Watershed Characterization Document
Hard Labor Creek (Hydrologic Unit Code: 03060107-010-010 & Station SV-151)
Fecal Coliform Bacteria

June 2005

SCDHEC Technical Report Number: 019-05

United States Environmental Protection Agency

Region 4 serving the southeast

In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et.seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S Environmental Protection Agency is hereby establishing a Total Maximum Daily Load (TMDL) for Fecal Coliform for Hard Labor Creek in the Savannah River Basin. Subsequent actions must be consistent with this TMDL.

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James D. Giattina, Director Date
Water Management Division

Abstract

Total Maximum Daily Loads (TMDLs) have been developed for Hard Labor Creek, which is a tributary of Stevens Creek in Greenwood County, SC. This creek has been on South Carolina's 303(d) list since 1998. During the assessment period for the 2004 303(d) list (1998-2002), 52 % of samples at SV-151 exceeded the water quality standard. Land uses in the watershed of Hard Labor Creek are mostly forest, developed, cropland, and pasture. The City of Greenwood operates a wastewater treatment facility that discharges into Hard Labor Creek. There are no designated Municipal Separate Storm Sewer Systems (MS4) in the watershed. The probable sources of fecal coliform bacteria in Hard Labor Creek are predominantly continual sources such as cattle-in-streams, failing septic systems, illicit discharges, and sewer leaks.

The load-duration curve methodology was used to calculate the existing load and the TMDL load for the creek. The existing load and TMDL load are presented in Table Ab-1. In order to reach the target load for Hard Labor Creek, reduction in the existing load to the creek of 64 % will be necessary. Resources and several TMDL implementation strategies to bring about these reductions are suggested.

Table Ab-1. Total Maximum Daily Loads for Hard Labor Creek at impaired stations.

Station ID	Existing Waste Load	TMDL WLA		Existing Load	TMDL LA	MOS	TMDL	Percent Reduction[3]
	Continuous (cfu/day)	Continuous[1] (cfu/day)	MS4[2]	(cfu/day)	(cfu/day)	(cfu/day)	(cfu/day)	
SV-151	1.66E+10	1.66E+10	NA	3.22E+11	1.15E+11	6.05E+09	1.38E+11	64 %

Table Notes:
1. WLA is expressed as total monthly average.
2. MS4 expressed as percent reduction equal to LA reduction.
3. Percent reduction applies to LA and MS4 components when an MS4 is in the watershed.

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1.0 INTRODUCTION

1.1 Background

Fecal coliform bacteria are widely used as an indicator of pathogens in surface waters and wastewater. Acute gastrointestinal illnesses affect millions of people in the United States and cause billions of dollars of costs each year (Gaffield et al., 2003). Of these illnesses many are caused by contaminated drinking water. Untreated stormwater runoff has been associated with a number of disease outbreaks, most notably the outbreak in Milwaukee that caused many deaths.

Though occurring at low levels from natural sources, the concentration of fecal coliform bacteria can be elevated in water bodies as the result of pollution. Sources of fecal coliform bacteria can be diffuse or nonpoint sources, such as runoff, failing septic systems, and leaking sewers. The source of the pollutant can also be a point source. 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

The watershed of Hard Labor Creek in Greenwood County is in the Piedmont of western South Carolina (Figure 1). The headwaters of the creek rise in the City of Greenwood. Hard Labor Creek then flows south and joins with Cuffytown Creek to form Stevens Creek, a tributary of the Savannah River.

The watershed is primarily rural except along the northern edge of the watershed, which is in the City of Greenwood. Approximately 6500 people live in the Hard Labor Creek watershed (2000 US Census). This TMDL includes the part of the watershed upstream of the water quality station SV-151. The location description of the water quality monitoring station and area of the watershed is given in Table 1.

Table 1. Hard Labor Creek water quality monitoring site description.

Watershed	Station ID	Sampling Station Description	Drainage Area Km^2	Drainage Area mi^2	Population (2000 Census)
Hard Labor Creek	SV-151	Hard Labor Creek at S-24-164	33.11	12.8	6630

The predominant land use in the Hard Labor Creek watershed, according to the 1992 NLCD, was forest, consisting of 53 % of the land area (Table 2 and Figure 2). Agricultural land uses made up

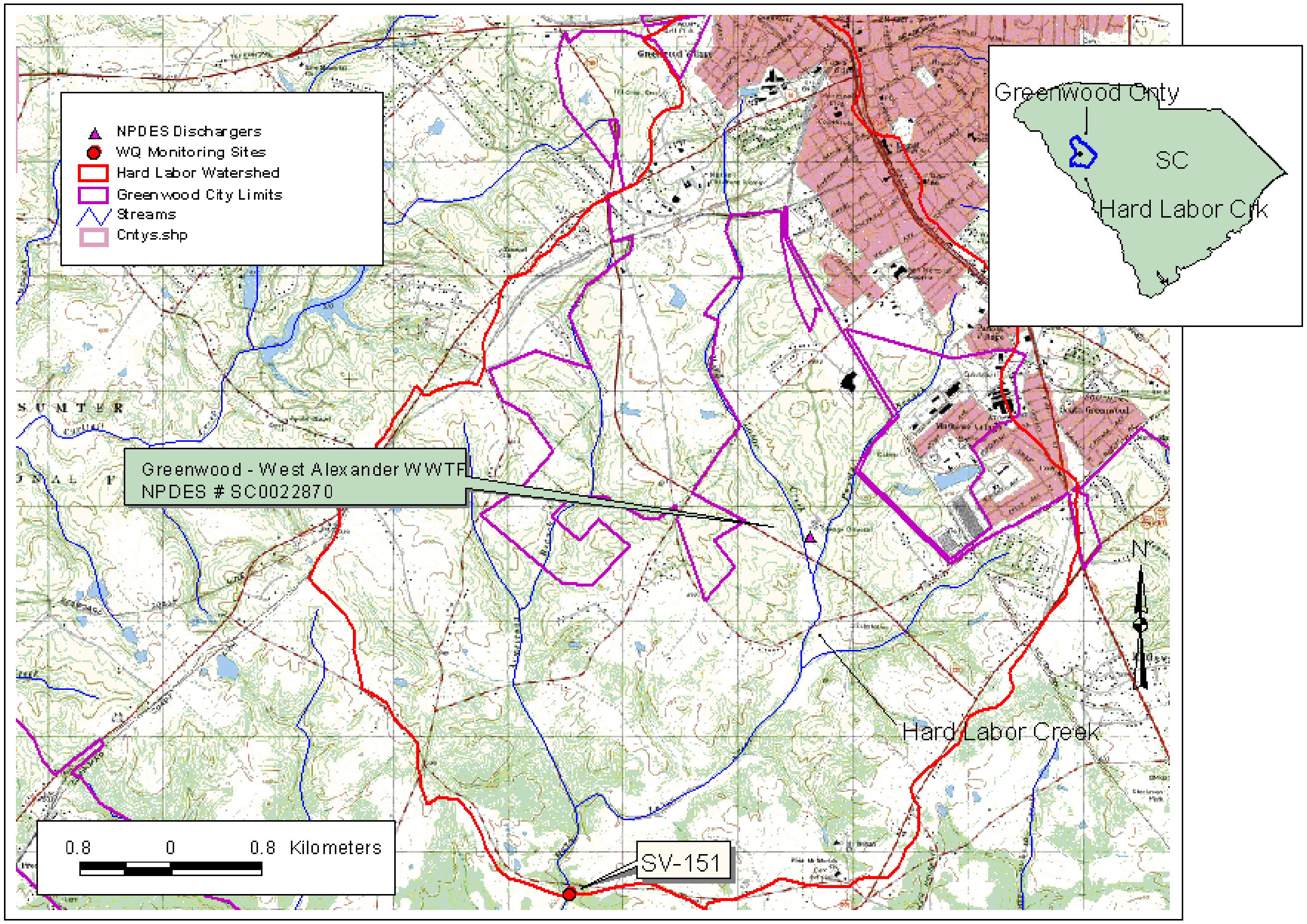

Figure 1. Map of the Hard Labor Creek watershed to SV-151, Savannah Basin.

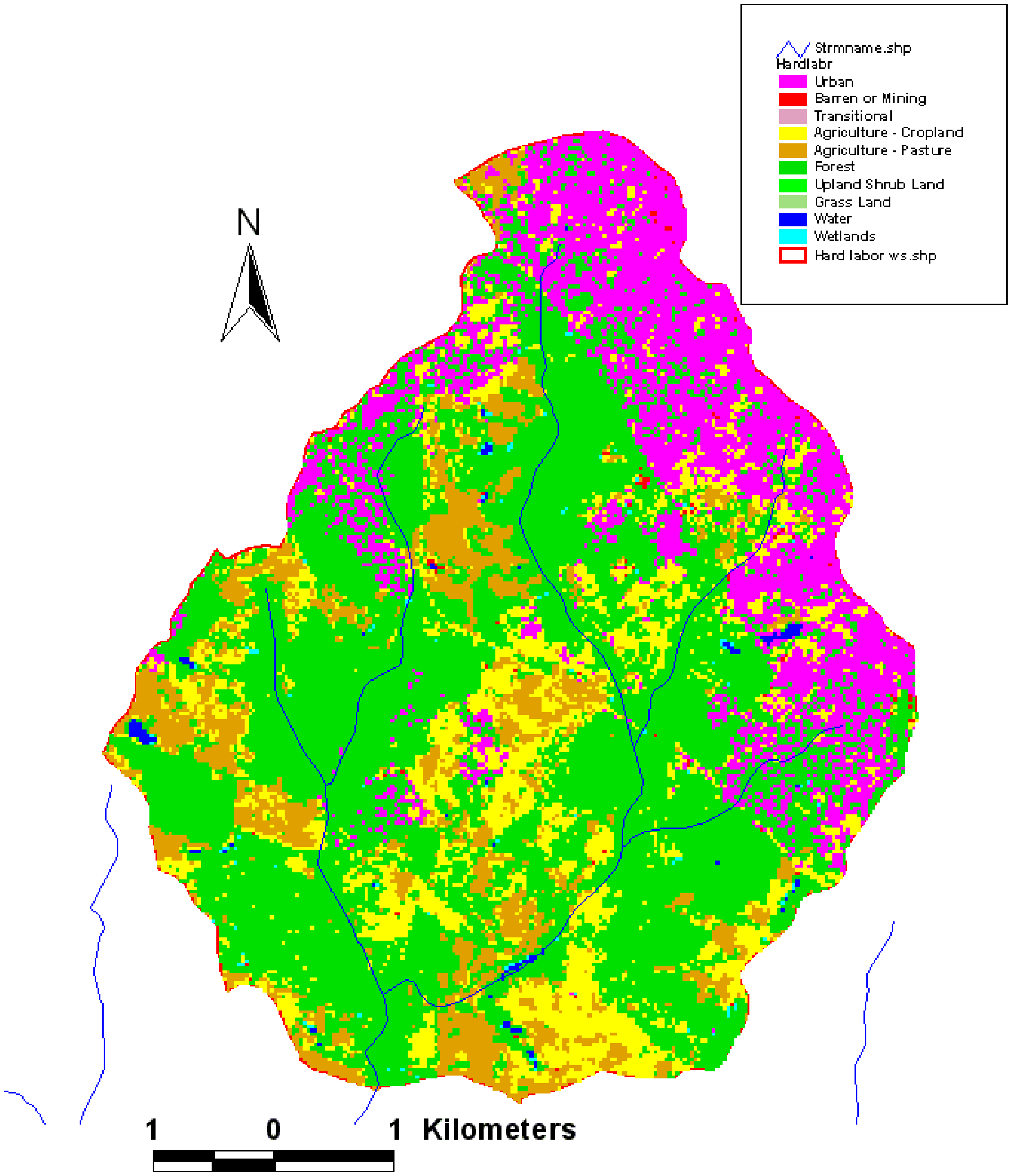

Figure 2. Map showing land uses in the Hard Labor Creek watershed.

28 % of the watershed; half was cropland and most of the rest pasture/hay. Developed land comprised 19 % of the area in the watershed. A windshield survey of the watershed indicated that some of the rural land south of the City of Greenwood has been converted to low-density residential use. This trend seems likely to continue with agricultural land converting to residential land uses. Figure 1 shows that much of this rural area has been annexed by the City of Greenwood

1.3 Water Quality Standard

The impaired stream segment of Hard Labor Creek 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 the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses." (R.61-68)

Table 2. Land uses in Hard Labor Creek watershed upstream of S-24-164.

Land Use Groups	Land Use	Area (hectares)	Area Sub-totals (hectares)	% Land Use	Sub-totals %
Water	Water	12.2	12.2		0.4%
	Residential Low Density	316.5		9.6%	
	Residential High Density	82.4		2.5%	
	Commercial, Industrial, & Transportation	236.3		7.1%	
Developed			**635.2**		**19.2%**
	Barren	7.9		0.2%	
	Forest Deciduous	782.7		23.6%	
	Forest Evergreen	568.2		17.2%	
	Forest Mixed	407.0		12.3%	
Forest			**1757.9**		**53.1%**
	Pasture/Hay	378.9		11.4%	
	Cropland	449.8		13.6%	
	Urban Grasses	59.8		1.8%	
Agricultural			**888.5**		**26.8%**
	Wetlands Woody	9.8		0.3%	
	Wetlands Herbaceous	0.7		0.0%	
Wetlands			10.5		0.3%
Total for Watershed		**3312.2**			**99.8%**

South Carolina's standard for fecal coliform in Freshwater 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).

Primary contact recreation is not limited to large streams and lakes. Even streams that are too small to swim in, will allow small children the opportunity to play and immerse their hands and faces. Essentially all perennial streams should therefore be protected from pathogen impairment.

2.0 WATER QUALITY ASSESSMENT

Hard Labor Creek has one water quality monitoring station, SV-151 (Table 1 and Figure 1). An assessment of water quality data for the 2004 303(d) list using data collected from 1998 through 2002 at this station, indicates that it is impaired for recreational use. Hard Labor Creek at SV-151 has been on the 303(d) list of impaired waters since 1998. Waters in which no more than 10% of the samples collected over a five year period are greater than 400 fecal coliform counts or cfu / 100 ml 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 for fecal coliform bacteria and placed on South Carolina's 303(d) list. During the most recent assessment period (1998-2002), 52 % of samples did not meet the fecal coliform criterion at SV-151. Descriptive statistics for data collected since 1990 at SV-151 is provided in Appendix A Table A-2. All of the data collected since 1990 is provided in Appendix A Table A-1.

Fecal coliform bacteria concentrations have remained about the same at location SV-151 in Hard Labor Creek since 1990 (Figure 3). However, the percentage of samples exceeding the standard of 400 cfu/100ml has increased substantially from 38 % during the 1992-1996 period to 52 % during the most recent period (Table 3). The watershed for SV-151 is becoming more urbanized, which increases the percentage of impervious surface. The higher percentage of impervious surface tends to degradation in water quality in the receiving streams.

Table 3. Change in percentage of standard violations at SV-151 by 303(d) list.

Percent of Samples exceeding Std by Assessment Period:		
303(d)	**Period**	**Percent**
1998	1992-1996	38%
2000	1994-1998	40%
2002	1996-2000	44%
2004	1998-2002	52%

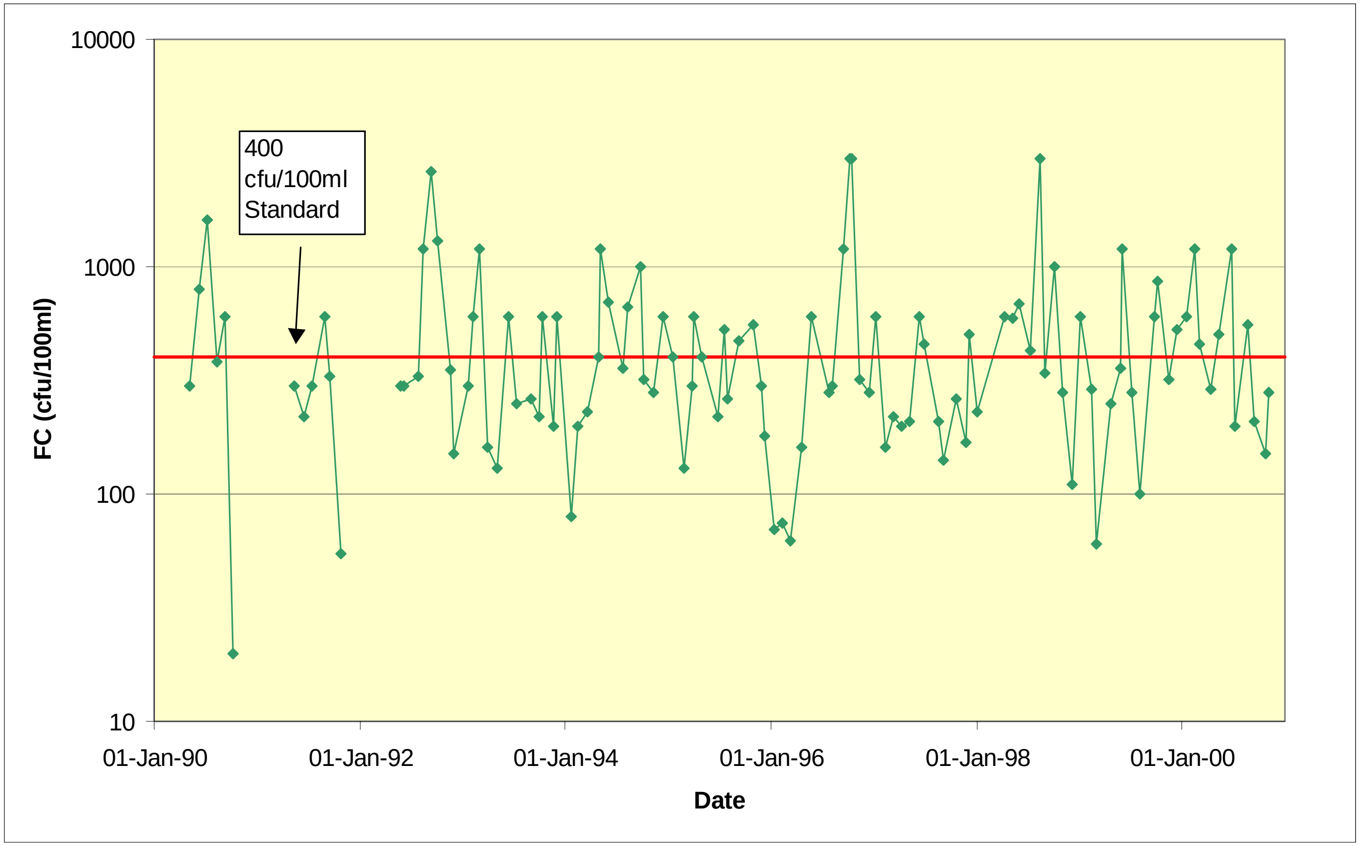

Figure 3. Fecal coliform concentrations in Hard Labor Creek at SV-151 over time.

Fecal coliform concentrations in Hard Labor Creek exhibited no discernible relationship to turbidity (Figure 4). The lack of a link between turbidity and fecal coliform concentrations suggests that runoff is not a primary mode of entry of fecal coliform bacteria into the creek. However, the load-duration plot for Hard Labor Creek shows a number of the samples that exceeded the standard were collected during high flow events (Figure 5). High flows are defined as flows that occur less than 10 % of the time. A smaller number of samples that exceeded the standard were collected during low flows. These somewhat contradicting findings indicate that both runoff and continual sources such as leaking sewers, failing septic systems, illicit discharges, or livestock-in-the-stream are the sources of fecal coliform bacteria in Hard Labor Creek.

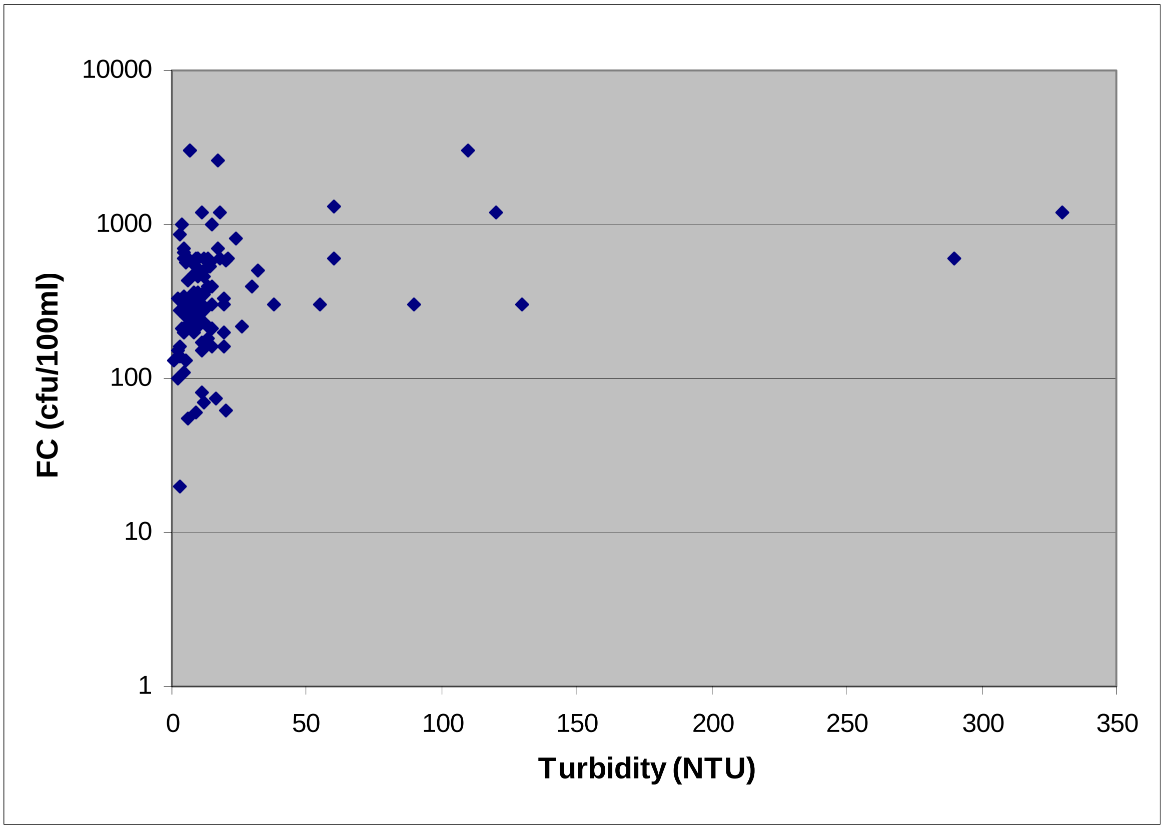

Figure 4. Relationship between turbidity and fecal coliform concentrations in Hard Labor Creek at SV-151.

3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

Fecal coliform bacteria are used by the State of South Carolina as the indicator for pathogens in surface waters. Pathogens, which are usually difficult to detect, cause disease and make full body contact recreation in lakes and streams risky. Indicators such as fecal coliform bacteria, enteroccoci, or *E. coli* are easier to measure, have the same sources as pathogens, and persist a similar or longer length of time in surface waters. These indicator bacteria are not in themselves usually disease causing.

There are many sources of pathogen pollution in surface waters. In general these sources may be classified as point and nonpoint sources. With the implementation of technology-based controls, pollution from point sources, such as factories and wastewater treatment facilities, has been greatly reduced. All point sources are required by the Clean Water Act to obtain a NPDES permit. In South Carolina NPDES permits require that dischargers of sanitary wastewater must meet the state standard for fecal coliform at the point of discharge. Municipal and private sanitary wastewater treatment facilities may occasionally be sources of pathogen or fecal coliform bacteria pollution. However, if these facilities are discharging wastewater that meets their permit limits, they are not causing the impairment. If one of these facilities is not meeting its permit limits, enforcement of the permit limit is required. A TMDL is not necessary for this purpose.

3.1 Point Sources

3.1.1 Continuous Point Sources

Currently there is one NPDES discharger that has a permit to discharge wastewater containing fecal coliform bacteria in the Hard Labor Creek watershed. The City of Greenwood's West Alexander WWTF (SC0022870) discharges wastewater into Hard Labor Creek some 4.5 km upstream of SV-151. This facility is permitted to treat and discharge 2.2 mgd (3.4 cfs) of wastewater. Effluent data reported by this municipal WWTF (Appendix B) indicates that the permitted discharge is not contributing to the impairment of Hard Labor Creek.

The City of Greenwood has a sewage collection system that is partly in the Hard Labor Creek watershed. Sewage collection systems typically are placed adjacent to waterways. At these locations, there is a potential for collection system leaks which could result in elevated instream concentrations of fecal coliform bacteria. Sanitary sewer overflows (SSOs) are also a potential source, particularly after periods of intense rainfall. This source is associated with infrequent events, limited in duration and likely to have an insignificant long-term impact instream on recreational use. Identified collection system and/or SSO problems are addressed by SCDHEC through compliance and enforcement mechanisms.

3.1.2 Intermittent Point Sources

There are no designated Municipal Separate Storm Sewer Systems or MS4s in this watershed at this time.

3.2 Nonpoint Sources

3.2.1 Wildlife

In these rural and suburban watersheds wildlife (mammals and birds), which is a source of fecal coliform bacteria, is possibly a significant though not major contributor. Wildlife in this area includes deer and other mammals as well as a variety of birds. Wildlife wastes are carried into nearby streams by runoff following rainfall or deposited directly in streams. Waterfowl also may be significant contributors of fecal coliform bacteria, particularly in urban and suburban ponds, which often provide a desirable habitat for geese and ducks. Forest lands, which typically have only low concentrations of wildlife as sources of fecal coliform bacteria, usually have low loading rates for fecal coliform bacteria.

3.2.2 Grazing Animals

Livestock, especially cattle, are frequently major contributors of fecal coliform bacteria to streams. Grazing cattle and other livestock may contaminate streams with fecal coliform bacteria in two ways. Runoff from pastures may carry the bacteria into streams following rain events. Cattle that are allowed access to streams deposit manure directly into the streams. Manure deposited in streams can be a significant source of fecal coliform bacteria. Loading of fecal coliform bacteria to this creek by this route is likely to be a significant source of loading of fecal coliform. The 2002 Agricultural Atlas reported 13,667 cattle and calves in Greenwood County. Using the ratio of pastureland in the watershed to that of the county, 549 cattle and calves were estimated to be in the SV-151 drainage area. Cattle in the creek are likely to be a major source of fecal coliform at this station, accounting for some of the samples at lower flows. Runoff from pastures is also likely to be a significant part of the loading to SV-151.

3.2.3 Failing Septic Systems

Septic systems that do not function properly may leak sewage unto the land surface where it can reach nearby streams. Failing septic systems may be improperly designed or constructed or they maybe systems that no longer function. The number of households that have septic systems was estimated using a GIS. The 2000 census database layer was compared to the town boundaries of Greenwood and the boundaries of the Hard Labor Creek watershed. In 2000 there were an estimated 1450 people in some 570 households without sewer service in the Hard Labor Creek watershed. The number of rural households should correlate with the number of septic systems. Based on the evidence of continuous sources in the SV-151 part of the watershed, failing septic systems could be a major source of fecal coliform bacteria going into the stream.

3.2.4 Urban Nonpoint Sources

The headwaters of Hard Labor Creek are in the City of Greenwood. At this time the city has not been designated as a MS4. At the time of data collection for the NLCD (about 1992), urban land made up 19 % of the watershed. A windshield survey of the watershed indicated that some of the wooded and agricultural land in the watershed has been converted to low-density residential development. As the percentage of impervious surface in a watershed increases with development, more of rainfall runs off the land and less infiltrates into the soil. The additional runoff compared to undeveloped land increases the amount of pollutants that are carried into receiving streams. Dogs and other pets are the primary source of fecal coliform deposited on the urban landscape. There are also ‘urban’ wildlife, such as squirrels, raccoons, pigeons, and other birds, all of which contribute to the fecal coliform load.

Table 4. Total and rural populations in Hard Labor Creek watershed.

Station	Total Population	Rural Population	Rural Households
SV-151	6630	1300	550

4.0 LOAD-DURATION CURVE METHOD

Load-duration curves were developed as a method of developing TMDLs that applies to all hydrologic conditions (Cleland, 2003). The load-duration curve method uses the cumulative frequency distribution of stream flow and pollutant concentration data to estimate the existing and the TMDL loads for a water body. Development of the load-duration curve is described in this chapter. The load-duration curve method uses the cumulative frequency distribution of stream flow and pollutant concentration data to estimate the existing and the TMDL loads for a water body. Development of the load-duration curve is described in this chapter.

The load-duration curve method requires flow data, which typically is not available for the site or stream. Hard Labor Creek, like many small streams in South Carolina is not gauged. Grove Creek, which is some 68 km north of Hard Labor Creek, is a comparable, gauged stream with similar land uses and topography. A table of Grove Creek watershed land use is provided in Appendix D Table D-1. Data from the gauge (USGS 021630967) on Grove Creek near Piedmont, South Carolina for the period of record (July 7, 1994 through September 30, 2003) was used to generate the flow-duration and load-duration curves. The Grove Creek watershed is similar in area, 49.5 km^2 compared to 33.1 km^2 for Hard Labor Creek watershed at SV-151.

The flows for Hard Labor Creek at the different water quality monitoring sites were estimated by multiplying the daily flow rates from Grove Creek by the ratio of the Hard Labor Creek drainage area to that of Grove Creek (0.6686). The flows were ranked from low to high and the values that exceed certain selected percentiles determined. A flow-duration curve for Hard Labor Creek at SV-151 is provided in Appendix D (Figure D-1). The load-duration curve was generated by calculating the load from the observed fecal coliform concentrations, the flow rate that corresponds to the date of sampling, and a conversion factor. The load was plotted against the appropriate flow recurrence interval to generate the curve (Figure 5). The target line was created by calculating the allowable load from the flow and the appropriate fecal coliform standard concentration in the same manner. Sample loads above this line are violations of the standard, while loads below the line are in compliance.

The water quality target was set at 380 cfu/100ml for the instantaneous criterion, which is five percent lower than the water quality criteria of 400 cfu/100ml. A five percent explicit Margin of

Safety (MOS) was reserved from the water quality criterion in developing the load-duration curves. The instantaneous criterion was targeted as a conservative approach and should be protective of both the instantaneous and 30-day geometric mean fecal coliform bacteria standards.

Trend lines were determined for sample loads that exceeded the standard for each station. The trend line for Hard Labor Creek was a power function (Figure 5). The correlation coefficient (r^2) for this curve was 0.7304. The existing loads to Hard Labor Creek at the monitoring stations were

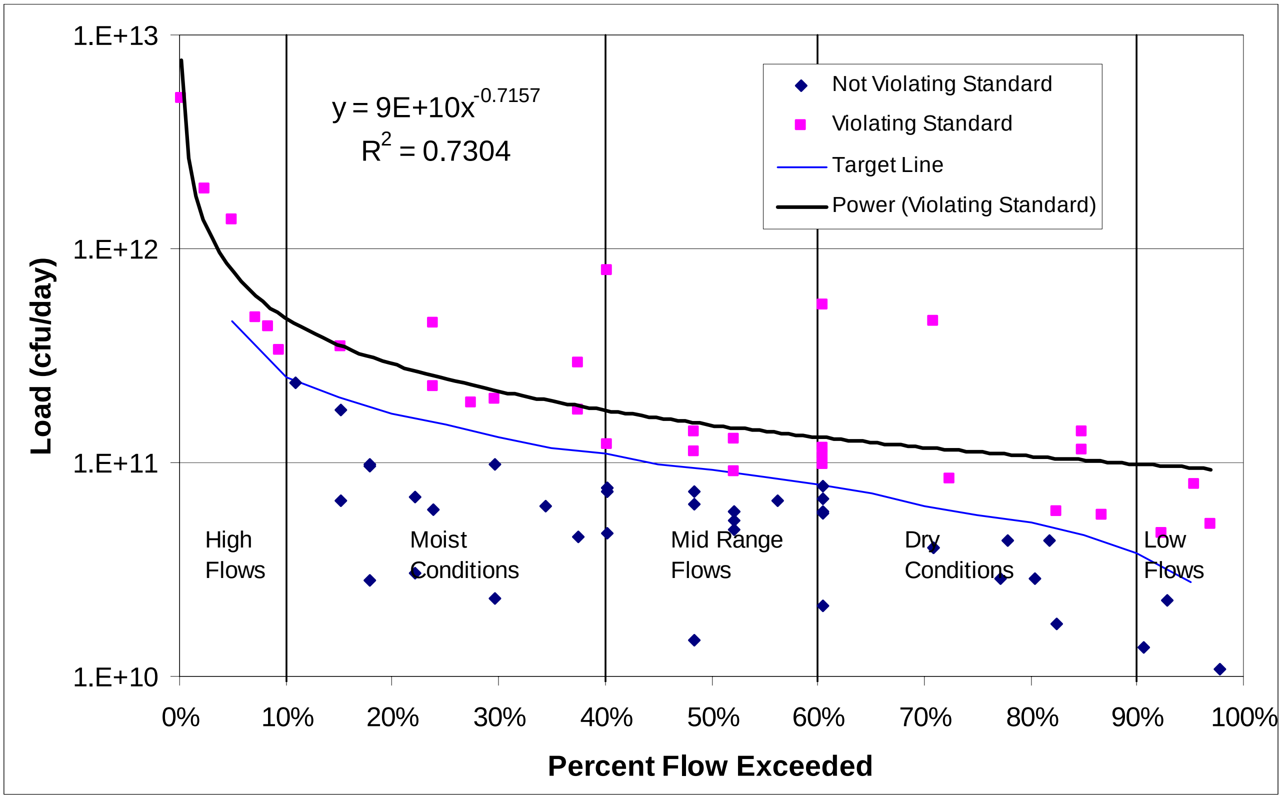

Figure 5. Load-duration Curve for Hard Labor Creek at SV-151.

calculated from the means of all loads that were between the 1 % and 90 % flow recurrence intervals for each location. This excludes some flows that occur infrequently. The trend line, which is usually the 10 – 95 % exceedence range, was extended to include flows with an exceedence value of 1 %, because several of the samples that exceeded the standard occurred at these flows.

The TMDL load is calculated from the target line. Load values at 5 % occurrence intervals along the target line from 5 to 95 % were averaged. The Load Allocation (LA) values are derived from the 380 cfu/100ml water quality target, which includes the explicit Margin of Safety. Calculations for both existing and TMDL loads are provided in Appendix C.

5.0 DEVELOPMENT OF 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:

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

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 number (#), cfu, or organism counts (or resulting concentration), in accordance with 40 CFR 130.2(l).

5.1 Critical Conditions

This TMDL is based on the flow recurrence interval between 1 % and 95 %. This encompasses 94 % of flows in Hard Labor Creek. Only flows that are characterized as ‘Low’ flows in Figure 5 or were at the very left end of the curve are not included in the analysis. For this TMDL critical conditions are this range of the flow recurrence interval.

5.2 Existing Load

The existing load was calculated from the trend line of observed values that exceeded the water quality standard and were between and including 1 % and 95 % recurrence limits. Loadings from all sources are included in this value: runoff, cattle-in-streams, and failing septic systems. The existing wasteload allocation and load allocation for Hard Labor Creek are provided in Table 5.

5.3 Margin of Safety

The margin of safety (MOS) may be explicit and/or implicit. The explicit margin of safety is 5 % of the TMDL or 20 counts/ 100ml of the instantaneous criterion of 400 cfu/100 ml. Values of the MOS for each location are given in Table 5.

5.4 Wasteload Allocation

The Wasteload Allocation (WLA) for Hard Labor Creek is the unchanged from the existing wasteload. The WLA for the City of Greenwood’s West Alexander WWTF (SC0022870) is 1.66E+10 cfu/day or simply the product of permitted flow and fecal coliform concentration limits.

5.5 TMDL

For most pollutants, TMDLs are expressed as a mass load (e.g., kilograms per day). For bacteria, however, TMDLs are expressed in terms of cfu or organism counts (or resulting concentration), in accordance with 40 CFR 130.2(l). The resulting TMDL should be protective of both the instantaneous, per day, and geometric mean, per 30-day, criteria.

The target loading value is the load to the creek that it can receive and meet the water quality standard. It is simply the TMDL minus the MOS. Values for each component of the TMDL for this location on Hard Labor Creek are provided in Table 5. The required reduction in load, expressed as a percentage is also provided in Table 5.

Table 5. TMDL components for Hard Labor Creek.

Impaired Station	Existing Load cfu/day	WLA cfu/day	LA cfu/day	MOS cfu/day	TMDL cfu/day	% Reduction
SV-151	3.22E+11	1.66E+10	1.15E+11	6.05E+09	1.38E+11	64

6.0 IMPLEMENTATION

As discussed in the *Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina* (SCDHEC,1998), South Carolina has several tools available for implementing this nonpoint source TMDL. Specifically, SCDHEC's animal agriculture permitting program addresses animal operations and land application of animal wastes. In addition, SCDHEC will work with the existing agencies in the area to provide nonpoint source education in the Hard Labor Creek watershed. Local sources of nonpoint source education and assistance include Clemson Extension Service, the Natural Resource Conservation Service (NRCS), the Greenwood County Soil and Water Conservation Services, and the South Carolina Department of Natural Resources. Clemson Extension Service offers a 'Farm-A-Syst' package to farmers. Farm-A-Syst allows the farmer to evaluate practices on their property and determine the nonpoint source impact they may be having. It recommends best management practices (BMPs) to correct nonpoint source problems on the farm. NRCS can provide cost share money to land owners installing BMPs.

SCDHEC is empowered under the State Pollution Control Act to perform investigations of and pursue enforcement for activities and conditions, which threaten the quality of waters of the state. In addition, other interested parties (universities, local watershed groups, etc.) may apply for section 319 grants to install BMPs that will reduce fecal coliform loading to Hard Labor Creek. TMDL implementation projects are given highest priority for 319 funding.

In addition to the resources cited above for the implementation of this TMDL in the Hard Labor Creek watershed, Clemson Extension has developed a Home-A-Syst handbook that can help rural homeowners reduce sources of NPS pollution on their property. This document guides homeowners through a self-assessment, including information on proper maintenance practices for septic tanks. SCDHEC also employs a nonpoint source educator who can assist with distribution of these tools as well as provide additional BMP information.

Using existing authorities and mechanisms, these measures will be implemented in this watershed in order to bring about the required reductions in fecal coliform bacteria loading to Hard Labor Creek. DHEC will continue to monitor, according to the basin monitoring schedule, the effectiveness of implementation measures and evaluate stream water quality as the implementation strategy progresses.

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APPENDIX A Fecal Coliform Data

Table A-1 Fecal coliform data for Hard Labor Creek at SV-151.

Date	FC (cfu/100ml)
5/7/1990	300
6/13/1990	800
7/11/1990	1600
8/14/1990	380
9/11/1990	600
10/9/1990	20
5/13/1991	300
6/18/1991	220
7/18/1991	300
8/28/1991	600
9/17/1991	330
10/29/1991	55
5/27/1992	300
6/9/1992	300
7/29/1992	330
8/11/1992	1200
9/10/1992	2600
10/5/1992	1300
11/17/1992	350
12/2/1992	150
1/21/1993	300
2/9/1993	600
3/4/1993	1200
4/1/1993	160
5/5/1993	130
6/16/1993	600
7/12/1993	250
8/31/1993	260
9/29/1993	220
10/12/1993	600
11/18/1993	200
12/1/1993	600
1/24/1994	80
2/16/1994	200
3/23/1994	230
4/27/1994	400
5/4/1994	1200
6/1/1994	700
7/25/1994	360
8/10/1994	660
9/27/1994	1000
10/6/1994	320
11/9/1994	280
12/15/1994	600
1/18/1995	400
2/27/1995	130
3/30/1995	300
4/3/1995	600
5/1/1995	400
6/28/1995	220
7/18/1995	530
8/1/1995	260
9/7/1995	470
10/30/1995	560
11/28/1995	300
12/13/1995	180
1/16/1996	70
2/13/1996	74
3/13/1996	62
4/18/1996	160
5/22/1996	600
7/29/1996	280
8/5/1996	300
9/17/1996	1200
10/7/1996	3000
10/17/1996	3000
11/14/1996	320
12/16/1996	280
1/7/1997	600
2/12/1997	160
3/11/1997	220
4/8/1997	200
5/6/1997	210
6/10/1997	600
7/1/1997	460
8/19/1997	210
9/3/1997	140
10/21/1997	260
11/24/1997	170
12/4/1997	500
1/5/1998	230
4/9/1998	600
5/7/1998	590
6/2/1998	690
7/14/1998	430
8/17/1998	3000
9/1/1998	340
10/7/1998	1000
11/4/1998	280
12/8/1998	110
1/4/1999	600
2/16/1999	290
3/2/1999	60
4/21/1999	250
5/26/1999	360
6/2/1999	1200
7/6/1999	280
8/4/1999	100
9/28/1999	600
10/4/1999	860
11/15/1999	320
12/15/1999	530
1/20/2000	600
2/16/2000	1200
3/6/2000	460
4/13/2000	290
5/10/2000	500
6/27/2000	1200
7/10/2000	200
8/21/2000	560
9/13/2000	210
10/25/2000	150
11/6/2000	280

Table A-2 Statistics for fecal coliform data 1990-2002 in Hard Labor Creek. (cfu/100ml)

Statistics:		**Value**
Minimum		20
Geometric Mean		360
Median		320
Maximum		3000
Percent Violations		41%

APPENDIX B DMR Data

Table B-1. DMR Data for Greenwood West Alexander WWTF. SC0022870.

Date	Flow (mgd)		FC (cfu/100ml)		FC Load (cfu/day)
	Mean	Maximum	Mean	Maximum	Mean
1/31/1989	0.51	0.55	0	0	0.00E+00
2/28/1989	0.69	0.83	0	4	0.00E+00
3/31/1989	0.89	1.11	0	4	0.00E+00
4/30/1989	0.95	1.09	0	1	0.00E+00
5/31/1989	1.02	1.08	0	0	0.00E+00
6/30/1989	0.97	1.1	1	2	3.67E+07
7/31/1989	1.44	1.8	5	12	2.73E+08
8/31/1989	1.12	1.16	0	1	0.00E+00
9/30/1989	0.65	0.76	0	24	0.00E+00
10/31/1989	1	1.49			0.00E+00
11/30/1989	1.44	1.8	5	12	2.73E+08
12/31/1989	0.95	1.44	0	32	0.00E+00
1/31/1990	0.96	1.04	67	364	2.43E+09
2/28/1990	1.3	1.67	23	52	1.13E+09
3/31/1990	1.1	2.5	10	22	4.16E+08
4/30/1990	1	2.5	66	148	2.50E+09
5/31/1990	0.95	1.5	18	40	6.47E+08
6/30/1990	0.93	1.2	16	28	5.63E+08
7/31/1990	0.9	1.3	2	20	6.81E+07
8/31/1990	1	1.3	5	100	1.89E+08
9/30/1990	0.94	1.4	28	40	9.96E+08
10/31/1990	1.2	3.1	3	25	1.36E+08
11/30/1990	0.9	1.2	6	40	2.04E+08
12/31/1990	0.9	1	19	40	6.47E+08
1/31/1991	1.5	1.8	5	37	2.84E+08
2/28/1991	1.4	1.9	3	28	1.59E+08
3/31/1991	1.4	2	4	20	2.12E+08
4/30/1991	1.2	1.3	10	87	4.54E+08
5/31/1991	1.2	1.4	17	178	7.72E+08
6/30/1991	1.2	1.4	232	291	1.05E+10
7/31/1991	1.1	1.5	33	160	1.37E+09
8/31/1991	1	1.1	84	160	3.18E+09
9/30/1991	0.9	1	10	375	3.41E+08
10/31/1991	0.8	1	3	173	9.08E+07
11/30/1991	1	1.1	19	38	7.19E+08
12/31/1991	1.1	1.1	3.7	45	1.54E+08
2/29/1992	1.3	1.7	33	79	1.62E+09

Date	Flow (mgd)			FC (cfu/100ml)				FC Load (cfu/day)
	Mean	Maximum		Mean		Maximum		Mean
3/31/1992	1.3	1.3		11		53		5.41E+08
4/30/1992	1.1	1.2		22		45		9.16E+08
5/31/1992	1.2	1.3		16		35		7.27E+08
6/30/1992	1.2	1.5		72		194		3.27E+09
7/31/1992	1.1	1.3		37		87		1.54E+09
8/31/1992	1.2	1.3		35		51		1.59E+09
9/30/1992	1.2	1.2		18		20		8.18E+08
10/31/1992	1.2	1.6		17		20		7.72E+08
11/30/1992	1.5	1.7		8		19		4.54E+08
12/31/1992	1.3	1.6		5.6		163		2.76E+08
1/31/1993	1.7	2.4	>	39	<	60		2.51E+09
2/28/1993	1.8	2.2		57		517		3.88E+09
3/31/1993	2.1	2.2		34.9		81.3		2.77E+09
4/30/1993	1.6	1.7		22.3		31		1.35E+09
5/31/1993	1.3	1.3		24		41		1.18E+09
6/30/1993	1.2	1.3		3		18		1.36E+08
7/31/1993	1.3	1.4		16.9		40		8.32E+08
8/31/1993	1.3	1.4		12.2		46.6		6.00E+08
9/30/1993	1.3	1.5		10		15		4.92E+08
10/31/1993	1.3	1.4		25		73		1.23E+09
11/30/1993	1.3	1.3		2		12		9.84E+07
12/31/1993	0.84	1		5		22		1.59E+08
1/31/1994	1.3	1.5		1		3		4.92E+07
2/28/1994	1.27	1.58		2		8		9.61E+07
3/31/1994	1.17	1.53		19		160		8.41E+08
4/30/1994	0.9	1		3		15		1.02E+08
5/31/1994	1	1		4		72		1.51E+08
6/30/1994	1.1	1.4		50	>	240		2.08E+09
7/31/1994	1	1.1		4		13		1.51E+08
8/31/1994	1.2	1.8		4		106		1.82E+08
9/30/1994	1	1.1		7		136		2.65E+08
10/31/1994	1.1	1.4		13		129		5.41E+08
11/30/1994	1	1.1		8.3		212		3.14E+08
12/31/1994	1.2	1.6	>	47		312		2.13E+09
1/31/1995	1.5	1.7	<	14		258		7.95E+08
2/28/1995	1.7	2.4		10		68		6.44E+08
3/31/1995	1.4	1.9		38		68		2.01E+09
4/30/1995	1.1	1.1	>	167	>	240		6.95E+09
5/31/1995	1.1	1.1	>	121	>	1200		5.04E+09
6/30/1995	1.2	1.3	<	4		18		1.82E+08
7/31/1995	1.2	1.4	<	6		27		2.73E+08

Date	Flow (mgd)		FC (cfu/100ml)						FC Load (cfu/day)
	Mean	Maximum			Mean		Maximum		Mean
8/31/1995	1.5	1.8			14		144		7.95E+08
9/30/1995	1.2	1.2		<	1		2		4.54E+07
10/31/1995	1.2	1.3		>	14	>	240		6.36E+08
11/30/1995	1.4	1.7			3		24		1.59E+08
12/31/1995	1.3	1.4		<	7		261		3.44E+08
1/31/1996	1.8	2		<	5		400		3.41E+08
2/29/1996	1.8	2.4		<	1		2		6.81E+07
3/31/1996	1.8	2		<	2		3		1.36E+08
4/30/1996	1.4	1.5			7		240		3.71E+08
5/31/1996	1.3	1.4			9		240		4.43E+08
6/30/1996	1.2	1.3		<	4		55		1.82E+08
7/31/1996	1.1	1.2		<	1		2		4.16E+07
8/31/1996	1.3	1.3		<	1		2		4.92E+07
9/30/1996	1.3	1.6		<	2		13		9.84E+07
10/31/1996	1.4	1.5		<	4		59		2.12E+08
11/30/1996	1.3	1.4			12		53		5.91E+08
12/31/1996	1.3	1.5			24		82		1.18E+09
1/31/1997	1.5	1.8		<	4		37		2.27E+08
2/28/1997	1.7	1.9		<	4		22		2.57E+08
3/31/1997	1.5	1.8		<	1		1		5.68E+07
4/30/1997	1.3	1.6		<	4		12		1.97E+08
5/31/1997	1.3	1.6			4		6		1.97E+08
6/30/1997	1.2	1.2		<	148		1960		6.72E+09
7/31/1997	1.2	1.3			13		22		5.91E+08
8/31/1997	1.1	1.1			29		290		1.21E+09
9/30/1997	1.1	1.3		<	2		4		8.33E+07
10/31/1997	1.2	1.3		>	24	>	1460		1.09E+09
11/30/1997	1.3	1.6		<	2		4		9.84E+07
12/31/1997	1.4	1.6			4		7		2.12E+08
1/31/1998	1.5	1.8		<	2		3		1.14E+08
2/28/1998	1.6	2		<	3		4		1.82E+08
3/31/1998	1.2	1.6		<	3		6		1.36E+08
4/30/1998	1.7	1.7			2		3		1.29E+08
5/31/1998	1.4	1.7		<	5		13		2.65E+08
6/30/1998	1.3	1.5			10		18		4.92E+08
7/31/1998	1.1	1.2			11		40		4.58E+08
8/31/1998	1.1	1.2			47		3500		1.96E+09
9/30/1998	1.2	1.3			33		534		1.50E+09
10/31/1998	1.1	1.1			7		27		2.91E+08
11/30/1998	1.1	1.2			11		18		4.58E+08
12/31/1998	1.1	1.3		<	6		29		2.50E+08

1/31/1999	1.3	1.3			27		269		1.33E+09
Date	Flow (mgd)		FC (cfu/100ml)						FC Load (cfu/day)
	Mean	Maximum			Mean		Maximum		Mean
2/28/1999	1.4	1.6			7		28		3.71E+08
3/31/1999	1.4	1.5			26		87		1.38E+09
4/30/1999	1.4	1.5			14		58		7.42E+08
5/31/1999	1.3	1.5		<	10		66		4.92E+08
6/30/1999	1.3	1.5		>	180	>	1540		8.86E+09
7/31/1999	1.1	1.5			104		602		4.33E+09
8/31/1999	1	1.1			6		12		2.27E+08
9/30/1999	1.1	1.1		<	2		2		8.33E+07
10/31/1999	1.1	1.2		<	2		2		8.33E+07
11/30/1999	1.1	1.2		<	4		20		1.67E+08
12/31/1999	1.1	1.2		<	8		29		3.33E+08
1/31/2000	1.2	1.3		<	3		5		1.36E+08
2/29/2000	1.3	1.4		<	2		2		9.84E+07
3/31/2000	1.3	1.4		<	3		5		1.48E+08
4/30/2000	1.2	1.2		<	2	<	2		9.08E+07
5/31/2000	1.2	1.2		<	2		2		9.08E+07
6/30/2000	1.2	1.3		<	2		2		9.08E+07
7/31/2000	1.3	1.5		<	2		4		9.84E+07
8/31/2000	1.3	1.5		<	2		2		9.84E+07
9/30/2000	1.3	1.6		<	4		10		1.97E+08
10/31/2000	1.2	1.3		<	4		8		1.82E+08
11/30/2000	1.1	1.2		<	3		6		1.25E+08
12/31/2000	1.2	1.2		<	4		13		1.82E+08
1/31/2001	1.2	1.3		<	2	<	2		9.08E+07
2/28/2001	1.2	1.3		<	2		2		9.08E+07
3/31/2001	1.4	1.6		<	4		8		2.12E+08
4/30/2001	1.3	1.3		<	3		4		1.48E+08
5/31/2001	1.2	1.3		<	3		40		1.36E+08
6/30/2001	1.2	1.3		<	1		4		4.54E+07
7/31/2001	1.2	1.3		<	2		3		9.08E+07
8/31/2001	1.2	1.2		<	1		2		4.54E+07
9/30/2001	1.2	1.2		<	1	<	1		4.54E+07
10/31/2001	1.1	1.2			2		3		8.33E+07
11/30/2001	1.1	1.2		<	1		1		4.16E+07
12/31/2001	1.1	1.2		<	1		4		4.16E+07
1/31/2002	1.2	1.4		<	2		13		9.08E+07
2/28/2002	1.2	1.3		<	1		2		4.54E+07
3/31/2002	1.3	1.4		<	1		1		4.92E+07
4/30/2002	1.3	1.4		<	2		9		9.84E+07
5/31/2002	1.4	1.8		<	1	<	1		5.30E+07

6/30/2002	1.2	1.3		<	2		8		9.08E+07
7/31/2002	1.3	1.3		<	5		450		2.46E+08
Date	Flow (mgd)		FC (cfu/100ml)						FC Load (cfu/day)
	Mean	Maximum			Mean		Maximum		Mean
8/31/2002	1.2	1.3		<	1		3		4.54E+07
9/30/2002	1.2	1.4		<	1	<	1		4.54E+07
10/31/2002	1.3	1.3		<	1		1		4.92E+07
11/30/2002	1.4	1.5		<	1	<	1		5.30E+07
12/31/2002	1.4	1.6		<	5		11		2.65E+08
1/31/2003	1.4	1.6			3		12		1.59E+08
2/28/2003	1.7	2		<	2		8		1.29E+08
3/31/2003	2	2.3			1		1		7.57E+07
4/30/2003	2	2.2		<	1		1		7.57E+07
5/31/2003	1.5	1.8			1		3		5.68E+07
6/30/2003	1.5	1.9			2		4		1.14E+08
7/31/2003	1.7	1.8			1		3		6.44E+07
8/31/2003	1.4	1.7			1		1		5.30E+07
9/30/2003	1.2	1.3			2		9		9.08E+07
10/31/2003	1.3	1.4			2		4		9.84E+07
11/30/2003	1.1	1.2			1		1		4.16E+07
12/31/2003	1.1	1.3			1		1		4.16E+07
1/31/2004	1.1	1.2			4		8		1.67E+08
2/29/2004	1.6	1.7			3		10		1.82E+08
3/31/2004	1.2	1.3		<	1	<	1		4.54E+07
4/30/2004	1.3	1.4		<	1	<	1		4.92E+07

APPENDIX C Calculation of Existing and TMDL Loads

Table C-1 Calculation of existing loads.

Calculation of Existing Load
Equation: y = 9E+10 X ^ -0.7157

% Exceeded	Load (cfu/day)
0.01	2.43E+12
0.05	7.68E+11
0.10	4.68E+11
0.15	3.50E+11
0.20	2.85E+11
0.25	2.43E+11
0.30	2.13E+11
0.35	1.91E+11
0.40	1.73E+11
0.45	1.59E+11
0.50	1.48E+11
0.55	1.38E+11
0.60	1.30E+11
0.65	1.23E+11
0.70	1.16E+11
0.75	1.11E+11
0.80	1.06E+11
0.85	1.01E+11
0.90	9.70E+10
0.95	9.34E+10
Mean Load	3.22E+11

Table C-2. Calculations of TMDL loads.

Calculation of TMDL Load
Target Conc 380 cfu/100ml
From Target Line

% Exceeded	Load (cfu/day)		Flow (cfs)
0.05	4.31E+11		46.40
0.10	2.36E+11		25.41
0.15	1.93E+11		20.73
0.20	1.62E+11		17.38
0.25	1.43E+11		15.38
0.30	1.24E+11		13.37
0.35	1.12E+11		12.04
0.40	1.06E+11		11.37
0.45	9.32E+10		10.03
0.50	8.70E+10		9.36
0.55	8.08E+10		8.69
0.60	7.46E+10		8.02
0.65	6.84E+10		7.35
0.70	5.97E+10		6.42
0.75	5.41E+10		5.82
0.80	4.97E+10		5.35
0.85	4.35E+10		4.68
0.90	3.61E+10		3.88
0.95	2.61E+10		2.81
Mean Load	**1.15E+11**		

Table C-3 Calculation of percent reduction.

Percent Reduction Required:		
Existing Load:	3.22E+11	cfu/day
TMDL Load:	1.15E+11	cfu/day
Load Reduction:	2.07E+11	cfu/day
Percent reduction:	64.4%	

APPENDIX D Miscellaneous Tables and Figures

Table D-1. Land Use in the Grove Creek watershed to USGS Gauging Station 21630967.

Land Use Groups	Land Use	Area (hectares)	Area Sub-totals (hectares)	% Land Use	Sub-totals %
Water	Water	10.0	10.0		0.2%
Developed	Residential Low Density	600.5		12.0%	
	Residential High Density	84.3		1.7%	
	Commercial, Industrial, & Transportation	281.7		5.6%	
			966.5		**19.4%**
Bare Rock, Clay, & Sand	Barren	12.3		0.2%	
	Transitional	78.8		1.6%	
			91.1		1.8%
Forest	Forest Deciduous	1235.4		24.7%	
	Forest Evergreen	1075.4		21.5%	
	Forest Mixed	768.5		15.4%	
			3079.4		**61.7%**
Agricultural	Pasture/Hay	570.5		11.4%	
	Cropland	116.1		2.3%	
	Urban Grasses	130.9		2.6%	
			817.5		**16.4%**
	Wetlands Woody	29.5		0.6%	
	Wetlands Herbacecous	0.4		0.0%	
Wetlands			29.9		0.6%
Total for Watershed		**4994.3**			**100.0%**

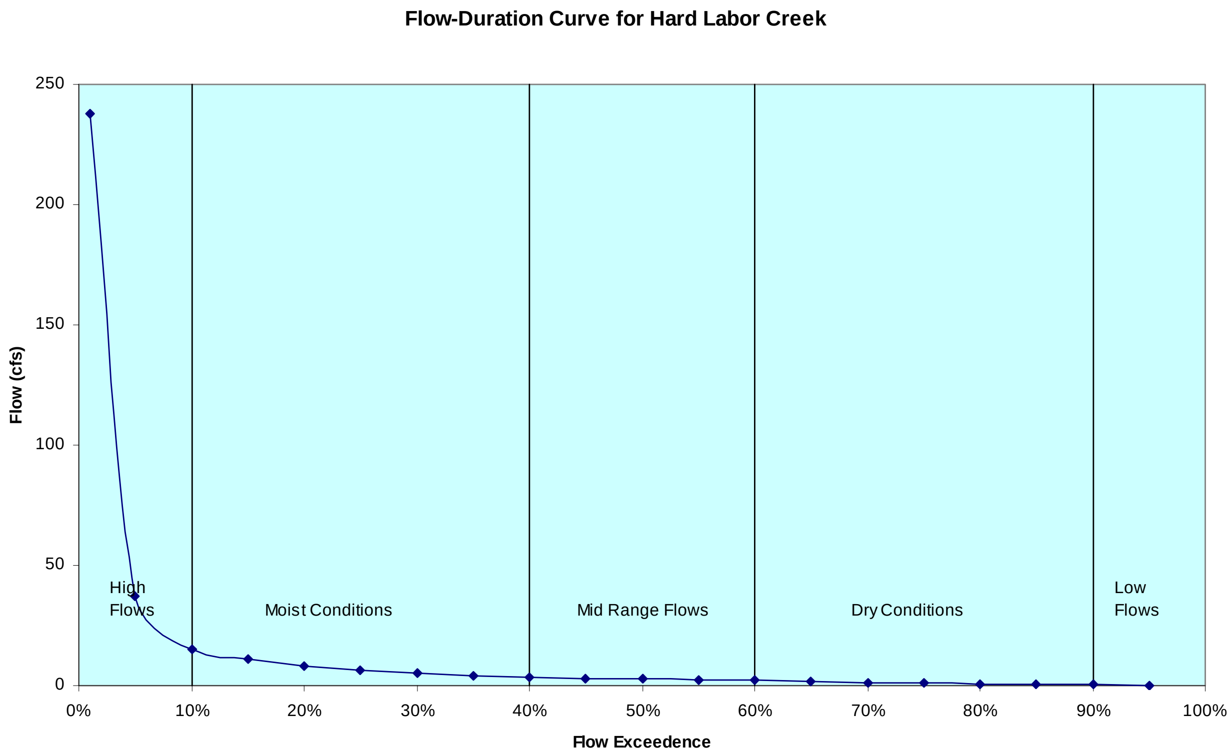

Figure D-1 Flow-duration curve for Hard Labor Creek at SV-151.

APPENDIX E Public Notification