FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
Division of Environmental Assessment and Restoration, Bureau of Watershed Restoration

SOUTHEAST DISTRICT • LAKE WORTH LAGOON–PALM BEACH COAST BASINS

Final
TMDL Report

Fecal Coliform TMDL for the E-1 Canal (WBID 3264A)

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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

STORET Program

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

2008 Integrated Report

http://www.dep.state.fl.us/water/docs/2008_Integrated_Report.pdf

Surface Water Quality Standards

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

Basin Status Report: Lake Worth Lagoon–Palm Beach Coast
http://www.dep.state.fl.us/water/basin411/lwl_pbc/status.htm

Water Quality Assessment Report: Lake Worth Lagoon–Palm Beach Coast
http://www.dep.state.fl.us/water/basin411/lwl_pbc/assessment.htm

U.S. Environmental Protection Agency

Region 4: Total Maximum Daily Loads 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 E-1 Canal, located in the Lake Worth Lagoon–Palm Beach Coast Basins. The freshwater stream was verified as impaired for fecal coliform, and therefore was included on the Verified List of impaired waters for the Lake Worth Lagoon–Palm Beach Coast Basins that was adopted by Secretarial Order on January 15, 2010. The TMDL establishes the allowable fecal coliform loading to the E-1 Canal 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 Lake Worth Lagoon–Palm Beach Coast Basins into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. The E-1 Canal is WBID 3264A.

1.2.1 The Unique Nature of South Florida Canals[1]

Developed over the past 100 years, the canal-based water management system in south Florida is one of the world's largest and most complex civil works projects. The South Florida Water Management District (SFWMD) uses over 1,300 water control structures, 64 pump stations, and 2,600 miles of canals to provide flood control, water supply, navigation, water quality improvements, and environmental management.

Canals are built to meet human needs by controlling the water levels and the movement of water from one place to another for water supply, flood control, drainage, and navigation, as well as to provide water needed to sustain natural communities in lakes, rivers, wetlands, and estuaries. One of the primary functions of a canal is to control water levels in order to maintain ground water levels in dry conditions. This is particularly important for water supply needs such as preventing saltwater intrusion. Canals also provide a conduit to remove excess water from drainage basins in wet periods to prevent flooding. They differ greatly in their design, construction, and operation. Canal operations depend primarily on their location, intended function, adjacent land use, and development within the basin.

Water quality in canals is affected by tributary sources, surrounding soil types, topography, ground water interaction, and adjacent land use. In some areas water quality is strongly influenced by ground water seepage. Sediments (soil types) are also known to affect water quality. The soil types surrounding south Florida canals range from the sandy upland soils of the Atlantic Coastal Ridge to the hydric sands, marls, and peats of the Everglades. Topography differs across south Florida, resulting in differences in canal depths, water levels, and flow rates. Water elevations in canals can range from less than 10 feet above sea level to 20 to 60 feet above sea level. Water quality varies greatly among regions of south Florida, individual canals within regions, and sections of the same canal. Compared with natural stream systems that are periodically disturbed through natural processes (such as droughts, fires, floods, and hurricanes), canals are disturbed almost continually by human activities for maintenance,

[1] SFWMD 2010.

including herbicide treatment, mowing, dredging, removing obstructions, and mechanical harvesting.

As artificial conveyances with large variations in flow, stage, and water turnover, canals provide less stable and predictable environments than natural stream systems. South Florida canals must convey large volumes of water during storm events. At the other extreme, during droughts and dry season operations, canals may become stagnant for long periods, with little to no water movement, and water may be absent from some canals.

1.2.2 The E-1 Canal

The area of the E-1 Canal watershed encompasses 12,982 acres. The predominant land uses are approximately 6,807 acres of urban and built-up, 2,107 acres of wetlands, and 1,801 acres of agriculture. The canal is located in Palm Beach County (see **Figures 1.1** and **1.2**).

The climate in Palm Beach County, specifically areas surrounding the E-1 Canal watershed, is subtropical, with annual rainfall averaging approximately 60.27 inches, although rainfall amounts can vary greatly from year to year (Southeast Regional Climate Center [SERCC] 2010). Based on data over a 30-year period (1971–2000), the average summer temperature is 91.0^{o}F, and the average winter temperature is 76.3^{o}F (SERCC 2010).

The physiography of the E-1 Canal watershed reflects its location within the Miami Ridge/Atlantic Coastal Strip or Southern Florida Coastal Plains ecoregion. Elevations range from 15 to 20 feet above sea level (Department 2010). The maintained canal elevation for the E-1 Canal is 16.0 feet National Geodetic Vertical Datum (NGVD). Multiple soil types are present within the watershed. Towards the east, the predominant soil type is shelly sand and clay and limestone (Department 2008). Towards the west, near Water Conservation Area 1 (WCA1) or the Loxahatchee Wildlife Refuge, the predominant soil type is peat.

There are several major population centers in the watershed, including the Hamptons at Boca Raton, Sandalfoot Cove, Whisper Walk, and Mission Bay.

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, 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 E-1 Canal. These activities will depend heavily on the active participation of the 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.

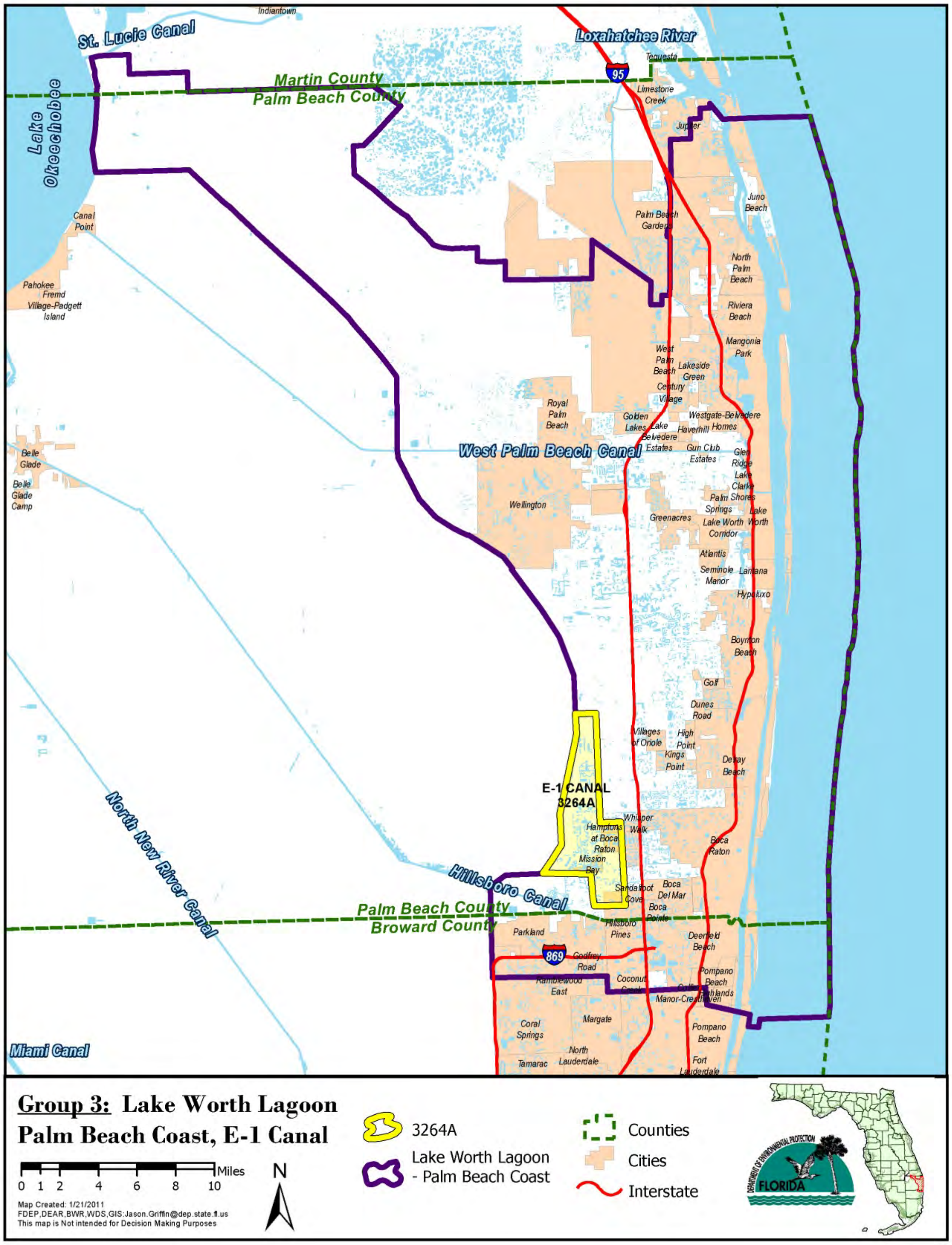


Figure 1.1. Location of the E-1 Canal (WBID 3264A) Watershed in the Lake Worth Lagoon–Palm Beach Coast Basins and Major Hydrologic and Geopolitical Features in the Area

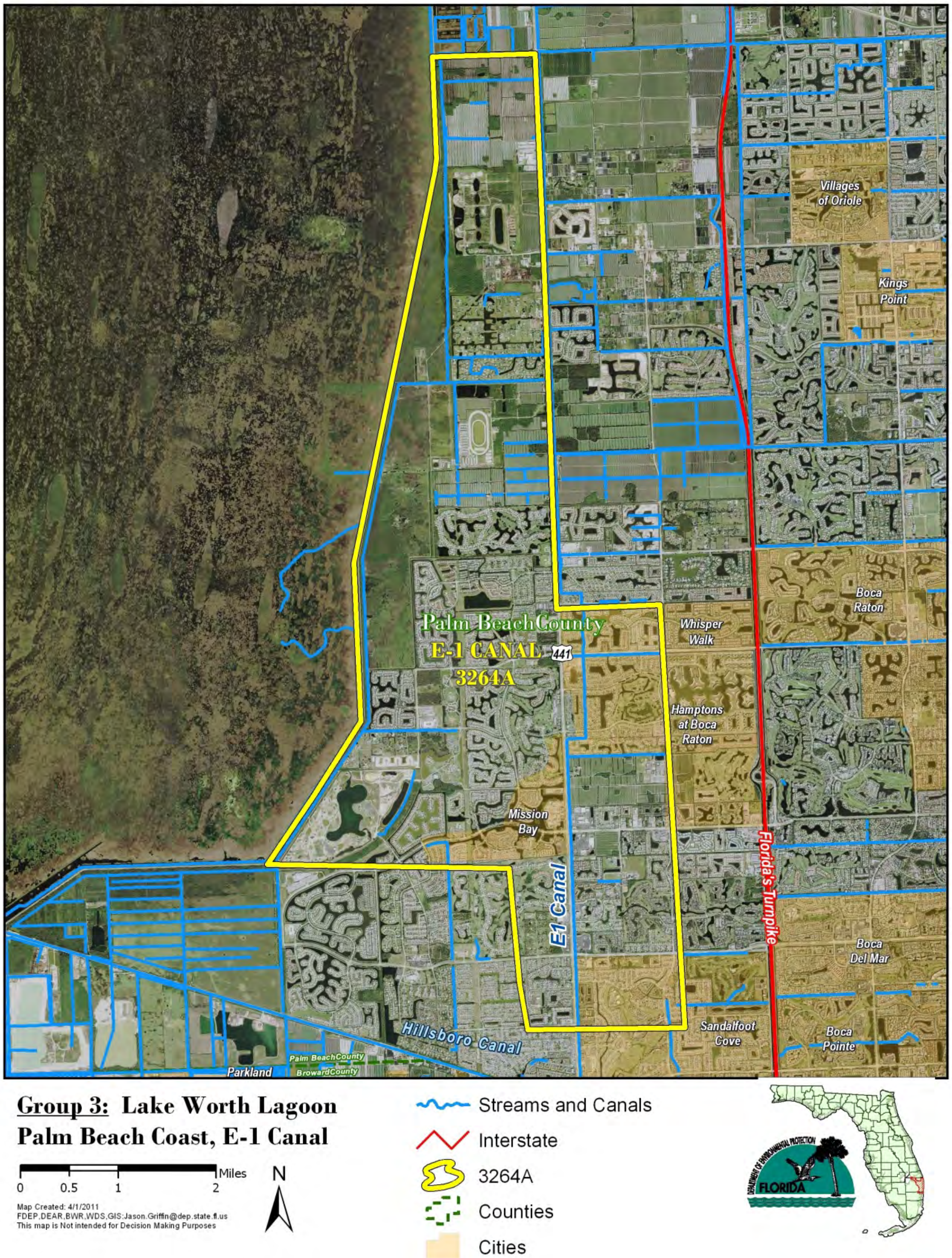


Figure 1.2. Location of the E-1 Canal (WBID 3264A) Watershed in Palm Beach County and Major Geopolitical and Hydrologic Features in the Area

Chapter 2: DESCRIPTION OF WATER QUALITY PROBLEM

2.1 Statutory Requirements and Rulemaking History

Section 303(d) of the federal Clean Water Act requires states to submit to the U.S. Environmental Protection Agency (EPA) lists of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing 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's 1998 303(d) Consent Decree list included 16 waterbodies in the Lake Worth Lagoon–Palm Beach Coast Basins. The E-1 Canal was one of the waterbodies listed on the 1998 303(d) list. 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 E-1 Canal and has verified that this waterbody segment is impaired for fecal coliform bacteria based on data collected during the Cycle 2 verified period (January 1, 2002–June 30, 2009). Using the IWR methodology, this waterbody was verified impaired for fecal coliform because more than 10% of the values exceeded the Class III waterbody criterion of 400 counts per 100 milliliters (counts/100mL) for fecal coliform. There were 5 exceedances out of 19 samples. **Table 2.1** summarizes the fecal coliform monitoring results for the Cycle 2 verified period for the E-1 Canal.

To ensure that the fecal coliform TMDL was developed based on current conditions in the canal and that recent trends in the canal's water quality were adequately captured, monitoring data collected from January 1, 2002, to June 30, 2009, were used to develop the TMDL. The data were primarily collected during 2003 and 2008. **Table 2.1** indicates that fecal coliform concentrations exceeding the criterion of 400 counts/100mL have been observed in the E-1 Canal.

Table 2.1. Summary of Fecal Coliform Monitoring Data for the E-1 Canal (WBID 3264A) During the Cycle 2 Verified Period (January 1, 2002–June 30, 2009)

- = Empty cell/no data

Waterbody (WBID)	Parameter	Fecal Coliform Cycle 2
E-1 Canal (3240G)	Total number of samples	19
E-1 Canal (3240G)	IWR-required number of exceedances for the Verified List	5
E-1 Canal (3240G)	Number of observed exceedances	5
E-1 Canal (3240G)	Number of observed nonexceedances	14
E-1 Canal (3240G)	Number of seasons during which samples were collected	4
E-1 Canal (3240G)	Highest observation (counts/100 mL)	13,500
E-1 Canal (3240G)	Lowest observation (counts/100 mL)	4
E-1 Canal (3240G)	Median observation (counts/100 mL)	74
E-1 Canal (3240G)	Mean observation (counts/100 mL)	1,615
-	**FINAL ASSESSMENT**	**Impaired**

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 E-1 Canal is a Class III fresh waterbody (IIIF), 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 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 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 the TMDL was not to exceed 400 counts/100mL in 10% of the samples.

The Department believes that the implementation of the percent reduction through best management practices (BMPs) required by this TMDL will improve water quality in the canal to meet the water quality criterion. Continued monitoring and assessment efforts by the Department and local stakeholders will provide the data and information necessary to demonstrate whether the canal has been fully restored.

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 E-1 Canal WBID Boundary

4.2.1 Point Sources

Wastewater Point Sources

There are no NPDES-permitted facilities located within the E-1 Canal WBID boundary.

Municipal Separate Storm Sewer System Permittees

Two NPDES municipal separate storm sewer system (MS4) permits cover the E-1 Canal watershed: Florida Atlantic University (Phase II FLR04E094), and Palm Beach County and Co-permittees (Phase I FLS000018), which includes the Florida Department of Transportation (FDOT) Turnpike District/District 4. The stormwater outfalls that discharge to the E-1 Canal are a combination of MS4 permitted and privately owned (non-MS4) outfalls.

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. For a watershed dominated also by rangeland, fecal coliform loadings can come from the runoff from areas with animal feeding operations or direct animal access to the receiving waters.

In addition to the sources associated with anthropogenic activities, birds and other wildlife can also act as fecal coliform contributors to the 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 E-1 Canal WBID boundary were aggregated using the simplified Level 1 codes and tabulated in **Table 4.1**. **Figure 4.1** shows the spatial distribution of the principal land uses.

As shown in **Table 4.1**, the total area within the WBID boundary is about 12,982 acres. The predominant land uses are approximately 6,807 acres (52.4%) of urban and built-up, including low-, medium-, and high-density residential; 2,107 acres (16.2%) of wetlands; and 1,801 acres (13.8%) of agriculture.

Table 4.1. Classification of Land Use Categories within the E-1 Canal (WBID 3264A) Boundary, 2004–05

- = Empty cell/no data

Level 1 Code	Land Use	Acreage	% Acreage
1000	Urban and built-up	2,080	16.02%
1100	Low-density residential	649	5.00%
1200	Medium-density residential	3,004	23.14%
1300	High-density residential	1,075	8.28%
2000	Agriculture	1,801	13.87%
3000	Rangeland	46	0.35%
4000	Upland forest	299	2.30%
5000	Water	1,225	9.44%
6000	Wetland	2,107	16.23%
7000	Barren land	207	1.59%
8000	Transportation, communication, and utilities	489	3.77%
-	**TOTAL**	**12,982**	**100%**

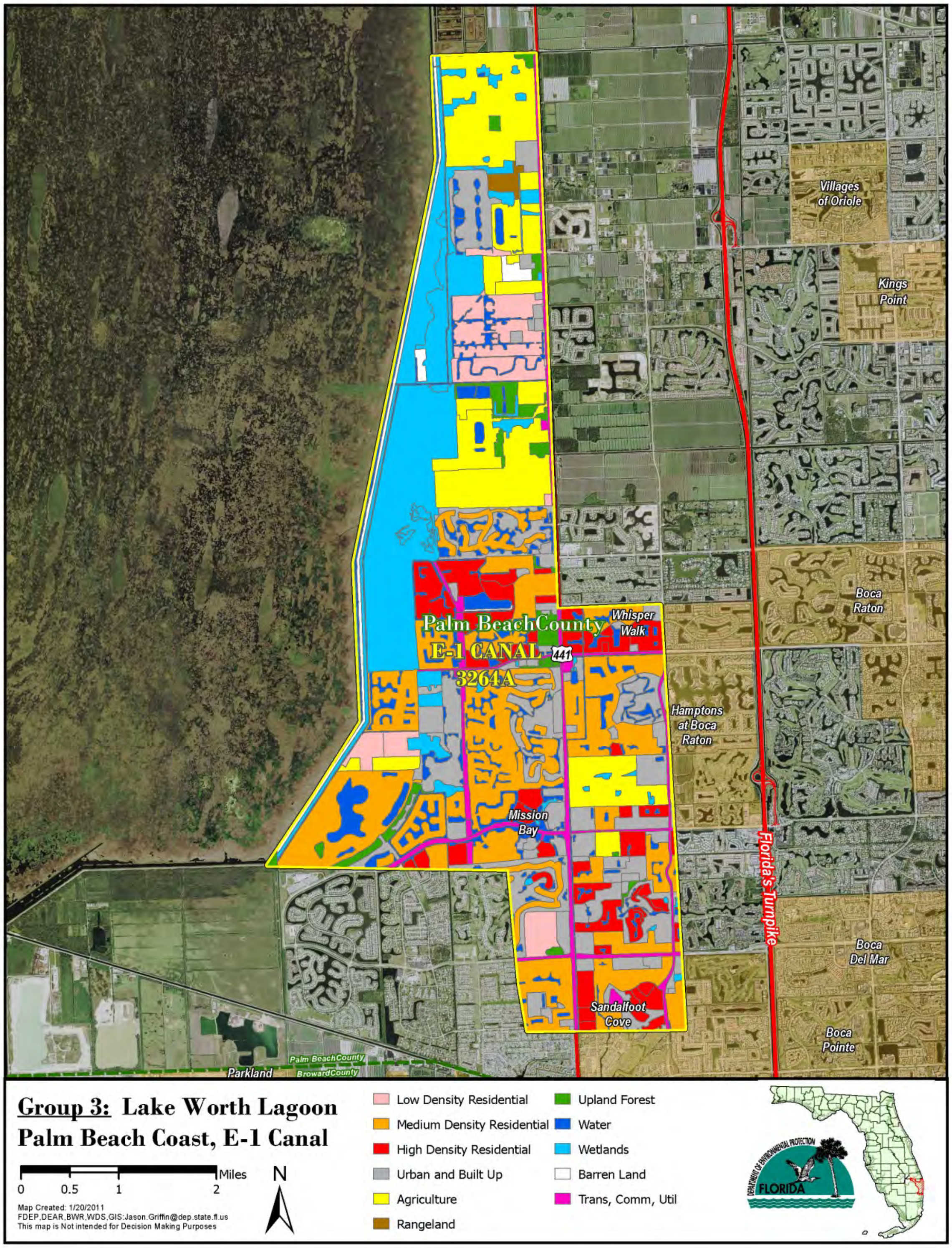


Figure 4.1. Principal Land Uses within the E-1 Canal (WBID 3264A) Watershed Boundary, 2004–05

Sources of Fecal Coliform Loads

In the E-1 Canal watershed, agricultural land use consists of field or row crop production, citrus groves, nurseries, or pasture. The most likely source of fecal coliform loadings from pastureland is from animal feeding operations or direct animal access to the canal. Failed septic tanks, septic tanks located in sand and gravel sediment types, and pet feces may also contribute fecal coliform loadings.

In addition, sanitary sewer overflows (SSOs) can also be a potential source of fecal bacteria pollution. Human sewage can be introduced into surface waters through collection system overflows and leaks. These 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. A large homeless encampment located at State Road (SR) 7/441 and Glades Road may also contribute to fecal coliform loads. Wildlife is another possible source of fecal coliform bacteria; however, the bacterial load from naturally occurring wildlife is assumed to be background.

A preliminary quantification of the fecal coliform loadings from pet feces, septic tanks, and SSOs 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 the appendix has been only used to demonstrate the possible relative contributions from different sources. The loading estimates have not been used in establishing the final TMDL.

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, which was developed by the Kansas Department of Health and Environment and provides daily bacteria load. However, flow data were not available for the E-1 Canal; therefore, the fecal coliform TMDL was developed using the "percent reduction" approach. Using the "percent reduction" 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, 2002–June 30, 2009).

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 EPA Region 4 uses this method to develop fecal coliform TMDLs. The percent reduction of fecal coliform needed to meet the applicable criterion was calculated as described in **Section 5.1.3**.

5.1.1 Data Used in the Determination of the TMDL

Data used to develop this TMDL were provided by the Department's Southeast District Office (Stations: 21FLWPB 28010587, 21FLWPB 28010588, 21FLWPB 28010589, and 21FLWPB32008020) and the Department's (Stations: 21FLGW 18842 and 21FLGW 18843). **Figure 5.1** shows the locations of the water quality stations where fecal coliform data were collected for the E-1 Canal. The majority of the data was collected in 2003 and 2008.

This analysis focuses on fecal coliform data collected from January 1, 2002, to June 30, 2009. During this period, 19 fecal coliform samples were collected from 6 sampling stations in the WBID. Concentrations ranged from 4 to 13,500 counts/100mL, with a median value of 74 counts/100mL, and averaged 1,615 counts/100mL during this period. **Table 5.1** summarizes the descriptive statistics for the fecal coliform results collected during the Cycle 2 verified period (January 1, 2002–June 30, 2009. **Figure 5.2** shows the temporal trends in fecal coliform concentrations observed in the E-1 Canal.

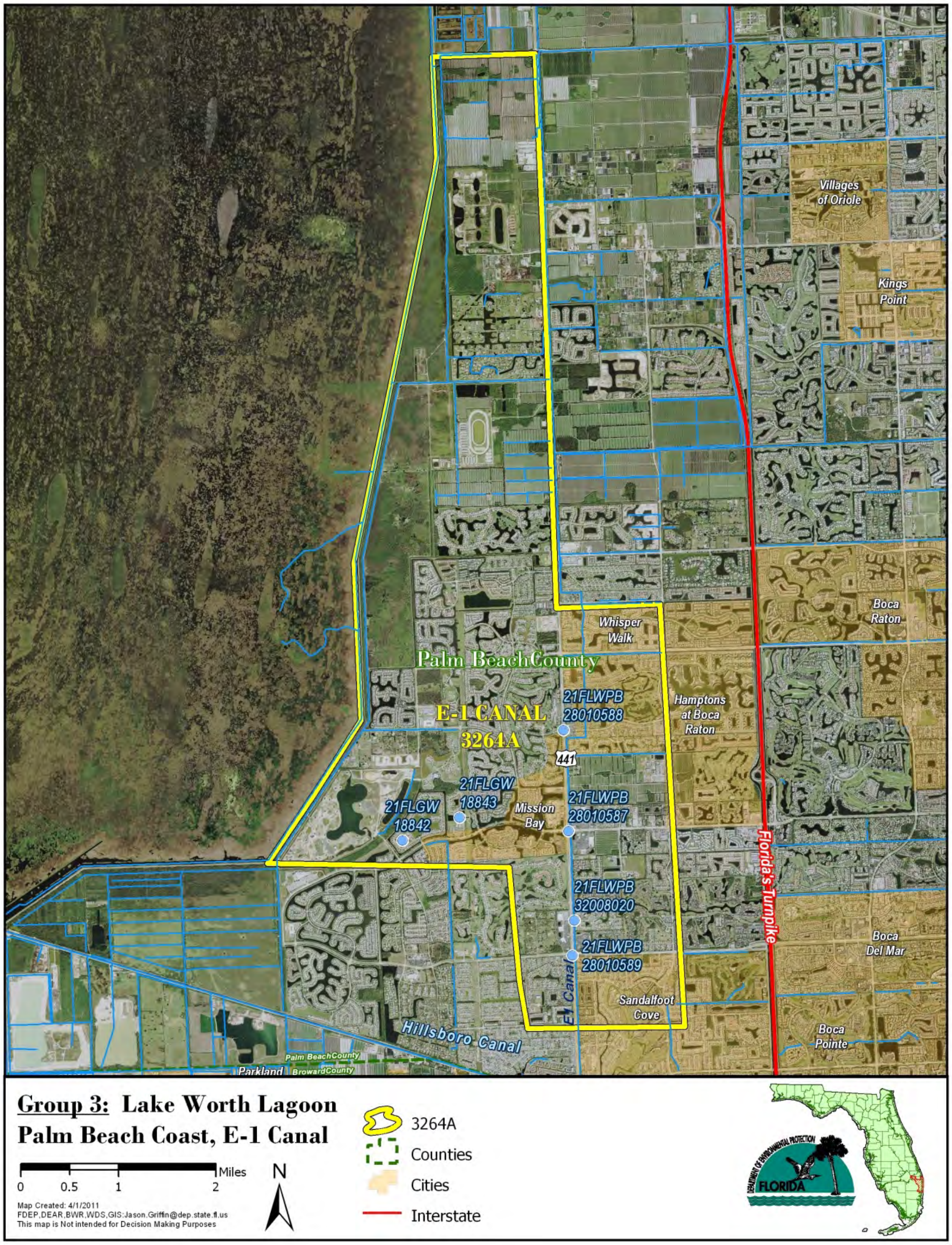
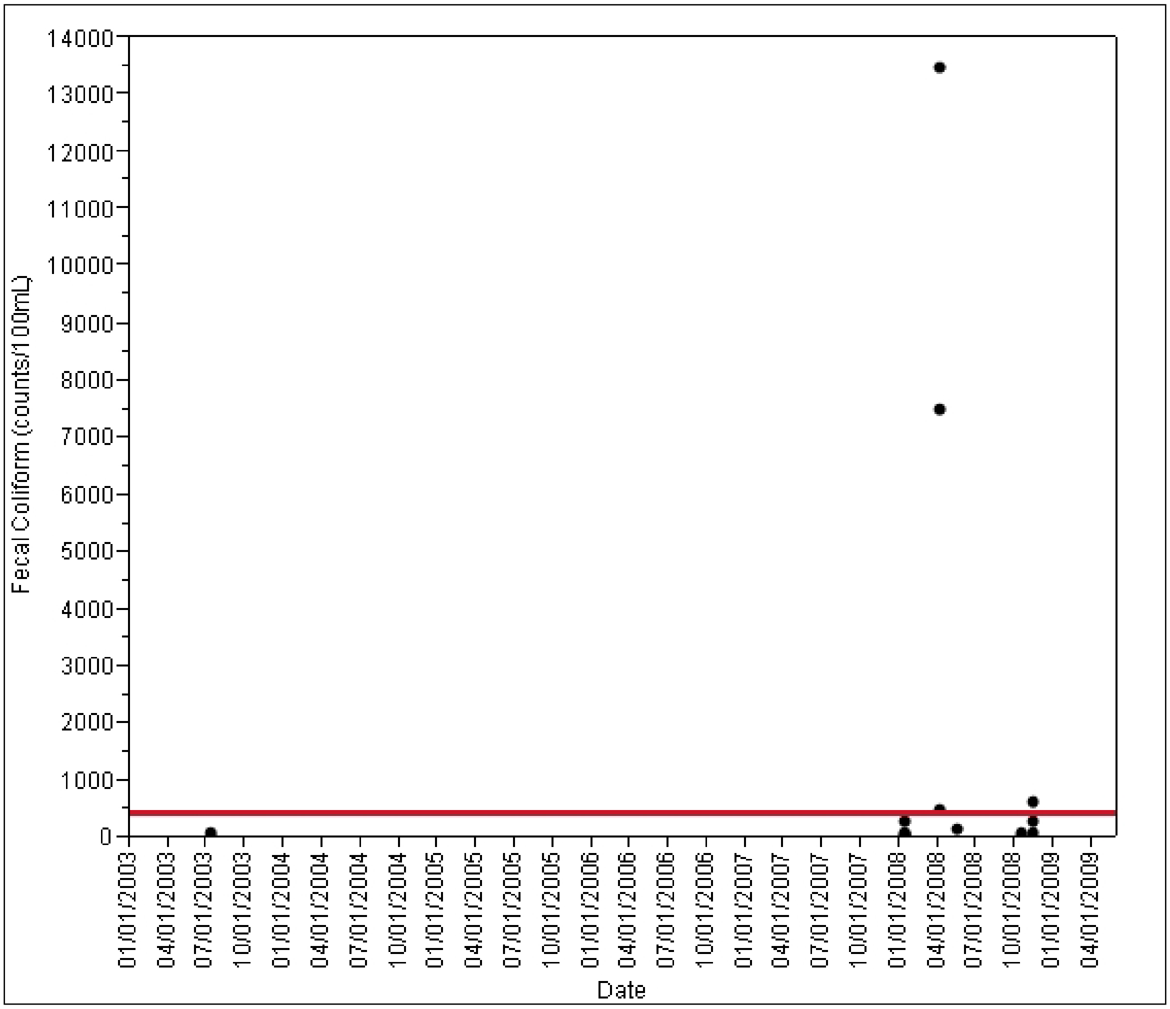


Figure 5.1. Location of Water Quality Stations with Fecal Coliform Data in the E-1 Canal (WBID 3264A)

Table 5.1. Descriptive Statistics of Fecal Coliform Data for the E-1 Canal (WBID 3264A) for the Cycle 2 Verified Period (January 1, 2002–June 30, 2009)

Descriptive Statistic	Result
Mean observation (counts/100mL)	1,615
Median observation (counts/100mL)	74
Highest observation (counts/100mL)	13,500
Lowest observation (counts/100mL)	4
25% quartile	20
75% quartile	460
Number of samples	19



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

Figure 5.2. Fecal Coliform Concentration Trends in the E-1 Canal (WBID 3264A), 2002–09

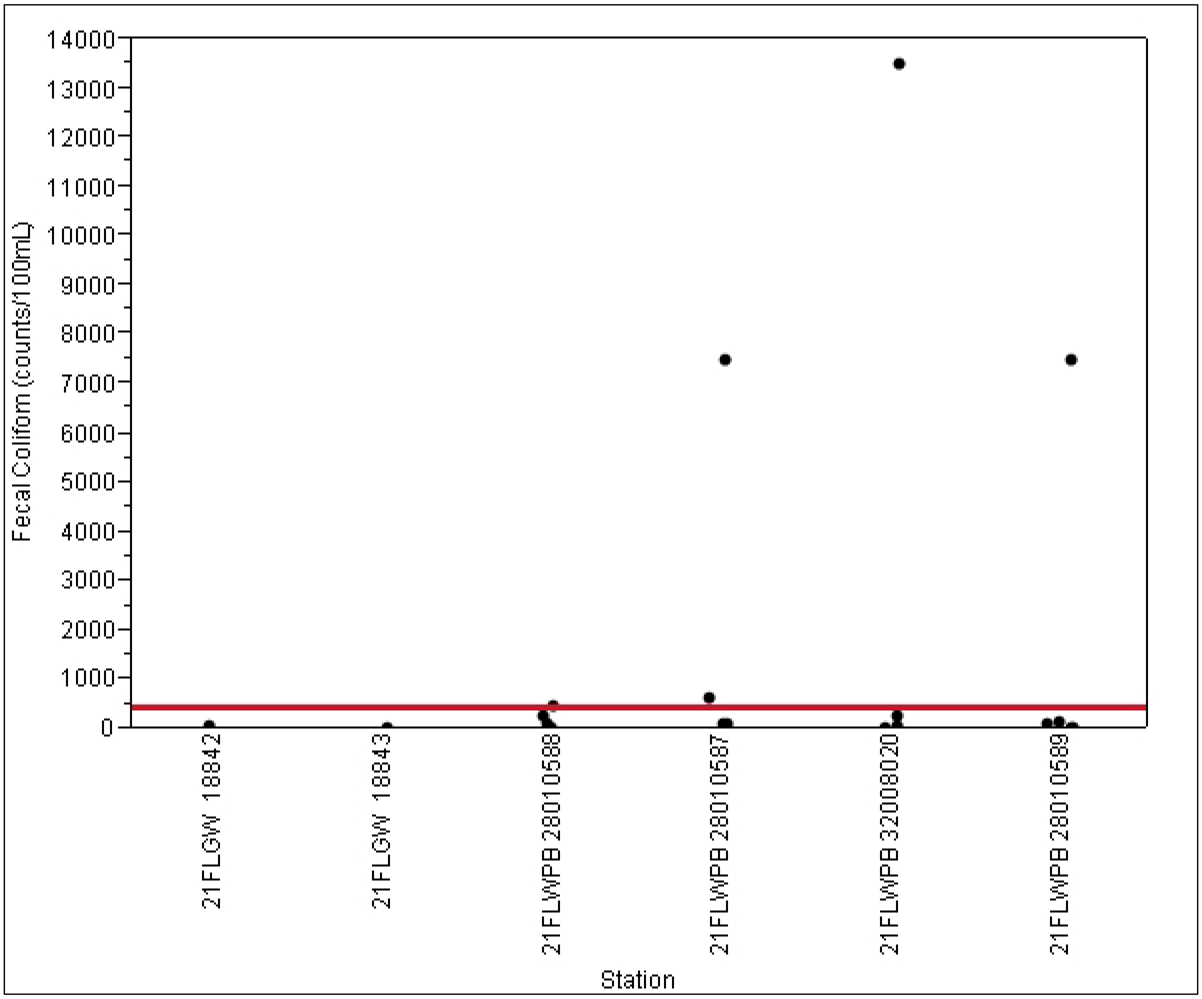
Spatial Patterns

Fecal coliform data from water quality sampling stations for the Cycle 2 verified period (January 1, 2002–June 30, 2009) were analyzed to detect spatial trends (**Figure 5.3** and **Table 5.2**). The data were collected in 2003 and 2008. During this period, 4 of 6 water quality stations exceeded the fecal coliform criterion of 400 counts/100mL: Stations 21FLWPB28010587, 21FLWPB28010588, 21FLWPB28010589, and 21FLWPB32008020. In particular, Station 21FLWPB28010587 had the highest fecal coliform exceedance rate (50%), and Station 21FLWPB32008020 had the highest fecal coliform concentration (13,500 counts/100mL). Land use surrounding these stations is primarily urban and built-up (**Figure 5.4**).

Table 5.2. Station Summary Statistics of Fecal Coliform Data for the E-1 Canal (WBID 3264A) During the Cycle 2 Verified Period (January 1, 2002–June 30, 2009)

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

Station	Period of Observation	Number of Samples	Minimum[1]	Maximum[1]	Mean[1]	Median[1]	Number of Exceedances[2]	% Exceedances
21FLGW 18842	2003	1	58	58	58	58	0	0%
21FLGW 18843	2003	1	6	6	6	6	0	0%
21FLWPB 28010587	2008	4	74	7,500	2,068	349	2	50%
21FLWPB 28010588	2008	4	14	460	200	164	1	25%
21FLWPB 28010589	2008	5	4	7,500	1,545	66	1	20%
21FLWPB 32008020	2008	4	20	13,500	3,453	147	1	25%



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

Figure 5.3. Fecal Coliform Concentration Trends in the E-1 Canal (WBID 3264A) During the Cycle 2 Verified Period (January 1, 2002–June 30, 2009)

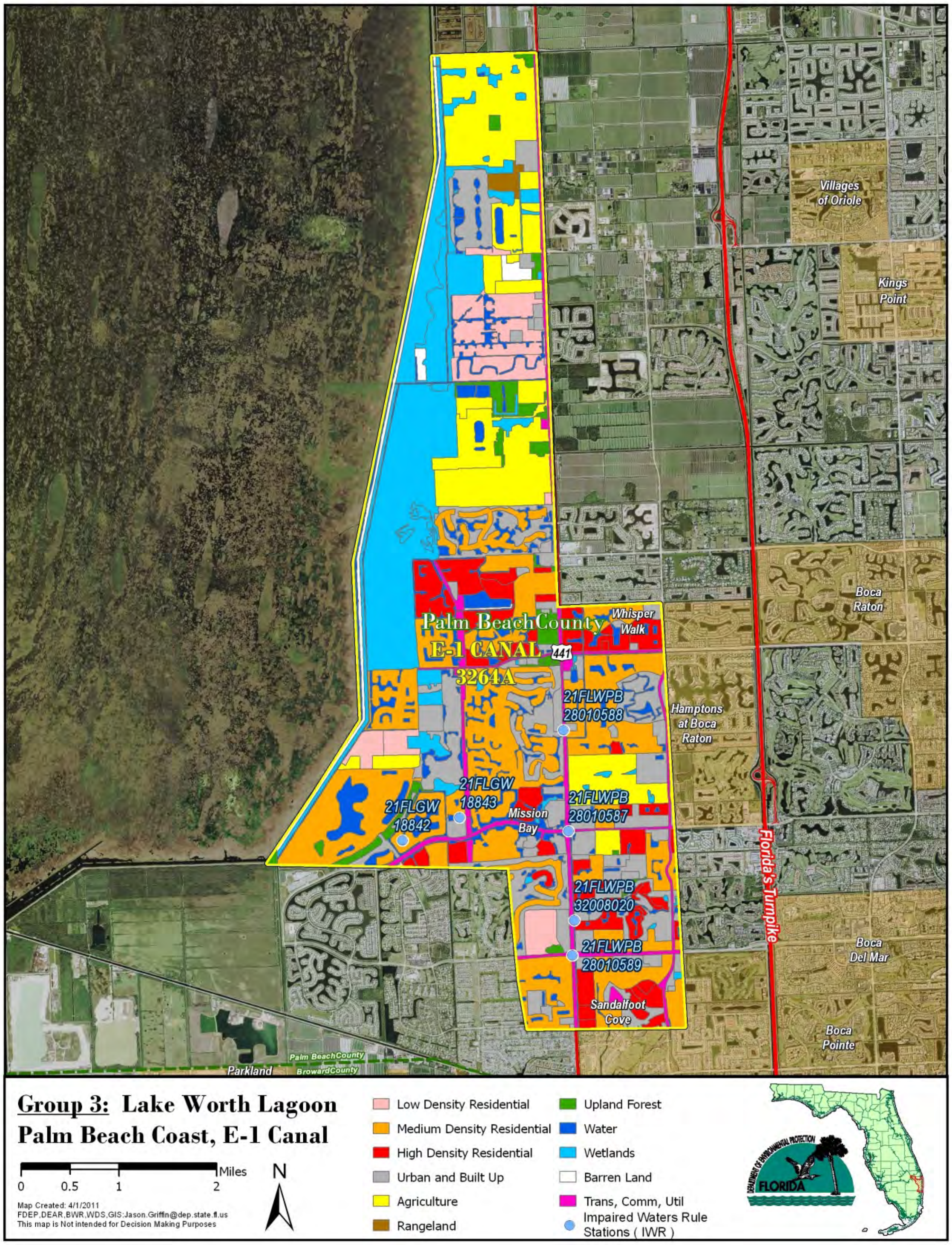


Figure 5.4. Location of Water Quality Stations with Fecal Coliform Data and Surrounding Land Uses in the E-1 Canal (WBID 3264A) Watershed

Temporal Patterns

Monthly and Seasonal Trends

Using rainfall data collected at the CLimate Information for Management and Operational Decisions (CLIMOD) station located in Loxahatchee, Florida (085152) (available: http://climod.meas.ncsu.edu/), it was possible to compare monthly rainfall from 2002 to 2009 with monthly fecal coliform exceedance rates for the same period, as well as average quarterly rainfall with average quarterly fecal coliform exceedance rates (**Figures 5.5** and **5.6**).

High fecal coliform concentrations exceeding the fecal coliform criterion of 400 counts/100mL were observed in April and November. However, data were only available for 6 months out of the entire year. Fecal coliform data were collected in January, April, May, July, October, and November. It should be noted that on April 7, 2008, the highest fecal coliform concentrations were observed (Station 21FLWPB 28010588 = 460 counts/100mL, Station 21FLWPB28010587 = 7,500 counts/100mL, Station 21FLWPB32008020 = 13,500 counts/100mL, and Station 21FLWPB28010589 = 7,500 counts/100mL). The monthly average rainfall for April was 2.74 inches. On April 7, 2008, within the E-1 Canal watershed, the 3-day precipitation accumulation was 4.55 inches.

Conversely, high fecal coliform concentrations were also observed during medium precipitation events within the watershed. For example, Station 21FLWPB28010587 had a fecal coliform concentration of 616 counts/100mL on November 13, 2008. The 3-day precipitation accumulation for that date was 1.42 inches. The elevated fecal coliform counts appear to be rainfall driven based on the limited data available. **Tables 5.3a** and **5.3b** summarize monthly and seasonal fecal coliform averages and percent exceedances, respectively, for the data collected from 2002 to 2009**.**

Period-of-Record trend

The period of record for the E-1 Canal is from 1986 to 2008. Plotting the historical fecal coliform data over time revealed a slight increasing trend. In 2008, fecal coliform concentrations exceeded 7,000 counts/100mL. Prior to 2008, they ranged from 1 to 1,000 counts/100mL (see **Figure 5.7**). The range of fecal coliform concentration data has not significantly differed from 1986 to 2010.

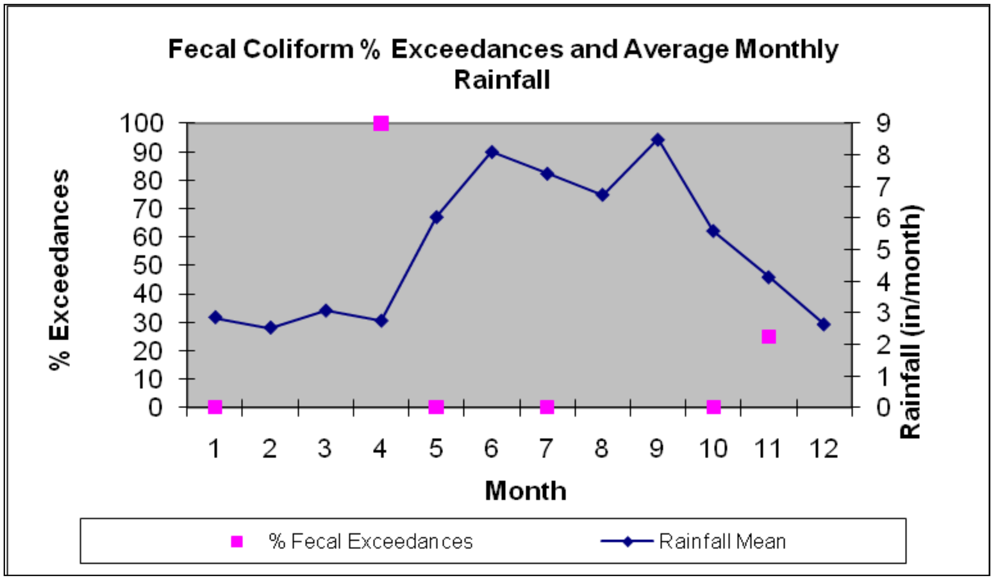


Figure 5.5. Fecal Coliform Exceedances and Rainfall in the E-1 Canal (WBID 3264A) by Month During the Cycle 2 Verified Period (January 1, 2002–June 30, 2009)

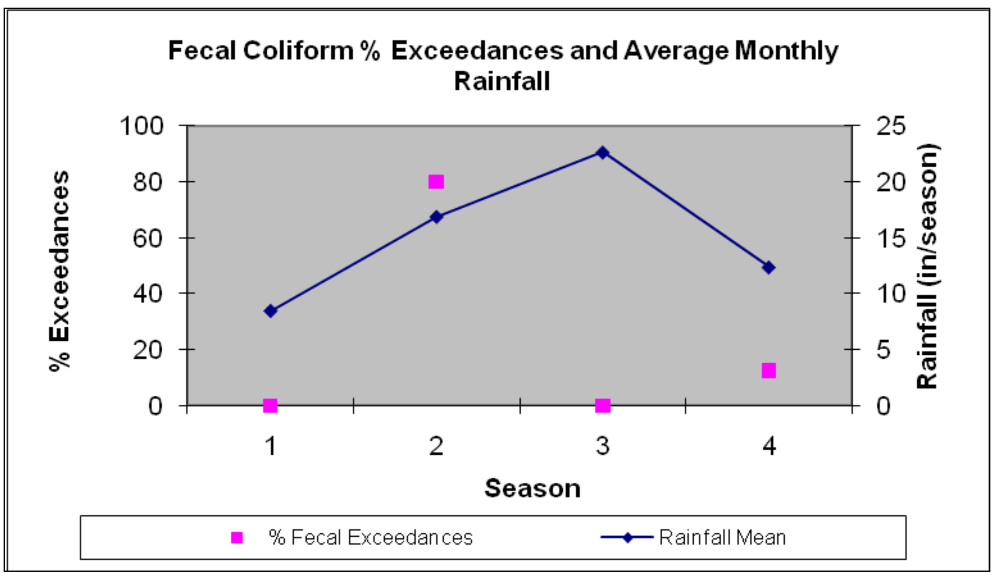


Figure 5.6. Fecal Coliform Exceedances and Rainfall in the E-1 Canal (WBID 3264A) by Season During the Cycle 2 Verified Period (January 1, 2002–June 30, 2009)

Table 5.3a. Summary Statistics of Fecal Coliform Data in the E-1 Canal (WBID 3264A) by Month During the Cycle 2 Verified Period (January 1, 2002–June 30, 2009)

\- = Empty cell/no data
[1] Coliform counts are #/100mL.
[2] Exceedances represent values above 400 counts/100mL.

Month	Number of Cases	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedances[2]	% Fecal Exceedances	Rainfall Mean (inches)
1	4	18	256	56	97	0	0%	2.85
2	-	-	-	-	-	-	-	2.52
3	-	-	-	-	-	-	-	3.06
4	4	460	13,500	7,500	7,240	4	100%	2.74
5	1	140	140	140	140	0	0%	6.03
6	-	-	-	-	-	-	-	8.1
7	2	6	58	32	32	0	0%	7.41
8	-	-	-	-	-	-	-	6.74
9	-	-	-	-	-	-	-	8.49
10	4	4	82	17	30	0	0%	5.59
11	4	66	616	164	253	1	25%	4.12
12	-	-	-	-	-	-	-	2.62

Table 5.3b. Summary Statistics of Fecal Coliform Data in the E-1 Canal (WBID 3264A) by Season During the Cycle 2 Verified Period (January 1, 2002–June 30, 2009)

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

Season	Number of Cases	Minimum[1]	Maximum[1]	Median[1]	Mean[1]	Number of Exceedances[2]	% Fecal Exceedances	Rainfall Mean (inches)
1	4	18	256	56	97	0	0%	8.43
2	5	140	13,500	7,500	5,820	4	80%	16.87
3	2	6	58	32	32	0	0%	22.64
4	8	4	616	69	141	1	13%	12.33

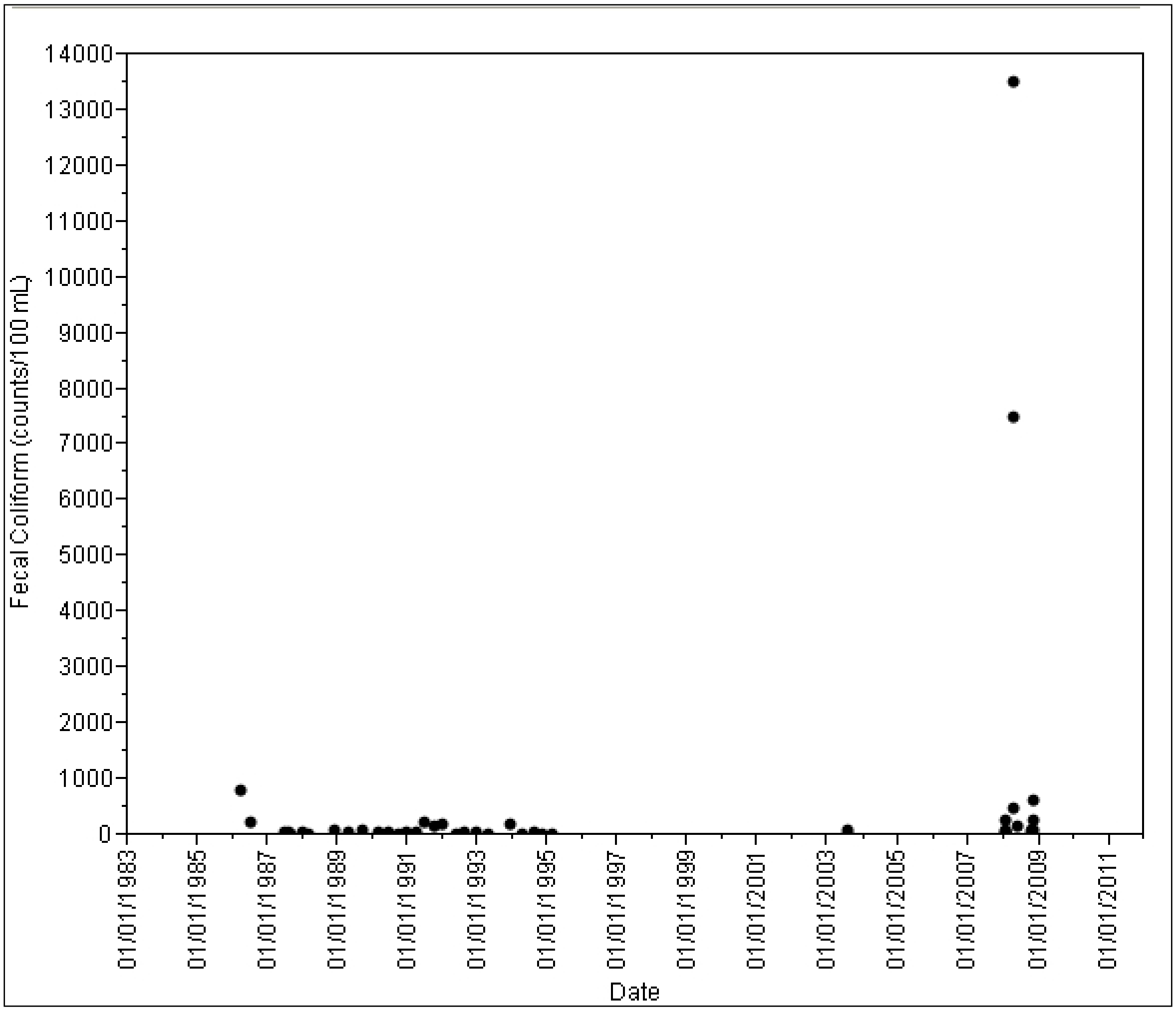


Figure 5.7. Fecal Coliform Concentration Trends in the E-1 Canal (WBID 3264A) for the Entire Period of Record (1986–2008)

Hydrologic Condition

As no current flow data were available, hydrologic conditions were analyzed using rainfall. A loading curve–type chart that would normally be applied to flow events was created using precipitation data from the Loxahatchee CLIMOD station (085152). 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). Three-day (the day of and 2 days prior to sampling) precipitation accumulations were used in the analysis (**Table 5.4** and **Figure 5.8**).

Fecal coliform data were collected only during extreme, medium, and small precipitation events. Because they were not collected during all types of precipitation events (extreme, large, medium, small, and none/not measurable), it is difficult to deduce whether there is a connection between fecal coliform data and hydrologic condition.

It should be noted that on April 7, 2008, the highest fecal coliform concentrations were observed (Station 21FLWPB 28010588 = 460 counts/100mL, Station 21FLWPB28010587 = 7,500 counts/100mL, Station 21FLWPB32008020 = 13,500 counts/100mL, and Station 21FLWPB28010589 = 7,500 counts/100mL). The 3-day precipitation accumulation for April 7, 2008, was 4.55 inches.

However, high fecal coliform concentrations were also observed during medium precipitation events. For example, Station 21FLWPB28010587 had a fecal coliform concentration of 616 counts/100mL on November 13, 2008. The 3-day precipitation accumulation for November 13 was 1.42 inches.

Table 5.4. Summary of Fecal Coliform Data in the E-1 Canal (WBID 3264A) by Hydrologic Condition Based on Three-Day Precipitation

N/A = Not Applicable?
[1] Exceedances represent values above 400 counts/100mL.

Precipitation Event	Event Range (Percentile)	Total Samples	Number of Exceedances[1]	% Exceedances	Number of Nonexceedances	% Nonexceedances
None/Not Measurable	60 – 100	0	0	NA	0	NA
Small	40 – 60	6	0	0%	6	100%
Medium	10 – 40	8	1	13%	7	88%
Large	5 – 10	0	0	NA	0	NA
Extreme	0 – 5	5	4	80.0%	1	20.0%

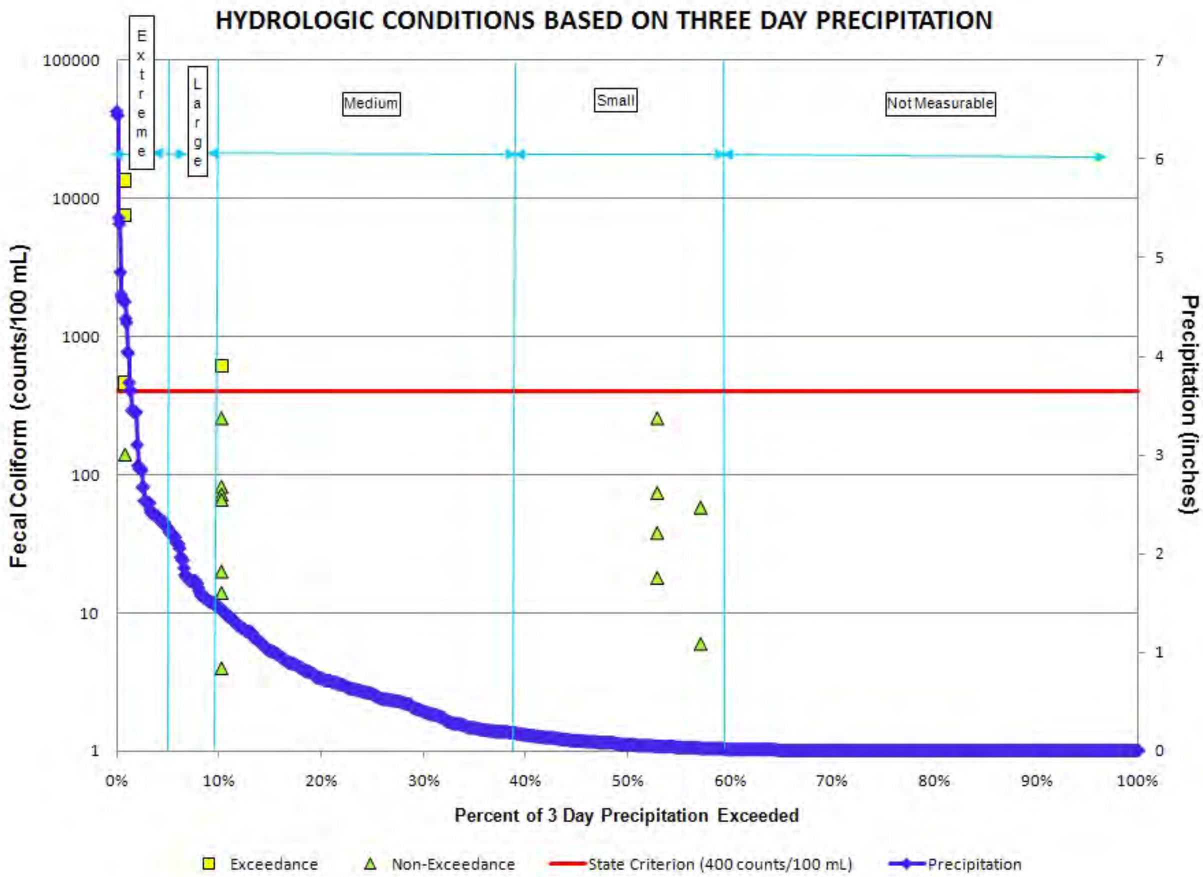


Figure 5.8. Fecal Coliform Data by Hydrologic Condition in the E-1 Canal (WBID 3264A) Based on Three-Day Precipitation

5.1.2 Critical Conditions

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 and livestock with direct access to the receiving water can be more noticeable during dry weather. The critical condition for point source loading typically occurs during periods of low stream flow, when dilution is minimized.

Since 52% of the total WBID area comprises urban land uses and 13.8% is agricultural, many of the exceedances are likely from nonpoint sources and MS4s entering surface waters through surface runoff during wet weather conditions and baseflow during dry weather conditions. Because the data were collected only during extreme, medium, and small precipitation events, it is impossible to exclude the possibility of exceedances under other hydrologic conditions. Therefore, the fecal coliform target established for this TMDL applies to all rainfall conditions.

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 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, 2002–June 30, 2009). 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 are shown to be the 90th percentile value, then the 90th percentile number (used to represent the existing condition concentration) is calculated by interpolating between the 2 data points adjacent (above and below) to the desired 90th percentile rank using **Formula 3:**

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

Where:

> *C_{lower} is the fecal coliform concentration corresponding to the percentile lower than the 90th percentile;*
>
> *P_{90th} is the percentile difference between the 90th percentile and the percentile number immediately lower than the 90th percentile (90% - percentile $_{lower}$ = P_{90th}); and*
>
> *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 were identified. Next, the fecal coliform concentrations corresponding to the lower and upper percentile values were identified. Then, the fecal coliform concentration difference between the lower and upper percentiles was then calculated and divided by the unit percentile. The unit percentile difference is the difference between the lower and upper percentiles. R was then calculated as (fecal coliform concentration $_{upper}$ – fecal coliform concentration $_{lower}$)/(percentile $_{upper}$ – percentile $_{lower}$) = R.

Then C_{lower}, P_{90th}, and R are substituted into **Formula 3** to calculate the 90th percentile fecal coliform concentration. The 90th percentile fecal coliform concentration is 7,500 counts/100mL [7,500 + [(3) * (0)] = 7,500 + 0 = 7,500].

Using **Formula 1**, the percent reduction for the period of observation (2002–09) was calculated as 94% for the E-1 Canal (i.e., % reduction needed = [(7,500-400)/7,500]*100 = 94%).

Table 5.5 shows the individual fecal coliform data, the ranks, the percentiles for each individual data, the existing 90th percentile concentration, the allowable concentration (400 counts/100mL), and the percent reduction needed to meet the applicable water quality criterion for fecal coliform.

Table 5.5. Calculation of Fecal Coliform Reductions for the E-1 Canal (WBID 3264A) TMDL Based on the Hazen Method

- = Empty cell/no data

Station	Date	Fecal Coliform Concentration (MPN/100mL)	Rank	Percentile by Hazen Method
21FLWPB 28010589	10/20/2008	4	1	3%
21FLGW 18843	7/16/2003	6	2	8%
21FLWPB 28010588	10/20/2008	14	3	13%
21FLWPB 28010589	1/15/2008	18	4	18%
21FLWPB 32008020	10/20/2008	20	5	24%
21FLWPB 32008020	1/15/2008	38	6	29%
21FLGW 18842	7/16/2003	58	7	34%
21FLWPB 28010589	11/13/2008	66	8	39%
21FLWPB 28010588	11/13/2008	72	9	45%
21FLWPB 28010587	1/15/2008	74	10	50%
21FLWPB 28010587	10/20/2008	82	11	55%
21FLWPB 28010589	5/19/2008	140	12	61%
21FLWPB 28010588	1/15/2008	256	13	66%
21FLWPB 32008020	11/13/2008	256	14	71%
21FLWPB 28010588	4/7/2008	460	15	76%
21FLWPB 28010587	11/13/2008	616	16	82%
21FLWPB 28010587	4/7/2008	7,500	17	87%
21FLWPB 28010589	4/7/2008	7,500	18	92%
21FLWPB 32008020	4/7/2008	13,500	19	97%
-	-	-	**Existing condition concentration– 90th percentile (counts/100mL)**	**7,500**
-	-	-	**Allowable concentration (counts/100mL)**	**400**
-	-	-	**Final % reduction**	**94%**

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 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 E-1 Canal is expressed in terms of counts/day and percent reduction, and represents the maximum daily fecal coliform load the canal can assimilate without exceeding the fecal coliform criterion (**Table 6.1**).

Table 6.1. TMDL Components for Fecal Coliform in the E-1 Canal (WBID 3264A)

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	94%	94%	Implicit

6.2 Load Allocation

Based on a percent reduction approach, the load allocation is a 94% 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**).

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

No NPDES-permitted wastewater facilities were permitted to discharge within the E-1 Canal WBID boundary. The state already requires all NPDES 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. These requirements will also be applied to any possible future point sources that may discharge in the WBID 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 94% reduction in current fecal coliform loading for WBID 3264A. 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 upon 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. Basin Management Action Plans 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 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 obligations of wastewater point source, MS4, and non-MS4 stakeholders in TMDL implementation; enhanced transparency in Department 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.

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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 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, stormwater PLRGs 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 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 FDOT 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/Rnvironmental 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 estimations for informational purposes only and did not use these estimates 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 at the time the calculation was made. The numbers provided do not represent actual loadings from the sources.

Pets

Pets (especially dogs) could be a significant source of coliform pollution through surface runoff within the E-1 Canal 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 2,200,000 counts/gram of 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 E-1 Canal WBID boundary is not known. Therefore, the statistics produced by APPMA were used in this analysis to estimate the possible fecal coliform loads contributed by dogs.

Using data obtained from the Florida Department of Health (FDOH) to calculate the number of properties in residential land use areas within the E-1 Canal WBID boundary, the number of households within the WBID boundary was estimated to be 8,442. The data provided by FDOH are described in the next section. Assuming that 40% of the households in this area have 1 dog, the total number of dogs within the WBID is about 3,377.

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). 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 in residential areas is approximately 6.07×10^5 grams/day. The total produced by dogs is 1.33×10^{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. Dog Population Density, Wasteload, and Fecal Coliform Density (Weiskel **et al.** 1996)

* Number from APPMA

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

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.

The number of properties connected to the sewer system within the E-1 Canal WBID boundary was based on data obtained from FDOH's ongoing inventory of wastewater treatment and disposal methods for developed properties. For septic tanks, if there was not enough information to determine with certainty whether a property was sewered, the probability of whether the property was served by a septic tank was determined. If that probability was low (less than 50%), the property was estimated to be served by a sewer system. Within the WBID boundary, 8,139 properties are known to be served by sewer systems. Information from the Palm Beach County Property Appraiser's Office was used to determine that some of the properties tied to the sewer system within the WBID boundary were high-density residential with multiple units (multiple households) on a property.

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 E-1 Canal WBID boundary can be made using **Equation B.1**.

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

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/100 mL);
F is the sewer line leakage rate; and
37.85 is a conversion factor (100 mL/gallon).

The number of households *(N)* within the WBID boundary that are served by sewer systems is 8,139. The discharge rate through sewers from each household (*Q*) was calculated by multiplying the average household size (2.46) 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/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 estimated fecal coliform loading from sewer line leakage in the WBID is approximately 2.65×10^{11} counts/day.

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 ground water (USGS 2010b). The risk of contamination is greater for unconfined (water table) aquifers than for confined aquifers because they usually are nearer to the land surface and lack an overlying confining layer to impede the movement of contaminants (USGS 2010b).

Sediment type (sand, silt, and clay) also determines the risk of contamination in a particular watershed. According to the USGS (2010), "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."

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.

In addition, watersheds located in karst regions are extremely vulnerable to contamination. Karst terrain is characterized by springs, caves, sinkholes, and a unique hydrogeology that results in aquifers that are highly productive (USGS 2010b). Compared with nonkarst areas, these features act as direct pathways for pollutants to enter waterbodies.

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 E-1 Canal WBID boundary can be made using **Equation B.2**:

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

Where:

L is the fecal coliform daily load (counts/day);
N is the number of households using 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 (100 mL/gallon).

Based on data provided by Mockroos & Associates, Inc., which is currently undertaking a project to inventory the use of onsite treatment and disposal systems (i.e., septic tanks) by determining the methods of wastewater disposal for developed property sites within Palm Beach County, 303 housing units *(N)* within the E-1 Canal WBID boundary are known or believed to be using septic tanks to treat their domestic wastewater (**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. An estimate of fecal coliform loads from failed septic tanks was generated using Palm Beach County information. Based on the information published by the Census Bureau, the average household size for Palm Beach County is about 2.46 people/household. The same population densities were assumed within the E-1 Canal 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 $1x10^6$ 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 Palm Beach County based on FDOH's septic tank inventory and the number of septic tank repair permits issued in Palm Beach County as published by FDOH (available: (http://www.doh.state.fl.us/environment/OSTDS/statistics/ostdsstatistics.htm). The cumulative number of septic tanks in Palm Beach 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 2009–10 inventory, and assuming that none of the installed septic tanks will be removed after being installed (**Table B.2**). 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 and listed in **Table B.2**.

Based on **Table B.2**, the average annual septic tank failure discovery rate is about 0.63% for Palm Beach County. 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 3.14%. Based on **Equation B.2**, the estimated fecal coliform loading from failed septic tanks within the E-1 Canal WBID boundary is about 6.20×10^{10} counts/day.

Sediments

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 methodology cannot quantify the exact amount of fecal coliform coming from each source. Therefore, the Department is unable to provide estimates of fecal coliform loading from sediments.

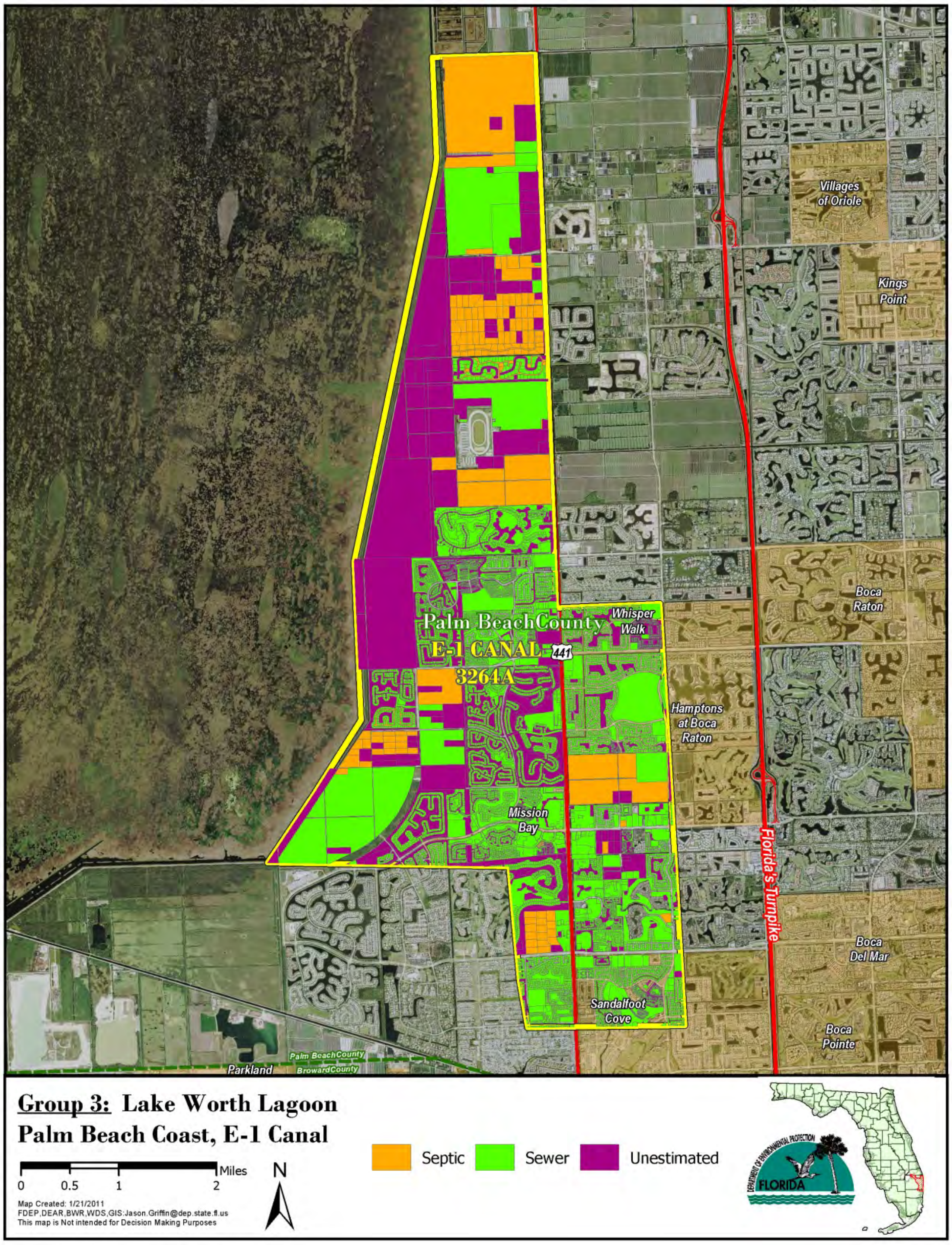

Figure B.1. Distribution of Onsite Sewage Disposal Systems (Septic Tanks) and Sewer Systems in Residential Land Use Areas within the E-1 Canal (WBID 3264A) Watershed Boundary

Table B.2. Estimated Number of Septic Tanks and Septic Tank Failure Rates for Palm Beach County, 2005–10

* The failure rate is 5 times the failure discovery rate.

Palm Beach County	2005	2006	2007	2008	2009	2010	Average
New installations (septic tanks)	788	691	776	314	245	114	488
Accumulated installations (septic tanks)	77,391	78,179	78,870	79,646	79,960	80,205	79,041.83
Repair permits (septic tanks)	682	407	531	520	402	434	496
Failure discovery rate (%)	0.88%	0.52%	0.67%	0.65%	0.50%	0.54%	0.63%
Failure rate (%)*	4.41%	2.60%	3.37%%	3.26	2.51%	2.71%	**3.14%**

Wildlife

Wildlife is another possible source of fecal coliform bacteria within the E-1 Canal WBID boundary. As shown in **Figure 4.1**, wetland areas border the E-1 Canal. These likely serve as habitat for wildlife that has the potential to contribute fecal coliform to the canal. Wildlife deposit coliform bacteria with their feces onto land surfaces, where they can be transported during storm events to nearby streams. Some wildlife (such as birds, otters, alligators, and raccoons) deposit their feces directly into the water. Cold-blooded animals, such as fish and iguanas, harbor *E. coli* in their intestines, and it is possible that they may reintroduce *E. coli* bacteria into waterways when they excrete their own waste (Hansen *et al.* 2008). The bacterial load from naturally occurring wildlife is assumed to be background. However, as these represent natural inputs, no reductions are assigned to these sources by this TMDL.

Livestock

Agricultural animal waste is associated with various pathogens in streams; these can include *E. coli, Salmonella, Giardia, Campylobacter, Shigella, and Cryptosporidiumparvum* (Landry and Wolfe 1999). High loading rates of pathogens to soils and waters can result from the presence of livestock and other agricultural animals. Livestock with direct access to a receiving water can contribute to exceedances during wet and dry weather conditions.

Problems with grazing animals and pathogen loading rates derive primarily from animal density (Hubbard *et al.* 2004). At low animal densities, livestock with free access to waterbodies can directly deposit urine and manure (Hubbard *et al.* 2004). At high animal densities, large amounts of urine and feces may be deposited in relatively small areas, increasing the probability of nutrients and pathogens being transported to surface waterbodies via surface runoff, or entering ground water (Hubbard *et al.* 2004).

Agricultural land uses, specifically crop and pastureland, occupy 13.8% of the total land area in the E-1 Canal watershed. High loading rates of fecal coliform to soils and waters can result from livestock and other agricultural animals. Livestock with direct access to a receiving water can contribute to the exceedances during wet and dry weather conditions. Livestock data from the 2007 census of agriculture for Palm Beach County are available at http://www.agcensus.usda.gov/Publications/2007/index.asp (U.S. Department of Agriculture 2007). Since a livestock inventory does not exist for the E-1 Canal watershed, a possible fecal coliform load from livestock could not be calculated.

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