FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Environmental Assessment and Restoration, Bureau of Watershed Restoration

SOUTHWEST DISTRICT • SPRINGS COAST BASIN -
ANCLOTE RIVER/COASTAL PINELLAS COUNTY PLANNING UNIT

Draft TMDL Report

Fecal Coliform TMDL for Curlew Creek Freshwater Segment (WBID 1538A)

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Acknowledgments

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TMDL Program

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

Identification of Impaired Surface Waters Rule

http://www.dep.state.fl.us/legal/Rules/shared/62-303/62-303.pdf

Florida STORET Program

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

2010 Integrated Report

http://www.dep.state.fl.us/water/docs/2010_Integrated_Report.pdf

Criteria for Surface Water Quality Classifications

http://www.dep.state.fl.us/water/wqssp/classes.htm

Basin Status Report: Springs Coast

http://waterwebprod.dep.state.fl.us/basin411/springscoast/status/SpringCst.pdf

Water Quality Assessment Report: Springs Coast

http://waterwebprod.dep.state.fl.us/basin411/springscoast/assessment/G5AS-Springs_Coast-LORES_Merged.pdf

U.S. Environmental Protection Agency

Region 4: TMDLs in Florida

http://www.epa.gov/region4/water/tmdl/florida/

National STORET Program

http://www.epa.gov/storet/

Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Load (TMDL) for fecal coliform bacteria for the Curlew Creek Freshwater Segment, located in the Springs Coast Basin. The system was verified as impaired for fecal coliform by the Florida Department of Environmental Protection (Department) based on the Cycle 1 assessment period data (January 1, 1999 through June 30, 2006), and therefore was included on the Verified List of impaired waters for the Springs Coast Basin that was adopted by Secretarial Order on December 12, 2007 (amended on May 19, 2009). The fecal coliform impairment in this WBID was confirmed by the Department during the Cycle 2 assessment period (January 1, 2004 through June 30, 2011). The TMDL establishes the allowable fecal coliform loading to the Curlew Creek Freshwater Segment that would restore the waterbody so that it meets its applicable water quality criterion for fecal coliform.

1.2 Identification of Waterbody

For assessment purposes, the Department has divided the Springs Coast Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. Curlew Creek Freshwater Segment has been identified as WBID 1538A.

Curlew Creek Freshwater Segment is one of 93 waterbody segments in the Springs Coast Basin, Anclote River / Coastal Pinellas County Unit, and one of 22 waterbody segments in the Springs Coast Basin included on the initial 1998 303(d) list submitted by the Department to the United States Environmental Protection Agency (EPA). The 1998 303(d) list was incorporated into a 1999 Consent Decree between EPA and Earth Justice.

The initial list used data from stations listed in Department's 1996 305(b) report. The report used best available information at the time to generally characterize the quality of Florida's waters. Some of the delineations of waterbody areas and locations of sampling stations for the 1998 303(d) list were inaccurate due to technical limitations at that time. With the primary goal of providing more accurate assessments, the Department has revised these delineations over time. EPA has labeled the redrawing of WBID boundaries "resegmentation," as the original stations corresponded to specific WBID areas or segments. Resegmented WBIDs are those WBIDs that have been altered from the initial 1998 303(d) Consent Decree or previous cycle boundaries. As a result of the resegmentation process for the Group 5 Basins, there are currently 40 Consent Decree waterbody segments in the Springs Coast Basin. This number is based on Impaired Waters Rule (IWR, 62-303, F.A.C) Run 44x.

The watershed of Curlew Creek Freshwater Segment is located in the northeast region of Pinellas County that drains into Clearwater Harbor and includes parts of the cities of Clearwater and Dunedin (**Figure 1.1**). There are three tributaries to the major outfall, with the outlet of the creek flowing west into St. Joseph Sound (**Figure 1.2**). The total length of the main channel is approximately 13 miles. Additional information about the hydrology of this area is available in the *General Hydrology of the Middle Gulf Area, Florida (Report of Investigation No. 56)*, by the US Geological Survey (Cherry et al., 1970).

The area within the Curlew Creek Freshwater Segment WBID boundary is approximately 6.1 square miles (mi^2) (3,911 acres) and is almost completely developed, with land use ranging from a combination of high density commercial and residential in the upper reaches to medium to low density in the mid to lower reaches.

WBID 1538A is located in the west-central coastal region of peninsular Florida, in the area identified as the Gulf Coastal Lowlands physiographic region, where soils are poorly drained and the watertable is near land surface. Soils in this region are variable, they range from excessively drained sands to moderate or poorly drained soils with a sandy subsoil (USDA, 2006). As a result of extensive changes of the land surface for development, large portions of this area have soils types characterized as Urban Land (SWFWMD, 2002).

Two main aquifers are found in Pinellas County, the surficial aquifer and the Floridan aquifer. The surficial aquifer system consists of undifferentiated sands, shell material, silts and clayey sands of varying thickness (Causseaux, 1985). The principal uses for the surficial aquifer in Pinellas County are irrigation, limited domestic use, and dewatering projects for mining and infrastructure installation (SWFWMD, 2006). The Floridan aquifer system consists primarily of highly permeable carbonate rocks and is separated into two principal zones consisting of the fresh potable water of the Upper Floridan aquifer and the highly mineralized water of the Lower Floridan aquifer (Causseaux, 1985). In Pinellas County, the Upper Floridan aquifer is the principal source of water and is used for industrial, mining, public supply, domestic use, and irrigation purposes, as well as brackish water desalination in coastal communities (SWFWMD, 2006).

An important feature of the area is karst topography. Watersheds located in karst regions are extremely vulnerable to contamination. Many of these karst features infiltrate the water table forming a direct connection between land surface and the underlying aquifer systems, allowing interaction between surface and ground waters (SWFWMD, 2002) increasing the threat of ground water contamination from surface water pollutants (Trommer, 1987). Potential sources of contamination include saltwater encroachment and infiltration of contaminants carried in surface water, direct infiltration of contaminants (chemicals or pesticides applied to or spilled on the land, fertilizer carried in surface runoff), landfills, septic tanks, sewage-plant treatment ponds, and wells used to dispose of stormwater runoff or industrial waste (Miller, 1990).

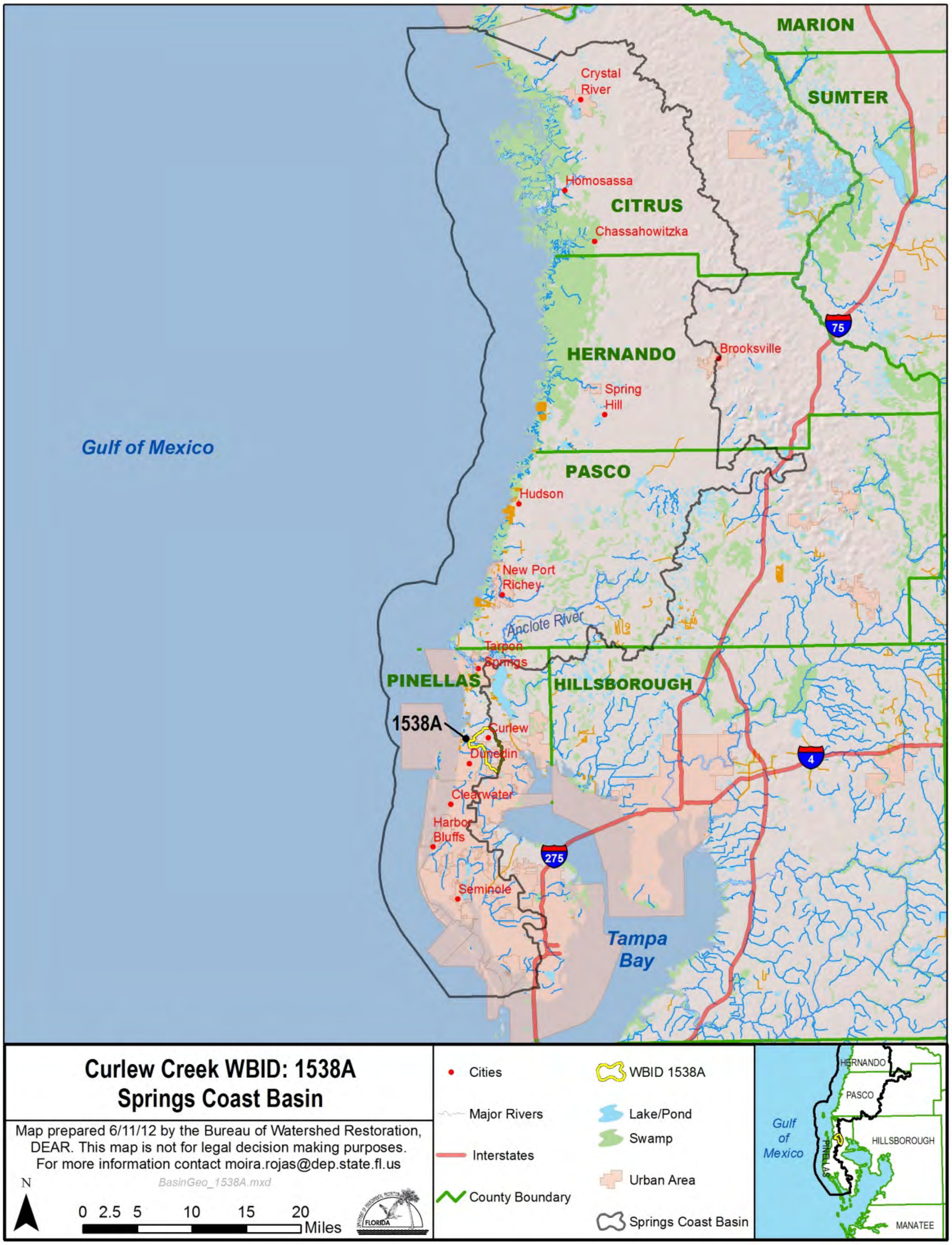

Figure 1.1. Location of the Curlew Creek Freshwater Segment (WBID 1538A) in the Springs Coast Basin and Major Hydrologic and Geopolitical Features in the Area

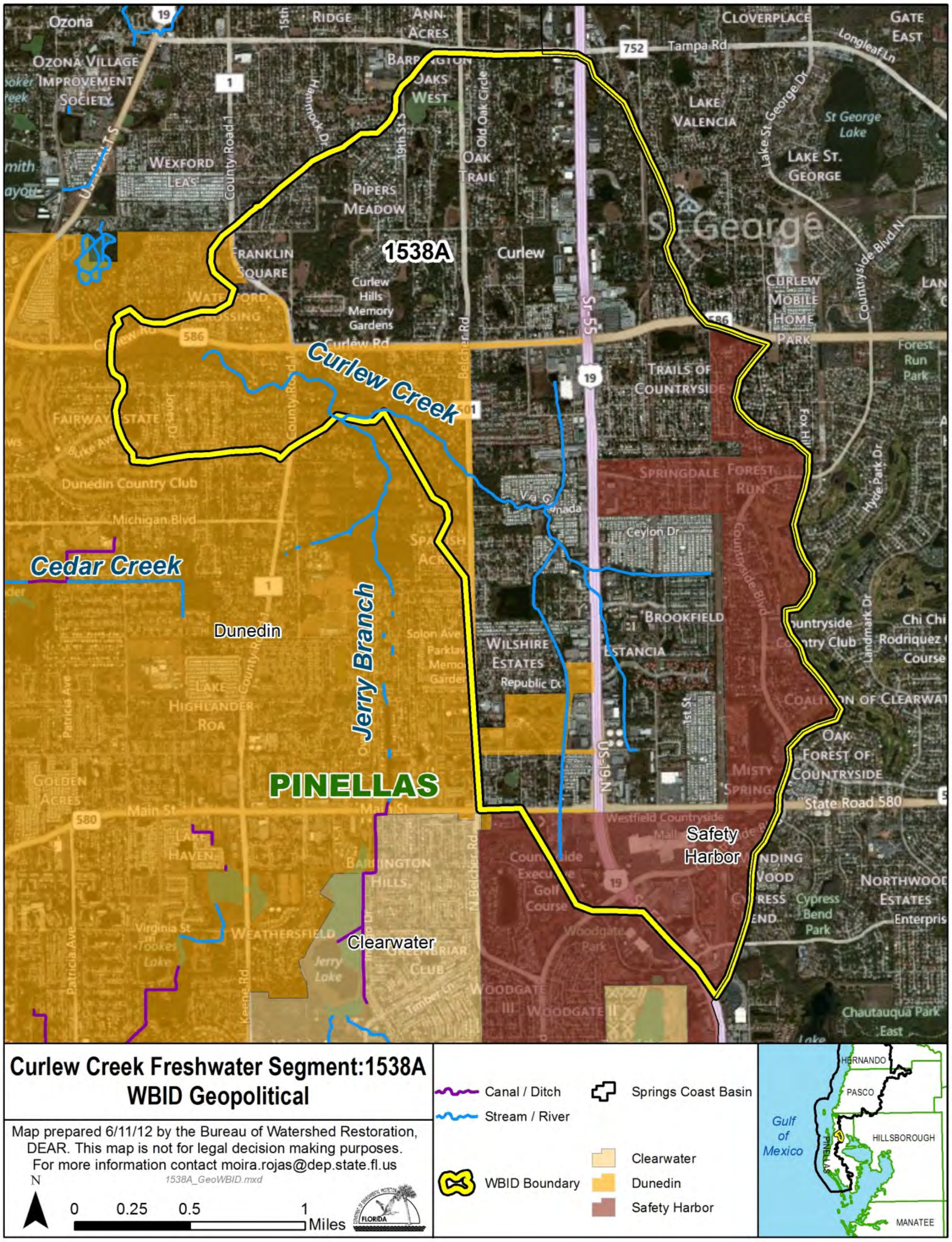

Figure 1.2. Location of the Curlew Creek Freshwater Segment (WBID 1538A) in Pinellas County

1.3 Background

This report was developed as part of the Department's 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, Section 403.067. 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. They provide important water quality restoration goals that will guide restoration activities.

This TMDL report will be followed by the development and implementation of a restoration plan designed to reduce the amount of fecal coliform that caused the verified impairment of the Curlew Creek Freshwater Segment. 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.

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 EPA lists of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing the 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 identified 22 impaired waterbodies in the Springs Coast Basin on its initial 1998 303(d) list. As a result of the resegmentation process for the Group 5 Basins, there are currently 40 Consent Decree waterbody segments in the Springs Coast Basin (see **Section 1.2**). However, the FWRA (Section 403.067, F.S.) stated that all Florida 303(d) lists created before the adoption of the FWRA 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 rulemaking process, the Environmental Regulation Commission adopted the new methodology as Rule 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001; the rule was modified in 2006 and 2007.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in the Curlew Creek Freshwater Segment and has verified that this waterbody segment is impaired for fecal coliform bacteria. Verified impairment was based on the observation that 21 out of 47 fecal coliform samples exceeded the 400 counts/100 ml criteria in the Cycle 1 verified period (January 1, 1999 through June 30, 2006) assessment. This impairment was confirmed in the Cycle 2 assessment, where 55 out of 60 fecal coliform samples collected during the verified period (January 1, 2004, through June 30, 2011), as more than 10 percent of the values exceeded the assessment threshold of 400 counts per 100 milliliters (counts/100mL) with more than a 90 percent confidence level (see **Section 3.2** for details).

Table 2.1 summarizes fecal coliform monitoring results for the Cycle 1 and Cycle 2 verified periods for the Curlew Creek Freshwater Segment. As they better represent the current conditions, only the results for the Cycle 2 verified period were used in the TMDL development process.

Table 2.1. Summary of Fecal Coliform Monitoring Data for the Curlew Creek Freshwater Segment (WBID 1538A) During the Cycle 1 Verified Period (January 1, 1999, through June 30, 2006) and Cycle 2 Verified Period (January 1, 2004 through June 30, 2011)

This is a three-column table. Column 1 lists the parameter, and Columns 2 and 3 list the Cycle 1 and Cycle 2 results, respectively.

Parameter	Fecal Coliform Cycle 1	Fecal Coliform Cycle 2
Total number of samples	47	60
IWR-required number of exceedances for the Verified List	8	10
Number of observed exceedances	21	55
Number of observed nonexceedances	26	5
Number of seasons during which samples were collected	4	4
Highest observation (counts/100mL)	-	14,000
Lowest observation (counts/100mL)	-	5
Median observation (counts/100mL)	-	1,650
Mean observation (counts/100mL)	-	2,290

Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criterion 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)**

The Curlew Creek Freshwater Segment (WBID 1538A) is a Class III (freshwater) waterbody, with a designated use of recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. The criterion applicable to this TMDL is the Class III freshwater criterion for fecal coliform.

3.2 Applicable Water Quality Standards and Numeric Water Quality Target

Numeric criteria for bacterial quality are expressed in terms of fecal coliform bacteria concentration. The water quality criterion for the protection of Class III (freshwater) waters, as established by Rule 62-302, F.A.C., states 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.

The criterion states that monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30-day period. There were insufficient data (fewer than 10 samples in a given month) available to evaluate the geometric mean criterion for fecal coliform bacteria. Therefore, the criterion selected for this TMDL was not to exceed 400 counts/100mL for fecal coliform.

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 impaired waterbody and the amount of pollutant loadings 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 System (NPDES) Program. These nonpoint sources included certain urban stormwater discharges, such as 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 within the Curlew Creek Freshwater Segment WBID Boundary

4.2.1 Point Sources

Wastewater Point Sources

There is one NPDES-permitted wastewater facility in the Curlew Creek Freshwater Segment watershed, i.e., the Mid-County Wastewater Treatment Facility (WWTP) (Permit Number FL0034789). This facility is classified as a surface water discharge in the Department's Wastewater Facility Regulation (WAFR) database, and is permitted to discharge treated effluent into Curlew Creek. The facility operates to provide advanced wastewater treatment and high-level disinfection.

The compliance of a domestic wastewater facility with a high-level disinfection for reclaimed waters, established by Rule 62-600, F.A.C, states the following:

1. *Fecal coliform samples shall be obtained as specified in Chapter 62-601, F.A.C (*Domestic Wastewater Treatment Plant Monitoring*). Over a 30-day period, 75 percent of the fecal coliform values shall be below the detection limits.*

2. *Any one sample shall not exceed 25 fecal coliform values per 100 mL of sample.*

Municipal Separate Storm Sewer System Permittees

One NPDES municipal separate storm sewer systems (MS4) permit covers WBID 1538A (permit FLS000005). **Table 4.1** lists the NPDES MS4 permit, the permit holder and co-permittees for the WBID.

Table 4.1. Municipal Separate Storm Sewer System Permittees in WBID 1538A

This is a three-column table. Column 1 lists the permit ID, Column 2 lists permit holder, and Column 3 lists the co-permittees.

Permit	Permit Holder	Co-Permittees
FLS000005	Pinellas County	City of Dunedin
		FDOT District 7
		Pinellas County
		City of Safety Harbor

4.2.2 Land Uses and Nonpoint Sources

Accurately quantifying the fecal coliform loadings from nonpoint sources requires identifying nonpoint source categories, locating the sources, determining the intensity and frequency at which these sources create high fecal coliform loadings, and specifying the relative contributions from these sources. Depending on the land use distribution in a given watershed, frequently cited nonpoint sources in urban areas include failed septic tanks, leaking sewer lines, and pet feces.

In addition to the sources associated with anthropogenic activities, birds and other wildlife can also act as fecal coliform contributors to receiving waters. While detailed source information is not always available for accurately quantifying the fecal coliform loadings from different sources, land use information can provide some hints on the potential sources of observed fecal coliform impairment.

Land Uses

The spatial distribution and acreage of different land use categories were identified using the SWFWMD's 2009 land use coverage contained in the Department's geographic information system (GIS) library. Land use categories within the Curlew Creek Freshwater Segment WBID boundary were aggregated using the Florida Land Use Code and Classification System (FLUCCS) expanded Level 1 codes (including low, medium, and high density residential) and tabulated in **Table 4.2**. **Figure 4.1** shows the spatial distribution of the principal land uses within the WBID boundary.

As shown in **Table 4.2**, the total area within the Curlew Creek Freshwater Segment WBID boundary is approximately 3,911 acres. The dominant land use categories are residential (medium- and high-density), which account for approximately 2,359 acres (60 percent), of the total WBID area. Total urban lands (urban and built-up; low-, medium-, and high-density residential; and transportation, communication, and utilities) occupy about 3,614 acres (92.4 percent) of the total WBID area.

Urban Development

Because the dominant land use categories contributing to nonpoint source pollution are urban land areas, possible sources for fecal coliform loadings can include failed septic tanks, sewer line leakages, and pet feces disposed of inappropriately. A preliminary quantification of the fecal coliform loadings from these sources was conducted to demonstrate the relative contributions. **Appendix B** provides detailed load estimates and describes the methods used for the quantification. It should be noted that the information included in **Appendix B** was only used to demonstrate the possible relative contributions from different sources.

Wildlife and Sediments

Wildlife and sediments could also contribute to fecal coliform exceedances in the watershed. Wildlife such as birds and raccoons have direct access to the waterbody and can deposit their feces directly into the water. Wildlife also deposit coliform bacteria with their feces onto land surfaces, where they can be transported during storm events to nearby streams. Studies have shown that fecal coliform bacteria can survive and reproduce in streambed sediments and can be re-suspended in surface water when conditions are right (Jamieson et al., 2005; Desmarais et al., 2002).

Current source identification methodologies cannot quantify the exact amount of fecal coliform loading from wildlife and/or sediment sources.

Table 4.2. Classification of Land Use Categories within the Curlew Creek Freshwater Segment Watershed (WBID 1538A) Boundary in 2009

This is a four-column table. Column 1 lists the Level 1 land use code, Column 2 lists the land use, Column 3 lists the acreage, and Column 4 lists the percent acreage.

Level 1 Code	Land Use	Acreage	% Acreage
1000	Urban and built-up	774	19.8%
-	Low-density residential	174	4.4%
-	Medium-density residential	643	16.4%
-	High-density residential	1,716	43.9%
2000	Agriculture	10	0.2%
3000	Rangeland	0	0%
4000	Upland forest	71	1.8%
5000	Water	91	2.3%
6000	Wetland	126	3.2%
7000	Barren land	0	0%
8000	Transportation, communication, and utilities	307	7.9%
-	**TOTAL**	**3,911**	**100%**

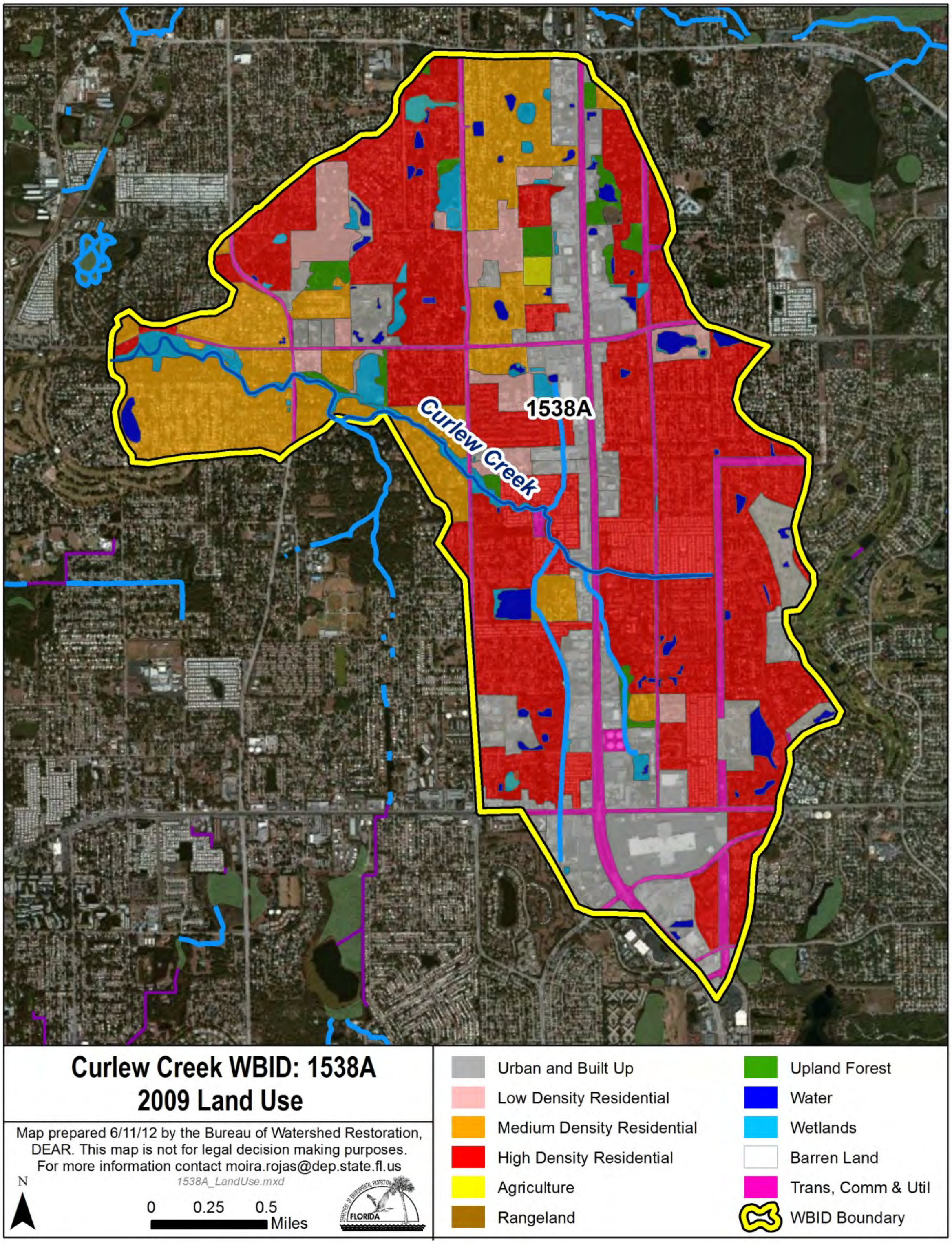

Figure 4.1. Principal Land Uses within the Curlew Creek Freshwater Segment Watershed (WBID 1538A) Boundary in 2009

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

The fecal coliform TMDL for the Curlew Creek Freshwater Segment was developed using the "percent reduction" approach. Using this method, the percent reduction needed to meet the applicable criterion is calculated based on the 90th percentile of all measured concentrations collected during the Cycle 2 verified period (January 1, 2004, through June 30, 2011). Because bacteriological counts in water are not normally distributed, a nonparametric method is more appropriate for the analysis of fecal coliform data (Hunter, 2002). The Hazen method, which uses a nonparametric formula, was used to determine the 90th percentile. The percent reduction of fecal coliform needed to meet the applicable criterion was calculated as described in **Section 5.1.2**.

5.1.1 Data Used in the Determination of the TMDL

Data used to develop this TMDL were collected primarily by the Department, the Department's Southwest District and Pinellas County Department of Environment and Infrastructure (DEMI). In addition, data collected for the City of Dunedin's Surface Water Quality Monitoring Program (Sites 4,6,7 and 9) (n=36) and data collected by the Mid-County WWTF (n=30) during the Cycle 2 verified period were also used in the development of this TMDL, as well as for the temporal, spatial and critical condition analyses. The City of Dunedin data were collected to assist in compliance with the City's MS4 permit, and the WWTF data were collected per requirements of the facility's NPDES permit. Neither of these data sets were available during the Cycle 2 assessment for Group 5 basins, and therefore were not used in verifying the fecal coliform impairment of WBID 1538A.

The Cycle 2 verified period includes data was collected from January 1, 2004, through June, 30, 2011. **Table 5.1** lists the stations where fecal coliform data were collected during this time period. **Figure 5.1** shows the locations of the water quality stations fin the Curlew Creek Freshwater Segment.

Table 5.1. Stations Where Water Quality Samples Were Collected for Fecal Coliform Data during the Cycle 2 Verified Period (January 1, 2004, through June 30, 2011)

This is a two-column table. Column 1 lists the agency collecting the data, and Column 2 lists the station ID

Agency	Station ID
FDEP	21FLGW 35420
FDEP	21FLGW 35426
FDEP	21FLGW 35435
Pinellas County DEMI	21FLPDEM10-02
FDEP Southwest District	21FLTPA 28013988244251
FDEP Southwest District	21FLTPA 28021908244378
FDEP Southwest District	21FLTPA 28025378246160
FDEP Southwest District	21FLTPA 28025718246087
City of Dunedin	Site 4
City of Dunedin	Site 6
City of Dunedin	Site 7
City of Dunedin	Site 9
Mid-County WWTF	Mid-County Upstream
Mid-County WWTF	Mid-County Downstream

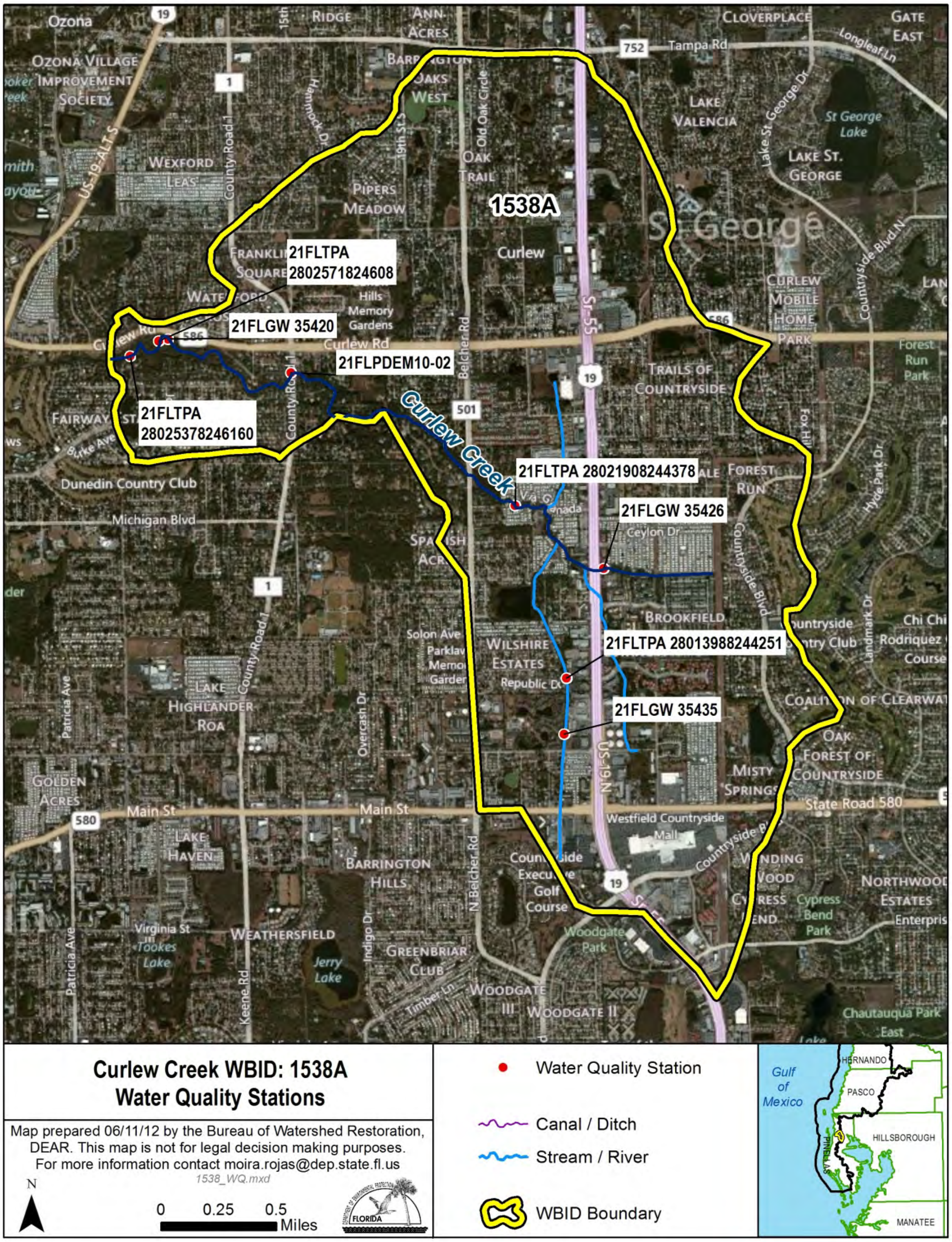

Figure 5.1. Location of Water Quality Stations with Fecal Coliform Data in Curlew Creek Freshwater Segment (WBID 1538A)

During the period of observation (January 1, 2004 through June 30, 2011), fecal coliform concentrations ranged from 1 to 42,000 counts/100mL and averaged 1,889 counts/100mL. A plot of fecal coliform data against time determined there was no significant (Prob>0.05) increasing or decreasing trend during the period of observation for this WBID.

Table 5.2 summarizes the descriptive statistics for the Cycle 2 Verified Period fecal coliform results based on IWR Run44x and the additional data provided by the City of Dunedin and the Mid-County WWTF. **Figure 5.2** shows the fecal coliform concentration trends observed in Curlew Creek Freshwater Segment during the Cycle 2 verified period.

Table 5.2. Descriptive Statistics of Fecal Coliform Data for the Curlew Creek Freshwater Segment (WBID 1538A) for Cycle 2 Verified Period (January 1, 2004 through June 30, 2011)

This is a two-column table. Column 1 lists the descriptive statistic, and Column 2 lists the result.

Descriptive Statistic	Result
Mean observation (counts/100mL)	1,889
Standard deviation	4,149
Median observation (counts/100mL)	925
Highest observation (counts/100mL)	42,000
Lowest observation (counts/100mL)	1
25% quartile	367.5
75% quartile	2,100
Number of samples	126

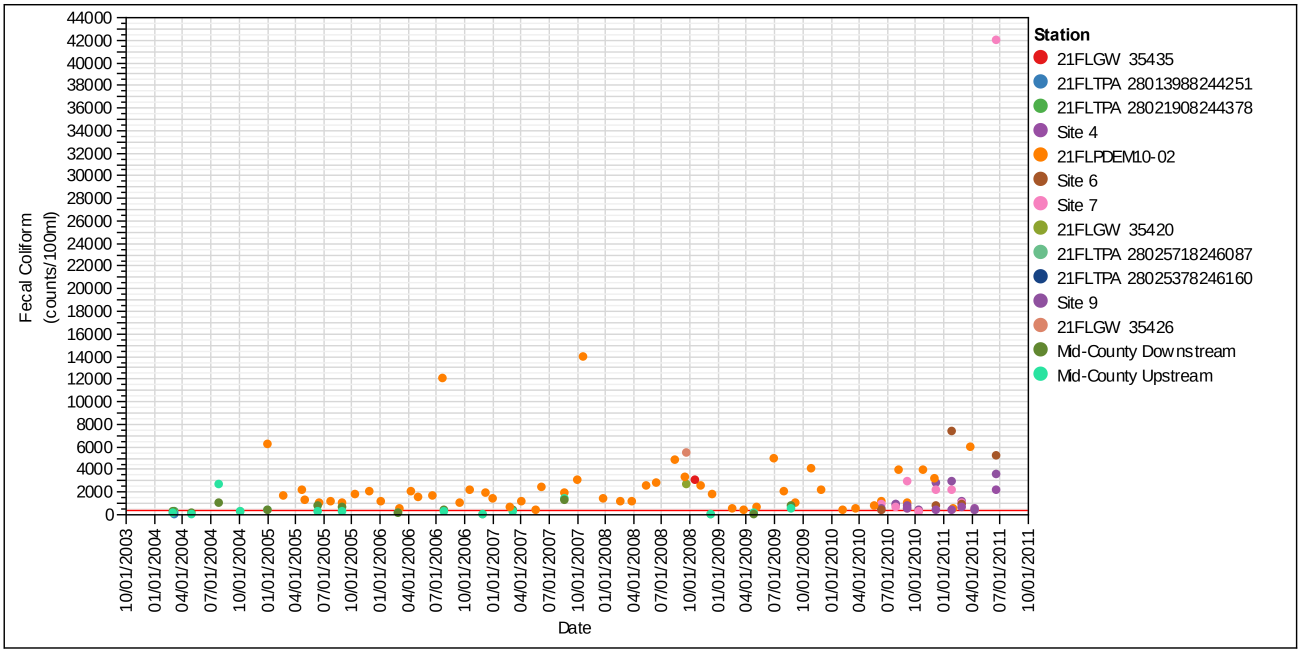

Figure 5.2. Fecal Coliform Concentration Trends in the Curlew Creek Freshwater Segment (WBID 1538A) for the Cycle 2 Verified Period (January 1, 2004 through June 30, 2011)

Note: The red line indicates the target concentration (400 counts/100mL).

Temporal Patterns

Monthly and Seasonal Trends

Seasonally, in an impaired water influenced mainly by nonpoint sources, higher fecal coliform concentrations and exceedance rates are expected to be observed during the third quarter (summer, July–September), when conditions are rainy and warm, and lower concentrations and exceedance rates in the first and fourth quarters (winter, January–March; and fall, October–December), when conditions are drier and colder.

WBID 1538A is located in an environment of humid southern temperate to subtropical climatic zones, with frosts/freezing temperatures occurring at least once a year. The average mean daily temperature is 70^{o}F, with mean summer temperatures in the low 80s and mean winter temperatures in the upper 50s. Average annual rainfall is approximately 53 inches, with two-thirds of rainfall occurring between June and September. Rainfall variability, both seasonally and from year to year, is high. The Gulf of Mexico is the prevailing factor affecting climate in this area; Gulf waters influence winter cold fronts and high summer temperatures (SWFWMD, 2002).

The highest quarterly exceedance rate was observed in the third quarter (93%). The highest quarterly average fecal coliform concentration was observed during the second quarter (2,551 counts/100mL). Episodic high fecal coliform concentrations occurred throughout the period of observation (2004-2011). Fecal coliform exceedance rates of 33% and greater were observed in every month. The highest monthly average fecal coliform concentration was observed in October (2,596 counts/100mL). **Tables 5.3a** and **5.3b** summarize the monthly and seasonal fecal coliform averages and percent exceedances, respectively, for data collected for the Cycle 2 verified period for this WBID.

Table 5.3a. Summary Statistics of Fecal Coliform Data for All Stations in the Curlew Creek Freshwater Segment (WBID 1538A) by Month during the Cycle 2 Verified Period (January 1, 2004 through June 30, 2011)

This is an eight-column table. Column 1 lists the month, Column 2 lists the number of samples, Column 3 lists the minimum coliform count/100mL, Column 4 lists the maximum count, Column 5 lists the median count, Column 6 lists the mean count, Column 7 lists the number of exceedances, and Column 8 lists the percent exceedances.

[1] Coliform counts are #/100mL.
[2] Exceedances represent values above 400 counts/100mL.

Month	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedances[2]	% Exceedances
January	9	350	7,300	1,400	2,481	7	78
February	10	68	1,700	415	547	5	50
March	15	5	6,000	460	886	9	60
April	11	1	2,100	390	645	5	45
May	6	420	2,500	1,040	1,190	6	100
June	16	200	42,000	1,400	4,372	13	81
July	10	310	12,000	925	2,080	9	90
August	10	200	4,800	1,350	1,733	9	90
September	11	460	5,500	1,000	1,817	11	100
October	13	220	14,000	1,800	2,596	8	62
November	3	1	2,500	10	837	1	33
December	12	1	3,150	1,850	1,534	9	75

Table 5.3b. Summary Statistics of Fecal Coliform Data for All Stations in the Curlew Creek Freshwater Segment (WBID 1538A) by Season during the Cycle 2 Verified Period (January 1, 2004 through June 30, 2011)

This is an eight-column table. Column 1 lists the season, Column 2 lists the number of samples, Column 3 lists the minimum coliform count/100mL, Column 4 lists the maximum count, Column 5 lists the median count, Column 6 lists the mean count, Column 7 lists the number of exceedances, and Column 8 lists the percent exceedances.

[1] Coliform counts are #/100mL.
[2] Exceedances represent values above 400 counts/100mL.

Season	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedances[2]	% Exceedances
Quarter 1	34	5	7,300	500	1208	21	63
Quarter 2	33	1	42000	870	2551	24	76
Quarter 3	31	200	12,000	1000	1875	29	93
Quarter 4	28	1	14,000	1800	1952	18	57

Using rainfall data collected at the Tampa International Airport by the CLimate Information for Management and Operational Decisions (CLIMOD) system of the Southeast Regional Climate Center (available at http://acis.sercc.com/), it was possible to compare monthly rainfall with monthly fecal coliform exceedance rates, as well as average quarterly rainfall with average quarterly fecal coliform exceedance rates at all stations.

The impact of rainfall on monthly and quarterly exceedances in WBID 1538A is inconclusive for the Cycle 2 verified period. Monthly exceedance rates do not appear to be correlated with monthly rainfall (**Figures 5.3**). Monthly exceedances were recorded both during drier and wetter months. Quarterly exceedance rates (57% and above) were also recorded in all four quarters, during drier and wetter seasons (**Figure 5.4**). The fact that higher exceedance rates occur during wet and dry seasons indicates that water quality in the watershed is negatively affected both by high rainfall, as well as local sources contributing to elevated fecal coliform concentrations.

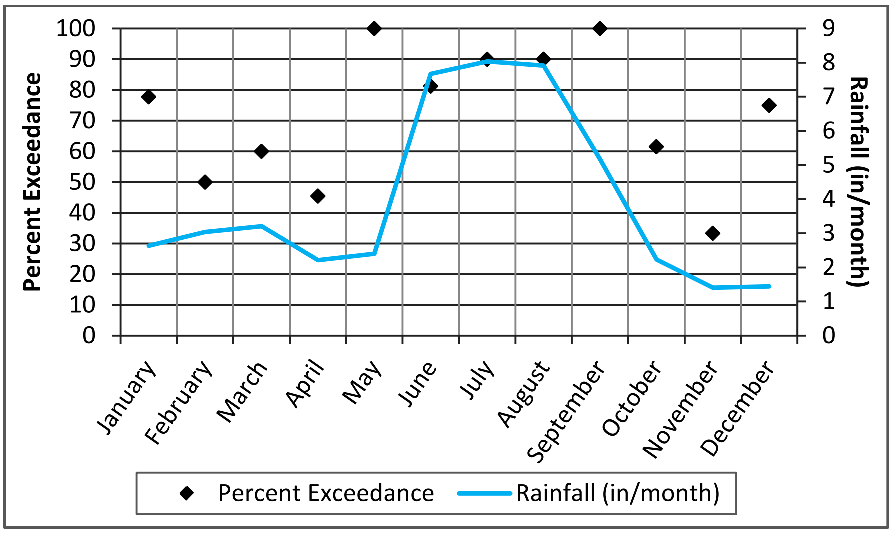

Figure 5.3. Fecal Coliform Exceedances and Rainfall at All Stations in the Curlew Creek Freshwater Segment (WBID 1538A) by Month during the Cycle 2 Verified Period (January 1, 2004 through June 30, 2011)

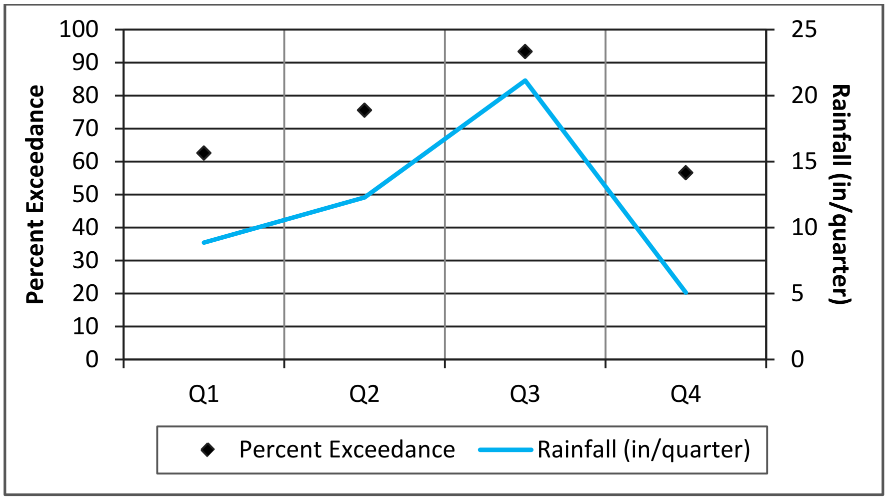

Figure 5.4. Fecal Coliform Exceedances and Rainfall at All Stations in the Curlew Creek Freshwater Segment (WBID 1538A) by Season during the Cycle 2 Verified Period (January 1, 2004 through June 30, 2011)

Period Of Record Trend

Although a plot of historical fecal coliform data against time revealed no significant (Prob > 0.05) increasing or decreasing trend for the entire period of record (1991-2011) in the Curlew Creek Freshwater Segment WBID (**Figure 5.5**), fecal coliform concentrations that exceed the criteria are frequently recorded in this WBID. Many of these samples are collected during periods of small or no rainfall, indicating that exceeding concentrations may not be a consequence of stormwater discharges, but rather local sources.

The SWFWMD has been working with Pinellas County and the City of Dunedin on stormwater improvement projects aimed at water quality and flood control. These projects, located within WBID 1538A, could improve the water quality of runoff and potentially reduce fecal coliform concentrations in the Curlew Creek channel.

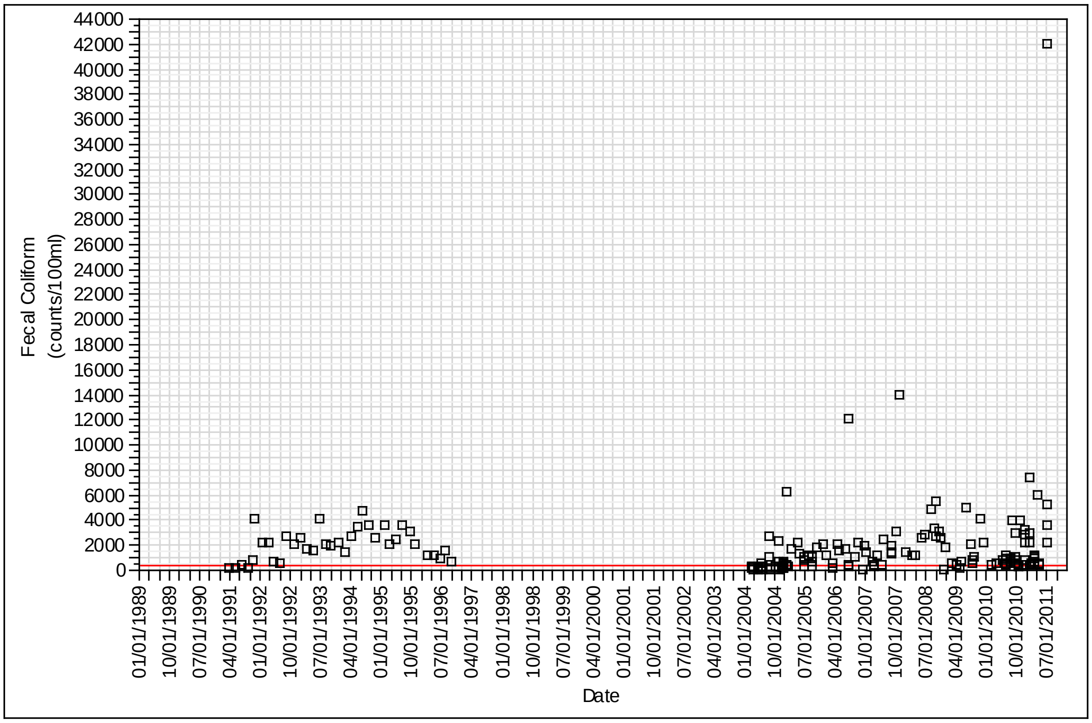

Figure 5.5. Fecal Coliform Concentration Trends at Curlew Creek Freshwater Segment (WBID 1538A) for the Entire Period of Record (1991-2011)

Note: The red line indicates the target concentration (400 counts/100mL).

Spatial Patterns

Fecal coliform data from the Cycle 2 verified period (January 1, 2004–June 30, 2011) were analyzed to detect spatial trends (**Figures 5.6**). With the exception of the WWTF stations, all other stations are displayed from upstream to downstream (left to right). **Figure 5.7** shows the spatial distribution of the principal land uses and the locations of the water quality stations within the WBID.

Fecal coliform concentrations that exceeded the State criteria where observed in ten of the fourteen sampling stations within the WBID (**Table 5.4**). The highest exceedance rates were recorded at Stations 21FLGW 35420, 21FLGW 35426 and 21FLGW 35435 (100%); however, only one sample was collected at each of these stations. Station 21FLPDEM10-02, which had the highest number of samples (n=53), had an exceedance rate of 98%. The highest fecal coliform concentration recorded in the WBID was at Site 7 (42,000 counts/100mL). Samples at ten of the fourteen stations exceeded the single sample maximum criteria of 800 counts/100mL. With the exception of Station 21FLGW 35426, all other sampling stations are located on the main channel of Curlew Creek.

Land use surrounding Stations 21FLTPA 28025378246160, Site 9, 21FLTPA 28025718246087and 21FLGW 35420 is predominantly classified as stream and lake swamps (bottomland), with some residential (medium- and high-density) areas. Land use surrounding the remaining stations in the WBID is primarily residential (low-, medium-, and high-density).

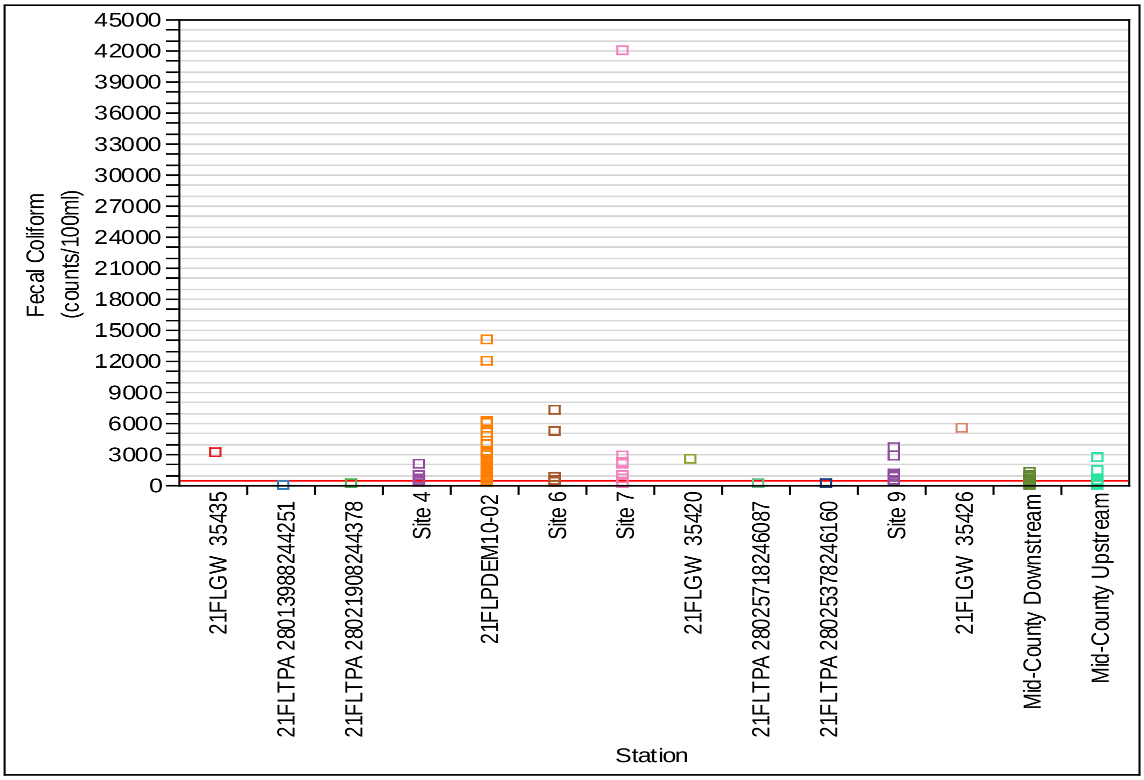

Figure 5.6. Spatial Fecal Coliform Concentration Trends in Curlew Creek Freshwater Segment (WBID 1538A) by Station during the Cycle 2 Verified Period (January 1, 2004 through June 30, 2011)

Note: The red line indicates the target concentration (400 counts/100mL).

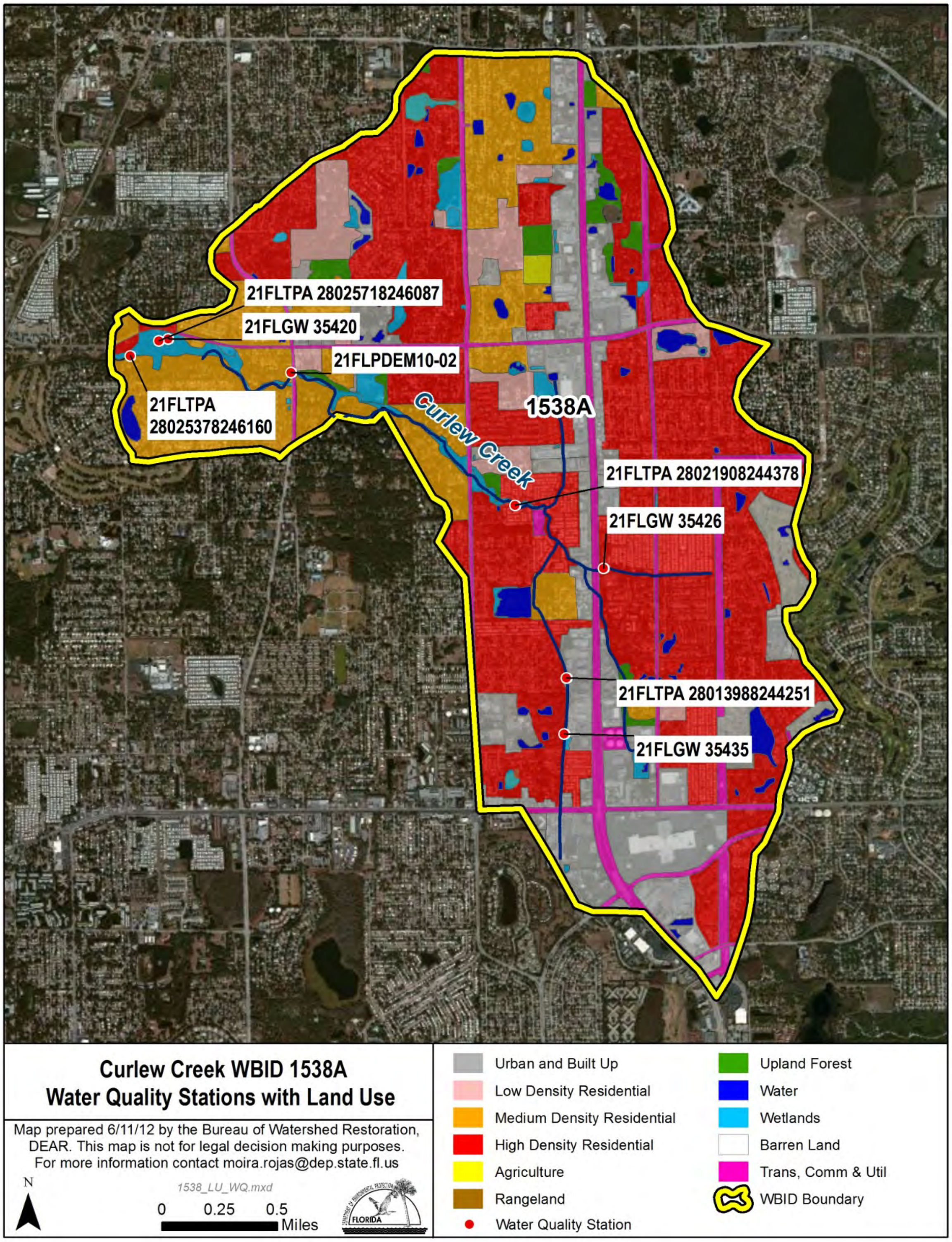

Figure 5.7. Principal Land Uses and Location of the IWR Water Quality Stations with Fecal Coliform Data in WBID 1538A

Table 5.4. Station Summary Statistics of Fecal Coliform Data for the Curlew Creek Freshwater Segment (WBID 1538A) during the Cycle 2 Verified Period (January 1, 2004 through June 30, 2011)

This is a nine-column table. Column 1 lists the station ID, Column 2 lists the period of observation for each station, Column 3 lists the number of samples, Column 4 lists the minimum count/100mL, Column 5 lists the maximum counts/100 ml, Column 6 lists the median count, Column 7 lists the mean count, Column 8 lists the number of exceedances, and Column 9 lists the percent exceedances.

[1] Coliform counts are #/100mL.
[2] Exceedances represent values above 400 counts/100mL.

Station	Period of Observation	Number of Samples	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedances[2]	% Exceedances
21FLGW 35420	2008	1	2,600	2,600	2,600	2,600	1	100
21FLGW 35426	2008	1	5,500	5,500	5,500	5,500	1	100
21FLGW 35435	2008	1	3,100	3,100	3,100	3,100	1	100
21FLPDEM10-02	2005-2011	53	330	14,000	1,700	2,369	52	98
21FLTPA 28013988244251	2004	1	5	5	5	5	0	0
21FLTPA 28021908244378	2004	1	215	215	215	215	0	0
21FLTPA 28025378246160	2004	1	215	215	215	215	0	0
21FLTPA 28025718246087	2004	1	170	170	170	170	0	0
Site 4	2010-2011	9	290	2,100	460	651	5	56
Site 6	2010-2011	9	270	7,300	730	1,827	7	78
Site 7	2010-2011	9	220	42,000	990	5,810	7	78
Site 9	2010-2011	9	370	3,600	930	1,484	8	89
Mid-County Downstream	2004-2009	15	2	1,300	320	419	6	40
Mid-County Upstream	2004-2009	15	1	2,700	200	430	4	27

5.1.2 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, the fecal coliform contribution of wildlife with direct access to the receiving water can be more noticeable by contributing to exceedances during dry weather. The critical condition for point source loading typically occurs during periods of low stream flow, when dilution is minimized.

Hydrologic conditions were analyzed using rainfall. A flow duration curve–type chart that would normally be applied to flow events was created using precipitation data from the CLIMOD

Tampa International Airport climate station. The chart was divided in the same manner as if flow were being analyzed, where extremely large precipitation events represent the upper percentiles (0–5th percentile), followed by large precipitation events (5th–10th percentile), medium precipitation events (10th–40th percentile), small precipitation events (40th–60th percentile), and not recordable precipitation events (60th–100th percentile). Event precipitation ranges were derived based on these percentiles. Extreme events for WBID 1538A were determined as those with rainfall greater than 1.82 inches, large events between 1.22 and 1.82 inches, medium events between 0.10 and 1.22 inches, small events between 0.01 and 0.10 inches, and non-measurable events less than 0.01 inch. Three-day (the day of and 2 days prior to sampling) precipitation accumulations were used in the analysis (**Table 5.5** and **Figure 5.8**).

Historical data show that fecal coliform exceedances (62% and greater) occurred over all hydrologic conditions. The highest percentage of exceedances occurred after periods of extreme precipitation (100%) and the lowest percentage of exceedances occurred after periods of no measurable precipitation (62%).

Given that high exceedance rates and high concentrations followed all of the sampled precipitation events, and that there are no point source dischargers within the WBID boundary other than a permitted point source (e.g., a WWTF), it can be assumed that various nonpoint sources are a major contributing factor to high fecal coliform concentrations within the Curlew Creek Freshwater Segment WBID boundary. While the lowest percentage of exceedances occurred after periods of no or little rainfall, the exceedance rate should not be considered insignificant and this might be an indication that local sources are contributing to elevated fecal coliform concentrations. **Table 5.5** and **Figure 5.8** show fecal coliform data by hydrologic condition.

As fecal coliform exceedances occurred in all the of the precipitation intervals the target fecal coliform reduction calculated in the following section and shown in **Table 5.6** is applicable under all rainfall conditions in the Curlew Creek Freshwater Segment watershed.

Table 5.5. Summary of Fecal Coliform Data for Cycle 2 Verified Period (January 1, 2004 through June 30, 2011) by Hydrologic Condition for the Curlew Creek Freshwater Segment (WBID 1538A)

This is a seven-column table. Column 1 lists the type of precipitation event, Column 2 lists the event range (in inches), Colum 3 lists the total number of samples, Column 4 lists the number of exceedances, Column 5 lists the percent exceedances, Column 6 lists the number of nonexceedances, and Column 7 lists the percent nonexceedances.

Precipitation Event	Event Range (in/3-Day)	Total Samples	Number of Exceedances	% Exceedances	Number of Non-exceedances	% Non-exceedances
Extreme	>1.82"	3	3	100%	0	0%
Large	1.22" - 1.82"	7	6	86%	1	14%
Medium	0.1" - 1.22"	40	34	85%	6	15%
Small	0.01" - 0.1"	15	11	73%	4	27%
None/ Not Measurable	<0.01"	61	38	62%	23	38%

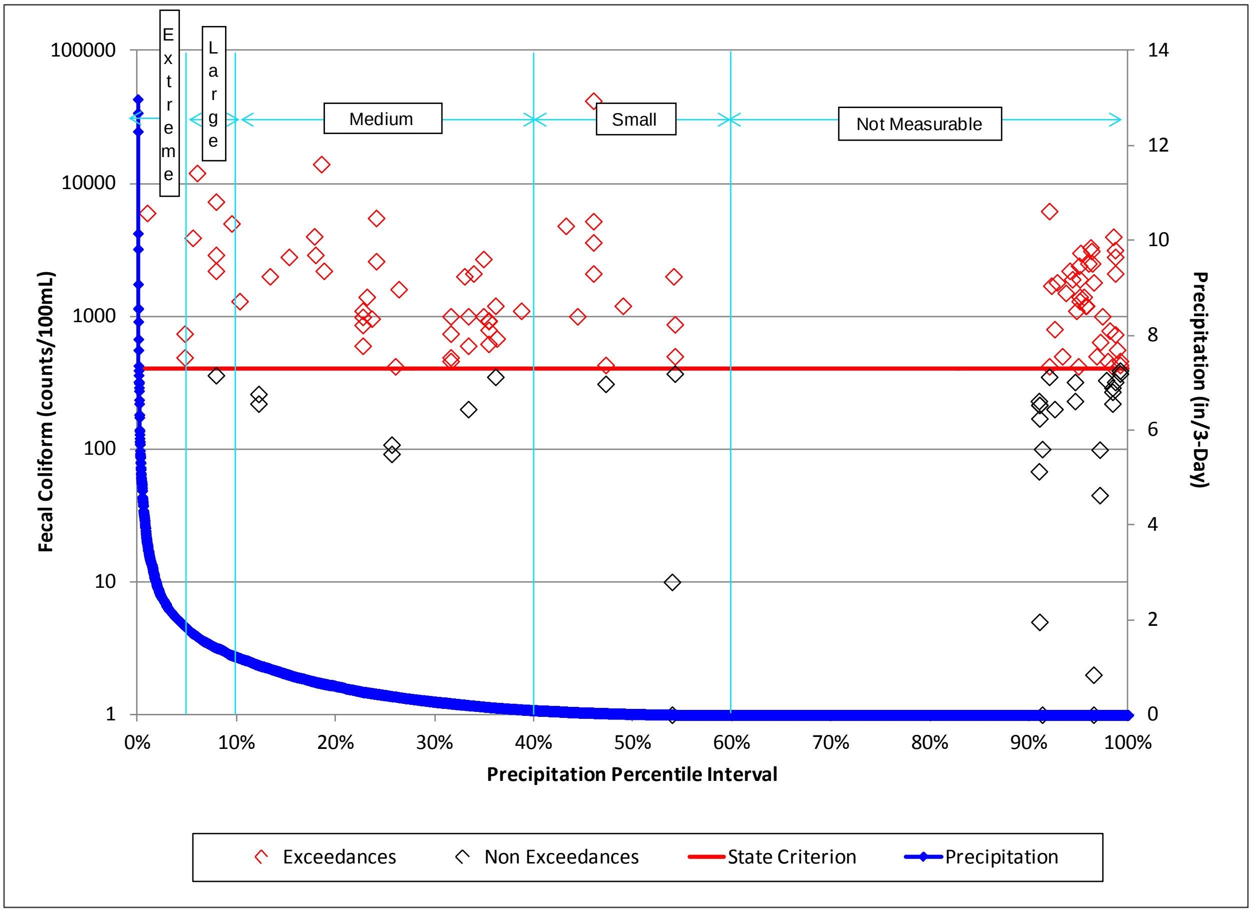

Figure 5.8. Fecal Coliform Data for Cycle 2 Verified Period (January 1, 2004 through June 30, 2011) by Hydrologic Condition for the Curlew Creek Freshwater Segment (WBID 1538A)

5.1.3 TMDL Development Process

A simple reduction calculation was performed to determine the reduction in fecal coliform concentration necessary to achieve the concentration target (400 counts/100mL). The percent reduction needed to reduce the pollutant load was calculated by comparing the existing concentrations and target concentration using **Formula 1**:

$$\text{Needed \% Reduction} = \frac{\text{Existing } 90^{th} \text{ Percentile Concentration} - \text{Allowable Concentration}}{\text{Existing } 90^{th} \text{ Percentile Concentration}} \times 100 \qquad \textbf{Formula 1}$$

Using the Hazen method for estimating percentiles, as described in Hunter (2002), the existing condition concentration was defined as the 90th percentile of all the fecal coliform data collected during the Cycle 2 verified period (January 1, 2004, to June 30, 2011). The 90th percentile is also called the 10 percent exceedance event. This will result in a target condition that is consistent with the state bacteriological water quality assessment threshold for Class III waters.

In applying this method, all of the available data are ranked (ordered) from the lowest to the highest (**Table 5.5**), and **Formula 2** is used to determine the percentile value of each data point.

$$\text{Percentile} = \frac{\text{Rank} - 0.5}{\text{Total Number of Samples Collected}}$$ **Formula 2**

If none of the ranked values is shown to be the 90^{th} percentile value, then the 90^{th} percentile number (used to represent the existing condition concentration) is calculated by interpolating between the two data points adjacent (above and below) to the desired 90^{th} percentile rank using **Formula 3,** as described below.

$$90^{\text{th}} \text{ Percentile Concentration} = C_{\text{lower}} + (P_{90\text{th}} * R)$$ **Formula 3**

Where:

- *C_{lower} is the fecal coliform concentration corresponding to the percentile lower than the 90^{th} percentile*
- *P_{90th} is the percentile difference between the 90^{th} percentile and the percentile number immediately lower than the 90^{th} percentile*
- *R is a ratio defined as R = (fecal coliform concentration $_{upper}$ – fecal coliform concentration $_{lower)}$ / (percentile $_{upper}$ – percentile $_{lower}$).*

To calculate *R*, the percentile values below and above the 90th percentile are identified. Next, the fecal coliform concentrations corresponding to the lower and upper percentile values are identified. The fecal coliform concentration difference between the lower and higher percentiles is then calculated and divided by the unit percentile. The unit percentile difference is the difference between the lower and upper percentiles. R is then calculated as (fecal coliform concentration $_{upper}$ – fecal coliform concentration $_{lower}$)/(percentile $_{upper}$ – percentile $_{lower}$) = R.

The C_{lower}, P_{90th}, and *R,* are substituted into **Formula 3** to calculate the 90^{th} percentile fecal coliform concentration.

Using **Formula 1**, the percent reduction for the period of observation (January 1, 2004, to June 30, 2011) was calculated as 92 percent for the Curlew Creek Freshwater Segment (i.e., % reduction needed = [(3,900 –400) / 3,900]*100 = 90%).

Table 5.6 shows the individual fecal coliform data, the ranks, the percentiles for each individual data, the existing 90^{th} percentile concentration, the allowable concentration (400 counts/100mL), and the percent reduction needed to meet the applicable water quality criterion for fecal coliform.

Table 5.6. Calculation of Fecal Coliform Reductions for the Curlew Creek Freshwater Segment (WBID 1538A) TMDL Based on the Hazen Method

This is a five-column table. Column 1 lists the date, Column 2 lists the sampling station, Column 3 lists the fecal coliform exceedance concentration (counts/100mL), Column 4 lists the target concentration (counts/100mL), and Column 5 lists the percent reduction.

\- = Empty cell/no data

Station	Date	Fecal Coliform Concentration (MPN/100mL)	Rank	Percentile by Hazen Method
Mid-County Upstream	4/30/2004	1	1	0%
Mid-County Upstream	11/30/2006	1	2	1%
Mid-County Upstream	12/9/2008	1	3	2%
Mid-County Downstream	12/9/2008	2	4	3%
21FLTPA 28013988244251	3/8/2004	5	5	4%
Mid-County Downstream	11/30/2006	10	6	4%
Mid-County Downstream	4/27/2009	45	7	5%
Mid-County Upstream	2/29/2004	68	8	6%
Mid-County Downstream	2/28/2006	92	9	7%
Mid-County Upstream	4/27/2009	99	10	8%
Mid-County Downstream	4/30/2004	100	11	8%
Mid-County Upstream	2/28/2006	108	12	9%
21FLTPA 28025718246087	3/8/2004	170	13	10%
Mid-County Upstream	6/15/2005	200	14	11%
Mid-County Upstream	8/31/2005	200	15	12%
21FLTPA 28021908244378	3/8/2004	215	16	12%
21FLTPA 28025378246160	3/8/2004	215	17	13%
Mid-County Upstream	10/5/2004	220	18	14%
Site 7	10/12/2010	220	19	15%
Mid-County Downstream	2/29/2004	230	20	15%
Mid-County Upstream	3/9/2007	230	21	16%
Mid-County Downstream	10/5/2004	260	22	17%
Site 6	10/12/2010	270	23	18%
Site 4	10/12/2010	290	24	19%
Mid-County Upstream	7/26/2006	310	25	19%
Mid-County Downstream	3/9/2007	320	26	20%
Site 4	12/8/2010	320	27	21%
21FLPDEM10-02	2/8/2010	330	28	22%
Mid-County Downstream	1/4/2005	350	29	23%
Site 4	6/16/2010	350	30	23%
Site 4	1/26/2011	360	31	24%
Site 6	6/15/2010	370	32	25%

Station	Date	Fecal Coliform Concentration (MPN/100mL)	Rank	Percentile by Hazen Method
Site 9	4/12/2011	370	33	26%
Site 7	4/12/2011	390	34	27%
Mid-County Upstream	1/4/2005	420	35	27%
21FLPDEM10-02	5/21/2007	420	36	28%
21FLPDEM10-02	3/23/2009	420	37	29%
Site 9	10/12/2010	420	38	30%
Mid-County Downstream	7/26/2006	430	39	31%
Site 6	4/12/2011	430	40	31%
21FLPDEM10-02	3/24/2010	460	41	32%
Site 4	9/7/2010	460	42	33%
Site 4	4/12/2011	460	43	34%
Mid-County Upstream	8/26/2009	490	44	35%
Site 6	9/7/2010	490	45	35%
21FLPDEM10-02	3/6/2006	500	46	36%
21FLPDEM10-02	2/17/2009	500	47	37%
Site 9	6/15/2010	500	48	38%
21FLPDEM10-02	2/1/2011	560	49	38%
Mid-County Downstream	8/31/2005	600	50	39%
Site 4	3/3/2011	600	51	40%
Site 7	7/29/2010	620	52	41%
21FLPDEM10-02	5/5/2009	640	53	42%
21FLPDEM10-02	2/28/2007	680	54	42%
Site 6	12/8/2010	730	55	43%
Mid-County Downstream	8/26/2009	740	56	44%
Site 9	9/7/2010	740	57	45%
21FLPDEM10-02	5/20/2010	780	58	46%
Site 6	7/30/2010	790	59	46%
Mid-County Downstream	6/15/2005	800	60	47%
Site 6	3/3/2011	860	61	48%
Site 7	6/15/2010	870	62	49%
Site 4	7/30/2010	920	63	50%
Site 9	7/29/2010	930	64	50%
21FLPDEM10-02	6/20/2005	960	65	51%
Site 7	3/3/2011	990	66	52%
Mid-County Downstream	7/31/2004	1,000	67	53%
21FLPDEM10-02	9/1/2005	1,000	68	54%
21FLPDEM10-02	9/18/2006	1,000	69	54%
21FLPDEM10-02	9/10/2009	1,000	70	55%
21FLPDEM10-02	9/7/2010	1,000	71	56%

Station	Date	Fecal Coliform Concentration (MPN/100mL)	Rank	Percentile by Hazen Method
21FLPDEM10-02	7/27/2005	1,100	72	57%
21FLPDEM10-02	4/3/2007	1,100	73	58%
Site 9	3/3/2011	1,100	74	58%
21FLPDEM10-02	1/4/2006	1,200	75	59%
21FLPDEM10-02	2/21/2008	1,200	76	60%
21FLPDEM10-02	3/26/2008	1,200	77	61%
21FLPDEM10-02	6/16/2010	1,200	78	62%
21FLPDEM10-02	5/2/2005	1,300	79	62%
Mid-County Downstream	8/22/2007	1,300	80	63%
21FLPDEM10-02	1/3/2007	1,400	81	64%
Mid-County Upstream	8/22/2007	1,400	82	65%
21FLPDEM10-02	12/27/2007	1,400	83	65%
21FLPDEM10-02	5/4/2006	1,500	84	66%
21FLPDEM10-02	6/20/2006	1,600	85	67%
21FLPDEM10-02	2/22/2005	1,700	86	68%
21FLPDEM10-02	10/12/2005	1,800	87	69%
21FLPDEM10-02	12/15/2008	1,800	88	69%
21FLPDEM10-02	12/12/2006	1,900	89	70%
21FLPDEM10-02	8/22/2007	1,900	90	71%
21FLPDEM10-02	12/1/2005	2,000	91	72%
21FLPDEM10-02	4/11/2006	2,000	92	73%
21FLPDEM10-02	8/3/2009	2,000	93	73%
21FLPDEM10-02	4/25/2005	2,100	94	74%
Site 7	12/8/2010	2,100	95	75%
Site 4	6/23/2011	2,100	96	76%
21FLPDEM10-02	10/19/2006	2,200	97	77%
21FLPDEM10-02	12/2/2009	2,200	98	77%
Site 7	1/26/2011	2,200	99	78%
21FLPDEM10-02	6/11/2007	2,400	100	79%
21FLPDEM10-02	5/14/2008	2,500	101	80%
21FLPDEM10-02	11/5/2008	2,500	102	81%
21FLGW 35420	9/22/2008	2,600	103	81%
Mid-County Upstream	7/31/2004	2,700	104	82%
21FLPDEM10-02	6/17/2008	2,800	105	83%
Site 9	12/8/2010	2,800	106	84%
Site 7	9/8/2010	2,900	107	85%
Site 9	1/26/2011	2,900	108	85%
21FLPDEM10-02	10/1/2007	3,000	109	86%
21FLGW 35435	10/16/2008	3,100	110	87%

Station	Date	Fecal Coliform Concentration (MPN/100mL)	Rank	Percentile by Hazen Method
21FLPDEM10-02	12/2/2010	3,150	111	88%
21FLPDEM10-02	9/16/2008	3,300	112	88%
Site 9	6/23/2011	3,600	113	89%
21FLPDEM10-02	**8/10/2010**	**3,900**	**114**	**90%**
21FLPDEM10-02	10/26/2010	3,973	115	91%
21FLPDEM10-02	10/28/2009	4,000	116	92%
21FLPDEM10-02	8/12/2008	4,800	117	92%
21FLPDEM10-02	6/30/2009	5,000	118	93%
Site 6	6/23/2011	5,200	119	94%
21FLGW 35426	9/22/2008	5,500	120	95%
21FLPDEM10-02	3/29/2011	6,000	121	96%
21FLPDEM10-02	1/4/2005	6,200	122	96%
Site 6	1/26/2011	7,300	123	97%
21FLPDEM10-02	7/24/2006	12,000	124	98%
21FLPDEM10-02	10/23/2007	14,000	125	99%
Site 7	6/23/2011	42,000	126	100%
-	-	-	Existing condition concentration–90th percentile (counts/100mL)	3,900
-	-	-	Allowable concentration (counts/100mL)	400
-	-	-	Final percent reduction	90

Note: Boldface type indicates concentration used in percent reduction calculations

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 (wasteload 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 best management practices (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. The TMDL for the Curlew Creek Freshwater Segment is expressed as a percent reduction, and represents the maximum daily fecal coliform load the stream can assimilate without exceeding the fecal coliform criterion (**Table 6.1**).

6.2 Load Allocation

Based on a percent reduction approach, the LA is a 90 percent reduction in fecal coliform 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

6.3.1 NPDES Wastewater Discharges

There is one NPDES-permitted wastewater facility within the WBID 1538A boundary, Mid-County WWTP (Permit Number FL0034789) that could potentially contribute coliform discharges to Curlew Creek. This facility must comply with its permitted limits.

It should be noted that the state requires all NPDES-permitted wastewater point source dischargers to meet bacteria criteria at the end of the pipe. It is the Department's current practice not to allow mixing zones for bacteria. Any future point sources that may discharge in the WBID in the future will also be required to meet end-of-pipe standards for coliform bacteria.

6.3.2 NPDES Stormwater Discharges

The WLA for stormwater discharges with an MS4 permit is a 92 percent reduction in current fecal coliform loading for WBID 1538A. It should be noted that any MS4 permittee is only responsible for reducing the anthropogenic 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

Consistent with the recommendations of the Allocation Technical Advisory Committee (Department, 2001), an implicit MOS was used in the development of this TMDL by not subtracting contributions from natural sources and sediments when the percent reduction was calculated. This makes the estimation of human contribution more stringent and therefore adds to the MOS.

Table 6.1. TMDL Components for Fecal Coliform in the Curlew Creek Freshwater Segment (WBID 1538A)

This is a six-column table. Column 1 lists the impaired parameter, Column 2 lists the TMDL (counts/100mL), Column 3 lists the WLA for wastewater (counts/100mL), Column 4 lists the WLA for NPDES stormwater (percent reduction), Column 5 lists the LA (percent reduction), and Column 6 lists the MOS.

Parameter	TMDL (counts/100mL)	WLA for Wastewater (counts/100mL)	WLA for NPDES Stormwater (% reduction)	LA (% reduction)	MOS
Fecal coliform	400	Must Meet Permit Conditions	90	90	Implicit

Chapter 7: TMDL IMPLEMENTATION

7.1 Basin Management Action Plan

Following the adoption of this TMDL by rule, the Department will determine the best course of action regarding its implementation. Depending on the pollutant(s) causing the waterbody impairment and the significance of the waterbody, the Department will select the best course of action leading to the development of a plan to restore the waterbody. Often this will be accomplished cooperatively with stakeholders by creating a Basin Management Action Plan, referred to as the BMAP. BMAPs are the primary mechanism through which TMDLs are implemented in Florida (see Subsection 403.067[7], F.S.). A single BMAP may provide the conceptual plan for the restoration of one or many impaired waterbodies.

If the Department determines that a BMAP is needed to support the implementation of this TMDL, a BMAP will be developed through a transparent, stakeholder-driven process intended to result in a plan that is cost-effective, technically feasible, and meets the restoration needs of the applicable waterbodies. Once adopted by order of the Department Secretary, BMAPs are enforceable through wastewater and municipal stormwater permits for point sources and through BMP implementation for nonpoint sources. Among other components, BMAPs typically include the following:

- *Water quality goals (based directly on the TMDL);*
- *Refined source identification;*
- *Load reduction requirements for stakeholders (quantitative detailed allocations, if technically feasible);*
- *A description of the load reduction activities to be undertaken, including structural projects, nonstructural BMPs, and public education and outreach;*
- *A description of further research, data collection, or source identification needed in order to achieve the TMDL;*
- *Timetables for implementation;*
- *Implementation funding mechanisms;*
- *An evaluation of future increases in pollutant loading due to population growth;*
- *Implementation milestones, project tracking, water quality monitoring, and adaptive management procedures; and*
- *Stakeholder statements of commitment (typically a local government resolution).*

BMAPs are updated through annual meetings and may be officially revised every five years. Completed BMAPs in the state have improved communication and cooperation among local stakeholders and state agencies; improved internal communication within local governments; applied high-quality science and local information in managing water resources; clarified the obligations of wastewater point source, MS4, and non-MS4 stakeholders in TMDL implementation; enhanced transparency in the Department's decision making; and built strong relationships between the Department and local stakeholders that have benefited other program areas.

7.2 Other TMDL Implementation Tools

However, in some basins, and for some parameters, particularly those with fecal coliform impairments, the development of a BMAP using the process described above will not be the most efficient way to restore a waterbody, such that it meets its designated uses. This is because fecal coliform impairments result from the cumulative effects of a multitude of potential sources, both natural and anthropogenic. Addressing these problems requires good old-fashioned detective work that is best done by those in the area.

Many assessment tools are available to assist local governments and interested stakeholders in this detective work. The tools range from the simple (such as Walk the WBIDs and GIS mapping) to the complex (such as bacteria source tracking). Department staff will provide technical assistance, guidance, and oversight of local efforts to identify and minimize fecal coliform sources of pollution. Based on work in the Lower St Johns River Tributaries and Hillsborough Basins, the Department and local stakeholders have developed a logical process and tools to serve as a foundation for this detective work.

In the near future, the Department will be releasing these tools to assist local stakeholders with the development of local implementation plans to address fecal coliform impairments. In such cases, the Department will rely on these local initiatives as a more cost-effective and simplified approach to identify the actions needed to put in place a road map for restoration activities, while still meeting the requirements of Subsection 403.067(7), F.S.

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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 Rule 62-40, F.A.C. In 1994, the Department's stormwater treatment requirements were integrated with the stormwater flood control requirements of the water management districts, along with wetland protection requirements, into the Environmental Resource Permit regulations.

Rule 62-40, F.A.C., also requires the state's water management districts to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a Surface Water Improvement and Management (SWIM) plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, they have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka.

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 permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementing the Phase I NPDES Stormwater Program in 1990. 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 the 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 implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 urban water control districts, and the Florida Department of Transportation throughout the 15 counties meeting the population criteria. The Department received authorization to implement the NPDES Stormwater Program in 2000.

An important difference between the federal NPDES and the state's stormwater/environmental resource permitting programs is that the NPDES Program covers both new and existing discharges, while the state's program focus on new discharges only. Additionally, Phase II of the NPDES Program, implemented in 2003, expands the need for these permits to construction sites between 1 and 5 acres, and to local governments with as few as 1,000 people. 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, as are other point sources of pollution such as domestic and industrial wastewater discharges. It should be noted that all MS4 permits issued in Florida include a reopener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.

Appendix B: Estimates of Fecal Coliform Loadings from Potential Sources

The Department provides these estimates for informational purposes only and did not use them to calculate the TMDL. These estimates are intended to give the public a general idea of the relative importance of each source in the waterbody. The estimates were based on the best information available to the Department when the calculation was made. The numbers provided do not represent the actual loadings from the sources.

Pets

Pets (especially dogs) could be a significant source of coliform pollution through surface runoff within the Curlew Creek Freshwater Segment WBID boundary. Studies report that up to 95 percent of the fecal coliform found in urban stormwater can have nonhuman origins (Alderiso et al., 1996; Trial et al., 1993).

The most important nonhuman fecal coliform contributors appear to be dogs and cats. In a highly urbanized Baltimore catchment, Lim and Olivieri (1982) found that dog feces were the single greatest source of fecal coliform and fecal strep bacteria. Trial et al. (1993) also reported that cats and dogs were the primary source of fecal coliform in urban subwatersheds. Using bacteria source tracking techniques, it was found in Stevenson Creek in Clearwater, Florida, that the amount of fecal coliform bacteria contributed by dogs was as important as that from septic tanks (Watson, 2002).

According to the American Pet Products Manufacturers Association (APPMA), about 4 out of 10 U.S. households include at least 1 dog. A single gram of dog feces contains about 2.2 million fecal coliform bacteria (van der Wel, 1995). Unfortunately, statistics show that about 40 percent of American dog owners do not pick up their dogs' feces. The number of dogs within the Curlew Creek Freshwater Segment WBID boundary is unknown. Therefore, the statistics produced by APPMA were used in this analysis to estimate the possible fecal coliform loads contributed by dogs.

Using information from the Florida Department of Revenue's (DOR) 2010 Cadastral tax parcel and ownership coverage contained in the Department's geographic information system (GIS) library, residential parcels were identified using DOR's land use codes. The number of households within the Curlew Creek Freshwater Segment WBID boundary was estimated to be approximately 9,581. Assuming that 40 percent of the households in this area have 1 dog, there are about 3,832 dogs within the WBID.

Assuming that 40 percent of dog owners do not pick up their dogs' feces, the total waste produced by dogs and left on the land surface in residential areas in the WBID is approximately 689,832 grams/day. The total load produced by dogs is about 1.52 x 10^{12} counts/day of fecal coliform.

It should be noted that this load only represents the fecal coliform load created in the WBID and is not intended to be used to represent a part of the existing load that reaches the receiving waterbody. The fecal coliform load that eventually reaches the receiving waterbody could be significantly less than this value due to attenuation in overland transport. **Table B.1** shows the waste production rate for a dog (450 grams/animal/day) and the fecal coliform counts per gram of dog waste (2,200,000 counts/gram).

Table B.1. Dog Population Density, Wasteload and Fecal Coliform Density Based on the Literature (Weiskel et al., 1996)

This is a four-column table. Column 1 lists the animal type (dog), Column 2 lists the population density, Column 3 lists per dog wasteload, and Column 4 lists the fecal coliform density.

- = Empty cell/no data
* Number from APPMA

Animal Type	Population Density (animals/household)	Wasteload (grams/ animal-day)	Fecal Coliform Density (counts/gram)
Dog	0.4*	450	2,200,000

Septic Tanks

Septic tanks are another potentially important source of coliform pollution in urban watersheds. When properly installed, most of the coliform from septic tanks should be removed within 50 meters of the drainage field (Minnesota Pollution Control Agency, 1999). However, the physical properties of an aquifer, such as thickness, sediment type (sand, silt, and clay), and location play a large part in determining whether contaminants from the land surface will reach the ground water (USGS, 2010). The risk of contamination is greater for unconfined (water-table) aquifers than for confined aquifers because they usually are nearer to land surface and lack an overlying confining layer to impede the movement of contaminants (USGS, 2010).

Sediment type (sand, silt, and clay) also determines the risk of contamination in a particular watershed. "Porosity, which is the proportion of a volume of rock or soil that consists of open spaces, tells us how much water rock or soil can retain. Permeability is a measure of how easily water can travel through porous soil or bedrock. Soil and loose sediments, such as sand and gravel, are porous and permeable. They can hold a lot of water, and it flows easily through them. Although clay and shale are porous and can hold a lot of water, the pores in these fine-grained materials are so small that water flows very slowly through them. Clay has a low permeability (USGS, 2010)."

Also, the risk of contamination is increased for areas with a relatively high ground water table. The drain field can be flooded during the rainy season, resulting in ponding and coliform bacteria can pollute the surface water through stormwater runoff. Additionally, in these circumstances, a high water table can result in coliform bacteria pollution reaching the receiving waters through baseflow.

Septic tanks may also cause coliform pollution when they are built too close to irrigation wells. Any well that is installed in the surficial aquifer system will cause a drawdown. If the septic tank system is built too close to the well (e.g., less than 75 feet), the septic tank discharge will be within the cone of influence of the well. As a result, septic tank effluent may enter the well, and once the polluted water is used to irrigate lawns, coliform bacteria may reach the land surface and wash into surface waters through stormwater runoff.

A rough estimate of fecal coliform loads from failed septic tanks within the WBID boundaries can be made using **Equation B.1**:

L = 37.85* N * Q * C * F **Equation B.1**

Where:

L is the fecal coliform daily load (counts/day);
N is the number of households using septic tanks in the WBID;
Q is the discharge rate for each septic tank (gallons/day);
C is the fecal coliform concentration for the septic tank discharge (counts/100mL);
F is the septic tank failure rate; and
37.85 is a conversion factor (100mL/gallon).

Based on the estimated total number of households within each WBID (9,581) and Onsite Sewage Treatment Disposal Systems (OSTDS) data obtained from FDOH (available: http://www.doh.state.fl.us/environment/programs/ehgis/EhGisDownload.htm), the number of housing units *(N)* within each WBID boundary thought to be using septic tanks to treat their domestic wastewater was estimated to be 104 (**Table B.2**) (**Figure B.1**).

The discharge rate from each septic tank (*Q*) was calculated by multiplying the average household size by the per capita wastewater production rate per day. Based on the information published by the Census Bureau, the average household size for Pinellas County is about 2.21 people/household. The same population density was assumed within the WBID boundary. A commonly cited value for per capita wastewater production rate is 70 gallons/day/person (EPA, 2001). The commonly cited concentration (*C*) for septic tank discharge is 1×10^6 counts/100mL for fecal coliform (EPA, 2001).

No measured septic tank failure rate data were available for the WBID when this TMDL was developed. Therefore, the failure rate was derived from the number of septic tanks in Pinellas County based on FDOH's septic tank inventory and the number of septic tank repair permits issued in both counties as published by FDOH (available: http://www.doh.state.fl.us/environment/OSTDS/statistics/ostdsstatistics.htm). The cumulative number of septic tanks in Pinellas county on an annual basis was calculated by subtracting the number of issued septic tank installation permits for each year from the current number of septic tanks in the county based on FDOH's 2010-2011 inventory, assuming that none of the installed septic tanks will be removed after being installed (**Table B.3**). The reported number of septic tank repair permits was also obtained from the FDOH Website.

Based on this information, the annual discovery rates of failed septic tanks were calculated (**Table B.3**). The average annual septic tank failure discovery rate for Pinellas County is approximately 0.67 percent. Assuming that failed septic tanks are not discovered for about 5 years, the estimated annual septic tank failure rate is about 5 times the discovery rate, or 3.34 percent for Miami-Dade County. Based on **Equation B.1,** the estimated fecal coliform loading from failed septic tanks within the WBID 1538A boundary is 2.03×10^{10} counts/day (**Table B.2**).

Table B.2. Estimated Number of Households Using Septic Tanks and Estimated Septic Tank Loading within each WBID Boundary

This is a three-column table. Column 1 lists the WBID number, Column 2 lists the number of households with a septic tank, and Column 3 lists the septic tank loading.

WBID	# Households Using Septic Tanks	Loading (counts/day)*
1538A	104	2.03×10^{10}

Table B.3. Estimated Number of Septic Tanks and Septic Tank Failure Rates for Pinellas County (1999-2010)

This is a six-column table. Column 1 lists the year, Columns 2 lists the number of septic tanks newly installed in each year, Column 3 lists the accumulated number of septic tanks for each year, Column 4 lists the number of septic tanks repair permits being issued, Column 5 lists the failed septic tank discovery rates, and Column 6 lists the final failure rates.

Year	New installation	Accumulated installation	Repair permit	Failure discovery rate (%)	Failure rate (%)
1999	35	23,436	94	0.40	2.01
2000	50	23,471	190	0.81	4.05
2001	57	23,521	185	0.79	3.93
2002	54	23,578	141	0.60	2.99
2003	47	23,632	193	0.82	4.08
2004	43	23,679	168	0.71	3.55
2005	43	23,722	180	0.76	3.79
2006	36	23,765	149	0.63	3.13
2007	34	23,801	150	0.63	3.15
2008	28	23,835	153	0.64	3.21
2009	6	23,863	159	0.67	3.33
2010	9	23,869	137	0.57	2.87
Average	**36.83**	**23,681**	**158**	**0.67**	**3.34**

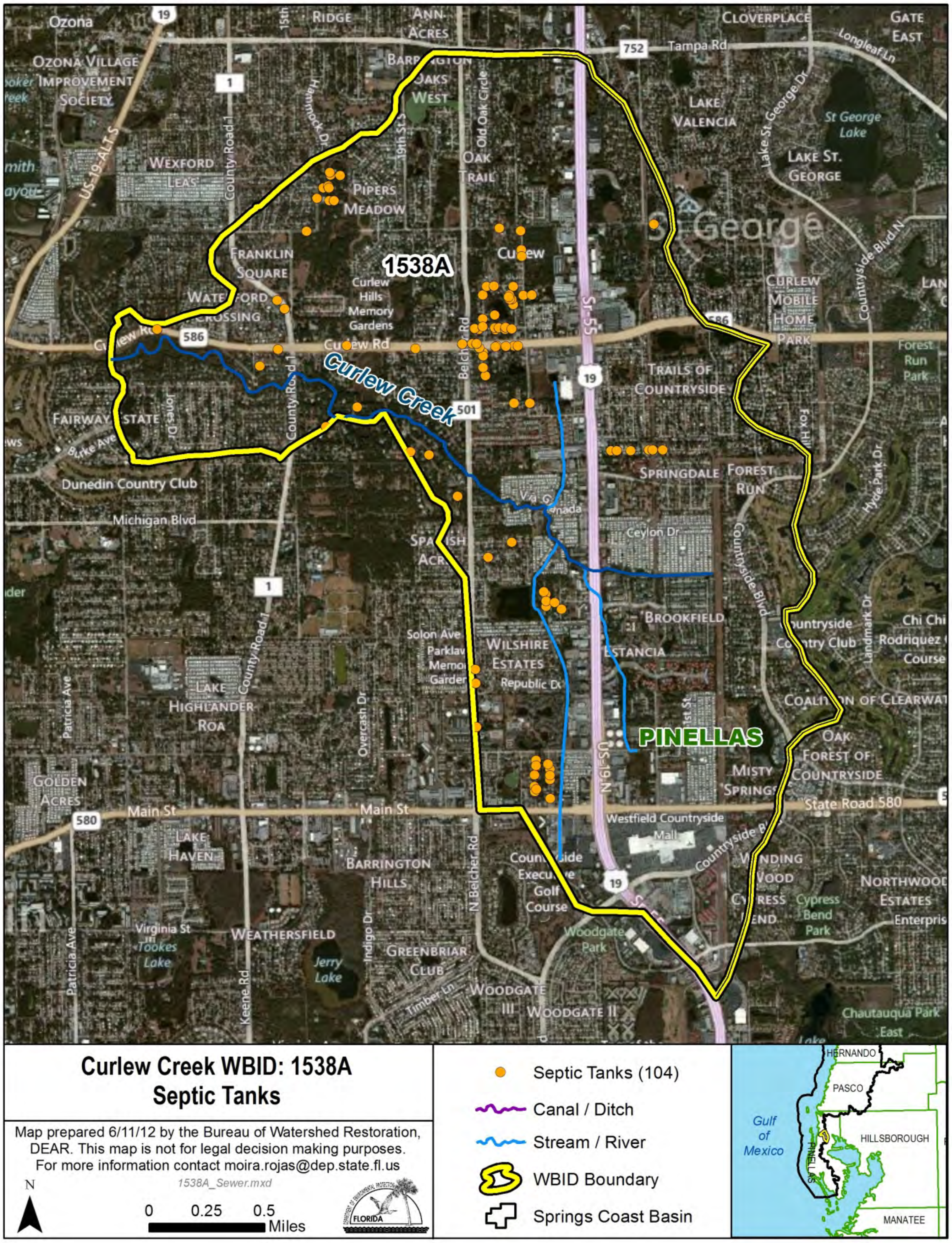

Figure B.1. Location of OSTDS Based on FDOH Data in the Residential Land Use Areas within the Curlew Creek WBID Boundaries

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) can also be a potential source of fecal bacteria pollution. Human sewage can be introduced into surface waters even when storm and sanitary sewers are separated. Leaks and overflows are common in many older sanitary sewers where capacity is exceeded, high rates of infiltration and inflow occur (i.e., outside water gets into pipes, reducing capacity), frequent blockages occur, or sewers are simply falling apart due to poor joints or pipe materials. Power failures at pumping stations are also a common cause of SSOs. The greatest risk of an SSO occurs during storm events; however, few comprehensive data are available to quantify SSO frequency and bacteria loads in most watersheds. Therefore, in this report, the possible fecal coliform load contributed by sewer line leakage was estimated based on an empirical leakage rate of 0.5 percent of the total raw sewage (Culver et al., 2002) created within the WBID by the households connected to the sewer system.

Fecal coliform loading from sewer line leakage can be calculated based on the number of people in the watershed, typical per household generation rates, and typical fecal coliform concentrations in domestic sewage, assuming a leakage rate of 0.5 percent (Culver et al., 2002). Based on this assumption, a rough estimate of fecal coliform loads from leaks and SSOs within the Curlew Creek Freshwater Segment WBID boundary can be made using **Equation B.2.**

$$L = 37.85 * N * Q * C * F \qquad \textbf{Equation B.2}$$

Where:

- *L* is the fecal coliform daily load (counts/day);
- *N* is the number of households using sanitary sewer in the WBID;
- *Q* is the discharge rate for each household (gallons/day);
- *C* is the fecal coliform concentration for domestic wastewater (counts/100mL);
- *F* is the sewer line leakage rate; and
- *37.85* is a conversion factor (100mL/gallon).

The number of households *(N)* within the Curlew Creek Freshwater Segment WBID boundary served by sewer systems is estimated to be 9,477 (the estimated number of households in the WBID minus the estimated number of household using septic tanks) (**Table B.4**) (**Figure B.1**). The discharge rate through sewers from each household (*Q*) was calculated by multiplying the average household size for Pinellas County (2.21) (US Census Bureau, 2010) by the per capita wastewater production rate per day (70 gallons/day/person). The commonly cited concentration (*C*) for domestic wastewater is 1×10^6 counts/100 mL for fecal coliform (EPA, 2001). The contribution of fecal coliform through sewer line leakage was assumed to be 0.5 percent of the total sewage loading created from the population not on septic tanks (Culver et al., 2002). Based on **Equation B.2**, the fecal coliform loading from sewer line leakage in the WBID is approximately 2.77×10^{11} counts/day (**Table B.4**).

Table B.4. Estimated Number of Households Served by Sanitary Sewers and Estimated Fecal Coliform Loading from Sewer Line Leakage in the WBID 1538A Boundary

This is a three-column table. Column 1 lists the WBID number, Column 2 lists the number of households served by sanitary sewers, Column 3 lists the SSO loading

WBID	# of Households Served by Sanitary Sewers	Loading (counts/day)
1538A	9,477	$2.77x10^{11}$

Wildlife

Wildlife (birds, raccoons) is another possible source of fecal coliform bacteria within the Curlew Creek Freshwater Segment WBID boundary. However, as these represent natural inputs, no reductions are assigned to these sources by this TMDL.

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