester Creek				0	0.0	200		0.00E+00	
Target Loads									
Sawmill Branch								1.16E+10	95.5%
Dorchester Creek								2.68E+10	93.1%

Calculation of Loading from Runoff (from Schueler, 1987)

Stormwater Loading Calculations from Schueler, 1997											
Loading daily (cfu / day)	**=**	**Conversion Factor ***	**x**	**Warm Season Runoff ** (in)**	**x**	**Conc (cfu/ 100 ml)**	**x**	**Area in land use (acres)**		**Loading (cfu / day)**	
Existing:											
Loading Built-up											
Sawmill Branch	=	5.60E+03	**x**	7.75	**x**	13,000	**x**	736	**=**	**4.15E+11**	
Dorchester Creek	=	5.60E+03	**x**	7.75	**x**	13,000	**x**	1521	**=**	**8.57E+11**	
		*** Conversion factor changes units from in, acres, & ml to Load in cfu/day**									
		= 1 / 12 x 43560 x 28.32 x 10 / # of days in period									
		**** Number of days represented by runoff:**									**184**
		(eg annual = 365; warm season = 184)									

Calculation of Runoff (from Schueler, 1987)

Runoff Calculations

Runoff - Warm = Season	**Rainfall * -warm season**	**Fraction of events producing runoff ***	**Runoff Coeffi-cient ***		**Runoff Coeff**	**% Imper-vious**
In	in					
Runoff built-up	31.3	0.9	0.275	**7.75 inches**	0.275	25

Rainfall is Mean of May-Oct 1968-97 data for Summerville, SC

*** Note: Runoff Coeff is function of % impervious surface as follows:**

$$Rc = 0.05 + 0.009 \times I$$

Area of Sawmill Branch watershed: 7.68 mi^2
Area of Dorchester Creek watershed: 9.99 mi^2

Warm Season Mean Q: **

Sawmill Branch	2.72 cfs	= 8 in x 7.68 mi^2 / 13.58 x (31.3 / 52)
Dorchester Creek	6.27 cfs	= 8 in x 17.67 mi^2 / 13.58 x (31.3 / 52)

**** Note: Warm Season Mean Flow is based on Terry Borders geographical analysis of annual flow in South Carolina (1980) and the ratio of warm season to annual precipitation for Summerville**

Estimated Loading from leaking sewer lines and sanitary sewer overflows in Sawmill Branch & Dorchester Creek Watersheds
Date: 12-Sep-02

Sub-Water sheds	Quantity of Leakage & Overflows (gal/day)	Flow (l/day)	F C Conc of Waste water (cfu/100ml)		FC Flux Rate (cfu/day)
Sawmill	100	378.5	3.0E+06		1.14E+10
Dorchester	100	378.5	3.0E+06		1.14E+10

Estimated Failing Septic Systems in Sawmill Branch & Dorchester Creek Watersheds
Date: 3-Sep-02

Failure Rate of Septic Systems: 20.00%

Sub-Water sheds	Total Popu-lation	# of Households	# of Failing Septic Systems	Pop served by Failing Septic Systems	Septic Flow (gal/day)	Septic Flow (l/day)	Septic Flow (cfs)	FC Flux Rate (cfu/day)
Sawmill	250	104	20.8	50.0	3500	13248	0.005	1.32E+09
Dorchester	1150	473	94.6	230.0	16100	60939	0.025	6.09E+09

Note: Population and household data from 1990 Census

Fecal Coliform concentration in discharge assumed to be 10000 cfu/100ml
Septic system overcharge rate is assumed to be 70 gal/day/person

Monthly Precipitation at Summerville (hundredths of inch), from NCDC

Monthly Precipitation at Summerville, SC Site # 388426 in hundredths of inch											9/4/02		
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
1968	281	121	114	339	291	690	415	474	438	1076	244	353	4836
1969	163	245	553	324	375	336	301	1279	737	182	465	249	5209
1970	246	300	737	224	413	356	393	527	128	254	79	309	3966
1971	334	283	690	391	593	397	763	984	509	700	173	219	6036
1972	589	564	313	10	485	622	319	596	170	20	435	612	4735
1973	509	494	762	291	183	1942	219	1273	512	73	75	556	6889
1974	198	569	309	254	440	830	434	1191	403	105	250	524	5507
1975	530	536	530	459	526	441	639	774	510	98	130	344	5517
1976	385	129	323	1	806	893	550	421	611	598	266	540	5523
1977	365	119	468	112	716	171	227	657	198	340	122	597	4092
1978	500	134	182	281	408	261	521	365	150	25	229	263	3319
1979	443	565	284	427	654	347	1022	303	1400	200	401	400	6446
1980	413	175	missing	414	347	141	418	171	550	267	253	227	3376
1981	100	258	261	188	307	449	1098	651	227	226	158	529	4452
1982	550	402	128	648	255	1489	685	363	466	271	297	480	6034
1983	726	470	1029	461	78	151	421	204	273	120	445	575	4953
1984	452	505	691	601	736	245	584	337	610	255	107	56	5179
1985	203	367	127	79	207	786	1029	636	190	249	555	213	4641
1986	255	414	366	127	217	319	462	1087	281	433	441	434	4836
1987	761	506	643	251	539	702	172	476	1184	102	272	105	5713
1988	371	264	199	342	250	455	132	1626	874	134	154	70	4871
1989	280	129	323	501	226	567	963	577	1359	608	164	461	6158
1990	336	232	364	162	214	179	586	637	3	929	379	170	4191
1991	929	175	481	435	838	620	712	1156	42	63	150	122	5723
1992	584	missing	325	284	500	998	452	951	813	556	724	206	6393
1993	870	305	missing	missing	308	220	242	265	422	396	302	300	3630
1994	566	219	408	85	160	931	1440	798	972	927	421	525	7452
1995	682	433	194	145	149	928	612	925	499	529	214	203	5513
1996	216	135	477	347	68	338	726	632	779	435	190	282	4625
1997	363	320	261	609	205	816	896	458	772	386	490	600	6176
Total	13200	9368	11542	8792	11494	17620	17433	20794	16082	10557	8585	10524	155991
Mean	440	323.034	412.214	303.172	383.133	587.333	581.1	693.133	536.067	351.9	286.167	350.8	5199.7
Warm Season (May-Oct) Total (1968-97)					**31.3**	**in**							

Appendix C Schueler's Simple Method to Calculate Urban Stormwater Loads

Modified from:
http://www.stormwatercenter.net/monitoring%20and%20assessment/simple%20meth/simple.htm

Introduction

The Simple Method estimates stormwater runoff pollutant loads for urban areas. The technique requires a modest amount of information, including the subwatershed drainage area and impervious cover, stormwater runoff pollutant concentrations, and annual precipitation. With the Simple Method, the investigator can either break up land use into specific areas, such as residential, commercial, industrial, and roadway and calculate annual pollutant loads for each type of land, or utilize more generalized pollutant values for land uses such as new suburban areas, older urban areas, central business districts, and highways.

Fecal coliform is more difficult to characterize than other pollutants. Data are extremely variable, even during repeated sampling at a single location. Because of this variability, it is difficult to establish different concentrations for each land use. Although some source monitoring data exists (Steuer *et al.*, 1997; Bannerman *et al.*, 1993), the simple method assumes a median urban runoff default value, derived from NURP data (Pitt, 1998), of 20,000 MPN/100ml. For more information on sources and pathways of bacteria in urban runoff, consult Schueler (1999).

The Simple Method estimates pollutant loads for chemical constituents as a product of annual runoff volume and pollutant concentration, as:

$$L = 0.226 * R * C * A$$

Where: L = Annual load (lbs) R = Annual runoff (inches)
C = Pollutant concentration (mg/l) A = Area (acres)
0.226 = Unit conversion factor

For bacteria, the equation is slightly different, to account for the differences in units. The modified equation for bacteria is:

$$L = 1.03 * 10^{-3} * R * C * A$$

Where: L = Annual load (Billion Colonies) R = Annual runoff (inches)
C = Bacteria concentration (#/100 ml) A = Area (acres)
$1.03 * 10^{-3}$ = Unit conversion factor

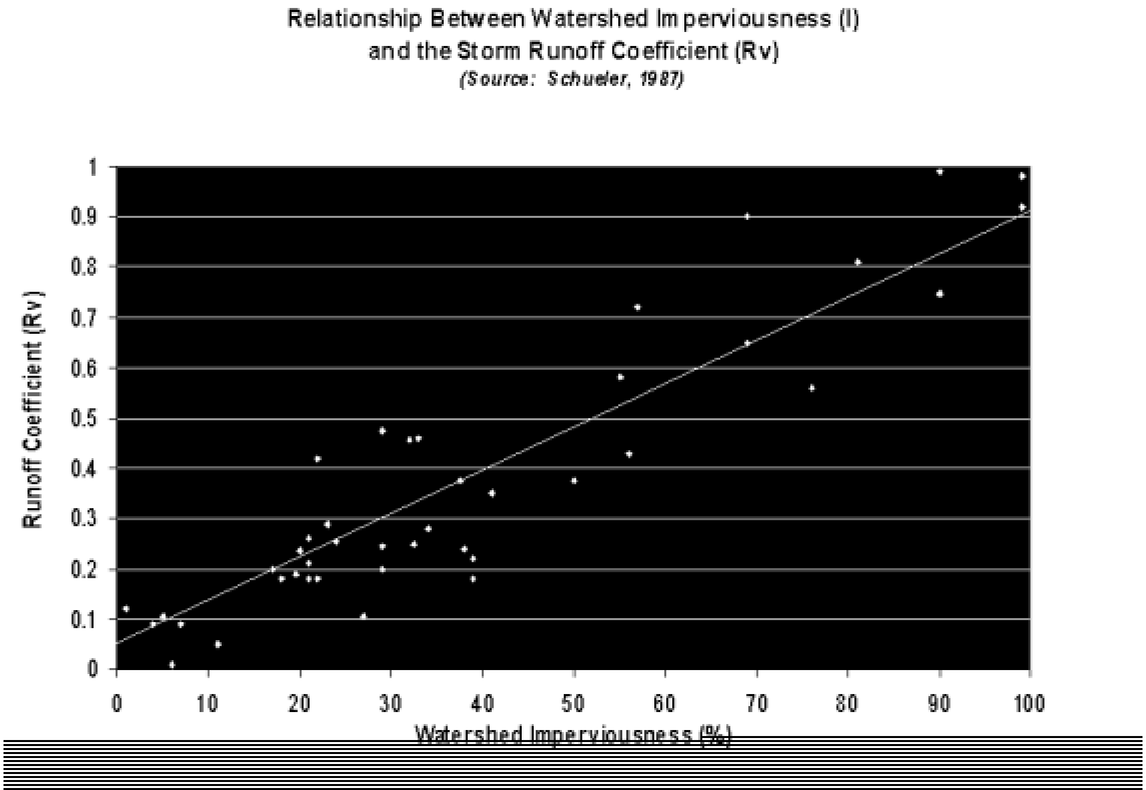
Annual Runoff

The Simple Method calculates annual runoff as a product of annual runoff volume, and a runoff coefficient (Rv). Runoff volume is calculated as:

$$R = P * P_j * Rv$$

Where: R = Annual runoff (inches) P = Annual rainfall (inches)
P_j = Fraction of annual rainfall events that produce runoff (usually 0.9)
Rv = Runoff coefficient

In the Simple Method, the runoff coefficient is calculated based on impervious cover in the subwatershed. This relationship is shown in Figure 1. Although there is some scatter in the data, watershed imperviousness does appear to be a reasonable predictor of Rv.



The following equation represents the best fit line for the dataset (N=47, R^2=0.71).

$$Rv=0.05+0.9Ia$$

Where: Ia = Impervious fraction

Impervious Cover Data

The model uses different impervious cover values for separate land uses within a subwatershed. Representative impervious cover data, along with Model default values, are presented (Table 5). A study is currently being conducted by the Center for Watershed Protection under a grant from the U.S. Environmental Protection Agency to update impervious cover estimates for these and other land uses. The results of this study will be available by 2001. In addition, some jurisdictions may have detailed impervious cover information if they maintain a detailed land use/land cover GIS database.

Limitations of the Simple Method

The Simple Method should provide reasonable estimates of changes in pollutant export resulting from urban development activities. However, several caveats should be kept in mind when applying this method.

The Simple Method is most appropriate for assessing and comparing the relative stormflow pollutant load changes of different land use and stormwater management scenarios. The Simple Method provides estimates of storm pollutant export that are probably close to the "true" but unknown value for a development site, catchment, or subwatershed. However, it is very important not to over emphasis the precision of the results obtained. For example, it would be inappropriate to use the Simple Method to evaluate relatively

Table 5. Impervious Cover (%) for Various Land Uses							
Land Use	**Density (dwelling units/acre)**	**Source**					
		Northern Virginia (NVPDC, 1980)[1]	**Olympia (COPWD, 1995)**	**Puget Sound (Aqua Terra, 1994)**	**NRCS (USDA, 1986)**	**Rouge River (Kluitenberg, 1994)**	**Model Default[2]**
Low Density Residential	<0.5	6	-	10	-	19	**10**
	0.5	-	-	10	12		
	1	12	-	10	20		
Medium Density Residential	2	18	-	-	25		**30**
	3	20	40	40	30		
	4	25	40	40	38		
High Density Residential	5-7	35	40	40	-	38	**40**
Multifamily	Townhouse (>7)	35-50	48	60	65	-	**60**
Industrial	--	60-80	86	90	72	76	**75**
Commercial	--	90-95	86	90	85	56	**85**
Roadway							**80**

1: NVPDC data measure effective impervious cover (i.e., rooftops are not included in residential data)

2: Model default values are approximately equal to the median of Olympia, Puget Sound, NRCS, and Rouge River data, with adjustments made where studies estimate impervious cover for a broad range of densities.

similar development scenarios (e.g., 34.3% versus 36.9% Impervious cover). The simple method provides a general planning estimate of likely storm pollutant export from areas at the scale of a development site, catchment or subwatershed. More sophisticated modeling may be needed to analyze larger and more complex watersheds.

In addition, the Simple Method only estimates pollutant loads generated during storm events. It does not consider pollutants associated with baseflow volume. Typically, baseflow is negligible or non-existent at the scale of a single development site, and can be safely neglected. However, catchments and subwatersheds do generate baseflow volume. Pollutant loads in baseflow are generally low and can seldom be distinguished from natural background levels (NVPDC, 1979). Consequently, baseflow pollutant loads normally constitute only a small fraction of the total pollutant load delivered from an urban area. Nevertheless, it is important to remember that the load estimates refer only to storm event derived loads and should not be confused with the total pollutant load from an area. This is particularly important when the development density of an area is low. For example, in a large low density residential subwatershed (Imp. Cover < 5%), as much as 75% of the annual runoff volume may occur as baseflow. In such a case, the annual baseflow nutrient load may be equivalent to the annual stormflow nutrient load.

References

Aqua Terra Consultants. 1994. *Chambers Watershed HSPF Calibration*. Prepared by D.C. Beyerlein and J.T. Brascher. Thurston County Storm and Surface Water Program. Thurston County, WA.

Bannerman, R.; D. Owens; R. Dodds and N. Hornewer. 1993. "Sources of Pollutants in Wisconsin Stormwater." *Water Science and Technology*. 28(3-5): 241-259.

Barrett, M. and J. Malina. 1998. "Comparison of Filtration Systems and Vegetated Controls for Stormwater Treatment." *3rd International Conference on Diffuse Pollution*: August 31-September 4, 1998. Scottish Environment Protection Agency. Edinburg, Scotland.

Caraco, D. and T. Schueler. 1999. "Stormwater Strategies for Arid and Semi-Arid Watersheds." *Watershed Protection Techniques*. 3(3): 695-706.

City of Olympia Public Works Department (COPWD). 1995. *Impervious Surface Reduction Study*. Olympia, WA.

Claytor, R. and T. Schueler. 1996. *Design of Stormwater Filtering Systems*. Center for Watershed Protection. Ellicott City, MD.

Driscoll, E. 1986. Lognormality of Point and Non-Point Source Pollution Concentrations*. Engineering Foundation Conference*: June 23-27, 1986. Proceedings. Published by the American Society of Civil Engineers. New York, NY.

Gibb, A., B. Bennett, and A. Birkbeck. 1991. *Urban Runoff Quality and Treatment: A Comprehensive Review*. British Columbia Research Corporation. Vancover, B.C.

Kluiteneberg, E. 1994. *Determination of Impervious Area and Directly Connected Impervious Area*. Memo for the Wayne County Rouge Program Office. Detroit, MI.

Northern Virginia Planning District Commission (NVPDC). 1980. *Guidebook for Screening Urban Nonpoint Pollution Management Strategies*. Northern Virginia Planning District Commission. Falls Church, VA.

Pitt, R. 1998. "Epidemiology and Stormwater Managment." *Stormwater Quality Management*. CRC /Lewis Publishers. New York, NY.

Schueler, T. 1999. "Microbes and Urban Watersheds." *Watershed Protection Techniques*. 3(1): 551-596.

Schueler, T. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban Best Management Practices*. MWCOG. Washington, D.C.

Shelley, P., and D. Gaboury. "Estimation of Pollution from Highway Runoff - Initial Results." *Engineering Foundation Conference*: June 23-27, 1986. Proceedings. Published by the American Society of Civil Engineers. New York, NY.

Smullen, J., and K. Cave.1998. "Updating the U.S. Nationwide Urban Runoff Quality Database." *3rd International Conference on Diffuse Pollution*: August 31 - September 4, 1998. Scottish Environment Protection Agency. Edinburg, Scotland.

Steuer, J., W. Selbig, N. Hornewer, and J. Prey. 1997. "Sources of Contamination in an Urban Basin in Marquette, Michigan and an Analysis of Concentrations, Loads, and Data Quality." U.S. Geological Survey, *Water-Resources Investigations Report 97-4242.*

United States Department of Agriculture (USDA). Natural Resources Conservation Service (NRCS). 1986. *Technical Release 55: Urban Hydrology for Small Watersheds, 2nd Edition*. Washington, D.C.

United States Environmental Protection Agency. 1983. *Final Report. Results of the Nationwide Urban Runoff Project*. Washington, DC.

Whalen, P., and M. Cullum. 1989. *An Assessment of Urban Land Use/Stormwater Runoff Quality Relationships and Treatment Efficiencies of Selected Stormwater Management Systems.* South Florida Management District Resource Planning Department, Water Quality Division. Technical Publication 88-9.

Appendix D Public Notice

This notice was published in the Charleston *Post and Courier* on Nov 25, 2002 and again on Jan 21, 2003. It was placed on DHEC's website, and sent to persons or organizations that had expressed an interest in TMDLs or these waters for both comment periods.

AVAILABILTY OF PROPOSED TOTAL MAXIMUM DAILY LOADs FOR WATERS AND POLLUTANTS OF CONCERN IN THE STATE OF SOUTH CAROLINA

Sawmill Branch and Dorchester Creek in Dorchester, Berkeley, and Charleston Counties

Section 303(d)(1) of the Clean Water Act (CWA), 33 U.S.C. ϶1313(d)(1)(C), and the implementing regulation of the US Environmental Protection Agency (EPA, 40 C.F.R. ϶ 130.7(c) (1), require the establishment of total maximum daily loads (TMDLs) for waters identified as impaired pursuant to ϶ 303(d)(1)(A) of the CWA. Each of these TMDLs is to be established at a level necessary to implement applicable water quality standards with seasonal variations and a margin of safety, to account for lack of knowledge concerning the relationship between effluent limitations and water quality. At this time, the South Carolina Department of Health and Environmental Control (DHEC) has developed proposed TMDLs for the ϶303(d)(1)(A) waters:

Sawmill Branch, Berkeley, Charleston, and Dorchester Counties, Fecal Coliform Bacteria, 03050202-030-020; Dorchester Creek, Dorchester County, Fecal Coliform Bacteria, 03050202-030-020.

Upon review of any public comment and revision, if necessary, the Department will submit these TMDLs to EPA for approval as final TMDLs.

Persons wishing to comment on the proposed TMDLs or to offer new data regarding the proposed TMDLs are invited to submit the same in writing no later than December 31, 2002, to:

South Carolina Department of Health and Environmental Control
Bureau of Water
2600 Bull St.
Columbia, S.C. 29201
Attn: Wayne Harden

Mr. Harden=s phone number is 803-898-4023. His E-mail address is hardencw@dhec.state.sc.us.

Copies of individual TMDLs can be obtained by calling, writing, or e-mailing Mr. Harden at the address above or from the Bureau of Water web site: <http://www.scdhec.net/water/>. The administrative record, including technical information, data and analyses supporting the proposed TMDLs, are available for review. Requests to review this information must be submitted in writing to DHEC=s Freedom of Information Office at 2600 Bull Street, Columbia, SC 29201 or requests can be submitted via FAX to the Freedom of Information Office at 803.898.3816. Reproduction of documents is available at a cost of $0.25 per page.

Appendix E Responsiveness Summary