FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
Division of Environmental Assessment and Restoration, Bureau of Watershed Restoration
SOUTHEAST DISTRICT • SOUTHEAST COAST–BISCAYNE BAY BASIN

FINAL TMDL Report

Fecal Coliform TMDL for Las Olas Isles Finger Canal System (WBID 3226G4)

Moira Rojas

May 16, 2012

Acknowledgments

This Total Maximum Daily Load (TMDL) analysis could not have been accomplished without significant contributions from staff in the Broward County Department of Planning and Environmental Protection, the city of Fort Lauderdale's Environmental Services Division, the Florida Department of Environmental Protection's (Department) Watershed Assessment Section, and its Watershed Evaluation and TMDL Section. Map production assistance was provided by the Watershed Data Services Section with the Department's Division of Environmental Assessment and Restoration.

Editorial assistance was provided by Jan Mandrup-Poulsen and Linda Lord.

For additional information on the watershed management approach and impaired waters in the Southeast Coast–Biscayne Bay Basin, contact:

Katie Hallas
Florida Department of Environmental Protection
Bureau of Watershed Restoration
Watershed Planning and Coordination Section
2600 Blair Stone Road, Mail Station 3565
Tallahassee, FL 32399-2400
Email: katie.hallas@dep.state.fl.us
Phone: (850) 245-8432
Fax: (850) 245–8434

Access to all data used in the development of this report can be obtained by contacting:

Moira Rojas
Florida Department of Environmental Protection
Bureau of Watershed Restoration
Watershed Evaluation and TMDL Section
2600 Blair Stone Road, Mail Station 3555
Tallahassee, FL 32399-2400
Email: moira.rojas@dep.state.fl.us
Phone: (850) 245–8460
Fax: (850) 245–8444

Contents

Chapter 1: INTRODUCTION *1*
1.1 Purpose of Report ____ 1
1.2 Identification of Waterbody ____ 1
1.3 Background ____ 4
Chapter 2: DESCRIPTION OF WATER QUALITY PROBLEM *5*
2.1 Statutory Requirements and Rulemaking History ____ 5
2.2 Information on Verified Impairment ____ 5
Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS *7*
3.1 Classification of the Waterbody and Criterion Applicable to the TMDL ____ 7
3.2 Applicable Water Quality Standards and Numeric Water Quality Target ____ 7
Chapter 4: ASSESSMENT OF SOURCES *8*
4.1 Types of Sources ____ 8
4.2 Potential Sources of Fecal Coliform within the Las Olas Isles WBID Boundary ____ 8
4.2.1 Point Sources ____ *8*
Wastewater Point Sources ____ 8
Municipal Separate Storm Sewer System Permittees ____ 8
4.2.2 Land Uses and Nonpoint Sources ____ *8*
Land Uses ____ 9
Urban Development ____ 9
Boats ____ 10
Wildlife and Sediments ____ 10
Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY *12*
5.1 Determination of Loading Capacity ____ 12
5.1.1 Data Used in the Determination of the TMDL ____ *12*
Temporal Patterns ____ 15
Spatial Patterns ____ 20
5.1.2 Critical Condition ____ *22*
5.1.3 TMDL Development Process ____ *24*
Chapter 6: DETERMINATION OF THE TMDL *27*
6.1 Expression and Allocation of the TMDL ____ 27
6.2 Load Allocation ____ 27

6.3 Wasteload Allocation 28

6.3.1 NPDES Wastewater Discharges 28

6.3.2 NPDES Stormwater Discharges 28

6.4 Margin of Safety 28

Chapter 7: TMDL IMPLEMENTATION 29

7.1 Basin Management Action Plan 29

7.2 Other TMDL Implementation Tools 30

References 31

Appendices 34

Appendix A: Background Information on Federal and State Stormwater Programs 34

Appendix B: Estimates of Fecal Coliform Loadings from Potential Sources 35

Pets 35

Sanitary Sewer Overflows 36

Septic Tanks 38

Wildlife 38

List of Tables

Table 2.1. ***Summary of Fecal Coliform Monitoring Data for Las Olas Isles (WBID 3226G4) During the Cycle 1 Verified Period (January 1, 1998, through June 30, 2005) and the Cycle 2 Verified Period (January 1, 2003 through June 30, 2010)................... 6***

Table 4.1. ***Classification of Land Use Categories within the Las Olas Isles Watershed (WBID 3226G4) Boundary in 2004–05...................... 9***

Table 5.1. ***Descriptive Statistics of Fecal Coliform Data for Las Olas Isles (WBID 3226G4) for the Cycle 2 Planning and Verified Periods (1998–2010) 14***

Table 5.2a. ***Summary Statistics of Fecal Coliform Data for All Stations in Las Olas Isles (WBID 3226G4) by Month During the Cycle 2 Planning and Verified Periods (1998–2010) 16***

Table 5.2b. ***Summary Statistics of Fecal Coliform Data for All Stations in Las Olas Isles (WBID 3226G4) by Season During the Cycle 2 Planning and Verified Periods (1998-2010).......................... 16***

Table 5.3. ***Station Summary Statistics of Fecal Coliform Data for Las Olas Isles (WBID 3226G4) During the Cycle 2 Planning and Verified Periods (1998–2010) 22***

Table 5.4. ***Summary of Fecal Coliform Data for the Cycle 2 Planning and Verified Periods (1998–2010) by Hydrologic Condition for Las Olas Isles (WBID 3226G4) 23***

Table 5.5. ***Calculation of Fecal Coliform Reduction for the Las Olas Isles (WBID 3226G4) TMDL Based on the Hazen Method 26***

Table 6.1. ***TMDL Components for Fecal Coliform in Las Olas Isles (WBID 3226G4)... 28***

Table B.1. ***Dog Population Density, Wasteload and Fecal Coliform Density Based on the Literature (Weiskel et al. 1996)...................... 36***

List of Figures

Figure 1.1. Location of the Las Olas Isles Watershed (WBID 3226G4) in the Southeast Coast–Biscayne Bay Basin and Major Hydrologic and Geopolitical Features in the Area 2

Figure 1.2. Location of the Las Olas Isles Watershed (WBID 3226G4) in Broward County 3

Figure 4.1. Principal Land Uses within the Las Olas Isles Watershed (WBID 3226G4) Boundary in 2004–05 11

Figure 5.1. Location of Water Quality Stations with Fecal Coliform Data in Las Olas Isles (WBID 3226G4) 13

Figure 5.2. Fecal Coliform Concentration Trends in Las Olas Isles (WBID 3226G4) for the Cycle 2 Planning and Verified Periods (1998–2010) 14

Figure 5.3. Fecal Coliform Concentrations by Wet and Dry Season During the Cycle 2 Planning and Verified Periods (1998–2010) 17

Figure 5.4. Fecal Coliform Exceedances and Rainfall at All Stations in Las Olas Isles (WBID 3226G4) by Month During the Cycle 2 Planning and Verified Periods (1998–2010)..................................... 18

Figure 5.5. Fecal Coliform Exceedances and Rainfall at All Stations in Las Olas Isles (WBID 3226G4) by Season During the Cycle 2 Planning and Verified Periods (1998–2010).................................. 18

Figure 5.6. Fecal Coliform Concentration Trends at Station 21FLBROW49 in Las Olas Isles (WBID 3226G4) for the Entire Period of Record (1991–2010) 20

Figure 5.7. Spatial Fecal Coliform Concentration Trends in Las Olas Isles (WBID 3226G4) by Station (1998–2010) 21

Figure 5.8. Spatial Fecal Coliform Concentration Trends in Las Olas Isles (WBID 3226G4) by Date (1998–2010)....................................... 21

Figure 5.9. Fecal Coliform Data for the Cycle 2 Planning and Verified Periods (1998–2010) by Hydrologic Condition for Las Olas Isles (WBID 3226G4)... 24

Figure B.1. Distribution of Sanitary Sewers in the Residential Land Use Areas within the Las Olas Isles Watershed (WBID 3226G4) Boundary... 37

Websites

Florida Department of Environmental Protection, Bureau of Watershed Restoration

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: Biscayne Bay–Southeast Coast

http://www.dep.state.fl.us/water/basin411/southeast/status.htm

Water Quality Assessment Report: Biscayne Bay–Southeast Coast

http://www.dep.state.fl.us/water/basin411/southeast/assessment.htm

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 Las Olas Isles Finger Canal System (Las Olas Isles), located in the Southeast Coast–Biscayne Bay Basin. The system was verified as impaired for fecal coliform, and therefore was included on the Verified List of impaired waters for the Southeast Coast–Biscayne Bay Basin that was adopted by Secretarial Order on May 6, 2006. The TMDL establishes the allowable fecal coliform loading to Las Olas Isles 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 Florida Department of Environmental Protection (Department) has divided the Southeast Coast–Biscayne Bay Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. Las Olas Isles is WBID 3226G4.

Las Olas Isles is 1 of 22 waterbody segments in the Broward County Planning Unit of the Southeast Coast–Biscayne Bay Basin, and 1 of 19 waterbody segments in the Southeast Coast–Biscayne Bay Basin included on the initial 1998 303(d) list submitted by the Department to the U.S. Environmental Protection Agency (EPA). This list was incorporated into a 1999 Consent Decree between the EPA and Earthjustice.

The initial list was based on data from stations listed in the Department's 1996 305(b) report, which used the best available information to generally characterize the quality of Florida's waters. Many of the delineations of waterbody areas and locations of sampling stations for the 1998 303(d) list were inaccurate due to technical limitations at the time.

With the primary goal of providing more accurate assessments, the Department has revised the delineations over time. The 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 4 basins, there are currently 37 Consent Decree waterbody segments in the Southeast Coast–Biscayne Bay Basin. This number is based on Impaired Surface Waters Rule (IWR) Run 41x.

The Las Olas Isles watershed is located in east-central Fort Lauderdale along Las Olas Isles Boulevard, in Broward County (**Figure 1.1**). The Las Olas Isles are a series of man-made islands that provide a transitional area between the New River and the Middle River on the Intracoastal Waterway (ICW) (Broward County Department of Planning and Environmental Protection [BCDPEP] 2001). They are bounded on the north by Rio Barcelona, on the west by Rio Navarro and Lake Stranahan, on the south by Las Olas Boulevard, and on the east by Rio Balboa (**Figure 1.2**).

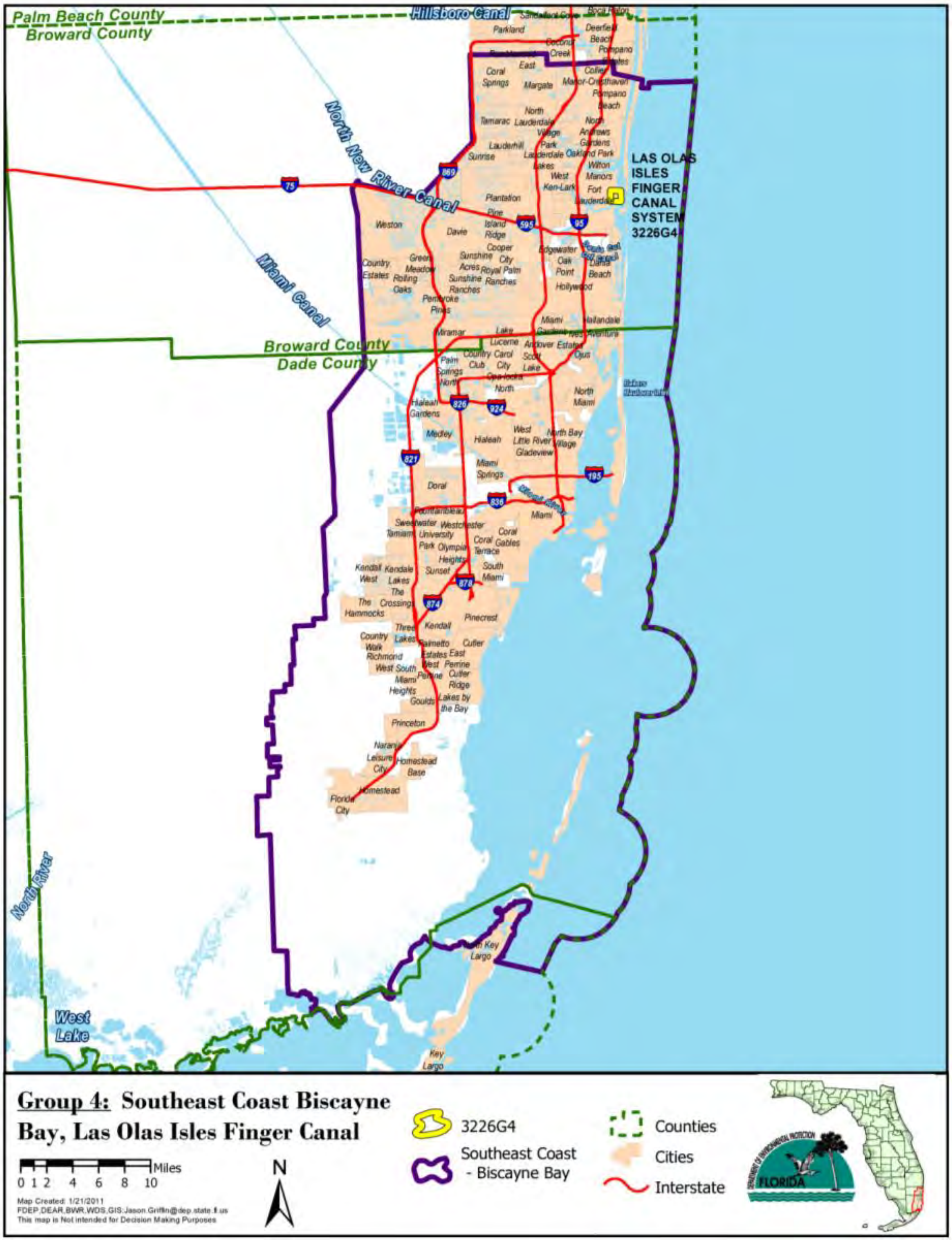

Figure 1.1. Location of the Las Olas Isles Watershed (WBID 3226G4) in the Southeast Coast–Biscayne Bay Basin and Major Hydrologic and Geopolitical Features in the Area

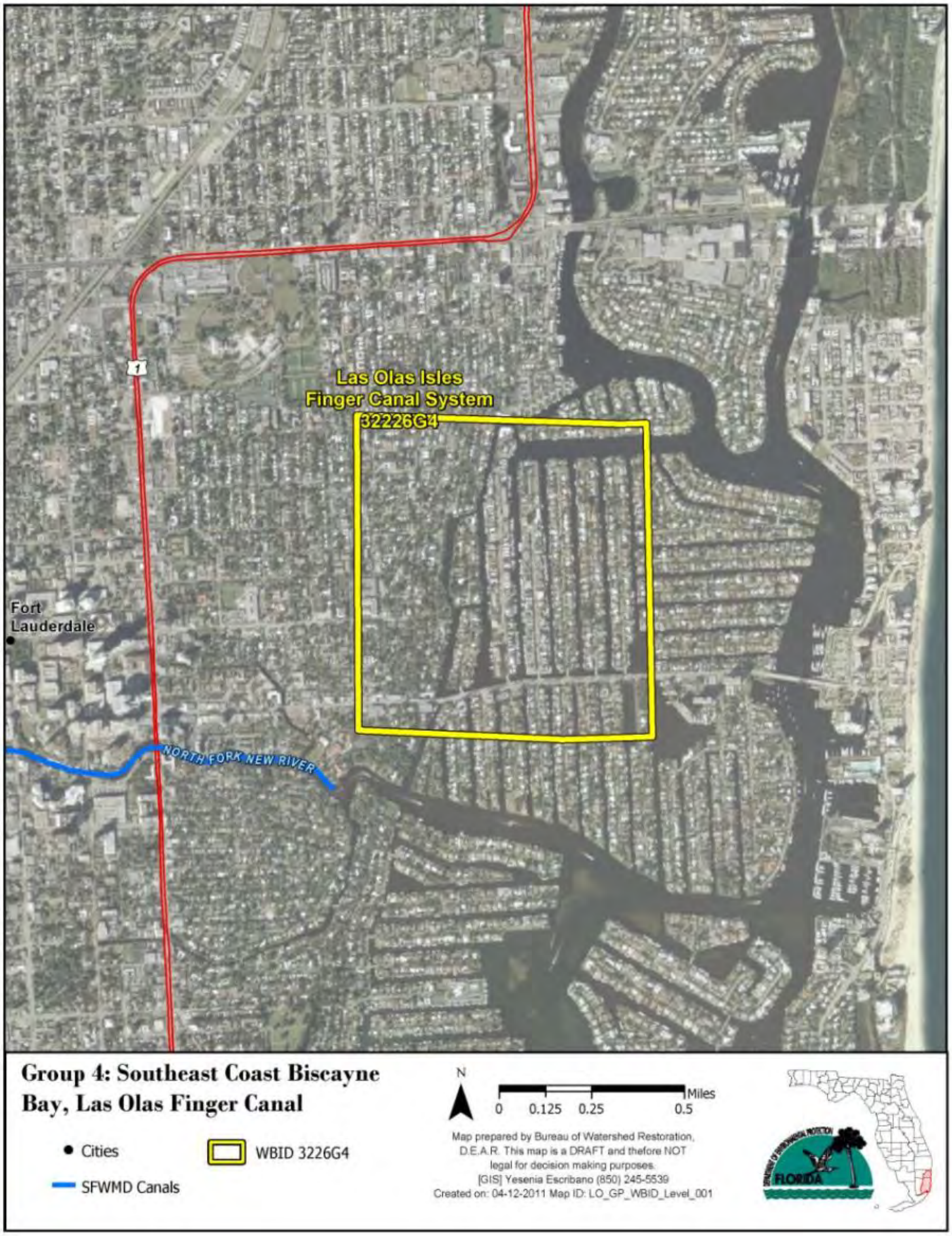

Figure 1.2. Location of the Las Olas Isles Watershed (WBID 3226G4) in Broward County

The Las Olas Isles canal system is circuitous in nature, with current speeds and directions influenced by the tides. Most of the navigable waterways in the system are available to larger vessels, and a portion of the area is zoned to permit inhabited, moored vessels (IMVs) (Broward County Department of Natural Resource Protection [BCDNRP] 1995).

The area within the Las Olas Isles WBID boundary covers approximately 0.67 square miles (mi^2) (428.45 acres) and is predominantly single and multifamily residential. Additional information about the hydrology of this area is available in a Broward County Department of Natural Resource Protection (BCDNRP) Technical Report (BCDNRP 1995).

WBID 3226G4 is located in the Atlantic Coastal Ridge physiographic region, which occupies the easternmost portions of Broward, Miami–Dade, and Palm Beach Counties. In Broward County, the ridge is composed of both sand and limestone (Schroeder *et al.* 1956). This part of southeastern Florida is underlain by the Biscayne aquifer, an unconfined and shallow part of the surficial aquifer system that consists of highly permeable limestone and less permeable sandstone and sand (Fish 1988). The aquifer supplies large quantities of water for municipal, industrial, and irrigational use in Broward County.

The Biscayne aquifer is particularly susceptible to contamination because it is unconfined, highly permeable, and shallow, and because it is located near the surface in highly urbanized areas (Whitman 1997). Potential sources of contamination include saltwater encroachment and infiltration of contaminants carried in canal 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).

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 Las Olas Isles canal system. These activities will depend heavily on the active participation of the South Florida Water Management District (SFWMD), 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 19 impaired waterbodies in the Southeast Coast–Biscayne Bay Basin on its initial 1998 303(d) list. As a result of the resegmentation process for the Group 4 basins, there are currently 37 Consent Decree waterbody segments in the Southeast Coast–Biscayne Bay 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 Las Olas Isles and has verified that this waterbody segment is impaired for fecal coliform bacteria. Verified impairment was based on the observation that 20 out of 74 fecal coliform samples exceeded the criterion of 400 counts per 100 milliliters (400 counts/100mL) in the Cycle 1 verified period assessment (January 1, 1998, through June 30, 2005). This impairment was confirmed in the Cycle 2 assessment, in which 6 out of 28 fecal coliform samples collected during the verified period (January 1, 2003, through June 30, 2010), or more than 10% of the values, exceeded the assessment threshold of 400 counts/100mL (see **Section 3.2** for details).

Table 2.1 summarizes fecal coliform monitoring results for the Cycle 1 and Cycle 2 verified periods for Las Olas Isles. 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 Las Olas Isles (WBID 3226G4) During the Cycle 1 Verified Period (January 1, 1998, through June 30, 2005) and the Cycle 2 Verified Period (January 1, 2003 through June 30, 2010)

This is a four-column table. Column 1 lists the waterbody and WBID number, Column 2 lists the parameter, Column 3 lists the Cycle 1 results, and Column 4 lists the Cycle 2 results.

Waterbody (WBID)	Parameter	Fecal Coliform Cycle 1	Fecal Coliform Cycle 2
Las Olas Isles (WBID 3226G4)	Total number of samples	74	28
Las Olas Isles (WBID 3226G4)	IWR-required number of exceedances for the Verified List	12	5
Las Olas Isles (WBID 3226G4)	Number of observed exceedances	20	6
Las Olas Isles (WBID 3226G4)	Number of observed nonexceedances	54	22
Las Olas Isles (WBID 3226G4)	Number of seasons during which samples were collected	4	4
Las Olas Isles (WBID 3226G4)	Highest observation (counts/100mL)	2,700	2,100
Las Olas Isles (WBID 3226G4)	Lowest observation (counts/100mL)	7	7
Las Olas Isles (WBID 3226G4)	Median observation (counts/100mL)	118	125
Las Olas Isles (WBID 3226G4)	Mean observation (counts/100mL)	387	311

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)**

Las Olas Isles (WBID 3226G4) is a Class III (marine) 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 marine water 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 (marine) 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 Las Olas Isles WBID Boundary

4.2.1 Point Sources

Wastewater Point Sources

There are no NPDES-permitted wastewater facilities in the Las Olas Isles watershed.

Municipal Separate Storm Sewer System Permittees

One NPDES municipal separate storm sewer system (MS4) permit covers the Las Olas Isles watershed: Permit FLS000017 (Phase I), held by the city of Fort Lauderdale.

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 SFWMD's 2004–05 land use coverage contained in the Department's geographic information system (GIS) library. Land use categories within the Las Olas Isles 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 4.1**. **Figure 4.1** shows the spatial distribution of the principal land uses within the WBID boundary.

As shown in **Table 4.1**, the total area within the WBID boundary is approximately 428.25 acres. The dominant land use categories are residential (medium- and high-density), which accounts for approximately 73% of the total WBID area, and water (streams and waterways), which accounts for approximately 24% of the total WBID area.

Table 4.1. Classification of Land Use Categories within the Las Olas Isles Watershed (WBID 3226G4) Boundary in 2004–05

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.

- = Empty cell/no data

Level 1 Code	Land Use	Acreage	% Acreage
1000	Urban and built-up	12.85	3%
-	Medium-density residential	199.70	46.6%
-	High-density residential	114.90	26.8%
5000	Water	101.00	23.6%
-	**TOTAL**	**428.45**	**100%**

Urban Development

Because the dominant land use categories contributing to nonpoint source pollution are urban areas—urban and built-up (commercial and services), and medium- and high-density residential—possible sources for fecal coliform loadings can include failed septic tanks, sewer line leakages, and pet feces that are 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. The loading estimates were not used in establishing the final TMDL. Based on information obtained from the Broward County Environmental Atlas Sewer Service map (available: http://www.broward.org/EnvironmentAndGrowth/EnvironmentalProgramsResources/Publications/Documents/SeweredAreasGISMap2000.pdf) and Florida Department of Health (FDOH) onsite sewage data, all housing units within the Las Olas Isles WBID boundary are served by sewer systems.

Boats

Based on the land use distribution listed in **Table 4.1**, a potentially important source of fecal coliform loading in the WBID includes boat sewage discharges. In areas with high boating densities and low hydrologic flushing, boats can be a significant source of fecal coliform bacteria (EPA 2010). Fecal coliform levels can become elevated near boats during periods of high occupancy and use (EPA 1993). Studies have found that water quality in canals is negatively affected by bacteria suspected to originate from the discharge of sanitary wastes from IMVs (BCDNRP 1994, 1995).

Bacteriological studies conducted by Broward County in Las Olas Isles in the 1990s identified 3 potential sources of bacteria in the system: sewage conveyance system failures, stormwater runoff, and discharges of sanitary waste from IMVs. To demonstrate the influence of IMVs in the area, data collected following 24 hours of rainfall (> 0.5 inches) or within 24 hours of a documented sewer failure, repair, or complaint were filtered out. A persistent, positive relationship between the density of IMVs and fecal coliform concentrations exceeding standards for fecal coliform bacteria in the area was observed in the remaining data (BCDNRP 1994, 1995).

Wildlife and Sediments

Wildlife and sediments could also contribute to fecal coliform exceedances in the watershed. Animals such as ibirds 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 resuspended in surface water when conditions are right (Jamieson *et al.* 2005). Current source identification methodologies cannot quantify the exact amount of fecal coliform loading from wildlife and/or sediment sources.

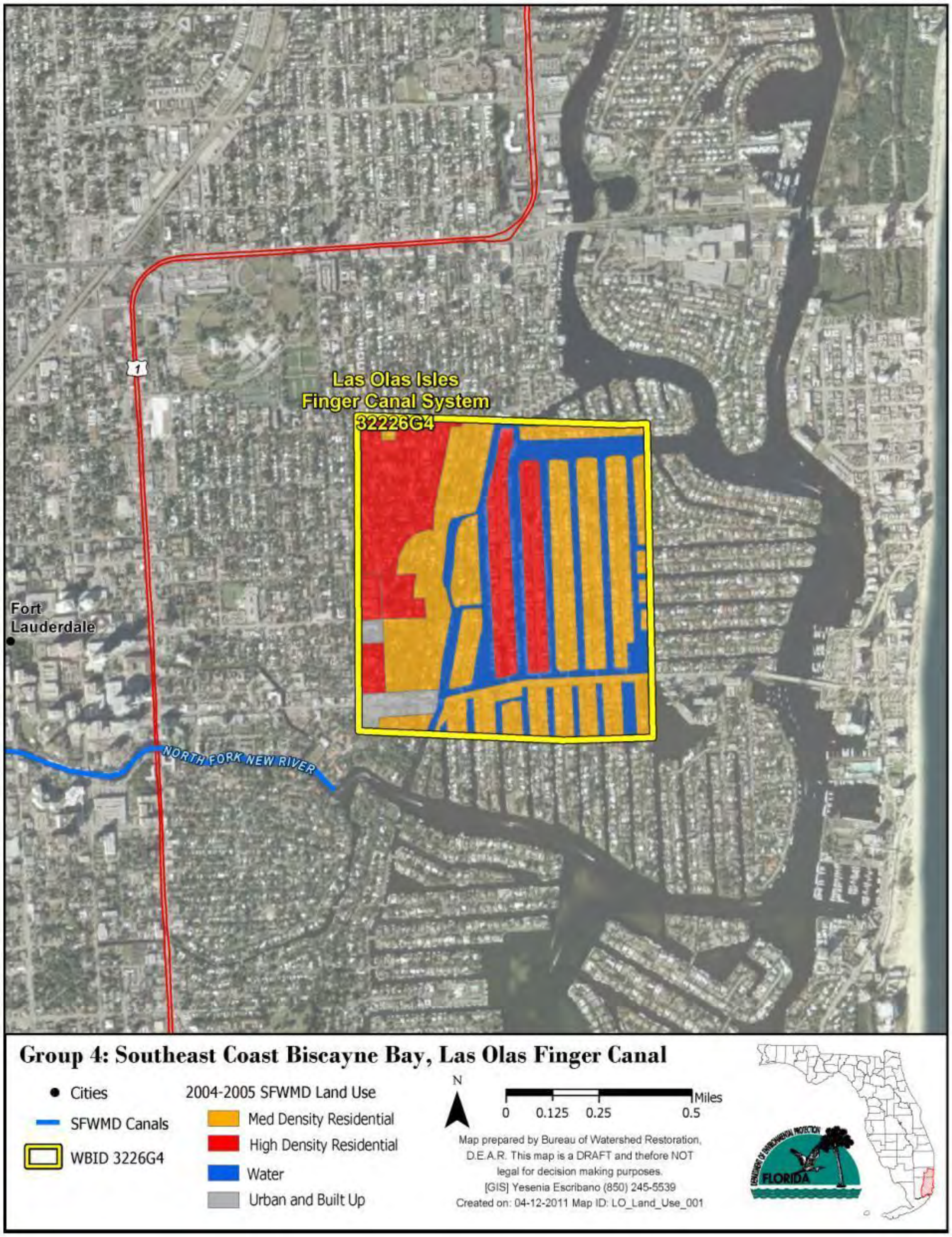

Figure 4.1. Principal Land Uses within the Las Olas Isles Watershed (WBID 3226G4) Boundary in 2004–05

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

When continuous flow measurements in a watershed are available, a bacteria TMDL can be developed using the load duration curve method. Developed by the Kansas Department of Health and Environment, this method provides the allowable daily bacteria load. However, flow data were not available for Las Olas Isles; therefore, the fecal coliform TMDL 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, 2003, through June 30, 2010). 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 provided by BCDPEP. The Cycle 2 verified period includes data collected from January 1, 2003, through June, 30, 2010. During this period, fecal coliform samples were only collected from Station 21FLBROW49. For a more comprehensive spatial and temporal analysis, this analysis incorporates fecal coliform data collected during the Cycle 2 planning and verified periods. Data were collected at the following stations during Cycle 2 (1998–2010): 21FLBROW107, 21FLBROW108, 21FLBROW49, 21FLBROW55, 21FLBROW57, 21FLBROW60, 21FLBROW62, 21FLBROW71, 21FLBROW87, and 21FLBROW91. See **Figure 5.1** for the locations of the water quality stations where fecal coliform data were collected for Las Olas Isles.

During the period of observation (1998–2010), concentrations ranged from 7 to 2,700 counts/100mL and averaged 360 counts/100mL. **Table 5.1** summarizes the descriptive statistics for the 1998–2010 fecal coliform results. A plot of fecal coliform data by time determined that there is no significant (Prob > F = 0.2000) increasing or decreasing trend during the period of observation. **Figure 5.2** shows the fecal coliform concentration trends observed in Las Olas Isles.

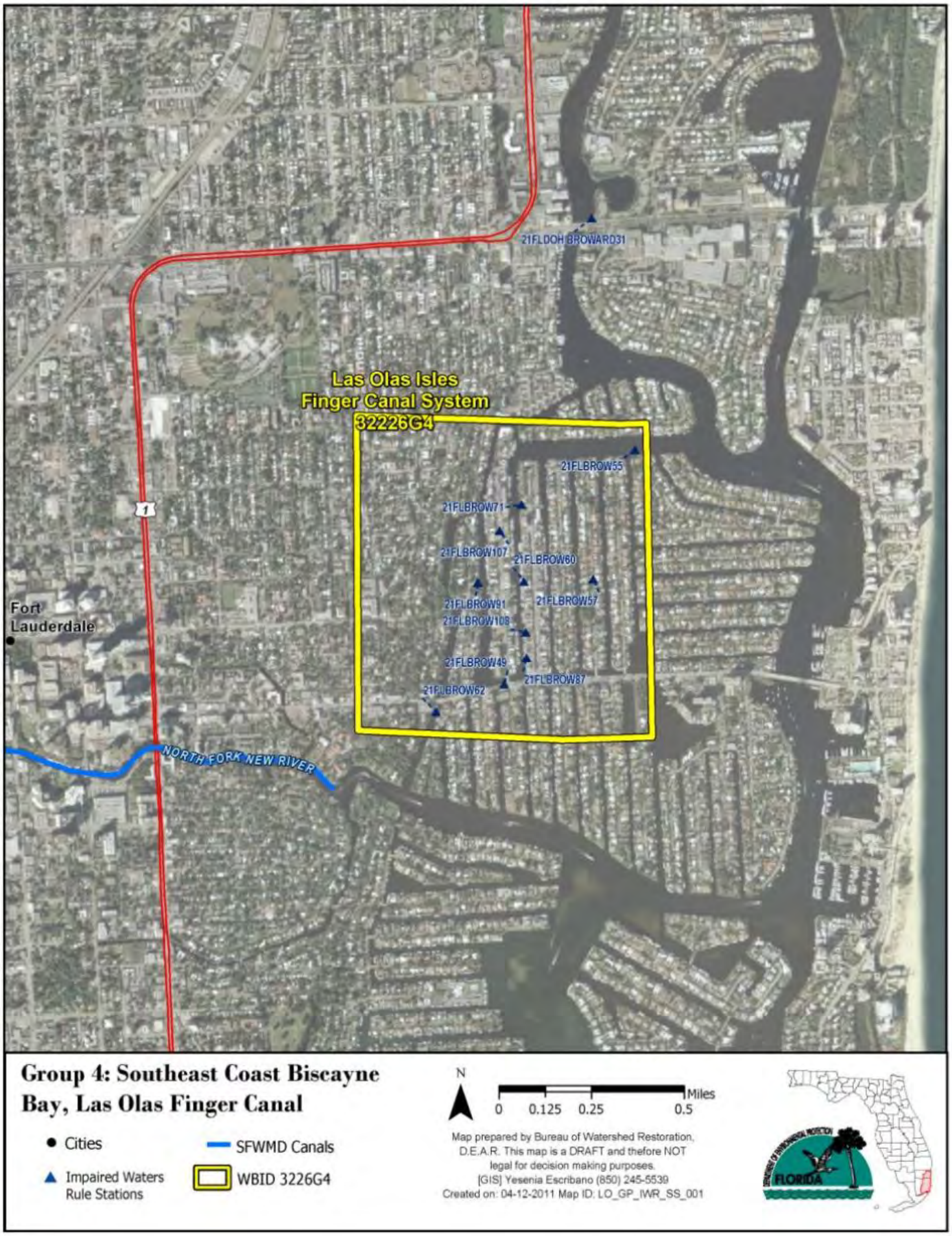

Figure 5.1. Location of Water Quality Stations with Fecal Coliform Data in Las Olas Isles (WBID 3226G4)

Table 5.1. Descriptive Statistics of Fecal Coliform Data for Las Olas Isles (WBID 3226G4) for the Cycle 2 Planning and Verified Periods (1998–2010)

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)	360
Standard deviation	530.8
Median observation (counts/100mL)	120
Highest observation (counts/100mL)	2,700
Lowest observation (counts/100mL)	7
25% quartile	58
75% quartile	435
Number of samples	92

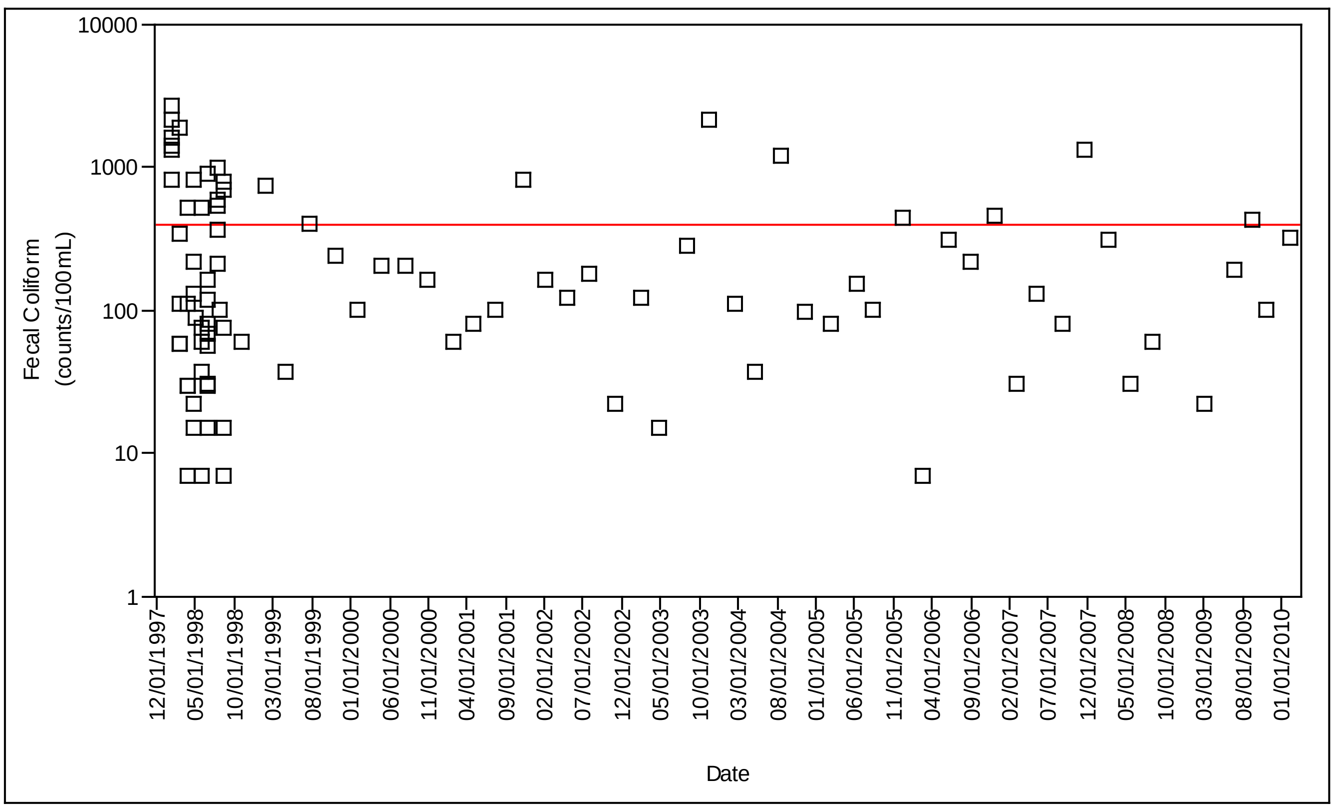

Figure 5.2. Fecal Coliform Concentration Trends in Las Olas Isles (WBID 3226G4) for the Cycle 2 Planning and Verified Periods (1998–2010)

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, a peak in fecal coliform concentrations and exceedance rates is commonly 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.

The Las Olas Isles WBID is located in an environment of extremes: dry in winter and wet in summer, with rainfall not distributed evenly either temporally or spatially (Broward County Natural Resources Planning and Management Division [BCNRPMD] 2009). In addition, rainfall variability from year to year is high, resulting in periodic droughts and floods (BCNRPMD 2009). This area is characterized by a subtropical climate where annual rainfall averages between 45 and 60 inches, with three-fourths of the rainfall occurring between May and November (BCNRPMD 2009), and an average annual temperature in Broward County of 74.4^{o}F, with a mean winter temperature of 66.5^{o}F and a mean summer temperature of 84.2^{o}F (Broward County Planning and Redevelopment Division [BCPRD] 2003). Rainy and warm conditions occur throughout most of the year.

The highest quarterly exceedance rate (45.5%) was observed in the fourth quarter. The highest quarterly average fecal coliform concentration (539 counts/100mL) was observed during the first quarter. Episodic peak fecal coliform concentrations occurred throughout the period of observation (1998–2010). Except for October, fecal coliform exceedances were observed in Las Olas Isles in all the other months in which measured fecal coliform concentrations were available. The highest monthly average fecal coliform concentration (1,095 counts/100mL) was observed in January. **Tables 5.2a** and **5.2b** summarize the monthly and seasonal fecal coliform averages and percent exceedances, respectively, for data collected for the Cycle 2 planning and verified periods (1998–2010) for the WBID.

Within Las Olas Isles, a relationship between seasons and bacteria levels may be affected by seasonal changes in the number of people on live-aboard vessels (BCDNRP 1995). The six-month period from November through April—the dry season—also defines the south Florida tourist season, when vessel occupancy rates are expected to be highest (BCDNRP 1995). **Figure 5.3** shows the fecal coliform concentrations by dry and wet season (May through October) for the WBID.

Using rainfall data collected at SFWMD Station G54_R from the DBHYDRO database (available: http://www.sfwmd.gov/dbhydroplsql/show_dbkey_info.main_menu), 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. A comparison of rainfall and fecal coliform exceedance rates in the planning and verified period years (1998–2010) with rainfall and fecal coliform exceedances in the verified period (2003–2010) yielded similar results (**Figures 5.4** and **5.5**), with exceedances observed during dry and wet periods.

Table 5.2a. Summary Statistics of Fecal Coliform Data for All Stations in Las Olas Isles (WBID 3226G4) by Month During the Cycle 2 Planning and Verified Periods (1998–2010)

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	10	59	2,700	1,050	1,095	7	70%
February	12	7	1,900	110	287	1	8.3%
March	6	7	510	29	118	1	16.7%
April	11	15	800	89	157	1	9.1%
May	8	7	510	48	111	1	12.5%
June	12	15	891	99	175	1	8.3%
July	10	100	1,000	285	367	3	30%
August	11	7	1,200	100	320	3	27.3%
September	1	420	420	420	420	1	100%
October	5	22	240	100	116	0	0.0%
November	5	96	2,100	800	949	4	80%
December	1	440	440	440	440	1	100%

Table 5.2b. Summary Statistics of Fecal Coliform Data for All Stations in Las Olas Isles (WBID 3226G4) by Season During the Cycle 2 Planning and Verified Periods (1998-2010)

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	28	7	2,700	115	539	9	32.1%
Quarter 2	31	7	891	81	152	3	9.7%
Quarter 3	22	7	1,200	215	346	7	31.8%
Quarter 4	11	22	2,100	240	524	5	45.5%

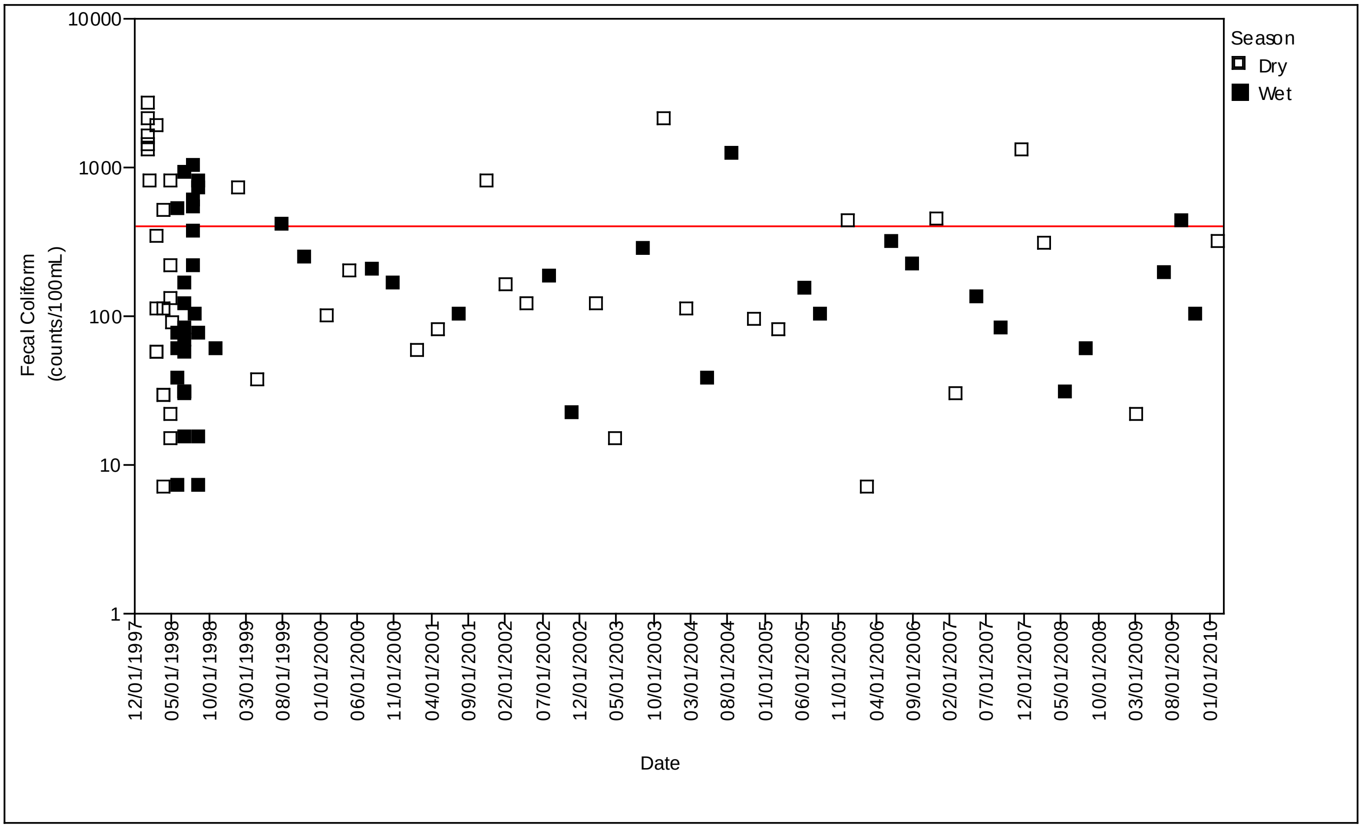

Figure 5.3. Fecal Coliform Concentrations by Wet and Dry Season During the Cycle 2 Planning and Verified Periods (1998–2010)

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

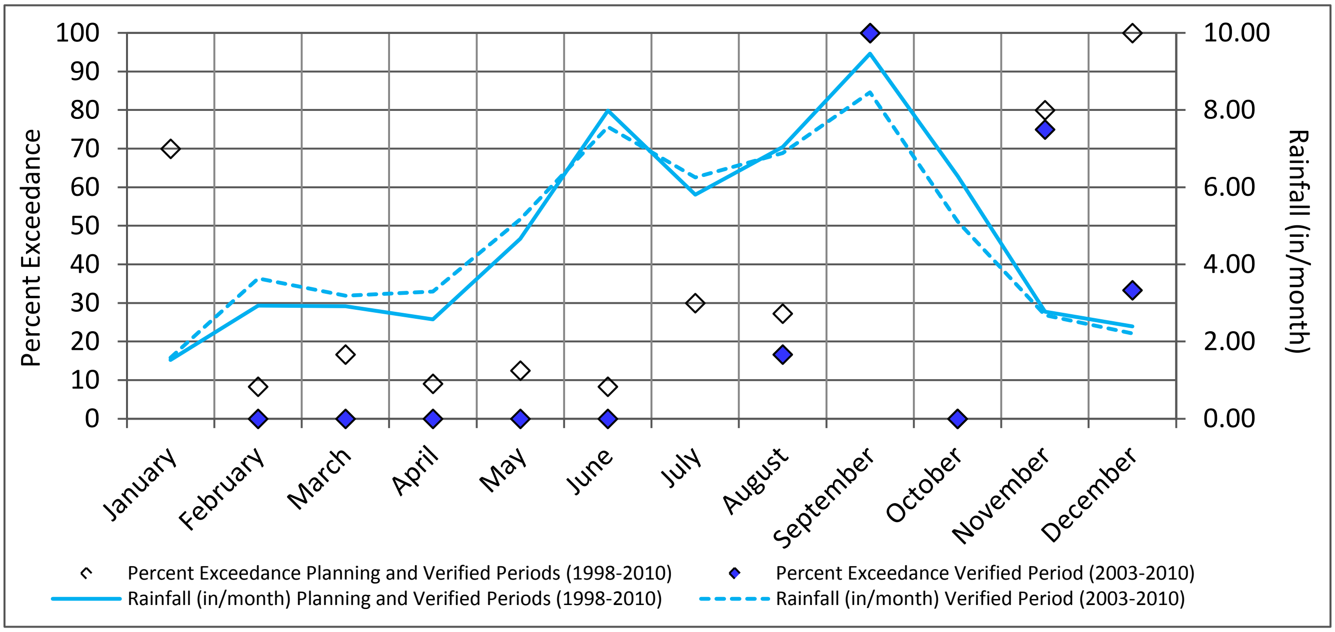

Figure 5.4. Fecal Coliform Exceedances and Rainfall at All Stations in Las Olas Isles (WBID 3226G4) by Month During the Cycle 2 Planning and Verified Periods (1998–2010)

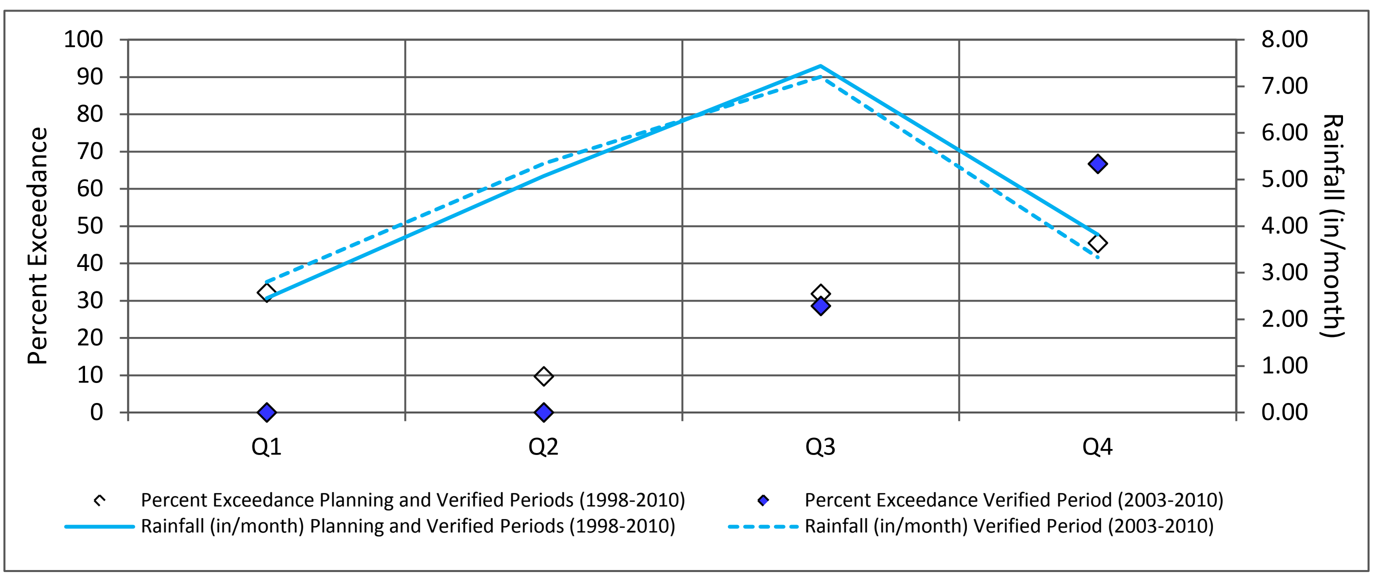

Figure 5.5. Fecal Coliform Exceedances and Rainfall at All Stations in Las Olas Isles (WBID 3226G4) by Season During the Cycle 2 Planning and Verified Periods (1998–2010)

Period-of-Record Trend

Plotting the historical fecal coliform data by time revealed no significant (Prob > F = 0.694) increasing or decreasing trend for the entire period of record (1991–2010) in the Las Olas Isles WBID. However, when period-of-record data for Station 21FLBROW49—the station with the highest number of samples collected (n=87)—were isolated and plotted by time, a significant decreasing trend in fecal coliform concentrations was observed (Prob > F = 0.0342) (**Figure 5.6**).

Lower magnitudes of fecal coliform concentrations (counts/100mL) have occurred at this station since approximately 1999, when the decreasing trend was first observed. Given that the sampling pattern for this station has remained consistent throughout the period of record, with samples collected during each of the four quarters, the decreasing trend reflects conditions across all seasons, accounting for variability in occupancy based on season.

The city of Fort Lauderdale has taken several actions aimed at reducing the inputs of sewage into its waterways. Specifically in Las Olas Isles, improvements to the sanitary sewer system in past years have included the replacements of water mains, sewage force mains, storm drainage, and sewage pump stations (BCDNRP 1995). In May 1997, the city adopted Ordinance C-97-11 (Section 8-156, Marine Sanitation Systems), under which property owners who allow live-aboard vessels on their property must require these vessels to be connected to marine sanitation systems at all times. The city has put significant effort into enforcing this ordinance (BCDPEP 2001).

In addition, the city's Water and Wastewater Capital Improvement Program (Waterworks 2011) includes approximately $555 million in utilities infrastructure repair, replacement, and upgrades. The program is carrying out improvements to the city's water and wastewater facilities, including the construction of new sanitary sewers to all unsewered areas of the city (City of Fort Lauderdale 2008).

However, even though a decreasing trend is observed in this station, indicating a potential improvement in fecal coliform bacteria levels in the WBID, fecal coliform concentrations that exceeded the criterion were recorded at this station during the Cycle 2 verified period. These samples (n=6) were collected during periods of small or no rainfall, indicating that exceedances in concentrations may not be a consequence of stormwater discharges, but instead may come from local sources.

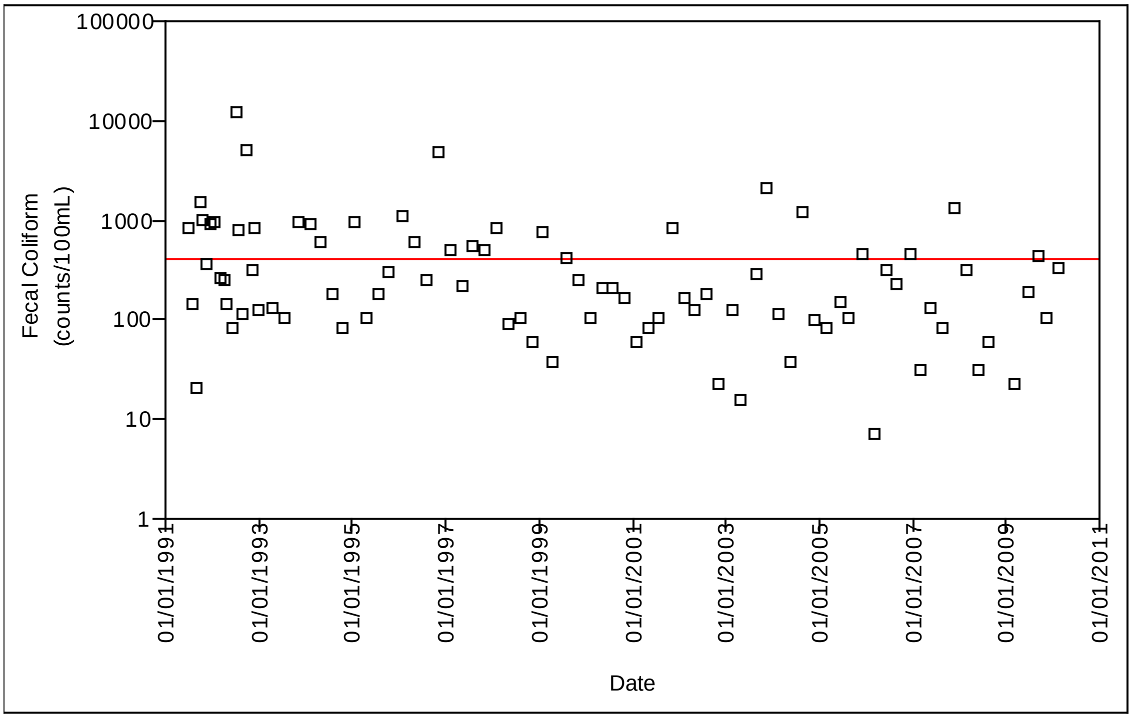

Figure 5.6. Fecal Coliform Concentration Trends at Station 21FLBROW49 in Las Olas Isles (WBID 3226G4) for the Entire Period of Record (1991–2010)

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

Spatial Patterns

Fecal coliform data from 1998 to 2010 were analyzed to detect spatial trends in the data (**Figures 5.7** and **5.8**). Exceedances in fecal coliform concentrations were observed in 7 of the 10 stations. The highest concentrations were recorded at Stations 21FLBROW49, 21FLBROW60, and 21FLBROW62 (2,100, 2,700, and 2,100 counts/100mL, respectively) (**Table 5.3**).

Station 21FLBROW60 is located where IMVs are most prevalent; the highest density of IMVs occurs in the Isle of Venice and Hendricks Isle, the two westernmost canals (BCDNRP 1995) (**Figure 5.1**). Past studies have shown that high levels of fecal coliform bacteria are consistently recorded in sample sites located in both these isles (BCDNRP 1994, 1995).

Given that the most recent data available were collected at only one station (21FLBROW49), and exceedances at this station were recorded during periods of small or no rainfall, the possibility that IMVs continue to be a source of high levels of bacteria in the system cannot be excluded. In particular, exceedances of fecal coliform bacteria continue to be recorded in the WBID in spite of improvements in the sanitary sewer system and city of Fort Lauderdale ordinances aimed at reducing inputs of sewage into the canal system.

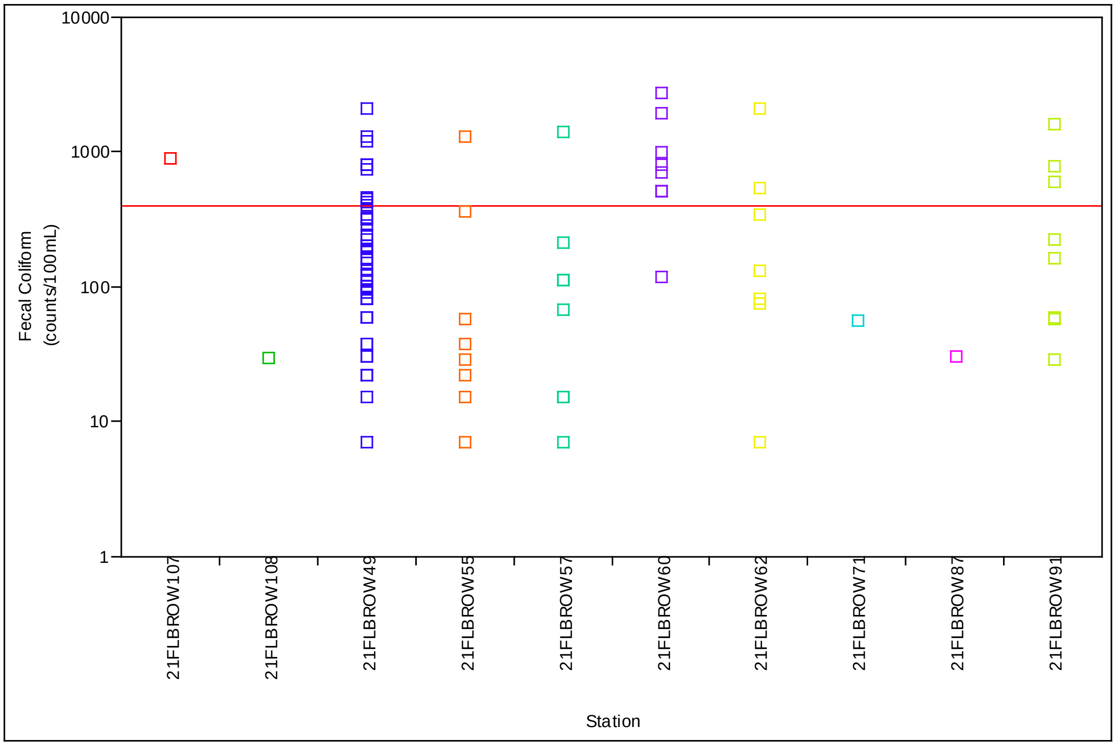

Figure 5.7. Spatial Fecal Coliform Concentration Trends in Las Olas Isles (WBID 3226G4) by Station (1998–2010)

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

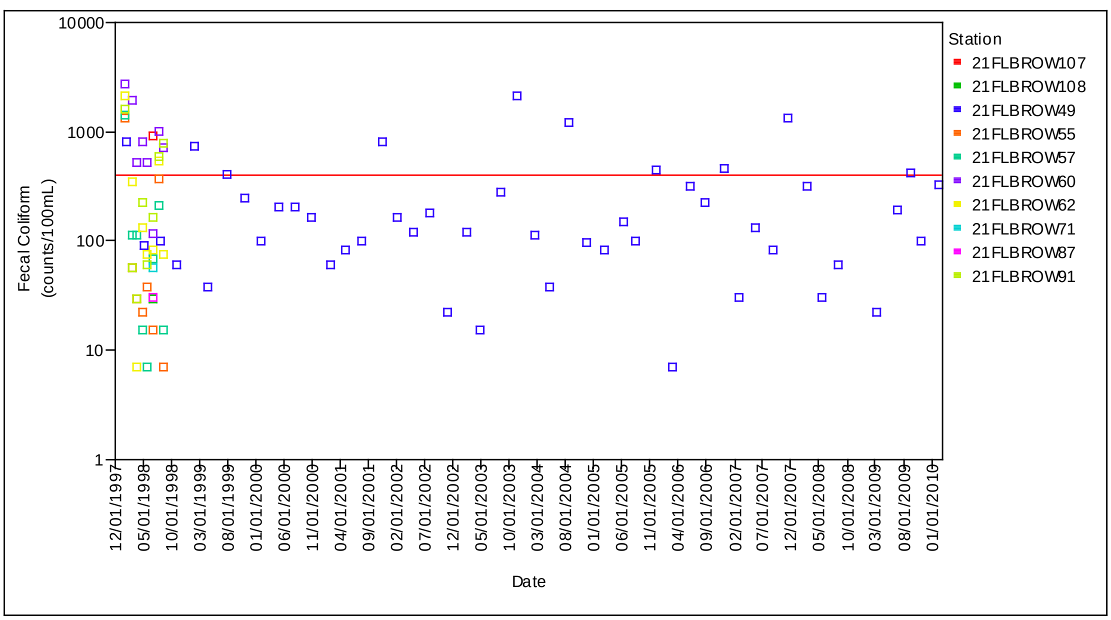

Figure 5.8. Spatial Fecal Coliform Concentration Trends in Las Olas Isles (WBID 3226G4) by Date (1998–2010)

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

Table 5.3. Station Summary Statistics of Fecal Coliform Data for Las Olas Isles (WBID 3226G4) During the Cycle 2 Planning and Verified Periods (1998–2010)

This is a nine-column table. Column 1 lists the station, Column 2 lists the period of observation, Column 3 lists the number of samples, Column 4 lists the minimum count/100mL, Column 5 lists the maximum count, 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
21FLBROW 107	1998	1	890.5	890.5	891	891	1	100%
21FLBROW 108	1998	1	29.5	29.5	30	30	0	0%
21FLBROW 49	1998–2010	48	7	2,100	125	278	9	18.75%
21FLBROW 55	1998	8	7	1,300	33	228	1	12.5%
21FLBROW 57	1998	8	7	1,400	89	242	1	12.5%
21FLBROW 60	1998	8	116	2,700	750	1,030	7	87.5%
21FLBROW 62	1998	8	7	2,100	106	417	2	25%
21FLBROW 71	1998	1	55.5	55.5	56	56	0	0%
21FLBROW 87	1998	1	30	30	30	30	0	0%
21FLBROW 91	1998	8	29	1,600	190	437	3	37.5%

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.

As no current flow data were available, 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 SFWMD G54_R climate station. The chart was divided in the same manner as if flow were being analyzed, where extreme 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 no recordable precipitation events (60th–100th percentile). Event precipitation ranges were derived based on these percentiles. Extreme events for WBID 3226G4 were determined as those with rainfall greater than 2.41 inches, large events between 1.55 and 2.41 inches, medium events between 0.18 and 1.55 inches, small events between 0.01 and 0.18 inches, and nonmeasurable 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 5.4** and **Figure 5.9**).

Historical data show that fecal coliform exceedances occurred over all hydrologic conditions except for extreme precipitation events. No observed exceedances in the extreme precipitation interval might be due to the small number of samples collected during these events (n=2). The highest percentage of exceedances (67%) occurred after large precipitation events. The lowest percentage (13.6%) occurred after periods of no measurable precipitation.

Given that exceedance rates and exceedances in concentrations followed all of the sampled precipitation events and that, other than MS4s, there are no traditional point source dischargers that would contribute to observed levels of fecal coliform bacteria within the Las Olas WBID boundary, it can be assumed that various nonpoint sources are a major contributing factor to high fecal coliform concentrations in the WBID. While the lowest percentage of exceedances occurred after periods of no or little rainfall, the exceedance rate should not be considered insignificant, as this might indicate that local sources are contributing to elevated fecal coliform concentrations. **Table 5.4** and **Figure 5.9** show fecal coliform data by hydrologic condition.

As fecal coliform exceedances occurred in the majority of precipitation events—large, medium, small, and not measurable—the target fecal coliform reduction calculated in the following section and shown in **Table 5.5** is applicable under all rainfall conditions in Las Olas Isles.

Table 5.4. Summary of Fecal Coliform Data for the Cycle 2 Planning and Verified Periods (1998–2010) by Hydrologic Condition for Las Olas Isles (WBID 3226G4)

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 (inches/ 3 days)	Total Samples	Number of Exceedances	% Exceedances	Number of Nonexceedances	% Nonexceedances
Extreme	> 2.41"	2	0	0%	2	100%
Large	1.55" - 2.41"	3	2	67%	1	33%
Medium	0.18" - 1.55"	26	12	46.2%	14	54%
Small	0.01" - 0.18"	17	4	23.5%	13	76%
None/ not measurable	< 0.01"	44	6	13.6%	38	86.4%

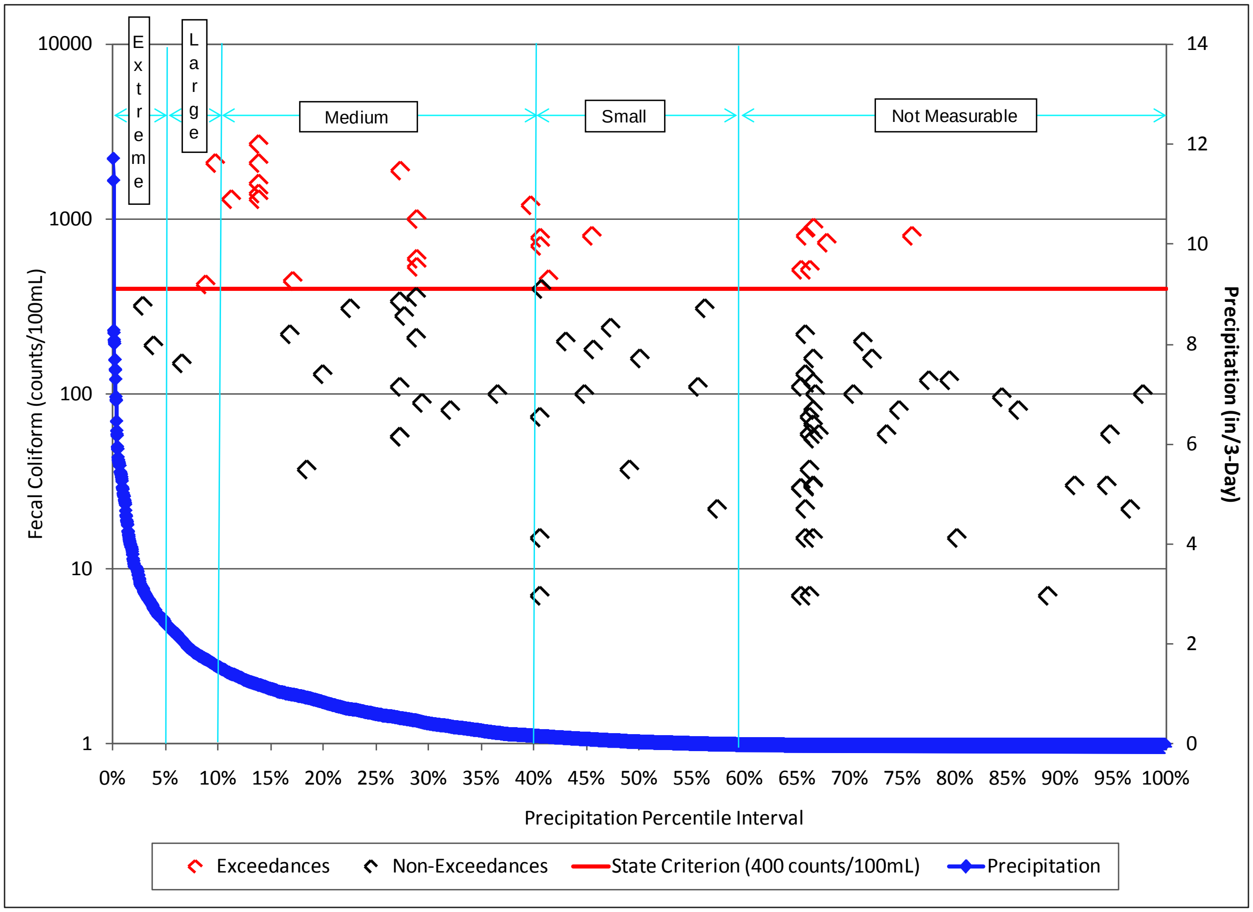

Figure 5.9. Fecal Coliform Data for the Cycle 2 Planning and Verified Periods (1998–2010) by Hydrologic Condition for Las Olas Isles (WBID 3226G4)

5.1.3 TMDL Development Process

Due to the lack of supporting information, mainly flow data, 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**:

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

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, 2003, to June 30, 2010). The 90th percentile is also called the 10% 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:

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

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:

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

Where:

- *C_{lower} is the fecal coliform concentration corresponding to the percentile lower than the 90^{th} percentile (in this case, 450 counts/100mL).*
- *P_{90th} is the percentile difference between the 90^{th} percentile and the percentile number immediately lower than the 90^{th} percentile (in this case, 88%), or 90% – 88% = 2%.*
- *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 90^{th} percentile were identified (in this case, 88% and 91%, respectively) (**Table 5.5**). Next, the fecal coliform concentrations corresponding to the lower and upper percentile values were identified (450 and 1,200 counts/100mL, respectively) (**Table 5.5**). The fecal coliform concentration difference between the lower and higher percentiles was then calculated and divided by the unit percentile. The unit percentile difference is the difference between the lower and upper percentiles (e.g., 91% – 88% = 3 percentile unit difference). R was then calculated as R = (1,200 – 450) / (91% – 88%) = 250.

C_{lower}, P_{90th}, and *R* were substituted into **Formula 3** to calculate the 90^{th} percentile fecal coliform concentration (i.e., 90^{th} percentile concentration = 450 + (2*250) = 950 counts/100mL).

Using **Formula 1**, the percent reduction for the period of observation (January 1, 2003, to June 30, 2010) was calculated as 58% for Las Olas Isles (i.e., % reduction needed = [(950 –400) / 950]*100 = 58%).

Table 5.5 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 in the WBID to meet the applicable water quality criterion for fecal coliform.

Table 5.5. Calculation of Fecal Coliform Reduction for the Las Olas Isles (WBID 3226G4) TMDL Based on the Hazen Method

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

- = Empty cell/no data

Station	Date	Fecal Coliform Concentration (MPN/100mL)	Rank	Percentile by Hazen Method
21FLBROW49	2/23/2006	7	1	2%
21FLBROW49	4/23/2003	15	2	5%
21FLBROW49	3/4/2009	22	3	9%
21FLBROW49	2/21/2007	30	4	13%
21FLBROW49	5/14/2008	30	5	16%
21FLBROW49	5/5/2004	37	6	20%
21FLBROW49	8/6/2008	59	7	23%
21FLBROW49	2/24/2005	81	8	27%
21FLBROW49	8/22/2007	81	9	30%
21FLBROW49	11/17/2004	96	10	34%
21FLBROW49	8/10/2005	100	11	38%
21FLBROW49	10/28/2009	100	12	41%
21FLBROW49	2/11/2004	110	13	45%
21FLBROW49	2/6/2003	120	14	48%
21FLBROW49	5/16/2007	130	15	52%
21FLBROW49	6/8/2005	150	16	55%
21FLBROW49	6/24/2009	190	17	59%
21FLBROW49	8/24/2006	220	18	63%
21FLBROW49	8/13/2003	280	19	66%
21FLBROW49	6/1/2006	310	20	70%
21FLBROW49	2/20/2008	310	21	73%
21FLBROW49	2/3/2010	320	22	77%
21FLBROW49	9/2/2009	420	23	80%
21FLBROW49	12/1/2005	440	24	84%
21FLBROW49	**11/30/2006**	**450**	**25**	**88%**
21FLBROW49	**8/11/2004**	**1,200**	**26**	**91%**
21FLBROW49	11/15/2007	1,300	27	95%
21FLBROW49	11/6/2003	2,100	28	98%
-	-	-	**Existing condition concentration– 90th percentile (counts/100mL)**	**950**
-	-	-	**Allowable concentration (counts/100mL)**	**400**
-	-	-	**Final % reduction**	**58%**

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 Las Olas Isles 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 58% 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 district that are not part of the NPDES Stormwater Program (see **Appendix A**).

Table 6.1. TMDL Components for Fecal Coliform in Las Olas Isles (WBID 3226G4)

This is a six-column table. Column 1 lists the 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.

[1]N/A = Not applicable

Parameter	TMDL (counts/100mL)	WLA for Wastewater (counts/100mL)	WLA for NPDES Stormwater (% reduction)	LA (% reduction)	MOS
Fecal coliform	400	N/A[1]	58%	58%	Implicit

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

No NPDES-permitted wastewater facilities were identified within the Las Olas Isles WBID boundary.

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 58% reduction in current fecal coliform loading for WBID 3226G4. 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.

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 and technically feasible, and that 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 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.

References

Alderiso, K., D. Wait, and M. Sobsey. 1996. Detection and characterization of make-specific RNA coliphages in a New York City reservoir to distinguish between human and nonhuman sources of contamination. In*:* J.J. McDonnell *et al.* (Eds.), *Proceedings of a symposium on New York City water supply studies* (Herndon, VA: American Water Resources Association). TPS-96-2.

Broward County Department of Natural Resource Protection (BCDNRP). 1994. *Summary of bacteriological testing in the Las Olas Isles, July, 1993 through August, 1994.* Technical Report Series, TR 94-03.

———. 1995. *Summary of bacteriological testing in the Las Olas Isles, August, 1994 through August, 1995.* Technical Report Series, TR 95-02.

Broward County Department of Planning and Environmental Protection (BCDPEP). 2001. *Broward County, Florida historical water quality atlas: 1972–1997.* Technical Report Series, TR 01-03.

Broward County Planning and Redevelopment Division (BCPRD). August 2003. *Quick facts for Broward County*. Urban Planning and Redevelopment, Planning Services Division. Available: http://www.broward.org/PlanningAndRedevelopment/DemographicsAndEconomics/Documents/bbtn2.pdf.

Broward County Natural Resources Planning and Management Division (BCNRPMD). November 2009. *Broward county-wide integrated water resources plan report*. Water Policy and Planning Program. Available: http://www.broward.org/IWRP/Documents/IntegratedWaterResourcePlan.pdf.

City of Fort Lauderdale. 2008. *City of Fort Lauderdale Comprehensive Plan (Ordinance C-08-18) Volume II – Capital improvements element*. Planning and Zoning Department. Available: http://ci.ftlaud.fl.us/documents/compplan/compplan_vol2_capital.pdf.

Culver, T.B., Y. Jia, R. TiKoo, J. Simsic, and R. Garwood. 2002. *Development of the Total Maximum Daily Load (TMDL) for fecal coliform bacteria in Moore's Creek, Albemarle County, Virginia.* Virginia Department of Environmental Quality.

Fish, J.E. 1988. *Hydrogeology, aquifer characteristics, and ground-water flow of the surficial aquifer system, Broward County, Florida*. U.S. Geological Survey Water-Resources Investigations Report 87-4034.

Florida Administrative Code. *Rule 62-302, Surface water quality standards.*

———. *Rule 62-303, Identification of impaired surface waters.*

Florida Department of Environmental Protection (FDEP). February 2001. *A report to the Governor and the Legislature on the allocation of Total Maximum Daily Loads in Florida.* Tallahassee, FL: Bureau of Watershed Management.

Florida Watershed Restoration Act. *Chapter 99-223, Laws of Florida.*

Hoffmeister, J.E., K.W. Stockman, and H.G. Multer. 1967. Miami limestone of Florida and its recent Bahamian counterpart. *Geological Society of America Bulletin 78*.

Hunter, P.R. 2002. Does calculation of the 95th percentile of microbiological results offer any advantage over percentage exceedance in determining compliance with bathing water quality standards? *Applied Microbiology* (34): 283–286.

Jamieson, R.C., D.M. Joy, H. Lee, R. Kostaschuk, and R.J. Gordon. 2005. Resuspension of sediment-associated Escherichia coli in a natural stream. *Journal of Environmental Quality* (34): 581–589.

Lim, S., and V. Olivieri. 1982. *Sources of microorganisms in urban runoff.* Johns Hopkins School of Public Health and Hygiene. Baltimore, MD: Jones Falls Urban Runoff Project.

Miller, J.A. 1990. *Ground water atlas of the United States: Alabama, Florida, Georgia, and South Carolina.* HA 730-G. U.S. Geological Survey. Available: http://pubs.usgs.gov/ha/ha730/ch_g/index.html.

Minnesota Pollution Control Agency. 1999. *Effect of septic systems on ground water quality.* Ground Water and Assessment Program. Baxter, MN.

Schroeder, M.C., H. Klein, and N.D. Hoy. 1956. *Biscayne aquifer in Dade and Broward Counties, Florida.* Florida Geological Survey Report of Investigations 17. Tallahassee, FL.

South Florida Water Management District (SFWMD) website. 2010. *DBHYDRO database.* Available: http://www.sfwmd.gov/dbhydroplsql/show_dbkey_info.main_menu.

Trial, W. *et al.* 1993. Bacterial source tracking: studies in an urban Seattle watershed. *Puget Sound Notes 30: 1-3.*

U.S. Census Bureau. 2000. Available: http://www.census.gov/.

U.S. Environmental Protection Agency (EPA). 1993. *Management measures for marinas and recreational boating.* Available: http://www.epa.gov/owow/NPS/MMGI/Chapter5/ch5-1.html#Pathogen.

———. January 2001. *Protocol for developing pathogen TMDLs*. EPA 841-R-00-002. Washington, DC: Office of Water.

———. 2010. *Sewage from recreational activities.* Fact sheet. Available: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=27&minmeasure=3

van der Wel, B. 1995. Dog pollution. *The Magazine of the Hydrological Society of South Australia* 2(1) 1.

Watson, T. June 6, 2002. Dog waste poses threat to water. *USA Today.*

Weiskel, P.K., B.L. Howes, and G.R. Heufflder. 1996. Coliform contamination of a coastal embayment: S ources and transport pathway. *Environmental Science and Technology* 1872–1881.

Whitman, D. 1997. *Notes on the geology and water resources of south Florida.* Miami, FL: Florida International University. Available: http://www2.fiu.edu/~whitmand/Courses/Fl_geo_notes.html.

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 Permit 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. They 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 Las Olas Isles WBID boundary. Studies report that up to 95% 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% of American dog owners do not pick up their dogs' feces. The number of dogs within the Las Olas Isles 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) 2009 cadastral tax parcel and ownership coverage contained in the Department's GIS library, residential parcels were identified using DOR's land use codes. The number of households within the Las Olas Isles WBID boundary was estimated to be approximately 1,651. Assuming that 40% of the households in this area have 1 dog, there are about 660 dogs within the WBID.

Assuming that 40% of dog owners do not pick up their dogs' feces, the total waste produced by dogs and left on the land surface of residential areas in the WBID is approximately 118,872 grams/day. The total load produced by dogs is about 2.62×10^{11} 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 the 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

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% of the total raw sewage (Culver *et al.* 2002) created within the WBID by the households connected to the sewer system.

The number of properties connected to the sewer system was based on data obtained from FDOH's ongoing inventory of wastewater treatment and disposal methods for developed properties. Using information from DOR's 2009 cadastral tax parcel and ownership coverage, residential parcels were identified using DOR's land use codes. The final number of households within the WBID boundary was calculated by adding the number of residential units on the parcels for all improved residential land use codes. As a result, it was estimated that 1,651 housing units within the Las Olas Isles WBID boundary are served by sewer systems (**Figure B.1**).

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% (Culver *et al.* 2002). Based on this assumption, a rough estimate of fecal coliform loads from leaks and SSOs within the Las Olas Isles WBID boundary can be made using **Equation B.1.**

$$L = 37.85 * N * Q * C * F \qquad \text{Equation B.1}$$

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).

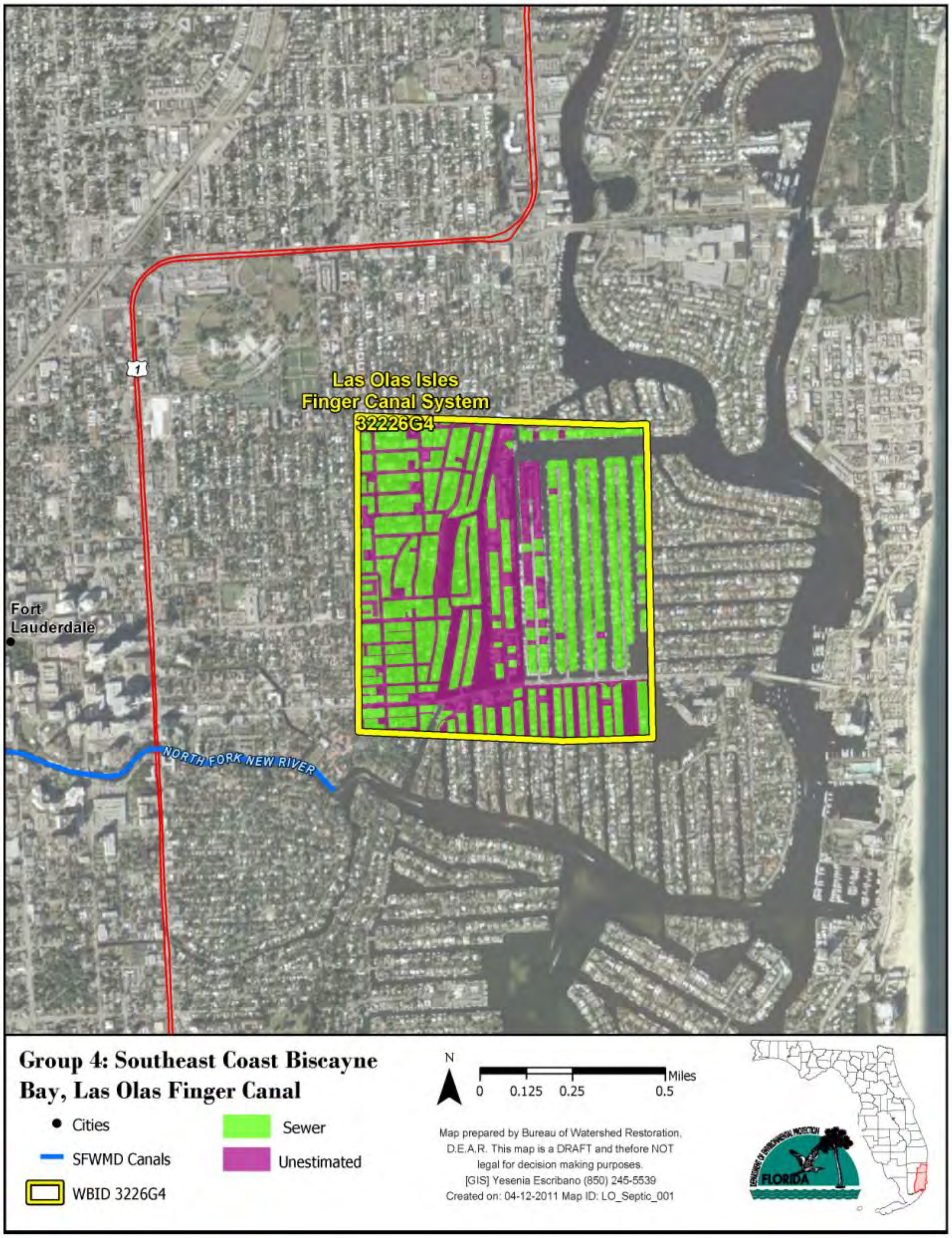

Figure B.1. Distribution of Sanitary Sewers in the Residential Land Use Areas within the Las Olas Isles Watershed (WBID 3226G4) Boundary

The number of households *(N)* within the Las Olas Isles WBID boundary served by sewer systems is estimated to be 1,651. The discharge rate through sewers from each household (*Q*) was calculated by multiplying the average household size for the city of Fort Lauderdale (2.14) (U.S. Census Bureau 2000) by the per capita wastewater production rate per day (70 gallons/day/person). The commonly cited concentration (*C*) for domestic wastewater is $1x10^6$ counts/100mL for fecal coliform (EPA 2001). The contribution of fecal coliform through sewer line leakage was assumed to be 0.5% of the total sewage loading created from the population not on septic tanks (Culver *et al.* 2002). Based on **Equation B.1**, the fecal coliform loading from sewer line leakage in the WBID is approximately 4.68×10^{10} counts/day.

Septic Tanks

Based on information obtained from the Broward County Environmental Atlas Sewer Service map and information from FDOH onsite sewage data, all housing units within the Las Olas Isles WBID boundary are served by sewer systems.

Wildlife

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

Florida Department of Environmental Protection
Division of Environmental Assessment and Restoration
Bureau of Watershed Restoration
2600 Blair Stone Road
Tallahassee, FL 32399-2400