FINAL

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Water Resource Management, Bureau of Watershed Management

SOUTHWEST DISTRICT • TAMPA BAY TRIBUTARIES BASIN

TMDL Report

Fecal Coliform and Total Coliform TMDL for Gamble Creek (WBID 1819)

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September 2004

Acknowledgments

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Florida Department of Environmental Protection, Bureau of Watershed Management

TMDL Program

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STORET Program

http://www.dep.state.fl.us/water/storet/index.htm

2002 305(b) Report

http://www.dep.state.fl.us/water/docs/2002_305b.pdf

Criteria for Surface Water Quality Classifications

http://www.dep.state.fl.us/legal/rules/shared/62-302t.pdf

Basin Status Report for the Tampa Bay Tributaries Basin

http://www.dep.state.fl.us/water/tmdl/stat_rep.htm

Allocation Technical Advisory Committee (ATAC) Report

http://www.dep.state.fl.us/water/tmdl/docs/Allocation.pdf

U.S. Environmental Protection Agency

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Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Load (TMDL) for fecal coliform for Gamble Creek in the Manatee River watershed, within the Tampa Bay Tributaries Basin. The stream was verified as impaired for fecal coliform and total coliform bacteria, and was included on the Verified List of impaired waters for the Tampa Bay Tributaries Basin that was adopted by Secretarial Order on May 27, 2004. Gamble Creek is located in the northern part of Manatee County and drains to the Manatee River **(Figure 1.1).** The TMDL establishes the allowable fecal coliform and total coliform loadings to Gamble Creek that would restore the waterbody so that it meets its applicable water quality criteria for fecal and total coliform.

1.2 Identification of Waterbody

Gamble Creek is a third-order stream located in the northern part of Manatee County. It flows in a northeast-to-southwest direction into the Manatee River and drains an area of about 55.8 square miles **(Figure 1.1).** The cities of Bradenton and Sarasota lie southwest of Gamble Creek. The creek's drainage area is part of the Desoto Plain, with an elevation ranging from 10 to 30 feet above sea level. Additional information on the creek's hydrology and geology is available in the Basin Status Report for the Tampa Bay Tributaries Basin (Florida Department of Environmental Protection, June 2002).

For assessment purposes, the Department has divided the Manatee River watershed into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. This TMDL addresses the following WBID:

WBID 1819, Gamble Creek – for fecal coliform and total coliform.

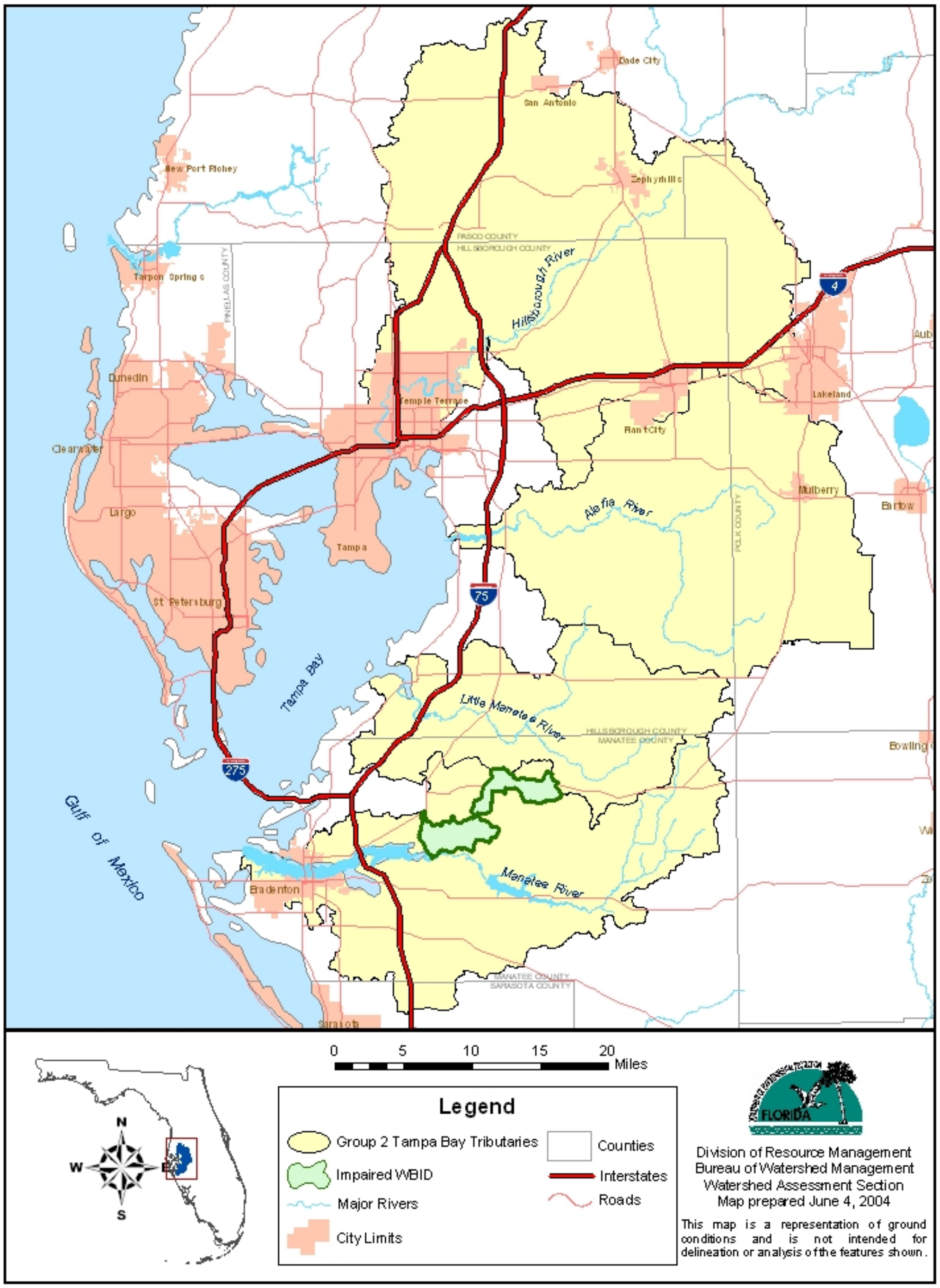
1.3 Background

This report was developed as part of the Florida Department of Environmental Protection's (Department) watershed management approach for restoring and protecting state waters and addressing TMDL Program requirements. The watershed approach, which is implemented using a cyclical management process that rotates through the state's 52 river basins over a 5-year cycle, provides a framework for implementing the TMDL Program–related requirements of the 1972 federal Clean Water Act and the 1999 Florida Watershed Restoration Act (FWRA, Chapter 99-223, Laws of Florida).

A TMDL represents the maximum amount of a given pollutant that a waterbody can assimilate and still meet water quality standards, including its applicable water quality criteria and its designated uses. TMDLs are developed for waterbodies that are verified as not meeting their water quality standards. TMDLs provide important water quality restoration goals that will guide restoration activities.

This TMDL Report will be followed by the development and implementation of a Basin Management Action Plan, or BMAP, to reduce the amount of fecal coliform and total coliform that caused the verified impairment of Gamble Creek. These activities will depend heavily on the active participation of the Southwest Florida Water Management District (SWFWMD), local governments, businesses, and other stakeholders. The Department will work with these organizations and individuals to undertake or continue reductions in the discharge of pollutants and achieve the established TMDLs for impaired waterbodies.

Figure 1.1: Location of Gamble Creek and Major Geopolitical Features in the Manatee River Watershed, within the Tampa Bay Tributaries Basin



Chapter 2: DESCRIPTION OF WATER QUALITY PROBLEM

2.1 Statutory Requirements and Rulemaking History

Section 303(d) of the federal Clean Water Act requires states to submit to the U.S. Environmental Protection Agency (EPA) lists of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing impairment of listed waters on a schedule. The Department has developed such lists, commonly referred to as 303(d) lists, since 1992. The list of impaired waters in each basin, referred to as the Verified List, is also required by the FWRA (Subsection 403.067[4)] Florida Statutes [F.S.]); the state's 303(d) list is amended annually to include basin updates.

Florida's 1998 303(d) list included 10 waterbodies in the Manatee Basin. However, the FWRA (Section 403.067, F.S.) stated that all previous Florida 303(d) lists were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. After a long rule-making process, the Environmental Regulation Commission adopted the new methodology as Chapter 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in the Gamble Creek watershed and has verified that the stream is impaired for fecal coliform and total coliform bacteria. **Table 2.1** lists the priority and projected year for TMDL development for each parameter. The verification of impairment was based on the observations that 28 out of 58 fecal coliform samples and 21 out of 44 total coliform samples collected during the verified period (January 1, 1996 – June 30, 2003) violated Florida water quality criteria. **Table 2.2** summarizes the fecal coliform and total coliform monitoring results for the verified period. As shown in Table 2.1, the projected year for both fecal coliform and total coliform bacteria TMDLs were 2003, but the Settlement Agreement between EPA and Earthjustice, which drives the TMDL development schedule for waters on the 1998 303(d) list, allows an additional nine months to complete the TMDLs. As such, this TMDL must be adopted and submitted to EPA by September 30, 2004.

Table 2.1. Verified Impairment for Fecal and Total Coliform in Gamble Creek, WBID 1819, TMDL Priority, and Projected Year for TMDL Development

Parameters of Concern	Priority for TMDL Development	Projected Year for TMDL Development
Fecal coliform	High	2003
Total coliform	High	2003

Table 2.2. Summary of Fecal Coliform Monitoring Data for Gamble Creek, WBID 1819

Parameter	Fecal Coliform	Total Coliform
Total number of samples	59	44
IWR required number of violations for the verified list	10	8
Number of observed violations	28	21
Number of observed nonviolations	31	23
Number of seasons during which samples were collected	4	4
Highest observation (MPN/100mL)*	8,700	42,000
Lowest observation (MPN/100 mL)	10	290
Median observation (MPN/100 mL)	400	2,150
Mean observation (MPN/100 mL)	809	4,524
FINAL ASSESSMENT	**Impaired**	**Impaired**

* Most probable number per 100 milliliters.

Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criteria Applicable to the TMDL

Florida's surface waters are protected for five designated use classifications, as follows:

Class I	**Potable water supplies**
Class II	**Shellfish propagation or harvesting**
Class III	**Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife**
Class IV	**Agricultural water supplies**
Class V	**Navigation, utility, and industrial use (there are no state waters currently in this class)**

Gamble Creek is a Class III waterbody, with a designated use of recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife.

3.2 Applicable Water Quality Standards and Numeric Water Quality Target

Numeric criteria for bacterial quality are expressed in terms of fecal coliform and total coliform bacteria concentrations. The water quality criteria for protection of Class III waters, as established by Chapter 62-302, F.A.C., state the following:

Fecal Coliform Bacteria:

The most probable number (MPN) or membrane filter (MF) counts per 100 ml of fecal coliform bacteria shall not exceed a monthly average of 200, nor exceed 400 in 10 percent of the samples, nor exceed 800 on any one day.

Total Coliform Bacteria:

The MPN or MF per 100 milliliters (mL) shall be less than or equal to 1,000 as a monthly average nor exceed 1,000 in more than 20 percent of the samples examined during any month; and less than or equal to 2,400 at any time.

The criteria state that monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30-day period. During the development of load duration curves for the impaired stream (as described in subsequent chapters), there were insufficient data (fewer than 10 samples in a given month) available to evaluate the geometric mean criterion for either fecal coliform or total coliform bacteria. Therefore, the criteria selected for the

TMDLs were not to exceed 400 MPN/100 mL in any sampling event for fecal coliform, and not to exceed 2,400 MPN/100mL in any sampling event for total coliform. The 10 percent exceedance allowed by the water quality criterion for fecal coliform bacteria was not used directly in estimating the target load, but was included in the TMDL margin of safety (as described in subsequent chapters).

Chapter 4: ASSESSMENT OF SOURCES

4.1 Types of Sources

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of pollutants in the Gamble Creek watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either “point sources” or “nonpoint sources.” Historically, the term point sources has meant discharges to surface waters that typically have a continuous flow via a discernable, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. In contrast, the term “nonpoint sources” was used to describe intermittent, rainfall driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, agriculture, silviculture, and mining; discharges from failing septic systems; and atmospheric deposition.

However, the 1987 amendments to the Clean Water Act redefined certain nonpoint sources of pollution as point sources subject to regulation under the EPA’s National Pollutant Discharge Elimination (NPDES) Program. These nonpoint sources included certain urban stormwater discharges, including those from local government master drainage systems, construction sites over five acres, and a wide variety of industries (see **Appendix A** for background information on the federal and state stormwater programs).

To be consistent with Clean Water Act definitions, the term “point source” will be used to describe traditional point sources (such as domestic and industrial wastewater discharges) ***and*** stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 6.1**). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES stormwater discharges and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.2 Potential Sources of Fecal Coliform and Total Coliform in the Gamble Creek Watershed

4.2.1 Point Sources

There is one wastewater facility permitted to discharge wastewater in the Gamble Creek watershed. The Florida Power and Light (FPL) facility (Permit Number FL0032174) is authorized to discharge via two outfalls (Site ID: I-005 and D-002). However, based on the Department’s Wastewater Facility Regulation (WAFR) database, Site I-005 discharges metal cleaning water and Site D-002 discharges uncontaminated stormwater. The FPL permit does not include effluent limits for bacteriological contaminants for either outfall, and the FPL facility is not expected to be a source of fecal coliform and total coliform for this TMDL.

Municipal Separate Storm Sewer System Permittees

The stormwater collection systems owned and operated by Manatee County and the Florida Department of Transportation (FDOT) in the Manatee Basin are covered by a Phase I NPDES municipal separate storm sewer system (MS4) permit. Although WBID 1819 lies far outside the US Census Bureau's 2000 urban area boundary that roughly defines the limit of the NPDES permit's Stormwater Management Program for Manatee County, the WBID is still covered by the county MS4 permit. In the Gamble Creek watershed, Manatee County is the leading permittee. There are no nontraditional Phase II permittees within the WBID.

4.2.2 Land Uses and Nonpoint Sources

Land Uses

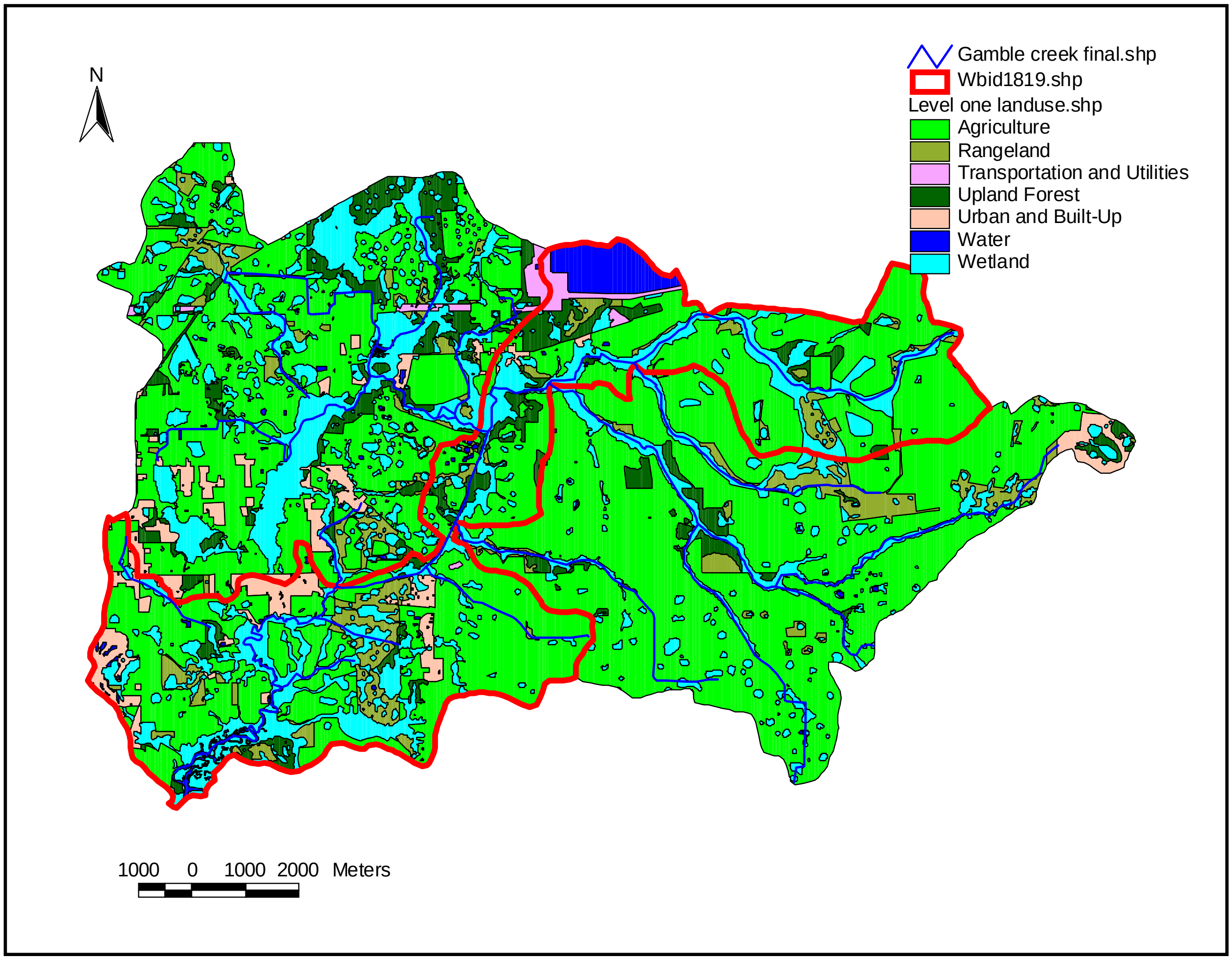
The spatial distribution and acreage of different land use categories were identified using the SWFWMD's land use coverage (scale 1:40,000) contained in the Department's geographic information system (GIS) library. Land use categories in the watershed were aggregated using the simplified Level 1 codes and tabulated in **Table 4.1. Figure 4.1** shows the acreage of the principal land uses in the watershed.

As shown in **Table 4.1,** the Gamble Creek watershed drains about 35,727 acres of land. The dominant land use category is agriculture, which accounts for 61 percent of the total watershed area. This, plus the 7 percent of the land used as rangeland, makes up 68 percent of the total watershed. The urban and built-up category (including high-, medium-, and low-density residential) and transportation, communication, and utilities account for only about 4 percent of the total watershed area. The majority of the residential category comprises low-density residences. Natural land uses, which include upland forest, water, and wetland, account for about 28 percent of the total watershed.

Table 4.1. Classification of Land Use Categories in the Gamble Creek Watershed, WBID 1819

Level 1 Code	Land Use	Acreage
1000	Urban open	438
	Low-density residential	857
	Medium-density residential	116
	High-density residential	0
2000	Agriculture	21,888
3000	Rangeland	2,026
8000	Transportation, communication, and utilities	298
4000	Forest/rural open	2,282
5000/6000	Water/wetland	7,822
	TOTAL	**35,727**

Figure 4.1. Principal Land Uses in the Gamble Creek Watershed (WBID 1819 is the area within the red boundary)



Source Assessment

Because no traditional point sources were identified in the Gamble Creek watershed, the primary loadings of fecal coliform to Gamble Creek are generated by nonpoint sources or MS4-permitted areas in the watershed. Nonpoint sources of coliform bacteria generally, but not always, come from the accumulation of coliform bacteria on land surfaces that washes off as a result of storm events, and the contribution from ground water from sources such as failed septic tanks and the improper land application of domestic wastewater residuals. Typical nonpoint sources of coliform bacteria include the following:

- Wildlife,
- Agricultural animals,
- Pets in residential areas,
- Onsite sewage treatment and disposal systems (septic tanks),
- Land application of domestic wastewater residuals, and
- Urban development (outside of Phase I or II MS4 discharges).

No data were available to specifically identify and quantify the major source(s) for fecal and total coliform bacteria in the Gamble Creek watershed. However, the land use analysis in the preceding section indicates that human land uses—including agriculture, rangeland, urban and built-up, and transportation, communications, and utilities—make up about 72 percent of the total watershed area. In particular, agriculture and rangeland claim 94 percent of the land, making them potentially important sources of fecal and total coliform bacteria to Gamble Creek. These bacteria can be brought into the creek through surface runoff from areas where animal wastes are used to supplement or partially substitute for chemical fertilizers, or from rangeland areas where animal wastes accumulate. Livestock directly accessing the stream can also cause contamination.

Detailed information on agricultural and livestock operations in the watershed was unavailable at the time that this TMDL report was developed. However, comparing the land use composition of the Gamble Creek watershed with that of Manatee County indicates a general similarity **(Table 4.2).** The area used for agriculture and rangeland for the entire county accounts for 56 percent of the county's total land area, while these two land use categories occupy about 68 percent of the land area in the Gamble Creek watershed. Natural land areas, including forest and water/wetland, comprise 29 percent of the total area for Manatee County and 28 percent for the Gamble Creek watershed. Because of these similarities, it is expected that livestock operations have a similar influence on water quality at the county level, compared with that in the Gamble Creek watershed.

Table 4.2. Land Use Compositions for Manatee County and the Gamble Creek Watershed

Level 1 Code	Land Use	Manatee County Land Use (acres)	Gamble Creek Watershed Land Use (acres)	Manatee County (percent of land use)	Gamble Creek Watershed (percent of land use)
1000	Urban open	69,673	1,411	15%	4%
2000	Agriculture	201,416	21,888	43%	61%
3000	Rangeland	61,774	2,026	13%	7%
8000	Transportation, communication, and utilities	6,391	298	1%	1%
4000	Forest/rural open	49,801	2,282	11%	6%
5000/6000	Water/wetland	83,385	7,822	18%	22%
	TOTAL	472,440	35,727		

Table 4.3 lists the annual cattle inventory for Manatee County (Witzig, 2003) and the annual median fecal and total coliform concentrations in Gamble Creek between 1996 and 2002. The median fecal and total coliform concentrations were calculated as the median values of all the sampling events carried out during those individual years.

Table 4.3. Relationship between Annual Fecal Coliform Concentrations in Gamble Creek and Number of Cattle in Manatee County, 1996 – 2002

Year	County Cattle Inventory	Median Fecal Coliform Concentration (MPN/100 mL)	Median Total Coliform Concentration (MPN/100 mL)
1996	74,000	855	-
1997	74,000	755	6,400
1998	68,000	510	4,200
1999	67,000	-	-
2000	66,000	795	2,425
2001	62,000	433	4,090
2002	61,000	215	1,180

Based on **Table 4.2,** Manatee County has about 263,190 acres of agriculture and rangeland, and the Gamble Creek watershed has about 23,914 acres of the same land use categories. The ratio between these two numbers is 11.0. Assuming that the ratio did not change between 1996 and 2000, the number of head of cattle in the Gamble Creek watershed was calculated using the ratio. **Table 4.4** lists the loading estimates for each year. Cattle may produce, on average, 5.4×10^9 fecal coliform bacteria per day (Metcalf and Eddy, 1991). Assuming that 10 percent of the fecal coliform load will eventually reach the stream alive after attenuation during overland transport and natural death (Roehl, 1962), the final fecal coliform load that may reach Gamble Creek can be calculated using the equation below. **Table 4.4** lists the loads estimated from this equation.

Final load = Number of cattle * fecal coliform daily production per cow * delivery ratio

Table 4.4. Estimated Annual Loadings of Fecal Coliform to Gamble Creek, 1996 – 2002

Year	County Cattle Inventory (head)	Gamble Creek Cattle Inventory Estimates (head)	Fecal Coliform Daily Production per Cow (fecal coliform/day)	Delivery Ratio	Estimated Final Fecal Coliform Load Reaching Gamble Creek (fecal coliform/day)
1996	74,000	6,724	5.4E+09	0.1	3.63E+12
1997	74,000	6,724	5.4E+09	0.1	3.63E+12
1998	68,000	6,179	5.4E+09	0.1	3.34E+12
1999	67,000	6,088	5.4E+09	0.1	3.29E+12
2000	66,000	5,997	5.4E+09	0.1	3.24E+12
2001	62,000	5,633	5.4E+09	0.1	3.04E+12
2002	61,000	5,543	5.4E+09	0.1	2.99E+12
Average	67,429	6,127			3.31E+12
Standard Deviation	5159	469			2.54E+11

The average daily load of fecal coliform that may eventually reach Gamble Creek, based on the estimates in **Table 4.4,** is $(3.31 \pm 0.25) \times 10^{12}$ fecal coliform/day, which is not significantly different from the existing loading capacity of fecal coliform, $(1.27 \pm 2.23) \times 10^{12}$ fecal coliform/day, estimated using the load duration curve approach (discussed in detail in the following chapter). This suggests the importance of livestock operations as a possible contributor to fecal coliform concentrations in Gamble Creek.

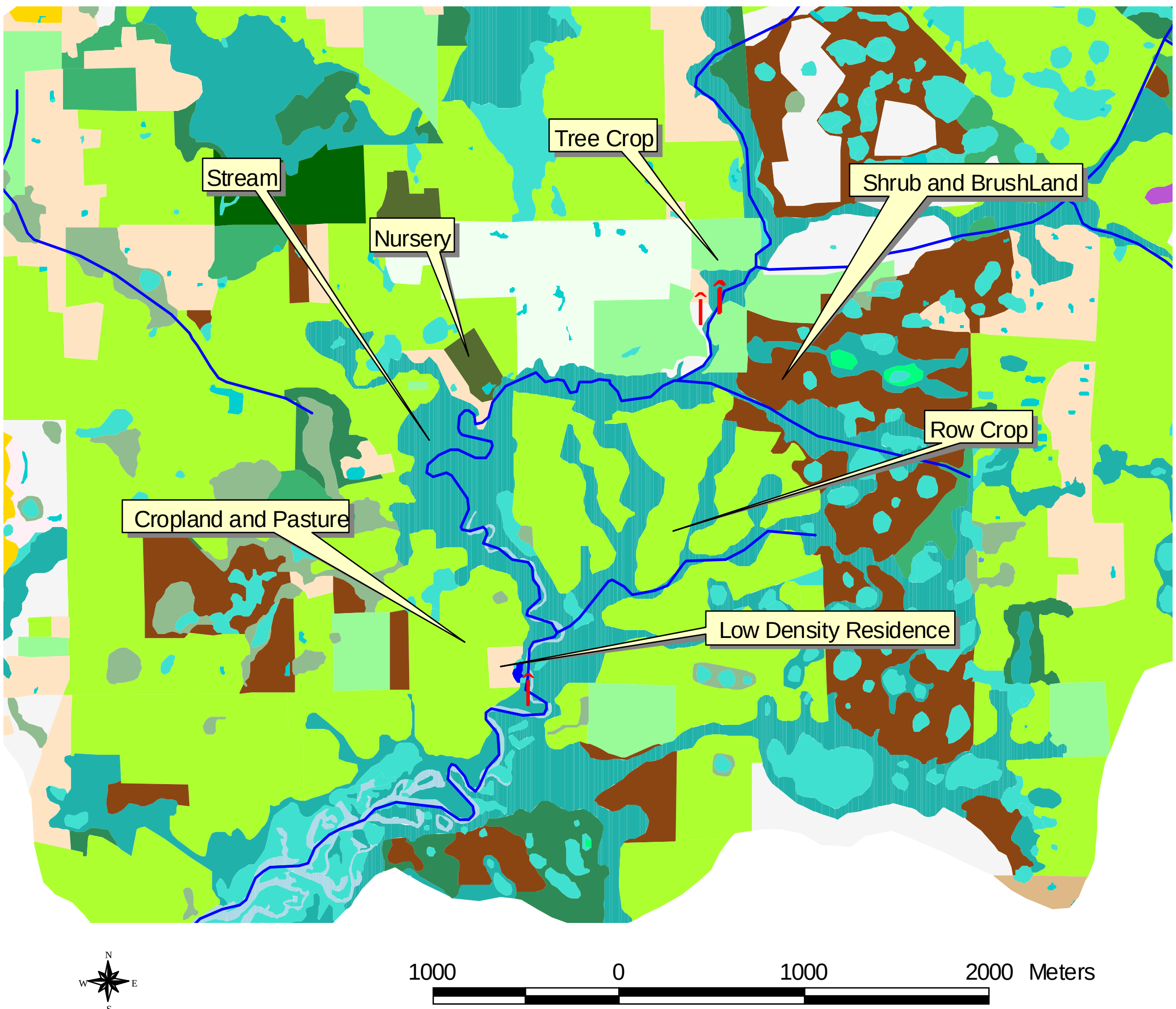
The data indicate a correlation between the county's cattle inventory and fecal and total coliform concentrations in Gamble Creek. As shown in **Table 4.3,** the cattle inventory in Manatee County steadily decreased from 1996 through 2002. During the same period, both the fecal and total coliform concentrations in Gamble Creek steadily decreased, except for the fecal coliform concentration in 2000 and the total coliform concentration in 2001. Excluding these two exceptions, the change in the cattle inventory explains about 90.7 percent of the variance in fecal coliform ($p = 0.012$) and 96.5 percent of the variance in total coliform ($p = 0.017$).

This correlation should be cautiously interpreted, because fecal and total coliform concentrations in Gamble Creek could be influenced by many other factors that vary from year to year, such as weather, soil moisture, the intensity of livestock operations, and the types of best management practices (BMPs) used by the agricultural community. However, the tight correlation between the livestock inventory and water quality in Gamble Creek may indicate the influence of livestock operations on the creek's water quality.

Wildlife. Wildlife may be another source of fecal and total coliform bacteria to Gamble Creek. Based on a 1999 multi-resolution seamless image database (MrSID) aerial photo of the watershed, tree farms were identified along the creek. In these areas, the banks of the creek are reasonably well covered by vegetation. The vegetative cover could provide habitat for wild animals, whose feces may be a direct source of fecal and total coliform to the creek.

Septic Tanks. Septic tank leakage is likely not a significant source of coliforms for Gamble Creek. As discussed in the previous section, residential land use accounts for only about 4 percent of the total watershed area. A closer look at the land use pattern along Gamble Creek, using the 1999 MrSID aerial photo, indicates that residential areas are very scarcely distributed along the creek **(Figure 4.2).** Most of these residential areas appear to contain single-unit residences or only a small number of housing units.

Figure 4.2. Detailed Land Use Patterns Along Gamble Creek in the Sampling Area



Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

The methodology used for this TMDL is the load duration curve. Also known as the "Kansas Approach", because it was developed by the state of Kansas, this method has been well documented in the literature, with improved modifications used by EPA Region 4. Basically, the method relates the pollutant concentration to the flow of the stream, in order to establish the existing loading capacity and the allowable pollutant load (TMDL) under a spectrum of flow conditions. It then determines the maximum allowable pollutant load and load reduction requirement based on the analysis of the critical flow conditions. Using this method, it takes four steps to develop the TMDL and establish the required load reduction:

1. Develop the flow duration curve,
2. Develop the load duration curve for both the allowable load and existing loading,
3. Define the critical conditions, and
4. Establish the needed load reduction by comparing the existing loading with the allowable load under critical conditions.

5.1.1 Data Used in the Determination of the TMDL

Fecal coliform and total coliform concentrations and flow measurements were required to estimate both the allowable pollutant load and existing loading to Gamble Creek. **Figure 5.1** shows the locations of the water quality sites from which fecal coliform and total coliform data were collected and the U.S. Geological Survey (USGS) gaging station from which the flow measurements were taken. Fecal and total coliform samples were collected in 1996, 1997, 1998, 2001, and 2002. There were a total of 60 fecal coliform samples and 45 total coliform samples collected from 5 sites. Water samples were collected from 2 sites located in the lower and middle reaches of Gamble Creek. Data used for this TMDL report were provided by the Department (sample ID prefix: 21FLGW), the Department's Southwest District Office (sample ID prefix: 21FLTPA), the SWFWMD (sample ID prefix: 21FLSWFD), and Manatee County Environmental Management Department (sample ID prefix: 21FLMANA).

Table 2.2 provides a statistical summary of fecal and total coliform measurements in Gamble Creek. **Figures 5.2a** and **5.2b** show the seasonal trends for fecal and total coliform concentrations in 1996, 1997, 1998, 2000, 2001, and 2002. For fecal coliform concentrations, it appears that the seasonal trend from 1996 through 1998 was different from that of 2000 through 2002. From 1996 to 1998, the lowest fecal coliform concentration always appeared in the first and third quarters of the year. In contrast, from 2000 through 2002, the lowest fecal coliform concentration was mostly found in the second quarter. Total coliform data were scarce between 1996 and 1998. However, the seasonal trend for total coliform from 2000 to 2002 was consistent with that of fecal coliform – that is, the lowest concentration mostly appeared in the second quarter.

The majority of samples used in this TMDL report were collected at Site 21FLMANAGC2, which is also known as 21FLGW FLO0017, 21FLSWDFLO0017, and 21FLTPA24010063 (multiple agencies collected samples at the site during different periods). The Department and SWFWMD sampled the site from 1996 through 1998, with data missing in the second quarter of 1996 and the fourth quarter of 1998. The Manatee County Environmental Management Department collected the majority of the fecal coliform data at the site from 2000 through 2002. The Department's Southwest District Office also collected fecal coliform samples at the site in 2002 that at least partially confirmed the trend of fecal coliform contamination represented by the data collected by other agencies. In addition, the Department's Southwest District Office collected samples at the lower reach (Site 21FLTPA273206982240096) in 2002.

For total coliform, the Department and SWFWMD collected samples from the fourth quarter of 1997 through the third quarter of 1998 at Site 21FLMANAGC2. Data for the first, second, and third quarters of 1997 and the fourth quarter of 1998 were missing at the site. Again, the majority of the total coliform data in 2000, 2001, and 2002 was collected by the Manatee County Environmental Management Department at the same site. Total coliform data were also collected at site 21FLTPA 273206982240096 by the Department's Southwest District Office in 2002.

Flow measurements from a USGS gauging station (Station 02300018: Gamble Creek near Parrish, Florida, Latitude: 27^{0}33'11", Longitude: 82^{0}23'23") were used in this TMDL report. Because the flow measurements from this station covered the period from October of 2000, through April of 2003, which did not totally match up with the period during which the water quality samples were collected, flow measurements from a nearby gaging station (USGS Station 02299950) were used to extend the flow data from USGS Station 02300018 using the "Move. 1" statistical routine, which is discussed in detail in the following section. The flow duration curve for Gamble Creek was developed based on a mixed flow data set, which includes both measured data when they were available, and the "Move. 1" estimated data when the measured data were not available. **Figure 5.1** shows the location of USGS gauging station 02300018.

Figure 5.1. Locations of Water Quality Stations and USGS Gaging Station from which Water Quality Data and Flow Measurements Were Collected for This Report

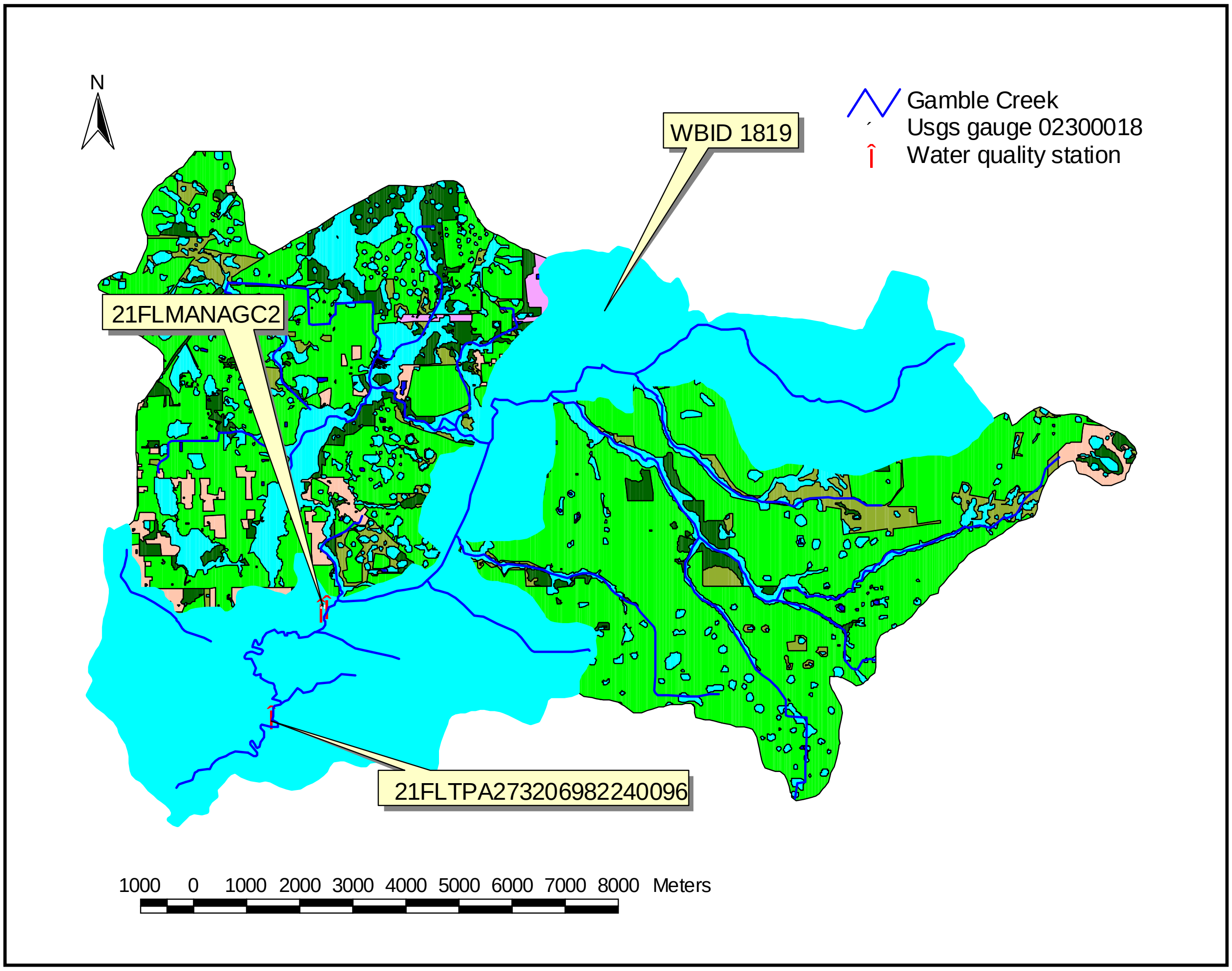


Figure 5.2a. Trend of Fecal Coliform Concentrations in Gamble Creek in 1996, 1997, 1998, 2000, 2001, and 2002

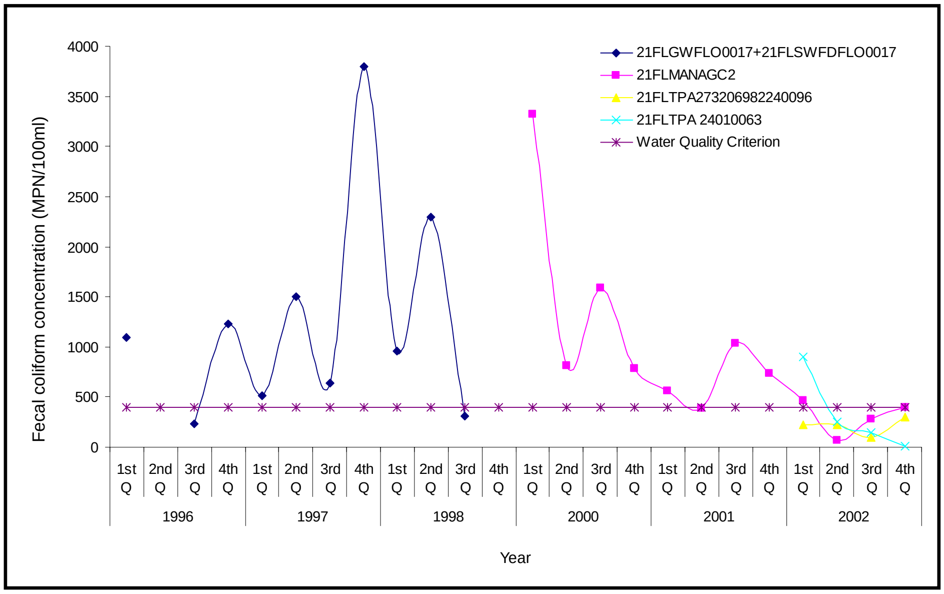
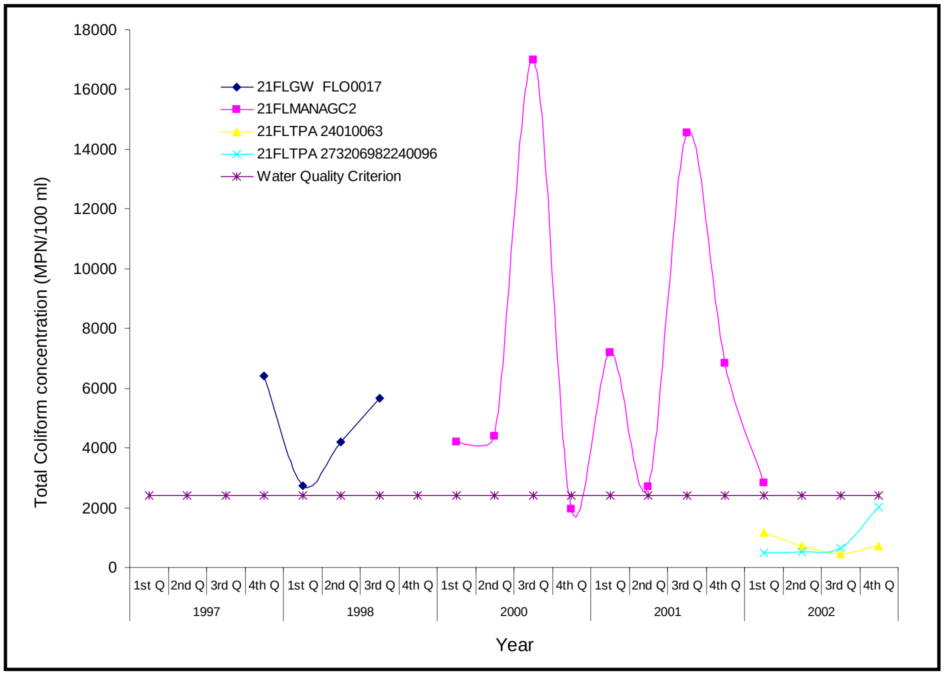


Figure 5.2b. Trend of Total Coliform Concentrations in Gamble Creek in 1996, 1997, 1998, 2000, 2001, and 2002



5.1.2 TMDL Development Process

Develop the Flow Duration Curve

The first step in the development of load duration curves is to create *flow duration curves*. A flow duration curve displays the cumulative frequency distribution of daily flow data over the period of record. The duration curve relates flow values measured at a monitoring station to the percent of time the flow values were equaled or exceeded. Flows are ranked from low, which are exceeded nearly 100 percent of the time, to high, which are exceeded less than 1 percent of the time.

As mentioned in the previous section, because the flow measurements collected at USGS Gaging Station 02300018 did not completely cover the period during which the water quality data were collected, the flow data set from the station was extrapolated using the "Move.1" statistical routine (Hirsch, 1982) based on the flow measurement collected from a nearby gaging station on the Manatee River (USGS 02299950). The flow record of this station covers the period from April 20, 1966, through September 30, 2003. "Move.1" extends the flow data set using the following equation:

$$\mathbf{Y} = \mathbf{mean(Y)} + \frac{\mathbf{stdev(Y)}}{\mathbf{stdev(X)}} * \mathbf{(X - mean(X))} \qquad \mathbf{(1)}$$

Where:

- Y is the simulated daily flow for Gamble Creek,
- Mean(Y) is the average logarithmic daily flow over the period of record for Gamble Creek,
- Stdev(Y) is the standard deviation of the daily flow over the period of record for Gamble Creek,
- X is the measured daily flow for the Manatee River,
- Mean(X) is the average logarithmic daily flow over the period of record for the Manatee River, and
- Stdev(X) is the standard deviation of the daily flow over the period of record for the Manatee River.

Table 5.1 shows the means and standard deviations of the logarithmic flow measurements for Gamble Creek and the Manatee River. Means and standard deviations for both Gamble Creek and the Manatee River were calculated based on the flow measurements for October 1, 2000, through September 30, 2001. During this period, both flow stations had flow measurements.

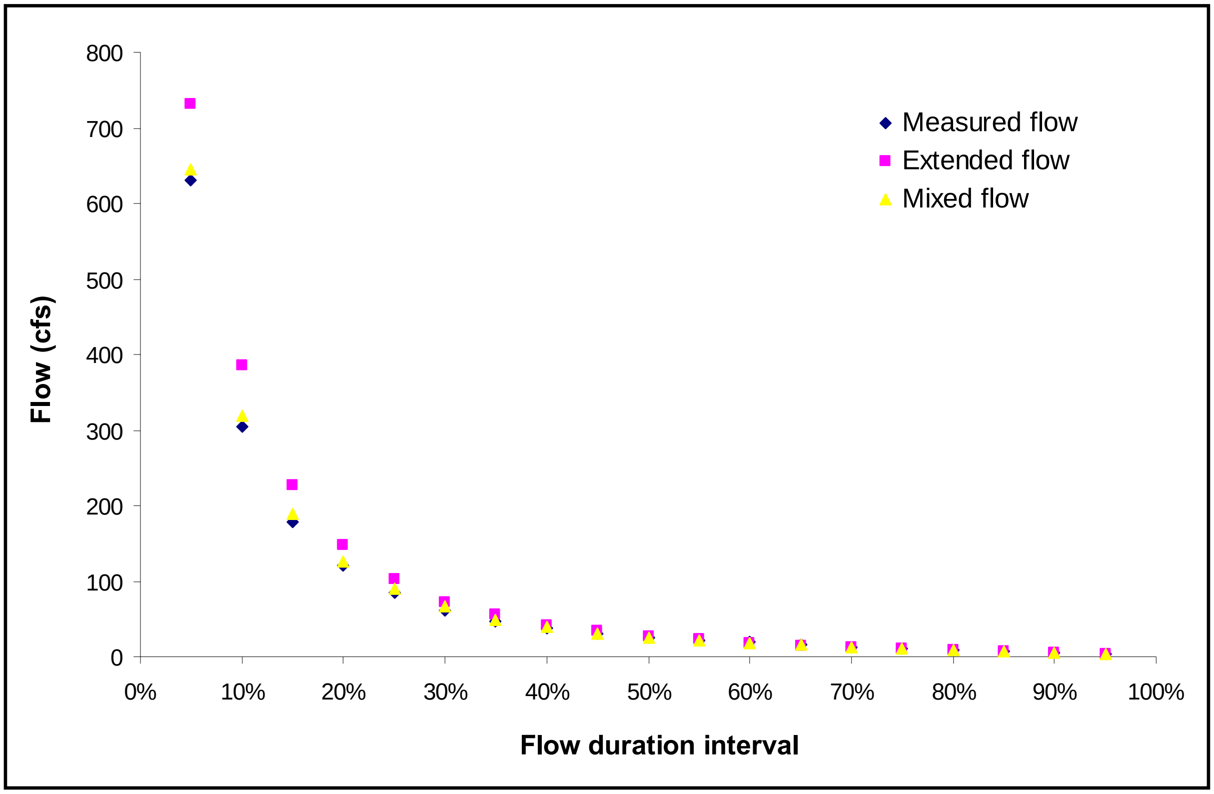
Table 5.1. Means and Standard Deviations of the Logarithmic Flow Measurements for Gamble Creek (Y) and the Manatee River (X)

	Log Manatee River Flow (X)	Log Gamble Creek Flow (Y)
Mean	1.265	1.294
Stdev	0.646	0.757
$\frac{stdev(Y)}{stdev(X)}$	1.173	

The flow duration curve was created by using the percentile function and the flow record to generate the flow at a given duration interval. For example, at the 90th duration interval, the percentile function calculates the flow that is equal or exceeded 90 percent of the time. **Figure 5.3** shows the flow duration curves for Gamble Creek generated from the measured flow and estimated flow using "Move. 1." Flows toward the right side of the plot are exceeded in greater frequency and are indicative of low-flow conditions. Flows on the left side of the plot represent high flows and occur less frequently.

To ensure that the final flow data set was as accurate as possible, measured flow was used whenever there was a measured record. This created a mixed data set that includes both the "Move. 1" predicted flow and measured flow. **Figure 5.3** demonstrates that the flow duration curves created based on measured, extended, and mixed data sets are very similar. In creating the load duration curve, this TMDL report used the flow duration interval based on the mixed data set.

Figure 5.3. Flow Duration Curve for Gamble Creek, WBID 1819



Develop the Load Duration Curves for Both the Allowable Load and Existing Loading Capacity

Flow duration curves are transformed into load duration curves by multiplying the flow values along the flow duration curve by the fecal coliform or total coliform concentration and the appropriate conversion factors. The final results of the load are typically expressed as MPN per day. The following equations were used to calculate the allowable loads and the existing loading:

Allowable load = (observed flow) x (conversion factor) x (state criteria) (2)

Existing loading = (observed flow) x (conversion factor) x (coliform measurement) (3)

On the load duration curve, allowable and existing loads are plotted against the flow duration ranking. The allowable load was calculated based on the water quality numeric criterion and flow values from the flow duration curve, and the line drawn through the data points representing the allowable load is called the target line. The existing loads are based on the instream fecal coliform or total coliform concentrations measured during ambient monitoring and an estimate of flow in the stream at the time of sampling. As noted previously, because insufficient data were collected to evaluate the fecal coliform geometric mean, 400 MPN/100mL and 2,400 MPN/100 mL were used as target criteria for fecal coliform and total coliform, respectively. **Figures 5.3a** and **5.3b** show both the allowable loads and the existing loads over the flow duration ranking for Gamble Creek. The points of the existing load that were higher than the allowable load at a given flow duration ranking were considered an exceedance of the criteria.

As shown in **Figures 5.3a** and **5.4b,** exceedances of the fecal coliform and total coliform criteria in Gamble Creek occur across the entire span of the flow record. In general, exceedances on the right side of the curve typically occur during low-flow events, which implies a contribution from either point sources or baseflow. The exceedances that appear on the left side of the curve usually represent loading from stormwater-related sources. In this case, the potential sources may include the land application of biosolids or contamination from wildlife, livestock, and pets that accumulates on the land surface and washes into the creek during wet weather. As no point sources are identified in the watershed, the broad occurrence of exceedances could have resulted from livestock directly accessing the stream during the relatively dry period and animal wastes on the land surface washing into the creek during high-flow conditions.

Define the Critical Condition

The critical condition for coliform loadings in a given watershed depends on many factors, including the presence of point sources and the land use pattern in the watershed. Typically, the critical condition for nonpoint sources is an extended dry period followed by a rainfall runoff event. During the wet weather period, rainfall washes off coliform bacteria that have built up on the land surface under dry conditions, resulting in the wet weather exceedances. However, significant nonpoint source contributions can also appear under dry conditions without any major surface runoff event. This usually happens when nonpoint sources contaminate the surficial aquifer, and fecal coliform bacteria are brought into the receiving waters through baseflow. In addition, as described above, livestock that have direct access to the receiving water can also contribute to the exceedance during dry weather. The critical condition for point source loading typically occurs during periods of low stream flow, when dilution is minimized.

For the Gamble Creek watershed, exceedances occurred across the entire span of the flow conditions. Because no major point sources were identified in the watershed, exceedances that appeared in all these intervals were considered to be from nonpoint sources. Critical conditions are accounted for in the load curve analysis by using the flow records and water quality data available in the 10^{th} to 90^{th} percentile flow duration interval.

Establish the Needed Load Reduction by Comparing the Existing Load with the Allowable Load under the Critical Condition

The fecal coliform and total coliform load reductions required to achieve water quality criteria were established by comparing the existing loading with the allowable load at each flow recurrence interval between the 10^{th} and 90^{th} percentile (in increments of 5 percent). The actual needed load reduction was calculated using the following equation:

$$\textbf{Load reduction} = \frac{\textbf{Existing loading} - \textbf{Allowable loading}}{\textbf{Existing loading}} \times \textbf{100\%} \qquad \textbf{(4)}$$

The *Allowable loading* at each recurrence interval was calculated as the product of the water quality criterion and the flow corresponding to the given recurrence interval. To calculate the *Exisiting loading,* a trend line was fitted to the loads that exceeded the *Allowable loading*. Several types of trend lines were examined, and the power function was found to have the highest correlation coefficient for both fecal coliform loading ($R^2 = 0.7811$) and total coliform loading ($R^2 = 0.7838$). Therefore, power functions were used to predict the existing loads corresponding to the flow recurrence intervals used by the *Allowable loading.* The following are the power equations developed for fecal coliform and total coliform:

For fecal coliform: $\mathbf{Y = 1E + 11X^{-2.0466}}$ **(5)**

For total coliform: $\mathbf{Y = 7E + 11X^{-1.7617}}$ **(6)**

Where:
X is the flow recurrence interval between the 10th and 90th percentile and
Y is the predicted *Existing loading* for fecal coliform (Equation 5) and total coliform (Equation 6).

Figures 5.4a and **5.4b** show the trend lines and power equations for both fecal and total coliform bacteria. After the trend lines were developed, they were used to determine the median percent reduction required to achieve the numeric criterion. At each recurrence interval between the 10th and 90th percentile (in increments of 5 percent), the equation of the trend line was used to estimate the *Existing loading*. Values for flows that are exceeded less than 10 percent of the time were not used because they represent abnormally high-flow events, and values for flows occurring greater than 90 percent of the time were not used because they are extreme low-flow events.

The percent reduction required to achieve the target load was then calculated at each interval, and the final percent reduction needed was the median of these values. The TMDL and percent reductions were calculated as the median of all the loads and percent reductions calculated at the various recurrence intervals between the 10th and 90th percentile. **Tables 5.2a** and **5.2b,** respectively, show the calculation of the TMDL and percent reductions for fecal coliform and total coliform in Gamble Creek.

Table 5.2a. Calculation of TMDL and Percent Reduction for Fecal Coliform in Gamble Creek, WBID 1819

Interval	Allowable Load (counts/day)	Existing Load[1] (counts/day)	Percent Reduction
90	5.69E+10	1.00E+11	43.2
85	7.15E+10	1.13E+11	36.5
80	9.06E+10	1.27E+11	28.9
75	1.08E+11	1.45E+11	26.0
70	1.28E+11	1.67E+11	23.5
65	1.52E+11	1.95E+11	22.2
60	1.88E+11	2.30E+11	18.2
55	2.15E+11	2.74E+11	21.5
50	2.50E+11	3.33E+11	24.9
45	2.94E+11	4.14E+11	29.0
40	3.62E+11	5.26E+11	31.2
35	4.55E+11	6.92E+11	34.2
30	6.07E+11	9.48E+11	36.0
25	8.22E+11	1.38E+12	40.3
20	1.17E+12	2.17E+12	46.0
15	1.74E+12	3.92E+12	55.5
10	2.98E+12	8.98E+12	66.9
Median	2.50E+11	3.33E + 11	**31.2**

Table 5.2b. Calculation of TMDL and Percent Reduction for Total Coliform in Gamble Creek, WBID 1819

Interval	Allowable Load (counts/day)	Existing Load[1] (counts/day)	Percent Reduction
90	3.41E+11	7.22E+11	52.7
85	4.29E+11	7.98E+11	46.3
80	5.43E+11	8.88E+11	38.8
75	6.46E+11	9.95E+11	35.1
70	7.69E+11	1.12E+12	31.6
65	9.09E+11	1.28E+12	29.0
60	1.13E+12	1.47E+12	23.6
55	1.29E+12	1.72E+12	24.8
50	1.50E+12	2.03E+12	26.1
45	1.76E+12	2.45E+12	28.0
40	2.17E+12	3.01E+12	27.8
35	2.73E+12	3.81E+12	28.3
30	3.64E+12	5.00E+12	27.1
25	4.93E+12	6.89E+12	28.4
20	7.05E+12	1.02E+13	31.0
15	1.05E+13	1.69E+13	38.3
10	1.79E+13	3.46E+13	48.4
Median	**1.50E + 12**	**2.03E + 12**	**29.0**

Figure 5.4a. Load Duration Curves for Allowable Load and Existing Loading Capacity of Fecal Coliform

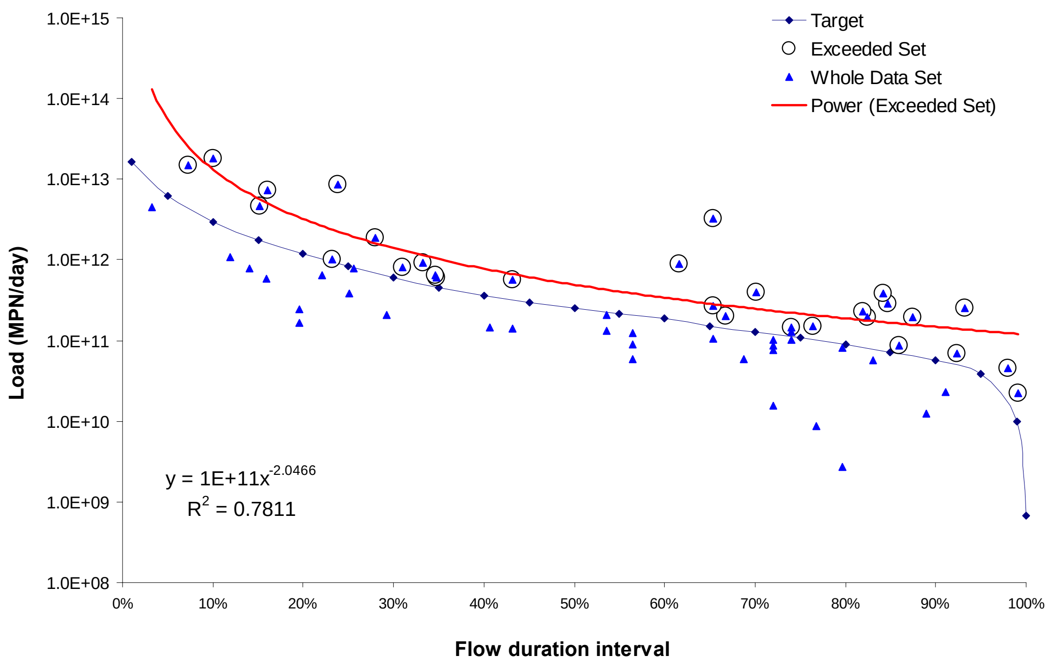
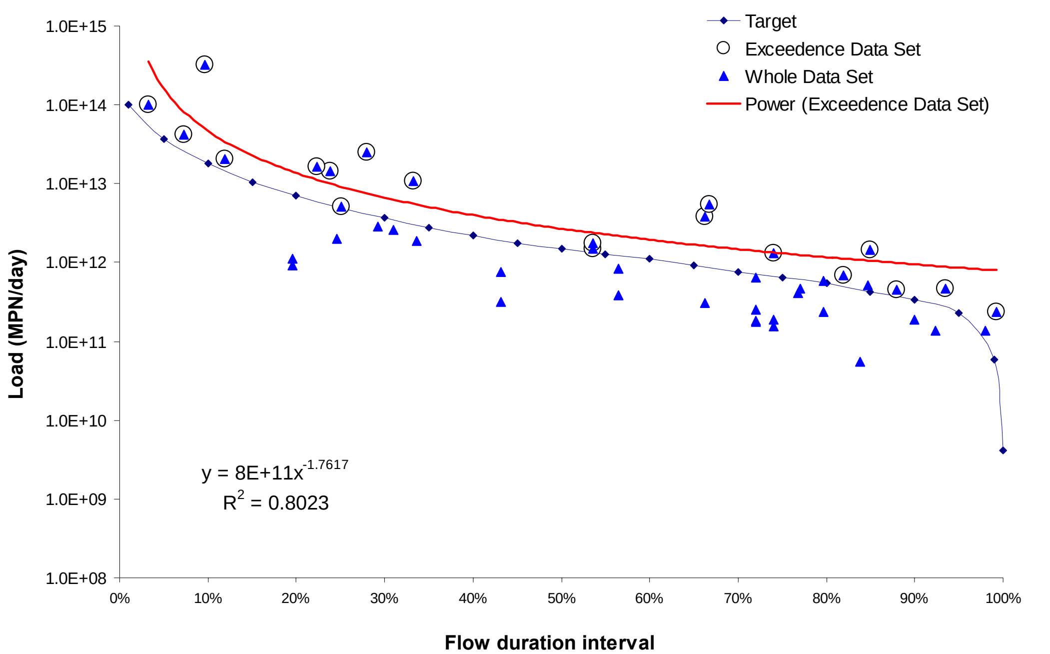


Figure 5.4b. Load Duration Curves for Allowable Load and Existing Loading Capacity of Total Coliform



Chapter 6: DETERMINATION OF THE TMDL

6.1 Expression and Allocation of the TMDL

The objective of a TMDL is to provide a basis for allocating acceptable loads among all of the known pollutant sources in a watershed so that appropriate control measures can be implemented and water quality standards achieved. A TMDL is expressed as the sum of all point source loads (Waste Load Allocations, or WLAs), nonpoint source loads (Load Allocations, or LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\textbf{TMDL} = \sum \textbf{WLAs} + \sum \textbf{LAs} + \textbf{MOS}$$

As discussed earlier, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

$$\textbf{TMDL} \cong \sum \textbf{WLAs}_{\textbf{wastewater}} + \sum \textbf{WLAs}_{\textbf{NPDES Stormwater}} + \sum \textbf{LAs} + \textbf{MOS}$$

It should be noted that the various components of the revised TMDL equation may not sum up to the value of the TMDL because a) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is also accounted for within the LA, and b) TMDL components can be expressed in different terms (for example, the WLA for stormwater is typically expressed as a percent reduction, and the WLA for wastewater is typically expressed as mass per day).

WLAs for stormwater discharges are typically expressed as “percent reduction” because it is very difficult to quantify the loads from MS4s (given the numerous discharge points) and to distinguish loads from MS4s from other nonpoint sources (given the nature of stormwater transport). The permitting of stormwater discharges also differs from the permitting of most wastewater point sources. Because stormwater discharges cannot be centrally collected, monitored, and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the “maximum extent practical” through the implementation of BMPs.

This approach is consistent with federal regulations (40 CFR § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or **other appropriate measure**. TMDLs for Gamble Creek are expressed in terms of MPN/day and percent reduction, and represent the maximum daily fecal coliform and total coliform loads the stream can assimilate and maintain the fecal coliform criterion **(Table 6.1).**

Table 6.1. TMDL Components for Fecal Coliform and Total Coliform in Gamble Creek, WBID 1819

Parameter	TMDL (colonies/day)	WLA		LA (percent reduction)	MOS
		Wastewater (colonies/day)	NPDES Stormwater (percent reduction)		
Fecal coliform	2.50×10^{11}	N/A	31.2%	31.2 %	Implicit
Total coliform	1.50×10^{12}	N/A	29.0%	29.0%	Implicit

6.2 Load Allocation (LA)

Based on a loading duration curve approach similar to that developed by Kansas (Stiles, 2002), the load allocation is a 31.2 percent reduction in fecal coliforms from nonpoint sources and a 29.0 percent reduction in total coliforms from nonpoint sources. It should be noted that the LA includes loading from stormwater discharges regulated by the Department and the water management districts that are not part of the NPDES Stormwater Program (see **Appendix A).**

6.3 Wasteload Allocation (WLA)

6.3.1 NPDES Wastewater Discharges

No NPDES-permitted wastewater facilities with fecal coliform limits were identified in the Gamble Creek watershed.

6.3.2 NPDES Stormwater Discharges

The WLA for stormwater discharges with an MS4 permit is a 31.2 percent and 29.0 percent reduction in current fecal coliform and total coliform loading from the MS4, respectively. It should be noted that any MS4 permittee will only be responsible for reducing the loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

6.4 Margin of Safety (MOS)

Consistent with the recommendations of the Allocation Technical Advisory Committee (Florida Department of Environmental Protection, February 2001), an implicit margin of safety (MOS) was used in the development of this TMDL. For fecal coliform, an implicit MOS was inherently incorporated by using 400 MPN/100 mL of fecal coliform as the water quality target for each and every sampling event, instead of setting the criteria as that no more than 10 percent of the samples exceeding 400 MPN/100 mL. For both fecal coliform and total coliform TMDLs, using the correlation lines fitting through only the existing loadings that exceeded the allowable loadings could overestimate the actual existing loading, which makes the estimation more conservative and therefore adds to the MOS.

Chapter 7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

7.1 Basin Management Action Plan

Following the adoption of this TMDL by rule, the next step in the TMDL process is to develop an implementation plan for the TMDL, which will be a component of the Basin Management Action Plan (BMAP) for the Manatee BAsin This document will be developed over the next year in cooperation with local stakeholders and will attempt to reach consensus on more detailed allocations and on how load reductions will be accomplished. The BMAP will include the following:

- Appropriate allocations among the affected parties,
- A description of the load reduction activities to be undertaken,
- Timetables for project implementation and completion,
- Funding mechanisms that may be utilized,
- Any applicable signed agreement,
- Local ordinances defining actions to be taken or prohibited,
- Local water quality standards, permits, or load limitation agreements, and
- Monitoring and follow-up measures.

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Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, F.S., was established as a technology-based program that relies on the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, F.A.C.

The rule requires the state's water management districts (WMDs) to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a SWIM plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation portion of a TMDL. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka. No PLRG has been developed for Newnans Lake at the time this TMDL report was developed.

In 1987, the U.S. Congress established Section 402(p) as part of the federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES stormwater permitting program to designate certain stormwater discharges as "point sources" of pollution. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific standard industrial classification (SIC) codes, construction sites disturbing 5 or more acres of land, and master drainage systems of local governments with a population above 100,000, which are better known as MS4s. However, because the master drainage systems of most local governments in Florida are interconnected, the EPA has implemented Phase 1 of the MS4 permitting program on a countywide basis, which brings in all cities (incorporated areas), Chapter 298 urban water control districts, and the FDOT throughout the 15 counties meeting the population criteria.

An important difference between the federal and state stormwater permitting programs is that the federal program covers both new and existing discharges, while the state program focuses on new discharges. Additionally, Phase 2 of the NPDES Program will expand the need for these permits to construction sites between 1 and 5 acres, and to local governments with as few as 10,000 people. The revised rules require that these additional activities obtain permits by 2003. While these urban stormwater discharges are now technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility similar to other point sources of pollution, such as domestic and industrial wastewater discharges. The Department recently accepted delegation from the EPA for the stormwater part of the NPDES Program. It should be noted that most MS4 permits issued in Florida include a re-opener clause that allows permit revisions to implement TMDLs once they are formally adopted by rule.

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