Assessment of Water Quality, Benthic Invertebrates, and Periphyton in the Threemile Creek Basin, Mobile, Alabama, 1999–2003

By Ann K. McPherson, Amy C. Gill, and Richard S. Moreland

Prepared in cooperation with the Mobile Area Water and Sewer System

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Contents

Abstract 1
Introduction 2
  Purpose and Scope..4
  Study Area 4
  Previous Investigations 8
  Acknowledgments 9
Watershed Characteristics of the Threemile Creek Basin 9
  Land Use...11
  Hydrology 13
Methods of Study 15
  Water-Quality Sample Collection 15
  Benthic Invertebrate and Periphyton Sample Collection...............................17
  Water-Quality Data Analysis and Review 19
    Quality-Control Methods and Results 21
  Benthic Invertebrate and Periphyton Data Analysis and Review.......................21
Water-Quality Results and Discussion 22
  Basic Water Chemistry 23
  Major Ions 23
  Instantaneous and Continuous Measurements of Water Properties 27
  Nutrients..32
    Nitrogen 32
    Phosphorus 34
  Suspended Chlorophyll *a* and *b* 36
  Biochemical Oxygen Demand and Total Organic Carbon 37
  Fecal-Indicator Bacteria 37
  Organic Wastewater Compounds 46
    Occurrence and Distribution of Wastewater Indicator Groups 55
    Organic Wastewater Compounds as Endocrine Disruptors 55
    Antioxidants...55
    Prescription and Nonprescription Drugs 58
    Steroids—Sterols and Stanols...58
    Fragrances...59
    Detergent Metabolites..59
    Antimicrobials..60
    Plasticizers/Flame Retardants 60
    Insect Repellent 60
    Insecticides..61
    Herbicides and Fungicides 61
    Polycyclic Aromatic Hydrocarbons...61
    Comparison of Organic Wastewater Compounds in the Threemile Creek Basin to Sites Nationwide 62
Benthic Invertebrates Results and Discussion 65

Periphyton Results and Discussion 69
Summary. 78
Selected References 80

Figures

1–4. Maps showing:
  1. Locations of sampling sites in the Threemile Creek basin, Mobile County, Alabama. 3
  2. Locations of stormwater outfalls, wastewater-treatment plants, sampling sites, and profile sites in the Threemile Creek basin, Mobile, Alabama. 5
  3. Delineations of the Level III and Level IV Ecoregion classifications and subbasin boundaries in the Threemile Creek basin, Mobile, Alabama 11
  4. Land-use characteristics in the Threemile Creek basin, Mobile, Alabama. 12
5. Graph showing land use in the Threemile Creek basin, Mobile, Alabama 12
6. Piper trilinear diagram showing major ion composition of surface-water samples collected at six sites in the Threemile Creek basin, Mobile, Alabama, 2000–2001 24
7–38. Graphs showing:
  7. Gage height, water temperature, specific conductance, dissolved oxygen, turbidity, and discharge at U.S. Geological Survey streamgaging stations (A) 02471013 (TM-1), (B) 0247101490 (TM-4), and (C) 02471016 (TM-5), August 25–September 4, 2001 30
  8. Number of days that continuous water-quality monitors recorded concentrations of dissolved oxygen less than 3.0 milligrams per liter at three sites on Threemile Creek, Mobile, Alabama, water years 2000–2003 31
  9. Distribution of total nitrogen, nitrite plus nitrate, total ammonia plus organic nitrogen, and ammonia concentrations at sites in the Threemile Creek basin, Mobile, Alabama 33
  10. Median concentrations of nitrite plus nitrate, ammonia, and total organic nitrogen at sites in the Threemile Creek Basin, Mobile, Alabama 34
  11. Distribution of total phosphorus, dissolved phosphorus, and dissolved orthophosphate at sites in the Threemile Creek basin, Mobile, Alabama 35
  12. Median concentrations of suspended phosphorus and dissolved phosphorus at sites in the Threemile Creek basin, Mobile, Alabama. 36
  13. Distribution of dissolved inorganic nitrogen and dissolved orthophosphate ratios for sites in the Threemile Creek Basin, Mobile, Alabama 36
  14. Concentrations of (A) enterococci, (B) *Escherichia coli*, and (C) fecal coliform concentrations in water samples collected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003 38
  15. Concentrations of (A) enterococci, (B) *Escherichia coli*, and (C) fecal coliform concentrations at three sites on Threemile Creek, Mobile, Alabama, December 13–15, 2001. 41
  16. Concentrations of (A) enterococci, (B) *Escherichia coli*, and (C) fecal coliform concentrations at three sites on Threemile Creek, Mobile, Alabama, June 24–26, 2002 42
  17. Concentrations of (A) enterococci and (B) *Escherichia coli* concentrations at three sites on Threemile Creek, Mobile, Alabama, February 26–28, 2003. 43

18. Concentrations of (A) enterococci, (B) *Escherichia coli*, and (C) fecal coliform concentrations at three sites on Threemile Creek, Mobile, Alabama, September 13–16, 2003 44
19. Relation between *Escherichia coli* and fecal coliform concentrations measured at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003. 45
20. Frequencies of detection for selected organic wastewater compounds in water samples from the Threemile Creek basin, Mobile, Alabama, 2000–2003 47
21. Summary of organic wastewater compounds detected per sample for (A) total concentration (summation of 48 compounds) and (B) number of compounds detected. 52
22. The 10 most frequently detected organic wastewater compounds at each site in the Threemile Creek basin, Mobile, Alabama, 2000–2003. 53
23. The 10 most frequently detected organic wastewater compounds in the Threemile Creek basin, Mobile, Alabama, 2000–2003 54
24. Relation between total concentration of organic wastewater compounds and total phosphorus, Threemile Creek basin, Mobile, Alabama, 2000–2003 54
25. Summary of the types of organic wastewater compounds detected per sample for (A) total concentration (summation of 48 compounds) and (B) number of compounds detected, Threemile Creek basin, Mobile, Alabama, 2000–2003 56
26. (A) Frequency of detection of organic wastewater compounds by general-use category and (B) percentage of total measured concentration of organic wastewater compounds by general-use category, Threemile Creek basin, Mobile, Alabama, 2000–2003 57
27. Frequencies of detection of selected organic wastewater compounds in water samples from the the Threemile Creek basin, Mobile, Alabama, and sites nationwide. 62
28. Benthic invertebrate taxa richness at selected sites on Threemile Creek, Mobile, Alabama, July 2000 65
29. Relative abundance of major benthic invertebrate taxa at selected sites on Threemile Creek, Mobile, Alabama, July 2000 67
30. Average U.S. Environmental Protection Agency national tolerance values for benthic invertebrate communities at selected sites on Threemile Creek, Mobile, Alabama, July 2000 68
31. Shannon-Weaver diversity index values for benthic invertebrate communities at selected sites on Threemile Creek, Mobile, Alabama, July 2000 69
32. Benthic chlorophyll *a* concentrations at selected sites in the Threemile Creek basin, Mobile, Alabama, September 2000 71
33. Benthic chlorophyll *a* concentrations at selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003. 71
34. Periphyton ash-free dry mass at selected sites in the Threemile Creek basin, Mobile, Alabama, September 2000 73
35. Periphyton ash-free dry mass at selected sites on Threemile Creek, Mobile, Alabama, 2000–2003 73
36. Periphyton taxa richness at selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002 74
37. Percentage of diatom taxa richness in each saprobic class for periphyton community samples collected from selected sites in the Threemile Creek basin, Mobile, Alabama, September 2000 77
38. Percentage of diatom biovolume in each saprobic class for periphyton community samples collected from selected sites in the Threemile Creek basin, Mobile, Alabama, September 2000 77

Tables

1. Description of surface-water sites selected for water-quality and biological sampling in the Threemile Creek basin, Mobile, Alabama, 2000–2003. 5
2. Land–use characteristics in the watersheds of sampling sites in the Threemile Creek basin, Mobile, Alabama 6
3. Rainfall summary for the Mobile Regional Airport and U.S. Geological Survey streamgaging station 02471013 (TM-1), Mobile, Alabama 10
4. Population changes (1990–2000) in the watersheds of sampling sites in the Threemile Creek basin, Mobile, Alabama 13
5. Number and type of water-quality, benthic invertebrate, and periphyton samples collected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003 16
6. Saprobic categories of diatoms and corresponding dissolved-oxygen concentrations and biochemical oxygen demand values 23
7. Results of the Kruskal-Wallis test and the Tukey multiple-comparison test illustrating statistically significant ($p \leq 0.05$) differences for selected water-quality constituents at sites in the Threemile Creek basin, Mobile, Alabama 25
8. Instantaneous field measurements of water-quality properties at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003, and corresponding water-quality criteria 27
9. Continuous measurements of water-quality properties at sites in the Threemile Creek basin, Mobile, Alabama, water years 2000–2003, and corresponding water-quality criteria 28
10. Results of multiple-comparison tests on selected nutrients at surface-water sites in Threemile Creek basin, Mobile, Alabama. 32
11. Ambient water-quality criteria recommendations for rivers and streams in Nutrient Ecoregions IX and XII 34
12. Statistical summary of enterococci, *Escherichia coli*, and fecal coliform concentrations at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003 . . . 37
13. State and Federal standards and criteria for bacteria in surface water. 39
14. Exceedance frequencies for fecal-indicator bacteria detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003. 45
15. Summary of organic wastewater compounds detected in water samples collected in the Threemile Creek basin, Mobile, Alabama, 2000–2003 48
16. Detection frequencies and concentrations of selected organic wastewater compounds in water samples from the Threemile Creek basin, Mobile, Alabama (2000–2003) and sites nationwide (1999–2000) 63
17. Five most abundant benthic invertebrate taxa and the respective percentages of total abundance for each taxa at selected sites in Threemile Creek, Mobile, Alabama, July 2000 66
18. North Carolina biotic index values and associated water-quality conditions 68
19. Periphyton chlorophyll a and ash-free dry mass concentrations at selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003 70
20. Mean total algal cell density and mean percentage of total algal cell density in major algal groups in samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002. 75
21. Mean total algal biovolume and mean percentage of total algal biovolume in major algal groups in samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002 76

Appendix 1. Quality Control

1-1. Concentrations of nutrients, major ions, and selected organic wastewater compounds detected in blank samples in the Threemile Creek basin, Mobile, Alabama, 2000–2003 88

Appendix 2. Water-Quality Samples

2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003 91
2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003 103

Appendix 3. Benthic Invertebrates and Periphyton

3-1. Benthic invertebrate taxa, percent abundance of each taxon, and total abundance at selected sites in Threemile Creek, Mobile, Alabama, July 2000 115
3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002 118

Conversion Factors, Datum, and Definitions

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
	Flow rate	
foot per day (ft/d)	0.3048	meter per day (m/d)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
	Hydraulic conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)

WATER-QUALITY DATA are reported in metric units, which can be converted to inch-pound units:

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
	Area	
square meter (m^2)	0.0002471	acre
square centimeter (cm^2)	0.001076	square foot (ft^2)
	Volume	
liter (L)	0.2642	gallon (gal)
	Mass	
gram (g)	0.03527	ounce, avoirdupois

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32) / 1.8$$

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Abbreviations and Acronyms

cells/cm^2	cells per square centimeter
col/100 mL	colonies per 100 milliliters
$\mu m^3/cm^2$	cubic micrometer per square centimeter
g/m^2	gram per square meter
$\mu g/cm^2$	microgram per square centimeter
µm	micrometer
mg	milligram
ADCP	acoustic doppler current profiler
ADEM	Alabama Department of Environmental Management
AFDM	ash-free dry mass
AHTN	6-acetyl-1,1,2,4,4,7-hexamethyltetraline
ANOVA	analysis of variance
APEO	alkylphenol polyethoxylate
BHA	butylated hydroxyanisole
BHT	butylated hydroxytoluene
BOD	biochemical oxygen demand
BOD_5	5-day biochemical oxygen demand
BU_ID	biological unit identification
EPT	ephemeroptera, plecoptera, and trichoptera
GIS	geographic information system
HHCB	1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran
IDAS	Invertebrate Data Analysis System
MCL	maximum contaminant level
MDL	minimum detection limit
MRL	minimum reporting level
MRLC	multi-resolution land characteristics
NAWQA	National Water-Quality Assessment Program
NP	nonylphenol
NPEO	nonylphenol ethoxylate
NP1EO	nonylphenol monoethoxylate
NP2EO	nonylphenol diethoxylate
NTU	nephelometric turbidity units
NWIS	National Water Information System
NWQL	National Water Quality Laboratory
OPEO	octylphenol ethoxylate
OP1EO	octylphenol monoethyoxylate
OP2EO	octylphenol diethoxylate
OWC	organic wastewater compound
PAH	polycyclic aromatic hydrocarbon
RBP	Rapid Bioassessment Protocol
TMDL	total maximum daily load
TOC	total organic carbon
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WWTP	wastewater-treatment plant
WY	water year

Assessment of Water Quality, Benthic Invertebrates, and Periphyton in the Threemile Creek Basin, Mobile, Alabama, 1999–2003

By Ann K. McPherson, Amy C. Gill, and Richard S. Moreland

Abstract

The U.S. Geological Survey conducted a 4-year investigation of water quality and aquatic-community structure in Threemile Creek, an urban stream that drains residential areas in Mobile, Alabama. Water-quality samples were collected between March 2000 and September 2003 at four sites on Threemile Creek, and between March 2000 and October 2001 at two tributary sites that drain heavily urbanized areas in the watershed. Stream samples were analyzed for major ions, nutrients, fecal-indicator bacteria, and selected organic wastewater compounds. Continuous measurements of dissolved-oxygen concentrations, water temperature, specific conductance, and turbidity were recorded at three sites on Threemile Creek during 1999–2003. Aquatic-community structure was evaluated by conducting one survey of the benthic invertebrate community and multiple surveys of the algal community (periphyton). Benthic invertebrate samples were collected in July 2000 at four sites on Threemile Creek; periphyton samples were collected at four sites on Threemile Creek and the two tributary sites during 2000–2003. The occurrence and distribution of chemical constituents in the water column provided an initial assessment of water quality in the streams; the structure of the benthic invertebrate and algal communities provided an indication of the cumulative effects of water quality on the aquatic biota. Information contained in this report can be used by planners and resource managers in the evaluation of proposed total maximum daily loads and other restoration efforts that may be implemented on Threemile Creek.

The three most upstream sites on Threemile Creek had similar water chemistry, characterized by a strong calcium-bicarbonate component; the most downstream site on Threemile Creek was affected by tidal fluctuations and mixing from Mobile Bay and had a strong sodium-chloride component. The water chemistry at the tributary site on Center Street was characterized by a strong sodium-chloride component; the water chemistry at the second tributary site, Toulmins Spring Branch, was characterized by a strong calcium component without a dominant anionic species. The ratios of sodium to chloride at the tributary at Center Street were higher than typical values for seawater, indicating that sources other than seawater (such as leaking or overflowing sewer systems or industrial discharge) likely are contributors to the increased levels of sodium and chloride. Concentrations of fluoride and boron also were elevated at this site, indicating possible anthropogenic sources.

Dissolved-oxygen concentrations were not always within levels established by the Alabama Department of Environmental Management; continuous monitors recorded dissolved-oxygen concentrations that were repeatedly less than the minimum criterion (3.0 milligrams per liter) at the most downstream site on Threemile Creek. Water temperature exceeded the recommended criterion (32.2 degrees Celsius) at five of six sites in the Threemile Creek basin. The pH values were within established criteria (6.0–8.5) at sites on Threemile Creek; however, pH values ranged from 7.2 to 10.0 at the tributary at Center Street and from 6.6 to 9.9 at Toulmins Spring Branch.

Nutrient concentrations in the Threemile Creek basin reflect the influences of both land use and the complex hydrologic systems in the lower part of the basin. Nitrite-plus-nitrate concentrations exceeded U.S. Environmental Protection Agency ecoregion nutrient criteria in 88 percent of the samples. In 45 percent of the samples, total phosphorus concentrations exceeded the U.S. Environmental Protection Agency goal of 0.1 milligram per liter for preventing nuisance aquatic growth. Ratios of nitrogen to phosphorus indicate that both nutrients have limiting effects.

Median concentrations of enterococci and fecal coliform bacteria were highest at the two tributary sites and lowest at the most upstream site on Threemile Creek. In general, concentrations of bacteria increased in a downstream direction on Threemile Creek. Enterococci concentrations exceeded the U.S. Environmental Protection Agency criterion of 151 colonies per 100 milliliters of water in 52 percent of the samples; *Escherichia coli* concentrations exceeded the U.S. Environmental Protection Agency criterion (576 colonies per 100 milliliters) in 41 percent of the samples; and fecal coliform concentrations exceeded the Alabama Department of Environmental Management criterion (4,000 colonies per 100 milliliters) in 16 percent of the samples. Concentrations of bacteria at two sites on Threemile Creek were elevated during high flow rather than low flow, indicating nonpoint sources; concentrations of bacteria at the other four sites were elevated during low and high flow, indicating both point and nonpoint sources.

Stream samples were analyzed for 48 chemical compounds that commonly are found in wastewater and urban runoff, which may indicate contamination from a human source—37 of these compounds were detected in at least one sample. Twelve of the detected compounds are known or suspected to be hormonally active, with the potential to disrupt endocrine function. Organic wastewater compounds were detected in each of the 63 samples collected from the Threemile Creek basin. Of the 48 compounds analyzed, 9 wastewater-indicator compounds were detected frequently (50-percent or greater detection frequency). The most frequently detected compounds were atrazine (herbicide), caffeine (stimulant), 2-butoxyethanol phosphate (household cleaning agent), cholesterol (plant and animal steroid), diazinon (insecticide), bromacil (herbicide), triclosan (antimicrobial disinfectant), fluoranthene (polycyclic aromatic hydrocarbon), and *N,N*-diethyl-*m*-toluamide (insect repellent commonly known as DEET). Steroids, detergent metabolites, plasticizer/flame retardants, and prescription/nonprescription drugs contributed almost 87 percent of the total measured concentration in all samples.

Benthic invertebrate communities at all but one site on Threemile Creek appeared to be impaired based on taxa richness, numbers of Ephemeroptera/Plecoptera/Trichoptera taxa, and measures of community diversity. When compared to the North Carolina biotic index values, however, average national pollution-tolerance values indicate very good water-quality condition at the most upstream site and good to fair conditions at all other sampling sites.

Algal data indicate that organic and nutrient enrichment contributed to occasional nuisance algal growth in the Threemile Creek basin. Benthic chlorophyll *a* occasionally was found at concentrations associated with nuisance algal growth. Ash-free dry mass, in contrast, did not indicate nuisance algal growth at any of the sites, but levels neared the nuisance level of 50 grams per square meter at Threemile Creek near Pine Grove during August 2003. Taxa richness indicated more diverse algal communities at the main-stem sites than at the tributary sites, perhaps because of the difference between concrete and tile substrates or the colonization period. Nitrogen-fixing algae accounted for less than 10 percent of the algal biovolume from artificial substrate samples at the main-stem sites, indicating that nitrogen was not a limiting nutrient. Nitrogen fixing *Amphithrix janthina* accounted for 40 to 45 percent of the algal community data at the tributary at Center Street, although water chemistry data indicate that both nitrogen and phosphorus were plentiful at the site.

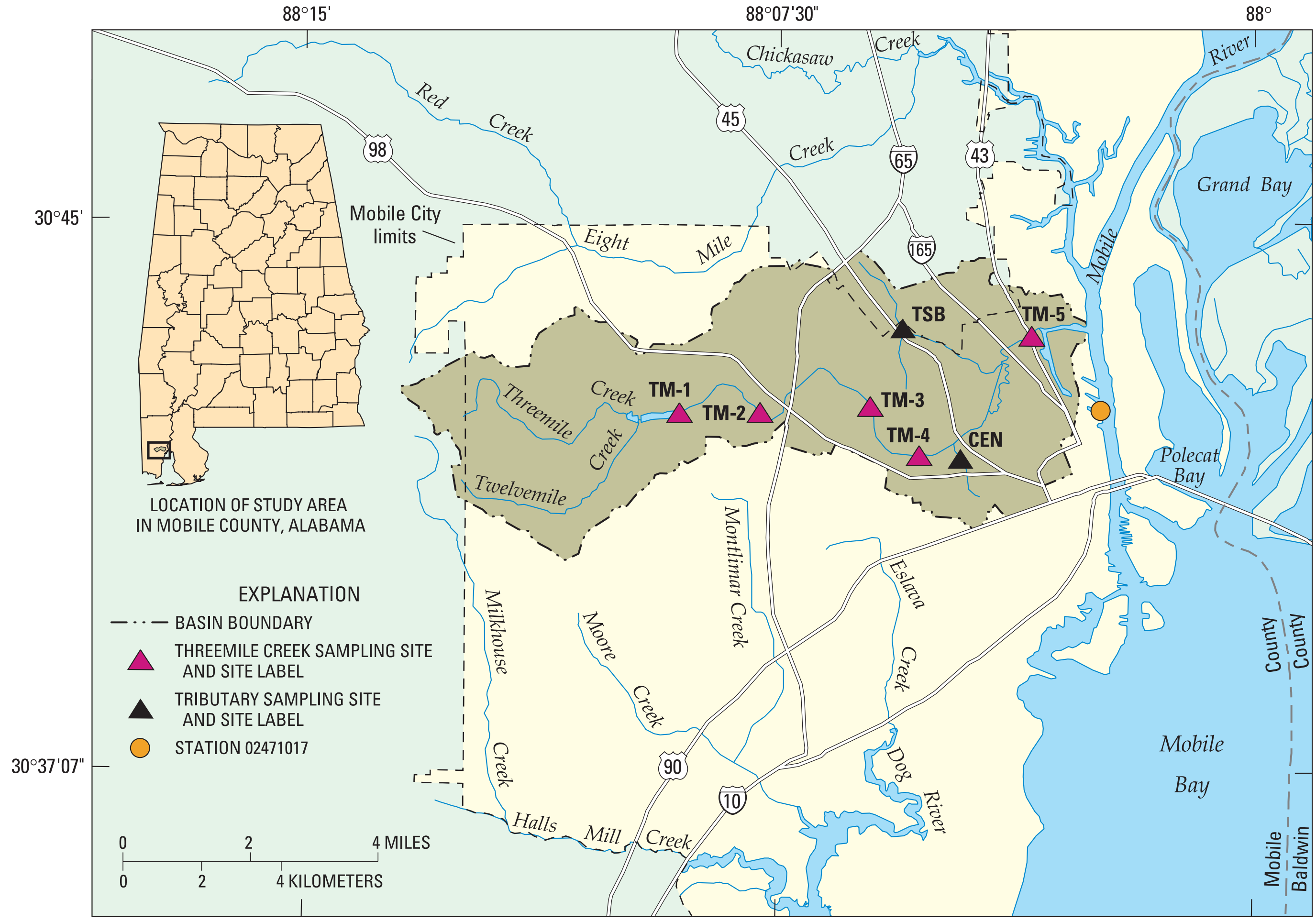
Saprobic classifications of periphyton indicated that tributary algal communities are subjected to more organic enrichment than the main-stem sites. During September 2000, β-saprobic and α-mesosaprobic diatoms were more common than oligosaprobic diatoms at all sites, indicating the occurrence of organic enrichment. At the tributary sites, however, oligosaprobic diatoms were not present, indicating lower dissolved-oxygen concentrations and higher biochemical oxygen demand, in contrast to measured water chemistry at the two sites. The discrepancy between algal and water chemistry data may be due to the diel cycle of dissolved-oxygen concentrations induced by actively photosynthesizing organisms.

The results of this investigation provide a detailed survey of water-quality conditions in Threemile Creek for the 4-year period during October 1999 to September 2003. The water quality and aquatic-community structure in Threemile Creek are degraded, with degradation increasing in a downstream direction and most intense at the tributaries draining into Threemile Creek. The degree of degradation may be related to point and nonpoint sources of contamination originating within the basins. The results also have long-range watershed-management implications, demonstrating the association between urban development and stream degradation.

Introduction

Mobile, the third most populated city in Alabama, is located in Mobile County in the southwestern part of the State (fig. 1). In 2000, the city had a population of about 200,000 and encompassed over 159 square miles (mi^2; U.S. Census Bureau, 2004). The opening of the Tennessee-Tombigbee Waterway in 1985 connected the port of Mobile with the Appalachian coalfields and Midwest grain fields, making the city the seaport for the second largest river system in the Nation. In 2002, the port of Mobile was ranked the 17th largest port in the United States (U.S. Army Corps of Engineers, 2003). Major industries located in the Mobile area include manufacturing of paper and paper products, chemicals and textiles, lumber products, shipbuilding, and seafood processing. Over 500 oil and gas wells operate at inland sites, and offshore drilling tests indicate that extensive gas fields also lie beneath Mobile Bay and in the Gulf of Mexico (Mobile Area Chamber of Commerce, 2004). Major crops grown in Mobile County include peanuts, cotton, corn, hay, nursery products, pecans, potatoes, and watermelon (Vanderberry and Placke, 2003; Mobile Area Chamber of Commerce, 2004). In 2002, Mobile County ranked second in the State of Alabama for pecan production and seventh for milk production (Vanderberry and Placke, 2003).

Threemile Creek is located entirely within the city of Mobile, Alabama, and extends approximately 15 miles (mi) upstream from its confluence with the Mobile River (fig. 1;



Base from U.S. Geological Survey
digital data, 1:100,000

Figure 1. Locations of sampling sites in the Threemile Creek basin, Mobile County, Alabama.

U.S. Army Corps of Engineers, 1985). The Alabama Department of Environmental Management (ADEM) has classified Threemile Creek as impaired due to organic enrichment and low dissolved-oxygen concentrations, leading to poor water-quality conditions (Alabama Department of Environmental Management, 2000a, 2002). Stream channelization and removal of riparian vegetation have altered the aquatic habitat by changing the natural flows and temperatures in the creek and altering streambed characteristics. Two segments of Threemile Creek have been listed on the 303(d) list of impaired waters (Alabama Department of Environmental Management, 2000a, 2002). Municipal collection system failure, highway/road/bridge construction, and land development have been reported by the ADEM as sources of contamination that degrade water quality, habitat, and biological communities in the 13.5-mi segment of Threemile Creek between its source and the Illinois Central Gulf Railroad bridge at Interstate 165, 1.5 mi upstream from its confluence with the Mobile River. In March 2000, the Alabama Department of Public Health issued a fish consumption advisory for the 0.5-mi segment of Threemile Creek upstream from U.S. Highway 43 advising “limited consumption” of striped bass and speckled trout and “no consumption” of Atlantic croaker because of elevated levels of chlordane in fish tissue.

In accordance with a 1998 judicial consent decree, the ADEM is required to establish total maximum daily loads (TMDLs) for waterbody segments in Alabama that are listed on the 1996 Clean Water Act Section 303(d) list of impaired waters. TMDLs are the maximum amounts of pollutants that a waterbody can assimilate without exceeding water-quality standards. Once the TMDL of a pollutant has been established for a stream of interest, the TMDL is allocated among the point and nonpoint dischargers to the stream. A water-quality model can then be developed to predict the pollutant loading effects on the stream by incorporating physical and chemical processes with the hydrodynamics associated with the stream. Such a water-quality model can be used as a tool to evaluate the effectiveness of TMDL management strategies; however, before the effectiveness of the proposed TMDL management strategies or restoration efforts can be assessed, sufficient water-quality, aquatic-habitat, and biological community data are needed to define current conditions in Threemile Creek.

The U.S. Geological Survey (USGS), in cooperation with the Mobile Area Water and Sewer System, conducted an investigation designed to characterize the hydrologic and water-quality conditions of Threemile Creek. The objectives of this investigation are to (1) conduct a structured scientific assessment of the chemical, biological, and physical properties characterizing water-quality and aquatic-ecosystem conditions in the Threemile Creek basin; (2) identify land-use activities that may serve as sources of contaminants; and (3) determine the cumulative effects of water quality on the benthic invertebrate and algal community health and structure. This report describes the water-quality and aquatic-community characterization of Threemile Creek, based on data collected during water years (WY)[1] 2000–2003.

Assessing water quality at varying temporal and spatial scales and understanding the effects of urbanization on stream ecosystems is one of the priorities of the USGS National Water-Quality Assessment (NAWQA) Program. The NAWQA Program was designed to evaluate water-quality conditions and factors affecting water quality on a national and regional basis. The results of this study when combined with other NAWQA studies from across the Nation will provide local resource managers and interested partners with a better understanding of how aquatic ecosystems respond to land-use changes associated with urbanization and how these responses vary across a range of environmental settings.

Purpose and Scope

The purpose of this report is to present the results of a 4-year study that assessed water-quality conditions based on water chemistry and aquatic-community structure at Threemile Creek, an urban stream draining parts of Mobile, Alabama. The natural and anthropogenic characteristics of watersheds in the study area are described, including the major land-use types. Water quality is described for a range of flow conditions, and the extent to which water quality is influenced by point sources during low flow and nonpoint sources during high flow is discussed for nutrients, bacteria, and organic chemicals that are wastewater indicators. The structures of the benthic invertebrate and algal communities are compared among sites sampled in the watersheds. During this investigation, water-quality and ecological data were examined in an upstream to downstream order to identify spatial differences in water quality on Threemile Creek. Statistical and graphical analyses of selected land-use, chemical, and biological data were used to provide a general assessment of current (2000–2003) conditions at the selected stream sites.

The USGS monitored water levels, streamflow, dissolved-oxygen concentrations, specific conductance, and turbidity at three sites on Threemile Creek that were equipped with continuous water-quality monitors for a 46−49 month period. Stream water-quality data, including major ions, nutrients, selected organic wastewater compounds (OWC), and fecal bacteria, were collected from March 2000 through September 2003 at various times. Water-quality samples were collected at four sites on Threemile Creek during the entire period; water-quality samples at the two tributaries were collected during the first year (March 2000−2001), with one additional sample collected in October 2001. Aquatic-community structure was evaluated by conducting one survey of the benthic invertebrate community (July 2000) at four sites in Threemile Creek and several surveys of the algal communities at six sites in the Threemile Creek basin (2000–2003). Information contained in this report can be used by planners and resource managers to evaluate the effectiveness of proposed TMDLs and future restoration efforts.

Study Area

Threemile Creek extends approximately 15 mi upstream from its confluence with the Mobile River to its headwaters (figs. 1, 2; U.S. Army Corps of Engineers, 1985). During the initial phase of the study (June through September 1999), a field reconnaissance was conducted to select representative sampling sites in the watersheds (figs. 1, 2; table 1). Several factors were considered in selecting the sites, including accessibility, stream hydraulics (tidal influences), and land-use characteristics in each watershed (table 2). Five sampling sites were identified on Threemile Creek (TM-1, TM-2, TM-3, TM-4, and TM-5); two additional sites (CEN and TSB) were selected on tributaries draining to Threemile Creek (figs. 1, 2). Water-quality samples were collected at all sites except TM-2 at varying frequencies during 2000−2003; benthic invertebrate samples were collected at TM-1, TM-2, TM-3, and TM-4 in July 2000; algal samples were collected at all sites except TM-5 during 2000–2003. Continuous monitors were installed at three of the sites (TM-1, TM-4, and TM-5); specific conductance, water temperature, and dissolved-oxygen profiles were measured at four locations between TM-4 and TM-5 (fig. 2).

Although land use throughout the Threemile Creek basin is predominantly residential, industrial and wastewater-treatment plant (WWTP) discharges are present in the lower reaches of the creek between TM-4 and TM-5 (fig. 2). The Mobile Area Water and Sewer System supplied geographic information system (GIS) coverages of stormwater outfall locations in the Threemile Creek basin (fig. 2). Aging sewer lines that sometimes overflow during storms also are present in sections of the Threemile Creek basin. Because of flooding caused by low gradients and tropical storms, most of Threemile

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[1] A water year is defined as the period October 1 to September 30 and is identified by the year in which the period ends.

Base from U.S. Geological Survey
digital data, 1:100,000
Stormwater outfall digital data from
Mobile Area Water and Sewer System

Figure 2. Locations of stormwater outfalls, wastewater-treatment plants, sampling sites, and profile sites in the Threemile Creek basin, Mobile, Alabama.

Table 1. Description of surface-water sites selected for water-quality and biological sampling in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

[USGS, U.S. Geological Survey; mi^2, square mile; —, none]

Site label (fig. 1)	USGS station number[a]	Station name	Site location		Drainage area (mi^2)	Period of continuous record	
			Latitude	Longitude		Streamflow	Water quality
TM-1	02471013	Threemile Creek at Ziegler Boulevard at Spring Hill	30° 42'22"	88° 09'04"	10.4	1999–2003	1999–2003
TM-2	0247101325	Threemile Creek near Pine Grove	30° 42'23"	88° 07'48"	12.0	—	—
TM-3	0247101475	Threemile Creek at Fillingim Street at Mobile	30° 42'28"	88° 06'04"	17.3	—	—
TM-4	0247101490	Threemile Creek at Stanton Road at Mobile	30° 41'48"	88° 05'17"	19.2	1999–2003	1999–2003
CEN	0247101495	Unnamed Tributary to Threemile Creek at Center Street at Mobile	30° 41'47"	88° 04'38"	1.078	—	—
TSB	0247101550	Toulmins Spring Branch at Graham Avenue at Mobile	30° 43'32"	88° 05'33"	0.618	—	—
TM-5	02471016	Threemile Creek at U.S. Highway 43 near Prichard	30° 43'27"	88° 03'32"	28.1	1999–2003	1999–2003

[a] USGS station number is based on geographic location and the downstream order of streamflow.

Table 2. Land-use characteristics in the watersheds of sampling sites in the Threemile Creek basin, Mobile, Alabama.

[Data from the 1992 Multi-Resolution Land Characteristics coverage (U.S. Environmental Protection Agency, 1992)]

Site label (fig. 1)	Land use, in percentage of basin							
	Grasses and agriculture	Forest	Urban land-use categories		Total urban (computed)	Wetlands	Open water	Transitional
			Commercial, industrial, and transportation	Residential				
TM-1	25.1	35.8	1.7	33.9	35.6	2.2	0.6	0.7
TM-2	23.6	36.3	1.8	33.3	35.1	3.9	0.5	0.6
TM-3	20.9	32.0	5.2	30.8	36.0	9.7	0.4	1.0
TM-4	20.2	30.8	5.7	33.4	39.1	8.7	0.4	0.9
CEN	7.8	22.5	1.5	68.0	69.5	0	0	0.2
TSB	9.0	12.4	6.6	71.7	78.3	0.2	0	0.1
TM-5	16.9	25.6	6.7	40.5	47.2	9.0	0.4	0.8

Creek and its tributaries have undergone stream-channel modifications to alleviate flooding and stabilize the channels (Federal Emergency Management Agency, 1998).

The most upstream site (TM-1) at USGS streamgaging station 02471013 (table 1) is located at Zeigler Boulevard, 9.4 mi upstream from the Mobile River (fig. 2). This site is located directly downstream from Municipal Lake (fig. 2). The altitude at TM-1 is approximately 72 feet (ft) above the National Geodetic Vertical Datum of 1929 (NGVD 29); downstream from TM-1, a series of drop structures (weirs) have been installed to decrease the effects of flooding in residential and commercial areas. These weirs are placed at periodic intervals along the next 5 mi of Threemile Creek. The next downstream site (TM-2) at USGS streamgaging station 0247101325 (table 1) was used only for biological sampling and is located approximately 1.7 mi downstream from TM-1 (fig. 2). USGS streamgaging station 0247101475 (TM-3) is located at Fillingim Street, approximately 4.1 mi downstream from TM-1 (5.3 mi upstream from the Mobile River; U.S. Army Corps of Engineers, 1985). The tidal cycle does not affect sites upstream from the last weir below Fillingim Street; however, the tidal cycle does affect sites downstream, including site TM-4 at USGS streamgaging station 0247101490 (table 1) located at Stanton Road, about 1.3 mi downstream from TM-3 (4.0 mi upstream from the Mobile River).


USGS streamgaging station 02471013, site TM-1, Threemile Creek at Ziegler Boulevard at Spring Hill and Municipal Lake

Water-quality samples could not be collected safely during high flow at TM-4; therefore, samples were collected at TM-3 when Threemile Creek was too deep to wade at TM-4. Approximately 1 mi downstream from TM-4, Threemile Creek flows down a straight channel through forested wetlands. The creek meanders throughout the wetlands and discharges into the constructed channel at Conception Street, 1.8 mi upstream from the Mobile River (fig. 2). From Conception Street, Threemile Creek meanders freely for 0.8 mi to site TM-5 at USGS streamgaging station 02471016 (table 1), located at U.S. Highway 43 (fig. 2). At TM-5, Threemile Creek is a wide, tidally influenced channel approximately 1 mi upstream from the Mobile River.

Water-quality samples were collected at two tributary sites—Toulmins Spring Branch (TSB) and an unnamed tributary to Threemile Creek at Center Street (CEN). The unnamed tributary at Center Street flows into Threemile Creek 3.3 mi upstream from the Mobile River and about 0.6 mi downstream from TM-4. Toulmins Spring Branch flows into Threemile Creek 1.9 mi upstream from the Mobile River and about 2.1 mi downstream from TM-4. The 12.8-million gallons per day (Mgal/d) Wright Smith, Jr., Wastewater Treatment Plant operated by the Mobile Area Water and Sewer System, is located near the confluence of Toulmins Spring Branch and Threemile Creek. The Carlos A. Morris Wastewater Treatment Plant, a 4.0-Mgal/d WWTP operated by the City of Prichard, is located about a mile away; discharge from this WWTP enters

Site TM-4, Threemile Creek at Stanton Road at Mobile

Samples were collected downstream from site CEN, unnamed tributary to Threemile Creek at Center Street at Mobile

Site TSB, Toulmins Spring Branch at Graham Avenue at Mobile

Threemile Creek near Interstate 165 (fig. 2). Although the Threemile Creek watershed extends to the Mobile River (fig. 1), the Threemile Creek study area is defined as the area upstream from TM-5, the most downstream sampling site.

Previous Investigations

Little information has been published on the water quality of Threemile Creek. Every other year, the ADEM provides a 305(b) report to Congress on the water quality of rivers, streams, lakes, and ground water in Alabama. In the most recent reports, the ADEM indicated that Threemile Creek was nonsupportive of its agricultural and industrial water-supply classification because of organic enrichment, low dissolved-oxygen concentrations, and elevated chlordane levels (Alabama Department of Environmental Management, 2000a, 2002).

In May 2003, a report was prepared summarizing available data pertaining to water chemistry, point-source discharges, meteorological, and bathymetry information in the Threemile Creek watershed (Tetra Tech, Inc., 2003a). Another report presented a dynamic watershed model, a dynamic instream hydraulic model, and an instream kinetic water-quality model in support of the development of a TMDL for the impaired segments of Threemile Creek (Tetra Tech, Inc., 2003b). A draft TMDL for the impaired segments of Threemile Creek was presented in October 2003 (Alabama Department of Environmental Management and Tetra Tech, Inc., 2003).

Numerous scientific studies have been conducted to investigate environmental factors that influence the streams in Mobile County. Maps and reports have been published describing the hydrology, geologic structure, stratigraphy, geohydrology, and lithology of the Mobile County area (Reed, 1971; Reed and McCain, 1972; Riccio and others, 1973; Hinkle, 1984; Mooty, 1988; Szabo and Copeland, 1988; and Moore, 1998). Information concerning the hydrogeology, characteristics of major aquifers, and public supply wells in Mobile County and neighboring Baldwin County is documented in a report by Gillett and others, 2000. Detailed descriptions of the geographic setting in the Mobile River Basin, including physiography, geology, soils, climate, hydrology, and ecoregions, are included in a report by Johnson and others (2002).

In 1991, Congress appropriated funds for the USGS to begin the NAWQA Program, which is an ongoing assessment of water-quality conditions in the Nation's surface- and ground-water resources, and the effects of land use on these resources. One component of the program is to determine the effects of urbanization on stream-water quality and ecosystem health. Results of NAWQA studies for selected river basins throughout the United States have been summarized in national synthesis reports, including descriptions of the occurrence of pesticides (Gilliom and others, 1999; Larson and others, 1999; Hoffman and others, 2000; Hopkins and others, 2000) and nutrients in surface- and ground-water resources (Puckett, 1994; Mueller and others, 1995; Mueller and Helsel, 1996; Fuhrer and others, 1999; Clark and others, 2000). Strong correlations have been identified between the degree of urbanization in a watershed and the extent of biological impairment (McMahon and Cuffney, 2000). The following paragraphs briefly summarize the complex relation between urbanization and aquatic-community structure.

The distribution of benthic invertebrates and algae in surface water is influenced by natural and human factors that affect water quality and habitat. Activities related to urbanization can modify watershed characteristics and influence patterns of runoff into streams. Several studies document the disruptive effects of urbanization on stream hydrology and ecology (Booth, 1990; Richards and Host, 1994; Finkenbine and others, 2000; Wang and others, 2000; Paul and Meyer, 2001). Walsh and others (2001) have shown that the composition of benthic invertebrate communities is a sensitive indicator of urban effects, and that urban density appears to be a key factor in the degradation of benthic invertebrate communities.

Urbanization can result in increased loadings of nutrients, pesticides, heavy metals, and other contaminants to stream water and bed sediment. Such contaminants can have substantial detrimental effects on invertebrate communities (Wang and others, 2000). Walsh and others (2001) studied urban streams with severely degraded benthic invertebrate communities and speculated that the transport of contaminants into receiving streams by stormwater drainage was a causative factor.

An increase in the amount of impervious area in an urban environment may cause sudden changes in flow and rapid fluctuations of water levels, which can lead to reduced biodiversity. For example, increased stream velocity during peak flow can alter or destroy habitat that normally provides resources and shelter for aquatic organisms (Finkenbine and others, 2000). Likewise, frequent and intense flooding can interfere with the life-cycle activities of aquatic organisms (Booth, 1990). Low base flow also can be detrimental to aquatic communities. As urbanization increases, the amount of area available for ground-water recharge decreases, resulting in low base flow (Finkenbine and others, 2000) and subsequent interference with aquatic organism life cycles.

Construction activities and removal of riparian vegetation adversely affect stream biota by increasing the sediment load in streams (Waters, 1995). As sediment in the water column settles to the bottom, it fills interstitial spaces and may prevent the attachment of primary producers, such as intolerant algal taxa, leading to a reduction in species richness. The negative effects of sediment on stream biota can persist for years (Richards and Host, 1994). Alternatively, removal of riparian plants can lead to an increase in the amount of sunlight that reaches a stream, thereby improving conditions for the growth of algae and aquatic plants.

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Watershed Characteristics of the Threemile Creek Basin

Mobile has a subtropical climate, with hot, humid summers and mild winters. Monthly mean temperatures range from 50.1 degrees Fahrenheit (°F) in January to 81.5 °F in July (Southeast Regional Climate Center, 2004a). The mean annual precipitation in the Mobile area for the 30-year period (1971–2000) is 66.29 inches per year (in/yr), ranging from 45.74 in/yr in 2000 (table 3) to 86.58 in/yr in 1975 (Southeast Regional Climate Center, 2004a, 2004b). Mean monthly rainfall averages are fairly well distributed throughout the year (table 3; Southeast Regional Climate Center, 2004a). Most of the rainfall during the summer is from scattered afternoon and evening thunderstorms; during the winter and spring, rainfall tends to be of longer duration and associated with frontal systems. Snowfall is extremely rare. Tropical systems that enter the Gulf of Mexico and move inland in late summer and early fall can produce intense rainfall. October generally is the driest month of the year; March, July, and August generally are the wettest months (Southeast Regional Climate Center, 2004a).

During the study period, recorded precipitation at the Mobile Regional Airport was less than the 30-year mean in 2000 (45.74 in/yr) and 2001 (54.44 in/yr) and greater than the 30-year mean in 2002 (72.48 in/yr) and 2003 (70.93 in/yr, table 3; Southeast Regional Climate Center, 2004b; National Weather Service Forecast Office, 2004a, 2004b). The differences between rainfall totals recorded at TM-1 and the Mobile Regional Airport illustrate how variable rainfall can be in the Mobile area (table 3). TM-1 is located only about 8 mi from the Mobile Regional Airport.

The Threemile Creek basin is located in the East Gulf Coastal Plain section of the Coastal Plain physiographic province (Sapp and Emplaincourt, 1975; Johnson and others, 2002). Altitudes in the Threemile Creek basin range from sea level at the coast to approximately 230 ft above NGVD 29 in the western part of the basin (U.S. Geological Survey, 1953, 1982). Relief is greatest in the upper reaches of Threemile Creek and diminishes as the creek meanders through Mobile to its confluence with the Mobile River. Altitude in the flood plain in Mobile ranges from 5 to 30 ft above NGVD 29 (Robinson and others, 1956); the altitude at TM-1 is approximately 72 ft above NGVD 29. A series of flat-topped hills rise west of the flood plain (Robinson and others, 1956). Geologic formations of the basin are predominantly the Pleistocene and Holocene Series overlying the Miocene Series undifferentiated (Reed, 1971).

Major soil associations were surveyed in Mobile County by the U.S. Department of Agriculture, Soil Conservation Service (Hickman and Owens, 1980). The Urban Land-Smithton-Benndale (89.3 percent) and the Dorovan-Johnston-Levy (8.0 percent) are the predominant soil associations in the Threemile Creek watershed (Hickman and Owens, 1980; U.S. Department of Agriculture, 1995). The Urban Land-Smithton-Benndale Association contains gently rolling land areas that are intermingled with poorly drained and well-drained soils that have loamy subsoils and are formed in loamy marine and fluvial sediments on uplands (Hickman and Owens, 1980). The Dorovan-Johnston-Levy Association is found predominantly in the lower reaches surrounding Threemile Creek and contains very poorly drained, mucky and loamy soils that have been formed in thick deposits of organic residues and alluvial sediments on bottomlands (Hickman and Owens, 1980).

The Threemile Creek basin is located in the Southeastern Plains Level III Ecoregion and the Southern Coastal Plain Level III Ecoregion (fig. 3; Omernik, 1987). Ecoregions are characterized by their distinctive vegetative patterns, which are a result of soil type, climate, rainfall, and human activities. The principal land use in the Southeastern Plains Ecoregion is cropland, pasture, woodland, and forest. Woodland and forests are characterized by longleaf pine, with smaller areas of oak-hickory-pine and southern mixed forest. The Southern Coastal Plain Ecoregion consists mostly of flat plains, including barrier islands, coastal lagoons, marshes, and swampy lowlands along the Gulf Coast. This ecoregion is lower in elevation, with less relief and wetter soils than the Southeastern Plains (Omernik, 1987). Land cover in the Southern Coastal Plain is dominated by slash and loblolly pine with oak-gum-cypress forest in some low-lying areas.

The six Level III Ecoregions that have been identified in Alabama were recently divided into 29 Level IV Ecoregions, illustrating the enormous ecological and biological diversity in the State (Griffith and others, 2001). The Threemile Creek watershed is located in three Level IV Ecoregions: (1) Gulf Coast Flatwoods, (2) Gulf Barrier Islands and Coastal Marshes, and (3) Southern Pine Plains and Hills (fig. 3). The Gulf Coast Flatwoods and the Gulf Barrier Islands and Coastal Marshes are subgroups of the Southern Coastal Plain Level III Ecoregion;

Table 3. Rainfall summary for the Mobile Regional Airport and U.S. Geological Survey streamgaging station 02471013 (TM-1), Mobile, Alabama.

[—, no data]

Site label (fig. 1)	Year	Monthly rainfall total, inches												Annual rainfall total, inches
		January	February	March	April	May	June	July	August	September	October	November	December	
Mobile Airport	2000	2.67	1.3	6.94	2.43	2.38	3.21	3.9	3.67	3.43	0.47	11.54	3.8	45.74
TM-1	2000	2.17	1.11	7.82	1.66	1.63	6.54	2.81	2.49	5.86	1.22	11.59	4.29	49.19
Mobile Airport	2001	4.08	2.7	11.04	0.88	1.52	5.99	8.55	9.49	2.59	3.53	1.24	2.83	54.44
TM-1	2001	3.87	2.25	9.24	4.87	0.98	7.85	12.59	10.28	5.94	3.26	1.30	2.70	65.13
Mobile Airport	2002	3.52	2.87	6.08	1.74	4.45	4.24	9.38	5.02	12.94	8.35	4.92	8.97	72.48
TM-1	2002	4.02	2.86	5.34	1.53	4.09	3.57	6.18	1.81	14.83	7.06	3.26	8.80	63.35
Mobile Airport	2003	0.55	5.57	4.3	3.59	9.51	20.66	9.48	5.17	1.57	3.04	3.7	3.79	70.93
TM-1	2003	0.37	5.93	4.89	3.96	8.23	18.18	8.81	7.04	1.83	—	—	—	—
Mean monthly normal Mobile Airport	1971–2000	5.75	5.1	7.2	5.06	6.1	5.01	6.54	6.2	6.01	3.25	5.41	4.66	66.29

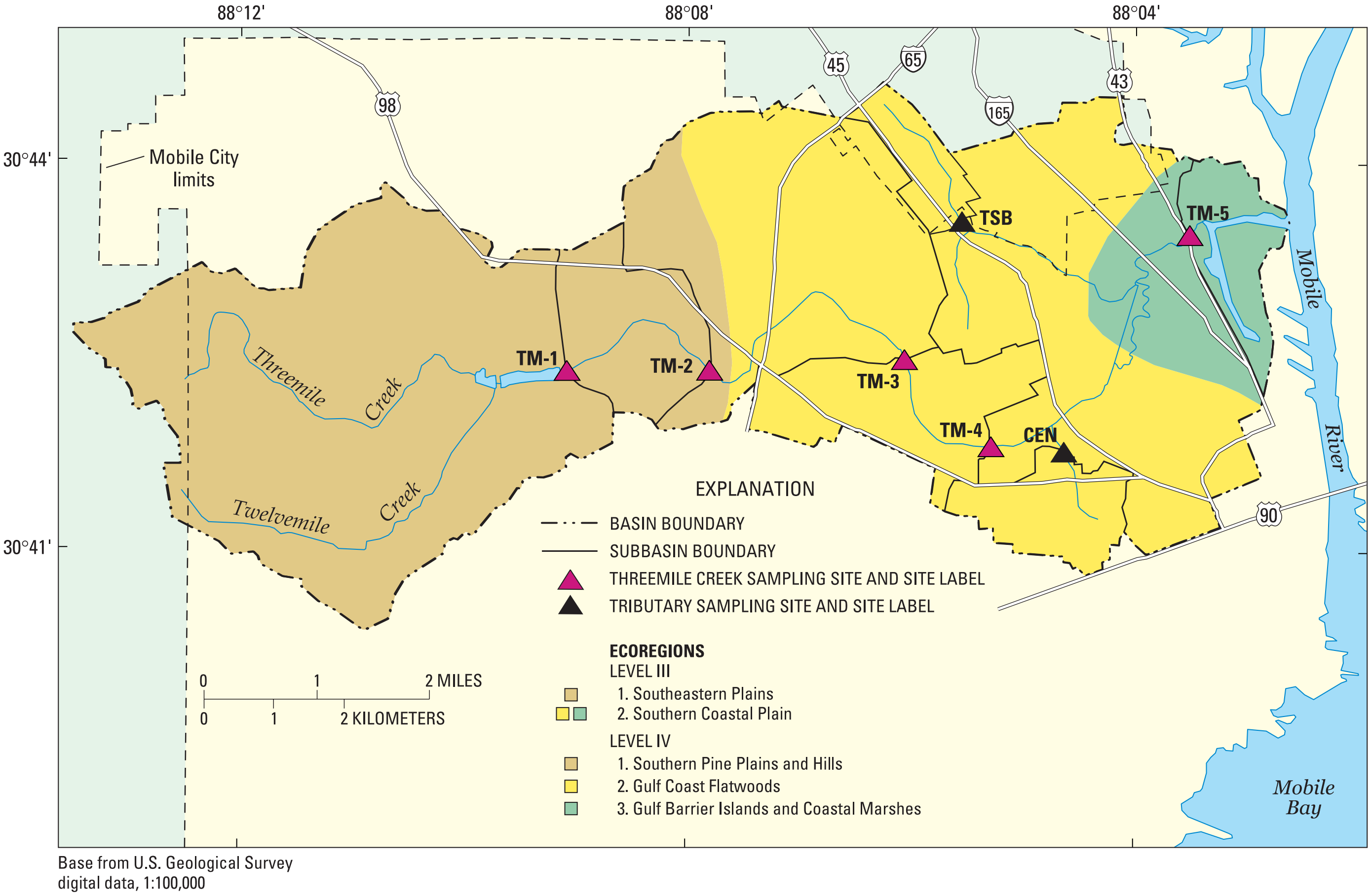


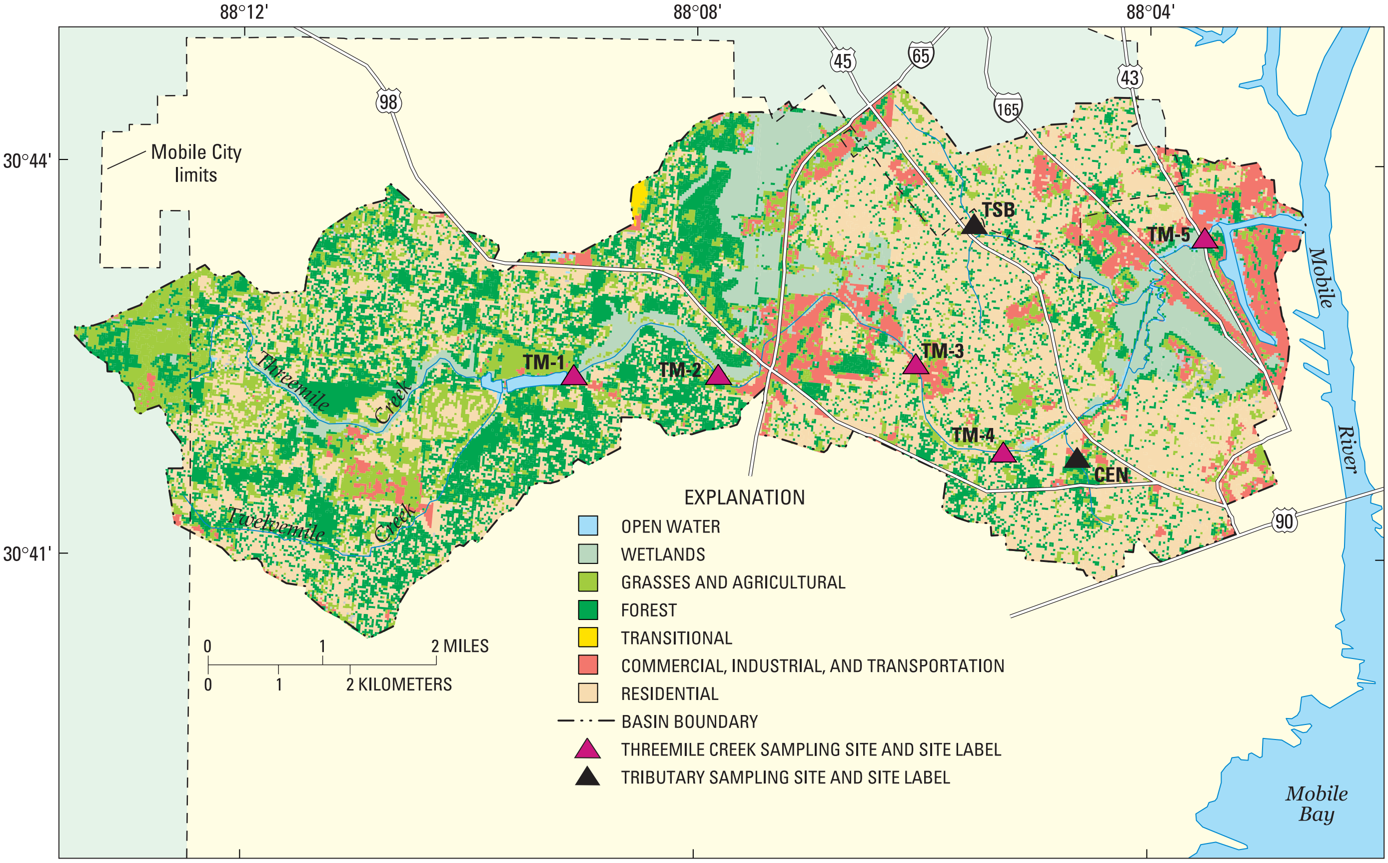
Figure 3. Delineations of the Level III and Level IV Ecoregion classifications and subbasin boundaries in the Threemile Creek basin, Mobile, Alabama (Omernik, 1987; Griffith and others, 2001).

the Southern Pine Plains and Hills is a subgroup of the Southeastern Plains Level III Ecoregion (fig. 3).

Land Use

Land use in the study area is characterized by forested and agricultural land interspersed with extensive areas of urbanization that include mostly residential and commercial activities (table 2). These land uses can be sources of both point- and nonpoint-source pollution, which can affect water quality and habitat in the streams. Fertilizers and pesticides applied in residential and commercial areas can wash into streams during storms or infiltrate the soil and enter the ground water, which ultimately discharges to streams. Storm runoff from parking lots and roadways can contribute trace elements and organic compounds from diesel fuel, gasoline, motor oils, and hydraulic fluid. Heavily commercialized or industrialized areas can contribute trace metals, motor oils, polycyclic aromatic hydrocarbons (PAHs), solvents, bacteria, and nutrients either by direct discharge into the stream (point source) or by storm runoff (nonpoint source). Elevated levels of bacteria, ammonia, detergents, and by-products of human waste can enter streams by sewer overflows during storms, or by leaky sewer lines during dry or wet periods. Municipal discharges of treated wastewater also can be sources of bacteria, nutrients, and biochemical oxygen demand (BOD) to streams.

The 1992 multi-resolution land characteristics (MRLC) map was used to quantify land-use characteristics in selected basins of Threemile Creek (figs. 4, 5; U.S. Environmental Protection Agency, 1992). The MRLC is a digital coverage (30-meter resolution) of Landsat satellite imagery of major land use and land. Commercial land use includes the sum of the commercial, industrial, and transportation categories; residential land use includes high- and low-intensity residential categories. Forested land use includes the sum of the deciduous, evergreen, and mixed-forest categories in the MRLC; grasses and agricultural is the sum of the pasture, hay, other grasses, and row crop categories; and wetlands is the sum of the woody wetlands and the emergent herbaceous wetlands. Total urban land use is considered to be the sum of the commercial,



Base from U.S. Environmental Protection Agency
National Land Cover Data, from Landsat-5 Thematic Mapper images
30-meter resolution, 1992

Figure 4. Land-use characteristics in the Threemile Creek basin, Mobile, Alabama (U.S. Environmental Protection Agency, 1992).

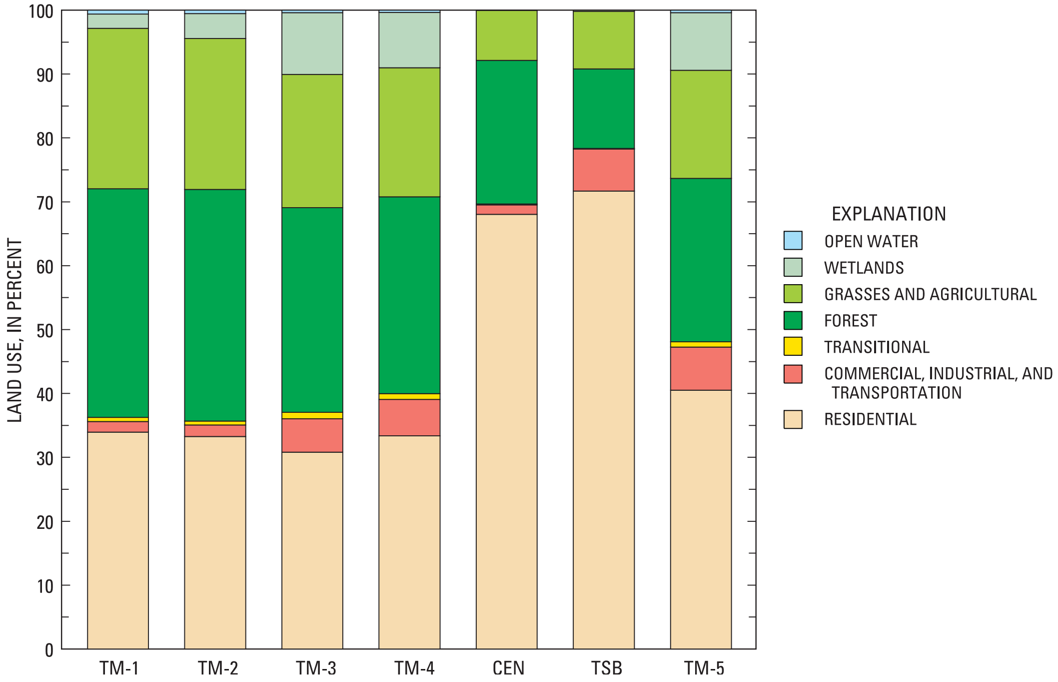


Figure 5. Land use in the Threemile Creek basin, Mobile, Alabama (U.S. Environmental Protection Agency, 1992).

industrial, transportation, and high- and low-intensity residential land-use categories in the MRLC coverage (table 2).

Urbanization accounts for about 36 percent of the land use in the Threemile Creek basin at TM-1 and about 47 percent of the land use at TM-5 (fig. 5; table 2). The two tributary basins (CEN and TSB) are more heavily urbanized than the Threemile Creek subbasins. Urbanization accounts for about 70 percent of the land use at CEN and about 78 percent of the land use at TSB (fig. 5; table 2). Residential land use represents about 95 percent of the urbanization at TM-1 and about 85 percent of the urbanization at TM-3, TM-4, and TM-5. Residential land use represents 98 percent of the urbanization at CEN and 92 percent of the urbanization at TSB (table 2). Forested land accounts for about 36 percent of the Threemile Creek basin at TM-1 and 26 percent of the basin at TM-5; grasses and agricultural land account for about 25 percent of the basin at TM-1 and 17 percent of the basin at TM-5. Wetlands cover about 2 percent of the basin at TM-1 and about 9–10 percent of the basins at TM-3, TM-4, and TM-5 (table 2). The percentage of grasses, agricultural, and forested land in the two tributary basins is less than in the Threemile Creek basins (table 2).

Land use in the Threemile Creek basin varies from site to site; however, the differences are small and are concentrated within three land-use groups—agricultural, forested, and residential. For example, the percentage of agricultural land decreases in a downstream direction (25 to 17 percent), as does the percentage of forested land (36 to 26 percent). Conversely, the percentage of urban land use (primarily residential) increases in a downstream direction (36 to 47 percent). Although differences in land use can sometimes be linked to differences in concentrations of chemical constituents or the condition of the aquatic community, greater percentage differences in land use may be required before statistically significant differences in water quality or aquatic-community structure can be observed.

Population density is used as an indicator of urbanization in a watershed. Digital coverages of population data for Mobile County for 1990–2000 were used to compute the population densities in the watersheds of the sampling sites (table 4). The population density in each of the two tributary basins (CEN and TSB) was 2–3 times higher throughout the 10-year period than in the Threemile Creek subbasins (table 4). Of the sites on Threemile Creek, TM-5 had the greatest population density (2,525 people per square mile), and TM-3 had the lowest population density in 2000 (1,965 people per square mile). From 1990 to 2000, population density decreased at all sites, with the greatest reduction at TSB (17.8 percent) and an overall reduction of about 9.5 percent in the Threemile Creek watershed.

Hydrology

Streamflow in Threemile Creek is affected by several factors, including (1) the degree of urbanization in the watershed, (2) streamflow in the Mobile River, (3) tidal fluctuations from Mobile Bay, (4) base flow in Threemile Creek, and (5) precipitation in the watershed. Urbanization influences the hydrology of streams in several ways. As the amount of impervious surface area in a watershed increases, the amount and velocity of runoff to streams increases (Dunne and Leopold, 1978), causing rapid increases in water level and velocity in streams during storms. Urbanization often results in channel modification, causing higher flows during storms and frequent flooding. An increase in the amount of impervious surface area also can cause a reduction of infiltration, resulting in less ground-water recharge and lower base flows. Long-term continuous streamflow monitoring provides hydrologic data that can be used to determine the effects of urbanization on the hydrology of streams over time.

The Mobile River is formed by the confluence of the Alabama and Tombigbee Rivers, about 45 mi north of downtown Mobile (U.S. Army Corps of Engineers, 1985). The Mobile River is confined to one channel for only about 6 mi—from the confluence of the Alabama and Tombigbee Rivers to the division between the lower Mobile River and the Tensaw River (Robinson and others, 1956). At that point, the river enters the Tensaw swamp—a labyrinth of channels, lakes, and bayous extending to Mobile Bay, an estuary of the Gulf of Mexico. Water flows into Mobile Bay in five distinct natural channels; the main channel is the Mobile River. In times of low flow, the Alabama River is the major contributor to the Mobile River; in times of high flow, either the Alabama or the Tombigbee River can be the major contributor to the Mobile River.

The Mobile River and the lower reaches of the Tombigbee and Alabama Rivers are affected by tidal fluctuations, except during periods when the streams are discharging substantial

Table 4. Population changes (1990–2000) in the watersheds of sampling sites in the Threemile Creek basin, Mobile, Alabama.

[Data from Hitt, 2003; Price, 2003; U.S. Census Bureau, 2004; mi^2, square mile]

Site label (fig. 1)	Drainage area (mi^2)	Population		Population, per square mile		Relative percent change
		1990	2000	1990	2000	
TM-1	10.4	23,265	22,090	2,237	2,124	-5.2
TM-2	12.0	26,477	25,169	2,206	2,097	-5.1
TM-3	17.3	35,326	33,995	2,042	1,965	-3.8
TM-4	19.2	42,124	40,457	2,194	2,106	-4.0
CEN	1.07	4,431	4,202	4,141	3,927	-5.3
TSB	0.618	3,817	3,194	6,177	5,168	-17.8
TM-5	28.1	77,887	70,941	2,772	2,525	-9.3

flood flows. Saltwater from the Gulf of Mexico enters Mobile Bay and the Mobile River and its tributaries, including Threemile Creek, as a wedge extending upstream along the river bottom beneath the freshwater. The extent of the tidal movement inland depends on such factors as stream discharge, tidal cycle, and shape and configuration of the stream channel (Reed and McCain, 1972). Specific conductance and dissolved-oxygen concentrations were measured at several sections on the lower reaches of Threemile Creek between TM-4 and TM-5. The saltwater wedge was detected at four sites between M.L. King Avenue and U.S. Highway 43 (TM-5, fig. 2; Pearman and others, 2003).

Tides at Mobile are diurnal—only one high and one low tide occur during a lunar day—except at the moon's quadrature (first and third quarters of the moon) when two highs and lows (neap tide) may occur with very little difference in vertical rise and fall (Robinson and others, 1956). Spring tides, which occur at the new and full moon, produce the greatest variations in the rise and fall of the tide. In coastal regions, tide levels may depend on additional factors, including wind, depth of water, and shape of the coastline (bays and estuaries). Funnel-shaped bays, for example, can dramatically increase tidal magnitudes. Tide levels in the Mobile River also depend on the water level (stage) in the river and the distance upstream from the river's mouth.

The Threemile Creek extends approximately 15 mi upstream from the Mobile River (U.S. Army Corps of Engineers, 1985); the lower reaches of the creek are affected by tidal fluctuations. The tidal cycle affects the 4.4-mi segment of Threemile Creek between the Mobile River and the last weir downstream from Fillingim Street. The series of drop structures and weirs installed between Municipal Lake and Fillingim Street prevent the tide from encroaching farther upstream, except during extreme events. About 2 mi downstream from the last drop structure, Threemile Creek flows down a straight channel through forested wetlands, whereas the original channel meanders throughout the wetlands. Saltwater was measured on the channelized section of the creek between the profile site at USGS streamgaging station 0247101520, approximately 400 ft downstream from M.L. King Avenue, and TM-5 (fig. 2; Pearman and others, 2003). Saline water was not measured at TM-4, although tidal effects on water levels at this site were recorded throughout the monitoring period.

The tidal range (amplitude) at Threemile Creek depends primarily on the strength of the tide, the stage of Threemile Creek, the stage of the Mobile River, the distance on Threemile Creek upstream from the Mobile River, and the lunar phase. Wind direction on the bay also can affect the strength of the tide. Like the Mobile River, the tidal effects are dampened during periods when Threemile Creek or the Mobile River is discharging substantial flood flows. The U.S. Army Corps of Engineers operates a streamgage (USGS station 02471017) at the Mobile State Docks in Mobile, Alabama, approximately 1.0 mi from the mouth of the Mobile River (fig. 1). Gage height for this station is available on-line at the USGS National Water Information System (NWIS) Web site (U.S. Geological Survey, 2004). During the sampling period (WY 2000–2003), the mean range of the tide at the Mobile State Docks was 1.69 feet per day (ft/d); the mean range of the tide at TM-5 was 1.72 ft/d; and the mean range of the tide at TM-4 was 1.39 ft/d.

In the upper reaches of Threemile Creek (TM-1), an increase in gage height was associated with precipitation. In the lower reaches of Threemile Creek, an increase in gage height could be associated with either precipitation or tidal effects. The frequency that stage exceeded certain gage heights differed substantially between TM-4 and TM-5. For example, gage height at TM-4 exceeded 4.0 ft on 27 days during the study period; however, gage height at TM-5 exceeded 4.0 ft only twice during the study period. At Threemile Creek, the streamgages at Stanton Road (TM-4) and U.S. Highway 43 (TM-5) recorded the same general shape and trend for gage height except for the time lag between TM-4 and TM-5; differences in range can be attributed to differences in tidal effects, varying amounts of precipitation in the basin, the presence or absence of wetlands, and channel size.

The hydrology of Threemile Creek is complex because of the degree of urbanization in the watershed, the presence of numerous weirs on the upper reaches of the creek, channelized sections of the creek, tidal fluctuations, and the presence of wetlands in some basins. The analysis is further complicated by the effects of streamflow from the Mobile River and Mobile Bay, which indirectly affect streamflow in Threemile Creek.

Site TM-5, Threemile Creek at U.S. Highway 43 near Prichard

Methods of Study

The principal factors affecting water quality are (1) natural conditions, such as the amount of precipitation, topographic and geologic features, and vegetation, and (2) human activities related to the use and reuse of water and the disposal of waste material. Causes of water-quality and aquatic-community degradation in urban watersheds can be difficult to identify because of the diversity of potential contamination sources and land-use activities. Industrial or municipal discharges, sewer overflows, runoff from parking lots, removal of riparian cover, and channel or flow modifications can alter stream hydrology, affect water quality, and influence the aquatic-community structure. The complicated relations among land-use activities, water quality, and aquatic biota in a watershed require an integrated approach to identify the factors that negatively affect a stream ecosystem.

Stream-water quality is variable over time, and organisms dwelling in streams respond to changes in water quality. Some organisms are more sensitive to certain water-quality conditions than others, so as water-quality conditions deteriorate, the assemblage of organisms in a stream becomes dominated by those most able to survive and flourish. Because of this, samples of the benthic (bottom-dwelling) organism communities in streams can provide useful information about stream-water quality. Algal biomass and community structure, benthic invertebrate structure, and water chemistry are environmental indicators that represent stream conditions at different times. Water samples represent water quality at the time of sample collection. Algal community structure and biomass typically reflect water-quality conditions for time periods ranging from several days to weeks (Porter and others, 1993) or the time period between major storms. Benthic invertebrates can integrate water-quality conditions over a span of many weeks to a year or more.

Another important aspect of stream-water quality is the condition of the hydrologic system at the time of sampling. Surface-water samples were collected during a wide range of flow conditions. Samples collected during low-flow periods represent surface-water-quality conditions resulting from ground-water seepage, septic tank leakage, and WWTP discharges; samples collected during storms or elevated flow represent water-quality conditions associated with surface runoff, shallow subsurface water flow to streams, and resuspension of stream-bottom deposits (Wicklein, 2004). Elevated flow in this study is represented by samples collected during a storm and samples collected immediately after a storm. Concentrations of contaminants from nonpoint sources typically increase during a storm as a result of overland runoff, but concentrations of contaminants from point sources may decrease during a storm as a result of dilution. Although the water-quality data collected during this study generally represent a fair range of hydrologic conditions, the majority of the samples were collected during periods of low flow; not enough samples were collected during high flow to perform comparisons and analysis for sample sets representing ground-water and stormflow components of the streamflow. By understanding the hydrologic condition at the time of sampling and reviewing the data in this context, the influence of point- and nonpoint-source contributions of contaminants on water quality can be examined in a more subjective manner.

A combination of approaches was used to assess conditions on Three Mile Creek: (1) water-quality monitors provided a continuous record of dissolved-oxygen concentrations, specific conductance, turbidity, and gage height throughout the sampling period; (2) water-quality samples were collected during a range of flow conditions to examine the potential source(s) of contaminants; and (3) water-quality, algal, and benthic invertebrate data were evaluated to assess which sites were most affected.

Water-Quality Sample Collection

Surface-water samples were collected from March 2000 to September 2003. The number of samples collected and the frequency of sampling varied from site to site (table 5). During the first year, seven samples were collected at TM-1, TM-3, TM-4, CEN, and TSB, and nine samples were collected at TM-5. Between April and August 2001, seven samples were collected at TM-1 and TM-4, eight samples were collected at TM-5, and one sample was collected at each of the two tributaries (CEN and TSB) in October 2001.

During the last 2 years of data collection, water-quality samples were collected during four specific time periods at sites on Threemile Creek to obtain data to calibrate a water-quality model. Sampling at the two tributary sites was discontinued. These four time periods (December 13–14, 2001; June 24–26, 2002; February 26–27, 2003; and September 15–16, 2003) represented different seasons and different flow conditions (storm, mixed flow, or base flow). Multiple samples (4–8) were collected at three sites on Threemile Creek during each of the four time periods. The frequency of sampling at TM-3 and TM-4 differed from that at TM-1 and TM-5, and the number of high-flow samples collected at TM-3 exceeded that at TM-4, TM-1, or TM-5.

Surface-water samples were analyzed for nutrients, major ions, total organic carbon (TOC), 5-day biochemical oxygen demand (BOD_5), suspended chlorophyll *a,* organic wastewater compounds (OWCs), color, turbidity, and fecal bacteria during a range of flow conditions. Sampling for some constituents, such as major ions, TOC, color, and turbidity, was limited to the first year; sampling for other constituents, such as BOD_5, suspended chlorophyll *a,* and OWCs, was intermittent throughout the sampling period (table 5). OWC samples were shipped to the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado, for analysis. All other samples were shipped to the USGS Water Quality and Research Laboratory in Ocala, Florida. Water-quality monitors installed at three sites on Threemile Creek (TM-1, TM-4, and TM-5) provided a continuous record of water temperature, dissolved-

Table 5. Number and type of water-quality, benthic invertebrate, and periphyton samples collected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

[BOD_5, 5-day biochemical oxygen demand; AFDM, ash-free dry mass]

Site label (fig. 1)	Number and type of water-quality samples									Number and type of benthic-invertebrate and periphyton samples		
	Nutrients[a]	Major ions[a]	BOD_5[a]	Suspended chlorophyll *a*[a]	Enterococci[a]	*Escherichia coli*[a]	Fecal coliform[a]	Organic wastewater compounds[b]	Total organic carbon[a]	Benthic invertebrate community survey[c]	Chlorophyll and AFDM periphyton[d]	Periphyton species[e]
TM-1	36	7	29	24	26	35	31	13	7	1	11	3
TM-2	0	0	0	0	0	0	0	0	0	1	8	2
TM-3	20	7	11	12	19	21	15	10	7	1	11	3
TM-4	20	7	18	18	20	19	20	11	7	1	2	1
CEN	8	7	6	8	8	8	8	8	7	0	1	1
TSB	8	7	6	8	8	8	8	8	7	0	1	1
TM-5	39	9	30	26	34	36	31	13	7	0	0	0

[a] See appendix table 2-1. [b] See appendix table 2-2. [c] See appendix table 3-1. [d] See table 19. [e] Each sample consists of three or more replicates. See appendix table 3-2.

oxygen concentration, specific conductance, and turbidity between WYs 2000 and 2003.

Data-collection procedures conformed to standard USGS protocols and included equal-width increment sampling, which produces a composite sample that is representative of flow in a cross section (Wilde and others, 1999). Most water samples were collected by using a DH-81 sampler or a weighted bottle sampler (Edwards and Glysson, 1999). Storm samples were discrete. Instantaneous field measurements of stream discharge, air temperature, water temperature, pH, dissolved-oxygen concentration, and specific conductance were made at the time of sampling. A security fence located on the bridge at TM-4 limited access to the site because of its height; consequently, discharge could only be measured when the creek was wadeable. Continuous water-quality monitors in the Threemile Creek watershed recorded data (water temperature, dissolved-oxygen concentrations, specific conductance, turbidity, and gage height) at 15-minute intervals.

An acoustic Doppler velocity meter was mounted at TM-5 to collect horizontal velocities at 15-minute intervals. These velocity measurements and stage data can be used in conjunction with discharge measurements made with an acoustic Doppler current profiler (ADCP) to construct an index-velocity rating at a station. Numerous discharge measurements were made during several tidal events at TM-5 using the ADCP, which was mounted on a small boat; however, efforts to develop an index-velocity rating were unsuccessful because of the complex tidal currents.

A plastic churn was used to composite the cross-section water subsamples, and water samples for BOD_5 and unfiltered constituents were taken directly from the churn. Water samples for dissolved constituents were filtered using a 0.45-micrometer (μm) pore-size filter that was pre-rinsed with de-ionized water and native stream water. Wastewater-indicator samples were collected as grab samples directly from the stream in 1-liter (L) glass bottles. Samples were preserved and chilled immediately after filtration and shipped overnight to the USGS laboratories in Denver and Ocala. All equipment used to collect and process samples was cleaned with a 0.2-percent nonphosphate detergent


USGS personnel using an ADCP to make a discharge measurement at site TM-5 on Threemile Creek

and rinsed with tap water, a solution of 5-percent hydrochloric acid, and de-ionized water.

Wastewater-indicator compounds were analyzed from unfiltered samples by continuous liquid-liquid extraction with methylene chloride and determined by capillary-column gas chromatography/mass spectrometry using selection-ion monitoring (Brown and others, 1999; Kolpin and others 2002). Information in Zaugg and others (2002) provides details about the specific wastewater-indicator compounds analyzed and their uses. Nutrient concentrations were determined at the USGS Ocala laboratory by using methods specifically designed to measure low levels of certain constituents (U.S. Environmental Protection Agency, 1983; Fishman and Friedman, 1989).

Water samples for analysis of fecal-indicator bacteria (enterococci, *Escherichia coli (E. coli)*, and fecal coliform) were processed in the field by USGS personnel according to published methods (U.S. Environmental Protection Agency, 1985, 1997). Samples were collected by using an autoclaved 1-L polyethylene bottle or glass bottle dipped at multiple points across the stream. Samples were processed by membrane-filtration techniques within 6 hours of collection, according to USGS guidelines (Myers and Wilde, 1999). Bacteria results were reported in units of colonies per 100 milliliters (col/100 mL) of water. Suspended chlorophyll *a* and *b* samples were collected in the same manner as fecal-indicator bacteria. Samples were processed through glass fiber filters, shipped on wet ice, and sent to the USGS Ocala laboratory for analysis. Suspended chlorophyll *a* and *b* samples were analyzed by using high-performance liquid chromatography.

Benthic Invertebrate and Periphyton Sample Collection

Benthic invertebrates are bottom-dwelling aquatic animals, such as insect larvae, mollusks, and worms, that occupy diverse functional niches in aquatic ecosystems. They recycle organic matter, consume smaller organisms, and are important components in the diet of fishes. Benthic invertebrates commonly are used to assess the health of aquatic communities because they are easy to collect and identify, usually abundant, and relatively sessile (Merritt and Cummins, 1996). Benthic invertebrates typically integrate the effects of water quality over periods of about a year and can be more sensitive indicators of water quality than chemical measures. Benthic invertebrates were sampled during July 2000 at four sites (TM-1, TM-2, TM-3, and TM-4) on Threemile Creek (table 5). A replicate sample also was collected at site TM-4. Project plans called for annual invertebrate collections at these sites, with a replicate sample at one site per year, to help evaluate variance between samples. Sampling in subsequent years was not possible because of destruction of the emergent and bank vegetation and dredging of the channel for flood control.

The richest instream habitat, or habitat type most likely to have the greatest number of distinct types (taxa) of invertebrates, was sampled at each site. Flow characteristics and substrate type, two important components of habitat, varied among the Threemile Creek sites. Streamflow at TM-1 consists of overflow (spillage) from Municipal Lake, a manmade impoundment of Threemile Creek located just upstream from this site. Invertebrate assemblages downstream from impoundments tend to be dominated by filtering collectors, such as the net spinning caddisflies. The sampled habitat at site TM-1 consisted of a riffle among large boulders left from previous road construction at the site. Riffle areas usually support diverse invertebrate communities because of high dissolved-oxygen concentrations, stable substrate, and large areas of available habitat; however, diversity and abundance can decrease with substrate larger than cobble (greater than 10 inches; Barbour and others, 1999; Moulton and others, 2002). The richest habitats for invertebrates at the other three sites (TM-2, TM-3, and TM-4) were emergent vegetation along the margins of the stream. Channel substrates at TM-2, TM-3, and TM-4 consisted of sand and gravel. The sample reach at TM-2 consisted of a run with steady, slow flow. The sample reach at TM-3 was located in a pooled area just downstream from a double weir located under Fillingim Street. The sample reach at TM-4 was located in a run with flows affected by tidal backwater.

Habitat differences at the sites required two different sampling strategies for benthic invertebrates. At TM-1, samples were taken from a large riffle area using a Slack sampler with a 425-µm mesh net that narrows to a collection receptacle (Cuffney and others, 1993). Invertebrates were collected from three areas of about 0.25 square meters (m^2) each and composited into a single sample. At TM-2, TM-3, and TM-4, samples were collected by sweeping a 210-µm mesh D-frame net under and through vegetation. For consistency of effort, six 30-second sweeps were made at each site and composited into a single sample. Simultaneous sweeps were made along the left and right banks, and each of the two samples was composed of material from six sweeps, three from each side of the stream. All samples were processed by placing collected material in a bucket, stirring to suspend the organisms, and pouring the liquid portion through a 425-µm sieve. Material in the sieve was picked through to remove large pieces of debris from the sample, transferred to polyethylene bottles, and preserved with a 10-percent buffered formalin solution. Material remaining in the bucket was inspected for invertebrates, which were added to the preserved sample. Samples were sent to the Biological Unit at the USGS NWQL for identification and enumeration of organisms, using the quantitative 300-organism count, as described in Moulton and others (2000).

Periphyton are algae that are attached to the stream bottom. Periphyton commonly are the primary producers in streams, providing food for benthic invertebrates, which feed fish and other vertebrates. Periphyton have relatively rapid growth rates and can respond quickly to changes in water quality, making them good indicator organisms of water quality over periods of days or weeks (Lowe and Pan, 1996). Samples of periphyton were collected from six sites (TM-1, TM-2, TM-3, TM-4, CEN, and TSB; table 5) during the summers of 2000–2003.

Stream periphyton samples can be collected from natural or in situ substrates or from artificial substrates placed in the stream. Artificial substrates made of glass, clay tiles, plastic, or other materials often are used when natural stream substrates differ among sites (Aloi, 1990; Porter and others, 1993). Periphyton communities developing on artificial substrates may differ substantially from communities on natural stream substrates because of differences in colonization time and substrate surface (Tuchman and Stevenson, 1980). Samples collected from natural substrates represent algal communities that have been developing over a period of months, while artificial substrates are often deployed for much shorter colonization periods (Lowe and Gale, 1980; Tuchman and Stevenson, 1980). According to Tuchman and Stevenson (1980), periphyton on clay tile substrates is less variable and more closely resembles natural communities than communities on sterilized rock substrates. Previous comparisons of periphyton communities have shown differences among various types of substrate (Lowe and Pan, 1996), and periphyton data should not be compared among multiple substrate types (Porter and others, 1993).


Site TM-2, Threemile Creek near Pine Grove

Artificial substrates made of unglazed clay tiles were used as uniform bases for periphyton colonization in the Threemile Creek basin to exclude the effects of multiple substrate types (concrete, boulder, and sand). After a colonization period of 2 to 8 weeks, material from a section of tile with a known surface area was scraped off and filtered onto a 47-millimeter (mm) glass-fiber filter. Filters were shipped on dry ice to the USGS NWQL for determination of benthic chlorophyll *a* by fluorometric methods and ash-free dry mass (AFDM).

Once a year (during 2000 to 2002), all material from another section of the clay tiles was scraped off, preserved with a sufficient volume of buffered formaldehyde to obtain a final concentration of 3- to 5-percent buffered formalin, and shipped to the Philadelphia Academy of Natural Sciences for species identification and enumeration. Laboratory protocols that were used were developed in the USGS NAWQA Program (C. Knowles, Philadelphia Academy of Natural Sciences, written commun., August 2000). Periphyton samples from 2000 and 2001 were analyzed by using a 600-count of diatoms and identification of all soft algae. In 2002, samples were analyzed by using Philadelphia Academy of Natural Sciences Protocol P-13-63 (Charles and others, 2002). Taxa richness and community diversity could appear to be greater for 2000–2001 because a greater number of individual algal cells were counted under the laboratory method used during those years than in 2002. Thus, comparisons of samples from September 2002 are presented independently.

Periphyton samples were collected at five sites (TM-1, TM-3, TM-4, CEN, and TSB) during September 2000. Sites CEN and TSB were too shallow for the clay tile substrates to be submerged, so the existing concrete channels were sampled instead. The set of clay tiles at site TM-4 was lost due to high streamflows or vandalism, so the sample at that site and a replicate sample at TM-3 were collected from the natural sand substrate. Samples taken from existing substrates can be used to describe the existing periphyton communities but should not be used to infer differences in water quality among the sites. Another set of samples was collected in November 2000 and analyzed for benthic chlorophyll *a* and AFDM only.

During 2001–2003, only sites TM-1, TM-2, and TM-3 were sampled because they allowed the use of the uniform artificial substrates. Four benthic chlorophyll *a* and AFDM samples were collected during the summer of 2001, three during


Site TM-3, Threemile Creek at Fillingim Street at Mobile

the summer of 2002, and two during the summer of 2003. Tile exposure periods, benthic chlorophyll *a,* and AFDM results are summarized later in this report. In addition, samples were collected once a year (during 2000 to 2002) for enumeration of periphyton assemblages. Three replicate samples were collected at each site each year and analyzed individually to assess reproducibility of sample results. Data are summarized in appendix table 3-2. Dates of tile exposure were the same for benthic chlorophyll *a* and AFDM samples and corresponding identification samples.

Water-Quality Data Analysis and Review

Methods used to interpret water-quality data in this report include various graphical tools and statistical methods. Graphical tools include the use of bar charts, which illustrate the speciation of certain nutrients (nitrogen and phosphorus) and groups of OWCs, the total concentration of OWCs, and the frequency of detection for other OWCs. Median concentrations of constituents were used when comparing constituent levels among sites in the Threemile Creek basin. Median concentrations represent the 50th percentile of the concentration data and are less affected than mean concentrations by the value of extremely high or low concentrations. Box plots are used to display the variability in nutrient concentrations, and elevated-flow/low-flow figures are used to illustrate the concentrations of fecal-indicator bacteria and the hydrologic condition at the time of sampling. If concentrations detected during low flow were consistently higher than those during elevated flow, a "P" was placed on the graph, indicating point sources. If the concentrations detected during elevated flow were consistently higher than those during low flow, an "NP" was placed on the graph, indicating nonpoint sources. If the results were mixed, a "B" was placed on the graph, indicating that both point and nonpoint sources may be contributing. Maximum concentrations and ranges of concentrations were evaluated with respect to flow. These data can be useful in determining the influence of point- and nonpoint-source contributions of contaminants on water quality. Statistical methods to evaluate the relation between discharge and concentration could not be applied at each site because (1) samples were collected over a limited range of flow, (2) discharge measurements were not made at every site during each sample collection (TM-4 and TM-5), and (3) discharge measurements at TM-5 were considered unreliable.

The USGS NWQL has implemented procedures for interpreting and reporting low-concentration data in water-quality samples (Childress and others, 1999). Concentrations of analytes that either were not detected or were not identified were reported as less than the minimum detection limit (< MDL) or less than the minimum reporting level (< MRL) and are considered to be nondetections. All qualitatively identified compounds detected less than the MRL are reported as estimated (Zaugg and others, 2002). Estimated concentrations are noted with the remark code E. The uncertainty associated with these estimated concentrations is greater than that associated with values that were detected at concentrations above the MRL and not estimated. The MRLs for OWCs were established by the NWQL. The MDL for nutrient compounds was established by the Ocala laboratory.

Sensitive analytical methods used in this study resulted in low detection limits and higher detection frequencies for many wastewater indicators. Comparison of detection frequencies among wastewater indicators can be misleading because of the different reporting levels associated with each of the wastewater indicators. For example, the pesticide diazinon has a reporting level of 0.5 microgram per liter (µg/L), and nonylphenol diethoxylate (NP2EO) has a reporting level of 1.1 or 5.0 µg/L. Diazinon was detected more frequently than NP2EO in this study; however, it is unknown whether the same would be true if the MRL of NP2EO also were 0.5 µg/L. To reduce this type of bias when calculating detection frequencies, data sometimes are adjusted by censoring to a common threshold. Nonadjusted data were used when evaluating the frequency of detection for wastewater indicator compounds in the Threemile Creek basin.

Nonparametric hypothesis tests were used to evaluate relations among water-quality constituents. Spearman's *rho* was used to measure the strength of association between constituents, including total nitrogen, total phosphorus, discharge, turbidity, fecal-indicator bacteria, and selected OWCs (SAS Institute, Inc., 1989). Spearman's *rho* is the linear correlation coefficient computed on the ranks of the data rather than actual values (Helsel and Hirsch, 1992). Values of *rho* range from -1.0 to 1.0, and the closer the value is to -1.0 or 1.0, the stronger the association between the two variables. The correlation coefficient, *rho*, is positive when both variables increase and negative when one variable increases as the other decreases. A probability statistic (p) of 0.05 means that there is a 95-percent probability that the correlation is statistically significant. For this report, significant correlation was determined by an absolute *rho* value of 0.7 or greater, provided that the p value was less than or equal to 0.05. All data sets with *rho* and p values within the designated ranges were verified by scatter plots to determine the distribution of the data. Plots that indicated poor distribution because of grouped data points or outliers were not considered in the correlation analysis. In many instances, correlation coefficients could not be calculated because of the large number of nondetection values, multiple detection levels, or the limited sample size. In the correlation analysis for nutrients, nondetection values were assumed to be equivalent to the detection level.

The determination that a correlation existed between constituents meant that the constituents varied with each other in a consistent pattern. This does not necessarily indicate a cause and effect relation (Helsel and Hirsch, 1992). Although statistically significant differences were found, the significance of the results and the power of the tests used are limited because of the small sample size. Thus, results should be viewed as preliminary and not conclusive.

The Kruskal-Wallis and the Tukey multiple-comparison tests were used to determine whether water-quality concentrations at one site were significantly different from concentrations at another site (SAS Institute, Inc., 1989). The Kruskal-Wallis test is a one-way, nonparametric analysis of variance (ANOVA) test that was used to determine whether significant differences existed among independent data sets—four sites on Threemile Creek (TM-1, TM-3, TM-4, TM-5), two sites on Threemile Creek (TM-1 and TM-5), the two tributary sites, and the two tributary sites with TM-4 and TM-5. The Tukey multiple-comparison test was then used to compare the differences in concentrations in an upstream-downstream order within these data sets. The simplest procedures for performing nonparametric multiple comparisons are rank transformation tests (Helsel and Hirsch, 1992). Ranks were substituted for the original data, and the Tukey multiple-comparison test was performed on the ranks. Data were censored to the highest detection level whenever multiple detection levels were present. Statistical tests were not performed if censoring resulted in a severe (near 50 percent or more) loss of data (Helsel and Hirsch, 1992).

To minimize the bias that could be created from testing data collected under different conditions at different sites, the Kruskal-Wallis and Tukey multiple-comparison tests were applied to time periods when sampling was uniform between sites: (1) Threemile Creek and tributary sites—7 samples collected between March 13, 2000, and March 13, 2001; and (2) TM-1 and TM-5—36 samples collected between March 13, 2000, and September 16, 2003. By grouping the data in this manner, it was possible to evaluate the differences in water quality among all the sites for a 1-year period (March 2000–March 2001), and because TM-1 and TM-5 were sampled evenly throughout the entire sampling period, differences in water quality between these two sites could be evaluated for the entire sampling period (March 2000–September 2003). Data from sites TM-4, CEN, TSB, and TM-5 were examined to evaluate whether differences between TM-4 and TM-5 could be attributed to the tributaries or to other sources, including discharges from the WWTPs. Definitive conclusions could not be made in most instances because samples were not collected from the discharge at the WWTP, and the influx of the tide at TM-5 further complicated the interpretation. The significance of the results and the power of the tests used are limited because of the small sample size; therefore, the results should be viewed as preliminary and not conclusive.

The U.S. Environmental Protection Agency (USEPA) has established water-quality standards and guidelines for chemicals that can have adverse effects on human health, aquatic organisms, and wildlife. Current drinking-water standards, which are enforceable and apply to drinking-water supply systems, set maximum contaminant levels (MCLs) for nitrite plus nitrate at 10 milligrams per liter (mg/L), maximum nitrate levels at 10 mg/L, and maximum nitrite levels at 1 mg/L (U.S. Environmental Protection Agency, 2002a). Although the MCLs established by the USEPA pertain to finished drinking water supplied by a community water supply, these levels provide values for comparison with the sampled concentrations. The USEPA also has developed nutrient guidelines for surface water, which are intended to represent background concentrations of selected nutrients (U.S. Environmental Protection Agency, 2000a, 2000b). In order to account for regional and local influences, these guidelines are established for streams in individual ecoregions. Ecoregions are land divisions based on a combination of causal and integrative factors, including land use, land-surface forms, potential natural vegetation, and soils (Omernik, 1987). The ecoregion nutrient criteria are not intended to be enforceable standards but rather serve as guidelines for certain nutrient concentrations within the ecoregions. Concentrations of total nitrogen, total phosphorus, and suspended chlorophyll *a* were compared to recommended criteria developed for nutrient ecoregions IX and XII (U.S. Environmental Protection Agency, 2000a, 2000b). Sites TM-1 and TM-2 are located in nutrient ecoregion IX, and sites TM-3, TM-4, TM-5, CEN, and TSB are located in nutrient ecoregion XII (U.S. Environmental Protection Agency, 2000a, 2000b). The USEPA also recommends that total phosphorus concentrations not exceed 0.10 mg/L in streams not entering lakes or impoundments in order to prevent nuisance aquatic plant growth (U.S. Environmental Protection Agency, 1986b).

Aquatic-life criteria established by the USEPA and the ADEM provide for the protection of aquatic organisms for short-term (acute) and long-term (chronic) exposures (Alabama Department of Environmental Management, 2000c; U.S. Environmental Protection Agency, 2002c). In some instances, Canadian guidelines were used for comparisons when other criteria were not available (Canadian Council of Ministers of the Environment, 2001, 2002). Some compounds that are known to be toxic to aquatic life currently are unregulated, even though some are on the USEPA Toxic Substance Control Act Priority Testing List (U.S. Environmental Protection Agency, 1996; Zaugg and others, 2002).

Fecal-bacteria concentrations were compared to established State and Federal standards and criteria. The USEPA has defined criteria for single-sample densities for enterococci and *E. coli* in recreational waters based on frequency of use and body contact (U.S. Environmental Protection Agency, 1986a, 2002b). For infrequent, full-body recreational contact, enterococci and *E. coli* samples should not exceed 151 and 576 col/100 mL, respectively. The ADEM continues to rely on fecal-coliform regulatory standards for most water-use classifications, although enterococci standards have been added for coastal waters (Alabama Department of Environmental Management, 2004). For fecal-coliform samples collected in streams classified for agricultural and industrial use, the geometric mean of at least five samples collected over a 30-day period should not exceed 2,000 col/100 mL, nor should any one fecal-coliform sample exceed a maximum of 4,000 col/100 mL (Alabama Department of Environmental Management, 2000c, 2004). Exceedance frequencies were calculated by summing the number of exceedances and dividing by the total number of samples collected for each type of bacteria.

Quality-Control Methods and Results

Quality-assurance and quality-control measures were practiced throughout the study according to established USGS guidelines (Mueller and others, 1997). Laboratory and field blank samples were processed using water certified to contain undetectable concentrations of constituents to be analyzed. Data from blank samples were used to determine the extent of contamination potentially introduced during sample collection, processing, and analysis. Blank water used for the inorganic constituent sample was distilled, de-ionized water obtained from the USGS Ocala laboratory. Blank water used for the organic constituent sample was either pesticide-grade or volatile-organic-compound grade blank water obtained from the USGS NWQL. Sterile water blanks (saline or peptone buffer) were processed at each site to check the effectiveness of sterilization and processing procedures for bacterial analysis.

Blank samples were analyzed for nutrients (14 blanks), major ions (7 blanks), organic carbon (6 blanks), BOD_5 (10 blanks), and wastewater indicators (11 field blanks; 14 laboratory blanks; appendix table 1-1). Detections of nutrients in blank samples were generally at or slightly greater than the MDL (appendix table 1-1). Total ammonia nitrogen was the most frequently detected nutrient in blank samples (5 of 14 samples); dissolved ammonia nitrogen and dissolved phosphorus were detected in 4 of 14 blank samples (appendix table 1-1). Dissolved calcium, total iron, dissolved iron, dissolved magnesium, total manganese, and dissolved sodium were detected one time each in seven blank samples; dissolved silica was detected in three of seven blanks. Concentrations of total iron, dissolved magnesium, and total manganese were below the MDL (appendix table 1-1). Total organic carbon was detected in 4 of 6 blank samples, and concentrations ranged from 0.3 to 0.6 mg/L (MDL < 0.01 mg/L); BOD_5 was detected in 6 of 10 blank samples, and concentrations ranged from 0.2 to 0.5 mg/L (MDL < 0.1 mg/L; appendix table 1-1).

The method designed by the NWQL for OWCs was under development during this investigation, and the final analysis of the associated method (lab code 8033) is pending (U.S. Geological Survey, 2003; S.D. Zaugg, U.S. Geological Survey, written commun., May 3, 2004). The method was developed in response to increasing concern over the effects of endocrine-disrupting chemicals in wastewater on aquatic organisms, and the method focuses on the determination of compounds that are an indicator of wastewater or that have been chosen on the basis of their endocrine-disrupting potential or toxicity (Zaugg and others, 2002).

The method used to report OWCs is considered to be “information rich” (Childress and others, 1999) because compound identifications are determined by mass spectrometry; consequently, results are not censored (Zaugg and others, 2002). For compounds that are either at a concentration less than the MRL or the lowest calibration standard (usually 0.05 µg/L) but meet qualitative criteria, results are reported by using the “E” code to indicate that the concentration is estimated. All qualitatively identified compounds detected less than the MRL are reported as estimated, regardless of the established MRL (Zaugg and others, 2002). The concentrations of 16 compounds always are reported as estimated for one of three reasons: unacceptable low-biased recovery (less than 60 percent) or highly variable method performance (greater than 25-percent relative standard deviation), unstable instrument response, or reference standards prepared from technical mixtures (Zaugg and others, 2002). Of the 48 compounds examined in this study, 7 were included in the group of 16 compounds that are always reported as estimated. Six of these constituents were detected in stream samples (carbaryl, 17β-estradiol, nonylphenol diethoxylate (NP2EO total), octylphenol monoethoxylate (OP1EO), octylphenol diethoxylate (OP2EO), and *para*-nonylphenol total), and four were detected in blank samples (17β-estradiol, NP2EO total, OP1EO, and *para*-nonylphenol total; appendix table 1-1). The specific compounds included in the wastewater schedule and the MRLs varied among samples because of method refinement during the 3 years (2000–2003) that samples were collected and because of matrix interference.

In this study, OWC data were censored according to the detection level of constituents found in laboratory and field blanks. If a constituent was found in either a laboratory or field blank and also detected in a stream sample during the same sampling trip at the same magnitude, then the detection was not included. Thirteen field blanks were sent to the NWQL; results from two of these field blanks were eliminated from the data set because of problems associated with these samples at the lab and in the field. The NWQL analyzed 14 laboratory blanks associated with samples from this study. Four of 48 compounds were detected in the 11 field blanks collected during this study; 16 of 48 compounds were detected in 14 laboratory blanks (appendix table 1-1). Only 3 of 27 detections in laboratory and field blanks were greater than the corresponding MRL associated with the sample. These low-level detections indicate little potential for contamination of stream-water samples, and few data were censored as a result of these detections.

Benthic Invertebrate and Periphyton Data Analysis and Review

Benthic invertebrate data were processed through the USGS Invertebrate Data Analysis System (IDAS) to calculate commonly used metrics and measures of invertebrate community diversity and evenness (Cuffney, 2003). The lowest taxonomic level, known as the NWQL Biological Unit identification, or BU_ID, was used in calculations. Ambiguous taxa were resolved by combining all samples and distributing ambiguous parents proportionately among their children (method RC4; Cuffney, 2003). Three ambiguous parent taxa were resolved manually by distributing parent abundance among children that accounted for greater than 10 percent of the combined sample abundance. The metrics were then used to assess similarities and differences among the sample sites. Metrics used in this report include total taxa richness;

Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa richness; percentage dominant taxon; relative abundance of major taxa; and the Shannon-Weaver Diversity Index.

Taxa richness, or total number of taxa, was used to describe the diversity of organisms present at each site. EPT taxa richness and chironomid taxa richness also were considered. EPT taxa richness is the number of taxa within the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) that generally are thought to be intolerant of organic enrichment and elevated trace metal concentrations. The chironomids, or midges, are members of the family Chironomidae and are considered more tolerant of organic enrichment than the EPT taxa. Healthy benthic-invertebrate communities have a fairly even distribution among Chironomidae and EPT taxa (Alabama Department of Environmental Management, 1996).

A stream that receives contaminants or has been altered from natural conditions tends to have a less diverse community of benthic invertebrates. Diversity is a measure combining richness and evenness—that is, the distribution of individuals among taxa. The percentage contribution of the dominant taxon is the percentage of total sample abundance that is contributed by the most abundant taxon. Large percentage contributions by a few taxa indicate less even invertebrate communities, which are indicative of less healthy streams. The abundance of a healthy benthic invertebrate community usually is distributed among several taxa. The relative abundances of major taxa were used to assess both evenness and diversity of benthic invertebrate communities. The Shannon-Weaver Diversity Index is a measure of the uncertainty associated with a taxon selected at random from the community (Peet, 1974; Cuffney, 2003). Greater uncertainty is associated with greater diversity. The ADEM uses the Shannon-Weaver Diversity Index to indicate diversity in quantitative benthic invertebrate samples and to evaluate stream impairment. According to the ADEM, index values less than 1 indicate impairment, and values between 3 and 4 indicate the diversity expected in healthy streams (Alabama Department of Environmental Management, 1996).

Chlorophyll *a* and AFDM often are used as surrogate measures for algal biomass. Chlorophyll *a* is the primary pigment used for photosynthesis in algal cells and accounts for about 0.5 to 2.0 percent of the algal biomass (Barbour and others, 1999). Ash-free dry mass is the mass of organic material in a sample, which may include fungi, bacteria, and other biota as well as periphyton. Algal biomass can respond to changes in light and nutrient availability, differences in substrate or flow conditions, grazing by other organisms, and the presence of toxins. Benthic chlorophyll *a* concentrations greater than 10 micrograms per square centimeter ($\mu g/cm^2$) and AFDM greater than 50 grams per square meter (g/m^2) may indicate nuisance algal growth (Barbour and others, 1999). In this report, benthic chlorophyll *a* and AFDM are used to compare standing crops of periphyton among sites and samples and as a screening tool for nuisance algal growth.

The ratio of AFDM to chlorophyll *a* in milligrams per square meter, known as the autotrophic index, can be used to evaluate the amount of fungal and bacterial material included in AFDM measurements. Organically enriched (high BOD) streams commonly have higher proportions of fungi and bacteria and, consequently, higher autotrophic indices (Lowe and Pan, 1996). Organic enrichment may have occurred if the autotrophic index is greater than 100 (Weber, 1973).

Periphyton community data are summarized using metrics much like the benthic invertebrate metrics. The abundance and relative abundance of certain algae types indicate whether nutrient enrichment, acidification, or other water-quality conditions exist. The metrics used for periphyton analysis were (1) species richness based on cell density, (2) percentage abundance and percentage biovolume represented by each of the major algal divisions found in Threemile Creek, diatoms, blue-green algae, green algae, cryptophyte algae, euglenoids, dinoflagellates, and others, and (3) percentage of taxa in each of the saprobic categories (van Dam and others, 1994).

Diversity of periphyton communities was measured using richness and relative abundance. Algal species richness is the number of algal species identified in the sample and tends to decrease as water-quality degradation increases. The intermediate disturbance hypothesis predicts that taxa richness will increase from background conditions at an intermediate level of stream disturbance and then decrease as disturbance becomes more severe. The percentage of algal cells and the percentage of total biovolume represented by each division were used to determine the dominant algal divisions at each site. Differences in algal community composition could be related to site water quality, and overwhelming dominance of a single division may indicate water-quality impairment.

The saprobic categories were used to further examine periphyton community response to water-quality conditions. The saprobic categories represent groups of diatoms that prefer various levels of dissolved-oxygen concentrations and BOD. The categories and their corresponding oxygen and BOD concentrations are given in table 6 (van Dam and others, 1994; T.F. Cuffney, U.S. Geological Survey, written commun., 2004). If diatoms of one saprobic category dominate the community, oxygen conditions favored by the dominant category are likely to have occurred frequently at that site during the colonization period.

Water-Quality Results and Discussion

The results and discussion of water-quality sampling and data analysis conducted during this investigation are presented here. The topics discussed include analytical results related to basic water chemistry, major ions, instantaneous and continuous measurements of water properties, nutrients, suspended chlorophyll *a* and *b*, biochemical oxygen demand, total organic carbon, fecal-indicator bacteria, and OWCs at four

Table 6. Saprobic categories of diatoms and corresponding dissolved-oxygen concentrations and biochemical oxygen demand values (van Dam and others, 1994).

[O_2, oxygen; >, greater than; <, less than; BOD_5, 5-day biochemical oxygen demand; mg/L, milligram per liter]

	Saprobic category				
	oligosaprobic	**β-mesosaprobic**	**α-mesosaprobic**	**α-mesosaprobic/ polysaprobic**	**polysaprobic**
O_2 saturation (percent)	>85	70–85	25–70	10–25	<10
BOD_5 (mg/L)	<2	2–4	4–13	13–22	>22

sites on Threemile Creek (TM-1, TM-3, TM-4, and TM-5) and at two tributary sites (CEN and TSB).

Basic Water Chemistry

The chemistry of surface water is the result of interactions between precipitation, ground water, rocks, and soils near the Earth's surface. Dissolved and particulate constituents enter a stream by surface runoff, precipitation, or ground-water discharge. The major dissolved constituents that give water its characteristic chemistry are cations and anions. Cations are positively charged ions and include calcium, magnesium, sodium, and potassium. Anions are negatively charged ions and include bicarbonate, carbonate, sulfate, chloride, nitrate, and fluoride. The concentrations of these dissolved ions generally are reported in milligrams per liter.

Stream-water chemistry varies with flow conditions because flow paths change in a watershed. Under low-flow conditions, stream water is predominantly ground-water discharge. The nature and concentration of dissolved constituents are dependent on the composition of the aquifers through which the ground water flows. During and immediately after a storm, stream water is a mixture of rainwater and surface runoff, shallow subsurface flow through the soil zone, and ground-water discharge. Precipitation generally produces an overall dilution of the major ion composition. The geochemistry of the ocean also can affect the water chemistry of a stream flowing into it. Water circulation in an estuary or tidally influenced stream is controlled by topography, tidal currents, and the volume of freshwater discharge (Drever, 1988). Stream water may consist of a mixture of seawater and freshwater, resulting in an increase in the number of sodium and chloride ions. Human activity can alter water chemistry by contributing additional ions, such as sodium and chloride from WWTP discharges, leaking or overflowing sewer systems, industrial discharge, or urban runoff. Although basic ions are not considered contaminants, elevated levels may indicate anthropogenic inputs of contaminants.

Major Ions

Major ions account for the greatest part of the dissolved solids in water. A summary of the major ion concentrations at six sites is included in appendix table 2-1, and a Piper diagram is presented in figure 6 to graphically depict the ionic composition of the stream water sampled during this investigation. The Piper diagram (Piper, 1944) consists of two trilinear plots that indicate the cationic and anionic composition of the water, and a diamond-shaped plot that indicates the overall ionic composition of the water. Calcium-bicarbonate dominant water, for example, plots to the far left of center portion of the diamond area, and a sodium-chloride dominant water plots to the far right of center (fig. 6). The two triangles at the base of the Piper diagram illustrate a further breakdown of the percentages of the individual cations (left) and anions (right) in each water sample (fig. 6). Each vertex on the Piper plot represents 100 percent of a particular ion or group of ions, and the coordinates of a point plotted on the diagram total to 100 percent.

The three most upstream sites (TM-1, TM-3, and TM-4) on Threemile Creek exhibited similar water quality, characterized by a strong calcium-bicarbonate component (fig. 6). The water chemistry at the two tributaries, CEN and TSB, differed from the main-stem sites on Threemile Creek. The tributary site at Center Street (CEN) was characterized by a strong sodium-chloride component; whereas the tributary site at Toulmins Spring Branch (TSB) was characterized by a strong calcium component without a dominant anionic species—sulfate, bicarbonate, and chloride were present at this site (fig. 6). The most downstream site on Threemile Creek (TM-5) also was characterized by a strong sodium-chloride component, indicative of the influx of seawater at this tidal site (fig. 6).

The elevated levels of sodium and chloride at CEN may indicate leaking or overflowing sewer systems or industrial discharge in the basin. Seawater typically contains sodium and chloride levels of about 10,500 mg/L and 19,000 mg/L, respectively, and the ratio of sodium to chloride typically is 0.55. The ratio of sodium to chloride at TM-5 ranged from 0.54 to 0.60 for eight of nine samples, whereas the ratio of sodium to

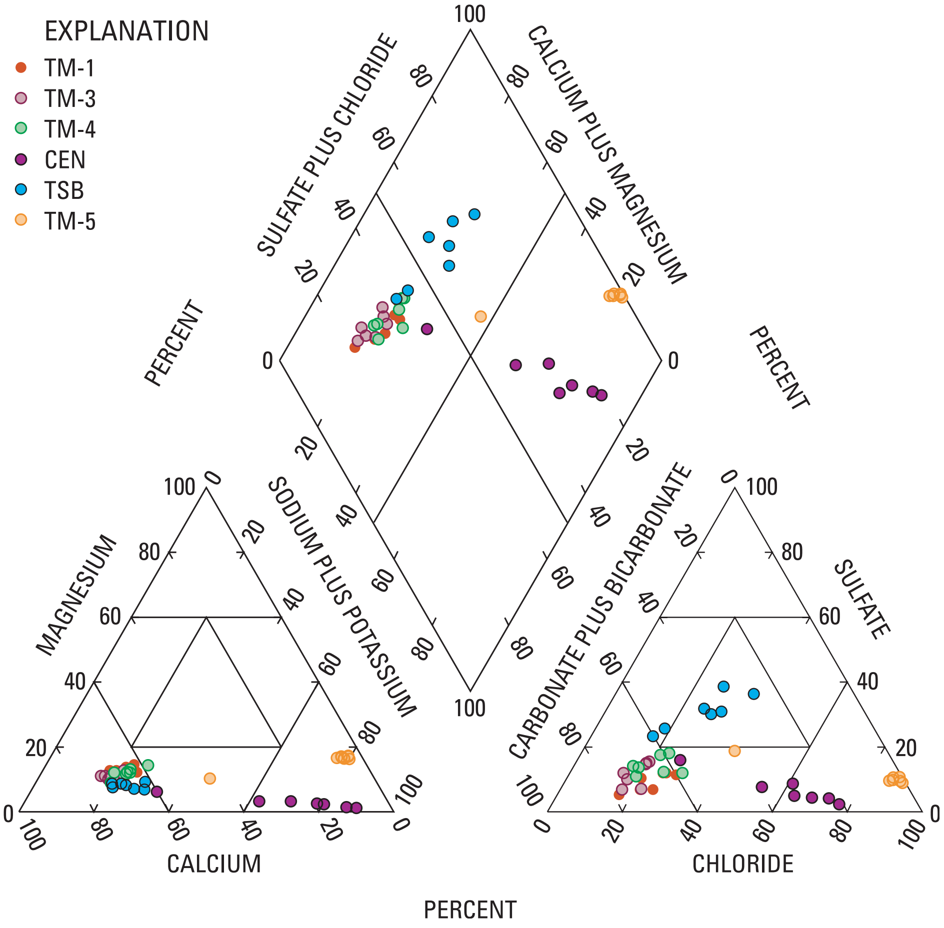


Figure 6. Piper trilinear diagram showing major ion composition of surface-water samples collected at six sites in the Threemile Creek basin, Mobile, Alabama, 2000–2001.

chloride at CEN ranged from 0.74 to 0.80 for seven of seven samples. Other sources likely are contributing to the high levels of sodium and chloride in the CEN basin.

Chloride is present in all natural waters, but concentrations generally are low (Hem, 1985). In most streams, chloride concentrations are lower than those of sulfate or bicarbonate. Exceptions occur when streams receive inflows of high-chloride ground water, industrial waste, or seawater. Concentrations of chloride at the three most upstream sites on Threemile Creek (TM-1, TM-3, and TM-4) ranged from 2.8 to 9.2 mg/L (TM-4; appendix table 2-1). Median concentrations of chloride increased in a downstream direction; chloride concentrations were less than the corresponding bicarbonate concentration in each of the samples. Concentrations of chloride at TSB ranged from 6.9 to 11 mg/L; chloride concentrations were less than the corresponding bicarbonate and sulfate concentrations in each of the samples (appendix table 2-1). Chloride concentrations at CEN ranged from 31 to 340 mg/L; chloride concentrations exceeded the bicarbonate concentrations in five of seven samples and sulfate concentrations in seven of seven samples. The highest concentration of chloride at CEN was detected during low flow; the lowest concentration of chloride was detected during elevated flow, which indicates that increased flows may dilute chloride concentrations, indicating point sources rather than nonpoint sources. Chloride concentrations at TM-5 ranged from 22 to 7,900 mg/L (appendix table 2-1). Seawater typically has a chloride concentration of about 19,000 mg/L (Hem, 1985), but because of the mixing with freshwater in Threemile Creek, lower values were measured.

The Kruskal-Wallis test and the Tukey multiple-comparison test were applied to the major ion data at six sites to determine if the variations in water chemistry among sites were statistically significant (table 7). Chloride concentrations were significantly higher at TM-5 than at TM-4; chloride concentrations at CEN and TSB were significantly higher than at TM-4, indicating that the tributaries may contribute to the higher levels of chloride found at TM-5 (table 7). The ratios of sodium to chloride at TM-5 indicate that the site was affected by seawater, whereas the ratios of sodium to chloride at CEN indicate that the elevated levels may have originated from anthropogenic sources.

Concentrations of fluoride in most natural waters are low, generally less than 1.0 mg/L (Hem, 1985). Fluoride is added to drinking water because of its importance in preventing cavities.

Table 7. Results of the Kruskal-Wallis test and the Tukey multiple-comparison test illustrating statistically significant ($p \leq 0.05$) differences for selected water-quality constituents at sites in the Threemile Creek basin, Mobile, Alabama.

[BOD_5, 5-day biochemical oxygen demand; OWC, organic wastewater compound]

Site label (fig. 1)	Dissolved oxygen	pH	Specific conductivity	Water temperature	Alkalinity	Calcium	Magnesium	Potassium
One-year period (March 2000–March 2001)								
TM-1 to TM-3			X	▨		X		
TM-1 to TM-4				▨			X	
TM-1 to TM-5			X	▨	X	X	X	X
TM-3 to TM-4		X		▨				
TM-3 to TM-5	X		X	▨	X	X	X	X
TM-4 to TM-5	X		X	▨	X	X	X	X
CEN to TSB	▨	▨	X	▨	X	X	X	X
TM-4 to CEN	X	X	X	▨	X	X	X	X
CEN to TM-5	X	X	X	▨	X		X	X
TM-4 to TSB	X	X	X	▨		X		X
TSB to TM-5	X	X	X	▨	X	X	X	X
Three-year period (March 2000–September 2003)								
TM-1 to TM-5	X	▨	X	▨	X	X	X	X

Site label (fig. 1)	Sodium	Bicarbonate	Carbonate	Chloride	Total organic carbon	BOD_5	Chlorophyll *a*	Enterococci
One-year period (March 2000–March 2001)								
TM-1 to TM-3		X	▨			▨		▨
TM-1 to TM-4	X		▨			▨		▨
TM-1 to TM-5	X	X	▨	X	X	▨	X	▨
TM-3 to TM-4			▨			▨		▨
TM-3 to TM-5	X	X	▨	X	X	▨	X	▨
TM-4 to TM-5	X	X	▨	X	X	▨	X	▨
CEN to TSB	X	X	▨	X	▨	X	▨	▨
TM-4 to CEN	X	X	X	X	X	▨		
CEN to TM-5	X			X		▨		
TM-4 to TSB	X			X		▨		X
TSB to TM-5	X	X		X		▨		
Three-year period (March 2000–September 2003)								
TM-1 to TM-5	X	X	▨	X	X	X	X	X

Site label (fig. 1)	Fecal coliform	*Escherichia coli*	Boron	Iron (dissolved)	Iron (total)	Manganese (dissolved)	Manganese (total)	OWC (number of detections)
One-year period (March 2000–March 2001)								
TM-1 to TM-3	▨	▨				▨	▨	
TM-1 to TM-4	▨	▨				▨	▨	
TM-1 to TM-5	▨	▨	X	X	X	▨	▨	X
TM-3 to TM-4	▨	▨				▨	▨	
TM-3 to TM-5	▨	▨	X	X	X	▨	▨	
TM-4 to TM-5	▨	▨	X	X	X	▨	▨	
CEN to TSB	▨	▨	X		X	▨	▨	X
TM-4 to CEN	X	▨	X		X	X	X	X
CEN to TM-5		▨				X	X	
TM-4 to TSB		▨			X	X	X	
TSB to TM-5		▨	X			X	X	
Three-year period (March 2000–September 2003)								
TM-1 to TM-5	X	X	X	X	X	▨	▨	X

▨ $p > 0.05$ No statistically significant differences between sites as determined by the Kruskal-Wallis test.

X $p \leq 0.05$ Statistically significant differences between sites as determined by the Tukey multiple-comparison test (nonparametric).

☐ $p > 0.05$ No statistically significant differences between sites as determined by the Tukey multiple-comparison test (nonparametric).

Table 7. Results of the Kruskal-Wallis test and the Tukey multiple-comparison test illustrating statistically significant ($p \leq 0.05$) differences for selected water-quality constituents at sites in the Threemile Creek basin, Mobile, Alabama.—Continued

[BOD_5, 5-day biochemical oxygen demand; OWC, organic wastewater compound]

Site label (fig. 1)	OWC (total concentration)	Ammonia (dissolved)	Ammonia + organic nitrogen (total)	Nitrite + nitrate (dissolved)	Nitrite (dissolved)	Total nitrogen	Total phosphorus
One-year period (March 2000–March 2001)							
TM-1 to TM-3							
TM-1 to TM-4							
TM-1 to TM-5	X		X	X	X	X	X
TM-3 to TM-4							
TM-3 to TM-5	X	X		X	X	X	X
TM-4 to TM-5	X	X	X	X	X	X	X
CEN to TSB	X	X	X	X	X	X	X
TM-4 to CEN	X	X	X	X	X		X
CEN to TM-5				X			
TM-4 to TSB	X						X
TSB to TM-5		X		X	X	X	X
Three-year period (March 2000–September 2003)							
TM-1 to TM-5	X	X	X	X	X	X	X

Site label (fig. 1)	Orthophosphate (dissolved)	Orthophosphate (total)	Phosphorus (dissolved)	Fluoride	Silica	Sulfate
One-year period (March 2000–March 2001)						
TM-1 to TM-3					▨	
TM-1 to TM-4					▨	X
TM-1 to TM-5	X	X	X	X	▨	X
TM-3 to TM-4					▨	
TM-3 to TM-5	X	X	X	X	▨	X
TM-4 to TM-5	X	X	X	X	▨	X
CEN to TSB	X	X	X	▨	X	
TM-4 to CEN	X	X	X	X	X	X
CEN to TM-5				X		X
TM-4 to TSB	X	X	X	X	▨	X
TSB to TM-5	X	X	X		▨	X
Three-year period (March 2000–September 2003)						
TM-1 to TM-5	X	X	X	X	▨	X

▨	$p > 0.05$ No statistically significant differences between sites as determined by the Kruskal-Wallis test.
X	$p \leq 0.05$ Statistically significant differences between sites as determined by the Tukey multiple-comparison test (nonparametric).
☐	$p > 0.05$ No statistically significant differences between sites as determined by the Tukey multiple-comparison test (nonparametric).

Fluoride is added to drinking water by the Mobile Area Water and Sewer System in order to meet the USEPA, American Medical Association, and American Dental Association recommended levels (Mobile Area Water and Sewer System, 2004). The presence of fluoride in stream water can be indicative of human activities, including leaking or overflowing sewer systems and WWTP discharges. Fluoride was not detected at the three upstream sites on Threemile Creek; however, it was detected in each of the samples at the two tributaries (CEN and TSB) and at TM-5. Concentrations ranged from 0.1 mg/L (TSB and TM-5) to 1.3 mg/L (CEN; appendix table 2-1). Fluoride concentrations were significantly higher at CEN than at TM-5 (table 7).

Median levels of sodium and boron increased in a downstream direction in Threemile Creek; sodium concentrations ranged from 1.8 mg/L at TM-1 to 4,300 mg/L at TM-5, and boron concentrations ranged from 10 µg/L at TM-1 to 1,900 µg/L at TM-5 (appendix table 2-1). Seawater typically has a sodium concentration of about 10,500 mg/L and a boron concentration of about 4,500 µg/L (Hem, 1985); thus, high concentrations at TM-5 indicate the presence of seawater. Boron compounds are used to make water softeners, soaps, and detergents; other uses include agricultural chemicals, pest controls, fire retardants, and medicines. The high range of boron concentrations (90–840 μg/L) at CEN may be indicative of leaking septic tanks or sewer lines or WWTP outflows in the basin. Both sodium and boron concentrations at CEN were highest during low flow, indicating point sources rather than nonpoint sources. The high concentrations of sodium at CEN are likely another indicator that water chemistry at this site may be influenced by anthropogenic sources.

Median levels of magnesium, potassium, and sulfate also increased in a downstream direction in Threemile Creek. Concentrations of magnesium ranged from 0.6 mg/L at TM-4 to 507 mg/L at TM-5; concentrations of potassium ranged from 0.3 mg/L at TM-1 to 160 mg/L at TM-5; and concentrations of sulfate ranged from 1.9 mg/L at TM-1 to 1,300 mg/L at TM-5 (appendix table 2-1). High levels of these constituents at TM-5 are indicative of the presence of seawater, in which concentrations of magnesium, potassium, and sulfate typically are about 1,350 mg/L, 390 mg/L, and 2,700 mg/L, respectively (Hem, 1985).

Instantaneous and Continuous Measurements of Water Properties

Instantaneous field measurements of physical properties of water, such as pH, temperature, specific conductance, and dissolved-oxygen concentrations, can be used to compare chemical conditions in the streams at the time of sampling. Water quality, however, continually changes over time, and repeated measurements are necessary to characterize variations. Continuous water-quality monitors have sensors and recording systems that measure water-quality properties at discrete intervals of time.

The ADEM criteria for pH, water temperature, dissolved-oxygen concentrations, and turbidity are based on water-use classification. Water-quality properties, including field measurements and continuous water-quality monitoring data, are summarized with corresponding criteria in tables 8 and 9, respectively. Continuous water-quality monitors in the Threemile Creek watershed recorded data (water temperature, dissolved-oxygen concentrations, specific conductance,

Table 8. Instantaneous field measurements of water-quality properties at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003, and corresponding water-quality criteria.

[μS/cm, microsiemens per centimeter; °C, degrees Celsius; NTU, nephelometric turbidity unit; mg/L, milligrams per liter; ≤, less than or equal to; ≥, greater than or equal to]

Site label (fig. 1)	Water year	Specific conductance (μS/cm)	Water temperature (°C)	Turbidity (NTU)	Dissolved-oxygen concentration (mg/L)	pH
Water-quality criteria for agricultural and industrial water supply[a]						
			≤32.2	≤50[b]	≥ 3.0	6.0 – 8.5
Water-quality criteria for fish and wildlife[a]						
			≤32.2	≤50[b]	≥ 5.0[c]	6.0 – 8.5
Field measurements						
TM-1	2000–2003	58 – 99	15 – 31.5	2 – 130	6.8 – 9.5	6 – 7.5
TM-3	2000–2003	64 – 116	15.1 – 31.1	4 – 420	7.1 – 10.5	6.5 – 8.2
TM-4	2000–2003	63 – 126	16.8 – 33.4	3.9 – 800	5.4 – 11.5	6.1 – 7.0
CEN	2000–2001	145 – 1,230	15.2 – 34.8	0.7 – 35	8.6 – 21.5	7.2 – 10.0
TSB	2000–2001	99 – 183	15 – 35.3	5 – 39	8.9 – 15.8	6.6 – 9.9
TM-5	2000–2003	201 – 21,400	14.1 – 30	4 – 68	2.2 – 11	6.5 – 8.2

[a] Criteria established by the Alabama Department of Environmental Management (2000c).

[b] Turbidity should not exceed 50 NTU above background (Alabama Department of Environmental Management, 2000c).

[c] Criterion for dissolved-oxygen concentrations under extreme conditions is 4.0–5.0 mg/L (Alabama Department of Environmental Management, 2000c).

Table 9. Continuous measurements of water-quality properties at sites in the Threemile Creek basin, Mobile, Alabama, water years 2000–2003, and corresponding water-quality criteria.

[µS/cm, microsiemens per centimeter; °C, degrees Celsius; NTU, nephelometric turbidity unit; mg/L, milligrams per liter; ≤, less than or equal to; ≥, greater than or equal to]

Site label (fig. 1)	Water year	Specific conductance (µS/cm)	Water temperature (°C)	Turbidity (NTU)	Dissolved-oxygen concentration (mg/L)	Number of days of good record for dissolved oxygen	Number of days that dissolved oxygen was less then 3.0 mg/L	Percentage of days dissolved-oxygen criterion was not met
Water-quality criteria for agricultural and industrial water supply[a]								
			≤32.2	≤50[b]	≥ 3.0			
			≤32.2	≤50[b]	≥ 5.0[c]			
TM-1	2000	37 – 88	8.8 – 35.1	0 – 130	0.5 – 10.6	213	23	10.8
	2001	31 – 104	5.2 – 32.8	0 – 760	0.3 – 10.9	319	3	0.9
	2002	25 – 169	5.8 – 30.3	0 – 470	0.1 – 13.3	278	47	16.9
	2003	32 – 111	8.0 – 32.9	0 – 470	0.1 – 13.2	349	11	3.2
TM-4	2000	41 – 445	7.6 – 35.2	0 – 260	0 – 11.5	115	57	49.6
	2001	48 – 309	5.3 – 32.6	0 – 650	0.2 – 12.0	224	19	8.5
	2002	56 – 477	7.1 – 34.2	0 – 420	0 – 16.6	319	64	20.1
	2003	40 – 202	7.8 – 31.7	0 – 580	0 – 13.5	342	110	32.2
TM-5	2000	83 – 35,800	10.6 – 32.3	0 – 130	0 – 10.7	333	274	82.3
	2001	60 – 37,200	7.9 – 31.2	0 – 810	0 – 12.7	304	197	64.8
	2002	134 – 34,700	8.9 – 31.6	0 – 290	0 – 14.6	298	176	59.1
	2003	63 – 22,700	9.2 – 30.6	0 – 400	0 – 13.8	300	181	60.3

[a] Criteria established by the Alabama Department of Environmental Management (2000c).

[b] Turbidity should not exceed 50 NTU above background (Alabama Department of Environmental Management, 2000c).

[c] Criterion for dissolved-oxygen concentrations under extreme conditions is 4.0–5.0 mg/L (Alabama Department of Environmental Management, 2000c).

turbidity, and gage height) at 15-minute intervals. More detailed information is available from continuous water-quality monitors in Threemile Creek in USGS annual data reports for Alabama (Pearman and others, 2001, 2002, 2003; Psinakis and others, 2004).

Long-term continuous water-quality data were not available from any of the sites prior to this study. Continuous measurements of dissolved-oxygen concentrations, water temperature, and specific conductance were recorded at TM-1 between December 1999 and September 2003, and continuous measurements of turbidity were recorded between May 2000 and September 2003. Continuous measurements of dissolved-oxygen concentrations, water temperature, specific conductance, and turbidity were recorded at the TM-4 site between September 1999 and September 2003 and at the TM-5 site between October 1999 and September 2003 (table 9; Pearman and others, 2001, 2002, 2003; Psinakis and others, 2004).

The pH of surface water generally ranges from 6.5 to 8.5. When pH falls below 4 or 5, possibly as a result of commercial or industrial discharges, urban runoff, or acid rain, the structure of an aquatic community can be affected. Likewise, when pH exceeds 9, prolonged exposure is harmful to some species of fish and benthic invertebrates. The pH of water determines the solubility and biological availability of chemical constituents, including nutrients and heavy metals; slight changes in pH can have indirect effects on a stream and the aquatic community. The ADEM established a pH range of 6 to 8.5 to reduce the effects of highly acidic or highly basic water on fish and wildlife (Alabama Department of Environmental Management, 2000c).

Field measurements of pH were made at all sites at the time of sampling (table 8; appendix table 2-1). In Threemile Creek, pH ranged from 6.0 at TM-1 to 8.2 at TM-3 and TM-5; in the two tributaries, pH ranged from 7.2 to 10.0 at CEN and from 6.6 to 9.9 at TSB (table 8; appendix table 2-1). The pH values at all sites on Threemile Creek were within the ADEM criteria established for agricultural and industrial water supply as well as fish and wildlife (Alabama Department of Environmental Management, 2000c). The higher pH values found at the two tributaries (CEN and TSB) may be indicative of contaminants from other sources. Seawater has a pH value of 8.2; natural water with a pH value greater than 9.0 is unusual (Hem, 1985). High pH values often are associated with photosynthesis in highly productive systems, particularly in streams with low gradient and low velocity. In the two tributaries, it is assumed that some combination of photosynthesis and industrial discharge or sewage effluent (containing soap or bleach) is contributing to the high pH values.

Specific conductance is an indicator of the ability of water to conduct an electric current and is proportional to the dissolved-solids concentration in the water. Many factors affect specific conductance in streams, including flow conditions, bedrock, and contributions of dissolved solids from point and nonpoint sources. Standards or criteria for specific conductance have not been established by the ADEM or the USEPA. Specific conductance was measured at the time of sample collection (table 8) and by continuous water-quality monitors at three sites (table 9). At site TM-1 in Threemile Creek, continuous measurements of specific conductance ranged from 25 to 169 microsiemens per centimeter (μS/cm) at 25 degrees Celsius (°C); specific conductance ranged from 40 to 477 μS/cm at TM-4 and from 60 to 37,200 μS/cm at TM-5 (table 9). The higher measurements of specific conductance at TM-5 are attributed to the presence of seawater at this site, which typically has a specific conductance of about 50,000 μS/cm (Hem, 1985). Specific conductance measurements ranged from 145 to 1,230 μS/cm at CEN and from 99 to 183 μS/cm at TSB (table 8). The higher measurements of specific conductance at CEN may be due to contaminants in the stream. The lowest specific conductance values recorded by field personnel in Threemile Creek were measured during periods of elevated flow, indicating that the stream water was diluted by rainwater.

Dissolved-oxygen concentration is widely used for evaluating the biochemistry of streams and lakes. Dissolved-oxygen concentrations may be depleted by processes that consume organic matter. Actively photosynthesizing algae and aquatic plants can increase concentrations of dissolved oxygen (Hem, 1985). The ADEM has established criteria for dissolved-oxygen concentrations in streams based on water-use classification (Alabama Department of Environmental Management, 2000c). To meet the criterion for diversified warm-water biota, daily dissolved-oxygen concentrations cannot fall below 5 mg/L. Under extreme conditions resulting from natural causes, dissolved-oxygen concentrations ranging from 4.0 to 5.0 mg/L are allowed provided that the water quality is favorable in all other properties (Alabama Department of Environmental Management, 2000c). To meet the criterion for streams classified for agricultural and industrial use, daily dissolved-oxygen concentrations cannot fall below 3.0 mg/L (Alabama Department of Environmental Management, 2000c). Low concentrations are commonly found in warm waters that are not well mixed. Dissolved-oxygen concentrations typically vary in a diurnal fashion, and differences between high and low values can exceed 10 mg/L within a 24-hour period. For example, during low-flow conditions (August 25–27, 2001) at TM-4, peak dissolved-oxygen concentrations (8.4–9.7 mg/L) were recorded between 1300 and 1700 each day, and minimum dissolved-oxygen concentrations (0.2–0.4 mg/L) were recorded between 0100 and 0300 each day (fig. 7B).

During this study, concentrations of dissolved oxygen did not always meet criterion established by the ADEM. The continuous monitors at TM-1, TM-4, and TM-5 recorded dissolved-oxygen concentrations that were less than the minimum criterion established for agricultural and industrial water supply (3.0 mg/L, table 9). The number of days that dissolved-oxygen concentrations did not meet the minimum criterion was greatest at TM-5 and ranged from 176 in WY 2002 to 274 in WY 2000 (fig. 8; table 9). In contrast, the number of days that dissolved-oxygen concentrations did not

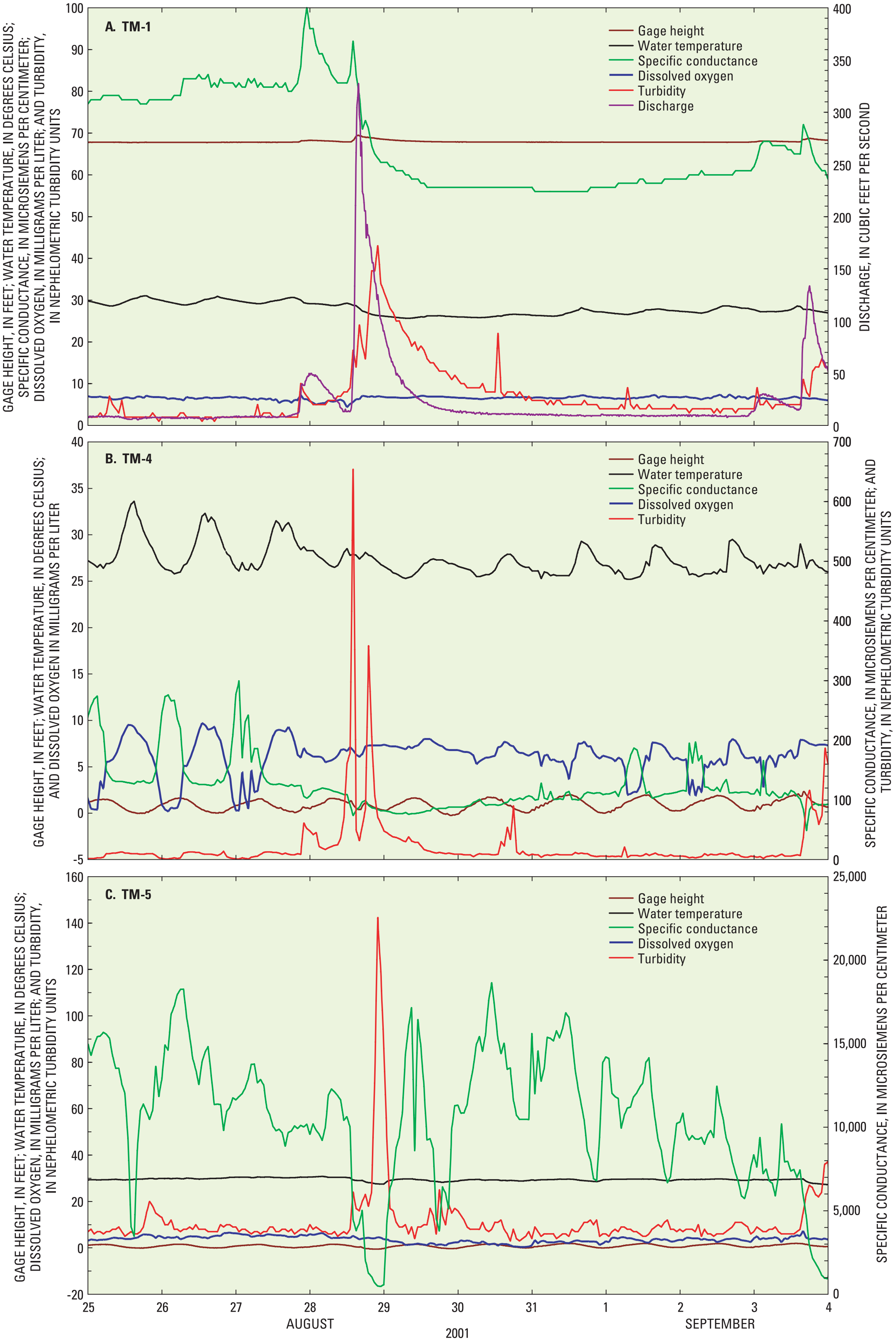


Figure 7. Gage height, water temperature, specific conductance, dissolved oxygen, turbidity, and discharge at U.S. Geological Survey streamgaging stations (A) 02471013 (TM-1), (B) 0247101490 (TM-4), and (C) 02471016 (TM-5), August 25–September 4, 2001. (Discharge is shown for site TM-1 only.)

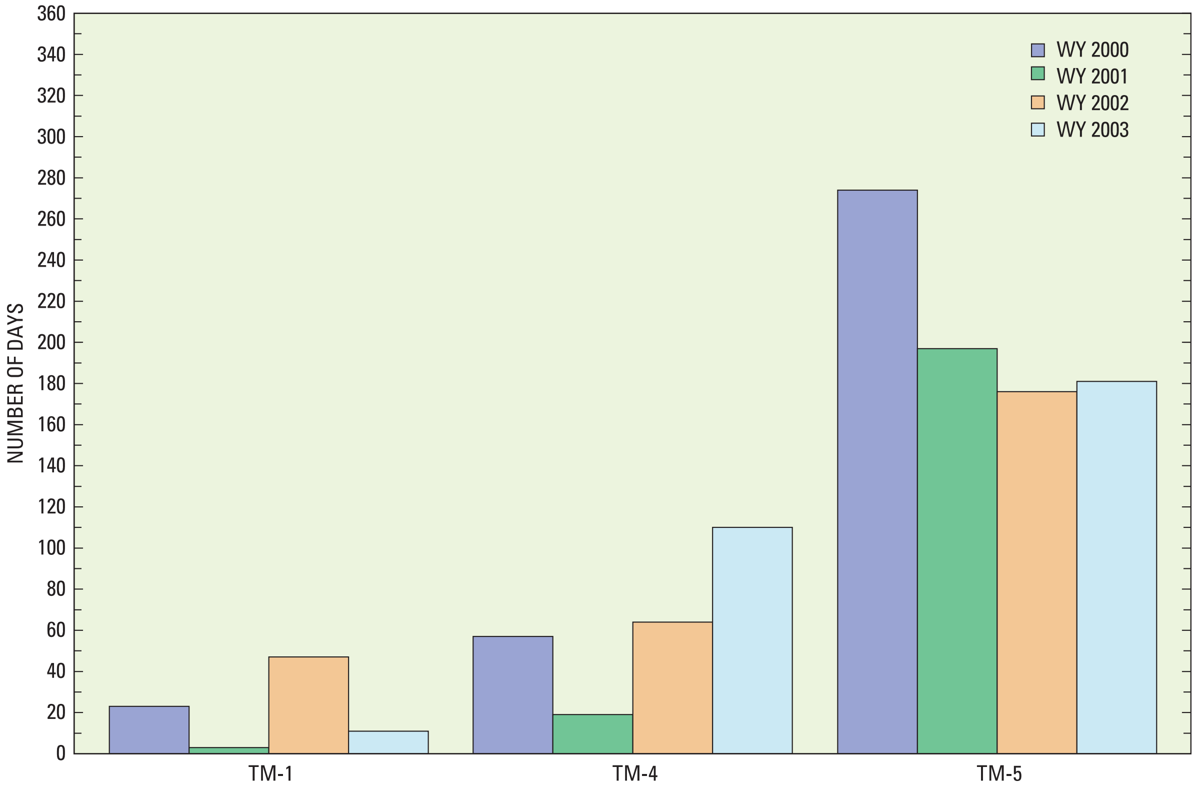


Figure 8. Number of days that continuous water-quality monitors recorded concentrations of dissolved oxygen less than 3.0 milligrams per liter at three sites on Threemile Creek, Mobile, Alabama, water years 2000–2003.

meet the minimum criterion at TM-1 ranged from 3 in WY 2001 to 47 in WY 2002 (fig. 8; table 9). At the two tributaries, dissolved-oxygen concentrations ranged from 8.6 to 21.5 mg/L at CEN and from 8.9 to 15.8 mg/L at TSB (table 8). The high levels of dissolved oxygen at the tributaries likely indicate the occurrence of photosynthesis at these sites.

Water temperature exceeded the recommended criterion (32.2 °C) for agricultural and industrial water supply and for fish and wildlife at five of six sites in the Threemile Creek basin (tables 8, 9). Instantaneous field measurements of water temperature exceeded the criterion at TM-4, CEN, and TSB (table 8)—all exceedances occurred during July 2000 or July 2001 (Pearman and others 2001, 2002, 2003; Psinakis and others, 2004). Continuous measurements of water temperature exceeded the criterion at TM-1, TM-4, and TM-5 (table 9). Exceedances occurred most frequently between June and August (Pearman and others 2001, 2002, 2003; Psinakis and others, 2004). Exceedances recorded by continuous monitors occurred most frequently at TM-1 (58) and TM-4 (57) rather than TM-5 (2) during the 4-year monitoring period (WY 2000–2003).

Turbidity, a measure of water clarity, is determined by measuring the degree that particles suspended in water decrease light penetration through the water. Particles may come from soil, sediment, algae, plankton, natural organic matter, or manmade substances. High turbidities commonly occur during storms when overland runoff erodes soil and carries it to the stream, and increased flow resuspends sediment in the streambed. Turbidity peaks associated with declines in specific conductance indicate stormwater runoff. High turbidities, however, also can be measured during low-flow conditions when certain materials or compounds are discharged from industrial or commercial facilities, or when algae production is high. Thus, high turbidities may be associated with higher-than-normal specific conductance measurements. The ADEM criterion requires that turbidity not exceed 50 nephelometric turbidity units (NTU) above background except due to natural origin (Alabama Department of Environmental Management, 2000c). Background levels have not been defined by the ADEM for Threemile Creek; consequently, turbidity values were not compared to this criterion. At TM-1, turbidity ranged from 0 to 760 NTU; at TM-4, turbidity ranged from 0 to 650 NTU; and at TM-5, turbidity ranged from 0 to 810 NTU (table 9). High turbidities were observed at all three sites and, in many cases, likely were the result of natural runoff (fig. 7).

Turbidity also can be used to examine whether high-flow samples were collected during the first flush, when many contaminants may be at a maximum level. Continuous water-quality data were recorded during a 3-day period at TM-1, TM-4, and TM-5 (August 27–30, 2001). During this period, a storm produced a small increase in discharge at TM-1 (fig. 7A). During the storm, turbidity at TM-1 peaked (41.5 NTU) at 2045 on August 28, yet discharge peaked (327 cubic feet per second [ft^3/s]) at 1545 (fig. 7A), illustrating the likelihood that there was no first flush associated with this storm. At TM-4, turbidity peaked (654 NTU) at 1400 on August 28 and gage height increased slightly (1.11–1.33 ft) between 1230 and 1315 because of the storm (fig. 7B). The first flush most likely occurred about 1400, when turbidity values were highest. At TM-5, turbidity increased slightly (6–24 NTU) from 1200 to 1400 and then peaked (142 NTU) at 2200 on August 28 as the tide reached its lowest point—gage height showed little variation outside of the normal tidal fluctuation (-0.5–1.6 ft) except for a small increase (0.28–0.46 ft) between 1600 and 1630, which may have been associated with rainfall or other discharges to the stream (fig. 7C). The hydrology at both TM-4 and TM-5 is complex due to the tidal influences at these sites that tend to dampen gage-height variation caused by stormwater inflow.

Nutrients

Nutrients, chemical elements that are necessary for life, consist primarily of the various species of nitrogen and phosphorus. Nutrient concentrations in aquatic systems are of interest because excess concentrations can have detrimental effects on aquatic health and anthropogenic uses of the system. Eutrophication in freshwater systems is usually linked to high phosphorus concentrations and can lead to nuisance plant growth and algal blooms, which in turn can cause reduced light penetration and dissolved-oxygen concentrations, fouled water intakes, and taste and odor problems in drinking water. Likewise, excess nitrogen has been linked to eutrophication in coastal systems. Excess concentrations of nitrogen and phosphorus in streams draining to the northern Gulf of Mexico also have been linked to hypoxia in that area (Rabalais and others, 1996).

Sources of nutrients can be natural or anthropogenic. Natural sources of nutrients include weathering of minerals in rocks and soils and biological remineralization of organic matter. Anthropogenic nutrient sources include fertilizers, manure, faulty sanitary sewers and septic tanks, and wastewater-treatment plant outfalls. Nutrient species measured for this study were total and dissolved ammonia, total and dissolved ammonia plus organic nitrogen, dissolved nitrite plus nitrate, dissolved and total orthophosphate, and dissolved and total phosphorus. Calculated nutrients were total nitrogen, the sum of total organic nitrogen plus ammonia and nitrite plus nitrate; total organic nitrogen, the difference in ammonia and total organic nitrogen plus ammonia; and suspended phosphorus, the difference in total phosphorus and dissolved phosphorus.

Nitrogen

Nitrogen concentrations generally were lower in the upstream main-stem sites (TM-1, TM-3, and TM-4) and higher in the tributary sites (CEN and TSB) and in the downstream-most main-stem site (TM-5). Tukey's multiple-comparison test was used to determine statistically significant differences among the water-quality sampling sites for the various nutrients. Because all sites were sampled on a similar schedule during the first year (March 2000 to March 2001), only samples collected during this time period were used for the test. Multiple-comparison test results for total nitrogen indicated four groups—A, AB, BC, and C (table 10). Sites with the same letter designation are considered to be statistically similar (Helsel and Hirsch, 1992). Sites with letter designation A have higher concentrations than those with letter designation B, which have higher concentrations than those with letter designation C. Sites can have multiple letter designations, meaning they are similar to other sites but the other sites are not necessarily similar to each other.

Table 10. Results of multiple-comparison tests on selected nutrients at surface-water sites in the Threemile Creek basin, Mobile, Alabama.

Nutrients	TM-1	TM-3	TM-4	CEN	TSB	TM-5
Total nitrogen	C	BC	BC	AB	C	A
Organic nitrogen plus ammonia	B	BC	BC	AB	B	AB
Ammonia	AB	B	B	A	B	AB
Nitrite-plus-nitrate nitrogen	B	B	B	B	B	A
Total phosphorus	C	C	BC	AB	B	A
Dissolved phosphorus	C	C	C	A	B	AB
Dissolved orthophosphate	C	C	C	AB	B	A

Total nitrogen concentrations ranged from 0.33 to 5.2 mg/L (appendix table 2-1; fig. 9). The highest maximum concentration (5.2 mg/L) was at TM-5, and the highest median concentration (2.5 mg/L) was at CEN (fig. 9). Median concentrations of total nitrogen at TM-3, TM-4, and TSB were lower than the ecoregion nutrient criteria; however, all samples at CEN and TM-5 exceeded the ecoregion nutrient criteria for total nitrogen (fig. 9; table 11; U.S. Environmental Protection Agency, 2000a, 2000b).

Total organic nitrogen plus ammonia concentrations ranged from < 0.200 to 3.2 mg/L (appendix table 2-1). The highest maximum and median concentrations occurred at CEN and were 3.2 mg/L and 1.85 mg/L, respectively. Results of multiple-comparison tests indicate three site groupings—AB, B, and BC (table 10). Total organic nitrogen plus ammonia concentrations exceeded the ecoregion nutrient criteria for all samples at CEN and TM-5; the majority of the remaining samples at TM-3, TM-4, and TSB were below the ecoregion criteria (fig. 9; table 11).

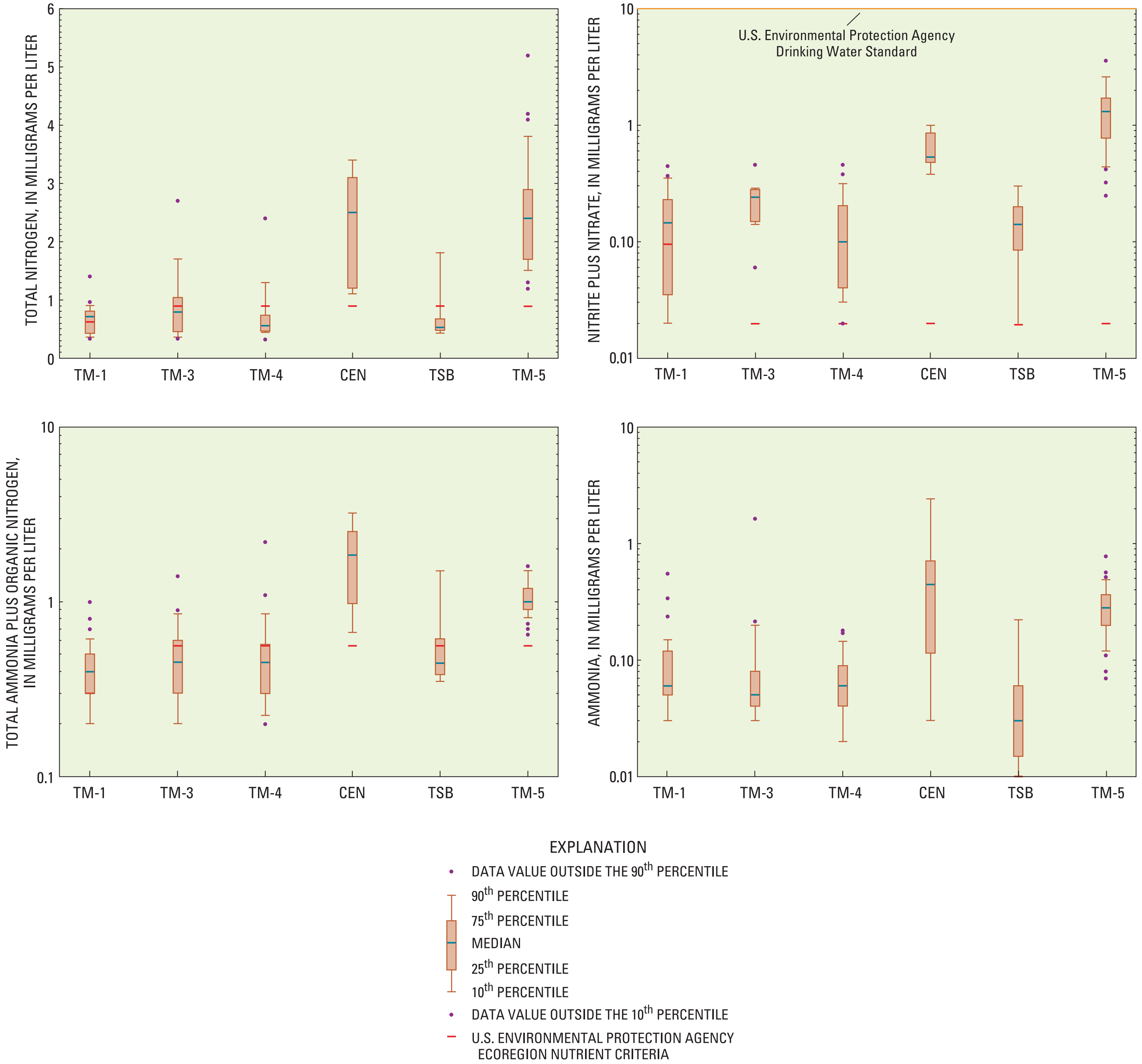


Figure 9. Distribution of total nitrogen, nitrite plus nitrate, total ammonia plus organic nitrogen, and ammonia concentrations at sites in the Threemile Creek basin, Mobile, Alabama.

Table 11. Ambient water-quality criteria recommendations for rivers and streams in Nutrient Ecoregions IX and XII (U.S. Environmental Protection Agency, 2000a, 2000b).

[mg/L, milligram per liter; µg/L, microgram per liter]

Ecoregion	Site label (fig. 1)	Total Kjeldahl nitrogen (mg/L)	Nitrite plus nitrate (mg/L)	Total nitrogen (mg/L)	Total phosphorus (mg/L)	Suspended chlorophyll *a* (µg/L)
Nutrient Ecoregion IX—Southeastern Temperate Forested Plains and Hills	TM-1, TM-2	0.3	0.095	0.618	0.0225	0.049
Nutrient Ecoregion XII—Southeastern Coastal Plain	TM-3, TM-4, CEN, TSB, TM-5	0.56	0.02	0.90	0.04	0.4

Dissolved ammonia concentrations ranged from < 0.010 to 2.4 mg/L (appendix table 2-1). The highest maximum concentration (2.4 mg/L) and the highest median concentration (0.445 mg/L) occurred at CEN (fig. 9). Results of multiple-comparison tests indicate three site groupings—A, AB, and B with CEN being the only site in group A (table 10). Because ammonia in aerated systems usually is converted to oxidized forms of nitrogen, the high dissolved ammonia concentrations at CEN are indicative of urban influences.

Dissolved nitrite-plus-nitrate concentrations ranged from < 0.02 to 3.6 mg/L (appendix table 2-1). The highest maximum concentration (3.6 mg/L) and median concentration (1.3 mg/L) of nitrite plus nitrate occurred at TM-5. Nitrite-plus-nitrate concentrations exceeded USEPA ecoregion nutrient criteria (table 11) in 88 percent of the samples. All samples at TM-3, TM-4, CEN, TSB, and TM-5 exceeded the ecoregion nutrient criteria (table 11) for nitrite plus nitrate (fig. 9); approximately 50 percent of the samples at TM-1 exceeded the ecoregion nutrient criteria (table 11) for nitrite plus nitrate (fig. 9). No samples for nitrate exceeded the drinking-water standard of 10 mg/L (U.S. Environmental Protection Agency, 2002a). Multiple-comparison tests indicated two groups for nitrite plus nitrate, A and B, with TM-5 being the only site in group A (table 10).

Nitrite was detected infrequently and, when detected, concentrations were very low except at sites CEN and TM-5 (appendix table 2-1). Nitrite concentrations ranged from < 0.01 mg/L to 0.15 mg/L. The highest maximum concentration (0.15 mg/L) and median concentration (0.07 mg/L) were at CEN. Because nitrite is generally unstable in oxygenated waters (Hem, 1985), its presence can be an indication of contamination from wastewater sources. The high concentrations of nitrite at CEN probably are a reflection of urban influences, but the variable influences on water quality at TM-5 make determining the source of nitrite difficult at TM-5.

Total organic nitrogen was the predominant species of the total nitrogen concentration at all sites except TM-5 and CEN. Excluding TM-5 and CEN, total organic nitrogen contributed 57 to 69 percent of the total nitrogen concentration; nitrate contributed 20 to 35 percent of the total nitrogen concentration; and ammonia contributed 9 to 16 percent of the total nitrogen concentration (fig. 10). The median contributions of total organic nitrogen plus ammonia and nitrate to the total nitrogen concentration at TM-5 were 52 and 47 percent, respectively. Determining the source of increased nitrate at TM-5 would be difficult because of the variable influences on water quality at this site, including Three Mile Creek and its tributaries, the Mobile River, and Mobile Bay.

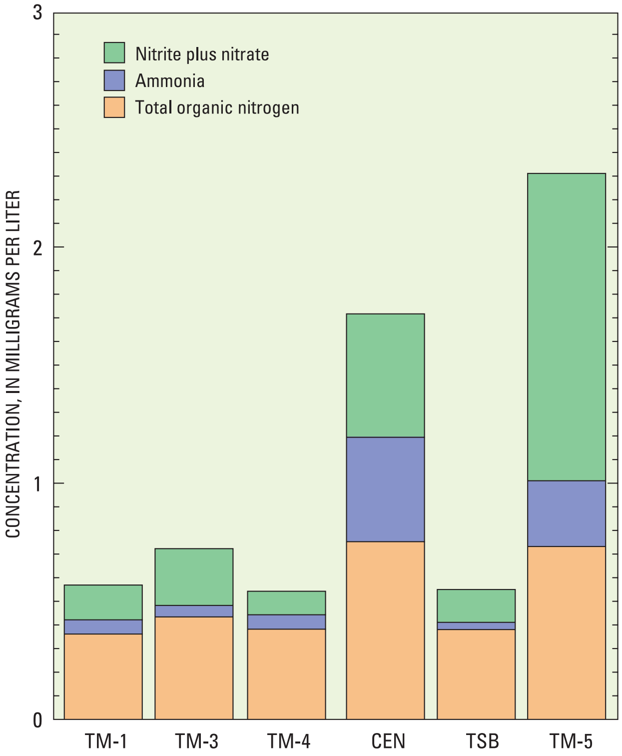


Figure 10. Median concentrations of nitrite plus nitrate, ammonia, and total organic nitrogen at sites in the Threemile Creek basin, Mobile, Alabama.

Phosphorus

Phosphorus concentrations exhibited similar distribution patterns as nitrogen concentrations, with thr three upstream main-stem sites (TM-1, TM-3, and TM-4) having significantly lower phosphorus concentrations than the tributaries (CEN and TSB) and downstream main-stem site (TM-5, fig. 11). Total phosphorus values ranged from < 0.002 to 0.831 mg/L (appendix table 2-1). The highest maximum concentration (0.831 mg/L) and median concentration (0.406 mg/L) of total phosphorus were at CEN (fig. 11). In 45 percent of the samples, total phosphorus concentrations exceeded the USEPA goal of 0.1 mg/L for preventing nuisance aquatic growth. The majority of total phosphorus concentrations at TM-1, TM-3, and TM-4 were below the ecoregion nutrient criteria (table 11) and the USEPA goal of 0.1 mg/L total phosphorus (fig. 11). Total phosphorus concentrations in all samples at CEN, TSB, and TM-5 exceeded both the ecoregion nutrient criteria for total phosphorus (table 11) and the USEPA goal of 0.1 mg/L total phosphorus (fig. 11; U.S. Environmental Protection Agency, 1986b, 2000a, 2000b).

Dissolved phosphorus concentrations ranged from < 0.002 to 0.45 mg/L, and dissolved orthophosphate concentrations ranged from < 0.001 to 0.405 mg/L (appendix table 2-1). The highest median concentrations for dissolved phosphorus (0.245 mg/L) and orthophosphate (0.228 mg/L) were at CEN. The highest maximum concentration for dissolved phosphorus (0.45 mg/L) was detected at CEN, and the highest dissolved orthophosphate concentration (0.405 mg/L) was detected at TM-5. Multiple-comparison test results indicated that concentrations at TM-1, TM-3, and TM-4 were significantly less than at CEN, TSB, and TM-5 for dissolved phosphorus and dissolved orthophosphate (table 10; fig. 11).

Dissolved phosphorus contributed 97 to 60 percent of the total phosphorus concentration, and suspended phosphorus contributed 3 to 40 percent of the total phosphorus concentration (fig. 12). The low percentage of suspended phosphorus at TM-4 may be because mostly base-flow samples were collected at this site. Because phosphorus tends to bind to suspended sediment and suspended-sediment concentrations generally are lower during base flow, the suspended phosphorus concentrations also are lower. Settling of suspended particles in the impoundment directly upstream from the sampling site may have caused the low suspended phosphorus values at TM-1.

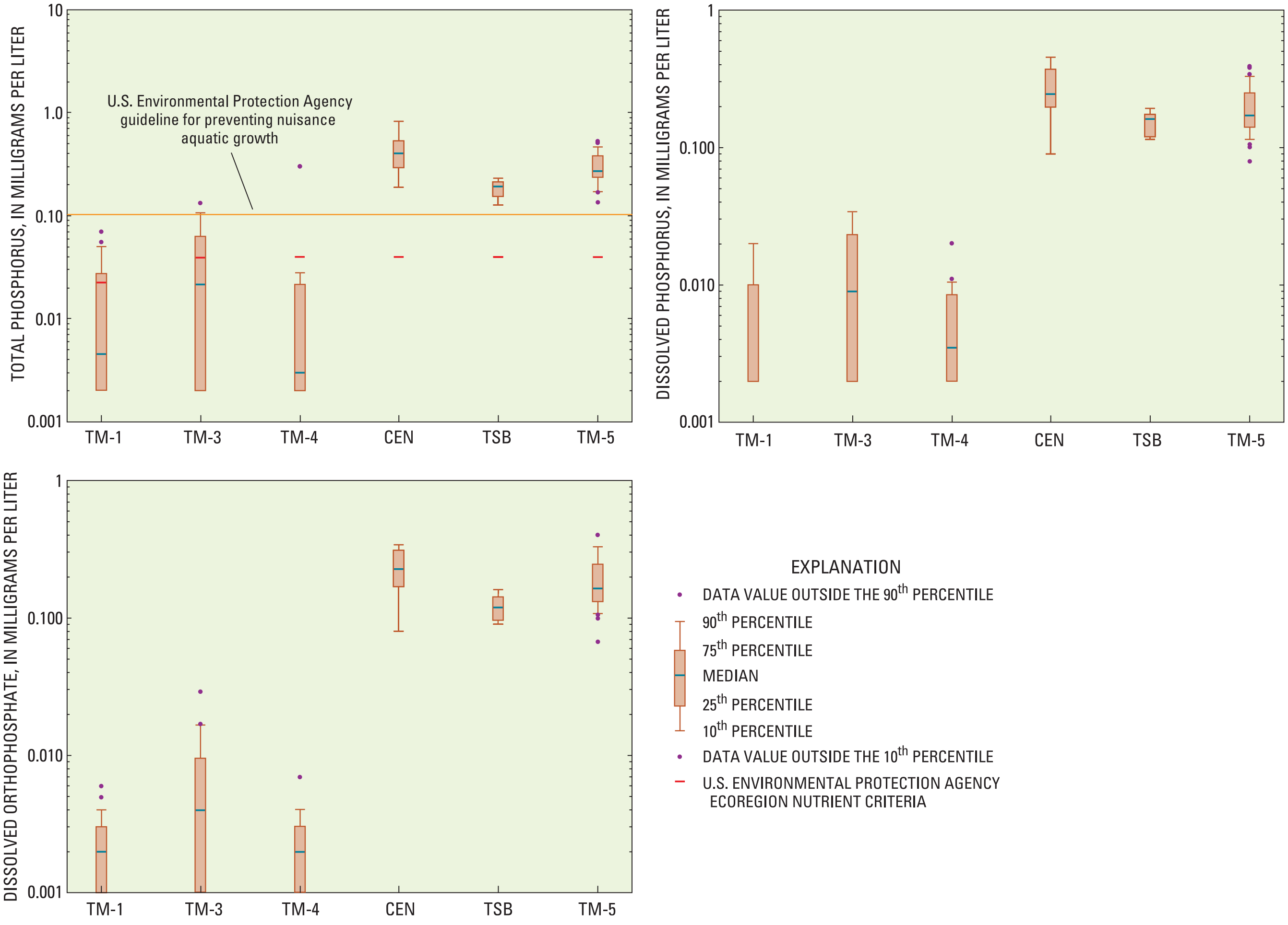


Figure 11. Distribution of total phosphorus, dissolved phosphorus, and dissolved orthophosphate at sites in the Threemile Creek basin, Mobile, Alabama.

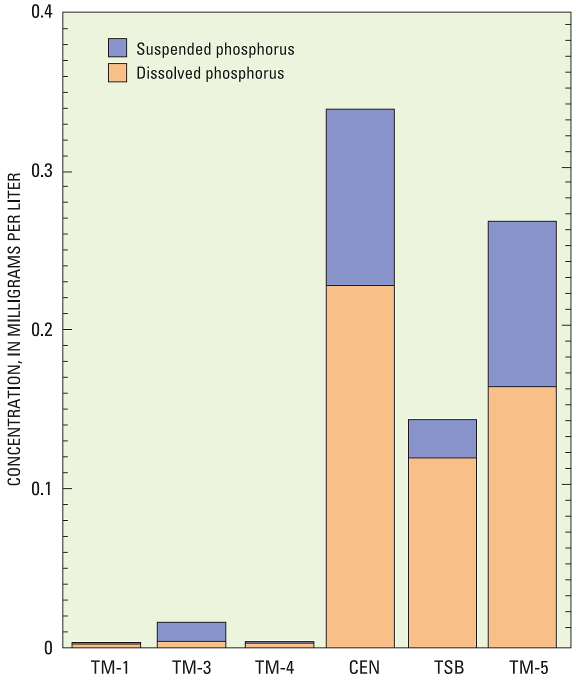


Figure 12. Median concentrations of suspended phosphorus and dissolved phosphorus at sites in the Threemile Creek basin, Mobile, Alabama.

The ratio of dissolved inorganic nitrogen to soluble reactive phosphorus provides an indication of the relative potential for the occurrence of nitrogen or phosphorus limitation (Borchardt, 1996). In aquatic systems, the limiting nutrient is the substance that is in shortest supply relative to plant demands. When the ratio of nitrogen to phosphorus by weight is greater than 10 to 1, phosphorus is considered to be the limiting nutrient; when the ratio is less than 5 to 1, nitrogen is considered to be the limiting nutrient. For nitrogen to phosphorus ratios in the ranges of 5 to 1 and 10 to 1, the effect of each major nutrient is equal. In most freshwater systems, phosphorus is the limiting nutrient, and for most estuarine or saltwater systems, nitrogen is the limiting nutrient. The distribution of the ratios of dissolved inorganic nitrogen to dissolved orthophosphate indicated two distinct groups for the sites in the study (fig. 13). The majority of samples in the three upstream main-stem sites (TM-1, TM-3, and TM-4) had total nitrogen to phosphorus ratios greater than 10 to 1, indicating that phosphorus is the limiting nutrient at these sites. Most nitrogen to phosphorus ratios at CEN and TM-5 indicated equal influence of nitrogen and phosphorus limitation. Nitrogen to phosphorus ratios for all but one sample at TSB were lower than 5, indicating the potential for nitrogen limitation at this site. Because water-quality conditions at TM-5 are influenced by freshwater inputs from Threemile Creek and the Mobile River and by the saline inputs from Mobile Bay, it is not unexpected that the nitrogen to phosphorus ratio indicates equal influences. Water-quality conditions at the two tributary sites (CEN and TSB) are not influenced by Mobile Bay, and the nitrogen to phosphorus ratios are probably a reflection of the point and nonpoint nitrogen and phosphorus sources from the higher percentage of urban land use in these basins.

Suspended Chlorophyll *a* and *b*

Suspended chlorophyll *a* was detected in 39 of 96 (40.6 percent) water-column samples, with concentrations ranging from < 0.1 to 100 µg/L (appendix table 2-1). Suspended chlorophyll *a* was detected at five sites (TM-3, TM-4, CEN, TSB, and TM-5) but was not detected at TM-1 (appendix table 2-1). The highest maximum concentration of suspended chlorophyll *a* was detected at TSB (100 µg/L); the highest median concentrations were detected at TM-5 (24.0 µg/L), TSB (5.35 µg/L), and CEN (4.85 µg/L, appendix table 2-1). For rivers and streams in Nutrient Ecoregion XII, the USEPA recommends that suspended chlorophyll *a* not exceed 0.4 µg/L (table 11; U.S. Environmental Protection Agency, 2000b). During this study, suspended chlorophyll *a* exceeded this recommendation in 39 of 96 samples (40.6 percent) collected in the Threemile Creek watershed (appendix table 2-1). Suspended chlorophyll *b* was not detected in any of the samples (appendix table 2-1).

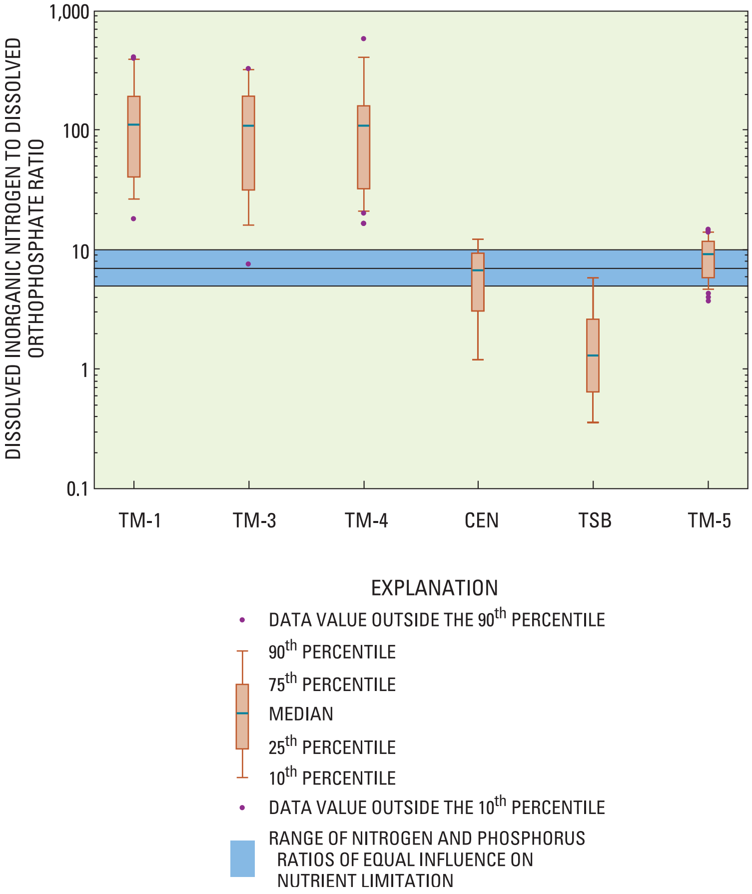


Figure 13. Distribution of dissolved inorganic nitrogen and dissolved orthophosphate ratios for sites in the Threemile Creek basin, Mobile, Alabama.

Biochemical Oxygen Demand and Total Organic Carbon

Five-day biochemical oxygen demand (BOD_5) is the amount of dissolved oxygen used by microorganisms to break down organic matter in water at 20 °C over a 5-day period. The standard BOD_5 value is useful as a measure of the amount of oxygen that will be depleted by organic material in a stream, often from domestic or industrial waste. Most moderately contaminated streams have BOD_5 values ranging between 1 and 8 mg/L (Nemerow, 1974). Typical domestic wastewater can have BOD_5 values ranging between 50 and 200 mg/L (Camp and Meserve, 1974; McGhee, 1991). In the Threemile Creek basin, BOD_5 ranged from 0.1 mg/L (TM-1) to 8.8 mg/L (CEN, appendix table 2-1). The Kruskal-Wallis test and the Tukey multiple-comparison test were applied to the BOD_5 data at six sites to determine if the variations in water chemistry among sites were statistically significant (table 7). BOD_5 concentrations at TM-5 were significantly higher than at TM-1 for WYs 2000–2003.

Total organic carbon (TOC) represents the amount of carbon present in organic molecules. The average TOC concentration in rivers is about 7 mg/L (Thurman, 1985). TOC concentrations can be higher because of elevated amounts of organic material, such as in marshland or boggy areas, where average concentrations may range from 17 to 33 mg/L (Thurman, 1985). In contaminated rivers, TOC concentrations can be even higher (30 to 58 mg/L; Dojlido and Best, 1993). In Threemile Creek, TOC ranged from 1.9 (TM-1) to 7.9 mg/L (TSB, appendix table 2-1). TOC concentrations at TM-5 were significantly higher than TOC concentrations at TM-1, TM-3, and TM-4; TOC concentrations at CEN were significantly higher than TOC concentrations at TM-4 (table 7).

Fecal-Indicator Bacteria

Fecal-indicator bacteria are nonpathogenic bacteria that are useful in assessing water quality because they are commonly associated with the presence of waterborne pathogens (Myers and Wilde, 1999). The presence or absence of indicator organisms is used to evaluate the microbiological quality of water, in part, because direct techniques to analyze for pathogens are either quantitatively unreliable or difficult to perform. The most commonly used fecal-indicator bacteria include fecal coliform, *E. coli*, and enterococci. Although most species of fecal coliform bacteria are from the feces of humans and other warm-blooded animals, some species can occur naturally in soils. As a result, the USEPA has recommended that *E. coli* or enterococci be used instead of fecal coliform bacteria as an indicator of fecal contamination in waters used for recreation (U.S. Environmental Protection Agency, 1986a, 2002b). This recommendation was based on studies that showed a strong correlation between the number of gastrointestinal illnesses associated with water-contact recreational activities and the concentrations of *E. coli* or enterococci bacteria.

Concentrations of fecal-indicator bacteria often depend on hydrologic conditions prior to and during sampling. For example, higher concentrations occur during high flow as a result of nonpoint sources, such as overland runoff that carries high concentrations of bacteria from many different sources, including waste from domestic pets and wildlife, and also as a result of re-suspension of bacteria in the streambed. Combined sewer overflows and sanitary sewer overflows also contribute high levels of bacteria during storms. Leaking sanitary sewer lines, connections to sewer lines, or septic tank effluent are likely the sources of high levels of bacteria during low flow. When point-source discharges contribute fecal-indicator bacteria, high concentrations may be present during low flow (leaking sanitary sewer lines or failing septic systems) as well as during high flow (combined sewer overflows; Gregory and Frick, 2000).

Concentrations of enterococci, *E. coli*, and fecal coliform bacteria in water samples collected from the Threemile Creek sites are summarized in table 12. Scatter plots, which differentiate between elevated-flow and low-flow samples, were used to display the variability in concentrations of enterococci, *E. coli*, and fecal coliform bacteria (fig. 14). The USEPA has defined criteria for single-sample densities of

Table 12. Statistical summary of enterococci, *Escherichia coli*, and fecal coliform concentrations at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

[col/100 mL, colonies per 100 milliliters; <, less than]

Site label (fig. 1)	Enterococci (col/100 mL)			*Escherichia coli* (col/100 mL)			Fecal coliform (col/100 mL)		
	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
TM-1	11	48	6,000	20	71	2,400	25	100	2,400
TM-3	10	1,200	31,000	14	1,500	29,000	44	300	12,000
TM-4	10	76	47,000	47	290	21,000	83	285	17,000
CEN	110	1,300	14,000	120	2,850	26,000	38	7,000	30,000
TSB	330	2,650	93,000	20	1,060	31,000	< 10	2,550	16,000
TM-5	9	225	22,000	30	470	20,000	20	540	15,000

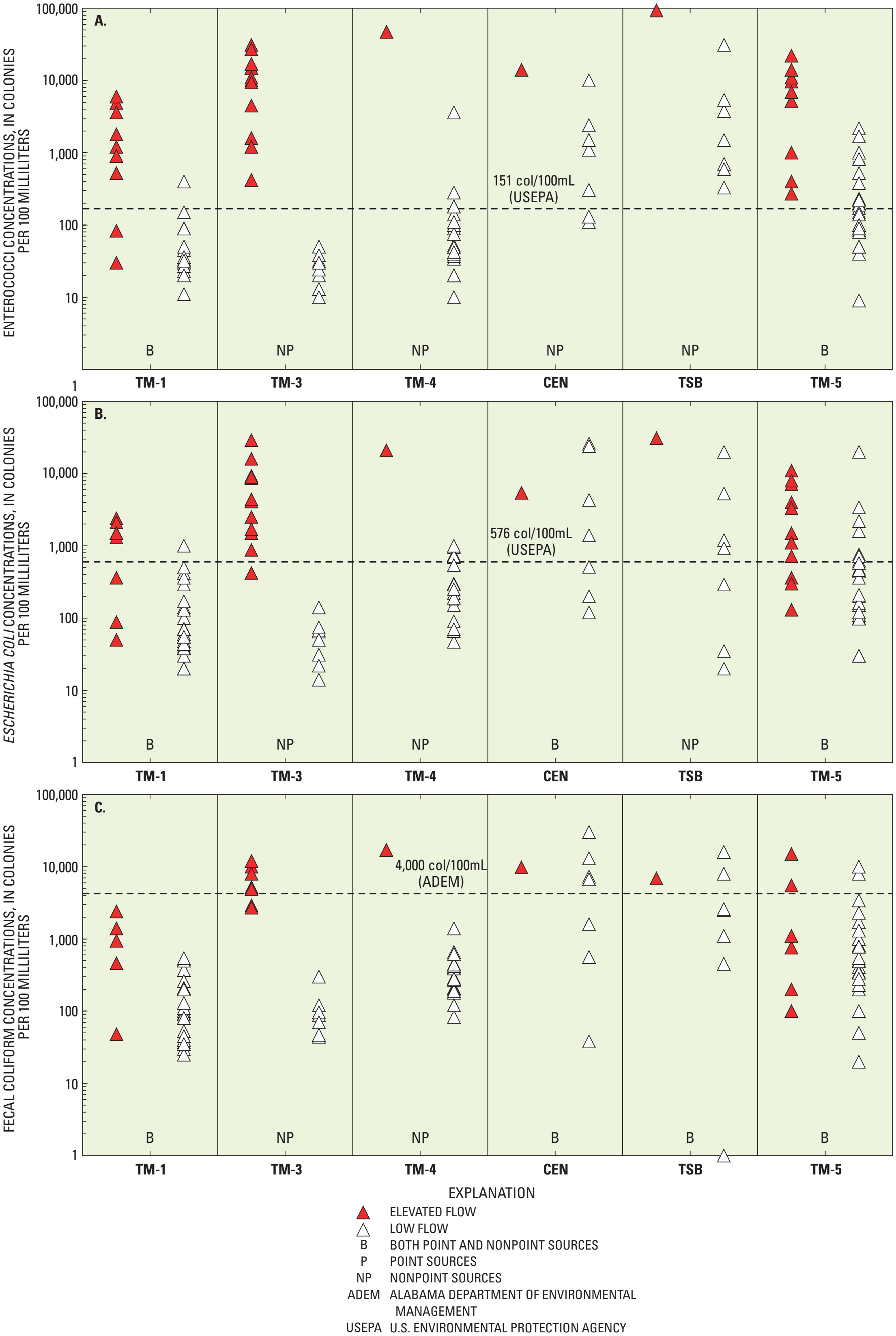


Figure 14. Concentrations of (A) enterococci, (B) *Escherichia coli*, and (C) fecal coliform concentrations in water samples collected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

enterococci and *E. coli* in recreational waters based on frequency of use and body contact (U.S. Environmental Protection Agency, 1986a, 2002b). For infrequent, full-body recreational contact, enterococci and *E. coli* samples should not exceed 151 and 576 col/100 mL of water, respectively (table 13). The ADEM has defined criteria for fecal coliform bacteria based on water-use classification (Alabama Department of Environmental Management, 2000c, 2004). For agricultural and industrial use, the geometric mean of at least five samples collected over a 30-day period should not exceed 2,000 col/100 mL, nor should any one sample exceed a maximum of 4,000 col/100 mL (table 13).

E. coli concentrations in the Threemile Creek basin ranged from 14 to 31,000 col/100 mL (table 12). The highest concentration in Threemile Creek (29,000 col/100 mL) was detected at TM-3 during a storm in December 2001. The highest concentration at TSB (31,000 col/100 mL) was detected during elevated flow in March 2001; the two highest concentrations at CEN (26,000 and 24,000 col/100 mL) were detected during low flow in April and November 2000. Median concentrations of *E. coli* were highest at CEN, followed by TM-3, TSB, TM-5, TM-4, and TM-1, respectively (table 12). In general, median concentrations of *E. coli* increased in a downstream direction in Threemile Creek. TM-3 was sampled more frequently during high flow (13 of 21 samples) than other sites on Threemile Creek; concentrations were highest at TM-3. Storm samples were collected at TM-3 instead of TM-4 whenever the creek could not be waded at TM-4; a security fence along the bridge at TM-4 prevented field personnel from collecting samples from the bridge.

Different patterns were observed for concentrations of enterococci and fecal coliform bacteria (table 12; fig. 14). Enterococci concentrations ranged from 9 to 93,000 col/100 mL; fecal coliform concentrations ranged from < 10 to 30,000 col/100 mL (table 12). Median concentrations of enterococci were highest at TSB, followed by CEN, TM-3, TM-5, TM-4, and TM-1; median concentrations of fecal coliform were highest at CEN, followed by TSB, TM-5, TM-3, TM-4, and TM-1 (table 12). For both enterococci and fecal coliform, median concentrations in the two tributaries were higher than median concentrations in Threemile Creek (table 12). The highest concentration of enterococci (93,000 col/100 mL) was detected at TSB during elevated flow in March 2001; the highest concentration of fecal coliform (30,000 col/100 mL) was detected at CEN during low flow in November 2000. The highest concentrations of enterococci (47,000 col/100 mL) and fecal coliform (17,000 col/100 mL) in Threemile Creek were detected at TM-4 during elevated flow in March 2001.

At the two tributaries, *E. coli*, enterococci, and fecal coliform concentrations exceeded 10,000 col/100 mL during low and high flow several times, indicating both point and nonpoint sources (fig. 14). In Threemile Creek, however, concentrations greater than 10,000 col/100 mL were detected almost exclusively during high flow; only one *E. coli* sample (20,000 col/100 mL) exceeded this magnitude during low flow at TM-5 (fig. 14).

During the last 2 years of data collection, water-quality samples were collected during four specific time periods at sites on Threemile Creek. Sampling at the two tributary sites was discontinued. These four time periods targeted different seasons and different flow conditions on Threemile Creek: (1) storm in December 2001, (2) mixed flow in June 2002, (3) storm in February 2003, and (4) base flow in September 2003. Four to

Table 13. State and Federal standards and criteria for bacteria in surface water.

[USEPA, U.S. Environmental Protection Agency; col/100 mL, colonies per 100 milliliters; ADEM, Alabama Department of Environmental Management]

Fecal-indicator bacteria	USEPA Primary Drinking Water Standard[a] (col/100 mL)	ADEM swimming and other whole-body water contact sports criterion[b] (col/100 mL)		USEPA single sample infrequent full-body contact criterion[c] (col/100 mL)	ADEM agricultural and industrial water-supply criterion[b] (col/100 mL)	
		Coastal waters	Noncoastal waters		Coastal waters	Noncoastal waters
Enterococci	0[a]	35[d], 104[e]	none	151[c]	500[e]	none
Escherichia coli (E. coli)	0[a]	none	none	576[c]	none	none
Fecal coliform	0[a]	none	200[d]	none	none	2,000[d] 4,000[e]

[a] Actual standard of the U.S. Environmental Protection Agency (2002a) is that no more than one sample per month (sampled daily) may be positive for total coliforms, of which fecal coliform and *E. coli* are a subgroup.

[b] Alabama Water Quality Criteria (Alabama Department of Environmental Management, 2004).

[c] Single sample maximum allowable density (U.S. Environmental Protection Agency, 1986a).

[d] Bacterial concentration is the geometric mean of not less than five samples taken over a 30-day period at intervals not less than 24 hours (Alabama Department of Environmental Management, 2004).

[e] Maximum bacterial concentration not to be exceeded in any sample (Alabama Department of Environmental Management, 2004).

eight bacteria samples were collected over a 2–3 day period at three sites on Threemile Creek (TM-1, TM-5, and either TM-3 or TM-4) during each of these periods.

In December 2001, four samples were collected at TM-1, TM-3, and TM-5 over a 2-day period during a winter storm (fig. 15). Antecedent conditions consisted of light rain on December 10, 2001, followed by a 48-hour period without rain. The highest concentrations of enterococci (15,000 col/100 mL), *E. coli* (29,000 col/100 mL), and fecal coliform (12,000 col/100 mL) occurred at TM-3 prior to peak discharge. At TM-1 and TM-5, concentrations of fecal coliform and enterococci increased throughout the storm and remained elevated after flow began to decline (fig. 15). At TM-3, the concentrations peaked about the same time that the second sample was collected and declined thereafter, although concentrations remained elevated after flow began to decline (fig. 15).

In June 2002, eight samples were collected at TM-1, TM-4, and TM-5 over a 3-day period representing mixed flow conditions (fig. 16). Antecedent conditions consisted of light rainfall during the preceding 48 hours. Enterococci concentrations were highest at TM-4 and ranged from 20 to 3,600 col/100 mL; *E. coli* concentrations also were highest at TM-4 and ranged from 38 to 1,000 col/100 mL; and fecal coliform concentrations were highest at TM-5 and ranged from 40 to 1,700 col/100 mL. Enterococci concentrations were higher at TM-5 than TM-4, except for one sample (fig. 16). Enterococci samples were not collected at TM-1. Fecal coliform concentrations exhibited a similar pattern and were consistently higher at TM-5, followed by TM-4 and TM-1 (fig. 16). *E. coli* results were mixed, with highest concentrations recorded at both TM-4 and TM-5 (fig. 16).

In February 2003, five samples were collected at TM-1, TM-3, and TM-5 over a 2-day period during a winter storm (fig. 17). Antecedent conditions consisted of heavy rain on February 21–22, 2003, with streamflow conditions returning to normal by February 24, 2003. Enterococci concentrations ranged from 30 to 27,000 col/100 mL and were highest at TM-3; *E. coli* concentrations ranged from 50 to 9,000 col/100 mL and also were highest at TM-3. Fecal coliform samples were not collected during this period. Initially, concentrations of all three types of bacteria appeared to increase or decrease according to flow; however, concentrations of enterococci and *E. coli* remained high even after flow had returned to normal conditions (fig. 17). Turbidity peaked prior to the last sample collected at each of the sites.

In September 2003, five samples were collected at TM-1, TM-3, and TM-5 over a 2-day period during base-flow conditions (fig. 18). Antecedent conditions consisted of light rainfall on September 13, 2003, with streamflow conditions returning to normal by September 15, 2003. Concentrations of enterococci ranged from 10 to 220 col/100 mL; concentrations of *E. coli* ranged from 14 to 20,000 col/100 mL; and concentrations of fecal coliform ranged from 35 to 10,000 col/100 mL. Concentrations of all three types of fecal-indicator bacteria were highest at TM-5. Concentrations of enterococci, *E. coli*, and fecal coliform at TM-1 remained moderate throughout the sampling period and never exceeded 200 col/100 mL; likewise, concentrations at TM-3 did not exceed 96 col/100 mL. Concentrations of *E. coli* and fecal coliform were consistently higher at TM-5, ranging from 580 to 20,000 col/100 mL (*E. coli*) and from 780 to 10,000 (fecal coliform); however, concentrations of enterococci at TM-5 ranged from 50 to 220 col/100 mL and were similar in magnitude to the concentrations of fecal-indicator bacteria at TM-1 and TM-3 (fig. 18). In general, enterococci bacteria are considered to be better indicators of potential waterborne pathogens than *E. coli* in marine waters (U.S. Environmental Protection Agency, 2002b). It is not known why the concentrations of *E. coli* and fecal coliform were so much higher than enterococci concentrations at TM-5 during this sampling period.

In 2002, the USEPA issued a draft guidance for States in adopting and implementing bacteriological water-quality criteria to protect waters designated for recreation (U.S. Environmental Protection Agency, 2002b). In this document, the USEPA encourages States to use *E. coli* or enterococci as the basis for their water-quality criteria. The ADEM continues to rely on fecal-coliform regulatory standards for most water-use classifications but has recently added enterococci criteria for coastal waters (Alabama Department of Environmental Management, 2004). To ensure consistency and continuity within regulatory programs, the USEPA recommends that States include both fecal coliform and *E. coli* or enterococci in their water-quality standards for a limited period of time, generally a 3-year period, while collecting data for newly adopted *E. coli* or enterococci criteria (U.S. Environmental Protection Agency, 2002b).

In order to examine the relations among concentrations of fecal-indicator bacteria, correlations were run. Concentrations of enterococci, *E. coli*, and fecal coliform were significantly correlated with each other when using a large data set (WY 2000–2003). The strongest, most consistent correlations were seen between fecal coliform and *E. coli* concentrations ($p = < 0.0001$; $rho = 0.861$; fig. 19). Because *E. coli* is a species of the fecal-coliform group (Francy and others, 2000), these results were not unexpected. These data should be useful for the ADEM as the agency considers which types of fecal-indicator bacteria to include in water-quality criteria for the State of Alabama.

Enterococci and *E. coli* concentrations in the study area were compared to the USEPA criteria (single-sample maximum for infrequent full-body contact; table 13), and exceedance frequencies were calculated (table 14). Fecal coliform concentrations were compared to ADEM single-sample criteria for streams classified for industrial and agricultural use (table 13). Concentrations of enterococcal bacteria at sites in the Threemile Creek basin exceeded the USEPA criterion (151 col/100 mL) in 52 percent of the samples; *E. coli* concentrations exceeded the USEPA criterion (576 col/100 mL) in 41 percent of the samples; and fecal coliform concentrations

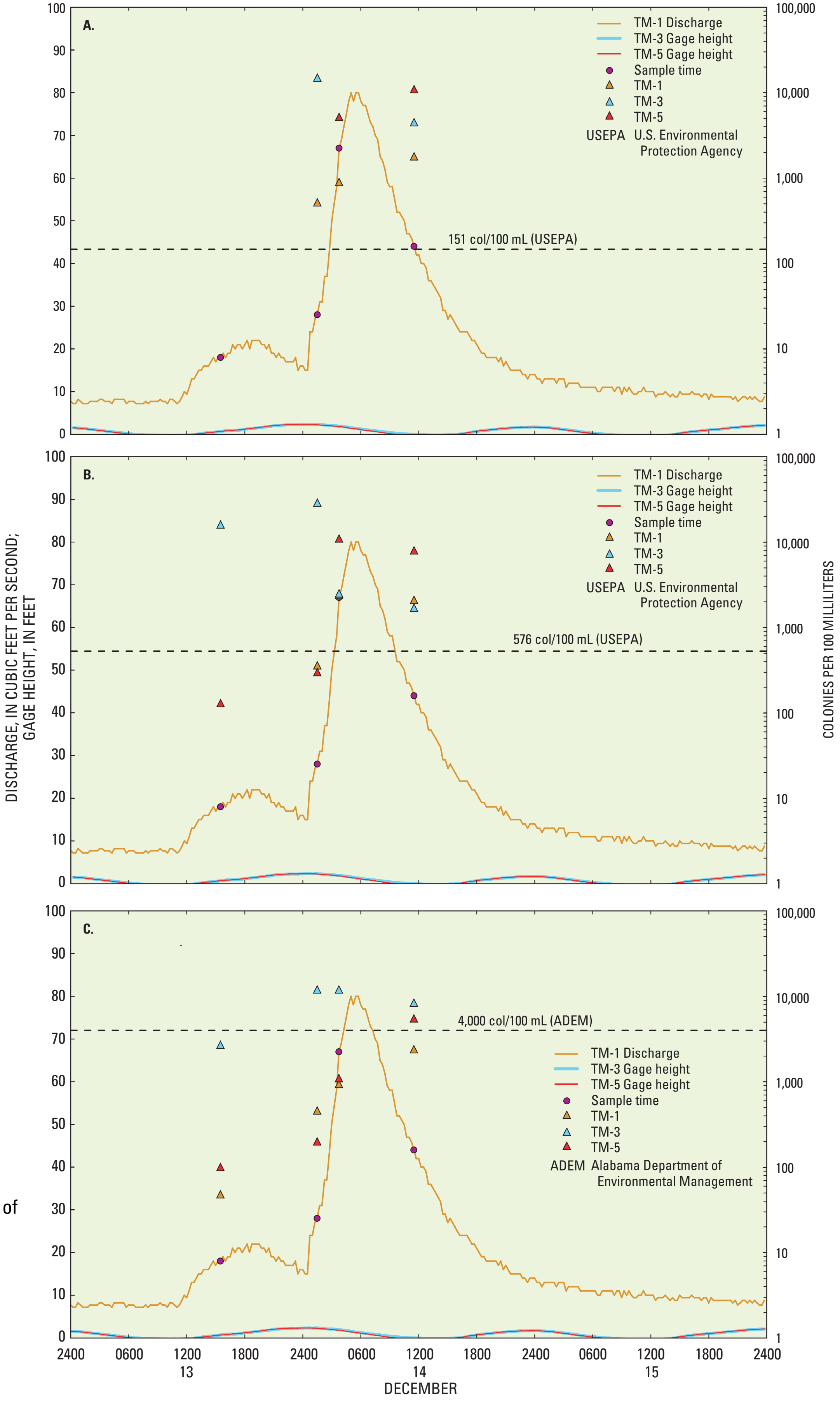


Figure 15. Concentrations of (A) enterococci, (B) *Escherichia coli*, and (C) fecal coliform concentrations at three sites on Threemile Creek, Mobile, Alabama, December 13–15, 2001.

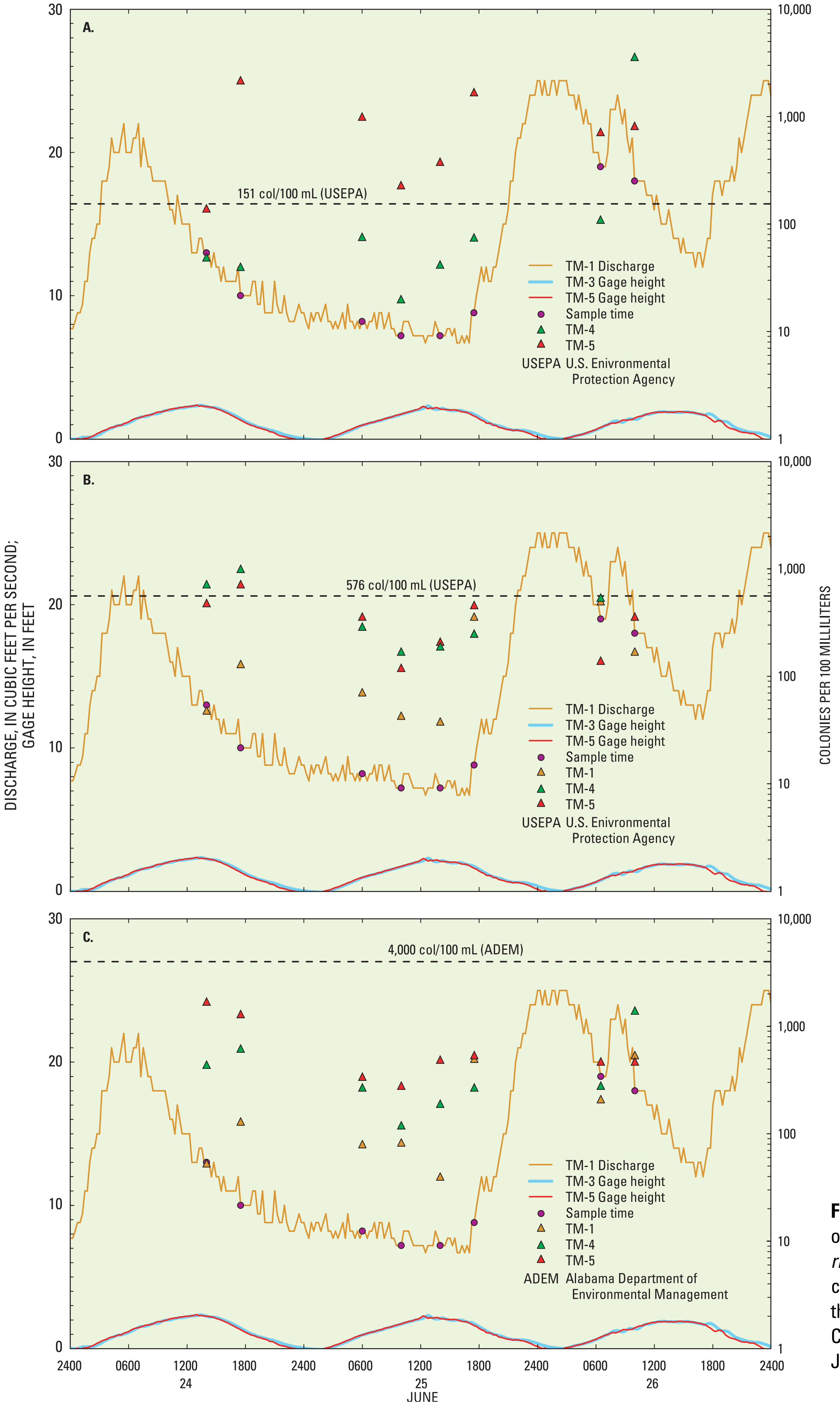


Figure 16. Concentrations of (A) enterococci, (B) *Escherichia coli*, and (C) fecal coliform concentrations at three sites on Threemile Creek, Mobile, Alabama, June 24–26, 2002.

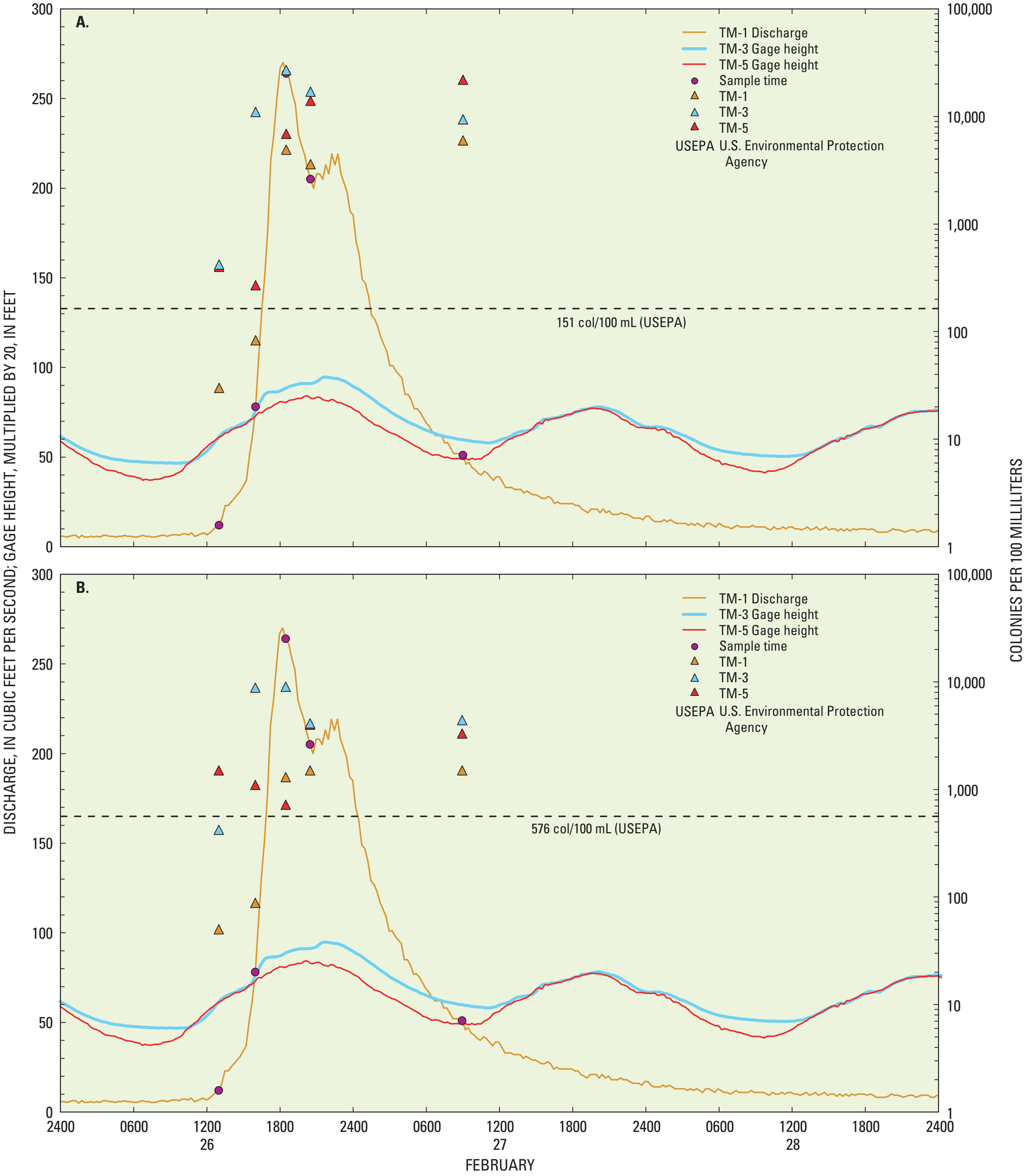


Figure 17. Concentrations of (A) enterococci and (B) *Escherichia coli* concentrations at three sites on Threemile Creek, Mobile, Alabama, February 26–28, 2003.

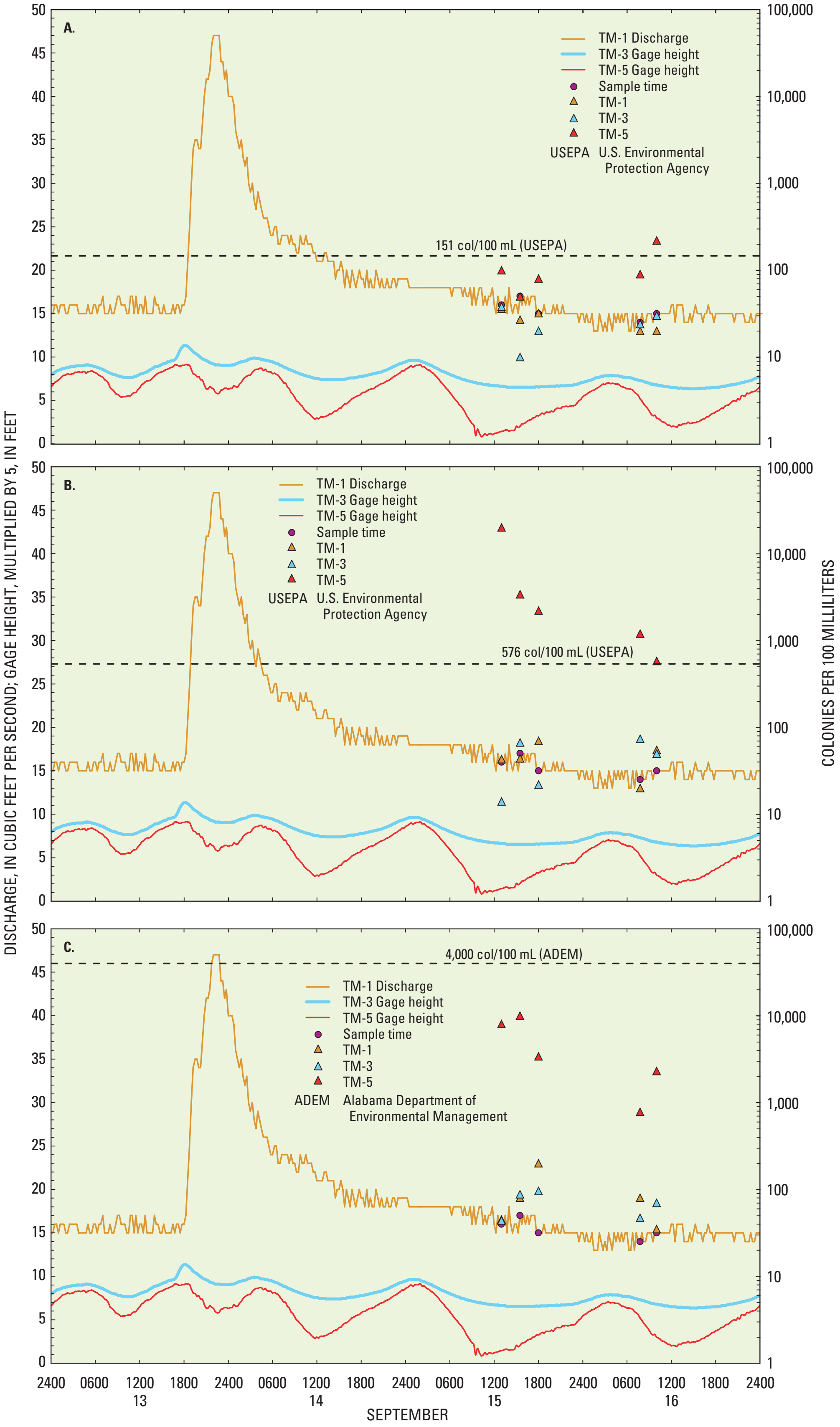


Figure 18. Concentrations of (A) enterococci, (B) *Escherichia coli,* and (C) fecal coliform concentrations at three sites on Threemile Creek, Mobile, Alabama, September 13–16, 2003.

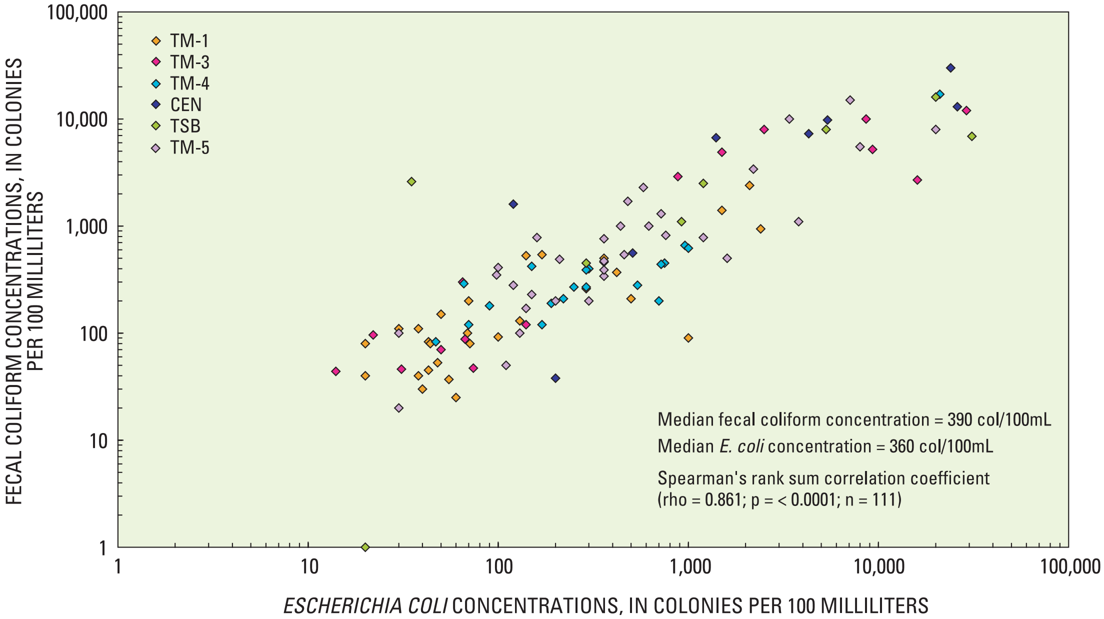


Figure 19. Relation between *Escherichia coli* and fecal coliform concentrations measured at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

Table 14. Exceedance frequencies for fecal-indicator bacteria detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

[USEPA, U.S. Environmental Protection Agency; col/100 mL, colonies per 100 milliliters; ADEM, Alabama Department of Environmental Management]

Site label (fig. 1)	Enterococci			*Escherichia coli*			Fecal coliform		
	Total number of samples	Samples exceeding USEPA criterion[a] (151 col/ 100 mL)	Exceedance frequency (percent)	Total number of samples	Samples exceeding USEPA criterion[a] (576 col/ 100 mL)	Exceedance frequency (percent)	Total number of samples	Samples exceeding ADEM criterion[b] (4,000 col/ 100 mL)	Exceedance frequency (percent)
TM-1	26	8	31	35	7	20	31	0	0
TM-3	19	11	58	21	12	57	15	5	33
TM-4	20	5	25	19	6	32	20	1	5
CEN	8	6	75	8	5	63	8	5	63
TSB	8	8	100	8	5	63	8	3	38
TM-5	34	22	65	36	17	47	31	4	13
TOTALS	115	60	52	127	52	41	111	18	16

[a] U.S. Environmental Protection Agency (1986a).

[b] Alabama Department of Environmental Management (2000c, 2004).

exceeded the ADEM criterion (4,000 col/100 mL) in 16 percent of the samples (table 14).

Statistically significant differences ($p < 0.05$) in bacteria concentrations were identified among sites (table 7). Enterococci, *E. coli*, and fecal coliform concentrations at TM-5 were significantly greater than concentrations at TM-1 for the entire sampling period (WY 2000–2003; table 7). For the 1-year period in WY 2000 when samples were collected at all sites, enterococci concentrations at TSB were significantly greater than TM-4, and fecal coliform concentrations at CEN were significantly greater than TM-4 (table 7).

Concentrations of fecal-indicator bacteria were not well correlated with discharge or turbidity except at TM-3 where more high-flow samples were collected. At TM-3, enterococci concentrations also were well correlated with discharge ($p < 0.0001$; $rho = 0.899$) and turbidity ($p < 0.0001$; $rho = 0.944$). Detection of detergents, dyes, or caffeine may indicate human sewage as the source of fecal contamination in a watershed (U.S. Environmental Protection Agency, 2002b). Although these constituents were widely detected in the basin (see Organic Wastewater Compounds), concentrations of fecal-indicator bacteria were not significantly correlated with concentrations of OWCs or with the number of wastewater compounds detected in a sample. The lack of correlations between these constituents may indicate that the sources of fecal contamination are different or that chemical and biological processes, such as survival times of indicator organisms and degradation of organic compounds, differ between these types of constituents. Other factors, including salinity, may affect the degradation of organic compounds or the survival times of indicator organisms.

Because of the tidal nature of the lower reaches of Threemile Creek, it is difficult to determine whether point or nonpoint sources affect bacteria concentrations at some sites, in particular TM-5. Concentrations of bacteria at TM-1 and TM-5 were elevated during low and high flows, indicating both point and nonpoint sources. Concentrations of bacteria at TM-3 and TM-4 were elevated during high flow rather than low flow, indicating nonpoint sources or possibly a reservoir of bacteria from a more distant source. The frequency of sampling at TM-3 and TM-4, however, differed from that at TM-1 and TM-5, and the proportion of high-flow samples collected at TM-3 exceeded that at TM-4, TM-1, or TM-5.

Concentrations of bacteria at the two tributaries were consistently higher than at the Threemile Creek sites, indicating that some significant source(s) of fecal contamination is(are) in these basins. The flow from the tributaries to Threemile Creek is small, however, compared to the amount of flow in Threemile Creek. These ambiguities make it difficult to determine the source affecting Threemile Creek the most: (1) point or nonpoint sources along Threemile Creek, (2) contributions from the tributaries, (3) contributions from the Mobile River, or (4) contributions from Mobile Bay. It appears that a variety of sources are contributing to the high levels of bacterial contaminants in the Threemile Creek basin—probably a combination of point and nonpoint sources originating from human and other sources (animal).

Organic Wastewater Compounds

Organic wastewater compounds, referred to as OWCs or wastewater indicators, are chemical compounds commonly found in wastewater and urban runoff that can be indicative of contamination associated with a human source. OWCs can originate from a variety of natural and anthropogenic sources in a watershed, including wastewater-treatment facilities. Household chemicals, pharmaceuticals, and other consumables are released to the environment after passing through WWTPs or domestic septic systems, which often are not designed to remove them from the effluent. Most compounds have anthropogenic sources although a few compounds, such as cholesterol and coprostanol, also occur naturally. Comparative analysis of detection frequency and concentrations provides clues to identify the sources and origins of these compounds.

The method used by the NWQL to identify OWCs was developed in response to increasing concern over the effects of endocrine-disrupting chemicals in wastewater on aquatic organisms (Zaugg and others, 2002). The method focuses on determining the compounds that are either an indicator of wastewater or that have been chosen on the basis of their endocrine-disrupting potential or general toxicity (Zaugg and others, 2002). Of the 48 compounds selected for analysis in the stream samples collected from the Threemile Creek basin, 37 compounds were detected in at least one sample (fig. 20; table 15; appendix table 2-2). Because of the large number of OWCs analyzed, they have been broadly characterized into the following 11 groups: antioxidants, prescription and nonprescription drugs (17β-estradiol, caffeine, and cotinine), steroids (sterols and stanols), fragrances, detergent metabolites, antimicrobials, plasticizers/flame retardants, insect repellents, insecticides, herbicides and fungicides, and polycyclic aromatic hydrocarbons (PAHs).

Wastewater indicators were detected in each of the 63 samples collected from the Threemile Creek basin (appendix table 2-2). Of the 48 compounds analyzed in stream samples from the study sites, 9 OWCs were detected frequently (50-percent or greater detection frequency) in samples from the Threemile Creek basin (fig. 20). The most frequently detected compounds were atrazine (herbicide), caffeine (stimulant), 2-butoxyethanol phosphate (household cleaning agent), cholesterol (plant and animal steroid), diazinon (insecticide), bromacil (herbicide), triclosan (antimicrobial disinfectant),

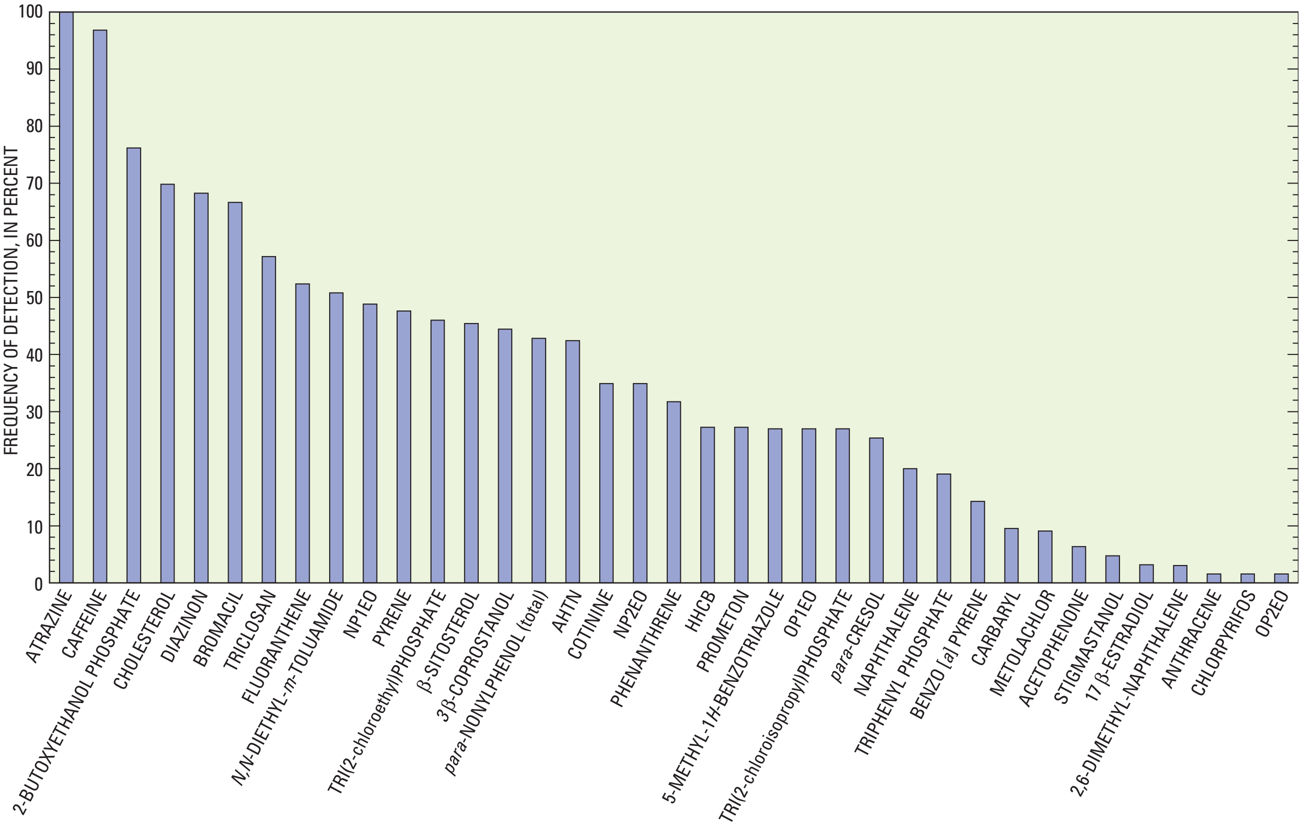


Figure 20. Frequencies of detection for selected organic wastewater compounds in water samples from the Threemile Creek basin, Mobile, Alabama, 2000–2003.

Table 15. Summary of organic wastewater compounds detected in water samples collected in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

[µg/L, micrograms per liter; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(*g*)-2-benzopyran; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol; OWCs, organic wastewater compounds; Compounds that are potential endocrine disruptors are in **bold**; Percent detections in **bold** indicate which site had the maximum concentration measured for a chemical]

Compound	Maximum concentration (µg/L)	Number of detections	Sample size	Detection frequency (percent)						
				All sites	TM-1	TM-3	TM-4	CEN	TSB	TM-5
Antioxidants										
2,6-di-*tert*-butylphenol		0	30	0	0	0	0	0	0	0
2,6-di-*tert*-*p*-benzoquinone		0	30	0	0	0	0	0	0	0
5-methyl-1*H*-benzotriazole	21.4	17	63	27	8	20	18	**88**	25	23
BHA		0	63	0	0	0	0	0	0	0
BHT		0	30	0	0	0	0	0	0	0
para-cresol	1.4	16	63	25	0	10	0	**75**	75	23
Prescription and nonprescription drugs										
17β-estradiol	E 0.636	2	63	3	0	**10**	0	0	13	0
Caffeine	9.8	61	63	97	92	100	100	**100**	100	92
Cotinine	E 0.469	22	63	35	23	0	18	**88**	63	38
Steroids (stanols and sterols)										
Cholesterol	E 7.0	44	63	70	43	50	64	**100**	88	85
3β-coprostanol	E 5.86	28	63	44	8	10	9	88	88	**85**
β-sitosterol	E 3.80	15	33	45	13	40	50	100	67	**50**
Stigmastanol	E 1.1	3	63	5	0	0	0	13	0	**15**
Fragrances										
Acetophenone	0.236	4	63	6	0	0	0	**13**	13	15
AHTN	E 0.42	14	33	42	25	0	0	100	67	**88**
HHCB	E 0.19	9	33	27	0	0	0	67	33	**75**
Detergent metabolites										
NP1EO	E 4.91	21	43	49	30	33	22	**100**	60	67
NP2EO	E 5.97	22	63	35	8	0	0	**100**	25	85
OP1EO	E 0.76	17	63	27	23	20	18	38	38	**31**
OP2EO	E 0.13	1	63	2	0	0	0	0	0	**8**
***para*-nonylphenol (total)**	E 3.33	27	63	43	8	30	18	**100**	38	77

Table 15. Summary of organic wastewater compounds detected in water samples collected in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[µg/L, micrograms per liter; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(*g*)-2-benzopyran; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol; OWCs, organic wastewater compounds; Compounds that are potential endocrine disruptors are in **bold**; Percent detections in **bold** indicate which site had the maximum concentration measured for a chemical]

Compound	Maximum concentration (µg/L)	Number of detections	Sample size	Detection frequency (percent)						
				All sites	TM-1	TM-3	TM-4	CEN	TSB	TM-5
Antimicrobials										
Triclosan	0.894	36	63	57	23	40	18	**100**	100	85
Plasticizers/flame retardants										
Triphenyl phosphate	E 0.085	12	63	19	8	20	18	**25**	25	23
Tri(2-chloroethyl)phosphate	0.31	29	63	46	31	30	55	**63**	38	69
Tri(2-chloroisopropyl)phosphate	0.214	17	63	27	8	30	9	**38**	25	54
2-butoxyethanol phosphate	12.0	48	63	76	38	60	73	**100**	100	100
Insect repellents										
N,*N*-diethyl-*m*-toluamide (DEET)	1.89	32	63	51	23	70	27	**88**	50	62
Insecticides										
Carbaryl	E 0.062	6	63	10	15	**20**	9	0	0	8
***cis*-chlordane**		0	30	0	0	0	0	0	0	0
Chlorpyrifos	0.036	1	63	2	0	0	0	0	**13**	0
Diazinon	0.307	43	63	68	69	**60**	100	75	38	62
Dieldrin		0	30	0	0	0	0	0	0	0
Lindane		0	30	0	0	0	0	0	0	0
Methyl parathion		0	30	0	0	0	0	0	0	0
Herbicides and fungicides										
Atrazine	0.64	16	16	100	100	100	100	n/a	n/a	**100**
Bromacil	E 0.34	22	33	67	38	60	100	33	**100**	75
Metolachlor	E 0.3	3	33	9	0	0	0	0	0	**38**
Prometon	E 0.059	9	33	27	0	0	67	**100**	0	25
Metalaxyl		0	33	0	0	0	0	0	0	0

Table 15. Summary of organic wastewater compounds detected in water samples collected in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[µg/L, micrograms per liter; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(*g*)-2-benzopyran; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol; OWCs, organic wastewater compounds; Compounds that are potential endocrine disruptors are in **bold**; Percent detections in **bold** indicate which site had the maximum concentration measured for a chemical]

Compound	Maximum concentration (µg/L)	Number of detections	Sample size	Detection frequency (percent)						
				All sites	TM-1	TM-3	TM-4	CEN	TSB	TM-5
Polycyclic aromatic hydrocarbons										
Anthracene	E 0.16	1	63	2	8	0	0	0	0	0
Benzo[*a*]pyrene	E 0.15	9	63	14	8	30	9	0	13	**23**
Fluoranthene	0.287	33	63	52	23	90	55	63	**50**	46
Naphthalene	E 0.120	11	55	20	17	**56**	10	0	50	0
1-methyl-naphthalene		0	30	0	0	0	0	0	0	0
2-methyl-naphthalene		0	33	0	0	0	0	0	0	0
2,6-dimethyl-naphthalene	E 0.086	1	33	3	0	0	0	0	0	**13**
Phenanthrene	E 0.15	20	63	32	**23**	70	27	38	25	15
Pyrene	0.217	30	63	48	8	80	55	63	**50**	46
Summary										
Number of OWCs detected				37	27	25	25	27	29	33
Median number of OWCs detected per sample				13	5	11	8	18	12	15
Number of OWCs with greatest concentration at that site					1	4	0	16	4	11
Median total concentration of OWCs detected per sample				2.98	0.75	1.30	2.13	20.1	4.20	11.0
Maximum total concentration of OWCs detected per sample				56.6	7.03	4.09	3.95	56.6	13.2	25.6

fluoranthene (PAH), and *N,N*-diethyl-*m*-toluamide (insect repellent commonly known as DEET). The frequent detection of several of these compounds in a national reconnaissance of 139 streams indicates that their environmental occurrence is widespread (Kolpin and others, 2002).

The median number of wastewater indicators detected in individual samples ranged from 5 (TM-1) to 18 (CEN, table 15). In Threemile Creek, the median number of detections was highest at TM-5 (15), followed by TM-3 (11), TM-4 (8), and TM-1 (5). The median number of detections at the tributary sites was highest at CEN (18), followed by TSB (12). The median of the total concentrations at each site ranged from 0.75 µg/L (TM-1) to 20.1 µg/L (CEN). In Threemile Creek, the median concentration was highest at TM-5 (11.0 µg/L), followed by TM-4 (2.13 µg/L), TM-3 (1.30 µg/L), and TM-1 (0.75 µg/L). At the two tributary sites, the median concentration was highest at CEN (20.1 µg/L), followed by TSB (4.20 µg/L).

The number of wastewater-indicator compounds detected in an individual sample ranged from 2 (TM-1) to 22 (TM-5, fig. 21). The maximum number of wastewater indicator compounds detected at individual sites throughout the study ranged from 25 (TM-3, TM-4) to 33 (TM-5, table 15). Mixtures of chemicals were common, and 50 of 63 samples (79.4 percent) contained total concentrations of OWCs that exceeded 1 µg/L. The maximum total concentration was greatest at CEN (56.6 µg/L, fig. 21; table 15). Total concentrations greater than 10 µg/L also were detected at TM-5 (25.6 µg/L) and TSB (13.2 µg/L, fig. 21; table 15). Concentrations were summed to illustrate the potential magnitude of the source—higher concentrations do not necessarily imply that a site is more contaminated than one with lower concentrations.

In at least two major studies (Atlanta, Georgia, and Kansas City, Missouri), a higher number of OWCs generally was detected in wet-weather samples than in base-flow samples (Wilkison and others, 2002; Frick and Zaugg, 2003). In the Threemile Creek study, this was not always true. Higher concentrations of OWCs were detected during low flow at two sites (CEN and TM-5), and a greater number of compounds was detected during low flow, rather than high flow, at four of six sites (TM-1, CEN, TSB, and TM-5; fig. 21). Conversely, a greater number of OWCs was detected during wet weather at TM-3, the site that was sampled most frequently during high flow (fig. 21). From the Threemile Creek study, it appears that point-source contributions may be more significant than contributions from nonpoint sources at several sites; however, fewer wet-weather samples were collected in the Threemile Creek basin compared to the other two major studies, which limits the interpretive comparison (Wilkison and others, 2002; Frick and Zaugg, 2003).

The detection frequencies of the 10 most frequently detected OWCs at each site and the 10 most frequently detected OWCs in the entire watershed are illustrated in figures 22 and 23. Compounds that were incorporated into the wastewater schedule midway through the sampling period, such as atrazine, were not included in figures 22 and 23. Caffeine was detected in each sample at four of six sites; 2-butoxyethanol phosphate was detected in each sample at three of six sites (figs. 22, 23).

The compounds detected most frequently at CEN also were detected most frequently at TSB and TM-5. Seven OWCs (caffeine, 2-butoxyethanol phosphate, cholesterol, triclosan, nonylphenol monoethoxylate (NP1EO), *para*-nonylphenol, and NP2EO) were detected in each sample collected at CEN; three of these compounds also were detected in each sample at TSB (fig. 22). Of the 10 most frequently detected compounds at CEN, 8 OWCs were among the 10 most frequently detected compounds at TSB and at TM-5 (fig. 22). The 10 most frequently detected compounds at CEN, TSB, and TM-5 were found in at least 50 percent of the samples; whereas only 2 compounds at TM-1 were detected in at least 50 percent of the samples (fig. 22). Five of the 10 most frequently detected OWCs in the Threemile Creek basin (2-butoxyethanol phosphate, cholesterol, triclosan, NP1EO, and tri(2-chloroethyl)phosphate) were detected more frequently at CEN and TM-5 than at the upstream sites on Threemile Creek (fig. 23). The detergent metabolites (NP1EO, NP2EO, and *para*-nonylphenol) were detected most frequently at CEN, followed by TM-5 (fig. 22). PAHs, such as fluoranthene and pyrene, were detected most frequently at TM-3, which probably indicates nonpoint-source contributions (figs. 22, 23).

Statistically significant differences in concentrations and number of detections of wastewater indicators among sites were identified. The number of OWC detections at CEN was significantly greater than at TM-4; the number of OWC detections at TM-5 was significantly greater than at TM-1 (table 7). The total concentration of wastewater indicators at CEN and TSB was significantly greater than at TM-4; the total concentration of OWC at TM-5 was significantly greater than at any site on Threemile Creek (TM1, TM-3, or TM-4; table 7). Strong correlations were found between total phosphorus and the total concentration of OWC ($p < 0.0001$; $rho = 0.744$; fig. 24). Strong correlations also were found between the number of wastewater indicator compounds detected and the total concentrations of OWCs ($p < 0.0001$; $rho = 0.885$), and between caffeine concentrations and the total concentrations of OWCs ($p < 0.0001$; $rho = 0.734$). Correlations that were significant when considering the entire data set were not always significant at each site.

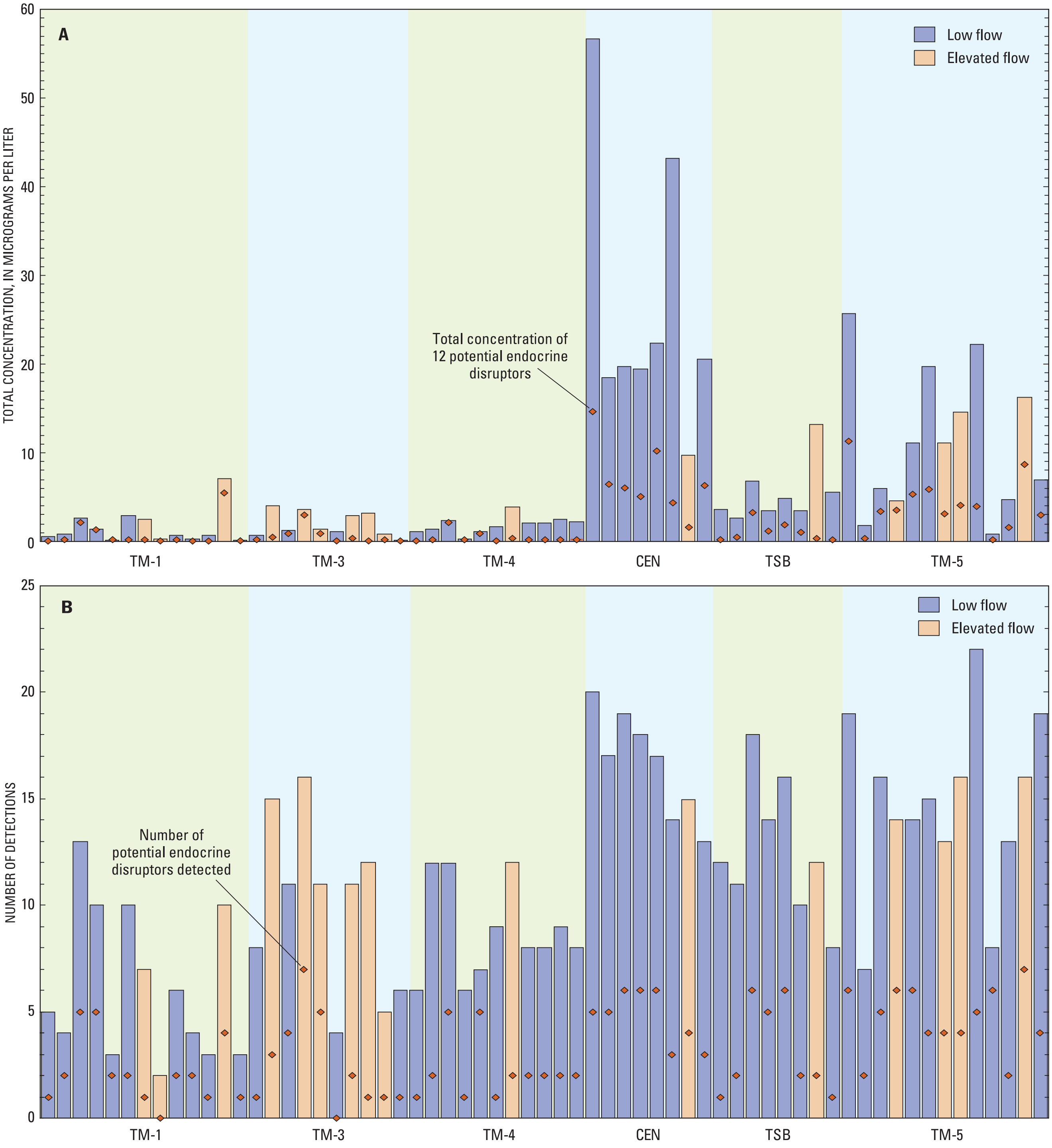


Figure 21. Summary of organic wastewater compounds detected per sample for (A) total concentration (summation of 48 compounds) and (B) number of compounds detected.

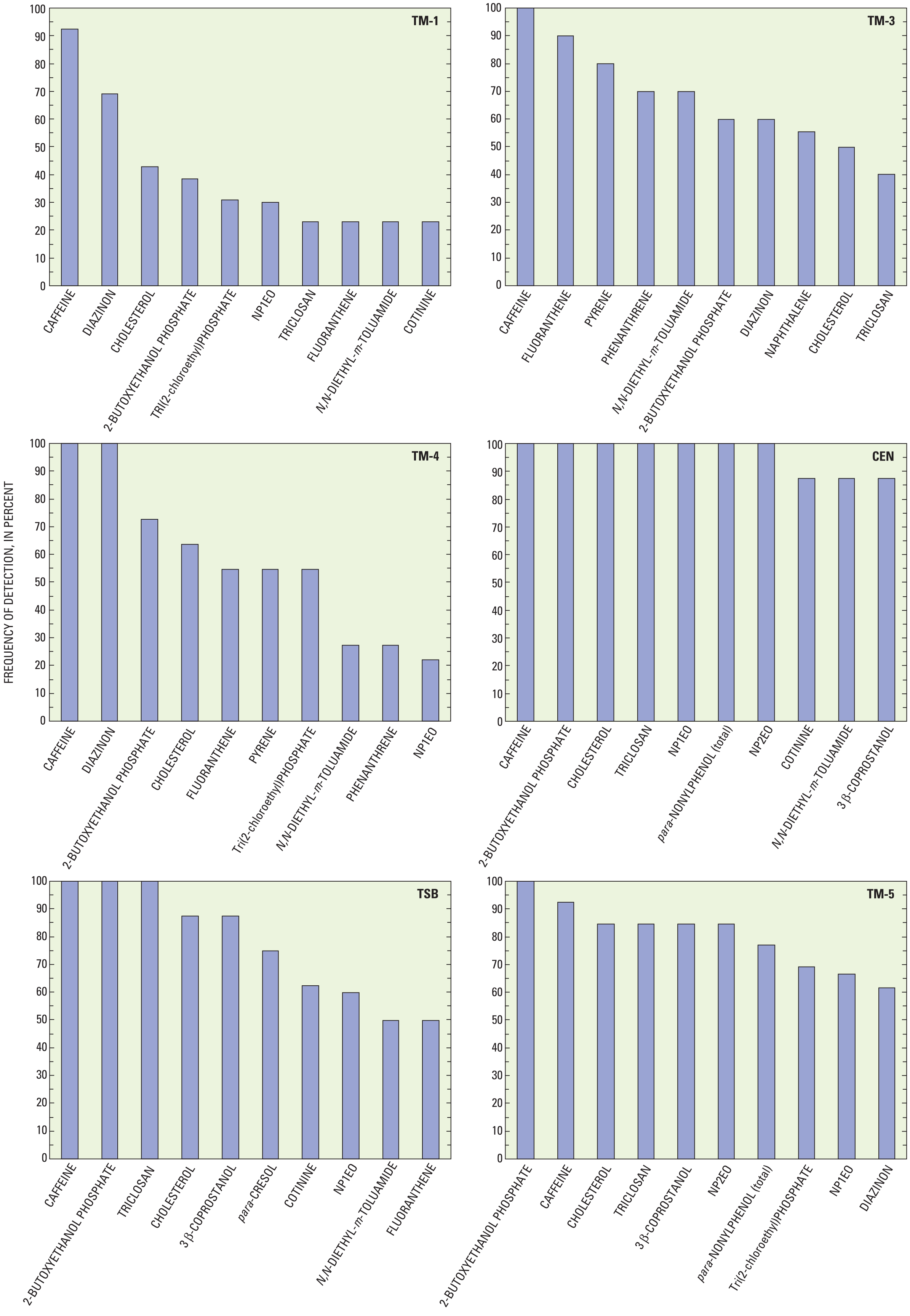


Figure 22. The 10 most frequently detected organic wastewater compounds at each site in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

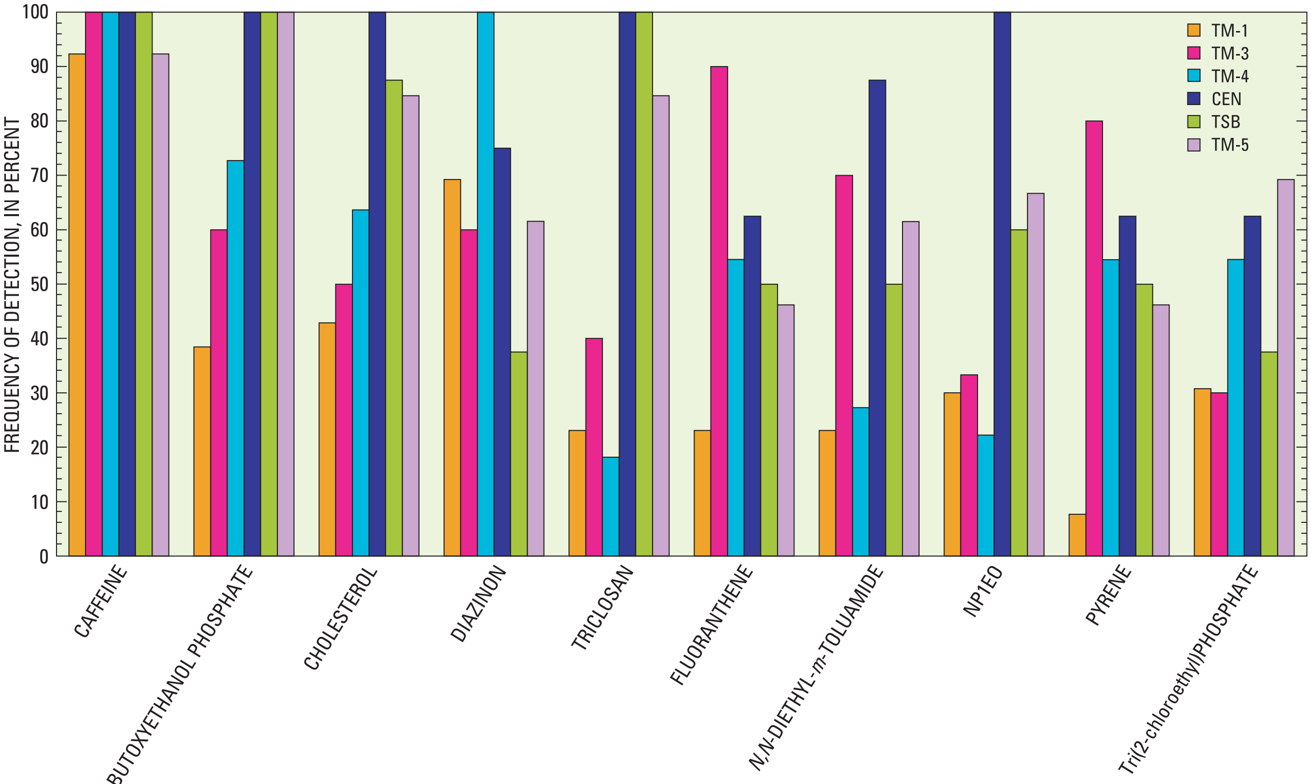


Figure 23. The 10 most frequently detected organic wastewater compounds in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

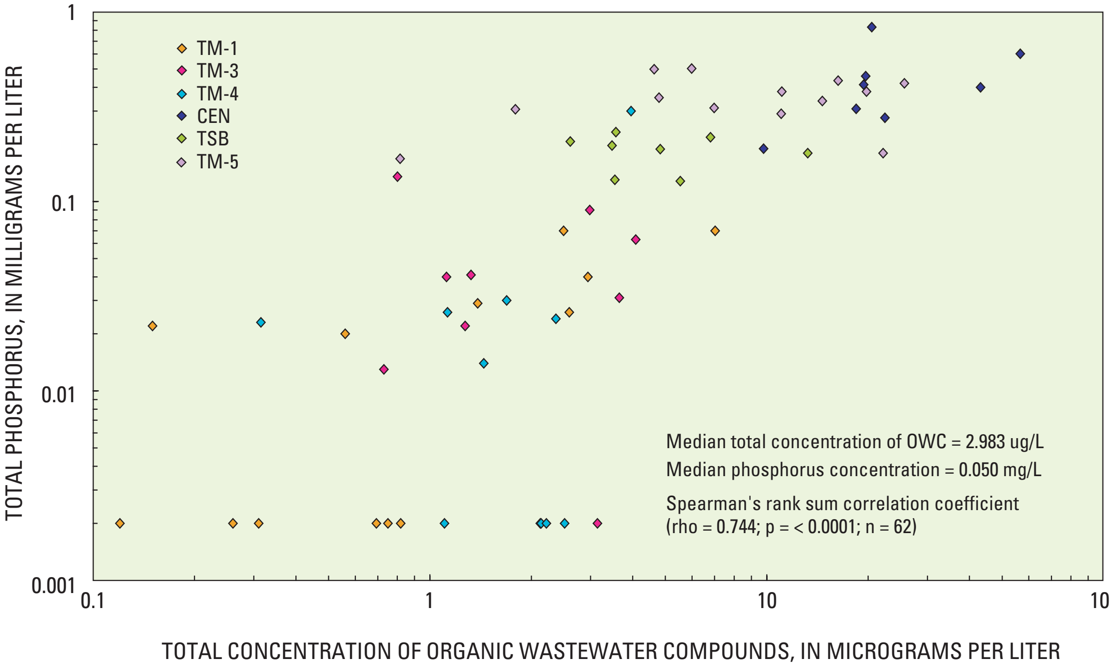


Figure 24. Relation between total concentration of organic wastewater compounds (OWC) and total phosphorus, Threemile Creek basin, Mobile, Alabama, 2000–2003.

Occurrence and Distribution of Wastewater Indicator Groups

The 37 detected compounds represent a wide variety of uses and origins, including residential, industrial, and agricultural sources. The OWCs were divided into 11 groups based on their general use and origins. Figure 25 illustrates the prevalence of the different groups of compounds with respect to each sample collected during the study period. The greatest concentrations of OWCs were from the following four groups: steroids, detergent metabolites, plasticizers/flame retardants, and prescription/nonprescription drugs (fig. 25A). There was greater diversity, however, among the compound groups detected in the Threemile Creek basin (fig. 25B) than illustrated by the concentrations shown in figure 25A. Concentrations of several groups of compounds, such as PAHs or herbicides, were low although these compounds were detected widely in the watershed (fig. 25).

Two observations can be made concerning how prevalent the groups of compounds were in terms of the entire data set (63 samples). In relation to frequency of detection, 9 of 11 groups were found in more than 50 percent of the samples (fig. 26A). In relation to percentage of total measured concentration for each group, four groups (steroids, detergent metabolites, plasticizer/flame retardants, and prescription/nonprescription drugs) contributed almost 87 percent of the total measured concentration in all samples (fig. 26B).

Although 79.4 percent of the samples contained total concentrations of OWCs exceeding 1 µg/L, only 17.9 percent of the samples contained concentrations of individual compounds that exceeded 1 µg/L (appendix table 2-2). More than 45 percent of the higher concentrations was derived from the steroids group (cholesterol, 3β-coprostanol, β-sitosterol); 35 percent was derived from the three detergent metabolites (*para*-nonylphenol total, NP1EO, and NP2EO); approximately 10 percent was derived from a plasticizer/cleaning agent (2-butoxyethanol phosphate); and 5.5 percent was derived from caffeine.

Organic Wastewater Compounds as Endocrine Disruptors

An endocrine disruptor is a natural or synthetic chemical, that when absorbed into the body, either mimics or blocks hormones and disrupts the body's normal functions. Exposure to endocrine disruptors can occur through direct contact with chemicals or through exposure to contaminated water, food, or air. Chemicals suspected of acting as endocrine disruptors are found in detergents, resins, plasticizers, insecticides, herbicides, fumigants, fungicides, industrial chemicals, and heavy metals. Of the 48 compounds included in this analysis, 19 are known or suspected to exhibit at least weak hormonal activity with the potential to disrupt endocrine function (table 15; Kolpin and others, 2002; S.D. Zaugg, U.S. Geological Survey, written commun., May 10, 2004). Twelve of these compounds were detected in the Threemile Creek study (appendix table 2-2) and can be grouped into five categories: prescription drugs (17β-estradiol), detergent metabolites (NP1EO, NP2EO, OP1EO, OP2EO, and *para*-nonylphenol), antimicrobials (triclosan), pesticides (atrazine, carbaryl, chlorpyrifos, and diazinon), and PAHs (benzo[*a*]pyrene).

Potential endocrine disruptors were detected in 61 of 63 samples (96.8 percent) in the Threemile Creek basin (fig. 21). The total concentration of potential endocrine disruptors detected in a single sample ranged from 0 µg/L (no detections) at TM-1 and TM-3 to 14.6 µg/L at CEN (fig. 21). The total concentration of potential endocrine disruptors exceeded 1 µg/L in 27 of 63 samples (42.8 percent) collected in the Threemile Creek basin, in 8 of 8 (100 percent) of the samples at CEN, and in 11 of 13 samples (84.6 percent) at TM-5. Median concentrations of potential endocrine disruptors were highest at CEN and TM-5, followed by TSB, TM-3, TM-4, and TM-1. The total concentration of potential endocrine disruptors was highest at CEN during low flow, indicating point sources; total concentrations at TM-5 were highest during low and high flow, indicating point and nonpoint sources (fig. 21). The number of potential endocrine disruptors detected in a single sample ranged from zero (TM-1, TM-3) to 7 (TM-3, TM-5; fig. 21); the median number of potential endocrine disruptors detected was greatest at CEN and TM-5 (5), followed by TM-4, TSB, TM-1, and TM-3 (2).

Previous research has shown that even low-level exposure (< 0.001 µg/L) to select hormones can illicit deleterious effects in aquatic species (Kolpin and others, 2002). In addition, research has shown that select chemical combinations can have additive or synergistic toxic effects (Kolpin and others, 2002). Little is known about the potential interactive effects (synergistic or antagonistic toxicity) that can occur from complex mixtures of OWCs in the environment. Much is yet to be learned pertaining to the effects (particularly chronic effects) on humans, plants, and animals exposed to low-level concentrations of pharmaceuticals and other OWCs that were detected in this study.

Antioxidants

Three antioxidants—butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and 5-methyl-1*H*-benzotriazole—as well as two metabolites of BHA and BHT— 2,6-di-*tert*-butylphenol and 2,6-di-*tert*-*p*-butyl benzoquinone—were analyzed in this study. Antioxidants commonly are used to delay the deterioration of food flavors and odors and to substantially increase the shelf life of many foods. *Para*-cresol, a common disinfectant, also is included in this subgroup of wastewater indicators because it is used to produce BHT. *Para*-cresol also is used in phenol-formaldehyde resins and in ultraviolet blockers for sunscreen and fragrances. BHA generally is used to keep fats from becoming rancid and is used widely in the food industry as a preservative. BHA is found in butter, lard, meats, cereals, baked goods, sweets, beer,

Figure 25. Summary of the types of organic wastewater compounds detected per sample for (A) total concentration (summation of 48 compounds) and (B) number of compounds detected, Threemile Creek basin, Mobile, Alabama, 2000–2003.

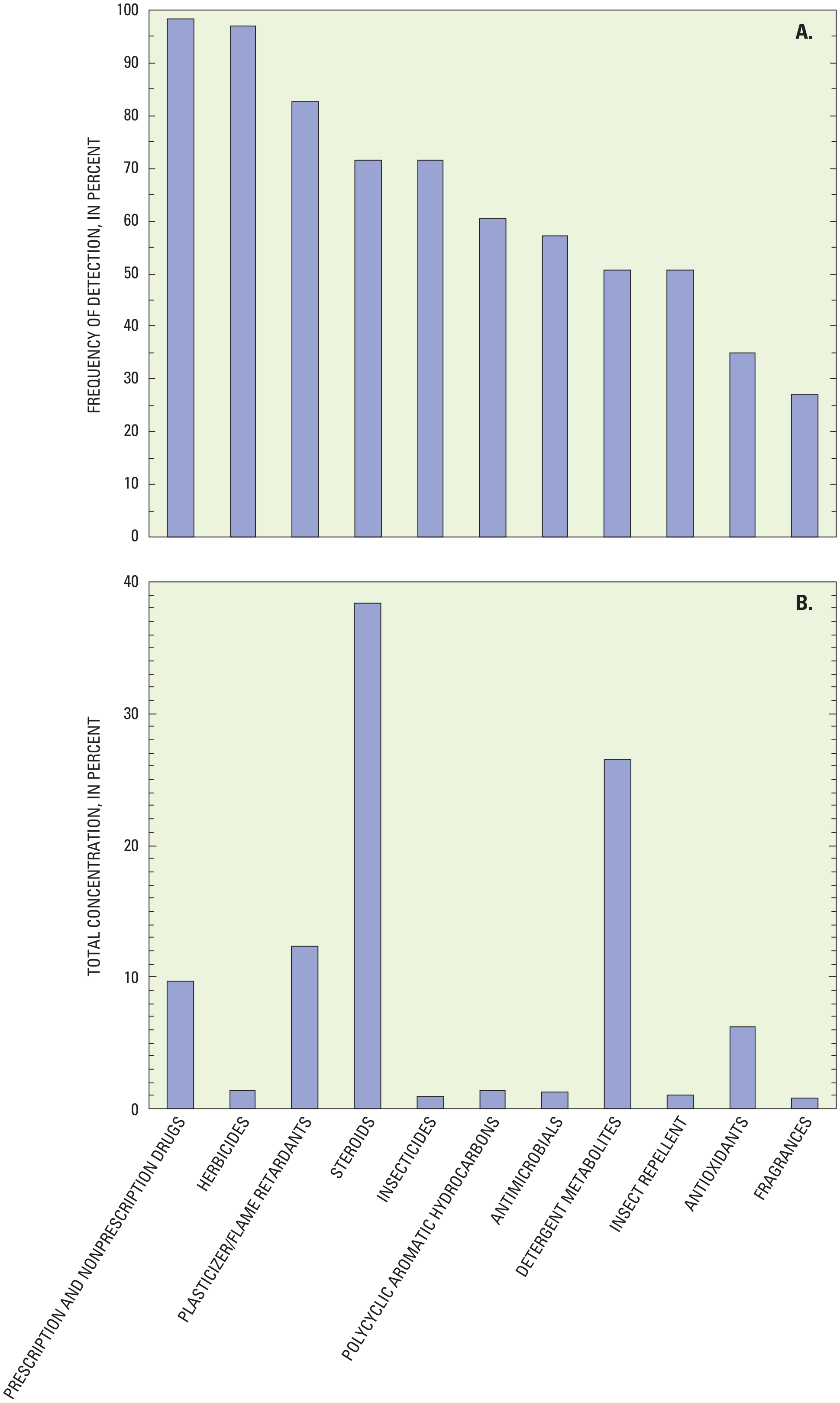


Figure 26. (A) Frequency of detection of organic wastewater compounds by general-use category and (B) percentage of total measured concentration of organic wastewater compounds by general-use category, Threemile Creek basin, Mobile, Alabama, 2000–2003.

vegetable oils, potato chips, snack foods, nuts, and flavoring agents; it also is found in animal feed, cosmetics, and in rubber and petroleum products (U.S. Department of Health and Human Services, 2002). BHT also prevents oxidative rancidity of fats and is used to preserve food odor, color, and flavor. Many packaging materials incorporate BHT, and it is added directly to shortening, cereals, and other foods containing fats and oils (Helmenstine, 2004). The antioxidant 5-methyl-1*H*-benzotriazole is used in anti-freeze and de-icers as an anti-corrosion agent (Wilkison and others, 2002).

Of the 63 samples collected, 17 (27 percent) contained 5-methyl-1*H*-benzotriazole, which was detected at each of the sites in the Threemile Creek basin (fig. 20; table 15; appendix table 2-2). This compound was most frequently detected (7 of 8 samples; 88 percent) at CEN, where the highest concentrations also were detected (table 15; appendix table 2-2). *Para*-cresol was detected in 16 of 63 samples (25 percent) in the Threemile Creek basin (fig. 20; table 15; appendix table 2-2). *Para*-cresol was detected in 75 percent of the samples at the two tributary sites (CEN, TSB) and in 23 percent of the samples at TM-5; it was not detected at TM-1 or TM-4 (appendix table 2-2). BHA, BHT, and their metabolites were not detected at any site in the Threemile Creek basin (appendix table 2-2).

Prescription and Nonprescription Drugs

17β-estradiol is a naturally occurring estrogen produced in the human body. As a prescription drug, it is used primarily for hormone replacement therapy and for the prevention of osteoporosis and breast cancer. Intermittent exposure to concentrations as low as 0.12 μg/L can induce adverse reproductive changes in fish (Panter and others, 2000; Rogers-Gray and others, 2000). This compound demonstrated poor or variable method performance, and detections were always qualified as estimated (E). 17β-estradiol was detected in 2 of 63 samples in the Threemile Creek basin (E 0.636 μg/L at TM-3 and E 0.314 μg/L at TSB, appendix table 2-2).

Detection of caffeine can be an important indicator of wastewater contamination in surface-water samples even though caffeine is not persistent in the environment because of rapid degradation by bacteria (Zaugg and others, 2002). Caffeine was one of the most frequently detected wastewater compounds in the Threemile Creek basin. It was detected in 61 of 63 samples (97 percent, fig. 20; table 15; appendix table 2-2). Caffeine is found in many substances, including coffee, tea, chocolate, soft drinks, and a variety of pharmaceutical products. A 6-ounce cup of coffee typically contains about 100 milligrams (mg); a 6-ounce cup of tea contains about 70 mg; and a 12-ounce cola contains about 70 mg (Brain, 2003). Caffeine is found in analgesic products, such as Anacin (32 mg per tablet); in products used to enhance alertness, such as No-doz (100 mg per tablet); and in appetite suppressants, such as Dexatrim (200 mg per tablet; Brain, 2003). Caffeine's half-life varies from several hours to several days, but for the average nonsmoking adult, it is about 5–7 hours (Erowid, 2003). Based on a daily per capita use rate of 280 mg per consumer (Barone and Roberts, 1996) and the most recent population figures (table 4), the average annual consumption of caffeine in the Threemile Creek basin is estimated to be about 16,000 pounds per year. Unconsumed coffee and soft drinks poured down drains likely contribute to the occurrence of caffeine in water samples. Caffeine was detected at each of the sites in the Threemile Creek basin (figs. 22, 23). The highest concentrations of caffeine were detected at CEN (appendix table 2-2). Median concentrations of the detected values were lowest at TM-1 (appendix table 2-2). Concentrations of caffeine were well correlated to concentrations of 2-butoxyethanol phosphate ($p = 0.0149$; $rho = 0.810$) at CEN. Caffeine also was well correlated to cholesterol concentrations ($p < 0.0001$; $rho = 0.890$) and 3β-coprostanol concentrations ($p = 0.0014$; $rho = 0.787$) at TM-5.

Cotinine is a metabolic by-product that is produced by the body as it processes nicotine. Nicotine is found in tobacco, tobacco products, cigarette smoke, and smoking-cessation products. Exposure to nicotine can be measured by analyzing cotinine levels; cotinine has a 24-hour half-life in blood, saliva, or urine. Cotinine was detected in 22 of 63 samples (35 percent) and was found at five of the six sites (TM-1, TM-4, CEN, TSB, and TM-5) in the Threemile Creek basin (table 15; appendix table 2-2). The highest concentrations of this compound were detected at CEN (table 15; appendix table 2-2) and it was detected most frequently (7 of 8 samples; 88 percent) at CEN (fig. 22).

Steroids—Sterols and Stanols

Plant sterols (phytosterols) and plant stanols (phytostanols) are naturally occurring substances in fruits, vegetables, nuts, seeds, legumes, and other plant sources, including wood pulp. Plant sterols and stanols are essential components of plant cell membranes and are similar in structure to cholesterol. Cholesterol is itself a sterol; however, it is predominantly an animal sterol. In humans, the liver synthesizes cholesterol although an appreciable amount may be consumed through the diet. The consumption of plant sterol and stanols lowers cholesterol levels by inhibiting the absorption of dietary cholesterol. Cholesterol is microbially reduced into coprostanol, which is a traditional indicator of sewage contamination because it is produced almost exclusively in the digestive tract of higher mammals (humans, pigs, and cats) and often correlates with the presence of other sewage-derived pollutants, such as pathogens, toxic metals, organic compounds, and hormones (Zaugg and others, 2002). β-sitosterol and β-sitostanol (stigmastanol) are plant steroids, which are components of pulp-mill wastes (Mahmood-Khan and Hall, 2003); their presence in the same sample generally indicates a substantial contribution from plant sterols (Zaugg and others, 2002). β-sitostanol may be released in the environment from the decomposition of paper or the breakdown of grass clippings (Wilkison and others, 2002). β-sitosterol is the most abundant plant sterol in the human diet (PDR*health*, 2004) and is found in saw palmetto, a plant that grows abundantly in the Threemile Creek basin.

Cholesterol was detected in 44 of 63 samples (70 percent) in the Threemile Creek basin (fig. 20; table 15). The highest concentrations of this compound, detected at the unnamed tributary at Center Street (CEN), ranged from 1.99 to 7.00 μg/L (appendix table 2-2). High concentrations also were detected at TSB (5.6 μg/L) and TM-5 (6.8 μg/L). Cholesterol was detected in 8 of 8 samples (100 percent) at CEN; it was detected in 85 to 88 percent of the samples at TM-5 and TSB, respectively. In contrast, cholesterol was detected in 43 percent of the samples at the most upstream site, TM-1 (fig. 22; table 15).

Coprostanol, a traditional indicator of sewage contamination, was detected in 28 of 63 samples (44 percent) in the Threemile Creek basin (fig. 20; table 15). The highest concentrations of this compound were detected at the most downstream site on Threemile Creek (TM-5), followed by the tributaries CEN and TSB (appendix table 2-2). Coprostanol was detected in 85–88 percent of the samples at three sites—CEN, TSB, and TM-5 (table 15). In contrast, coprostanol was detected in only 8–10 percent of the samples at the upstream sites on Threemile Creek.

β-sitosterol was detected in 15 of 33 samples (45 percent) in the Threemile Creek basin (fig. 20; table 15). The highest concentration of this compound was detected at the most downstream site on Threemile Creek (TM-5), followed by the tributaries CEN and TSB. β-sitosterol was detected in 3 of 3 samples (100 percent) at CEN and in 4 of 8 samples (50 percent) at TM-5, but in only 1 of 8 samples (13 percent) at TM-1 (table 15). Stigmastanol (β-sitostanol) was detected in only 3 of 63 samples (5 percent) in the Threemile Creek basin (table 15).

Sterols are important predictors of wastewater contamination (LeBlanc and others, 1992). Cholesterol, 3β-coprostanol, and β-sitosterol showed similar distribution patterns, which indicate that source and fate may be similar for each compound. Higher detection frequencies and concentrations of these compounds were observed at the two tributaries (CEN and TSB) and at the most downstream site on Threemile Creek (TM-5). The concentrations of cholesterol and 3β-coprostanol were significantly correlated at CEN ($p = 0.0011$; $rho = 0.922$), TSB ($p = 0.0149$; $rho = 0.810$), and TM-5 ($p < 0.0001$; $rho = 0.899$). Concentrations of cholesterol were well correlated to caffeine ($p < 0.0001$; $rho = 0.890$) at TM-5, and concentrations of cholesterol also were well correlated to fecal coliform ($p = 0.0149$; $rho = 0.809$) and enterococci ($p = 0.0065$; $rho = 0.857$) at TSB.

Fragrances

Acetophenone is used as a fragrance ingredient in soaps, detergents, creams, lotions, and perfumes. It also is used as a flavoring agent in foods, nonalcoholic beverages, and tobacco and as a specialty solvent for plastics and resins. Acetophenone was detected in 4 of 63 samples (6 percent) and was detected at the two tributary sites (CEN and TSB) and at TM-5 (table 15; appendix table 2-2).

AHTN[2] and HHCB[3] belong to a group of substances used in fragrances that are known collectively as polycyclic musks. These substances are important ingredients in fragrances because of their fixative properties and their ability to make a fragrance long lasting. Musk fragrances are used as low-cost fragrances in soaps, perfumes, air fresheners, detergents, fabric softeners, and other household cleaning products. Over the last decade, synthetic musks have attracted the attention of environmental researchers because of their presence in the environment and the fact that they can be secreted in human breast milk. There also is recent evidence concerning bioaccumulation and potential toxicity of these substances in aquatic life (Franke and others, 1999; Zaugg and others, 2002). AHTN was detected at four sites (TM-1, CEN, TSB, TM-5) in 14 of 33 samples (42 percent); HHCB was detected at three sites (CEN, TSB, and TM5) in 9 of 33 samples (27 percent, table 15). Concentrations of AHTN and HHCB were highest at TM-5 (table 15; appendix table 2-2).

Detergent Metabolites

Alkylphenol polyethoxylates (APEO) are nonionic surfactants that are used widely in commercial and household detergents in the United States. During the wastewater-treatment process, these compounds can degrade to more toxic, estrogenic, and lipophilic compounds (La Guardia and others, 2001). These include *para*-nonylphenol (*para*-NP), nonylphenol monoethoxylate (NP1EO), nonylphenol diethoxylate (NP2EO), octylphenol monoethoxylate (OP1EO), and octylphenol diethoxylate (OP2EO). These degradation products are more persistent and toxic than the parent compounds (Wilkison and others, 2002). Alkylphenol ethoxylates have been used for more than 40 years as detergents, emulsifiers, wetting agents, and dispersing agents in many industries, including textile processing, pulp and paper processing, resins and protective coatings, steel manufacturing, and power generation (Canadian Council of Ministers of the Environment, 2001). These compounds also are a component in many paints, herbicides, pesticides, and cosmetics. In the United States, most APEO surfactants are nonylphenol ethoxylates (NPEO; Wilkison and others, 2002).

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[2] 6-acetyl-1,1,2,4,4,7-hexamethyltetraline.

[3] 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(*g*)-2-benzopyran.

NP1EO was detected in 21 of 43 samples (49 percent); NP2EO was detected in 22 of 63 samples (35 percent); and *para*-NP was detected in 27 of 63 samples (43 percent, fig. 20; table 15). The highest concentrations of NP1EO, NP2EO, and *para*-NP were detected at CEN, followed by TM-5 (table 15; appendix table 2-2). These three compounds also were detected most frequently at CEN (100 percent) and TM-5 (67–85 percent); the frequency of detection was lower at the most upstream sites on Threemile Creek (0–33 percent, table 15). OP1EO was detected in 17 of 63 samples (27 percent); OP2EO was detected in 1 of 63 samples (TM-5, fig. 20; table 15). The frequency of detection of OP1EO was slightly higher at the tributary sites (38 percent) than at the sites on Threemile Creek (18–31 percent, table 15).

These detergent metabolites are synthetic compounds that do not occur naturally; thus, concentrations in stream water can be solely attributed to human activities. All of these detergent metabolites are considered to be potential endocrine disruptors. Of the degradation products, nonylphenols (NP) are considered to be more toxic than NP1EO and NP2EO. In general the OPEOs are considered to be more toxic than the NPEOs. Chronic toxicity values for NP are as low as 6 µg/L in fish and 3.9 µg/L in invertebrates (Canadian Council of Ministers of the Environment, 2002). Concentrations of *para*-NP (12 estimated values), NP1EO (14 estimated values), and NP2EO (19 estimated values) exceeded the Canadian aquatic-life guideline of 1 µg/L numerous times (appendix table 2-2). Because of the uncertainty associated with estimated values, however, these concentrations should not be compared directly to the criteria for regulatory purposes. It also is important to consider that these degradation products are found as complex mixtures in effluents and streams. The potential synergistic effects created from low concentrations of multiple endocrine disrupters have yet to be quantified.

Antimicrobials

Triclosan is a broad-spectrum antibacterial/antimicrobial agent that has been in use for more than 30 years. Triclosan use has increased substantially in the last few years as it has been added to deodorants, dish soaps, laundry soaps, detergents, lotions, crèmes, cosmetics, toothpastes, and mouthwashes. The presence of triclosan in the environment is a concern for several reasons: (1) it may promote development of antiseptic-resistant bacteria strains, (2) it has been detected in human breast milk and blood plasma, and (3) it is a potential endocrine disruptor (Kolpin and others, 2002; Wilkison and others, 2002). Triclosan was detected in 36 of 63 samples (57 percent) in the Threemile Creek basin (fig. 20; table 15). Triclosan was detected in all of the samples at the two tributary sites (CEN and TSB) and in 85 percent of the samples at TM-5 (figs. 22, 23; table 15); it was less frequently detected at the other sites on Threemile Creek (18–40 percent, table 15). Concentrations were highest at CEN and TM-5 (appendix table 2-2). Concentrations of triclosan were well correlated to concentrations of NP2EO ($p = 0.0102$; $rho = 0.833$) at CEN; triclosan concentrations also were well correlated to *para*-NP concentrations ($p < 0.0001$; $rho = 0.876$) at TM-5.

Plasticizers/Flame Retardants

Flame retardant compounds are used in a variety of products, including fabrics, carpets, and plastics. Three phosphate-based flame retardants (triphenyl phosphate, tri(2-chloroethyl)phosphate, and tri(2-chlorisopropyl)phosphate) were analyzed by the wastewater indicator compound method. Triphenyl phosphate commonly is used as a flame retardant in certain resins for the manufacture of electrical and automobile components. It also is used as a plasticizer in cellulose acetate for photographic films and is a component of hydraulic fluids and lubricant oils. Tri(2-chloroethyl)phosphate is used in flexible foams in automobiles and furniture and in rigid foams used for building insulation. Tri(2-chloroisopropyl)phosphate is used extensively in rigid and flexible polyurethane foams as well as for textile finishes. One additional phosphate-based compound, 2-butoxyethanol phosphate, which is used as a plasticizer in packaging plastics and rubber gaskets and as a cleaning agent in floor care products, also was included in this OWC group.

All four of these compounds were detected at each of the sites in the Threemile Creek basin (table 15). Triphenyl phosphate was detected in 12 of 63 samples (19 percent, fig. 20; table 15). Occurrence of this compound was fairly evenly distributed between sites in the Threemile Creek basin. Tri(2-chloroethyl)phosphate was detected in 29 of 63 samples (46 percent), and tri(2-chloroisopropyl)phosphate was detected in 17 of 63 samples (27 percent, fig. 20; table 15). Both of these compounds were detected most frequently at TM-5 (table 15). The plasticizer and cleaning agent, 2-butoxyethanol phosphate, was the third most frequently detected OWC in the Threemile Creek basin (fig. 20) and was found in 48 of 63 samples (76 percent, table 15). It was detected in every sample at three sites (CEN, TSB, and TM-5) and was detected less frequently at TM-1 (38 percent), TM-3 (60 percent), and TM-4 (73 percent, figs. 22, 23; table 15).

Insect Repellent

DEET (*N,N*-diethyl-*m*-toluamide) is the active ingredient in most insect repellents that are formulated for personal use against mosquitoes, ticks, and other biting insects (Wilkison and others, 2002). DEET is designed to repel insects rather than kill them. DEET was developed by the U.S. Army in 1946 and was registered for use by the general public in 1957. Although DEET can be applied directly to human skin, it also can be applied to clothing but is removed during laundering or bathing. DEET can then be transported to WWTPs, where it can survive the treatment process and be discharged directly into receiving streams (Wilkison and others, 2002). DEET was the ninth most frequently detected wastewater compound in the Threemile

Creek basin (fig. 20) and was detected in 32 of 63 samples (51 percent, table 15). DEET was most frequently detected at CEN, TM-3, and TM-5 (88, 70, and 62 percent, respectively) and was least frequently detected at TM-1 (23 percent, figs. 22, 23; table 15). The highest concentration (1.89 µg/L) was detected at CEN in July 2000 (table 15; appendix table 2-2).

Insecticides

Three of seven insecticides were detected at sites in the Threemile Creek basin. Diazinon was detected in 43 of 63 samples (68 percent); carbaryl was detected in 6 of 63 samples (10 percent); and chlorpyrifos was detected in 1 of 63 samples (2 percent, table 15; fig. 20). Chlordane, dieldrin, lindane, and methyl parathion were not detected in any sample. Diazinon and carbaryl are used in urban areas to control insects on lawns and gardens. The maximum concentration of diazinon (0.307 µg/L) was found at TM-3 (table 15; appendix table 2-2). The Great Lakes Water Quality Agreement of 1977 established an aquatic life criterion of 0.08 µg/L for diazinon (International Joint Commission United States and Canada, 1978). This criterion was exceeded 18 times (including six estimated values); exceedances occurred at each of the surface-water sampling sites (appendix table 2-2). The maximum concentration of carbaryl (0.062 µg/L) was found at TM-3 and did not exceed the Canadian Water Quality Guideline of 0.2 µg/L (Canadian Council of Ministers of the Environment, 2002).

Chlorpyrifos is an organophosphate insecticide used in gardens, in residential areas, and on a wide variety of crops to control insects, including the pine beetle. Chlorpyrifos also is used for termite control in residential and industrial settings and in pet shampoo. Chlorpyrifos was detected one time (0.036 µg/L) at TSB and did not exceed the USEPA recommended water-quality criteria for criterion maximum concentration (0.083 µg/L) or criterion minimum concentration (0.041 µg/L) for nonpriority pollutants (appendix table 2-2; U.S. Environmental Protection Agency, 2002c). The Canadian aquatic-life guideline of 0.0035 µg/L for the protection of aquatic life was exceeded (Canadian Council of Ministers of the Environment, 2002).

Herbicides and Fungicides

Four herbicides (atrazine, bromacil, metolachlor, and prometon) were detected at sites in the Threemile Creek basin; the fungicide, metalaxyl, was not detected at any site. Atrazine is the most heavily applied herbicide in the United States (Majewski and Capel, 1995). It is used to control broadleaf and grassy weeds in corn and several other crops, and also is used as a nonselective herbicide on noncropped industrial lands and on fallow lands. Atrazine was detected in 16 of 16 samples (100 percent, table 15; fig. 20). The maximum concentration of atrazine (0.64 µg/L) did not exceed the USEPA and the ADEM drinking-water standard (3 µg/L) or the Canadian aquatic-life guideline (1.8 µg/L, Alabama Department of Environmental Management, 2000b; U.S. Environmental Protection Agency, 2002a; Canadian Council of Ministers of the Environment, 2002). Bromacil is a herbicide used for brush control along roads and on noncropland areas. It is especially useful against perennial grasses. Bromacil was detected in 22 of 33 samples (67 percent) at each of the sites in the basin (table 15; fig. 20). The maximum concentration (E 0.34 µg/L) did not exceed the Canadian aquatic-life guideline of 5.0 µg/L (Canadian Council of Ministers of the Environment, 2002).

Metolachlor generally is applied as a preemergent herbicide for a variety of crops (field corn, soybeans, peanuts, sorghum, and cotton). Metolachlor is used to control broadleaf and annual grassy weeds and also is applied along highways and other rights-of-way and on woody ornamentals. Metolachlor was detected at TM-5 in 3 of 33 samples (9 percent, table 15; fig. 20). Concentrations did not exceed the Canadian aquatic-life guideline of 7.8 µg/L (Canadian Council of Ministers of the Environment, 2002). Prometon is a nonselective herbicide that is used to control most annual and many perennial broadleaf weeds and grasses. It is faster acting than simazine, but does not have as long a residual effect as either simazine or atrazine. Prometon was detected in 9 of 33 samples (27 percent, table 15; fig. 20). No standards or criteria are available for comparison.

The number of pesticides present in a stream may be important from a toxicological standpoint. Generally, the effects of pesticide mixtures on biota or humans are not included in water-quality criteria, which are most commonly based on single-species, single-chemical toxicity tests conducted under laboratory conditions (Hampson and others, 2000). Some pesticides may become more toxic when combined with other toxic compounds. The synergistic effects created from the low concentrations of multiple pesticides have yet to be quantified (Hoffman and others, 2000), and the combined ecological effects of pesticides in streams are unknown.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are formed during combustion processes and may enter surface-water systems through atmospheric deposition, surface runoff, and soil leaching (Smith and others, 1988). Sources of PAHs include domestic sewage, asphalt surfaces, car tires, vehicular exhaust, crude oil, and petroleum (Dojlido and Best, 1993). An important source of PAHs is runoff from roads—PAH compounds come from the asphalt surfaces of the roads, car tires, and from the gases emitted by cars (Dojlido and Best, 1993). Several PAHs have been identified as carcinogens or mutagens (Dojlido and Best, 1993). Seven of nine PAHs were detected in water samples from the Threemile Creek basin (anthracene, benzo[*a*]pyrene, fluoranthene, naphthalene, 2,6-dimethyl-naphthalene, phenanthrene, and pyrene); 1-methyl-napthalene and 2-methyl-napthalene were not detected in any water sample (table 15; appendix table 2-2).

PAHs were detected at all sites but were most frequently detected at TM-3, which likely is due to the large number of samples collected at this site during periods of storm runoff (figs. 22, 23; appendix table 2-2). Seventy-six percent of the detections were estimated values; these values should not be compared to criteria for regulatory purposes because of uncertainty associated with the estimated value. Fluoranthene and pyrene were the most frequently detected PAHs (table 15; fig. 20). The maximum concentration of fluoranthene was 0.287 µg/L (TSB)—22 water samples (including 12 estimated values) exceeded the Canadian guideline of 0.04 µg/L for the protection of aquatic life (Canadian Council of Ministers of the Environment, 2002). The maximum concentration of pyrene was 0.217 µg/L (TSB)—23 water samples (including 14 estimated values) exceeded the Canadian guideline of 0.025 µg/L for the protection of aquatic life (Canadian Council of Ministers of the Environment, 2002). The maximum concentration of benzo[*a*]pyrene was 0.15 µg/L at TM-5—nine water samples (including six estimated values) exceeded the Canadian guideline of 0.015 µg/L for the protection of aquatic life (Canadian Council of Ministers of the Environment, 2002).

Comparison of Organic Wastewater Compounds in the Threemile Creek Basin to Sites Nationwide

Organic wastewater data from the Threemile Creek basin were compared to data collected in the first nationwide reconnaissance of the occurrence of pharmaceuticals, hormones, and other OWCs in water resources (fig. 27; table 16). The USGS used five newly developed analytical methods to measure concentrations of 95 OWCs in water samples from 139 streams across 30 states during 1999 and 2000 (Kolpin and others, 2002). The selection of sites in the nationwide reconnaissance was biased toward streams susceptible to contamination (downstream from intense urbanization and livestock production). OWCs were found in 80 percent of the streams sampled and represented a wide range of residential, industrial, and agricultural origins and uses. Eighty-two of the 95 OWCs were found during the national study (Kolpin and others, 2002). Thirty-five of the OWCs sampled in the nationwide reconnaissance were included in the group of 48 OWCs discussed in the Threemile Creek study (fig. 27; table 16).

Sixty-three samples were collected during 2000–2003 in the Threemile Creek study; 85 samples were collected during

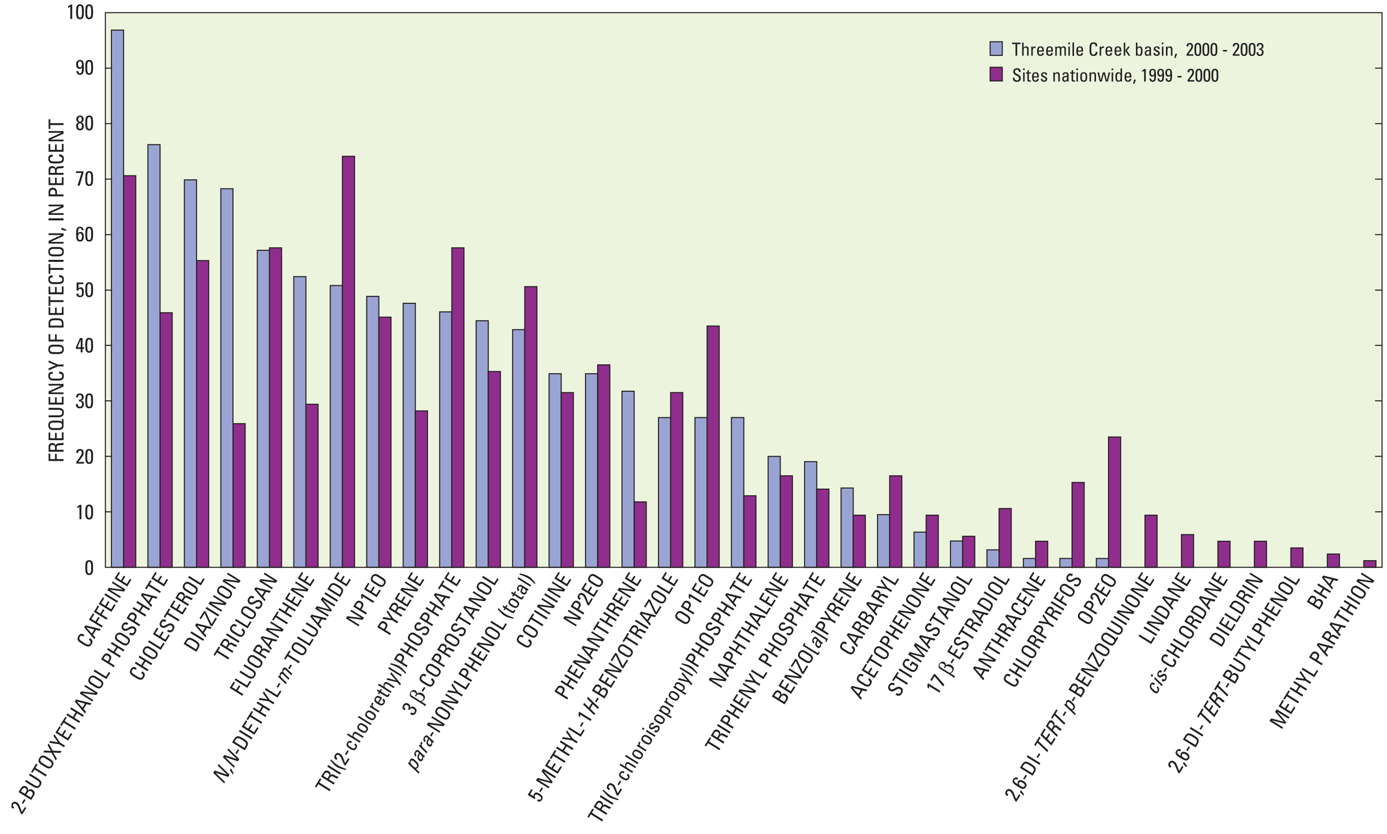

Figure 27. Frequencies of detection of selected organic wastewater compounds in water samples from the Threemile Creek basin, Mobile, Alabama, and sites nationwide.

Table 16. Detection frequencies and concentrations of selected organic wastewater compounds in water samples from the Threemile Creek basin, Mobile, Alabama (2000–2003) and sites nationwide (1999–2000).

[μg/L, micrograms per liter; MCL, maximum contaminant level; HAL, lifetime health advisory; ND, not detected; —, data not available; E, estimated; BHA, butylated hydroxyanisole; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol. Compounds that are potential endocrine disruptors are in **bold**]

	Detection frequency (percent)		Maximum (μg/L)		Median of detected values (μg/L)		MCL[a] (μg/L)	HAL[a] (μg/L)
	Threemile Creek basin	Sites nationwide	Threemile Creek basin	Sites nationwide	Threemile Creek basin	Sites nationwide		
2-butoxyethanol phosphate	76.2	45.9	12.0	6.7	0.51	0.51	—	—
2,6-di-*tert*-*p*-benzoquinone	0	9.4	ND	0.46	ND	0.13	—	—
2,6-di-*tert*-butylphenol	0	3.5	ND	0.11[b]	ND	0.06[b]	—	—
3β-coprostanol	44.4	35.3	5.86	9.8[b]	1.33	0.7[b]	—	—
5-methyl-1*H*-benzotriazole	27	31.5	21.4	2.4	0.19	0.39	—	—
17β-estradiol	3.2	10.6	E 0.636	0.2[b]	0.48	0.16[b]	—	—
Acetophenone	6.3	9.4	0.236	0.41	0.124	0.15	—	—
Anthracene	1.6	4.7	E 0.16	0.11	0.16	0.07	—	—
Benzo[*a*]pyrene	14.3	9.4	E 0.15	0.24	0.056	0.04	0.2	—
BHA	0	2.4	ND	0.2[b]	ND	0.1[b]	—	—
Caffeine	96.8	70.6	9.8	5.7	0.143	0.1	—	—
Carbaryl	9.5	16.5	E 0.062	0.1[b]	0.046	0.04[b]	—	700
***cis*-chlordane**	0	4.7	ND	0.1	ND	0.02	2	—
Chlorpyrifos	1.6	15.3	0.036	0.31	0.036	0.06	—	20
Cholesterol	69.8	55.3	E 7	10[b]	1.26	1[b]	—	—
Cotinine	34.9	31.5	E 0.469	0.57	0.10	0.05	—	—
Diazinon	68.3	25.9	0.307	0.35	0.066	0.07	—	0.6
Dieldrin	0	4.7	ND	0.21	ND	0.18	—	—

Table 16. Detection frequencies and concentrations of selected organic wastewater compounds in water samples from the Threemile Creek basin, Mobile, Alabama (2000–2003) and sites nationwide (1999–2000).—Continued

[µg/L, micrograms per liter; MCL, maximum contaminant level; HAL, lifetime health advisory; ND, not detected; —, data not available; E, estimated; BHA, butylated hydroxyanisole; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol. Compounds that are potential endocrine disruptors are in **bold**]

	Detection frequency (percent)		Maximum (µg/L)		Median of detected values (µg/L)		MCL[a] (µg/L)	HAL[a] (µg/L)
	Threemile Creek basin	Sites nationwide	Threemile Creek basin	Sites nationwide	Threemile Creek basin	Sites nationwide		
Fluoranthene	52.4	29.4	0.287	1.2	0.055	0.04	—	—
Lindane	0	5.9	ND	0.11	ND	0.02	0.2	0.2
Methyl parathion	0	1.2	ND	0.01	ND	0.01	—	2
Naphthalene	20	16.5	E 0.12	0.08	0.03	0.02	—	100
N,N-diethyl-*m*-toluamide	50.8	74.1	1.89	1.1	0.061	0.06	—	—
***para*-nonylphenol (total)**	42.9	50.6	E 3.33	40[c]	0.92	0.8[c]	—	—
NP1EO	48.8	45.9	E 4.91	20[c]	1.15	1[c]	—	—
NP2EO	34.9	36.5	E 5.97	9[c]	2.47	1[c]	—	—
OP1EO	27	43.5	E 0.76	2[c]	0.11	0.2[c]	—	—
OP2EO	1.6	23.5	E 0.13	1[c]	0.13	0.1[c]	—	—
Phenanthrene	31.7	11.8	E 0.15	0.53	0.033	0.04	—	—
Pyrene	47.6	28.2	0.217	0.84	0.041	0.05	—	—
Stigmastanol	4.8	5.6	E 1.1	4[b]	0.80	2[b]	—	—
Triclosan	57.1	57.6	0.894	2.3	0.098	0.14	—	—
Tri(2-chloroethyl)phosphate	46	57.6	0.31	0.54	0.06	0.1	—	—
Tri(2-chloroisopropyl)phosphate	27	12.9	0.214	0.16	0.077	0.1	—	—
Triphenyl phosphate	19	14.1	E 0.085	0.22	0.054	0.04	—	—

[a] U.S. Environmental Protection Agency, 2002a.

[b] Concentration estimated; average recovery less than 60 percent.

[c] Concentration estimated; reference standard prepared from a technical mixture.

1999–2000 in the nationwide reconnaissance study. Samples for both studies were processed by the NWQL using the same methods; however, the specific compounds analyzed and the MRLs varied among samples because of method refinement during the 5 years (1999–2003) of sampling and because of matrix interference (Kolpin and others, 2002). Wastewater indicators were detected in each of the 63 samples collected in the Threemile Creek basin. Of the 35 constituents that were common to both studies, 28 were detected in the Threemile Creek basin and 35 were detected at sites nationwide (fig. 27; table 16). The diversity of site selection in the nationwide reconnaissance study likely contributed to the greater diversity of the detected compounds.

The most frequently detected compounds in the Threemile Creek basin include caffeine, 2-butoxyethanol phosphate, cholesterol, diazinon, and triclosan; the most frequently detected compounds (using the same analytical method) in the national study include DEET, caffeine, triclosan, tri(2-chloroethyl)phosphate, and cholesterol. Of the 28 compounds detected in the Threemile Creek basin, 14 were detected more frequently in the Threemile Creek basin than at sites nationwide—many at frequencies much greater than those seen nationwide. Some of the constituents were detected at similar frequencies, such as triclosan, detected in 57.1 percent of the Threemile Creek basin samples and in 57.6 percent of the sites nationwide. Other constituents were found in much greater frequencies in the Threemile Creek basin (caffeine, 2-butoxyethanol phosphate, diazinon, fluoranthene, phenanthrene, and pyrene); four constituents (chlorpyrifos, DEET, OP1EO, and OP2EO) were detected much less frequently in the Threemile Creek basin than nationwide (fig. 27; table 16).

Concentrations of eight OWCs (caffeine, 5-methyl-1*H*-benzotriazole, anthracene, 2-butoxyethanol phosphate, naphthalene, DEET, tri(2-chlorisopropyl) phosphate, and 17β-estradiol) detected in the Threemile Creek basin exceeded maximum concentrations detected in the nationwide reconnaissance (table 16; Kolpin and others, 2002). Median concentrations of 15 OWCs detected in the Threemile Creek basin exceeded median concentrations detected in the nationwide reconnaissance (table 16; Kolpin and others, 2002).

Benthic Invertebrates Results and Discussion

Analysis of samples at selected sites in Threemile Creek identified 77 benthic invertebrate taxa. After ambiguous taxa were resolved by distributing ambiguous parent taxa among their children, the final data set used for analysis contained 56 distinct taxa, which represented 6 phyla, 6 classes, and 11 orders of invertebrates (appendix table 3-1). Taxa richness was highest at site TM-2 (38 taxa) and decreased downstream at sites TM-3 (30 taxa) and TM-4 (19 taxa) and in the replicate sample from TM-4 (21 taxa, fig. 28). Lowest total taxa richness occurred at the most upstream site, TM-1 (17 taxa). Site TM-2 also had the highest EPT taxa richness with seven taxa present.

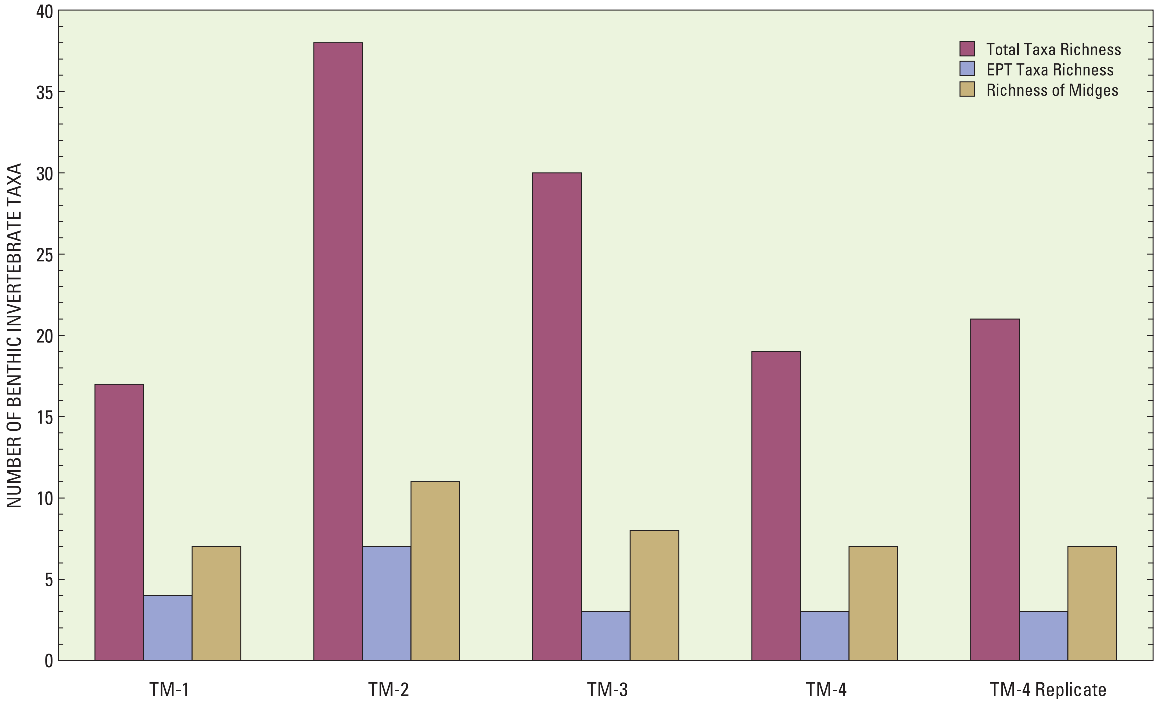

Figure 28. Benthic invertebrate taxa richness at selected sites on Threemile Creek, Mobile, Alabama, July 2000.

Four EPT taxa were present at site TM-1, and three at each of the downstream sites TM-3 and TM-4. The TM-4 replicate sample also contained three EPT taxa, but two of the three taxa found in the TM-4 replicate were not present in the regular sample from TM-4. At all sites, chironomid (midges) taxa richness was greater than EPT taxa richness. Eleven chironomid taxa were present at site TM-2, eight were present at site TM-3, and seven at all other sites.

Percentage contributions of the most dominant taxa were used to screen for impaired sites. An impaired community commonly is dominated by a few tolerant species. The five most abundant taxa for samples collected in the Threemile Creek basin and the relative percentage abundance of each are listed in table 17. At all sites except TM-2, the two most abundant taxa accounted for more than 60 percent of the total abundance in the samples, and when the five most abundant

Table 17. Five most abundant benthic invertebrate taxa and the respective percentages of total abundance for each taxa at selected sites in Threemile Creek, Mobile, Alabama, July 2000.

Common name group	Most common taxa	Relative abundance, in percent
	TM-1	
Caddisflies	Hydropsyche rossi Flint, Voshell, and Parker/simulans Ross	48.0
Worms	Prostoma sp.	18.4
Midges	Cricotopus/Orthocladius sp.	12.0
Midges	Thienemanniella sp.	7.91
Midges	Parachironomus sp.	2.69
Total percent abundance		89.1
	TM-2	
Mayflies	Caenis sp.	28.1
Mayflies	Paracloeodes minutus (Daggy)	10.0
Mites	Acari	6.46
Snails	Hydrobiidae	5.15
Clams	Corbicula sp.	5.06
Total percent abundance		54.8
	TM-3	
Worms	Turbellaria	61.8
Dragonflies	Gomphidae	17.6
Midges	Larsia sp.	4.38
Snails	Planorbella sp.	2.70
Snails	Prosobranchia	1.99
Total percent abundance		88.4
	TM-4	
Clams	Corbicula sp.	45.6
Water Striders	Trepobates sp.	40.2
Midges	Cryptochironomus sp.	3.12
Snails	Prosobranchia	2.83
Dragonflies	Erythemis simplicicollis (Say)	1.57
Total percent abundance		93.4
	TM-4 replicate	
Dragonflies	Gomphidae	45.0
Mayflies	Caenis sp.	34.6
Mosquitoes	Culex sp.	6.17
Midges	Ablabesmyia sp.	1.69
Clams	Corbicula sp.	1.61
Worms	Naididae	1.61
Total percent abundance		90.6

taxa were considered at TM-1, TM-3, and TM-4, about 90 percent of the total abundance was included. In contrast, TM-2 had a more even benthic invertebrate community with the five most abundant taxa accounting for only about 55 percent of the total abundance. According to ADEM, the most abundant taxon usually accounts for 30 percent or less of total abundance in healthy streams (Alabama Department of Environmental Management, 1996). Site TM-2 is the only site that met this criterion.

Relative abundance of the major groups of taxa in a sample can reveal differences in sites. The percentage of total abundance contained in each of 15 major taxa groups is illustrated in figure 29. The major taxa groups were (1) mosquitoes, (2) butterflies, (3) water beetles, (4) water striders, (5) giant water bugs, (6) dragonflies, (7) springtails, (8) mites, (9) midges, (10) biting midges, (11) caddisflies, (12) mayflies, (13) clams, (14) snails, and (15) worms. Sites varied greatly in group composition (figure 29; appendix table 3-1). Only 6 of the 15 major taxa groups were identified at site TM-1. Almost 50 percent of the sample at TM-1 was composed of hydro-psychid caddisflies, which filter particulate matter out of the water column for food. The worms and midges, two generally tolerant groups, accounted for another 48 percent of the total abundance (fig. 29; appendix table 3-1). Site TM-2 had the greatest number of groups present (fig. 29). A generally pollution-intolerant group, the mayflies group (39.1 percent) was the most common (fig. 29; appendix table 3-1). Eleven of the groups were represented at site TM-3, but more than 60 percent of the sample was composed of the class Turbellaria, a group of flatworms containing many detritivores. Turbellarians commonly are found in areas with large amounts of decaying organic material. The two samples at TM-4 were very different in taxa composition, and two different groups dominated each sample. In the regular sample, the water striders composed about 40 percent, and the clams composed about 46 percent (fig. 29; appendix table 3-1). In contrast, the dragonflies (46 percent) and mayflies (36 percent) were the most dominant taxa in the replicate sample (fig. 29; appendix table 3-1).

Average tolerance values for the communities were calculated on the basis of taxa richness. Tolerance values for taxa range from zero to 10, with zero indicating least tolerant and 10 indicating most tolerant to contamination. Regional tolerance values from USEPA's Rapid Bioassessment Protocol (RBP; Appendix B; Barbour and others, 1999) were averaged to create national tolerance values. The national tolerance values were then used to calculate community tolerance values (fig. 30). The percentage of taxa with assigned tolerance values ranged from 89.5 to 94.1 percent of total taxa collected in each sample, indicating that the community is well represented in the average tolerance value. Average tolerance values at all sites were similar and ranged from 5.8 at site TM-1 to 6.5 at site TM-2 (fig. 30).

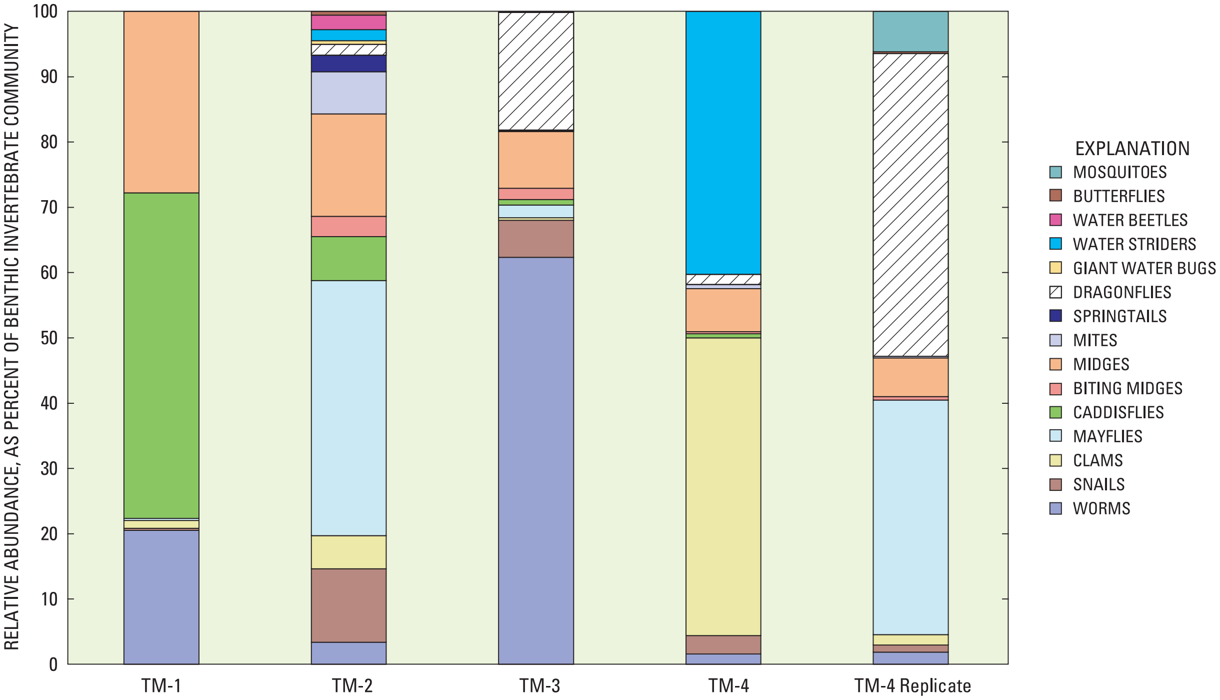

Figure 29. Relative abundance of major benthic invertebrate taxa at selected sites on Threemile Creek, Mobile, Alabama, July 2000.

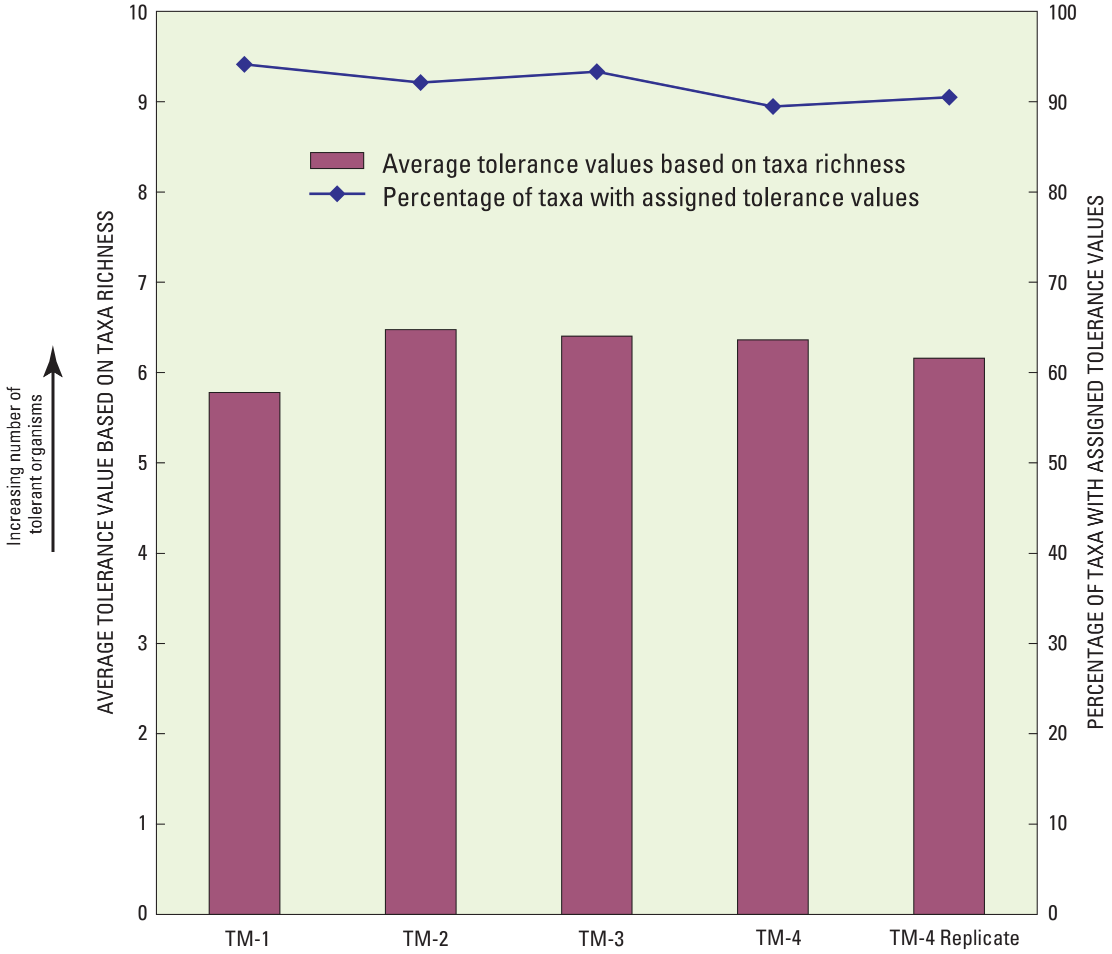

Figure 30. Average U.S. Environmental Protection Agency national tolerance values for benthic invertebrate communities at selected sites on Threemile Creek, Mobile, Alabama, July 2000.

Regional tolerance values listed in the RBP for the southeastern United States were developed by the North Carolina Department of Environmental Management for use in calculating a biotic index, or average tolerance value normalized for abundance. Table 18 summarizes relations between North Carolina biotic index values and stream-water quality (Alabama Department of Environmental Management, 1996). If equal North Carolina biotic index and average national tolerance values based on taxa richness are assumed to represent similar water-quality conditions, then average national tolerance scores indicate very good water quality at TM-1 and good to fair water quality at all other sites.

The Shannon-Weaver Diversity Index (also known as Shannon's Diversity Index) produces a score indicating the diversity of a biologic community. Scores between 3 and 4 indicate healthy streams, and scores below 1 indicate impairment (Alabama Department of Environmental Management, 1996). Site TM-2 had a score of 4.1, indicating high diversity (fig. 31). All other sites had scores of 1.9 to 2.5, indicating water quality between impaired and unimpaired.

Table 18. North Carolina biotic index values and associated water-quality conditions.

[Alabama Department of Environmental Management, 1996]

Coastal Plain biotic index values	Water-quality conditions
0.00–5.46	Excellent
5.47–6.05	Very good
6.06–6.72	Good–Fair
6.73–7.73	Fair
7.74–10.00	Poor

Based on total and EPT taxa richness, percentage of dominant taxa, relative contribution of major taxonomic groups, and the Shannon-Weaver Diversity Index, site TM-2 appeared to support a more diverse benthic invertebrate community and was the least impaired sampling site on Threemile Creek. Site TM-1 appeared to be the least diverse, with a community composed predominantly of just a few major

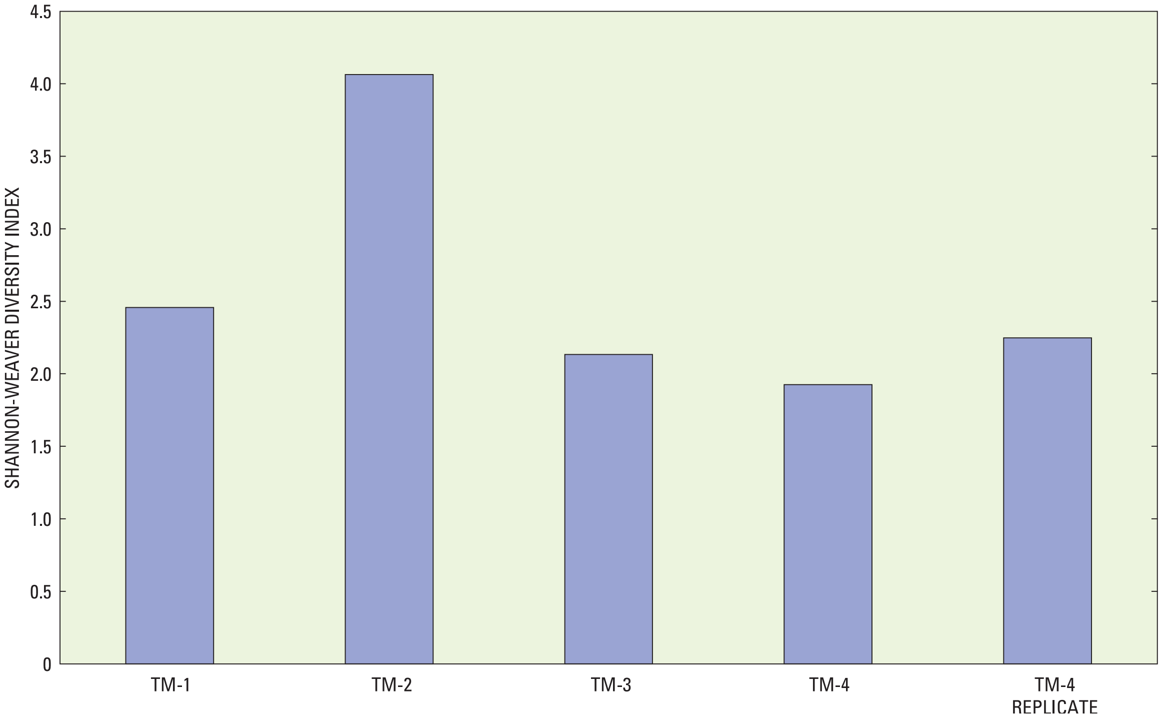

Figure 31. Shannon-Weaver diversity index values for benthic invertebrate communities at selected sites on Threemile Creek, Mobile, Alabama, July 2000.

taxa groups. Average tolerance values, however, indicated that site TM-1 supported a slightly less tolerant benthic invertebrate community than the other sites. All sampling sites, except TM-2, appear to be affected by contamination or habitat alteration based on percentage of abundance contained in the two most dominant taxa.

Habitat and riparian zone differences may account for some of the variance in invertebrate communities among sites. TM-1 appears to be greatly affected by the upstream impoundment, with an invertebrate assemblage dominated by the species *Hydropsyche rossi*, a group of filtering collector caddisflies that are relatively intolerant (USEPA tolerance score = 4.9) to pollution. The dominance of this group may lower the overall tolerance value for TM-1. The riparian area at TM-2, though previously modified for flood control, was largely vegetated with uncut grasses at the time of sampling and may have limited the flow of excess nutrients and other contaminants to the stream. Water-chemistry samples were not collected at site TM-2, so this hypothesis cannot be tested. Site TM-3 is adjacent to commercial and residential properties, and the width of the riparian zone was much less than at site TM-2. The influence of tides on stage and flow at site TM-4 would be expected to restrict the invertebrate community to only those organisms able to cope with large changes in flow.

Periphyton Results and Discussion

Periphyton biomass was estimated by using benthic chlorophyll *a* concentrations and AFDM (table 19). The greatest chlorophyll *a* concentrations during September 2000 were measured at sites TM-3 and TSB, with concentrations of 8.1 and 6.2 μg/cm^2, respectively (fig. 32). The smallest benthic chlorophyll *a* concentration measured in September 2000 was at TM-4 in a sand substrate sample. Benthic chlorophyll *a* levels in samples from sand and tile substrates at site TM-3 differed considerably, with a much smaller number of periphyton found on the sand substrate. During this period, benthic chlorophyll *a* concentrations at all sites were below the suggested nuisance algal growth level of 10 μg/cm^2 (Barbour and others, 1999). Benthic chlorophyll *a* concentrations from subsequent sampling periods were highly variable, with two exceedances—TM-3 during August 2001 and TM-2 during July 2002—of the nuisance algal growth threshold (fig. 33). Greater concentrations generally occurred in late summer and fall than in the May samples. Except for one sample collected in July 2001, benthic chlorophyll *a* tended to be greater at TM-3 than at TM-1 (fig. 33). No other consistent trends were evident among sites.

Ash-free dry mass levels did not exceed the nuisance level of 50 g/m^2 (Biggs, 1996; Barbour and others, 1999) at any of the

Table 19. Periphyton chlorophyll *a* and ash-free dry mass concentrations at selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

[μg/cm^2, microgram per square centimeter; AFDM, ash-free dry mass; g/m^2, gram per square meter; μg/cm^2/d, microgram per square centimeter per day; E, estimated concentration; —, no data]

Site label (fig. 1)	Date	Days of exposure for tile substrate	Chlorophyll *a* (μg/cm^2) [70957][a]	AFDM (g/m^2) [49954][a]	Autotrophic index (ratio of AFDM to chlorophyll *a*)	Chlorophyll *a* per day (μg/cm^2/d)
TM-1	9/12/2000	55	2.2	9	410	0.04
TM-1	9/12/2000	55	2.6	16	620	.047
TM-1	11/14/2000	35	E6.4	6.8	110	.18
TM-1	5/22/2001	28	2.1	9.9	470	.075
TM-1	7/2/2001	26	.75	5.2	690	.029
TM-1	7/16/2001	26	3.1	9.8	320	.12
TM-1	8/8/2001	28	1.4	5.8	410	.05
TM-1	5/9/2002	22	.34	30	8,800	.015
TM-1	7/17/2002	28	.97	5.2	540	.035
TM-1	9/19/2002	28	2.6	10	380	.093
TM-1	7/15/2003	43	1.0	4.7	470	.023
TM-1	8/28/2003	44	1.3	8.5	650	.03
TM-2	5/22/2001	14	0.57	2.1	370	0.041
TM-2	7/2/2001	26	.96	4.3	450	.037
TM-2	7/16/2001	26	E5.4	17	320	.21
TM-2	8/8/2001	28	2.0	5.2	260	.071
TM-2	5/9/2002	22	2.2	14	640	.1
TM-2	7/17/2002	28	12	36	300	.43
TM-2	9/19/2002	30	3.6	12	330	.12
TM-2	8/28/2003	44	.41	48	12,000	.0093
TM-3	9/13/2000	56	3.4	19	560	0.061
TM-3	9/13/2000	56	8.1	38	470	.14
TM-3	11/14/2000	35	E7.7	19	250	.22
TM-3	5/22/2001	13	2.8	28	1,000	.22
TM-3	7/2/2001	26	2.4	19	790	.092
TM-3	7/16/2001	26	1.9	8.2	430	.073
TM-3	8/7/2001	27	12	33	280	.44
TM-3	8/7/2001	27	7.9	31	390	.29
TM-3	5/9/2002	22	.89	16	1,800	.04
TM-3	7/17/2002	28	5.6	28	500	.2
TM-3	9/19/2002	30	6.9	28	410	.23
TM-3	7/15/2003	43	5.3	24	450	.12
TM-3	8/28/2003	44	5.7	28	490	.13
TM-4	9/13/2000	Existing substrate	1.4	4.6	330	—
TM-4	11/14/2000	Existing substrate	E1.1	7	640	—
CEN	9/14/2000	Existing substrate	3.2	8.3	260	—
TSB	9/13/2000	Existing substrate	6.2	17	270	—

[a] U.S. Geological Survey National Water Information System parameter code.

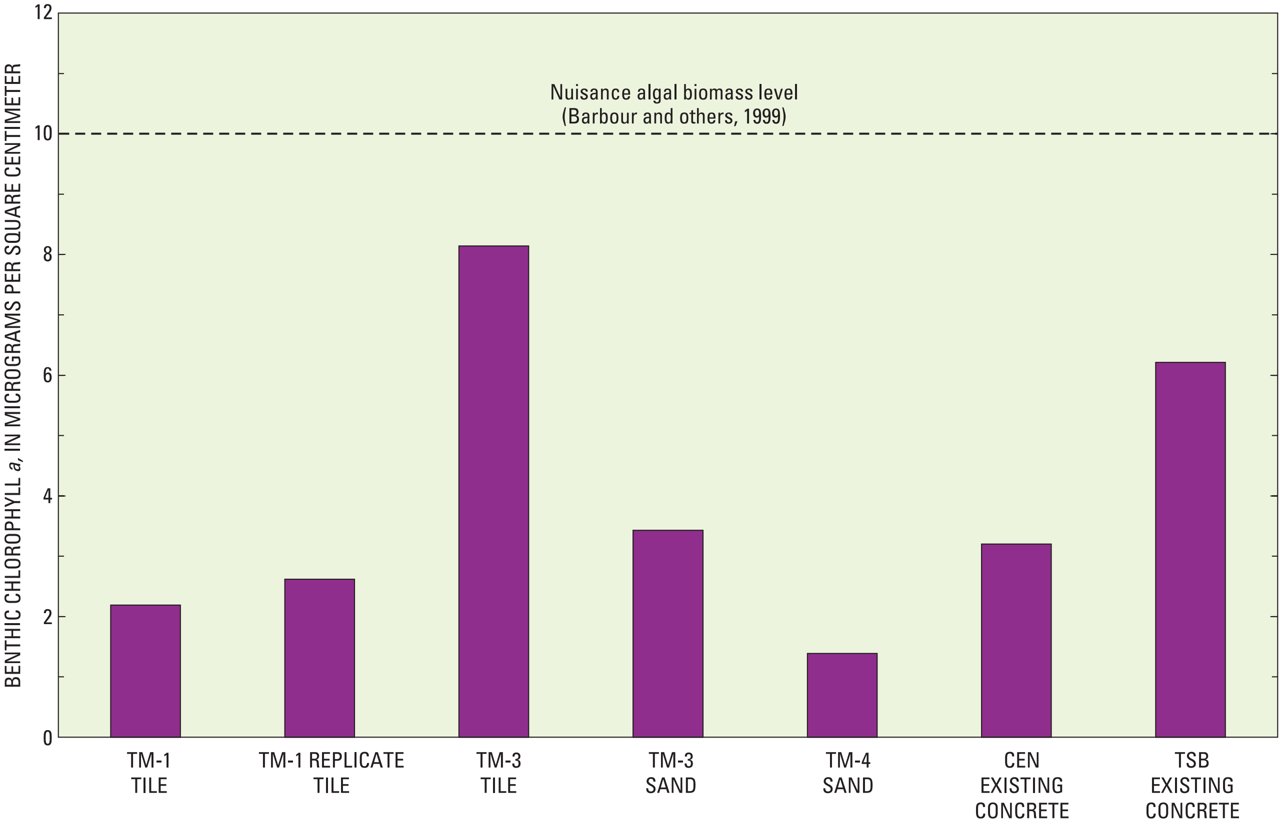

Figure 32. Benthic chlorophyll *a* concentrations at selected sites in the Threemile Creek basin, Mobile, Alabama, September 2000.

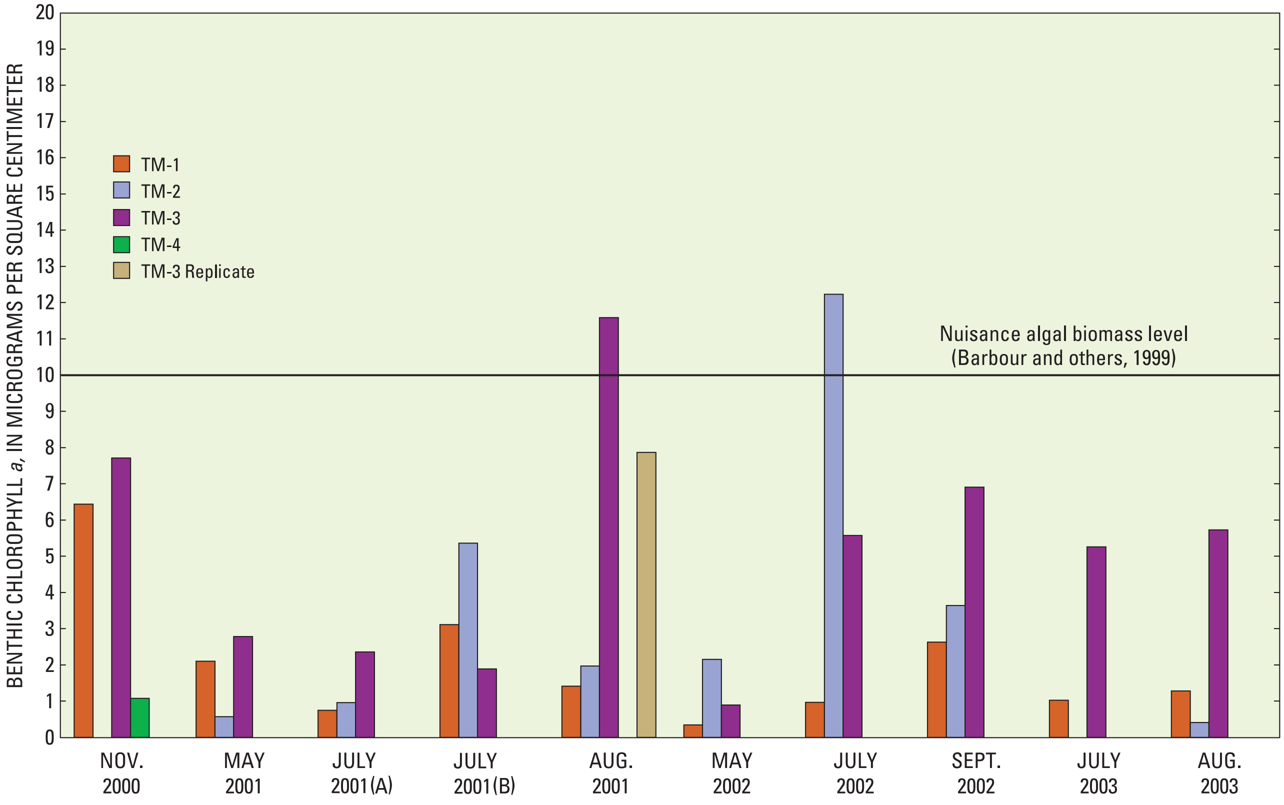

Figure 33. Benthic chlorophyll *a* concentrations at selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

sites in Threemile Creek (figs. 34, 35). During September 2000, the tile sample at TM-3 had the greatest amount of AFDM (38.1 g/m^2), more than twice the amount at any of the other sites, including the TM-3 sand substrate sample. The sand sample at TM-4 contained the least AFDM. During the other sampling periods, site TM-3 often contained the greatest AFDM among the sites (table 19), indicating more accumulation of organic matter. Site TM-2 had the greatest AFDM in July 2001 (17 g/m^2), July 2002 (36 g/m^2), and in August 2003 (48 g/m^2), when AFDM approached the nuisance level of 50 g/m^2. Levels of AFDM at site TM-1 were relatively low for all samples, except May 2002 (30 g/m^2). Greater velocities at site TM-1 may inhibit the accumulation of algal cells and, therefore, reduce the amount of AFDM.

Autotrophic index values at all sites in the Threemile Creek basin were greater than 100, indicating possible organic enrichment; the index values ranged from 110 at TM-1 to 12,000 at TM-2 (table 19). Median index values ranged from 260 at CEN to 485 at TM-4. These results do not agree well with the water-chemistry measurements, which indicated greater concentrations of BOD at CEN than at the other sites in the basin. Some of the difference may be because BOD measurements were made from material suspended in the water column, whereas AFDM was calculated from material on the stream substrates. Additionally, lower autotrophic indices at the tributaries may be caused by adequate colonization periods for the development of mature periphyton communities, and the shorter exposure times for the artificial substrates at sites TM-1, TM-2, and TM-3 may have limited the development of algal biomass.

Periphyton taxa richness was analyzed in samples from four sites on Threemile Creek and the two tributary sites. Maximum, median, and minimum periphyton taxa richness are presented in figure 36. Replicate samples were similar to each other, indicating good reproducibility of results. In September 2000, median taxa richness was greatest at site TM-3 (44). Slightly fewer taxa were found in the sand sample than in the clay tile substrate sample at site TM-3. Taxa richness in samples from the sand substrate at site TM-4 was less than that in sand from TM-3, perhaps because of differences in flow. Samples from the existing concrete stream substrates at tributary sites CEN and TSB had fewer algal taxa than samples from artificial substrates at the main-stem sites, probably because of differences in colonization and substrate type. Samples from August 2001, showed an increase in taxa richness on clay tile substrates from TM-1 to TM-3. In September 2002, no upstream to downstream pattern was noted, and median taxa richness ranged from 26 at site TM-3 to 43 at site TM-2.

Differences in algal growth and representation of dominant algal groups among sites can be evaluated using estimates of algal biomass. Total algal biomass can be estimated by using algal cell density, the number of algal cells per unit area, or algal biovolume, which is the total volume of algal cells. Cell density usually is a good indicator of algal biomass if algal cell sizes are similar among taxa. Algal biovolume is a better indicator of algal biomass when there is large variation in cell sizes among taxa (Stevenson, 1996). Relative biomass in each of the major algal groups can be used to evaluate community structure.

The percentage of total cell density and total biovolume accounted for by the nitrogen-fixing algae and each of the major algal divisions are presented in tables 20 and 21, respectively. Mean total algal density ranged from about 165,000 cells per square centimeter (cells/cm^2) at site TM-1 in September 2002 to more than 4.7 million cells/cm^2 at site TM-3 in September 2000 (table 20; appendix table 3-2). Mean algal biovolume ranged from more than 2.3 billion cubic micrometers per square centimeter ($\mu m^3/cm^2$) at site TM-3 in September 2000 to about 56 million $\mu m^3/cm^2$ at site TM-4 in September 2000 (table 21; appendix table 3-2). Different laboratory protocols were used for the 2002 samples, so percentages of relative abundance of the major groups were compared among 2000 and 2001 samples, and then among 2002 samples.

Samples collected during September 2000 indicate community composition differences among sites. In terms of cell density, blue-green algae dominated at TM-1, TM-3, and CEN (table 20). Diatoms and blue-green algae codominated in the community at TSB. Abundant growth of blue-green algae is a common response to phosphorus enrichment in lakes and also has been noted in streams (Walker, 1983; Borchardt, 1996). Periphyton from TM-4 was collected from sand substrate, and green algae were the dominant group. The formation of filamentous green algal colonies commonly occurs when excess phosphorus and nitrogen are present in streams (Borchardt, 1996; Cuffney and others, 1997). In contrast to the sample from TM-4, blue-green algae were more numerous in a sand sample collected at site TM-3. Site TM-4 is affected by tidal backwater and has somewhat higher conductivities than the other sites, which may account for the difference in community composition.

Percentage contributions by biovolume differed from percentages by cell density in September 2000 (table 21). Green algae contributed most of the biovolume in the tile sample from TM-3 and the sand sample from TM-4. These sites are likely to be affected by nutrient enrichment. The TM-3 sand sample biovolume was divided nearly equally among diatoms, green, and blue-green algae. One replicate sample each from TM-1 and TSB was dominated by green algae, but other samples at those sites had a greater proportion of diatoms. Site CEN was dominated by blue-green algae, particularly *Amphithrix janthina*, which accounted for 40–45 percent of the total biovolume. The dominance of this single taxon and the presence of *Lyngbya* sp. and *Oscillatoria* sp., two blue-green algal genera known to be tolerant to organic pollution, indicate that the aquatic community at CEN may be stressed.

Different groups of taxa dominated samples collected in subsequent years. In August 2001, green algae and blue-green algae accounted for the greatest percentages of cell density at sites TM-1 and TM-2, and blue-green algae were more common at TM-3 (table 20). Biovolume measurements for August 2001 indicated that green algae accounted for the majority of the algal biomass (table 21). Diatoms were the most numerous algal

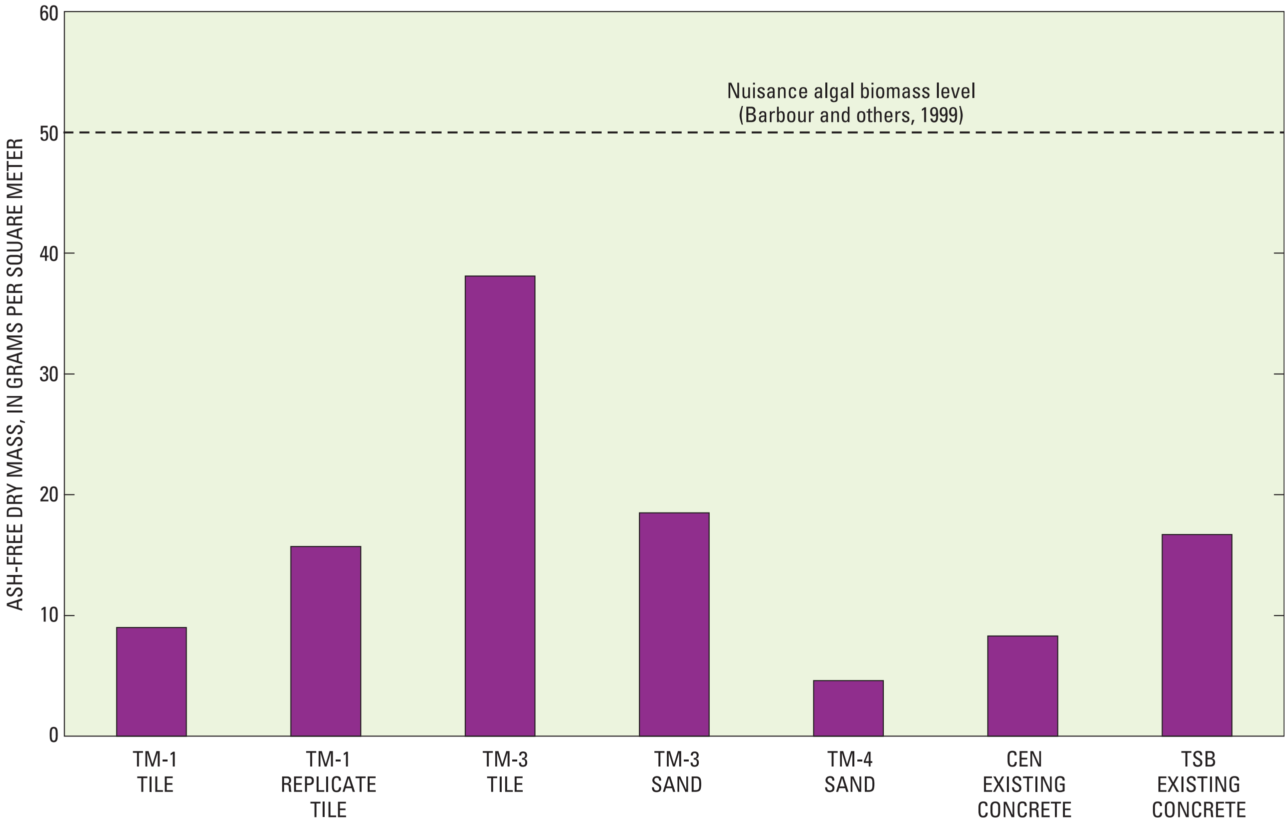

Figure 34. Periphyton ash-free dry mass at selected sites in the Threemile Creek basin, Mobile, Alabama, September 2000.

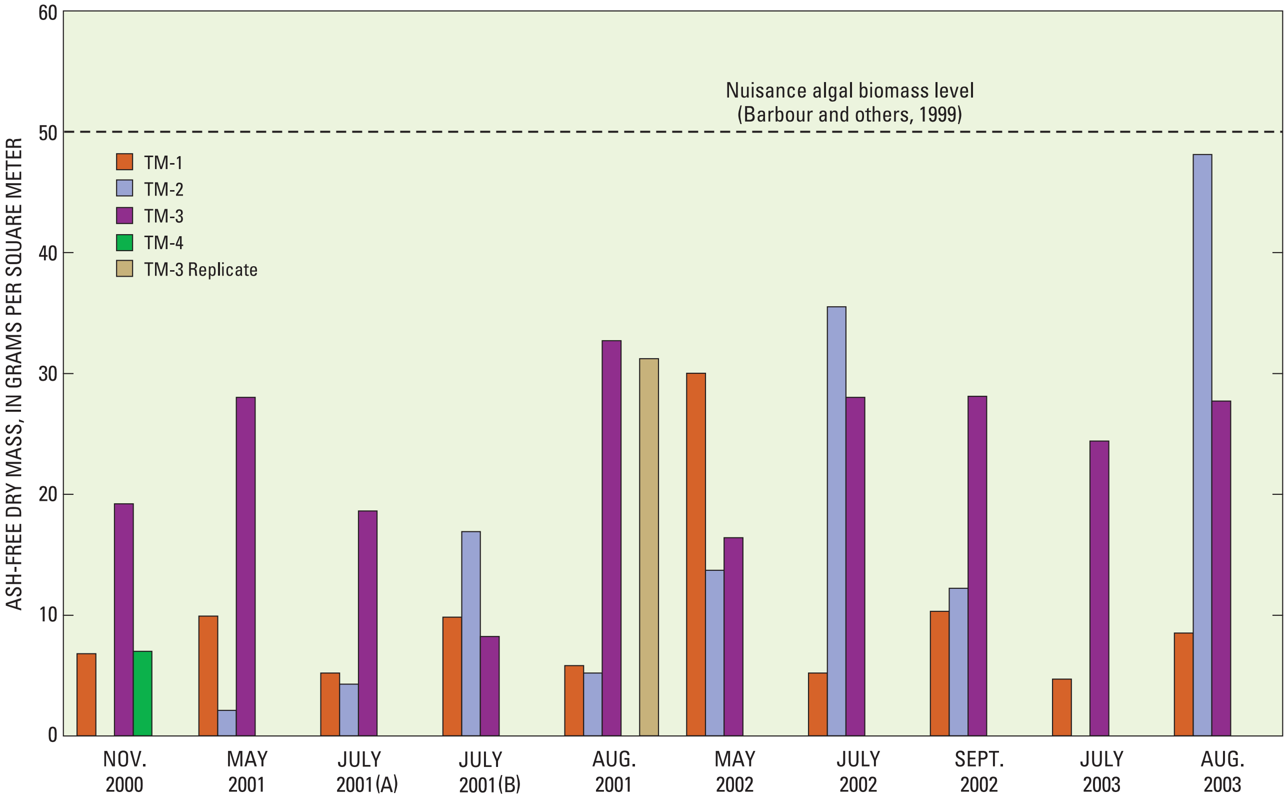

Figure 35. Periphyton ash-free dry mass at selected sites on Threemile Creek, Mobile, Alabama, 2000–2003.

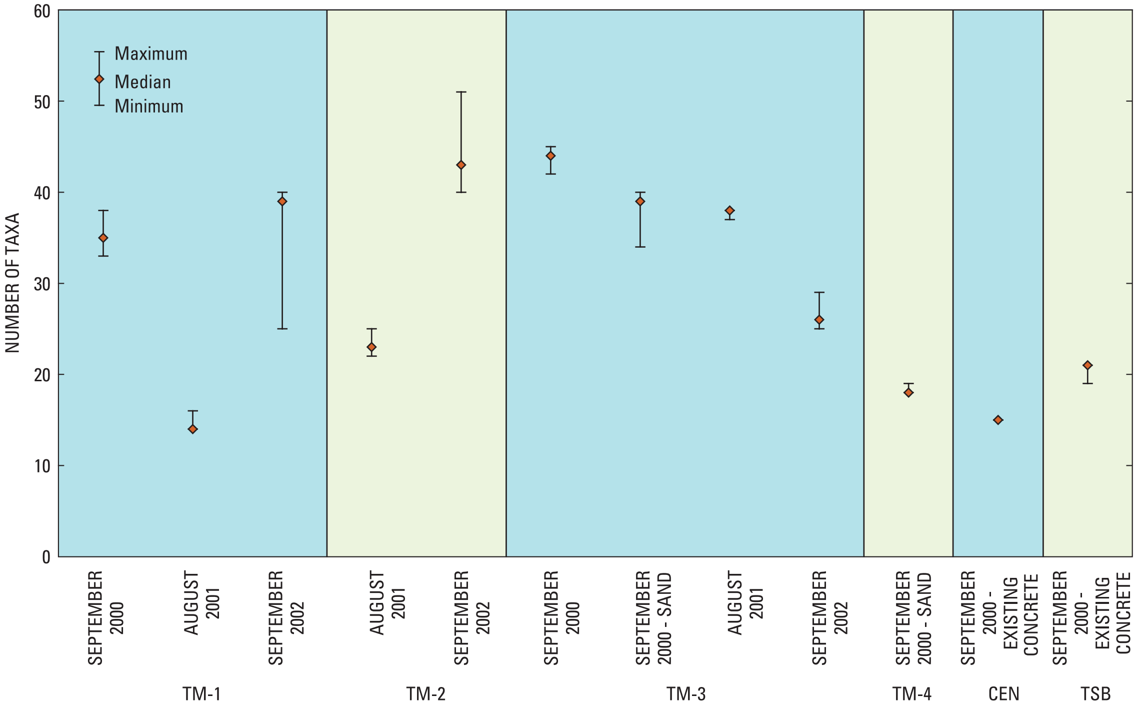

Figure 36. Periphyton taxa richness at selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.

group in samples collected during September 2002 (table 20), but in terms of percent biovolume, green algae and diatoms codominated in communities at TM-1 and TM-3, and green algae accounted for over 80 percent of biovolume at TM-2 (table 21).

Nitrogen-fixing algae can use atmospheric nitrogen dissolved in water to fuel growth, and these algae tend to dominate in low-nitrogen concentration—nitrogen limiting—conditions. Nitrogen-fixing algal species accounted for less than 10 percent of total cell density in all samples except one sample collected at TM-1 in August 2001 (table 20). Results for percentages of biovolume were more variable than results calculated from cell density. Except for one sample collected in September 2000 at TM-1, nitrogen-fixing algae composed less than 10 percent of the total biovolume on tile substrates (table 21). Sand substrates at sites TM-3 and TM-4 had greater proportions of nitrogen-fixing algae than tile substrates. Nitrogen-fixing algae—represented by a single taxon, *Amphithrix janthina*—made up an average of 45 percent of the total biovolume in samples from CEN (table 21). Water-chemistry data from all sites indicate that nitrogen is present in ample amounts for algal growth. The abundance of the one nitrogen-fixing species at CEN probably is due to other habitat or water-quality conditions at that site.

Based on the absence of oligosaprobic taxa and the large proportion of α-mesosaprobic biovolume at TSB in September 2000, lower dissolved-oxygen concentrations and greater BOD concentrations would be expected at the tributary sites, especially TSB, than at the main-stem sites. The percentages of taxa richness in each of the saprobic categories (table 6) were calculated for the September 2000 sample period for comparison among sites (fig. 37). The percentage of diatom taxa with assigned saprobic classifications ranged from 52 to 86 percent. The β-mesosaprobic (dissolved-oxygen saturation = 70–85 percent; BOD_5 = 2–4 mg/L) category contained the highest percentage of taxa in samples from TM-3 and TM-4 in September 2000. These samples also had 9 to 20 percent of their taxa classified as oligosaprobic, or intolerant of low dissolved oxygen and high BOD. TM-1 and tributary sites CEN and TSB generally had greater percentages of taxa classified as α-meso/polysaprobic and polysaprobic. In addition, there were no oligosaprobic taxa present at the two tributary sites.

Percentages of sample diatom biovolume with assigned saprobic classifications ranged from 15 to 93 percent (fig. 38) and were lower in samples from tile substrates. The majority of the diatom biovolume was classified as β-mesosaprobic at TM-3, TM-4, and CEN (fig. 38). At TSB, the α-mesosaprobic category accounted for the greatest proportion of diatom biovolume. TM-1 had similar percentages of β-mesosaprobic, α-mesosaprobic, and α-meso/polysaprobic biovolume; taxa in the oligosaprobic class accounted for a slightly lower percentage of biovolume. Oligosaprobic taxa were absent and β-mesosaprobic taxa represented the majority of diatom biovolume in August 2001 samples from TM-1 and TM-2. TM-3 samples, however, indicated a greater proportion of

Table 20. Mean total algal cell density and mean percentage of total algal cell density in major algal groups in samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.

[Values are percent of total algal cell density per square centimeter; cells/cm^2, cells per square centimeter]

September 2000						
Site substrate	**TM-1 tile**	**TM-3 tile**	**TM-3 sand**	**TM-4 sand**	**CEN concrete**	**TSB concrete**
Nitrogen-fixing algae	2.43	1.89	8.19	6.13	7.33	0
Diatom	30.0	25.7	6.76	10.3	11.4	46.6
Green algae	3.89	3.09	3.47	72.3	3.09	6.47
Blue-green algae	65.1	71.1	87.8	13.9	85.5	46.8
Cryptophyte algae	0	0	.696	.312	0	0
Euglenoid algae	1.01	.0258	0	.0271	0	.159
Dinoflagellate algae	0	0	0	.0665	0	0
Unknown algal taxa	0	0	1.30	3.21	0	0
Mean total cell density (cells/cm^2)	460,000	4,790,000	2,320,000	1,140,000	4,040,000	3,190,000

August 2001			
	TM-1 tile	**TM-2 tile**	**TM-3 tile**
Nitrogen-fixing algae	11.9	4.84	4.35
Diatom	5.72	1.03	17.4
Green algae	64.8	60.3	5.09
Blue-green algae	29.4	38.7	77.5
Cryptophyte algae	0	0	0
Euglenoid algae	.123	0	.0295
Dinoflagellate algae	0	0	0
Unknown algal taxa	0	0	0
Mean total cell density (cells/cm^2)	1,040,000	985,000	2,900,000

	TM-1 tile	**TM-2 tile**	**TM-3 tile**
Nitrogen-fixing algae	0	2.30	1.75
Diatom	91.8	90.6	98.6
Green algae	7.65	8.89	1.41
Blue-green algae	.539	.535	0
Cryptophyte algae	0	0	0
Euglenoid algae	0	0	0
Dinoflagellate algae	0	0	0
Unknown algal taxa	0	0	0
Mean total cell density (cells/cm^2)	165,000	211,000	2,010,000

Table 21. Mean total algal biovolume and mean percentage of total algal biovolume in major algal groups in samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.

[Values are percent of total algal biovolume in cubic micrometers per square centimeter; $\mu m^3/cm^2$, cubic micrometer per square centimeter]

September 2000

Site substrate	TM-1 tile	TM-3 tile	TM-3 sand	TM-4 sand	CEN existing concrete	TSB existing concrete
Nitrogen-fixing algae	13.0	0.161	15.0	9.96	45.0	0
Diatom	51.8	41.2	33.5	21.6	32.5	54.3
Green algae	37.4	44.0	29.1	60.7	9.24	31.1
Blue-green algae	6.98	14.6	35.6	10.0	58.3	13.8
Cryptophyte algae	0	0	.349	.312	0	0
Euglenoid algae	3.81	.200	0	.370	0	.725
Dinoflagellate algae	0	0	0	.302	0	0
Unknown algal taxa	0	0	1.40	6.66	0	0
Mean total biovolume ($\mu m^3/cm^2$)	166,000,000	2,330,000,000	181,000,000	56,300,000	188,000,000	1,400,000,000

August 2001

	TM-1 tile	TM-2 tile	TM-3 tile
Nitrogen-fixing algae	1.49	3.43	1.47
Diatom	3.14	1.02	10.2
Green algae	94.9	97.2	88.1
Blue-green algae	1.38	1.76	1.53
Cryptophyte algae	0	0	0
Euglenoid algae	.613	0	.0818
Dinoflagellate algae	0	0	0
Unknown algal taxa	0	0	0
Mean total biovolume ($\mu m^3/cm^2$)	326,000,000	240,000,000	991,000,000

	TM-1 tile	TM-2 tile	TM-3 tile
Nitrogen-fixing algae	0	0.0179	0.921
Diatom	45.7	16.5	59.9
Green algae	54.2	83.5	40.1
Blue-green algae	.0443	.0404	0
Cryptophyte algae	0	0	0
Euglenoid algae	0	0	0
Dinoflagellate algae	0	0	0
Unknown algal taxa	0	0	0
Mean total biovolume ($\mu m^3/cm^2$)	329,000,000	796,000,000	1,120,000,000

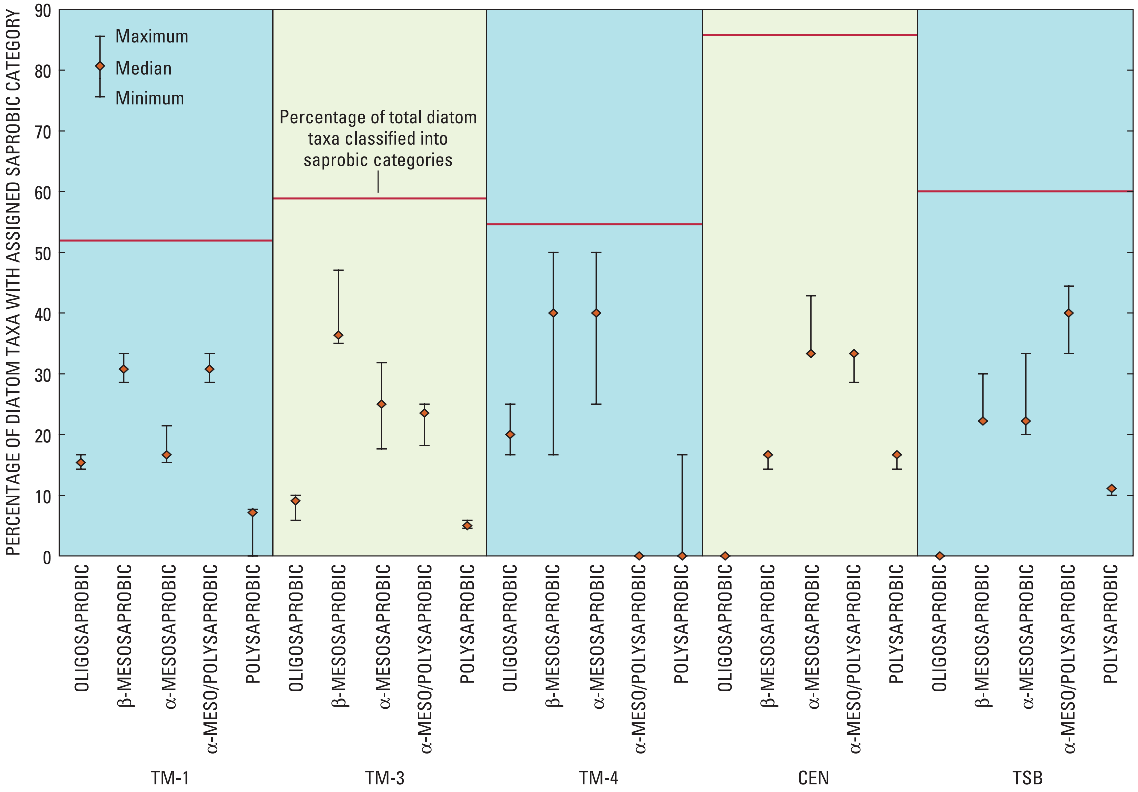

Figure 37. Percentage of diatom taxa richness in each saprobic class for periphyton community samples collected from selected sites in the Threemile Creek basin, Mobile, Alabama, September 2000.

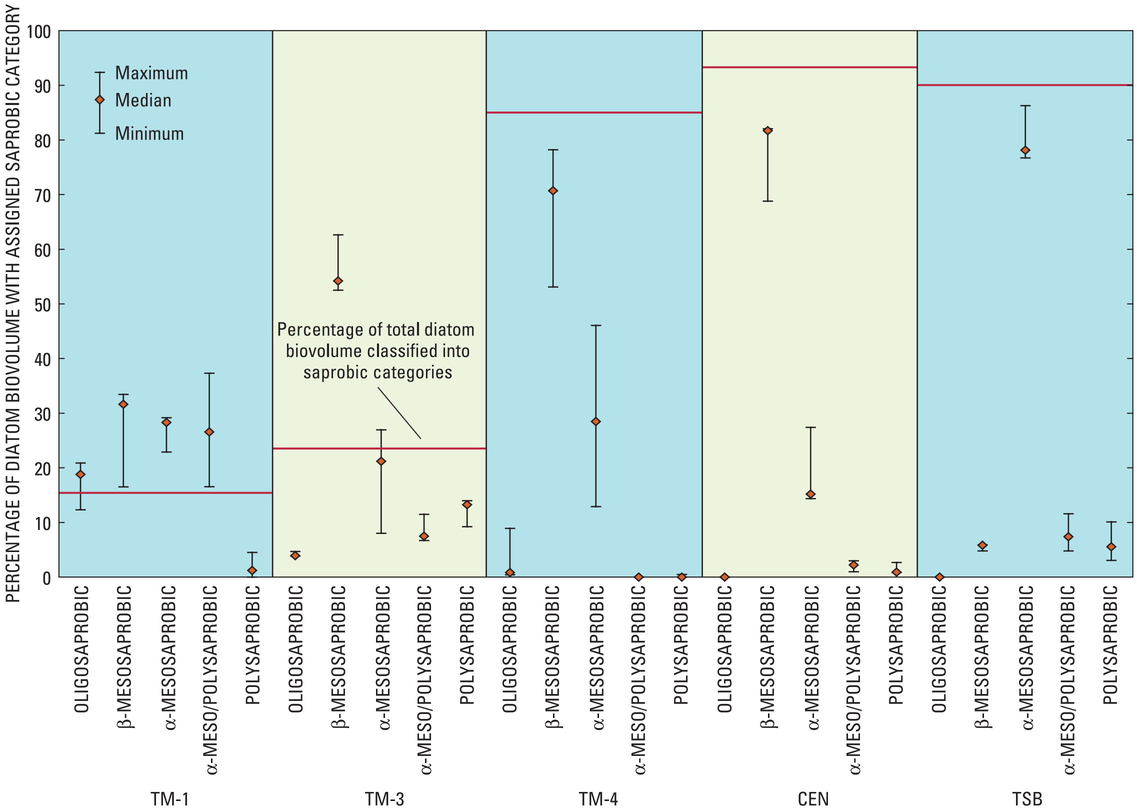

Figure 38. Percentage of diatom biovolume in each saprobic class for periphyton community samples collected from selected sites in the Threemile Creek basin, Mobile, Alabama, September 2000.

polysaprobic organisms. In the September 2002 samples, the TM-1 community was dominated by a meso/polysaprobic taxa, and TM-2 and TM-3 taxa were more evenly distributed among the categories (appendix table 3-2; T.F. Cuffney, U.S. Geological Survey, written commun., 2004).

The water-chemistry data somewhat agree with the September 2000 results of the saprobic index evaluation. Abundant growths of algae can cause great diel variation in dissolved-oxygen concentrations as a result of production during photosynthesis and consumption during respiration (Hem, 1985). If photosynthesis and respiration affect the dissolved-oxygen concentrations, morning concentrations should be much lower than afternoon concentrations. Median dissolved-oxygen concentrations at CEN and TSB were the highest in this study. All but one of the measurements of dissolved-oxygen concentrations at CEN and TSB were made in the afternoon, when oxygen production by photosynthesis normally peaks. Most measurements indicated that the creeks were supersaturated with oxygen. Dissolved-oxygen concentration measurements taken at CEN and TSB on March 13, 2001, in the morning, when dissolved-oxygen concentrations should be lowest were also fairly high (greater than 85 percent saturation), but were influenced by higher flows from recent rainfall. The common afternoon supersaturation at these sites indicates that photosynthesis affects dissolved-oxygen concentrations, and very low concentrations, though not observed directly, probably occur in the early morning. In addition, median BOD values at CEN and TSB were slightly higher than BOD values at the main-stem sites, though the Kruskal-Wallis test did not indicate that the difference was significant.

Summary

The USGS conducted a 4-year investigation of water quality and aquatic-community structure in Threemile Creek, an urban stream that drains residential areas in Mobile, Alabama. Water-quality data were collected between March 2000 and September 2003 at four sites on Threemile Creek (TM-1, TM-3, TM-4, and TM-5), and between March 2000 and October 2001 at two tributary sites (CEN, TSB) that drain heavily urbanized areas in the watershed. Stream samples were analyzed for major ions, nutrients, fecal-indicator bacteria, and selected organic wastewater constituents. Continuous measurements of dissolved-oxygen concentrations, water temperature, specific conductance, and turbidity were recorded at three sites on Threemile Creek during 1999–2003. Aquatic-community structure was evaluated by conducting one survey of the benthic invertebrate community and multiple surveys of the algal community (periphyton). Benthic invertebrate samples were collected in July 2000 at four sites on Threemile Creek (TM-1, TM-2, TM-3, and TM-4); periphyton samples were collected during 2000–2003 at four sites on Threemile Creek and the two tributary sites (TM-1, TM-2, TM-3, TM-4, CEN, and TSB). The occurrence and distribution of chemical constituents in the water column provided an initial assessment of water quality in the streams, and the structure of the benthic invertebrate and algal communities provided an indication of the cumulative effects of water quality on the aquatic biota. Water-quality data from this investigation can be used by planners and resource managers in the evaluation of proposed TMDLs and other restoration efforts that may be implemented on Threemile Creek.

The three most upstream sites (TM-1, TM-3, and TM-4) on Threemile Creek had similar water chemistry, characterized by a strong calcium-bicarbonate component. The most downstream site on Threemile Creek (TM-5) was affected by tidal fluctuations and had a strong sodium-chloride component. The tributary site at Center Street (CEN) was characterized by a strong sodium-chloride component; the tributary site at Toulmins Spring Branch (TSB) was characterized by a strong calcium component without a dominant anionic species. The ratios of sodium to chloride at CEN were higher (0.77) than typical values for seawater (0.55), indicating that other sources, such as leaking or overflowing sewer systems or industrial discharge, are likely contributors to the increased levels of sodium and chloride at this site. Concentrations of fluoride and boron also were elevated at this site, indicating possible anthropogenic sources.

Dissolved-oxygen concentrations were not always within the recommended criterion established by the ADEM. The continuous monitors at TM-1, TM-4, and TM-5 recorded dissolved-oxygen concentrations that were repeatedly less than the minimum criterion (3.0 mg/L) established for agricultural and industrial water supply. The number of days with exceedances ranged from 3 at TM-1 (WY 2001) to 274 at TM-5 (WY 2000). Water temperature exceeded the recommended criterion established by the ADEM (32.2 °C) for agricultural and industrial water supply at five of six sites in the Threemile Creek basin. The pH values at all sites on Threemile Creek were within the ADEM criterion established for agricultural and industrial water supply (6.0–8.5); however, pH ranged from 7.2 to 10.0 at CEN and from 6.6 to 9.9 at TSB. The higher pH measurements at the two tributaries may be indicative of active photosynthesis or contaminants from other sources, such as industrial discharge or sewage effluent.

Nutrient concentrations generally were higher at the two tributary sites (CEN and TSB) and the most downstream main-stem site (TM-5); nutrient concentrations were lower at the upstream main-stem sites (TM-1, TM-3, and TM-4). Total nitrogen concentrations ranged from 0.33 to 5.2 mg/L and exceeded the USEPA ecoregion criterion for all samples at CEN and TM-5. Nitrite-plus-nitrate concentrations ranged from < 0.02 to 3.6 mg/L and exceeded the USEPA ecoregion criteria in 88 percent of the samples. All samples at TM-3, TM-4, CEN, TSB, and TM-5 exceeded the ecoregion nutrient criterion for nitrite plus nitrate; approximately 50 percent of the samples at TM-1 exceeded the ecoregion nutrient criterion for nitrite plus nitrate. Total ammonia plus organic nitrogen concentrations ranged from < 0.200 to 3.2 mg/L. Total organic nitrogen was the predominant species of the total nitrogen concentration at all sites except TM-5 and CEN.

Total phosphorus concentrations ranged from < 0.002 to 0.831 mg/L. In 45 percent of the samples, total phosphorus concentrations exceeded the USEPA goal of 0.1 mg/L for preventing nuisance aquatic growth. The majority of total phosphorus concentrations at TM-1, TM-3, and TM-4 were below the ecoregion nutrient criteria and the USEPA goal of 0.1 mg/L total phosphorus; however, total phosphorus concentrations in all samples at CEN, TSB, and TM-5 exceeded both the ecoregion nutrient criterion for total phosphorus and the USEPA goal of 0.1 mg/L total phosphorus. Distributions of dissolved phosphorus and dissolved orthophosphate concentrations were similar and ranged from < 0.002 to 0.45 mg/L and < 0.001 to 0.405 mg/L, respectively.

The distribution of nitrogen to phosphorus ratios indicated two distinct groupings. The three most upstream main-stem sites (TM-1, TM-3, and TM-4) generally had nitrogen to phosphorus ratios of 10 to 1 or more, indicating that phosphorus is the limiting nutrient at these sites. Nitrogen to phosphorus ratios at CEN and TM-5 generally were less than 10 to 1 but higher than 5 to 1, indicating that nitrogen and phosphorus have equal influence on nutrient limitation at these sites. With the exception of one sample, nitrogen to phosphorus ratios at TSB were less than 5, indicating the potential for nitrogen limitation at this site. Saline waters from Mobile Bay at TM-5 may account for the ratio at TM-5, but the effects of urbanization probably account for the ratios at CEN and TSB, because these are freshwater systems.

Enterococci concentrations at sites in the Threemile Creek watershed exceeded the USEPA criterion (151 col/100 mL) in 52 percent of the samples; *E. coli* concentrations exceeded the USEPA criterion (576 col/100 mL) in 41 percent of the samples; and fecal coliform concentrations exceeded the ADEM criterion (4,000 col/100 mL) in 16 percent of the samples. Median values of enterococci and fecal coliform were highest at the two tributaries. Concentrations of fecal-indicator bacteria increased in a downstream direction in Threemile Creek except at TM-3, where more high-flow samples were collected. Concentrations of bacteria at TM-3 and TM-4 were elevated during high flow rather than low flow, indicating nonpoint sources; concentrations of bacteria at the other sites were elevated during low and high flow, indicating both point and nonpoint sources. Enterococci, *E. coli*, and fecal coliform concentrations at TM-5 were significantly greater than concentrations at TM-1. Concentrations of fecal-indicator bacteria were not well correlated with discharge or turbidity, except at TM-3. *E. coli* and fecal coliform concentrations were significantly correlated with each other at all sites.

Stream samples were analyzed for 48 chemical compounds that are commonly found in wastewater and urban runoff, which may indicate contamination attributed to a human source—37 of these compounds were detected in at least one sample. Organic wastewater compounds (OWCs) were detected in each of the 63 samples collected from the Threemile Creek basin. Of the 48 compounds analyzed, 9 OWCs were detected frequently (50-percent or greater detection frequency) in samples from the Threemile Creek basin. The most frequently detected compounds were atrazine (herbicide), caffeine (stimulant), 2-butoxyethanol phosphate (household cleaning agent), cholesterol (plant and animal steroid), diazinon (insecticide), bromacil (herbicide), triclosan (antimicrobial disinfectant), fluoranthene (PAH), and *N,N*-diethyl-*m*-toluamide (insect repellent commonly known as DEET).

The number of OWCs detected in an individual sample ranged from 2 to 22; the median number of wastewater indicators detected per site ranged from 5 to 18. The concentration of OWCs detected in individual samples ranged from 0.15 μg/L (TM-1) to 56.6 μg/L (CEN); the median concentration of OWCs detected in individual samples ranged from 0.75 μg/L (TM-1) to 20.1 μg/L (CEN). Mixtures of chemicals were common, and 50 of 63 samples (79.4 percent) contained total concentrations of OWCs that exceeded 1 μg/L; only 17.9 percent of the samples contained individual compounds with concentrations that exceeded 1 μg/L.

Organic wastewater compounds were grouped into 11 categories based on their general use and origins: antioxidants, prescription and nonprescription drugs (17β-estradiol, caffeine, and cotinine), steroids (sterols and stanols), fragrances, detergent metabolites, antimicrobials, plasticizers/flame retardants, insect repellents, insecticides, herbicides and fungicides, and PAHs. Four groups (steroids, detergent metabolites, plasticizer/flame retardants, and prescription/nonprescription drugs) contributed almost 87 percent of the total measured concentration of all samples, and 9 of 11 groups were found in more than 50 percent of the samples.

Although few of the OWCs measured have drinking-water standards or other human or ecological health criteria, there were exceedances of Canadian aquatic-life guidelines for NP, NP1EO, NP2EO, chlorpyrifos, fluoranthene, benzo[*a*]pyrene, pyrene, and diazinon. The concentrations of many of these compounds were estimated values, however, and should not be compared directly to the criteria for regulatory purposes. The detergent metabolites (NP1EO, NP2EO, and *para*-nonylphenol) were detected most frequently at CEN and TM-5. PAHs, such as fluoranthene and pyrene, were detected most frequently at TM-3, indicative of nonpoint-source contributions and the large number of high-flow samples collected at this site. Higher concentrations of OWCs were detected at two sites (CEN and TM-5) throughout the study—concentrations were highest during low flow at these sites, indicating point sources. Greater numbers of compounds were detected during low flow at four of six sites. The total concentration of OWCs at TM-5 was significantly greater than at any site on Threemile Creek (TM1, TM-3, or TM-4); the number of OWC detections at TM-5 was significantly greater than at TM-1. The total concentration of wastewater indicators at CEN and TSB was significantly greater than at TM-4; the number of OWC detections at CEN was significantly greater than at TM-4. Strong correlations were seen between the total concentration of OWCs and (1) total phosphorus, (2) caffeine, and (3) the number of wastewater indicator compounds detected.

Nineteen of the 48 compounds analyzed are known or suspected to exhibit at least weak hormonal activity, with the potential to disrupt endocrine function—12 of these compounds were detected in at least one sample. Potential endocrine disruptors were detected in 61 of 63 samples (96.8 percent) in the Threemile Creek basin. The total concentration of potential endocrine disruptors detected in a single sample ranged from 0 μg/L (TM-1) to 14.6 μg/L (CEN). The total concentration of potential endocrine disruptors exceeded 1 μg/L in about 43 percent of the samples collected in the Threemile Creek basin, in all of the samples at CEN, and in about 85 percent of the samples at TM-5. Median concentrations of potential endocrine disruptors were highest at CEN and TM-5, followed by TSB, TM-3, TM-4, and TM-1.

Organic wastewater data from the Threemile Creek basin were compared to data collected in the first nationwide reconnaissance of the occurrence of pharmaceuticals, hormones, and other OWCs in water resources. Of the 35 constituents that were common to both studies, 28 were detected in the Threemile Creek basin and 35 were detected at sites nationwide. The most frequently detected OWCs at sites nationwide included DEET, caffeine, triclosan, tri(2-chlorethyl)phosphate, and cholesterol; the most frequently detected OWCs in the Threemile Creek basin were caffeine, 2-butoxyethanol phosphate, cholesterol, diazinon, and triclosan. Many constituents in the Threemile Creek basin were detected more frequently than at sites nationwide (caffeine, 2-butoxyethanol phosphate, diazinon, fluoranthene, pyrene, and phenanthrene); other constituents (DEET and OP2EO) were detected more frequently at sites nationwide. Concentrations of eight OWCs (caffeine, 5-methyl-1*H*-benzotriazole, anthracene, 2-butoxyethanol phosphate, naphthalene, DEET, tri(dichlorisopropyl) phosphate, and 17β-estradiol) in the Threemile Creek basin exceeded maximum concentrations detected in the nationwide reconnaissance. Median concentrations of 15 OWCs detected in the Threemile Creek basin exceeded median concentrations detected in the nationwide reconnaissance.

In general, benthic invertebrate communities at sampled sites in Threemile Creek appeared to be impaired based on taxa richness, numbers of EPT taxa, and measures of community diversity. Benthic invertebrate communities appeared impaired at sites TM-1, TM-3, and TM-4; site TM-2 had a more diverse benthic invertebrate community, indicating better water quality than the other sites. Available tolerance values indicate very good water quality at TM-1 and good to fair water-quality conditions at all other sampling sites, with community average national tolerance values ranging from 5.8 at site TM-1 to 6.5 at TM-2.

Algal data indicate that organic and nutrient enrichment fueled occasional nuisance algal growth in the Threemile Creek basin. Benthic chlorophyll *a* occasionally was found at concentrations associated with nuisance algal growth. In contrast, AFDM did not indicate nuisance algal growth at any of the sites. Taxa richness indicated more diverse algal communities at the main-stem sites than at the tributary sites, perhaps because of the difference between concrete and tile substrates or colonization period. Nitrogen-fixing algae composed less than 10 percent of the algal biovolume from artificial substrate samples at the main-stem sites, indicating nitrogen-enriched water quality. In contrast, site CEN had an algal community 45 percent composed of a single species of nitrogen-fixing algae. Water-chemistry data indicate that nitrogen was not limiting at CEN, so some other water-quality or habitat factor must be influencing the dominance of that algal species.

Measures of pollution tolerance of algae in the Threemile Creek basin indicated communities that are tolerant of organic enrichment at many of the sampling sites. The green algae, a generally more pollution-tolerant division, contributed most of the biovolume in the tile sample from site TM-3 and the sand sample from TM-4 during September 2000. In August 2001, green algae contributed most of the biovolume at sites TM-1, TM-2, and TM-3. Diatoms were the most numerous algal group in samples collected during September 2002 but in terms of biovolume, green algae and diatoms dominated at TM-1 and TM-3, and green algae accounted for over 80 percent of biovolume at TM-2. During September 2000, the more tolerant β-mesosaprobic and α-mesosaprobic diatom taxa accounted for more of the diatom biovolume than the less tolerant oligosaprobic taxa at all sites. Algae classified as oligosaprobic were not present at the tributary sites CEN and TSB, indicating lower dissolved-oxygen concentrations and higher BOD levels, in contrast to measured water chemistry at the two sites. The discrepancy between algal and water-chemistry data may be due to the diel cycle of dissolved-oxygen concentrations induced by actively photosynthesizing organisms.

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Appendixes

Appendix 1. Quality Control

Table 1-1. Concentrations of nutrients, major ions, and selected organic wastewater compounds detected in blank samples in the Threemile Creek basin, Mobile, Alabama, 2000–2003

Appendix 2. Water-Quality Samples

Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003

Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003

Appendix 3. Benthic Invertebrates and Periphyton

Table 3-1. Benthic invertebrate taxa, percent abundance of each taxon, and total abundance at selected sites in Threemile Creek, Mobile, Alabama, July 2000

Table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002

Appendix 1. Table 1-1. Concentrations of nutrients, major ions, and selected organic wastewater compounds detected in blank samples in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

[N, nitrogen; mg/L, milligram per liter; <, less than; MDL, minimum detection limit; BOD_5, 5-day biochemical oxygen demand; µg/L, microgram per liter; MRL, minimum reporting level; E, estimated; *, Concentrations of these compounds are always reported as estimated; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol]

Constituent	Number of blanks with no detection	Number of blanks	Concentration	Reporting level	Reporting level type	Type of blank
Ammonia-plus-organic N, total as N	13	14	0.2 mg/L	< 0.20 mg/L	MDL	Field
Ammonia, dissolved as N	10	14	0.03 mg/L	< 0.01 mg/L	MDL	Field
Ammonia, dissolved as N	10	14	0.01 mg/L	< 0.01 mg/L	MDL	Field
Ammonia, dissolved as N	10	14	0.01 mg/L	< 0.01 mg/L	MDL	Field
Ammonia, dissolved as N	10	14	0.014 mg/L	< 0.01 mg/L	MDL	Field
Ammonia, total as N	9	14	0.02 mg/L	< 0.01 mg/L	MDL	Field
Ammonia, total as N	9	14	0.01 mg/L	< 0.01 mg/L	MDL	Field
Ammonia, total as N	9	14	0.02 mg/L	< 0.01 mg/L	MDL	Field
Ammonia, total as N	9	14	0.01 mg/L	< 0.01 mg/L	MDL	Field
Ammonia, total as N	9	14	0.01 mg/L	< 0.01 mg/L	MDL	Field
BOD_5	4	10	0.2 mg/L	< 0.1 mg/L	MDL	Field
BOD_5	4	10	0.5 mg/L	< 0.1 mg/L	MDL	Field
BOD_5	4	10	0.2 mg/L	< 0.1 mg/L	MDL	Field
BOD_5	4	10	0.2 mg/L	< 0.1 mg/L	MDL	Field
BOD_5	4	10	0.2 mg/L	< 0.1 mg/L	MDL	Field
BOD_5	4	10	0.2 mg/L	< 0.1 mg/L	MDL	Field
Calcium, dissolved	6	7	0.02 mg/L	< 0.02 mg/L	MDL	Field
Iron, dissolved	6	7	2.4 µg/L	< 2 µg/L	MDL	Field
Iron, total	6	7	1.7 µg/L	< 2 µg/L	MDL	Field
Magnesium, dissolved	6	7	0.004 mg/L	< 0.03g/L	MDL	Field
Manganese, total	6	7	0.3 µg/L	< 1 µg/L	MDL	Field
Organic carbon, total	2	6	0.6 mg/L	< 0.1 mg/L	MDL	Field
Organic carbon, total	2	6	0.3 mg/L	< 0.1 mg/L	MDL	Field
Organic carbon, total	2	6	0.4 mg/L	< 0.1 mg/L	MDL	Field
Organic carbon, total	2	6	0.6 mg/L	< 0.1 mg/L	MDL	Field
Phosphorus, dissolved	10	14	0.003 mg/L	< 0.002 mg/L	MDL	Field
Phosphorus, dissolved	10	14	0.004 mg/L	< 0.002 mg/L	MDL	Field

Appendix 1. Table 1-1. Concentrations of nutrients, major ions, and selected organic wastewater compounds detected in blank samples in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[N, nitrogen; mg/L, milligram per liter; <, less than; MDL, minimum detection limit; BOD_5, 5-day biochemical oxygen demand; µg/L, microgram per liter; MRL, minimum reporting level; E, estimated; *, Concentrations of these compounds are always reported as estimated; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol]

Constituent	Number of blanks with no detection	Number of blanks	Concentration	Reporting level	Reporting level type	Type of blank
Phosphorus, dissolved	10	14	0.002 mg/L	< 0.002 mg/L	MDL	Field
Phosphorus, dissolved	10	14	0.003 mg/L	< 0.002 mg/L	MDL	Field
Phosphorus, total	11	14	0.003 mg/L	< 0.002 mg/L	MDL	Field
Phosphorus, total	11	14	0.002mg/L	< 0.002 mg/L	MDL	Field
Phosphorus, total	11	14	0.005mg/L	< 0.002 mg/L	MDL	Field
Silica, dissolved	4	7	0.05 mg/L	< 0.01 mg/L	MDL	Field
Silica, dissolved	4	7	0.02 mg/L	< 0.01 mg/L	MDL	Field
Silica, dissolved	4	7	0.09 mg/L	< 0.01 mg/L	MDL	Field
Sodium, dissolved	6	7	0.1 mg/L	< 0.1 mg/L	MDL	Field
2,6-di-*tert*-*p*-benzoquinone	4	5	0.096 µg/L	< 0.070 µg/L	MRL	Lab
1-Methylnaphthalene	8	9	E 0.004 µg/L	< 0.500 µg/L	MRL	Lab
2-Methylnaphthalene	8	9	E 0.0039 µg/L	< 0.500 µg/L	MRL	Lab
17β-estradiol*	12	14	E 0.870 µg/L	< 5.00 µg/L	MRL	Lab
17β-estradiol*	12	14	E 0.450 µg/L	< 5.00 µg/L	MRL	Lab
Acetophenone	13	14	E 0.02 µg/L	< 0.500 µg/L	MRL	Lab
Benzo[*a*]pyrene	13	14	E 0.370 µg/L	< 0.500 µg/L	MRL	Lab
Cholesterol	13	14	E 0.260 µg/L	< 2.00 µg/L	MRL	Lab
Cotinine	13	14	E 0.200 µg/L	< 1.00 µg/L	MRL	Lab
Fluoranthene	13	14	E 0.0029 µg/L	< 0.500 µg/L	MRL	Lab
Naphthalene	11	14	E 0.034 µg/L	< 0.500 µg/L	MRL	Lab
Naphthalene	11	14	E 0.027 µg/L	< 0.030 µg/L	MRL	Lab
Naphthalene	10	11	E 0.048 µg/L	< 0.020 µg/L	MRL	Field
Naphthalene	11	14	E 0.017 µg/L	< 0.020 µg/L	MRL	Lab
N,N-diethyl-*m*-toluamide	13	14	E 0.028 µg/L	< 0.040 µg/L	MRL	Lab
N,N-diethyl-*m*-toluamide	10	11	E 0.031 µg/L	< 0.040 µg/L	MRL	Field
NP2EO, total*	13	14	E 0.940 µg/L	< 5.00 µg/L	MRL	Lab
OP1EO*	11	14	E 0.130 µg/L	< 1.00 µg/L	MRL	Lab
OP1EO*	11	14	E 0.120 µg/L	< 1.00 µg/L	MRL	Lab

Appendix 1. Table 1-1. Concentrations of nutrients, major ions, and selected organic wastewater compounds detected in blank samples in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[N, nitrogen; mg/L, milligram per liter; <, less than; MDL, minimum detection limit; BOD_5, 5-day biochemical oxygen demand; µg/L, microgram per liter; MRL, minimum reporting level; E, estimated; *, Concentrations of these compounds are always reported as estimated; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol]

Constituent	Number of blanks with no detection	Number of blanks	Concentration	Reporting level	Reporting level type	Type of blank
OP1EO*	11	14	E 0.160 µg/L	< 1.00 µg/L	MRL	Lab
para-nonylphenol total*	13	14	E 0.685 µg/L	< 0.500 µg/L	MRL	Field
Phenanthrene	13	14	E 0.0025 µg/L	< 0.500 µg/L	MRL	Lab
Pyrene	13	14	E 0.053 µg/L	< 0.500 µg/L	MRL	Field
Tri(2-chloroisopropyl)phosphate	13	14	E 0.064 µg/L	< 0.100 µg/L	MRL	Lab
Tri(2-chloroethyl)phosphate	13	14	0.046 µg/L	< 0.040 µg/L	MRL	Lab
Tributylphosphate	7	9	E 0.076 µg/L	< 0.500 µg/L	MRL	Lab
Tributylphosphate	7	9	E 0.077 µg/L	< 0.500 µg/L	MRL	Lab

Appendix 2. Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; °C, Celsius; mg/L, milligrams per liter; --, value not calculated; <, less than; $CaCO_3$, calcium carbonate; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit; N, nitrogen; P, phosphorus; BOD, biochemical oxygen demand; µg/L, micrograms per liter; mL, milliliter. Site locations are shown in figure 1]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95%	75%	50%	25%	5%
TM-1, Threemile Creek at Ziegler Boulevard at Spring Hill, Alabama, March 2000–September 2003										
00061	Discharge, ft^3/s	36	287	5.1	30.4	217	21.8	11	7.92	6.88
00065	Gage height, feet	36	69.25	67.74	67.99	69.07	67.97	67.86	67.80	67.75
00095	Specific conductance, µS/cm at 25 °C	36	99	58	76	95	86	73	70	58
00400	pH	36	7.5	6	7.0	7.4	7.2	7	6.8	6.3
61028	Turbidity (field), NTU	32	130	2	16	94	13	6.4	3.3	2
00076	Turbidity (lab), NTU	7	24	1	5.7	24	3.4	3	2.5	1
00010	Water temperature, °C	36	31.5	15	23.7	31.1	27.9	26.2	17.8	15.2
00300	Dissolved oxygen, mg/L	36	9.5	6.8	7.9	9.5	8.6	7.8	7.3	6.9
00020	Air temperature, °C	22	34	15	23.4	33.6	28.0	24.4	18.0	15.2
00915	Calcium, mg/L	7	11	7	8.971	11	9.9	8.7	8.4	7
00925	Magnesium, mg/L	7	1.2	0.8	1.086	1.2	1.2	1.1	1.1	0.8
00935	Potassium, mg/L	7	1.2	0.3	0.857	1.2	1.1	0.9	0.6	0.3
00930	Sodium, mg/L	7	3.8	1.8	2.986	3.8	3.7	3.1	2.2	1.8
00453	Bicarbonate, mg/L	7	36	22	29	36	35	29	26	22
00452	Carbonate, mg/L	7	0	--	--	--	--	--	--	--
00940	Chloride, mg/L	7	8.7	3.1	5.286	8.7	5.7	5.2	4.2	3.1
00950	Fluoride, mg/L	7	< 0.100	< 0.100	--	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
00955	Silica, mg/L	7	4.7	3	4.029	4.7	4.5	4.2	3.8	3
00945	Sulfate, mg/L	7	5.2	1.9	3.2	5.2	4.4	2.6	2.2	1.9
39086	Alkalinity, mg/L as $CaCO_3$	7	30	18	24	30	28	23	21	18
00623	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	36	0.86	< 0.200	0.314*	*0.673	*0.400	*0.300	*0.191	*0.116
00625	Nitrogen, ammonia plus organic, total (mg/L as N)	36	1	< 0.200	0.427*	*0.830	*0.500	*0.400	*0.300	*0.176
00608	Ammonia, dissolved (mg/L as N)	36	0.55	0.02	0.095	0.372	0.12	0.06	0.05	0.029
00610	Ammonia, total (mg/L as N)	36	0.63	0.02	0.096	0.307	0.125	0.06	0.05	0.029
00618	Nitrate, dissolved (mg/L as N)	7	0.43	0.17	0.26	0.43	0.33	0.2	0.2	0.17
00620	Nitrate, total (mg/L as N)	9	0.33	0.14	0.216	0.33	0.265	0.19	0.18	0.14
00631	Nitrite plus nitrate, dissolved (mg/L as N)	36	0.45	< 0.020	0.159*	*0.382	*0.235	*0.145	*0.039	*0.017

Appendix 2. Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; °C, Celsius; mg/L, milligrams per liter; --, value not calculated; <, less than; $CaCO_3$, calcium carbonate; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit; N, nitrogen; P, phosphorus; BOD, biochemical oxygen demand; µg/L, micrograms per liter; mL, milliliter. Site locations are shown in figure 1]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95%	75%	50%	25%	5%
TM-1, Threemile Creek at Ziegler Boulevard at Spring Hill, Alabama, March 2000–September 2003 (Continued)										
00630	Nitrite plus nitrate, total (mg/L as N)	36	0.52	< 0.020	0.161*	*0.384	*0.232	*0.145	*0.040	*0.018
00613	Nitrite, dissolved (mg/L as N)	36	0.04	< 0.010	0.006*	*0.032	*0.006	*0.002	*0.001	*0.000
00615	Nitrite, total (mg/L as N)	36	0.03	< 0.010	0.008*	*0.030	*0.010	*0.005	*0.003	*0.001
00600	Total nitrogen, mg/L	20	1.4	0.34	0.679	1.378	0.817	0.73	0.433	0.341
00665	Total phosphorus, mg/L	36	0.07	< 0.002	0.016*	*0.070	*0.028	*0.004	*0.002	*0.000
00666	Phosphorus, dissolved mg/L	36	0.02	< 0.002	0.006*	*0.020	*0.010	*0.003	*0.002	*0.001
00671	Orthophosphate, dissolved (mg/L as P)	36	0.006	< 0.001	0.002*	*0.006	*0.003	*0.002	*0.001	*0.001
70507	Orthophosphate, total (mg/L as P)	36	0.03	< 0.001	0.008*	*0.025	*0.009	*0.006	*0.003	*0.001
00680	Total organic carbon, mg/L	7	3.9	1.9	2.743	3.9	3.2	2.8	2	1.9
00310	BOD, 5-day, mg/L	29	2.4	0.1	1.1	2.05	1.25	1.1	0.9	0.3
70953	Suspended chlorophyll *a*, µg/L	24	< 0.100	< 0.100	--	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
70954	Suspended chlorophyll *b*, µg/L	11	< 0.100	< 0.100	--	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
90909	Enterococci, colonies/100 mL	26	6,000	11	775	5,615	615	48	30	14
31633	*Escherichia coli*, colonies/100 mL	35	2,400	20	420	2,160	420	71	44	20
31625	Fecal coliforms, colonies/100 mL	31	2,400	25	299	1,800	370	100	48	28
01020	Boron, dissolved µg/L	7	20	10	13.6	20	15	13	11	10
01046	Iron, dissolved µg/L	7	833	299	461.9	833	529	392	331	299
01045	Iron, total µg/L	7	1600	733	1212	1600	1600	1300	851	733
01056	Manganese, dissolved µg/L	7	110	10	50.3	110	90	39	23	10
01055	Manganese, total µg/L	7	130	41	76.6	130	110	68	48	41

Appendix 2. Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; °C, Celsius; mg/L, milligrams per liter; --, value not calculated; <, less than; $CaCO_3$, calcium carbonate; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit; N, nitrogen; P, phosphorus; BOD, biochemical oxygen demand; µg/L, micrograms per liter; mL, milliliter. Site locations are shown in figure 1]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95%	75%	50%	25%	5%
TM-3, Threemile Creek at Fillingim Street at Mobile, Alabama, March 2000–September 2003										
00061	Discharge, ft^3/s	21	930	11	126	881	114	40	22	11
00065	Gage height, feet	16	10.22	7.93	8.34	10.22	8.34	8.20	8.17	7.93
00095	Specific conductance, µS/cm at 25 °C	21	116	64	92	115	101	96	83	65
00400	pH	16	8.2	6.5	7.5	8.2	7.9	7.4	7.1	6.5
61028	Turbidity (field), NTU	15	420	4	72	420	95	33	4	4
00076	Turbidity (lab), NTU	7	240	2.3	40	240	11	6.2	2.5	2.3
00010	Water temperature, °C	21	31.1	15.1	21.2	30.9	26.8	19.1	16.0	15.1
00300	Dissolved oxygen, mg/L	21	10.5	7.1	9.0	10.5	9.8	9.6	7.8	7.1
00020	Air temperature, °C	7	33	14.9	22.1	33	27.3	20	16	14.9
00915	Calcium, mg/L	7	16	8.5	13.071	16	15	14	11	8.5
00925	Magnesium, mg/L	7	1.5	0.8	1.257	1.5	1.4	1.3	1.2	0.8
00935	Potassium, mg/L	7	1.3	0.6	0.943	1.3	1.2	0.9	0.8	0.6
00930	Sodium, mg/L	7	5	2.1	3.657	5	4.3	3.8	3.1	2.1
00453	Bicarbonate, mg/L	7	50	23	41	50	49	43	37	23
00452	Carbonate, mg/L	7	0	--	--	--	--	--	--	--
00940	Chloride, mg/L	7	6.9	3.2	5.3	6.9	6	5.8	4.2	3.2
00950	Fluoride, mg/L	7	< 0.100	< 0.100	--	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
00955	Silica, mg/L	7	5.2	2.5	3.786	5.2	4.7	4.2	2.6	2.5
00945	Sulfate, mg/L	7	8.8	2.9	5.243	8.8	7	4.6	3.6	2.9
39086	Alkalinity, mg/L as $CaCO_3$	7	41	19	33	41	40	35	30	19
00623	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	20	0.61	< 0.200	0.335*	*0.610	*0.500	*0.260	*0.200	*0.102
00625	Nitrogen, ammonia plus organic, total (mg/L as N)	20	1.4	0.2	0.488	1.375	0.6	0.45	0.3	0.2
00608	Ammonia, dissolved (mg/L as N)	19	0.2	0.03	0.071	0.2	0.08	0.05	0.04	0.03
00610	Ammonia, total (mg/L as N)	19	0.25	0.04	0.068	0.25	0.06	0.05	0.04	0.04
00618	Nitrate, dissolved (mg/L as N)	4	0.45	0.22	--	--	--	--	--	--
00620	Nitrate, total (mg/L as N)	9	0.47	0.16	0.258	0.47	0.27	0.24	0.2	0.16
00631	Nitrite plus nitrate, dissolved (mg/L as N)	19	0.46	0.06	0.222	0.46	0.28	0.24	0.15	0.06

Appendix 2. Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; °C, Celsius; mg/L, milligrams per liter; --, value not calculated; <, less than; $CaCO_3$, calcium carbonate; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit; N, nitrogen; P, phosphorus; BOD, biochemical oxygen demand; µg/L, micrograms per liter; mL, milliliter. Site locations are shown in figure 1]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95%	75%	50%	25%	5%
TM-3, Threemile Creek at Fillingim Street at Mobile, Alabama, March 2000–September 2003 (Continued)										
00630	Nitrite plus nitrate, total (mg/L as N)	19	0.48	0.06	0.226	0.48	0.28	0.25	0.15	0.06
00613	Nitrite, dissolved (mg/L as N)	19	0.02	< 0.010	--	0.02	< 0.010	< 0.010	< 0.010	< 0.010
00615	Nitrite, total (mg/L as N)	19	0.02	< 0.010	0.010*	*0.020	*0.010	*0.008	*0.005	*0.003
00600	Total nitrogen, mg/L	16	1.7	0.35	0.756	1.7	0.942	0.765	0.45	0.35
00665	Total phosphorus, mg/L	19	0.135	< 0.002	0.038*	*0.135	*0.063	*0.022	*0.008	*0.003
00666	Phosphorus, dissolved mg/L	19	0.034	< 0.002	0.013*	*0.034	*0.023	*0.009	*0.003	*0.002
00671	Orthophosphate, dissolved (mg/L as P)	20	0.029	< 0.001	0.007*	*0.028	*0.010	*0.004	*0.001	*0.000
70507	Orthophosphate, total (mg/L as P)	20	0.036	< 0.001	0.012*	*0.036	*0.023	*0.009	*0.003	*0.001
00680	Total organic carbon, mg/L	7	5.6	2.7	3.857	5.6	5.3	3.6	2.9	2.7
00310	BOD, 5-day, mg/L	11	3	0.2	1.709	3	2.5	1.3	1.2	0.2
70953	Suspended chlorophyll *a*, µg/L	12	6.1	< 0.100	--	6.1	< 0.100	< 0.100	< 0.100	< 0.100
70954	Suspended chlorophyll *b*, µg/L	7	< 0.100	< 0.100	--	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
90909	Enterococci, colonies/100 mL	19	31,000	10	6,760	31,000	11,000	1,200	30	10
31633	*Escherichia coli*, colonies/100 mL	21	29,000	14	4,600	27,700	8,700	1,500	66	15
31625	Fecal coliforms, colonies/100 mL	15	12,000	44	3,130	12,000	5,200	300	70	44
01020	Boron, dissolved µg/L	7	28	10	20	28	23	20	17	10
01046	Iron, dissolved µg/L	7	572	258	397.6	572	432	390	348	258
01045	Iron, total µg/L	7	3300	567	1388.3	3300	1400	1300	851	567
01056	Manganese, dissolved µg/L	7	93	27	53.7	93	65	47	44	27
01055	Manganese, total µg/L	7	140	31	81.1	140	110	72	50	31

Appendix 2. Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; °C, Celsius; mg/L, milligrams per liter; --, value not calculated; <, less than; $CaCO_3$, calcium carbonate; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit; N, nitrogen; P, phosphorus; BOD, biochemical oxygen demand; µg/L, micrograms per liter; mL, milliliter. Site locations are shown in figure 1]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95%	75%	50%	25%	5%
TM-4, Threemile Creek at Stanton Road at Mobile, Alabama, March 2000–June 2002										
00061	Discharge, ft^3/s	17	52	-16	18.3	52	29.5	17	1.25	-16
00065	Gage height, feet	20	5.62	0.21	1.30	5.45	1.73	1.20	0.32	0.21
00095	Specific conductance, µS/cm at 25 °C	20	126	63	103	126	112	103	97	64
00400	pH	20	7	6.1	6.6	7.0	6.8	6.6	6.4	6.1
61028	Turbidity (field), NTU	16	800	3.9	57	800	9.7	5.4	4.4	3.9
00076	Turbidity (lab), NTU	7	530	1.5	79	530	7.7	3.2	1.8	1.5
00010	Water temperature, °C	20	33.4	16.8	26.6	33.4	30	28	21.9	16.8
00300	Dissolved oxygen, mg/L	20	11.5	5.4	8.2	11.4	9.3	8.0	7.6	5.4
00020	Air temperature, °C	17	36	15.5	26.4	36	30.8	26.2	23.4	15.5
00915	Calcium, mg/L	7	14	7.8	11.686	14	14	12	10	7.8
00925	Magnesium, mg/L	7	1.6	0.6	1.343	1.6	1.5	1.5	1.2	0.6
00935	Potassium, mg/L	7	1.4	0.7	1.029	1.4	1.3	1	0.8	0.7
00930	Sodium, mg/L	7	5.3	2	4.1	5.3	4.9	4.4	3.6	2
00453	Bicarbonate, mg/L	7	46	23	35	46	45	33	27	23
00452	Carbonate, mg/L	7	0	--	--	--	--	--	--	--
00940	Chloride, mg/L	7	9.2	2.8	6.214	9.2	7.1	6.5	5.2	2.8
00950	Fluoride, mg/L	7	< 0.100	< 0.100	--	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
00955	Silica, mg/L	7	5.9	1.8	4.171	5.9	5.3	4.6	3.2	1.8
00945	Sulfate, mg/L	7	9.3	3.6	6.086	9.3	7.2	5.6	5.1	3.6
39086	Alkalinity, mg/L as $CaCO_3$	7	37	18	29	37	37	27	22	18
00623	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	20	0.54	< 0.200	0.340*	*0.538	*0.400	*0.385	*0.207	*0.168
00625	Nitrogen, ammonia plus organic, total (mg/L as N)	20	2.2	< 0.200	0.531*	*2.145	*0.585	*0.450	*0.300	*0.140
00608	Ammonia, dissolved (mg/L as N)	20	0.18	0.02	0.069	0.18	0.095	0.06	0.04	0.02
00610	Ammonia, total (mg/L as N)	20	0.21	< 0.010	0.074*	*0.209	*0.098	*0.060	*0.040	*0.010
00618	Nitrate, dissolved (mg/L as N)	3	0.37	0.19	--	--	--	--	--	--
00620	Nitrate, total (mg/L as N)	3	0.38	0.21	--	--	--	--	--	--
00631	Nitrite plus nitrate, dissolved (mg/L as N)	20	0.46	< 0.020	0.136*	*0.456	*0.207	*0.100	*0.040	*0.012

Appendix 2. Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; °C, Celsius; mg/L, milligrams per liter; --, value not calculated; <, less than; $CaCO_3$, calcium carbonate; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit; N, nitrogen; P, phosphorus; BOD, biochemical oxygen demand; µg/L, micrograms per liter; mL, milliliter. Site locations are shown in figure 1]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95%	75%	50%	25%	5%
TM-4, Threemile Creek at Stanton Road at Mobile, Alabama, March 2000–June 2002 (Continued)										
00630	Nitrite plus nitrate, total (mg/L as N)	20	0.45	< 0.020	0.138*	*0.447	*0.225	*0.100	*0.040	*0.012
00613	Nitrite, dissolved (mg/L as N)	20	0.02	< 0.010	--	0.02	< 0.010	< 0.010	< 0.010	< 0.010
00615	Nitrite, total (mg/L as N)	20	0.02	< 0.010	--	0.02	< 0.010	< 0.010	< 0.010	< 0.010
00600	Total nitrogen, mg/L	17	2.4	0.33	0.734	2.4	0.765	0.56	0.465	0.33
00665	Total phosphorus, mg/L	20	0.3	< 0.002	0.025*	*0.287	*0.022	*0.004	*0.002	*0.000
00666	Phosphorus, dissolved mg/L	20	0.02	< 0.002	0.006*	*0.020	*0.009	*0.004	*0.002	*0.001
00671	Orthophosphate, dissolved (mg/L as P)	20	0.007	< 0.001	0.002*	*0.007	*0.003	*0.002	*0.001	*0.000
70507	Orthophosphate, total (mg/L as P)	20	0.02	< 0.001	0.007*	*0.020	*0.008	*0.006	*0.004	*0.001
00680	Total organic carbon, mg/L	7	5.9	2.4	3.357	5.9	3.5	2.8	2.7	2.4
00310	BOD, 5-day, mg/L	18	4.6	0.4	1.444	4.6	1.5	1.3	0.8	0.4
70953	Suspended chlorophyll *a*, µg/L	18	35	< 0.100	--	35	< 0.100	< 0.100	< 0.100	< 0.100
70954	Suspended chlorophyll *b*, µg/L	10	< 0.100	< 0.100	--	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
90909	Enterococci, colonies/100 mL	20	47,000	10	2,610	44,830	170	76	38	11
31633	*Escherichia coli*, colonies/100 mL	19	21,000	47	1,460	21,000	720	290	150	47
31625	Fecal coliforms, colonies/100 mL	20	17,000	83	1,200	16,200	448	285	190	85
01020	Boron, dissolved µg/L	7	23	10	19.1	23	23	20	19	10
01046	Iron, dissolved µg/L	7	650	176	322.5	650	418	304	179	176
01045	Iron, total µg/L	7	5,500	466	1,545	5,500	1,300	1,000	686	466
01056	Manganese, dissolved µg/L	7	83	24	51.3	83	65	52	26	24
01055	Manganese, total µg/L	7	230	28	80.9	230	88	67	29	28

Appendix 2. Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; °C, Celsius; mg/L, milligrams per liter; --, value not calculated; <, less than; $CaCO_3$, calcium carbonate; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit; N, nitrogen; P, phosphorus; BOD, biochemical oxygen demand; µg/L, micrograms per liter; mL, milliliter. Site locations are shown in figure 1]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95%	75%	50%	25%	5%
CEN, Unnamed tributary to Threemile Creek at Center Street at Mobile, Alabama, March 2000–October 2001										
00061	Discharge, ft^3/s	8	2.90	0.180	0.778	2.90	1.33	0.315	0.195	0.180
00065	Gage height, feet	6	1.94	1.74	1.82	1.94	1.88	1.82	1.74	1.74
00095	Specific conductance, µS/cm at 25 °C	8	1,230	145	668	1,230	1,060	632	370	145
00400	pH	8	10	7.2	8.8	10	9.6	9.0	8.0	7.2
61028	Turbidity (field), NTU	4	35	0.7	--	--	--	--	--	--
00076	Turbidity (lab), NTU	7	20	1.1	4.9	20	4.6	1.8	1.2	1.1
00010	Water temperature, °C	8	34.8	15.2	23.1	34.8	30.3	20.45	17.8	15.2
00300	Dissolved oxygen, mg/L	7	21.5	8.6	14.5	21.5	18.4	14.5	9.6	8.6
00020	Air temperature, °C	7	34	15	25.5	34	32	27.3	18.6	15
00915	Calcium, mg/L	7	41	23	29	41	32	29	24	23
00925	Magnesium, mg/L	7	2.6	1.7	2.086	2.6	2.4	2	1.7	1.7
00935	Potassium, mg/L	7	4.5	2.4	3.329	4.5	3.7	3.2	3.1	2.4
00930	Sodium, mg/L	7	250	25	130.429	250	240	110	59	25
00453	Bicarbonate, mg/L	7	163	36	100	163	120	118	60	36
00452	Carbonate, mg/L	7	62	0	13	62	26	1	0	0
00940	Chloride, mg/L	7	340	31	169.4	340	300	140	75	31
00950	Fluoride, mg/L	7	1.3	0.2	0.7	1.3	1.2	0.6	0.3	0.2
00955	Silica, mg/L	7	7.6	4.7	6.4	7.6	7.6	6.3	5.3	4.7
00945	Sulfate, mg/L	7	26	14	19.1	26	26	15	15	14
39086	Alkalinity, mg/L as $CaCO_3$	7	133	78	104	133	133	97	93	78
00623	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	8	2.4	0.49	1.328	2.4	1.975	1.35	0.533	0.49
00625	Nitrogen, ammonia plus organic, total (mg/L as N)	8	3.2	0.67	1.816	3.2	2.55	1.85	0.87	0.67
00608	Ammonia, dissolved (mg/L as N)	8	2.4	0.03	0.621	2.4	0.72	0.445	0.112	0.03
00610	Ammonia, total (mg/L as N)	8	2.4	0.03	0.731	2.4	1.013	0.54	0.207	0.03
00618	Nitrate, dissolved (mg/L as N)	7	0.91	0.33	0.59	0.91	0.85	0.5	0.39	0.33
00620	Nitrate, total (mg/L as N)	8	0.91	0.33	0.564	0.91	0.815	0.48	0.363	0.33
00631	Nitrite plus nitrate, dissolved (mg/L as N)	8	1	0.38	0.64	1	0.93	0.53	0.475	0.38

Appendix 2. Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; °C, Celsius; mg/L, milligrams per liter; --, value not calculated; <, less than; $CaCO_3$, calcium carbonate; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit; N, nitrogen; P, phosphorus; BOD, biochemical oxygen demand; µg/L, micrograms per liter; mL, milliliter. Site locations are shown in figure 1]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95%	75%	50%	25%	5%
CEN, Unnamed tributary to Threemile Creek at Center Street at Mobile, Alabama, March 2000–October 2001 (Continued)										
00630	Nitrite plus nitrate, total (mg/L as N)	8	1	0.38	0.644	1	0.938	0.53	0.475	0.38
00613	Nitrite, dissolved (mg/L as N)	8	0.15	0.03	0.074	0.15	0.098	0.07	0.035	0.03
00615	Nitrite, total (mg/L as N)	8	0.15	0.03	0.08	0.15	0.127	0.07	0.043	0.03
00600	Total nitrogen, mg/L	7	3.4	1.1	2.271	3.4	3.1	2.5	1.2	1.1
00665	Total phosphorus, mg/L	8	0.831	0.19	0.435	0.831	0.566	0.406	0.284	0.19
00666	Phosphorus, dissolved mg/L	8	0.45	0.09	0.271	0.45	0.397	0.245	0.191	0.09
00671	Orthophosphate, dissolved (mg/L as P)	8	0.341	0.08	0.229	0.341	0.315	0.228	0.159	0.08
70507	Orthophosphate, total (mg/L as P)	8	0.457	0.13	0.308	0.457	0.402	0.323	0.222	0.13
00680	Total organic carbon, mg/L	7	7.8	3.6	5.19	7.8	6.6	4.4	4.1	3.6
00310	BOD, 5-day, mg/L	6	8.8	1.7	4.517	8.8	6.25	4.35	2.3	1.7
70953	Suspended chlorophyll *a*, µg/L	8	66	< 0.100	16.265*	*66.000	*28.250	*4.850	*0.523	*0.137
70954	Suspended chlorophyll *b*, µg/L	7	< 0.100	< 0.100	--	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
90909	Enterococci, colonies/100 mL	8	14,000	110	3,690	14,000	8,100	1,300	174	110
31633	*Escherichia coli*, colonies/100 mL	8	26,000	120	7,740	26,000	19,350	2,850	278	120
31625	Fecal coliforms, colonies/100 mL	8	30,000	38	8,620	30,000	12,200	7,000	820	38
01020	Boron, dissolved µg/L	7	840	90	431.4	840	780	360	190	90
01046	Iron, dissolved µg/L	7	337	75	189.9	337	251	178	115	75
01045	Iron, total µg/L	7	825	240	544.6	825	723	689	301	240
01056	Manganese, dissolved µg/L	7	34	3	12.6	34	19	9	4	3
01055	Manganese, total µg/L	7	35	4	15.1	35	22	15	6	4

Appendix 2. Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; °C, Celsius; mg/L, milligrams per liter; --, value not calculated; <, less than; $CaCO_3$, calcium carbonate; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit; N, nitrogen; P, phosphorus; BOD, biochemical oxygen demand; µg/L, micrograms per liter; mL, milliliter. Site locations are shown in figure 1]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95%	75%	50%	25%	5%
TSB, Toulmins Spring Branch at Graham Avenue at Mobile, Alabama, March 2000–October 2001										
00061	Discharge, ft^3/s	8	6.2	0.11	1.17	6.20	1.21	0.315	0.190	0.110
00065	Gage height, feet	8	12.60	12.30	12.40	12.60	12.40	12.40	12.38	12.26
00095	Specific conductance, µS/cm at 25 °C	8	183	99	134	183	146	135	111	99
00400	pH	8	9.9	6.6	8.8	9.9	9.7	9.2	7.9	6.6
61028	Turbidity (field), NTU	3	39	5	--	--	--	--	--	--
00076	Turbidity (lab), NTU	7	16	0.8	3.4	16	2.1	1.2	1.1	0.79
00010	Water temperature, °C	8	35.3	15	23.6	35.3	27.9	23.2	18.2	15
00300	Dissolved oxygen, mg/L	8	15.8	8.9	12.6	15.8	15.4	11.7	10.8	8.9
00020	Air temperature, °C	7	33.4	23.4	27.2	33.4	30	26.5	24	23.4
00915	Calcium, mg/L	7	21	11	16.3	21	20	16	15	11
00925	Magnesium, mg/L	7	1.6	1	1.186	1.6	1.3	1.2	1	1
00935	Potassium, mg/L	7	1.7	1.4	1.5	1.7	1.6	1.5	1.4	1.4
00930	Sodium, mg/L	7	7.2	4.5	6	7.2	7.2	6	5.1	4.5
00453	Bicarbonate, mg/L	7	49	13	27	49	43	22	13	13
00452	Carbonate, mg/L	7	9	0	2	9	6	0	0	0
00940	Chloride, mg/L	7	11	6.9	9.29	11	11	9.3	8.2	6.9
00950	Fluoride, mg/L	7	0.7	0.1	0.486	0.7	0.6	0.5	0.4	0.1
00955	Silica, mg/L	7	5.1	3.4	3.871	5.1	4.1	3.6	3.4	3.4
00945	Sulfate, mg/L	7	20	14	17	20	20	16	15	14
39086	Alkalinity, mg/L as $CaCO_3$	7	40	12	26	40	35	26	22	12
00623	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	8	1.3	0.2	0.451	1.3	0.463	0.325	0.267	0.2
00625	Nitrogen, ammonia plus organic, total (mg/L as N)	8	1.5	0.35	0.591	1.5	0.655	0.445	0.382	0.35
00608	Ammonia, dissolved (mg/L as N)	8	0.22	< 0.010	0.054*	*0.220	*0.070	*0.030	*0.012	*0.003
00610	Ammonia, total (mg/L as N)	8	0.41	0.01	0.105	0.41	0.167	0.045	0.015	0.01
00618	Nitrate, dissolved (mg/L as N)	4	0.29	0.14	--	--	--	--	--	--
00620	Nitrate, total (mg/L as N)	3	0.3	0.13	--	--	--	--	--	--
00631	Nitrite plus nitrate, dissolved (mg/L as N)	8	0.3	< 0.020	0.148*	*0.300	*0.225	*0.140	*0.067	*0.037

Appendix 2. Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; °C, Celsius; mg/L, milligrams per liter; --, value not calculated; <, less than; $CaCO_3$, calcium carbonate; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit; N, nitrogen; P, phosphorus; BOD, biochemical oxygen demand; µg/L, micrograms per liter; mL, milliliter. Site locations are shown in figure 1]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95%	75%	50%	25%	5%
TSB, Toulmins Spring Branch at Graham Avenue at Mobile, Alabama, March 2000–October 2001 (Continued)										
00630	Nitrite plus nitrate, total (mg/L as N)	8	0.31	< 0.020	0.150*	*0.310	*0.225	*0.140	*0.067	*0.036
00613	Nitrite, dissolved (mg/L as N)	8	0.02	< 0.010	--	0.02	0.01	< 0.010	< 0.010	< 0.010
00615	Nitrite, total (mg/L as N)	8	0.02	< 0.010	--	0.02	0.01	< 0.010	< 0.010	< 0.010
00600	Total nitrogen, mg/L	6	1.8	0.43	0.742	1.8	0.952	0.535	0.468	0.43
00665	Total phosphorus, mg/L	8	0.232	0.128	0.185	0.232	0.215	0.193	0.142	0.128
00666	Phosphorus, dissolved mg/L	8	0.192	0.114	0.152	0.192	0.175	0.161	0.12	0.114
00671	Orthophosphate, dissolved (mg/L as P)	8	0.16	0.09	0.121	0.16	0.147	0.119	0.093	0.09
70507	Orthophosphate, total (mg/L as P)	8	0.168	0.1	0.134	0.168	0.158	0.132	0.112	0.1
00680	Total organic carbon, mg/L	7	7.9	2.7	4.386	7.9	5.7	3.7	3	2.7
00310	BOD, 5-day, mg/L	6	3.2	0.8	1.75	3.2	2.3	1.75	0.95	0.8
70953	Suspended chlorophyll *a*, µg/L	8	100	< 0.100	18.761*	*100.000	*17.750	*5.350	*1.989	*0.468
70954	Suspended chlorophyll *b*, µg/L	7	< 0.100	< 0.100	--	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
90909	Enterococci, colonies/100 mL	8	93,000	330	17,040	93,000	24,600	2,650	618	330
31633	*Escherichia coli*, colonies/100 mL	8	31,000	20	7,350	31,000	16,320	1,060	99	20
31625	Fecal coliforms, colonies/100 mL	8	16,000	--	4,710*	*16,000	*7,720	*2,550	*612	*145
01020	Boron, dissolved µg/L	7	30	18	22	30	27	20	19	18
01046	Iron, dissolved µg/L	7	348	84	187.6	348	333	148	109	84
01045	Iron, total µg/L	7	705	89	296.1	705	519	195	165	89
01056	Manganese, dissolved µg/L	7	26	1	7.57	26	13	4	1	1
01055	Manganese, total µg/L	7	27	1	8.57	27	15	4	4	1

Appendix 2. Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; °C, Celsius; mg/L, milligrams per liter; --, value not calculated; <, less than; $CaCO_3$, calcium carbonate; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit; N, nitrogen; P, phosphorus; BOD, biochemical oxygen demand; µg/L, micrograms per liter; mL, milliliter. Site locations are shown in figure 1]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95%	75%	50%	25%	5%
TM-5, Threemile Creek at U.S. Highway 43 near Prichard, Alabama, March 2000–September 2003										
00065	Gage height, feet	39	2.41	-0.35	1.20	2.27	1.75	1.28	0.65	-0.07
00095	Specific conductance, µS/cm at 25 °C	39	21,400	201	9,340	21,300	17,500	6,460	1,780	216
00400	pH	34	8.2	6.5	7.1	8.0	7.4	7.1	6.8	6.6
61028	Turbidity (field), NTU	36	68	4	17	42	22	12	9.7	4.8
00076	Turbidity (lab), NTU	8	33	0.2	8.7	33	8.6	6.1	3.2	0.2
00010	Water temperature, °C	39	30	14.1	23.9	30	29.4	27.5	18.5	14.2
00300	Dissolved oxygen, mg/L	39	11	2.2	5.9	9.6	7.3	5.6	4.3	2.3
00020	Air temperature, °C	15	35.4	17.5	26.9	35.4	30	29.5	23	17.5
00915	Calcium, mg/L	9	170	17	74.6	170	145	41	35.5	17
00925	Magnesium, mg/L	9	507	2.4	185.9	507	401.5	80	60.5	2.4
00935	Potassium, mg/L	9	160	2.4	61.8	160	135	27	21.5	2.4
00930	Sodium, mg/L	9	4,300	19	1614.3	4300	3550	690	515	19
00453	Bicarbonate, mg/L	7	123	44	77	123	103	61	56	44
00452	Carbonate, mg/L	7	0	--	--	--	--	--	--	--
00940	Chloride, mg/L	9	7,900	22	2,926.9	7,900	6,500	1,200	910	22
00950	Fluoride, mg/L	9	0.4	0.1	0.233	0.4	0.3	0.2	0.2	0.1
00955	Silica, mg/L	9	5.9	2.8	4.156	5.9	5.35	3.7	3.3	2.8
00945	Sulfate, mg/L	9	1,300	16	442.9	1300	895	200	140	16
39086	Alkalinity, mg/L as $CaCO_3$	7	101	36	63	101	84	50	46	36
00623	Nitrogen, ammonia plus organic, dissolved (mg/L as N)	39	1.2	0.29	0.716	1.1	0.82	0.7	0.6	0.46
00625	Nitrogen, ammonia plus organic, total (mg/L as N)	39	1.6	0.65	1.084	1.5	1.2	1	0.9	0.7
00608	Ammonia, dissolved (mg/L as N)	39	0.78	0.07	0.299	0.57	0.36	0.28	0.2	0.08
00610	Ammonia, total (mg/L as N)	39	0.86	0.08	0.322	0.66	0.37	0.29	0.21	0.1
00618	Nitrate, dissolved (mg/L as N)	38	3.56	0.24	1.348	2.61	1.695	1.23	0.755	0.307
00620	Nitrate, total (mg/L as N)	38	3.56	0.24	1.377	2.705	1.695	1.285	0.75	0.297
00631	Nitrite plus nitrate, dissolved (mg/L as N)	39	3.6	0.25	1.376	2.6	1.7	1.3	0.78	0.32

Appendix 2. Table 2-1. Summary of selected constituents at sampling sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[NWIS, National Water Information System; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; NTU, nephelometric turbidity units; °C, Celsius; mg/L, milligrams per liter; --, value not calculated; <, less than; $CaCO_3$, calcium carbonate; *, value is estimated by using a log-probability regression to predict the values of data below the detection limit; N, nitrogen; P, phosphorus; BOD, biochemical oxygen demand; µg/L, micrograms per liter; mL, milliliter. Site locations are shown in figure 1]

NWIS parameter code	Water-quality constituent	Sample size	Maximum	Minimum	Mean	Median				
						95%	75%	50%	25%	5%
TM-5, Threemile Creek at U.S. Highway 43 near Prichard, Alabama, March 2000–September 2003 (Continued)										
00630	Nitrite plus nitrate, total (mg/L as N)	39	3.6	0.25	1.391	2.7	1.7	1.3	0.77	0.32
00613	Nitrite, dissolved (mg/L as N)	39	0.05	0.01	0.027	0.05	0.04	0.03	0.02	0.01
00615	Nitrite, total (mg/L as N)	39	0.06	0.01	0.028	0.05	0.04	0.03	0.02	0.01
00600	Total nitrogen, mg/L	39	5.2	1.2	2.472	4.2	2.9	2.4	1.7	1.3
00665	Total phosphorus, mg/L	39	0.53	0.136	0.301	0.503	0.38	0.272	0.235	0.168
00666	Phosphorus, dissolved mg/L	39	0.388	0.08	0.196	0.379	0.25	0.172	0.14	0.102
00671	Orthophosphate, dissolved (mg/L as P)	39	0.405	0.067	0.194	0.403	0.246	0.164	0.13	0.1
70507	Orthophosphate, total (mg/L as P)	39	0.49	0.109	0.22	0.47	0.272	0.196	0.152	0.113
00680	Total organic carbon, mg/L	7	7.8	3.8	6.257	7.8	7.6	6.2	5.9	3.8
00310	BOD, 5-day, mg/L	30	7.6	1	2.937	6.61	3.75	2.4	2	1.11
70953	Suspended chlorophyll *a*, µg/L	26	91	< 0.100	30.070*	*84.700	*46.250	*24.000	*10.300	*3.107
70954	Suspended chlorophyll *b*, µg/L	13	< 0.100	< 0.100	--	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
90909	Enterococci, colonies/100 mL	34	22,000	9	2,350	16,000	1,170	225	98	32
31633	*Escherichia coli*, colonies/100 mL	36	20,000	30	2,000	12,350	1,580	470	153	30
31625	Fecal coliforms, colonies/100 mL	31	15,000	20	1,870	12,000	1,300	540	230	38
01020	Boron, dissolved µg/L	9	1,900	70	738.9	1,900	1,550	350	275	70
01046	Iron, dissolved µg/L	9	229	21	80.7	229	111.5	67	31	21
01045	Iron, total µg/L	9	773	319	514.2	773	724.5	407	324.5	319
01056	Manganese, dissolved µg/L	9	150	33	75.1	150	98	68	41.5	33
01055	Manganese, total µg/L	9	170	42	88.2	170	118.5	77	55.5	42

Appendix 2. Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.

[µg/L, micrograms per liter; --, no data; <, less than; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; *, censored; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol]

Site number (fig. 1)	Sample date	Sample time	1-methyl-naphthalene (µg/L)	2-methyl-naphthalene (µg/L)	2,6-Dimethyl-napthalene (µg/L)	2,6-Di-*tert*-butylphenol (µg/L)	2,6-Di-*tert*-*p*-benzoquinone (µg/L)	5-Methyl-1*H*-benzotriazole (µg/L)	AHTN (µg/L)	Acetophenone (µg/L)
TM-1	3/13/2000	1100				< 0.090	< 0.070	< 0.10		< 0.100
TM-1	4/25/2000	1430				< 0.090	< 0.070	< 0.10		< 0.100
TM-1	7/26/2000	900				< 0.080	< 0.5	< 0.10		< 0.150
TM-1	9/12/2000	1300				< 0.080	< 0.5	< 0.10		< 0.220
TM-1	11/15/2000	845				< 0.150	< 0.5	< 0.150		< 0.220
TM-1	2/13/2001	1720	< 0.50	< 0.50	< 0.50			< 2.0	E 0.079	< 0.500
TM-1	3/12/2001	1050	< 0.50	< 0.50	< 0.50			< 2.0	E 0.055	< 0.500
TM-1	12/14/2001	1130	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-1	6/25/2002	600	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 5.000
TM-1	6/25/2002	1400	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 5.000
TM-1	6/25/2002	1730	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-1	2/26/2003	1830	< 0.50	< 0.50	< 0.50			E 0.120	< 0.50	< 0.500
TM-1	9/15/03	1800		< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-3	3/13/2000	1500				< 0.090	< 0.070	< 0.10		< 0.100
TM-3	4/26/2000	1630				< 0.090	< 0.070	0.171		< 0.100
TM-3	7/26/2000	1330				< 0.080	< 0.5	< 0.10		< 0.150
TM-3	9/13/2000	1545				< 0.080	< 0.5	< 0.10		< 0.220
TM-3	11/13/2000	1445				< 0.150	< 0.5	E 0.143		< 0.220
TM-3	2/13/2001	1330	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-3	3/12/2001	1625	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-3	12/14/2001	245	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-3	2/26/2003	1830	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-3	9/15/03	1530		< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-4	3/15/2000	1100				< 0.090	< 0.070	< 0.10		< 0.100
TM-4	4/26/2000	845				< 0.090	< 0.070	0.12		< 0.100
TM-4	7/25/2000	1620				< 0.080	< 0.5	< 0.10		< 0.150
TM-4	9/13/2000	750				< 0.080	< 0.5	< 0.10		< 0.220
TM-4	11/13/2000	1330				< 0.150	< 0.5	E 0.124		< 0.220
TM-4	2/14/2001	930	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-4	3/12/2001	1445	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-4	6/25/2002	600	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500

Appendix 2. Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[µg/L, micrograms per liter; --, no data; <, less than; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; *, censored; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol]

Site number (fig. 1)	Sample date	Sample time	1-methyl-napthalene (µg/L)	2-methyl-napthalene (µg/L)	2,6-Dimethyl-napthalene (µg/L)	2,6-Di-*tert*-butylphenol (µg/L)	2,6-Di-*tert*-*p*-benzoquinone (µg/L)	5-Methyl-1*H*-benzotriazole (µg/L)	AHTN (µg/L)	Acetophenone (µg/L)
TM-4	6/25/2002	1000	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-4	6/25/2002	1400	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-4	6/25/2002	1730	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
CEN	3/14/2000	1000				< 0.090	< 0.070	21.4		0.236
CEN	4/27/2000	1415				< 0.090	< 0.070	0.361		< 0.100
CEN	7/24/2000	1300				< 0.080	< 0.5	0.264		< 0.150
CEN	9/14/2000	1330				< 0.080	< 0.5	0.299		< 0.220
CEN	11/14/2000	1445				< 0.150	< 0.5	0.318		< 0.220
CEN	2/12/2001	1330	< 0.50	< 0.50	< 0.50			E 0.240	E 0.120	< 0.500
CEN	3/13/2001	800	< 0.50	< 0.50	< 0.50			< 2.0	E 0.110	< 0.500
CEN	10/31/2001	1345	< 0.50	< 0.50	< 0.50			E 0.590	E 0.110	< 0.500
TSB	3/14/2000	1400				< 0.090	< 0.070	< 0.10		0.125
TSB	4/26/2000	1205				< 0.090	< 0.070	0.144		< 0.100
TSB	7/24/2000	1500				< 0.080	< 0.5	< 0.10		< 0.150
TSB	9/13/2000	1030				< 0.080	< 0.5	< 0.10		< 0.220
TSB	11/15/2000	1400				< 0.150	< 0.5	0.164		< 0.220
TSB	2/12/2001	1615	< 0.50	< 0.50	< 0.50			< 2.0	E .053	< 0.500
TSB	3/13/2001	930	< 0.50	< 0.50	< 0.50			< 2.0	E 0.130	< 0.500
TSB	10/31/2001	1130	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-5	3/15/2000	100				< 0.090	< 0.070	< 0.10		0.122
TM-5	4/27/2000	915				< 0.090	< 0.070	< 0.10		< 0.100
TM-5	7/25/2000	1040				< 0.080	< 0.5	< 0.10		< 0.150
TM-5	9/14/2000	915				< 0.080	< 0.5	0.128		< 0.220
TM-5	11/16/2000	955				< 0.150	< 0.5	0.186		< 0.220
TM-5	2/13/2001	915	< 0.50	< 0.50	< 0.50			< 2.0	E 0.360	< 0.500
TM-5	3/13/2001	1730	< 0.50	< 0.50	< 0.50			< 2.0	E 0.250	< 0.500
TM-5	12/14/2001	1120	< 0.50	< 0.50	< 0.50			< 2.0	E 0.420	< 0.500
TM-5	6/25/2002	600	< 0.50	< 0.50	E 0.086			E 0.60	E 0.150	< 0.500
TM-5	6/25/2002	1400	< 0.50	< 0.50	< 0.50			< 2.0	< 0.50	< 0.500
TM-5	6/25/2002	1800	< 0.50	< 0.50	< 0.50			< 2.0	E 0.066	< 0.500
TM-5	2/26/2003	2015	< 0.50	< 0.50	< 0.50			< 2.0	E 0.270	< 0.500
TM-5	9/15/03	1400		< 0.50	< 0.50			< 2.0	E 0.16	E 0.09

Appendix 2. Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[μg/L, micrograms per liter; --, no data; <, less than; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; *, censored; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol]

Site number (fig. 1)	Sample date	Sample time	Anthracene (μg/L)	Atrazine (μg/L)	Benzo[*a*] pyrene (μg/L)	β-- sitosterol (μg/L)	BHA (μg/L)	BHT (μg/L)	Bromacil (μg/L)	Caffeine (μg/L)	Carbaryl (μg/L)	*cis*-chlordane (μg/L)
TM-1	3/13/2000	1100	< 0.050		< 0.050		< 0.120	< 0.080		E0.053	< 0.060	< 0.040
TM-1	4/25/2000	1430	< 0.050		< 0.050		< 0.120	< 0.080		0.083	E0.045	< 0.040
TM-1	7/26/2000	900	< 0.050		< 0.050		< 0.120	< 0.080		0.091	< 0.060	< 0.040
TM-1	9/12/2000	1300	< 0.050		0.054		< 0.120	< 0.080		E0.046	E0.047	< 0.040
TM-1	11/15/2000	845	< 0.060		< 0.070		< 0.120	< 0.110		E0.068	< 0.060	< 0.040
TM-1	2/13/2001	1720	< 0.50		< 0.50	< 2.0	< 5.000		E0.120	0.69	< 1.000	
TM-1	3/12/2001	1050	< 0.50		< 0.50	E 0.57	< 5.000		E0.047	0.74	< 1.000	
TM-1	12/14/2001	1130	E 0.160		< 0.50	< 2.0	< 5.000		< 0.500	< 0.500	< 1.000	
TM-1	6/25/2002	600	< 0.50	E0.066	< 0.50	< 2.0	< 5.000		E0.200	E0.077	< 1.000	
TM-1	6/25/2002	1400	< 0.50	E0.052	< 0.50	< 2.0	< 5.000		< 0.500	E0.072	< 1.000	
TM-1	6/25/2002	1730	< 0.50	E0.030	< 0.50	< 2.0	< 5.000		< 0.500	E0.110	< 1.000	
TM-1	2/26/2003	1830	< 0.50	E0.270	< 0.50	< 2.0	< 5.000		< 0.500	E0.130	< 1.000	
TM-1	9/15/03	1800	< 0.50	E0.050	< 0.50	< 2.0	< 5.000		< 0.500	E 0.02	< 1.000	
TM-3	3/13/2000	1500	< 0.050		< 0.050		< 0.120	< 0.080		0.094	< 0.060	< 0.040
TM-3	4/26/2000	1630	< 0.050		< 0.050		< 0.120	< 0.080		0.218	E0.062	< 0.040
TM-3	7/26/2000	1330	< 0.050		< 0.050		< 0.120	< 0.080		E0.069	< 0.060	< 0.040
TM-3	9/13/2000	1545	< 0.050		0.063		< 0.120	< 0.080		E0.064	E0.052	< 0.040
TM-3	11/13/2000	1445	< 0.060		< 0.070		< 0.120	< 0.110		0.169	< 0.060	< 0.040
TM-3	2/13/2001	1330	< 0.50		< 0.50	< 2.0	< 5.000		E0.110	E0.320	< 1.000	
TM-3	3/12/2001	1625	< 0.50		E 0.071	E 1.0	< 5.000		E0.150	E0.260	< 1.000	
TM-3	12/14/2001	245	< 0.50		E 0.054	E 1.1	< 5.000		E0.110	E0.160	< 1.000	
TM-3	2/26/2003	1830	< 0.50	E0.110	< 0.50	< 2.0	< 5.000		< 0.500	E0.074	< 1.000	
TM-3	9/15/03	1530	< 0.50	E 0.0470	< 0.50	< 2.0	< 5.000		< 0.500	E 0.03	< 1.000	
TM-4	3/15/2000	1100	< 0.050		< 0.050		< 0.120	< 0.080		E0.047	< 0.060	< 0.040
TM-4	4/26/2000	845	< 0.050		< 0.050		< 0.120	< 0.080		E0.063	E0.020	< 0.040
TM-4	7/25/2000	1620	< 0.050		< 0.050		< 0.120	< 0.080		E0.044	< 0.060	< 0.040
TM-4	9/13/2000	750	< 0.050		< 0.050		< 0.120	< 0.080		E0.067	< 0.060	< 0.040
TM-4	11/13/2000	1330	< 0.060		< 0.070		< 0.120	< 0.110		0.143	< 0.060	< 0.040
TM-4	2/14/2001	930	< 0.50		< 0.50	< 2.0	< 5.000		E0.150	E0.270	< 1.000	
TM-4	3/12/2001	1445	< 0.50		E 0.056	E 1.20	< 5.000		E0.064	E0.260	< 1.000	
TM-4	6/25/2002	600	< 0.50	E0.054	< 0.50	< 2.0	< 5.000		E0.280	E0.290	< 1.000	

Appendix 2. Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[µg/L, micrograms per liter; --, no data; <, less than; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; *, censored; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol]

Site number (fig. 1)	Sample date	Sample time	Anthracene (µg/L)	Atrazine (µg/L)	Benzo[*a*] pyrene (µg/L)	β–Sitosterol (µg/L)	BHA (µg/L)	BHT (µg/L)	Bromacil (µg/L)	Caffeine (µg/L)	Carbaryl (µg/L)	*cis*-chlordane (µg/L)
TM-4	6/25/2002	1000	< 0.50	E0.060	< 0.50	E 1.0	< 5.000		E0.240	E0.110	< 1.000	
TM-4	6/25/2002	1400	< 0.50	E0.070	< 0.50	E 0.65	< 5.000		E0.240	E0.120	< 1.000	
TM-4	6/25/2002	1730	< 0.50	E0.050	< 0.50	< 2.0	< 5.000		E0.260	E0.110	< 1.000	
CEN	3/14/2000	1000	< 0.050		< 0.050		< 0.120	< 0.080		3.04	< 0.060	< 0.040
CEN	4/27/2000	1415	< 0.050		< 0.050		< 0.120	< 0.080		1.35	< 0.060	< 0.040
CEN	7/24/2000	1300	< 0.050		< 0.050		< 0.120	< 0.080		4.26	< 0.060	< 0.040
CEN	9/14/2000	1330	< 0.050		< 0.050		< 0.120	< 0.080		6.63	< 0.060	< 0.040
CEN	11/14/2000	1445	< 0.060		< 0.070		< 0.120	< 0.110		2.2	< 0.060	< 0.040
CEN	2/12/2001	1330	< 0.50		< 0.50	E 2.60	< 5.000		< 0.500	9.8	< 1.000	
CEN	3/13/2001	800	< 0.50		< 0.50	E 1.50	< 5.000		E0.095	0.9	< 1.000	
CEN	10/31/2001	1345	< 0.50		< 0.50	2.2	< 5.000		< 0.500	2.6	< 1.000	
TSB	3/14/2000	1400	< 0.050		< 0.050		< 0.120	< 0.080		0.091	< 0.060	< 0.040
TSB	4/26/2000	1205	< 0.050		< 0.050		< 0.120	< 0.080		E0.048	< 0.060	< 0.040
TSB	7/24/2000	1500	< 0.050		< 0.050		< 0.120	< 0.080		0.336	< 0.060	< 0.040
TSB	9/13/2000	1030	< 0.050		0.06		< 0.120	< 0.080		0.163	< 0.060	< 0.040
TSB	11/15/2000	1400	< 0.060		< 0.070		< 0.120	< 0.110		0.159	< 0.060	< 0.040
TSB	2/12/2001	1615	< 0.50		< 0.50	< 2.0	< 5.000		E0.100	E0.100	< 1.000	
TSB	3/13/2001	930	< 0.50		< 0.50	E 1.80	< 5.000		E0.160	0.6	< 1.000	
TSB	10/31/2001	1130	< 0.50		< 0.50	E 1.60	< 5.000		E0.340	E0.300	< 1.000	
TM-5	3/15/2000	100	< 0.050		E 0.018		< 0.120	< 0.080		0.617	E0.040	< 0.040
TM-5	4/27/2000	915	< 0.050		< 0.050		< 0.120	< 0.080		E0.060	< 0.060	< 0.040
TM-5	7/25/2000	1040	< 0.050		< 0.050		< 0.120	< 0.080		0.103	< 0.060	< 0.040
TM-5	9/14/2000	915	< 0.050		< 0.050		< 0.120	< 0.080		0.127	< 0.060	< 0.040
TM-5	11/16/2000	955	< 0.060		< 0.070		< 0.120	< 0.110		0.273	< 0.060	< 0.040
TM-5	2/13/2001	915	< 0.50		< 0.50	< 2.0	< 5.000		E0.170	0.6	< 1.000	
TM-5	3/13/2001	1730	< 0.50		< 0.50	E 1.40	< 5.000		E0.170	E0.290	< 1.000	
TM-5	12/14/2001	1120	< 0.50		E 0.052	E 1.60	< 5.000		E0.140	0.53	< 1.000	
TM-5	6/25/2002	600	< 0.50	E0.042	E 0.150	E 3.80	< 5.000		E0.230	< 0.500	< 1.000	
TM-5	6/25/2002	1400	< 0.50	E0.080	< 0.50	< 2.0	< 5.000		E0.240	E0.070	< 1.000	
TM-5	6/25/2002	1800	< 0.50	E0.096	< 0.50	E 0.660	< 5.000		E0.260	E0.097	< 1.000	
TM-5	2/26/2003	2015	< 0.50	E0.095	< 0.50	< 2.0	< 5.000		< 0.500	E0.350	< 1.000	
TM-5	9/15/03	1400	< 0.50	0.64	< 0.50	< 2.0	< 5.000		< 0.500	E 0.18	< 1.000	

Appendix 2. Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[µg/L, micrograms per liter; --, no data; <, less than; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; *, censored; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol]

Site number (fig. 1)	Sample date	Sample time	Chlorpyrifos (µg/L)	Cholesterol (µg/L)	3β-coprostanol (µg/L)	Cotinine (µg/L)	Diazinon (µg/L)	Dieldrin (µg/L)	*N,N*-diethyl-*m*-toluamide (µg/L)	17β–estradiol (µg/L)	2-butoxy-ethanol phosphate (µg/L)
TM-1	3/13/2000	1100	< 0.020	E0.404	< 0.600	< 0.040	0.067	< 0.080	< 0.040	< 0.500	< 0.070
TM-1	4/25/2000	1430	< 0.020	E0.569	< 0.600	< 0.040	0.122	< 0.080	< 0.040	< 0.500	< 0.070
TM-1	7/26/2000	900	< 0.020	< 1.500	< 0.600	< 0.040	0.134	< 0.080	0.069	< 0.500	E0.164
TM-1	9/12/2000	1300	< 0.020	< 1.500	< 0.600	E0.013	0.096	< 0.080	0.042	< 0.500	< 0.200
TM-1	11/15/2000	845	< 0.020	< 1.500	< 0.600	< 0.080	0.034	< 0.080	< 0.080	< 0.500	< 0.200
TM-1	2/13/2001	1720	< 0.500	E 1.100	E0.360	< 1.000	E0.045		< 0.500	< 5.000	E0.340
TM-1	3/12/2001	1050	< 0.500	E0.700	< 2.000	< 1.000	E0.120		< 0.500	< 5.000	E0.260
TM-1	12/14/2001	1130	< 0.500	< 2.000	< 2.000	< 1.000	< 0.500		< 0.500	< 5.000	< 0.500
TM-1	6/25/2002	600	< 0.500	< 2.000	< 2.000	E0.100	E0.020		< 0.500	< 5.000	E0.230
TM-1	6/25/2002	1400	< 0.500	< 2.000	< 2.000	E0.120	E0.016		< 0.500	< 5.000	< 0.500
TM-1	6/25/2002	1730	< 0.500	E0.610	< 2.000	< 1.000	< 0.500		< 0.500	< 5.000	< 0.500
TM-1	2/26/2003	1830	< 0.500	E0.870	< 2.000	< 1.000	< 0.500		< 0.500	< 5.000	E0.370
TM-1	9/15/03	1800	< 5.000	< 2.000	< 2.000	< 1.000	< 0.500		E 0.05	< 5.000	< 0.5
TM-3	3/13/2000	1500	< 0.020	E0.368	< 0.600	< 0.040	0.086	< 0.080	E 0.038	< 0.500	< 0.070
TM-3	4/26/2000	1630	< 0.020	E 1.640	E0.800	< 0.040	0.307	< 0.080	0.05	< 0.500	0.397
TM-3	7/26/2000	1330	< 0.020	< 1.500	< 0.600	< 0.040	0.074	< 0.080	0.057	< 0.500	< 0.200
TM-3	9/13/2000	1545	< 0.020	< 1.500	< 0.600	< 0.040	0.088	< 0.080	0.047	E0.636	0.374
TM-3	11/13/2000	1445	< 0.020	< 1.500	< 0.600	< 0.080	0.05	< 0.080	E 0.056	< 0.500	< 0.200
TM-3	2/13/2001	1330	< 0.500	E0.580	< 2.000	< 1.000	< 0.500		< 0.500	< 5.000	E0.110
TM-3	3/12/2001	1625	< 0.500	E0.690	< 2.000	< 1.000	E0.150		< 0.500	< 5.000	E0.160
TM-3	12/14/2001	245	< 0.500	E 1.000	< 2.000	< 1.000	< 0.500		E 0.064	< 5.000	E0.250
TM-3	2/26/2003	1830	< 0.500	< 2.000	< 2.000	< 1.000	< 0.500		< 0.500	< 5.000	E0.470
TM-3	9/15/03	1530	< 5.000	< 2.000	< 2.000	< 1.000	< 0.500		E 0.05	< 5.000	< 0.5
TM-4	3/15/2000	1100	< 0.020	E0.467	< 0.600	< 0.040	0.056	< 0.080	< 0.040	< 0.500	0.477
TM-4	4/26/2000	845	< 0.020	E0.767	< 0.600	E0.010	0.062	< 0.080	E 0.019	< 0.500	0.269
TM-4	7/25/2000	1620	< 0.020	< 1.500	< 0.600	E0.025	0.089	< 0.080	0.056	< 0.500	< 0.200
TM-4	9/13/2000	750	< 0.020	< 1.500	< 0.600	< 0.040	0.108	< 0.080	E 0.040	< 0.500	< 0.200
TM-4	11/13/2000	1330	< 0.020	< 1.500	< 0.600	< 0.080	0.052	< 0.080	< 0.080	< 0.500	< 0.200
TM-4	2/14/2001	930	< 0.500	E0.560	< 2.000	< 1.000	E0.034		< 0.500	< 5.000	E0.200
TM-4	3/12/2001	1445	< 0.500	E 1.100	E0.400	< 1.000	E0.290		< 0.500	< 5.000	E0.150
TM-4	6/25/2002	600	< 0.500	E0.660	< 2.000	< 1.000	E0.047		< 0.500	< 5.000	0.71

Appendix 2. Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[µg/L, micrograms per liter; --, no data; <, less than; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; *, censored; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol]

Site number (fig. 1)	Sample date	Sample time	Chlorpyrifos (µg/L)	Cholesterol (µg/L)	3β-coprostanol (µg/L)	Cotinine (µg/L)	Diazinon (µg/L)	Dieldrin (µg/L)	*N,N*-diethyl-*m*-toluamide (µg/L)	17β-estradiol (µg/L)	2-butoxy-ethanol phosphate (µg/L)
TM-4	6/25/2002	1000	< 0.500	< 2.000	< 2.000	< 1.000	E0.047		< 0.500	< 5.000	0.61
TM-4	6/25/2002	1400	< 0.500	E0.630	< 2.000	< 1.000	E0.050		< 0.500	< 5.000	0.67
TM-4	6/25/2002	1730	< 0.500	E0.940	< 2.000	< 1.000	E0.038		< 0.500	< 5.000	0.74
CEN	3/14/2000	1000	< 0.020	E 6.810	E 4.420	0.469	0.173	< 0.080	0.175	< 0.500	4.12
CEN	4/27/2000	1415	< 0.020	E 4.860	E 3.020	0.075	0.163	< 0.080	0.086	< 0.500	2.04
CEN	7/24/2000	1300	< 0.020	E 2.240	E 1.150	0.224	0.03	< 0.080	1.89	< 0.500	3.05
CEN	9/14/2000	1330	< 0.020	E 1.990	< 0.600	0.19	0.067	< 0.080	0.074	< 0.500	4.41
CEN	11/14/2000	1445	< 0.020	E 4.670	E 3.020	0.138	0.044	< 0.080	E 0.058	< 0.500	1.47
CEN	2/12/2001	1330	< 0.500	E 7.000	E 5.400	E0.230	< 0.500		< 0.500	< 5.000	12
CEN	3/13/2001	800	< 0.500	E 2.500	E 1.500	< 1.000	E0.120		E 0.064	< 5.000	1.4
CEN	10/31/2001	1345	< 0.500	5.3	2.1	E0.088	< 0.500		E 0.180	< 5.000	1.1
TSB	3/14/2000	1400	< 0.020	E 1.710	E 1.090	0.053	< 0.030	< 0.080	E 0.036	< 0.500	0.168
TSB	4/26/2000	1205	< 0.020	E 1.190	E0.452	E0.020	< 0.030	< 0.080	E 0.035	< 0.500	0.171
TSB	7/24/2000	1500	< 0.020	E 1.310	E0.465	0.204	E0.024	< 0.080	0.432	< 0.500	0.614
TSB	9/13/2000	1030	< 0.020	< 1.500	< 0.600	0.05	E0.013	< 0.080	0.52	< 0.500	0.895
TSB	11/15/2000	1400	0.036	E 1.340	E0.864	< 0.080	< 0.030	< 0.080	< 0.080	E0.314	0.25
TSB	2/12/2001	1615	< 0.500	E0.990	E0.510	< 1.000	< 0.500		<0.500	< 5.000	E0.110
TSB	3/13/2001	930	< 0.500	E 5.600	E 4.100	< 1.000	E0.120		<0.500	< 5.000	E0.160
TSB	10/31/2001	1130	< 0.500	E 1.900	E0.850	E0.096	< 0.500		<0.500	< 5.000	E0.340
TM-5	3/15/2000	100	< 0.020	E 5.210	E 5.860	0.121	< 0.030	< 0.080	0.146	< 0.500	1.21
TM-5	4/27/2000	915	< 0.020	E0.737	E0.298	< 0.040	0.299	< 0.080	E 0.032	< 0.500	0.321
TM-5	7/25/2000	1040	< 0.020	E 1.120	E0.431	E0.037	0.035	< 0.080	0.145	< 0.500	0.631
TM-5	9/14/2000	915	< 0.020	< 1.500	< 0.600	< 0.040	0.057	< 0.080	0.067	< 0.500	0.614
TM-5	11/16/2000	955	< 0.020	E 2.180	E 1.860	< 0.080	0.205	< 0.080	E 0.043	< 0.500	1.18
TM-5	2/13/2001	915	< 0.500	E 6.200	E 3.900	< 1.000	E0.066		< 0.500	< 5.000	2.2
TM-5	3/13/2001	1730	< 0.500	E 3.100	E 2.000	< 1.000	E0.140		< 0.500	< 5.000	0.57
TM-5	12/14/2001	1120	< 0.500	3.4	E 1.800	< 1.000	< 0.500		E 0.076	< 5.000	2.3
TM-5	6/25/2002	600	< 0.500	E 6.800	E 4.100	E0.120	< 0.500		< 0.500	< 5.000	E0.540
TM-5	6/25/2002	1400	< 0.500	< 2.000	< 2.000	E0.100	E0.011		< 0.500	< 5.000	E0.290
TM-5	6/25/2002	1800	< 0.500	E 1.200	E0.380	E0.100	E0.017		< 0.500	< 5.000	E0.470
TM-5	2/26/2003	2015	< 0.500	E 2.500	E 2.100	< 1.000	< 0.500		E 0.065	< 5.000	E 2.200
TM-5	9/15/03	1400	< 5.000	E 1.4	E 1	< 1.000	< 0.500		E 0.12	< 5.000	0.6

Appendix 2. Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[µg/L, micrograms per liter; --, no data; <, less than; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; *, censored; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol]

Site number (fig. 1)	Sample date	Sample time	Fluoranthene (µg/L)	HHCB (µg/L)	Lindane (µg/L)	Metalaxyl (µg/L)	Methyl parathion (µg/L)	Metolachlor (µg/L)	Naphthalene (µg/L)
TM-1	3/13/2000	1100	E 0.019		< 0.050		< 0.060		E 0.017
TM-1	4/25/2000	1430	< 0.030		< 0.050		< 0.060		< 0.030
TM-1	7/26/2000	900	E 0.033		< 0.050		< 0.060		*
TM-1	9/12/2000	1300	< 0.020		< 0.050		< 0.060		0.021
TM-1	11/15/2000	845	< 0.030		< 0.050		< 0.060		< 0.025
TM-1	2/13/2001	1720	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
TM-1	3/12/2001	1050	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
TM-1	12/14/2001	1130	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
TM-1	6/25/2002	600	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
TM-1	6/25/2002	1400	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
TM-1	6/25/2002	1730	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
TM-1	2/26/2003	1830	E 0.069	< 0.50		< 0.500		< 0.500	< 0.50
TM-1	9/15/03	1800	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
TM-3	3/13/2000	1500	0.059		< 0.050		< 0.060		E 0.027
TM-3	4/26/2000	1630	0.098		< 0.050		< 0.060		E 0.030
TM-3	7/26/2000	1330	E 0.055		< 0.050		< 0.060		*
TM-3	9/13/2000	1545	0.046		< 0.050		< 0.060		0.022
TM-3	11/13/2000	1445	E 0.029		< 0.050		< 0.060		0.031
TM-3	2/13/2001	1330	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
TM-3	3/12/2001	1625	E 0.160	< 0.50		< 0.500		< 0.500	E 0.120
TM-3	12/14/2001	245	E 0.099	< 0.50		< 0.500		< 0.500	< 0.50
TM-3	2/26/2003	1830	E 0.086	< 0.50		< 0.500		< 0.500	< 0.50
TM-3	9/15/03	1530	E 0.02	< 0.50		< 0.500		< 0.500	< 0.50
TM-4	3/15/2000	1100	0.038		< 0.050		< 0.060		< 0.030
TM-4	4/26/2000	845	E 0.043		< 0.050		< 0.060		< 0.030
TM-4	7/25/2000	1620	E 0.036		< 0.050		< 0.060		*
TM-4	9/13/2000	750	E 0.028		< 0.050		< 0.060		< 0.020
TM-4	11/13/2000	1330	< 0.030		< 0.050		< 0.060		< 0.025
TM-4	2/14/2001	930	E 0.190	< 0.50		< 0.500		< 0.500	< 0.50
TM-4	3/12/2001	1445	E 0.160	< 0.50		< 0.500		< 0.500	E 0.054
TM-4	6/25/2002	600	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50

Appendix 2. Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[µg/L, micrograms per liter; --, no data; <, less than; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; *, censored; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol]

Site number (fig. 1)	Sample date	Sample time	Fluoranthene (µg/L)	HHCB (µg/L)	Lindane (µg/L)	Metalaxyl (µg/L)	Methyl parathion (µg/L)	Metolachlor (µg/L)	Naphthalene (µg/L)
TM-4	6/25/2002	1000	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
TM-4	6/25/2002	1400	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
TM-4	6/25/2002	1730	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
CEN	3/14/2000	1000	0.105		< 0.050		< 0.060		< 0.030
CEN	4/27/2000	1415	0.076		< 0.050		< 0.060		< 0.030
CEN	7/24/2000	1300	E 0.104		< 0.050		< 0.060		*
CEN	9/14/2000	1330	0.055		< 0.050		< 0.060		*
CEN	11/14/2000	1445	0.065		< 0.050		< 0.060		< 0.025
CEN	2/12/2001	1330	< 0.50	E 0.060		< 0.500		< 0.500	< 0.50
CEN	3/13/2001	800	< 0.50	E 0.048		< 0.500		< 0.500	< 0.50
CEN	10/31/2001	1345	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
TSB	3/14/2000	1400	0.038		< 0.050		< 0.060		< 0.030
TSB	4/26/2000	1205	< 0.030		< 0.050		< 0.060		< 0.030
TSB	7/24/2000	1500	E 0.030		< 0.050		< 0.060		*
TSB	9/13/2000	1030	0.287		< 0.050		< 0.060		*
TSB	11/15/2000	1400	0.047		< 0.050		< 0.060		E 0.024
TSB	2/12/2001	1615	< 0.50	< 0.50		< 0.500		< 0.500	E 0.090
TSB	3/13/2001	930	< 0.50	E 0.120		< 0.500		< 0.500	E 0.082
TSB	10/31/2001	1130	< 0.50	< 0.50		< 0.500		< 0.500	< 0.50
TM-5	3/15/2000	100	0.093		< 0.050		< 0.060		< 0.030
TM-5	4/27/2000	915	< 0.030		< 0.050		< 0.060		< 0.030
TM-5	7/25/2000	1040	E 0.040		< 0.050		< 0.060		*
TM-5	9/14/2000	915	E 0.029		< 0.050		< 0.060		< 0.020
TM-5	11/16/2000	955	< 0.030		< 0.050		< 0.060		< 0.025
TM-5	2/13/2001	915	E 0.069	E 0.190		< 0.500		< 0.500	< 0.50
TM-5	3/13/2001	1730	< 0.50	E 0.130		< 0.500		< 0.500	< 0.50
TM-5	12/14/2001	1120	< 0.50	E 0.130		< 0.500		< 0.500	< 0.50
TM-5	6/25/2002	600	E 0.210	E 0.058		< 0.500		< 0.500	< 0.50
TM-5	6/25/2002	1400	< 0.50	< 0.50		< 0.500		E 0.014	< 0.50
TM-5	6/25/2002	1800	< 0.50	< 0.50		< 0.500		E 0.020	< 0.50
TM-5	2/26/2003	2015	< 0.50	E 0.100		< 0.500		< 0.500	< 0.50
TM-5	9/15/03	1400	E 0.02	E0.05		< 0.500		E 0.3	< 0.50

Appendix 2. Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[µg/L, micrograms per liter; --, no data; <, less than; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; *, censored; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol]

Site number (fig. 1)	Sample date	Sample time	*para-* nonylphenol (total) (µg/L)	NP1EO (µg/L)	NP2EO (µg/L)	OP1EO (µg/L)	OP2EO (µg/L)	*para-* cresol (µg/L)	Phenanthrene (µg/L)	Prometon (µg/L)
TM-1	3/13/2000	1100	< 0.500	< 1.0	< 1.100	< 0.100	< 0.200	< 0.030	< 0.060	
TM-1	4/25/2000	1430	< 0.500	< 11.0	< 1.100	< 0.100	< 0.200	< 0.030	< 0.060	
TM-1	7/26/2000	900	E 0.767	E 1.010	< 1.100	E 0.053	< 0.200	< 0.030	E 0.021	
TM-1	9/12/2000	1300	< 0.500	E 0.949	< 1.100	E 0.066	< 0.200	< 0.060	< 0.060	
TM-1	11/15/2000	845	< 0.700	< 1.0	< 1.100	< 0.120	< 0.200	< 0.060	< 0.050	
TM-1	2/13/2001	1720	< 5.000		< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	< 0.500
TM-1	3/12/2001	1050	< 5.000		< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	< 0.500
TM-1	12/14/2001	1130	< 5.000		< 5.000	< 1.000	< 1.000	< 1.0	E 0.150	< 0.500
TM-1	6/25/2002	600	< 5.000	< 5.0	< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	< 0.500
TM-1	6/25/2002	1400	< 5.000	< 5.0	< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	< 0.500
TM-1	6/25/2002	1730	< 5.000	< 5.0	< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	< 0.500
TM-1	2/26/2003	1830	< 5.000	E 0.820	E 3.700	E 0.630	< 1.000	< 1.0	E 0.051	< 0.500
TM-1	9/15/03	1800	< 5.000		< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	< 0.500
TM-3	3/13/2000	1500	< 0.500	< 1.0	< 1.100	< 0.100	< 0.200	< 0.030	E 0.028	
TM-3	4/26/2000	1630	< 0.500	< 1.10	< 1.100	< 0.100	< 0.200	< 0.030	0.067	
TM-3	7/26/2000	1330	E 0.706	< 1.0	< 1.100	E 0.042	< 0.200	< 0.030	E 0.035	
TM-3	9/13/2000	1545	E 0.864	E 1.150	< 1.100	< 0.100	< 0.200	< 0.060	E 0.023	
TM-3	11/13/2000	1445	E 0.272	E 0.368	< 1.100	E 0.127	< 0.200	E 0.036	< 0.050	
TM-3	2/13/2001	1330	< 5.000		< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	< 0.500
TM-3	3/12/2001	1625	< 5.000		< 5.000	< 1.000	< 1.000	< 1.0	E 0.092	< 0.500
TM-3	12/14/2001	245	< 5.000		< 5.000	< 1.000	< 1.000	< 1.0	E 0.10	< 0.500
TM-3	2/26/2003	1830	< 5.000	< 5.0	< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	< 0.500
TM-3	9/15/03	1530	< 5.000		< 5.000	< 1.000	< 1.000	< 1.0	E 0.02	< 0.500
TM-4	3/15/2000	1100	< 0.500	< 1.0	< 1.100	< 0.100	< 0.200	< 0.030	< 0.060	
TM-4	4/26/2000	845	< 0.500	< 1.10	< 1.100	< 0.100	< 0.200	< 0.030	E 0.026	
TM-4	7/25/2000	1620	E 0.789	E 1.020	< 1.100	E 0.076	< 0.200	< 0.030	< 0.060	
TM-4	9/13/2000	750	< 0.500	< 1.0	< 1.100	< 0.100	< 0.200	< 0.060	< 0.060	
TM-4	11/13/2000	1330	E 0.232	E 0.435	< 1.100	E 0.108	< 0.200	< 0.060	< 0.050	
TM-4	2/14/2001	930	< 5.000		< 5.000	< 1.000	< 1.000	< 1.0	E 0.073	< 0.500
TM-4	3/12/2001	1445	< 5.000		< 5.000	< 1.000	< 1.000	< 1.0	E 0.10	< 0.500
TM-4	6/25/2002	600	< 5.000	< 5.0	< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	E 0.018

Appendix 2. Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[µg/L, micrograms per liter; --, no data; <, less than; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; *, censored; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol]

Site number (fig. 1)	Sample date	Sample time	*para*-nonylphenol (total) (µg/L)	NP1EO (µg/L)	NP2EO (µg/L)	OP1EO (µg/L)	OP2EO (µg/L)	*para*-cresol (µg/L)	Phenanthrene (µg/L)	Prometon (µg/L)
TM-4	6/25/2002	1000	< 5.000	< 5.0	< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	E 0.013
TM-4	6/25/2002	1400	< 5.000	< 5.0	< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	E 0.020
TM-4	6/25/2002	1730	< 5.000	< 5.0	< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	E 0.023
CEN	3/14/2000	1000	E 3.330	E 4.910	E 5.340	< 0.100	< 0.200	0.112	E 0.028	
CEN	4/27/2000	1415	E 1.030	E 2.460	E 2.460	< 0.100	< 0.200	0.053	< 0.060	
CEN	7/24/2000	1300	E 1.150	E 1.56	E 2.990	E0.095	< 0.200	E 0.058	E 0.027	
CEN	9/14/2000	1330	E 1.220	E 1.890	E 1.460	E0.159	< 0.200	0.241	E 0.023	
CEN	11/14/2000	1445	E0.952	E 2.610	E 5.970	E0.268	< 0.200	0.213	< 0.050	
CEN	2/12/2001	1330	E 1.200		E 2.800	< 1.000	< 1.000	1.4	< 0.50	E 0.021
CEN	3/13/2001	800	E0.520		E0.770	< 1.000	< 1.000	< 1.0	< 0.50	E 0.059
CEN	10/31/2001	1345	E 1.100		E 4.800	< 1.000	< 1.000	< 1.0	< 0.50	E 0.048
TSB	3/14/2000	1400	< 0.500	< 1.0	< 1.100	< 0.100	< 0.200	0.11	< 0.060	
TSB	4/26/2000	1205	< 0.500	E 0.372	< 1.100	< 0.100	< 0.200	0.065	< 0.060	
TSB	7/24/2000	1500	E0.882	E 1.270	E0.748	E0.112	< 0.200	E 0.052	E 0.030	
TSB	9/13/2000	1030	E0.877	< 1.0	< 1.100	E0.134	< 0.200	< 0.060	E 0.047	
TSB	11/15/2000	1400	E0.340	E 0.876	< 1.100	E0.206	< 0.200	E 0.052	< 0.050	
TSB	2/12/2001	1615	< 5.000		E0.890	< 1.000	< 1.000	E 0.610	< 0.50	< 0.500
TSB	3/13/2001	930	< 5.000		< 5.000	< 1.000	< 1.000	E 0.160	< 0.50	< 0.500
TSB	10/31/2001	1130	< 5.000		< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	< 0.500
TM-5	3/15/2000	100	E 3.300	E 3.430	E 3.920	< 0.100	< 0.200	E 0.020	< 0.060	
TM-5	4/27/2000	915	< 0.500	< 1.10	< 1.100	< 0.100	< 0.200	< 0.030	< 0.060	
TM-5	7/25/2000	1040	E0.825	E 1.070	E 1.190	E0.071	< 0.200	< 0.030	< 0.060	
TM-5	9/14/2000	915	E0.921	E 1.210	E 1.160	E0.082	< 0.200	< 0.060	< 0.060	
TM-5	11/16/2000	955	E 1.030	E 1.280	E 2.480	E0.149	< 0.200	E 0.032	< 0.050	
TM-5	2/13/2001	915	E 2.400		E 3.200	< 1.000	< 1.000	< 1.0	< 0.50	< 0.500
TM-5	3/13/2001	1730	E 1.400		E 1.400	< 1.000	< 1.000	< 1.0	< 0.50	< 0.500
TM-5	12/14/2001	1120	E0.840		E 2.900	< 1.000	< 1.000	< 1.0	< 0.50	< 0.500
TM-5	6/25/2002	600	E 1.500	E 0.510	E 1.600	< 1.000	< 1.000	E 0.140	E 0.080	< 0.500
TM-5	6/25/2002	1400	< 5.000	< 5.0	< 5.000	< 1.000	< 1.000	< 1.0	< 0.50	E 0.010
TM-5	6/25/2002	1800	< 5.000	< 5.0	E 1.400	< 1.000	< 1.000	< 1.0	< 0.50	E 0.024
TM-5	2/26/2003	2015	E 1.100	E 1.20	E 5.100	E0.760	E0.130	< 1.0	< 0.50	< 0.500
TM-5	9/15/03	1400	E 0.5		E 1.7	< 1.000	< 1.000	< 1.0	E 0.02	< 0.500

Appendix 2. Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[µg/L, micrograms per liter; --, no data; <, less than; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; *, censored; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol]

Site number (fig. 1)	Sample date	Sample time	Pyrene (µg/L)	Stigmastanol (µg/L)	Triclosan (µg/L)	Tri(2-chloroethyl) phosphate (µg/L)	Tri(2-chloroiso-propyl)phosphate (µg/L)	Triphenyl phosphate (µg/L)
TM-1	3/13/2000	1100	< 0.030	< 2.0	< 0.040	< 0.040	< 0.100	< 0.100
TM-1	4/25/2000	1430	< 0.030	< 2.0	< 0.040	< 0.040	< 0.100	< 0.100
TM-1	7/26/2000	900	E 0.019	< 2.0	0.092	0.066	E 0.072	< 0.100
TM-1	9/12/2000	1300	< 0.030	< 2.0	< 0.040	0.052	< 0.100	< 0.100
TM-1	11/15/2000	845	< 0.030	< 2.0	E 0.048	< 0.040	< 0.100	< 0.100
TM-1	2/13/2001	1720	*	< 2.0	E 0.089	E 0.071	< 0.500	E 0.051
TM-1	3/12/2001	1050	< 0.50	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-1	12/14/2001	1130	< 0.50	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-1	6/25/2002	600	< 0.50	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-1	6/25/2002	1400	< 0.50	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-1	6/25/2002	1730	< 0.50	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-1	2/26/2003	1830	< 0.50	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-1	9/15/03	1800	< 0.50	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-3	3/13/2000	1500	E 0.030	< 2.0	< 0.040	< 0.040	< 0.100	< 0.100
TM-3	4/26/2000	1630	0.06	< 2.0	0.079	0.044	< 0.100	E 0.062
TM-3	7/26/2000	1330	E 0.031	< 2.0	0.072	0.059	E 0.072	< 0.100
TM-3	9/13/2000	1545	0.035	< 2.0	0.064	0.058	E 0.064	< 0.100
TM-3	11/13/2000	1445	< 0.030	< 2.0	E 0.043	< 0.040	< 0.100	< 0.100
TM-3	2/13/2001	1330	< 0.50	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-3	3/12/2001	1625	E 0.130	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-3	12/14/2001	245	E 0.058	< 2.0	< 1.000	< 0.500	E 0.091	E 0.055
TM-3	2/26/2003	1830	E 0.061	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-3	9/15/03	1530	E 0.009	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-4	3/15/2000	1100	E 0.020	< 2.0	< 0.040	< 0.040	< 0.100	< 0.100
TM-4	4/26/2000	845	E 0.026	< 2.0	< 0.040	< 0.040	< 0.100	E 0.020
TM-4	7/25/2000	1620	E 0.020	< 2.0	0.075	0.06	E 0.075	< 0.100
TM-4	9/13/2000	750	E 0.020	< 2.0	< 0.040	0.052	< 0.100	< 0.100
TM-4	11/13/2000	1330	< 0.030	< 2.0	E 0.033	< 0.040	< 0.100	< 0.100
TM-4	2/14/2001	930	E 0.130	< 2.0	< 1.000	< 0.500	< 0.500	E 0.082
TM-4	3/12/2001	1445	E 0.120	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-4	6/25/2002	600	< 0.50	< 2.0	< 1.000	E 0.067	< 0.500	< 0.500

Appendix 2. Table 2-2. Concentrations of selected organic wastewater compounds detected at sites in the Threemile Creek basin, Mobile, Alabama, 2000–2003.—Continued

[µg/L, micrograms per liter; --, no data; <, less than; E, estimated; AHTN, 6-acetyl-1,1,2,4,4,7-hexamethyltetraline; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; HHCB, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl-cyclopenta(g)-2-benzopyran; *, censored; NP1EO, monoethoxylate nonylphenol; NP2EO, diethoxylate nonylphenol; OP1EO, monoethoxylate octylphenol; OP2EO, diethoxylate octylphenol]

Site number (fig. 1)	Sample date	Sample time	Pyrene (µg/L)	Stigmastanol (µg/L)	Triclosan (µg/L)	Tri(2-chloroethyl) phosphate (µg/L)	Tri(2-chloroiso-propyl)phosphate (µg/L)	Triphenyl phosphate (µg/L)
TM-4	6/25/2002	1000	< 0.50	< 2.0	< 1.000	E0.058	< 0.500	< 0.500
TM-4	6/25/2002	1400	< 0.50	< 2.0	< 1.000	E0.062	< 0.500	< 0.500
TM-4	6/25/2002	1730	< 0.50	< 2.0	< 1.000	E0.057	< 0.500	< 0.500
CEN	3/14/2000	1000	0.063	E 0.597	0.894	0.31	< 0.100	E0.085
CEN	4/27/2000	1415	0.049	< 2.0	0.221	0.064	< 0.100	E0.062
CEN	7/24/2000	1300	E 0.067	< 2.0	0.18	0.138	0.181	< 0.100
CEN	9/14/2000	1330	0.049	< 2.0	0.214	0.211	0.214	< 0.100
CEN	11/14/2000	1445	0.047	< 2.0	0.346	E0.038	< 0.100	< 0.100
CEN	2/12/2001	1330	< 0.50	< 2.0	E0.280	< 0.500	< 0.500	< 0.500
CEN	3/13/2001	800	< 0.50	< 2.0	E0.130	< 0.500	E0.063	< 0.500
CEN	10/31/2001	1345	< 0.50	< 2.0	E0.290	< 0.500	< 0.500	< 0.500
TSB	3/14/2000	1400	E 0.024	< 2.0	0.085	< 0.040	< 0.100	E0.036
TSB	4/26/2000	1205	< 0.030	< 2.0	0.084	< 0.040	< 0.100	E0.031
TSB	7/24/2000	1500	E 0.025	< 2.0	0.1	0.072	E0.099	< 0.100
TSB	9/13/2000	1030	0.217	< 2.0	0.077	0.057	E0.077	< 0.100
TSB	11/15/2000	1400	0.033	< 2.0	0.085	E0.035	< 0.100	< 0.100
TSB	2/12/2001	1615	< 0.50	< 2.0	E0.087	< 0.500	< 0.500	< 0.500
TSB	3/13/2001	930	< 0.50	< 2.0	E0.200	< 0.500	< 0.500	< 0.500
TSB	10/31/2001	1130	< 0.50	< 2.0	E0.110	< 0.500	< 0.500	< 0.500
TM-5	3/15/2000	100	0.053	E 0.801	0.5	0.123	< 0.100	E0.053
TM-5	4/27/2000	915	< 0.030	< 2.0	0.046	< 0.040	< 0.100	< 0.100
TM-5	7/25/2000	1040	E 0.030	< 2.0	0.095	0.066	E0.092	< 0.100
TM-5	9/14/2000	915	E 0.025	< 2.0	0.074	0.064	E0.074	< 0.100
TM-5	11/16/2000	955	< 0.030	< 2.0	0.125	0.065	< 0.100	< 0.100
TM-5	2/13/2001	915	E 0.059	< 2.0	E0.230	E0.053	E0.080	< 0.500
TM-5	3/13/2001	1730	< 0.50	< 2.0	E0.140	< 0.500	E0.054	< 0.500
TM-5	12/14/2001	1120	< 0.50	< 2.0	E0.180	E0.062	E0.130	E0.055
TM-5	6/25/2002	600	E 0.180	E 1.100	E0.120	E0.053	< 0.500	< 0.500
TM-5	6/25/2002	1400	< 0.50	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-5	6/25/2002	1800	< 0.50	< 2.0	< 1.000	< 0.500	< 0.500	< 0.500
TM-5	2/26/2003	2015	< 0.50	< 2.0	E0.180	E0.060	E0.082	< 0.500
TM-5	9/15/03	1400	E 0.01	< 2.0	E 0.06	E 0.06	E 0.06	E 0.01

Appendix 3. Table 3-1. Benthic invertebrate taxa, percent abundance of each taxon, and total abundance at selected sites in Threemile Creek, Mobile, Alabama, July 2000.

BU_ID	Sites				
	TM-1 (percent)	TM-2 (percent)	TM-3 (percent)	TM-4 (percent)	TM-4 replicate (percent)
Worms: flatworms, ribbon worms, roundworms, and annelids					
Turbellaria	0.907	1.96	61.8	0.945	
Prostoma sp.	18.4		0.139		
Nematoda			0.277	0.314	0.267
Megadrile	0.907				
Naididae	0.305	1.13	0.139	0.314	1.61
Tubificidae		0.279			
TOTAL	20.519	3.369	62.355	1.573	1.877
Snails (Gastropods)					
Prosobranchia		0.023	1.99	2.83	1.07
Ferrissia sp.		0.928	0.001		
Hydrobiidae		5.15	0.284		
Stagnicola sp.		2.81	0.567		
Physella sp.	0.305	2.34	0.142		
Planorbella sp.		0.023	2.70		
TOTAL	0.305	11.274	5.68	2.83	1.07
Clams (Bivalves)					
Corbicula sp.	1.20	5.06	0.416	45.6	1.61
Mites					
Acari		6.46	0.139	0.628	0.267
Springtails					
Collembola		2.52	0.139		
Mayflies					
Caenis sp.	0.009	28.1	1.94		34.6
Tricorythodes sp.	0.305	0.056			1.07
Centroptilum/Procloeon sp.		0.302			
Paracloeodes minutus (Daggy)		10.0		0.004	0.267
Pseudocloeon sp.		0.603			
TOTAL	0.314	39.061	1.94	0.004	35.937

Appendix 3. Table 3-1. Benthic invertebrate taxa, percent abundance of each taxon, and total abundance at selected sites in Threemile Creek, Mobile, Alabama, July 2000.—Continued

BU_ID	Sites				
	TM-1 (percent)	TM-2 (percent)	TM-3 (percent)	TM-4 (percent)	TM-4 replicate (percent)
Dragonflies					
Argia sp.		0.669	0.056		0.555
Enallagma sp.		1.00	0.083		0.833
Gomphidae			17.6		45.0
Erythemis simplicicollis (Say)			0.294	1.57	
TOTAL		1.669	18.033	1.57	46.388
Giant water bugs					
Belostoma flumineum Say		0.557			
Water strider					
Trepobates sp.		1.13		40.2	
Veliidae		0.557			
TOTAL		1.687		40.2	
Caddisflies					
Hydroptila sp.		1.96			
Cheumatopsyche sp.	1.83				
Hydropsyche rossi Flint, Voshell, and Parker/*simulans* Ross	48.0				
Oecetis sp.				0.628	
Orthotrichia sp.			0.692		
Oxyethira sp.		4.78	0.139	0.004	
TOTAL	49.83	6.74	0.831	0.632	
Butterflies					
Lepidoptera		0.557			0.267
Water beetles					
Peltodytes sp.		2.24	0.139		
Biting midges					
Bezzia/Palpomyia sp.		3.09	1.73	0.329	0.535

Appendix 3. Table 3-1. Benthic invertebrate taxa, percent abundance of each taxon, and total abundance at selected sites in Threemile Creek, Mobile, Alabama, July 2000.—Continued

BU_ID	Sites				
	TM-1 (percent)	TM-2 (percent)	TM-3 (percent)	TM-4 (percent)	TM-4 replicate (percent)
Midges					
Cryptochironomus sp.				3.12	
Dicrotendipes sp.	0.671	5.02	0.170	0.346	0.949
Parachironomus sp.	2.69				
Paracladopelma sp.			1.52		
Polypedilum sp.	1.01	1.67		0.346	1.58
Saetheria sp.			0.339		
Pseudochironomus sp.		0.289			
Micropsectra/Tanytarsus sp.					0.280
Tanytarsus sp.		0.289	0.170		0.280
Cricotopus/Orthocladius sp.	12.0	0.384			
Cricotopus bicinctus group	1.90	0.384			
Nanocladius sp.		1.56	1.10	0.346	
Thienemanniella sp.	7.91				
Tvetenia sp.	1.58				
Clinotanypus sp.		0.910			
Thienemannimyia group sp. (Coffman and Ferrington, 1996)				0.484	
Ablabesmyia sp.		0.573	0.324	1.46	1.69
Labrundinia sp.		0.573	0.648	0.484	0.560
Larsia sp.		4.04	4.38		0.560
TOTAL	27.761	15.692	8.651	6.586	5.899
Mosquitoes					
Culex sp.					6.17
Total abundance	**11,100**	**7,180**	**84,900**	**28,000**	**25,100**

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
TM-1 9/12/2000 Subsample Identifier A			
Cosmarium punctulatum Bréb.	Green algae	1.88%	40.30%
Stigeoclonium lubricum (Dillw.) Kütz.	Green algae	3.76%	16.79%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.77%	12.10%
Gomphonema patrickii Kociolek & Stoermer	Diatoms	3.06%	10.08%
Euglena sp.	Euglenoids	0.88%	3.35%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	4.34%	2.43%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	57.13%	2.34%
Gomphonema augur var. turris (Ehr.) Lange-Bert.	Diatoms	0.68%	2.24%
Navicula leptostriata Jorg.	Diatoms	1.62%	1.36%
Trachelomonas volvocina Ehr.	Euglenoids	0.33%	1.12%
Nitzschia amphibia Grun.	Diatoms	1.87%	1.08%
Cymbella gracilis (Ehr.) Kütz.	Diatoms	0.85%	1.03%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	5.28%	0.94%
Nitzschia intermedia Hantz. ex Cl. et Grun.	Diatoms	0.26%	0.59%
Hydrocoleum brebissonii Kütz.	Blue-green algae	8.62%	0.54%
Navicula cryptocephala Kütz.	Diatoms	0.43%	0.41%
Fragilaria crotonensis Kitton	Diatoms	0.43%	0.39%
Navicula trivialis Lange-Bert.	Diatoms	0.13%	0.37%
Encyonema minutum (Hilse) Mann	Diatoms	0.60%	0.35%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.43%	0.34%
Gomphonema minutum (Ag.) Ag.	Diatoms	0.34%	0.33%
Navicula veneta Kütz.	Diatoms	0.94%	0.29%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.17%	0.23%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.77%	0.21%
Cyclotella atomus Hust.	Diatoms	0.51%	0.11%
Cosmarium granatum Bréb. ex Ralfs	Green algae	0.44%	0.09%
Euastrum ciastonii Raciborski	Green algae	0.44%	0.09%
Caloneis bacillum (Grun.) Cl.	Diatoms	0.09%	0.09%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	0.17%	0.07%
Scenedesmus ecornis (Ralfs) Chod.	Green algae	0.88%	0.06%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample Cell density (cells/cm^2)	Percentage of sample Biovolume (µm^3/cm^2)
Navicula minima Grun.	Diatoms	0.43%	0.06%
Nitzschia dissipata (Kütz.) Grun.	Diatoms	0.09%	0.06%
Navicula decussis Østr.	Diatoms	0.09%	0.05%
Amphora pediculus (Kütz) Grun.	Diatoms	0.09%	0.03%
Navicula seminulum Grun.	Diatoms	0.09%	0.03%
Closterium gracile Bréb.	Green algae	0.11%	0.02%
Achnanthes lanceolata var. frequentissima Lange-Bert.	Diatoms	0.09%	0.01%
Nitzschia archibaldii Lange-Bertalot	Diatoms	0.98%	0.00%
Totals (cell density and biovolume)		684,273	270,816,652
TM-1 9/12/2000 Subsample Identifier B			
Gomphonema patrickii Kociolek & Stoermer	Diatoms	12.52%	38.91%
Cosmarium punctulatum Bréb.	Green algae	1.29%	26.24%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.61%	9.16%
Euglena sp.	Euglenoids	1.01%	3.61%
Gomphonema augur var. turris (Ehr.) Lange-Bert.	Diatoms	0.86%	2.67%
Calothrix parientina (Näg.) Thuret	Blue-green algae	12.66%	2.35%
Nitzschia amphibia Grun.	Diatoms	3.93%	2.14%
Fragilaria crotonensis Kitton	Diatoms	2.46%	2.10%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	44.03%	1.70%
Ankistrodesmus falcatus (Corda) Ralfs	Green algae	0.86%	1.58%
Trachelomonas cylindrica Ehr.	Euglenoids	0.43%	1.55%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	2.46%	1.30%
Encyonopsis microcephala (Grun.) Kram.	Diatoms	0.25%	1.09%
Encyonema minutum (Hilse) Mann	Diatoms	1.84%	1.03%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	5.40%	0.91%
Navicula leptostriata Jorg.	Diatoms	0.86%	0.68%
Trachelomonas volvocina Ehr.	Euglenoids	0.14%	0.46%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	1.11%	0.46%
Navicula notha Wallace	Diatoms	0.98%	0.35%
Navicula cryptocephala Kütz.	Diatoms	0.37%	0.33%
Achnanthes exigua var. heterovalva Krasske	Diatoms	1.23%	0.31%
Nitzschia intermedia Hantz. ex Cl. et Grun.	Diatoms	0.12%	0.27%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Cymbella affinis Kütz.	Diatoms	0.12%	0.15%
Hydrocoleum brebissonii Kütz.	Blue-green algae	2.45%	0.15%
Cymbella gracilis (Ehr.) Kütz.	Diatoms	0.12%	0.14%
Caloneis bacillum (Grun.) Cl.	Diatoms	0.12%	0.13%
Gomphonema kobayasii Kociolek & Kingston	Diatoms	0.25%	0.06%
Cosmarium granatum Bréb. ex Ralfs	Green algae	0.29%	0.06%
Navicula minima Grun.	Diatoms	0.37%	0.05%
Navicula veneta Kütz.	Diatoms	0.12%	0.04%
Cyclotella atomus Hust.	Diatoms	0.12%	0.03%
Navicula subminuscula Mang.	Diatoms	0.12%	0.02%
Nitzschia archibaldii Lange-Bertalot	Diatoms	0.49%	0.00%
Totals (cell density and biovolume)		269,421	112,899,700
TM-1 9/12/2000 Subsample Identifier C			
Gomphonema patrickii Kociolek & Stoermer	Diatoms	7.24%	34.78%
Cosmarium punctulatum Bréb.	Green algae	0.86%	26.80%
Calothrix parientina (Näg.) Thuret	Blue-green algae	40.46%	11.60%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.28%	6.34%
Pinnularia brebissonii (Kütz.) Rabh.	Diatoms	0.09%	2.54%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	2.48%	2.02%
Nitzschia amphibia Grun.	Diatoms	2.29%	1.93%
Fragilaria crotonensis Kitton	Diatoms	1.38%	1.82%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	5.23%	1.36%
Euglena sp.	Euglenoids	0.24%	1.35%
Hydrocoleum brebissonii Kütz.	Blue-green algae	13.69%	1.26%
Gomphonema minutum (Ag.) Ag.	Diatoms	0.73%	1.05%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	16.38%	0.98%
Encyonema minutum (Hilse) Mann	Diatoms	0.92%	0.79%
Encyonopsis microcephala (Grun.) Kram.	Diatoms	0.09%	0.63%
Navicula notha Wallace	Diatoms	1.10%	0.60%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.28%	0.55%
Achnanthes exigua var. heterovalva Krasske	Diatoms	1.19%	0.47%
Navicula leptostriata Jorg.	Diatoms	0.37%	0.45%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Gomphonema augur var. turris (Ehr.) Lange-Bert.	Diatoms	0.09%	0.44%
Cymbella gracilis (Ehr.) Kütz.	Diatoms	0.18%	0.32%
Nitzschia intermedia Hantz. ex Cl. et Grun.	Diatoms	0.09%	0.31%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	0.46%	0.29%
Caloneis bacillum (Grun.) Cl.	Diatoms	0.18%	0.29%
Staurastrum alternans Bréb.	Green algae	0.73%	0.23%
Navicula minima Grun.	Diatoms	0.92%	0.18%
Cymbella affinis Kütz.	Diatoms	0.09%	0.17%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.09%	0.11%
Nitzschia acicularis (Kützing) Smith	Diatoms	0.18%	0.10%
Navicula veneta Kütz.	Diatoms	0.18%	0.08%
Navicula seminulum Grun.	Diatoms	0.09%	0.04%
Staurastrum manfeldtii Delponte	Green algae	0.12%	0.04%
Gomphonema kobayasii Kociolek & Kingston	Diatoms	0.09%	0.03%
Achnanthes pusilla (Grun.) DeT.	Diatoms	0.09%	0.03%
Nitzschia archibaldii Lange-Bertalot	Diatoms	1.10%	0.00%
Totals (cell density and biovolume)		425,803	115,452,882
TM-1 8/8/2001 Subsample Identifier A			
Stigeoclonium lubricum (Dillw.) Kütz.	Green algae	53.58%	81.04%
Cosmarium punctulatum Bréb.	Green algae	0.09%	5.74%
Cosmarium botrytes Meneghini	Green algae	0.09%	3.25%
Calothrix parientina (Näg.) Thuret	Blue-green algae	16.88%	2.43%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.10%	2.26%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	7.94%	1.66%
Trachelomonas volvocina Ehr.	Euglenoids	0.28%	1.46%
Fragilaria crotonensis Kitton	Diatoms	0.62%	0.75%
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	20.09%	0.55%
Frustulia rhomboides var. capitata (A. Mayer) Patr.	Diatoms	0.01%	0.40%
Gomphonema subclavatum var. mexicanum (Grun. in V. H.) Patr.	Diatoms	0.04%	0.22%
Encyonema prostratum (Berkeley) Kützing	Diatoms	0.01%	0.10%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.06%	0.05%
Nitzschia amphibia Grun.	Diatoms	0.06%	0.04%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Encyonema minutum (Hilse) Mann	Diatoms	0.04%	0.03%
Cosmarium regnellii Wille	Green algae	0.09%	0.03%
Totals (cell density and biovolume)		1,162,458	322,141,004
TM-1 8/8/2001 Subsample Identifier B			
Stigeoclonium lubricum (Dillw.) Kütz.	Green algae	58.66%	76.44%
Oedogonium sp.	Green algae	0.34%	19.73%
Closterium venus Kützing	Green algae	0.04%	1.15%
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	37.86%	0.89%
Fragilaria crotonensis Kitton	Diatoms	0.85%	0.89%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	2.00%	0.36%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.02%	0.29%
Gomphonema subclavatum var. mexicanum (Grun. in V. H.) Patr.	Diatoms	0.03%	0.13%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.07%	0.05%
Encyonema minutum (Hilse) Mann	Diatoms	0.06%	0.04%
Pleurotaenium baculoides var. brevius (Skuja) Krieger	Green algae	0.04%	0.01%
Navicula notha Wallace	Diatoms	0.01%	0.01%
Nitzschia amphibia Grun.	Diatoms	0.02%	0.01%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.01%	0.00%
Totals (cell density and biovolume)		1,410,146	453,544,187
TM-1 8/8/2001 Subsample Identifier C			
Stigeoclonium lubricum (Dillw.) Kütz.	Green algae	81.26%	94.65%
Cosmarium botrytes Meneghini	Green algae	0.09%	2.53%
Fragilaria crotonensis Kitton	Diatoms	0.85%	0.80%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	4.00%	0.64%
Trachelomonas volvocina Ehr.	Euglenoids	0.09%	0.38%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.02%	0.29%
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	13.27%	0.28%
Gomphonema subclavatum var. mexicanum (Grun. in V. H.) Patr.	Diatoms	0.05%	0.20%
Encyonema minutum (Hilse) Mann	Diatoms	0.10%	0.06%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.09%	0.06%
Navicula notha Wallace	Diatoms	0.06%	0.05%
Eunotia bilunaris (Ehrenberg) Mills	Diatoms	0.02%	0.04%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Penium margaritaceum (Ehrenberg) Brébisson	Green algae	0.09%	0.02%
Navicula cryptotenella L.B. in Kramm. & L.-B.	Diatoms	0.01%	0.01%
Totals (cell density and biovolume)		561,144	201,930,133
TM-1 9/19/2002 Subsample Identifier A			
Oedogonium sp.	Green algae	4.85%	49.00%
Synedra ulna (Nitz.) Ehr.	Diatoms	8.89%	28.38%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	45.03%	7.11%
Eunotia formica Ehrenberg	Diatoms	0.78%	3.63%
Gomphonema gracile Ehr. emend. V. H.	Diatoms	3.30%	2.17%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	2.96%	1.84%
Brachysira brebissonii Ross	Diatoms	0.31%	1.28%
Cymbella tumida (Brébisson ex Kützing) Van Heurck	Diatoms	0.62%	0.96%
Cymbella mesiana Cholnoky	Diatoms	0.62%	0.73%
Frustulia rhomboides var. capitata (A. Mayer) Patr.	Diatoms	0.31%	0.68%
Encyonema minutum (Hilse) Mann	Diatoms	5.46%	0.61%
Eunotia incisa Smith ex Gregory	Diatoms	2.34%	0.57%
Eunotia pectinalis var. undulata (Ralfs) Rabenhorst	Diatoms	0.31%	0.56%
Gomphonema angustatum (Kütz.) Rabh.	Diatoms	2.10%	0.41%
Gomphonema subclavatum var. mexicanum (Grun. in V. H.) Patr.	Diatoms	0.94%	0.41%
Fragilaria vaucheriae (Kützing) Petersen	Diatoms	3.28%	0.39%
Eunotia implicata Nörpel, Lange-Bert. & Alles	Diatoms	0.94%	0.38%
Cymbella gracilis (Ehr.) Kütz.	Diatoms	1.72%	0.33%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	10.92%	0.25%
Navicula notha Wallace	Diatoms	1.40%	0.13%
Gomphonema kobayasii Kociolek & Kingston	Diatoms	0.90%	0.09%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	0.78%	0.05%
Achnanthes deflexa Reimer	Diatoms	0.47%	0.02%
Scenedesmus quadricauda (Turp.) Bréb.	Diatoms	0.61%	0.01%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.16%	0.01%
Totals (cell density and biovolume)		155,694	283,757,242
TM-1 9/19/2002 Subsample Identifier B			
Closterium moniliferum Ehrenberg	Green algae	1.32%	58.64%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Synedra ulna (Nitz.) Ehr.	Diatoms	8.15%	23.27%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	38.05%	4.85%
Eunotia formica Ehrenberg	Diatoms	0.57%	2.38%
Eunotia soleirolii (Kütz.) Rabh.	Diatoms	2.00%	1.76%
Frustulia rhomboides var. capitata (A. Mayer) Patr.	Diatoms	0.72%	1.65%
Encyonema silesiacum (Bleisch) Mann	Diatoms	2.29%	1.36%
Encyonema minutum (Hilse) Mann	Diatoms	7.72%	0.77%
Synedra acus Kützing	Diatoms	0.86%	0.60%
Brachysira brebissonii Ross	Diatoms	0.14%	0.53%
Gomphonema gracile Ehr. emend. V. H.	Diatalgaeoms	0.92%	0.49%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	0.86%	0.48%
Eunotia incisa Smith ex Gregory	Diatoms	1.86%	0.41%
Navicula notha Wallace	Diatoms	3.29%	0.28%
Encyonopsis microcephala (Grun.) Kram.	Diatoms	0.29%	0.26%
Microspora sp.	Green algae	6.94%	0.26%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	5.58%	0.25%
Gomphonema affine Kütz.	Diatoms	0.31%	0.20%
Gomphonema aff. affine ANS NAWQA EAM	Diatoms	0.31%	0.20%
Eunotia minor (Kützing) Grunow	Diatoms	0.43%	0.20%
Cymbella tumida (Brébisson ex Kützing) Van Heurck	Diatoms	0.14%	0.20%
Eunotia pectinalis var. undulata (Ralfs) Rabenhorst	Diatoms	0.14%	0.20%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	7.72%	0.16%
Cymbella gracilis (Ehr.) Kütz.	Diatoms	0.86%	0.15%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	3.97%	0.07%
Navicula cryptocephala Kütz.	Diatoms	0.43%	0.07%
Nitzschia intermedia Hantz. ex Cl. et Grun.	Diatoms	0.14%	0.07%
Nitzschia amphibia Grun.	Diatoms	0.57%	0.05%
Cosmarium pseudoretusum Ducellier	Green algae	0.99%	0.04%
Gomphonema kobayasii Kociolek & Kingston	Diatoms	0.46%	0.04%
Fragilaria vaucheriae (Kützing) Petersen	Diatoms	0.29%	0.03%
Caloneis bacillum (Grun.) Cl.	Diatoms	0.14%	0.03%
Gomphonema angustatum (Kütz.) Rabh.	Diatoms	0.15%	0.02%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	**Biovolume (µm^3/cm^2)**
Micrasterias radiosa Ralfs	Green algae	0.33%	0.01%
Staurastrum dickiei Ralfs	Green algae	0.33%	0.01%
Nitzschia acicularis (Kützing) Smith	Diatoms	0.14%	0.01%
Fragilaria famelica (Kützing) Lange-Bertalot	Diatoms	0.29%	0.01%
Achnanthidium exiguum var. heterovalvum (Krasske) Czarnecki	Diatoms	0.14%	0.01%
Achnanthidium pyrenaicum (Hustedt) Kobayasi	Diatoms	0.14%	0.01%
Totals (cell density and biovolume)		207,044	421,819,680
TM-1 9/19/2002 Subsample Identifier C			
Closterium moniliferum Ehrenberg	Green algae	1.29%	54.53%
Synedra ulna (Nitz.) Ehr.	Diatoms	10.05%	27.24%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	37.51%	4.41%
Encyonema silesiacum (Bleisch) Mann	Diatoms	4.87%	2.74%
Gomphonema gracile Ehr. emend. V. H.	Diatoms	4.87%	2.38%
Eunotia formica Ehrenberg	Diatoms	0.31%	1.24%
Cymbella mesiana Cholnoky	Diatoms	0.94%	0.94%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	1.57%	0.83%
Encyonema minutum (Hilse) Mann	Diatoms	6.59%	0.63%
Synedra acus Kützing	Diatoms	0.94%	0.62%
Gomphonema patrickii Kociolek & Stoermer	Diatoms	4.39%	0.57%
Brachysira brebissonii Ross	Diatoms	0.16%	0.55%
Eunotia incisa Smith ex Gregory	Diatoms	2.35%	0.49%
Eunotia minor (Kützing) Grunow	Diatoms	0.94%	0.42%
Frustulia rhomboides var. capitata (A. Mayer) Patr.	Diatoms	0.16%	0.29%
Cymbella tumidula Grunow ex Schmidt	Diatoms	0.31%	0.27%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	5.34%	0.23%
Navicula notha Wallace	Diatoms	2.83%	0.22%
Eunotia pectinalis var. undulata (Ralfs) Rabenhorst	Diatoms	0.16%	0.20%
Navicula viridula var. linearis Hustedt	Diatoms	0.31%	0.20%
Cymbella gracilis (Ehr.) Kütz.	Diatoms	0.94%	0.15%
Encyonopsis microcephala (Grun.) Kram.	Diatoms	0.16%	0.14%
Lyngbya sp. 1 ANS FWA	Blue-green algae	1.62%	0.13%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	6.12%	0.12%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Gomphonema turris Ehrenberg	Diatoms	0.16%	0.10%
Navicula cryptocephala Kütz.	Diatoms	0.47%	0.07%
Cymbella delicatula Kützing	Diatoms	0.31%	0.05%
Cymbella laevis Naegeli ex Kützing	Diatoms	0.16%	0.04%
Cosmarium margaritatum (Lund) Roy & Biss.	Green algae	0.97%	0.04%
Caloneis bacillum (Grun.) Cl.	Diatoms	0.16%	0.03%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	0.97%	0.02%
Navicula kotschyi Grunow	Diatoms	0.16%	0.02%
Fragilaria vaucheriae (Kützing) Petersen	Diatoms	0.16%	0.02%
Nitzschia amphibia Grun.	Diatoms	0.16%	0.01%
Micrasterias radiosa Ralfs	Green algae	0.32%	0.01%
Pediastrum tetras var. tetraodon (Corda) Rabenhorst	Green algae	0.32%	0.01%
Navicula cincta var. rostrata Reim.	Diatoms	0.16%	0.01%
Achnanthidium pyrenaicum (Hustedt) Kobayasi	Diatoms	0.31%	0.01%
Achnanthidium exiguum var. heterovalvum (Krasske) Czarnecki	Diatoms	0.16%	0.01%
Ankistrodesmus falcatus (Corda) Ralfs	Green algae	0.32%	0.01%
Totals (cell density and biovolume)		131,594	282,242,996
TM-2 8/8/2001 Subsample Identifier A			
Stigeoclonium lubricum (Dillw.) Kütz.	Green algae	28.13%	60.29%
Unknown *Chlorophyte coccoid*	Green algae	24.48%	36.31%
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	44.61%	1.73%
Oscillatoria princeps Vauch.	Blue-green algae	2.12%	0.79%
Fragilaria crotonensis Kitton	Diatoms	0.21%	0.36%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.18%	0.20%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.01%	0.17%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	0.23%	0.07%
Capartogramma crucicula (Grun. ex Cl.) Ross	Diatoms	0.00%	0.02%
Navicula cryptotenella L.B. in Kramm. & L.-B.	Diatoms	0.01%	0.02%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	0.00%	0.01%
Gomphonema rhombicum Fricke	Diatoms	0.00%	0.01%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.00%	0.00%
Cymbella affinis Kütz.	Diatoms	0.00%	0.00%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Fragilaria nanana Lange-Bertalot	Diatoms	0.00%	0.00%
Placoneis elginensis (Greg.) Cox	Diatoms	0.00%	0.00%
Nitzschia gracilis Hantz. ex Rabh.	Diatoms	0.00%	0.00%
Nitzschia amphibia Grun.	Diatoms	0.00%	0.00%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	0.00%	0.00%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	0.00%	0.00%
Navicula capitata var. hungarica (Grun.) Ross	Diatoms	0.00%	0.00%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.00%	0.00%
Totals (cell density and biovolume)		1,282,191	250,761,405
TM-2 8/8/2001 Subsample Identifier B			
Spirogyra sp.	Green algae	0.28%	41.82%
Stigeoclonium lubricum (Dillw.) Kütz.	Green algae	43.52%	34.27%
Unknown *Chlorophyte coccoid*	Green algae	42.83%	23.35%
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	12.48%	0.18%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.34%	0.14%
Fragilaria crotonensis Kitton	Diatoms	0.20%	0.12%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.00%	0.03%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	0.30%	0.03%
Placoneis clementis (Grun) Cox	Diatoms	0.00%	0.02%
Navicula cryptotenella L.B. in Kramm. & L.-B.	Diatoms	0.01%	0.01%
Cymbella affinis Kütz.	Diatoms	0.00%	0.00%
Gomphonema rhombicum Fricke	Diatoms	0.01%	0.00%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.01%	0.00%
Navicula viridula var. linearis Hustedt	Diatoms	0.00%	0.00%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	0.00%	0.00%
Eunotia bilunaris (Ehrenberg) Mills	Diatoms	0.00%	0.00%
Encyonema minutum (Hilse) Mann	Diatoms	0.01%	0.00%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	0.00%	0.00%
Fragilaria nanana Lange-Bertalot	Diatoms	0.00%	0.00%
Nitzschia amphibia Grun.	Diatoms	0.00%	0.00%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.00%	0.00%
Amphora inariensis Krammer	Diatoms	0.00%	0.00%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	**Biovolume (µm^3/cm^2)**
Achnanthes lanceolata var. rostrata Hust.	Diatoms	0.00%	0.00%
Totals (cell density and biovolume)		520,802	277,201,953
TM-2 8/8/2001 Subsample Identifier C			
Unknown *Chlorophyte coccoid*	Green algae	35.57%	61.77%
Oedogonium sp.	Green algae	0.16%	17.17%
Stigeoclonium lubricum (Dillw.) Kütz.	Green algae	5.89%	14.77%
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	56.80%	2.57%
Mougeotia sp.	Green algae	0.06%	1.91%
Fragilaria crotonensis Kitton	Diatoms	0.48%	0.97%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.27%	0.35%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	0.67%	0.23%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.00%	0.09%
Navicula cryptotenella L.B. in Kramm. & L.-B.	Diatoms	0.02%	0.04%
Cymbella affinis Kütz.	Diatoms	0.01%	0.03%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.01%	0.02%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	0.01%	0.01%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	0.01%	0.01%
Encyonema minutum (Hilse) Mann	Diatoms	0.01%	0.01%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.00%	0.01%
Placoneis elginensis (Greg.) Cox	Diatoms	0.00%	0.01%
Asterionella formosa Hassal	Diatoms	0.00%	0.01%
Gomphonema rhombicum Fricke	Diatoms	0.00%	0.01%
Eunotia exigua (Bréb. ex Kütz.) Rabh.	Diatoms	0.01%	0.01%
Fragilaria nanana Lange-Bertalot	Diatoms	0.01%	0.00%
Nitzschia amphibia Grun.	Diatoms	0.00%	0.00%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.01%	0.00%
Cymbella hustedtii Krass.	Diatoms	0.00%	0.00%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	0.00%	0.00%
Totals (cell density and biovolume)		1,153,306	192,693,059
TM-2 9/19/2002 Subsample Identifier A			
Closterium moniliferum Ehrenberg	Green algae	0.97%	72.14%
Synedra ulna (Nitz.) Ehr.	Diatoms	1.33%	6.34%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Brachysira brebissonii Ross	Diatoms	0.74%	4.54%
Craticula submolesta (Hustedt) Lange-Bertalot	Diatoms	0.44%	2.73%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	61.42%	2.08%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	5.16%	1.22%
Encyonema silesiacum (Bleisch) Mann	Diatoms	1.18%	1.17%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	5.02%	1.05%
Eunotia formica Ehrenberg	Diatoms	0.15%	1.03%
Navicula viridula var. linearis Hustedt	Diatoms	0.88%	0.99%
Placoneis clementis (Grun) Cox	Diatoms	0.15%	0.91%
Cymbella tumidula Grunow ex Schmidt	Diatoms	0.59%	0.87%
Gomphonema gracile Ehr. emend. V. H.	Diatoms	0.81%	0.71%
Navicula notha Wallace	Diatoms	3.68%	0.52%
Frustulia rhomboides var. capitata (A. Mayer) Patr.	Diatoms	0.15%	0.48%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	0.44%	0.41%
Navicula cryptocephala Kütz.	Diatoms	1.33%	0.37%
Eunotia pectinalis var. undulata (Ralfs) Rabenhorst	Diatoms	0.15%	0.34%
Encyonema minutum (Hilse) Mann	Diatoms	1.47%	0.25%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	1.03%	0.22%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.44%	0.19%
Achnanthidium exilis (Kützing) Round et Bukhtiyarova	Diatoms	0.15%	0.18%
Fragilaria vaucheriae (Kützing) Petersen	Diatoms	0.88%	0.16%
Nitzschia capitellata Hustedt	Diatoms	0.44%	0.14%
Nitzschia amphibia Grun.	Diatoms	0.88%	0.13%
Geissleria decussis (Hustedt) Lange-Bertalot et Metzeltin	Diatoms	0.59%	0.12%
Gomphonema patrickii Kociolek & Stoermer	Diatoms	0.49%	0.11%
Microspora sp.	Green algae	1.62%	0.10%
Lyngbya sp. 1 ANS FWA	Blue-green algae	0.65%	0.09%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	2.27%	0.07%
Achnanthidium pyrenaicum (Hustedt) Kobayasi	Diatoms	1.03%	0.06%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	0.74%	0.06%
Achnanthes minutissima var. scotica (Carter) Lange-Bertalot	Diatoms	0.44%	0.04%
Gomphonema angustatum (Kütz.) Rabh.	Diatoms	0.16%	0.04%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Tabellaria flocculosa (Roth) Kütz.	Diatoms	0.15%	0.04%
Anabaena oscillarioides Bory	Blue-green algae	0.65%	0.03%
Cosmarium margaritatum (Lund) Roy & Biss.	Green algae	0.32%	0.02%
Achnanthidium exiguum var. heterovalvum (Krasske) Czarnecki	Diatoms	0.15%	0.02%
Planothidium rostratum (Østrup) Lange-Bertalot	Diatoms	0.15%	0.01%
Psammothidium subatomoides (Hustedt) Bukhtiyarova et Round	Diatoms	0.15%	0.01%
Navicula minima Grun.	Diatoms	0.29%	0.01%
Encyonopsis microcephala (Grun.) Kram.	Diatoms	0.15%	0.01%
Navicula arvensis Hust.	Diatoms	0.15%	0.01%
Totals (cell density and biovolume)		234,068	284,588,201
TM-2 9/19/2002 Subsample Identifier B			
Spirogyra sp.	Green algae	12.39%	91.51%
Closterium moniliferum Ehrenberg	Green algae	0.31%	2.56%
Brachysira brebissonii Ross	Diatoms	1.41%	0.97%
Synedra ulna (Nitz.) Ehr.	Diatoms	1.55%	0.83%
Frustulia rhomboides var. capitata (A. Mayer) Patr.	Diatoms	1.97%	0.72%
Eunotia formica Ehrenberg	Diatoms	0.56%	0.44%
Eunotia incisa Smith ex Gregory	Diatoms	9.73%	0.40%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	14.30%	0.34%
Encyonema silesiacum (Bleisch) Mann	Diatoms	2.82%	0.31%
Cymbella turgidula Grunow	Diatoms	2.54%	0.21%
Eunotia implicata Nörpel, Lange-Bert. & Alles	Diatoms	2.82%	0.19%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	1.83%	0.19%
Eunotia pectinalis var. undulata (Ralfs) Rabenhorst	Diatoms	0.56%	0.14%
Nitzschia sigma (Kütz.) W. Sm.	Diatoms	0.14%	0.14%
Gomphonema gracile Ehr. emend. V. H.	Diatoms	0.95%	0.09%
Neidium ampliatum (Ehr.) Kramm.	Diatoms	0.14%	0.09%
Cymbella mesiana Cholnoky	Diatoms	0.42%	0.08%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	21.28%	0.08%
Cymbella tumida (Brébisson ex Kützing) Van Heurck	Diatoms	0.28%	0.07%
Encyonema minutum (Hilse) Mann	Diatoms	3.52%	0.07%
Capartogramma crucicula (Grun. ex Cl.) Ross	Diatoms	0.42%	0.06%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	**Biovolume (µm^3/cm^2)**
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	2.26%	0.05%
Pinnularia gibba Ehrenberg	Diatoms	0.28%	0.04%
Hippodonta capitata (Ehrenberg) Lange-Bertalot, Metzeltin et Witkowski	Diatoms	0.14%	0.04%
Hippodonta lueneburgensis (Grunow) Lange-Bertalot, Metzeltin et Witkowski	Diatoms	0.14%	0.04%
Synedra acus Kützing	Diatoms	0.28%	0.04%
Pinnularia microstauron (Ehr.) Cl.	Diatoms	0.28%	0.03%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	3.66%	0.03%
Geissleria decussis (Hustedt) Lange-Bertalot et Metzeltin	Diatoms	1.27%	0.03%
Cymbella gracilis (Ehr.) Kütz.	Diatoms	0.85%	0.03%
Gomphonema patrickii Kociolek & Stoermer	Diatoms	0.95%	0.03%
Navicula cryptocephala Kütz.	Diatoms	0.70%	0.02%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.42%	0.02%
Achnanthidium exilis (Kützing) Round et Bukhtiyarova	Diatoms	0.14%	0.02%
Navicula notha Wallace	Diatoms	0.99%	0.02%
Fragilaria vaucheriae (Kützing) Petersen	Diatoms	0.70%	0.01%
Cosmarium margaritatum (Lund) Roy & Biss.	Green algae	1.55%	0.01%
Caloneis bacillum (Grun.) Cl.	Diatoms	0.28%	0.01%
Cymbella naviculiformis Auerswald ex Héribaud	Diatoms	0.70%	0.01%
Cymbella hustedtii Krass.	Diatoms	0.28%	0.01%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	1.55%	0.01%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.14%	0.00%
Achnanthidium pyrenaicum (Hustedt) Kobayasi	Diatoms	0.42%	0.00%
Planothidium rostratum (Østrup) Lange-Bertalot	Diatoms	0.28%	0.00%
Planothidium delicatulum (Kützing) Round et Bukhtiyarova	Diatoms	0.14%	0.00%
Euastrum ciastonii Raciborski	Green algae	0.31%	0.00%
Eunotia exigua (Bréb. ex Kütz.) Rabh.	Diatoms	0.14%	0.00%
Staurosirella pinnata (Ehrenberg) Williams et Round	Diatoms	0.14%	0.00%
Encyonopsis microcephala (Grun.) Kram.	Diatoms	0.28%	0.00%
Achnanthidium exiguum var. heterovalvum (Krasske) Czarnecki	Diatoms	0.42%	0.00%
Anabaena oscillarioides Bory	Blue-green algae	0.31%	0.00%
Totals (cell density and biovolume)		128,796	1,407,183,322

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
TM-2 9/19/2002 Subsample Identifier C			
Spirogyra sp.	Green algae	2.69%	84.03%
Brachysira brebissonii Ross	Diatoms	1.43%	4.16%
Synedra ulna (Nitz.) Ehr.	Diatoms	1.59%	3.58%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	12.69%	1.26%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	47.15%	0.75%
Eunotia incisa Smith ex Gregory	Diatoms	3.98%	0.69%
Encyonema minutum (Hilse) Mann	Diatoms	8.60%	0.68%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	1.43%	0.63%
Cymbella mesiana Cholnoky	Diatoms	0.64%	0.53%
Encyonema silesiacum (Bleisch) Mann	Diatoms	1.11%	0.52%
Eunotia implicata Nörpel, Lange-Bert. & Alles	Diatoms	1.75%	0.50%
Nupela sp. 1 ANS NEW JERSEY KCP	Diatoms	0.16%	0.46%
Eunotia pectinalis var. undulata (Ralfs) Rabenhorst	Diatoms	0.32%	0.38%
Gomphonema gracile Ehr. emend. V. H.	Diatoms	0.67%	0.28%
Cymbella turgidula Grunow	Diatoms	0.80%	0.27%
Hippodonta capitata (Ehrenberg) Lange-Bertalot, Metzeltin et Witkowski	Diatoms	0.16%	0.18%
Navicula notha Wallace	Diatoms	1.75%	0.12%
Capartogramma crucicula (Grun. ex Cl.) Ross	Diatoms	0.16%	0.10%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	0.80%	0.08%
Pinnularia microstauron (Ehr.) Cl.	Diatoms	0.16%	0.07%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	2.07%	0.07%
Navicula cryptocephala Kütz.	Diatoms	0.48%	0.06%
Geissleria decussis (Hustedt) Lange-Bertalot et Metzeltin	Diatoms	0.64%	0.06%
Nitzschia intermedia Hantz. ex Cl. et Grun.	Diatoms	0.16%	0.06%
Nitzschia amphibia Grun.	Diatoms	0.80%	0.06%
Cymbella hustedtii Krass.	Diatoms	0.64%	0.06%
Gomphonema patrickii Kociolek & Stoermer	Diatoms	0.50%	0.05%
Fragilaria vaucheriae (Kützing) Petersen	Diatoms	0.64%	0.05%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.32%	0.04%
Cosmarium granatum Bréb. ex Ralfs	Green algae	1.01%	0.03%
Achnanthidium pyrenaicum (Hustedt) Kobayasi	Diatoms	1.11%	0.03%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.16%	0.03%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	1.68%	0.02%
Cymbella gracilis (Ehr.) Kütz.	Diatoms	0.16%	0.02%
Cymbella naviculiformis Auerswald ex Héribaud	Diatoms	0.32%	0.02%
Staurosirella pinnata (Ehrenberg) Williams et Round	Diatoms	0.32%	0.02%
Brachysira microcephala (Grunow) CompËre	Diatoms	0.16%	0.02%
Planothidium rostratum (Østrup) Lange-Bertalot	Diatoms	0.32%	0.01%
Achnanthidium exiguum var. heterovalvum (Krasske) Czarnecki	Diatoms	0.32%	0.01%
Achnanthes subhudsonis var. kraeuselii (Cholnoky) Cholnoky	Diatoms	0.16%	0.00%
Totals (cell density and biovolume)		269,452	696,521,447
TM-3 9/13/2000 Subsample Identifier A			
Oscillatoria princeps Vauch.	Blue-green algae	15.80%	16.18%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.45%	16.17%
Hydrocoleum brebissonii Kütz.	Blue-green algae	25.56%	13.43%
Gomphonema patrickii Kociolek & Stoermer	Diatoms	1.41%	10.58%
Cymbella affinis Kütz.	Diatoms	2.24%	6.48%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	0.64%	5.51%
Mougeotia sp.	Green algae	0.15%	4.37%
Melosira varians Ag.	Diatoms	0.13%	3.95%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	35.79%	3.35%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	1.02%	1.86%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	3.71%	1.51%
Eunotia soleirolii (Kütz.) Rabh.	Diatoms	0.13%	1.32%
Fragilaria crotonensis Kitton	Diatoms	0.58%	1.19%
Capartogramma crucicula (Grun. ex Cl.) Ross	Diatoms	0.13%	1.18%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	0.77%	1.15%
Navicula notha Wallace	Diatoms	1.28%	1.09%
Encyonema minutum (Hilse) Mann	Diatoms	0.77%	1.04%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	0.96%	0.96%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.70%	0.90%
Nitzschia linearis (Ag. ex W. Sm.) W. Sm.	Diatoms	0.06%	0.86%
Navicula schroeteri var. symmetrica (Patrick) Lang.-Bert.	Diatoms	0.13%	0.85%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm, micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Encyonopsis microcephala (Grun.) Kram.	Diatoms	0.06%	0.68%
Diadesmis confervacea Kütz.	Diatoms	0.38%	0.64%
Trachelomonas volvocina Ehr.	Euglenoids	0.08%	0.60%
Nitzschia amphibia Grun.	Diatoms	0.45%	0.59%
Navicula molestiformis Hust.	Diatoms	0.70%	0.50%
Nitzschia fonticola Grun.	Diatoms	0.70%	0.39%
Navicula germanii Wallace	Diatoms	0.13%	0.38%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	0.06%	0.35%
Nitzschia intermedia Hantz. ex Cl. et Grun.	Diatoms	0.06%	0.34%
Navicula laevissima Kütz.	Diatoms	0.06%	0.27%
Luticola mutica (Kutz.) Mann	Diatoms	0.06%	0.24%
Anabaena oscillarioides Bory	Blue-green algae	1.86%	0.24%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.32%	0.20%
Merismopedia glauca (Ehr.) Näg.	Blue-green algae	0.62%	0.19%
Cosmarium quadrum Lundell	Green algae	0.31%	0.15%
Navicula decussis Østr.	Diatoms	0.06%	0.09%
Navicula seminulum Grun.	Diatoms	0.06%	0.05%
Navicula veneta Kütz.	Diatoms	0.06%	0.05%
Cosmarium granatum Bréb. ex Ralfs	Green algae	0.08%	0.04%
Navicula reichardtiana Lange-Bert.	Diatoms	0.06%	0.03%
Achnanthes lanceolata var. frequentissima Lange-Bert.	Diatoms	0.06%	0.02%
Navicula minima Grun.	Diatoms	0.06%	0.02%
Navicula caterva Hohn & Hellerm.	Diatoms	1.09%	0.00%
Nitzschia archibaldii Lange-Bertalot	Diatoms	0.19%	0.00%
Totals (cell density and biovolume)		6,381,257	1,104,512,224
TM-3 9/13/2000 Subsample Identifier B			
Oedogonium sp.	Green algae	1.12%	64.19%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.71%	6.24%
Hydrocoleum brebissonii Kütz.	Blue-green algae	34.79%	5.10%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	2.33%	4.89%
Navicula arvensis DW WHTRV 98/99	Diatoms	0.41%	4.28%
Gomphonema patrickii Kociolek & Stoermer	Diatoms	1.32%	2.41%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Cymbella affinis Kütz.	Diatoms	2.94%	2.07%
Mougeotia sp.	Green algae	0.22%	1.53%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	1.93%	0.85%
Eunotia soleirolii (Kütz.) Rabh.	Diatoms	0.30%	0.76%
Melosira varians Ag.	Diatoms	0.10%	0.76%
Onychonema filiforme (Ehr.) Roy & Biss.	Green algae	6.13%	0.73%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	26.98%	0.61%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	0.41%	0.56%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	4.77%	0.47%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	1.22%	0.45%
Navicula notha Wallace	Diatoms	2.13%	0.44%
Gomphonema affine Kütz.	Diatoms	0.20%	0.43%
Gomphonema aff. affine ANS NAWQA EAM	Diatoms	0.20%	0.43%
Nitzschia amphibia Grun.	Diatoms	1.22%	0.39%
Navicula germanii Wallace	Diatoms	0.51%	0.37%
Encyonopsis microcephala (Grun.) Kram.	Diatoms	0.10%	0.26%
Encyonema minutum (Hilse) Mann	Diatoms	0.71%	0.23%
Capartogramma crucicula (Grun. ex Cl.) Ross	Diatoms	0.10%	0.23%
Nitzschia fonticola Grun.	Diatoms	1.22%	0.16%
Navicula molestiformis Hust.	Diatoms	0.91%	0.16%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.51%	0.16%
Nitzschia intermedia Hantz. ex Cl. et Grun.	Diatoms	0.10%	0.13%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.71%	0.11%
Fragilaria crotonensis Kitton	Diatoms	0.20%	0.10%
Navicula minima Grun.	Diatoms	1.32%	0.10%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.10%	0.08%
Navicula cryptocephala Kütz.	Diatoms	0.10%	0.05%
Diadesmis confervacea Kütz.	Diatoms	0.10%	0.04%
Nitzschia liebethruthii Rabh.	Diatoms	0.20%	0.04%
Nitzschia dissipata (Kütz.) Grun.	Diatoms	0.10%	0.04%
Navicula decussis Østr.	Diatoms	0.10%	0.04%
Eunotia exigua (Bréb. ex Kütz.) Rabh.	Diatoms	0.10%	0.03%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample Cell density (cells/cm^2)	 Biovolume (µm^3/cm^2)
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	0.10%	0.02%
Navicula seminulum Grun.	Diatoms	0.10%	0.02%
Pleurotaenium trabecula var. trabecula Näg.	Green algae	0.11%	0.01%
Navicula reichardtiana Lange-Bert.	Diatoms	0.10%	0.01%
Navicula caterva Hohn & Hellerm.	Diatoms	1.12%	0.00%
Nitzschia archibaldii Lange-Bertalot	Diatoms	1.83%	0.00%
Totals (cell density and biovolume)		4,179,941	2,975,656,456
TM-3 9/13/2000 Subsample Identifier C			
Spirogyra sp.	Green algae	0.42%	60.82%
Pinnularia maior (Kütz.) Rabh.	Diatoms	0.09%	11.02%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.71%	5.86%
Hydrocoleum brebissonii Kütz.	Blue-green algae	27.79%	3.81%
Gomphonema patrickii Kociolek & Stoermer	Diatoms	1.96%	3.36%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	1.69%	3.32%
Navicula arvensis DW WHTRV 98/99	Diatoms	0.27%	2.64%
Cymbella affinis Kütz.	Diatoms	3.03%	2.00%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	38.32%	0.82%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	1.87%	0.78%
Fragilaria crotonensis Kitton	Diatoms	0.98%	0.46%
Eunotia soleirolii (Kütz.) Rabh.	Diatoms	0.18%	0.42%
Navicula notha Wallace	Diatoms	2.14%	0.42%
Gyrosigma nodiferum (Grun.) Reim.	Diatoms	0.09%	0.39%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	1.25%	0.36%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	0.27%	0.34%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	3.48%	0.32%
Nitzschia amphibia Grun.	Diatoms	1.07%	0.32%
Navicula germanii Wallace	Diatoms	0.45%	0.30%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	0.71%	0.24%
Encyonopsis microcephala (Grun.) Kram.	Diatoms	0.09%	0.22%
Nitzschia intermedia Hantz. ex Cl. et Grun.	Diatoms	0.18%	0.22%
Navicula schroeteri var. escambia Patr.	Diatoms	0.18%	0.20%
Gomphonema affine Kütz.	Diatoms	0.09%	0.18%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Gomphonema aff. affine ANS NAWQA EAM	Diatoms	0.09%	0.18%
Encyonema minutum (Hilse) Mann	Diatoms	0.53%	0.17%
Navicula molestiformis Hust.	Diatoms	0.98%	0.16%
Nitzschia fonticola Grun.	Diatoms	0.71%	0.09%
Navicula cryptocephala Kütz.	Diatoms	0.18%	0.09%
Navicula seminulum Grun.	Diatoms	0.53%	0.09%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.62%	0.09%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	0.42%	0.06%
Achnanthes lanceolata var. apiculata Patr.	Diatoms	0.09%	0.06%
Anabaena oscillarioides Bory	Blue-green algae	1.58%	0.05%
Cosmarium granatum Bréb. ex Ralfs	Green algae	0.32%	0.04%
Diadesmis confervacea Kütz.	Diatoms	0.09%	0.03%
Gomphosphaeria lacustris Chod.	Blue-green algae	4.32%	0.03%
Amphora montana Krass.	Diatoms	0.09%	0.03%
Navicula minima Grun.	Diatoms	0.36%	0.02%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	0.09%	0.02%
Navicula caterva Hohn & Hellerm.	Diatoms	0.45%	0.00%
Nitzschia archibaldii Lange-Bertalot	Diatoms	1.25%	0.00%
Totals (cell density and biovolume)		3,820,411	2,906,294,039
TM-3 9/13/2000 Subsample Identifier A			
Spirogyra sp.	Green algae	0.14%	75.83%
Gomphoneis eriense (Grun.) Skv. & Meyer	Diatoms	0.10%	3.64%
Placoneis gastrum (Ehr.) Meresch.	Diatoms	0.09%	3.18%
Chlamydomonas sp.	Green algae	1.16%	2.13%
Anabaena oscillarioides Bory	Blue-green algae	6.41%	2.04%
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	64.67%	1.94%
Unknown *alga flagellate* (<10 µm)	Unknown Phyla	2.52%	1.25%
Craticula halophila (Grunow in Van Heurck) Mann	Diatoms	0.03%	1.06%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	3.33%	1.05%
Cymbella cymbiformis Ag.	Diatoms	0.25%	1.00%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.65%	0.95%
Achnanthes exigua var. heterovalva Krasske	Diatoms	1.93%	0.76%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Hydrocoleum brebissonii Kütz.	Blue-green algae	5.32%	0.74%
Calothrix parientina (Näg.) Thuret	Blue-green algae	3.21%	0.70%
Sellaphora rectangularis (Greg.) Lange-Bertalot & Metzeltin	Diatoms	0.01%	0.53%
Merismopedia convoluta Bréb.	Blue-green algae	2.66%	0.44%
Cryptomonas sp.	Cryptophytes	1.57%	0.42%
Scenedesmus acutus Meyen	Green algae	2.18%	0.41%
Capartogramma crucicula (Grun. ex Cl.) Ross	Diatoms	0.04%	0.34%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	0.23%	0.29%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	1.36%	0.24%
Navicula cryptotenella L.B. in Kramm. & L.-B.	Diatoms	0.16%	0.21%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	0.69%	0.19%
Navicula submuralis Hust.	Diatoms	0.78%	0.19%
Navicula rhynchocephala Kütz.	Diatoms	0.03%	0.09%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.03%	0.08%
Cosmarium margaritatum (Lund) Roy & Biss.	Green algae	0.14%	0.06%
Planothidium lanceolatum	Diatoms	0.06%	0.05%
Achnanthes oblongella Østrup	Diatoms	0.09%	0.05%
Placoneis elginensis (Greg.) Cox	Diatoms	0.01%	0.04%
Navicula arvensis Hust.	Diatoms	0.09%	0.03%
Nitzschia amphibia Grun.	Diatoms	0.03%	0.03%
Nitzschia fonticola Grun.	Diatoms	0.03%	0.01%
Navicula bryophila Peters. & Østr.	Diatoms	0.01%	0.00%
Totals (cell density and biovolume)		1,359,844	277,023,802
TM-3 9/13/2000 Subsample Identifier B			
Hydrocoleum brebissonii Kütz.	Blue-green algae	29.85%	18.89%
Craticula halophila (Grunow in Van Heurck) Mann	Diatoms	0.10%	17.58%
Cymbella cymbiformis Ag.	Diatoms	0.41%	7.63%
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	49.06%	6.73%
Nitzschia commuta Grun.	Diatoms	0.02%	5.49%
Sellaphora rectangularis (Greg.) Lange-Bertalot & Metzeltin	Diatoms	0.03%	5.27%
Anabaena oscillarioides Bory	Blue-green algae	3.13%	4.54%
Chlamydomonas sp.	Green algae	0.51%	4.25%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; μm^3/cm^2, cubic micrometers per square centimeter; μm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (μm^3/cm^2)
Placoneis clementis (Grun) Cox	Diatoms	0.02%	3.52%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	2.42%	3.48%
Capartogramma crucicula (Grun. ex Cl.) Ross	Diatoms	0.08%	3.01%
Merismopedia convoluta Bréb.	Blue-green algae	3.64%	2.73%
Achnanthes exigua var. heterovalva Krasske	Diatoms	1.13%	2.03%
Unknown *alga flagellate* (<10 μ)	Unknown Phyla	0.88%	1.98%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	0.28%	1.65%
Microcystis sp.	Blue-green algae	2.86%	1.60%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	1.93%	1.55%
Placoneis elginensis (Greg.) Cox	Diatoms	0.10%	1.24%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.17%	1.12%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	0.75%	0.94%
Scenedesmus acutus Meyen	Green algae	0.92%	0.80%
Nitzschia amphibia Grun.	Diatoms	0.19%	0.79%
Navicula cryptotenella L.B. in Kramm. & L.-B.	Diatoms	0.10%	0.62%
Cryptomonas sp.	Cryptophytes	0.41%	0.51%
Calothrix parientina (Näg.) Thuret	Blue-green algae	0.41%	0.41%
Surirella minuta Bréb.	Diatoms	0.02%	0.41%
Navicula submuralis Hust.	Diatoms	0.37%	0.41%
Nitzschia gracilis Hantz. ex Rabh.	Diatoms	0.02%	0.19%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.01%	0.13%
Gomphonema brasiliense Grun.	Diatoms	0.02%	0.13%
Navicula arvensis Hust.	Diatoms	0.05%	0.09%
Diadesmis confervacea Kütz.	Diatoms	0.01%	0.06%
Synedra rumpens Kütz.	Diatoms	0.02%	0.05%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.01%	0.05%
Karayevia clevei Grun. in Cl. et Grun.	Diatoms	0.01%	0.04%
Cymbella hustedtii Krass.	Diatoms	0.01%	0.03%
Nitzschia fonticola Grun.	Diatoms	0.01%	0.02%
Navicula subminuscula Mang.	Diatoms	0.01%	0.02%
Nitzschia siliqua Arch.	Diatoms	0.01%	0.01%
Totals (cell density and biovolume)		2,835,731	126,581,979

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
TM-3 9/13/2000 Subsample Identifier C			
Oscillatoria limosa (Dillw.) Ag.	Blue-green algae	2.13%	36.46%
Cymbella cymbiformis Ag.	Diatoms	0.53%	8.68%
Hydrocoleum brebissonii Kütz.	Blue-green algae	15.43%	8.62%
Microcystis sp.	Blue-green algae	16.37%	8.10%
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	51.03%	6.18%
Nitzschia commuta Grun.	Diatoms	0.03%	6.00%
Anabaena oscillarioides Bory	Blue-green algae	2.86%	3.67%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	2.70%	3.44%
Merismopedia convoluta Bréb.	Blue-green algae	4.33%	2.87%
Craticula halophila (Grunow in Van Heurck) Mann	Diatoms	0.02%	2.56%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.02%	2.04%
Placoneis elginensis (Greg.) Cox	Diatoms	0.16%	1.71%
Navicula pupula var. rostrata Hust.	Diatoms	0.01%	1.28%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	1.68%	1.19%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.17%	1.02%
Unknown *alga flagellate* (<10 µ)	Unknown Phyla	0.49%	0.98%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.50%	0.79%
Chlamydomonas sp.	Green algae	0.10%	0.78%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	0.46%	0.50%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	0.09%	0.49%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.03%	0.38%
Navicula cryptotenella L.B. in Kramm. & L.-B.	Diatoms	0.06%	0.32%
Capartogramma crucicula (Grun. ex Cl.) Ross	Diatoms	0.01%	0.27%
Navicula heufleri var. leptocephala (Brèb ex Grun.) Perag.	Diatoms	0.03%	0.22%
Encyonema silesiacum (Bleisch) Mann	Diatoms	0.02%	0.22%
Scenedesmus acutus Meyen	Green algae	0.28%	0.21%
Eunotia implicata Nörpel, Lange-Bert. & Alles	Diatoms	0.01%	0.21%
Nitzschia amphibia Grun.	Diatoms	0.04%	0.16%
Navicula minima Grun.	Diatoms	0.18%	0.14%
Cryptomonas sp.	Cryptophytes	0.10%	0.11%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.03%	0.11%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample: Cell density (cells/cm^2)	Percentage of sample: Biovolume (µm^3/cm^2)
Navicula capitata var. hungarica (Grun.) Ross	Diatoms	0.01%	0.11%
Encyonema minutum (Hilse) Mann	Diatoms	0.02%	0.06%
Gomphonema brasiliense Grun.	Diatoms	0.01%	0.05%
Navicula submuralis Hust.	Diatoms	0.03%	0.03%
Sellaphora seminulum (Grun.) Mann	Diatoms	0.02%	0.02%
Navicula arvensis Hust.	Diatoms	0.01%	0.01%
Navicula cincta var. rostrata Reim.	Diatoms	0.01%	0.01%
Navicula bryophila Peters. & Østr.	Diatoms	0.01%	0.01%
Nitzschia siliqua Arch.	Diatoms	0.01%	0.01%
Totals (cell density and biovolume)		2,778,226	140,454,317
TM-3 8/7/2001 Subsample Identifier A			
Oedogonium sp.	Green algae	1.19%	51.30%
Mougeotia sp.	Green algae	2.14%	25.74%
Cosmarium botrytes Meneghini	Green algae	0.36%	8.20%
Staurastrum punctulatum Brébisson	Green algae	0.12%	4.11%
Cymbella affinis Kütz.	Diatoms	1.46%	2.03%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	10.24%	1.39%
Fragilaria crotonensis Kitton	Diatoms	1.61%	1.27%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	1.43%	1.02%
Gomphonema rhombicum Fricke	Diatoms	0.94%	0.93%
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	51.01%	0.90%
Navicula molestiformis Hust.	Diatoms	0.03%	0.54%
Navicula radiosa Kützing	Diatoms	0.15%	0.40%
Navicula cryptotenella L.B. in Kramm. & L.-B.	Diatoms	0.43%	0.26%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	19.14%	0.23%
Nitzschia amphibia Grun.	Diatoms	0.52%	0.23%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.40%	0.20%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	0.30%	0.19%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	1.90%	0.16%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	0.06%	0.15%
Anabaena oscillarioides Bory	Blue-green algae	2.62%	0.14%
Cyclotella meneghiniana Kütz.	Diatoms	0.06%	0.12%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Placoneis elginensis (Greg.) Cox	Diatoms	0.09%	0.11%
Scenedesmus perforatus Lemmermann	Green algae	0.48%	0.09%
Encyonema minutum (Hilse) Mann	Diatoms	0.12%	0.06%
Cosmarium granatum Bréb. ex Ralfs	Green algae	0.24%	0.05%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.03%	0.04%
Eunotia exigua (Bréb. ex Kütz.) Rabh.	Diatoms	0.06%	0.03%
Cosmarium quadrum Lundell	Green algae	0.12%	0.02%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	0.09%	0.02%
Cymbella hustedtii Krass.	Diatoms	0.06%	0.02%
Brachysira neoexilis Lange-Bertalot	Diatoms	0.03%	0.01%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.06%	0.01%
Fragilaria nanana Lange-Bertalot	Diatoms	0.03%	0.01%
Nitzschia nana Grun. in V. H.	Diatoms	0.03%	0.01%
Nitzschia perminuta (Grun.) Peragallo	Diatoms	0.03%	0.01%
Navicula gysingensis Foged	Diatoms	0.03%	0.01%
Merismopedia tenuissima Lemmermann	Blue-green algae	2.38%	0.01%
Totals (cell density and biovolume)		2,213,197	944,918,976
TM-3 8/7/2001 Subsample Identifier B			
Oedogonium sp.	Green algae	1.52%	85.77%
Mougeotia sp.	Green algae	0.23%	3.68%
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	72.74%	1.69%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	8.21%	1.46%
Cymbella affinis Kütz.	Diatoms	0.73%	1.33%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	1.40%	1.31%
Navicula molestiformis Hust.	Diatoms	0.04%	0.96%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.04%	0.78%
Nitzschia modesta Hustedt	Diatoms	0.02%	0.75%
Fragilaria crotonensis Kitton	Diatoms	0.40%	0.41%
Gomphonema rhombicum Fricke	Diatoms	0.25%	0.32%
Nitzschia amphibia Grun.	Diatoms	0.42%	0.24%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	9.46%	0.15%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	0.04%	0.14%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	1.17%	0.12%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.17%	0.11%
Encyonema minutum (Hilse) Mann	Diatoms	0.15%	0.09%
Navicula gregaria Donk.	Diatoms	0.04%	0.09%
Navicula cryptotenella L.B. in Kramm. & L.-B.	Diatoms	0.10%	0.08%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.04%	0.07%
Navicula radiosa Kützing	Diatoms	0.02%	0.07%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	0.08%	0.06%
Cyclotella meneghiniana Kütz.	Diatoms	0.02%	0.06%
Navicula capitatoradiata Germain	Diatoms	0.02%	0.04%
Placoneis elginensis (Greg.) Cox	Diatoms	0.02%	0.03%
Cymbella naviculiformis Auerswald ex Héribaud	Diatoms	0.04%	0.02%
Diadesmis confervacea Kütz.	Diatoms	0.02%	0.02%
Cymbella hustedtii Krass.	Diatoms	0.04%	0.02%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.06%	0.02%
Cosmarium granatum Bréb. ex Ralfs	Green algae	0.06%	0.02%
Gomphonema kobayasii Kociolek & Kingston	Diatoms	0.02%	0.01%
Scenedesmus ecornis (Ralfs) Chod.	Green algae	0.35%	0.01%
Nitzschia perminuta (Grun.) Peragallo	Diatoms	0.04%	0.01%
Nitzschia fonticola Grun.	Diatoms	0.04%	0.01%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	0.06%	0.01%
Brachysira neoexilis Lange-Bertalot	Diatoms	0.02%	0.01%
Merismopedia tenuissima Lemmermann	Blue-green algae	1.87%	0.01%
Navicula atomus (Kütz.) Grun.	Diatoms	0.02%	0.00%
Totals (cell density and biovolume)		3,503,954	1,142,183,442
TM-3 8/7/2001 Subsample Identifier C			
Oedogonium sp.	Green algae	0.89%	54.89%
Closterium moniliferum Ehrenberg	Green algae	0.09%	26.92%
Cosmarium botrytes Meneghini	Green algae	0.09%	2.93%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	14.59%	2.85%
Navicula molestiformis Hust.	Diatoms	0.10%	2.62%
Cymbella affinis Kütz.	Diatoms	1.04%	2.07%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Nitzschia palea (Kütz.) W. Sm.	Diatoms	1.46%	1.49%
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	40.92%	1.04%
Fragilaria crotonensis Kitton	Diatoms	0.90%	1.02%
Gomphonema rhombicum Fricke	Diatoms	0.38%	0.54%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.59%	0.43%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	24.27%	0.41%
Nitzschia amphibia Grun.	Diatoms	0.59%	0.37%
Eunotia bilunaris (Ehrenberg) Mills	Diatoms	0.10%	0.32%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	2.48%	0.29%
Euglena sp.	Euglenoids	0.09%	0.25%
Navicula viridula var. rostellata (Kütz.) Cl.	Diatoms	0.07%	0.21%
Capartogramma crucicula (Grun. ex Cl.) Ross	Diatoms	0.03%	0.19%
Navicula cryptotenella L.B. in Kramm. & L.-B.	Diatoms	0.17%	0.15%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.07%	0.13%
Placoneis elginensis (Greg.) Cox	Diatoms	0.07%	0.12%
Encyonema minutum (Hilse) Mann	Diatoms	0.17%	0.12%
Scenedesmus spinosus Chodat	Green algae	1.77%	0.10%
Navicula schroeteri var. escambia Patr.	Diatoms	0.03%	0.09%
Navicula gregaria Donk.	Diatoms	0.03%	0.08%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	0.07%	0.06%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	0.21%	0.05%
Ankistrodesmus falcatus (Corda) Ralfs	Green algae	0.09%	0.04%
Nitzschia fonticola Grun.	Diatoms	0.10%	0.03%
Merismopedia tenuissima Lemmermann	Blue-green algae	8.15%	0.03%
Navicula decussis Østr.	Diatoms	0.03%	0.03%
Achnanthes exigua var. heterovalva Krasske	Diatoms	0.10%	0.03%
Nitzschia debilis Arnott	Diatoms	0.03%	0.03%
Brachysira neoexilis Lange-Bertalot	Diatoms	0.03%	0.02%
Nitzschia cf. lacuum Lange-Bert.	Diatoms	0.07%	0.02%
Navicula reichardtiana Lange-Bert.	Diatoms	0.03%	0.02%
Cymbella hustedtii Krass.	Diatoms	0.03%	0.01%
Navicula subminuscula Mang.	Diatoms	0.03%	0.01%
Totals (cell density and biovolume)		2,983,663	886,943,554

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample: Cell density (cells/cm^2)	Percentage of sample: Biovolume (µm^3/cm^2)
TM-3 9/19/2002 Subsample Identifier A			
Cymbella turgidula Grunow	Diatoms	19.31%	48.67%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.65%	10.78%
Encyonopsis microcephala (Grun.) Kram.	Diatoms	1.64%	8.59%
Cymbella hustedtii Krass.	Diatoms	10.47%	6.63%
Cymbella mesiana Cholnoky	Diatoms	0.98%	5.96%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	50.24%	5.84%
Hippodonta capitata (Ehrenberg) Lange-Bertalot, Metzeltin et Witkowski	Diatoms	0.33%	2.77%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	0.49%	1.57%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	1.64%	1.21%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	4.58%	1.19%
Gomphonema patrickii Kociolek & Stoermer	Diatoms	1.23%	0.92%
Gomphonema turris Ehrenberg	Diatoms	0.25%	0.87%
Navicula notha Wallace	Diatoms	1.80%	0.87%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.98%	0.80%
Cyclotella meneghiniana Kütz.	Diatoms	0.33%	0.79%
Navicula cryptocephala Kütz.	Diatoms	0.82%	0.78%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.33%	0.48%
Encyonema minutum (Hilse) Mann	Diatoms	0.49%	0.28%
Nitzschia amphibia Grun.	Diatoms	0.49%	0.26%
Cosmarium granatum Bréb. ex Ralfs	Green algae	0.99%	0.24%
Planothidium rostratum (Østrup) Lange-Bertalot	Diatoms	0.49%	0.15%
Geissleria decussis (Hustedt) Lange-Bertalot et Metzeltin	Diatoms	0.16%	0.11%
Euastrum ciastonii Raciborski	Green algae	0.33%	0.08%
Achnanthidium exiguum var. heterovalvum (Krasske) Czarnecki	Diatoms	0.65%	0.08%
Nitzschia fonticola Grun.	Diatoms	0.16%	0.05%
Achnanthidium pyrenaicum (Hustedt) Kobayasi	Diatoms	0.16%	0.04%
Totals (cell density and biovolume)		1,767,127	624,107,867
TM-3 9/19/2002 Subsample Identifier B			
Closterium moniliferum Ehrenberg	Green algae	0.33%	52.86%
Cymbella turgidula Grunow	Diatoms	15.12%	23.94%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.65%	6.73%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	55.76%	4.07%
Cymbella hustedtii Krass.	Diatoms	5.04%	2.00%
Rhopalodia gibba (Ehr.) O. Müll.	Diatoms	0.16%	1.99%
Encyonema silesiacum (Bleisch) Mann	Diatoms	0.65%	1.40%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	6.83%	1.12%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	1.14%	1.05%
Navicula cryptocephala Kütz.	Diatoms	1.30%	0.78%
Navicula notha Wallace	Diatoms	1.95%	0.59%
Gomphonema gracile Ehr. emend. V. H.	Diatoms	0.27%	0.51%
Synedra acus Kützing	Diatoms	0.16%	0.41%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	0.81%	0.38%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.81%	0.36%
Fragilaria vaucheriae (Kützing) Petersen	Diatoms	0.81%	0.32%
Gomphonema patrickii Kociolek & Stoermer	Diatoms	0.54%	0.27%
Encyonopsis microcephala (Grun.) Kram.	Diatoms	2.11%	0.26%
Nitzschia amphibia Grun.	Diatoms	0.49%	0.16%
Cosmarium margaritatum (Lund) Roy & Biss.	Green algae	0.99%	0.15%
Achnanthidium exiguum var. heterovalvum (Krasske) Czarnecki	Diatoms	0.65%	0.15%
Achnanthidium pyrenaicum (Hustedt) Kobayasi	Diatoms	0.81%	0.11%
Psammothidium subatomoides (Hustedt) Bukhtiyarova et Round	Diatoms	0.65%	0.09%
Planothidium rostratum (Østrup) Lange-Bertalot	Diatoms	0.49%	0.09%
Geissleria decussis (Hustedt) Lange-Bertalot et Metzeltin	Diatoms	0.16%	0.07%
Micrasterias radiosa Ralfs	Green algae	0.33%	0.05%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	0.66%	0.04%
Nitzschia fonticola Grun.	Diatoms	0.16%	0.03%
Nitzschia perminuta (Grun.) Peragallo	Diatoms	0.16%	0.03%
Totals (cell density and biovolume)		2,320,269	1,304,510,077
TM-3 9/19/2002 Subsample Identifier C			
Spirogyra sp.	Green algae	0.61%	66.90%
Cymbella turgidula Grunow	Diatoms	12.86%	15.61%
Synedra ulna (Nitz.) Ehr.	Diatoms	0.49%	3.92%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	56.70%	3.18%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Cymbella hustedtii Krass.	Diatoms	9.72%	2.97%
Cymbella mesiana Cholnoky	Diatoms	0.33%	0.96%
Fragilaria capucina var. rumpens (Kützing) Lange-Bertalot	Diatoms	6.43%	0.81%
Gomphonema patrickii Kociolek & Stoermer	Diatoms	1.83%	0.76%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	1.83%	0.69%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	1.65%	0.59%
Encyonema silesiacum (Bleisch) Mann	Diatoms	0.33%	0.54%
Navicula cryptocephala Kütz.	Diatoms	1.15%	0.53%
Cocconeis placentula var. lineata (Ehr.) V. H.	Diatoms	0.33%	0.51%
Gomphonema gracile Ehr. emend. V. H.	Diatoms	0.30%	0.48%
Nitzschia amphibia Grun.	Diatoms	0.99%	0.25%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.33%	0.23%
Navicula notha Wallace	Diatoms	0.99%	0.23%
Cymbella affinis Kütz.	Diatoms	0.16%	0.21%
Encyonema minutum (Hilse) Mann	Diatoms	0.66%	0.18%
Gomphonema subclavatum var. mexicanum (Grun. in V. H.) Patr.	Diatoms	0.16%	0.18%
Planothidium rostratum (Østrup) Lange-Bertalot	Diatoms	0.49%	0.07%
Achnanthidium exiguum var. heterovalvum (Krasske) Czarnecki	Diatoms	0.33%	0.06%
Psammothidium subatomoides (Hustedt) Bukhtiyarova et Round	Diatoms	0.49%	0.05%
Encyonopsis microcephala (Grun.) Kram.	Diatoms	0.49%	0.05%
Nitzschia fonticola Grun.	Diatoms	0.33%	0.04%
Totals (cell density and biovolume)		1,948,694	1,428,716,619
TM-4 9/13/2000 Subsample Identifier A			
Scenedesmus acutus Meyen	Green algae	58.62%	51.47%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	20.74%	16.85%
Unknown *alga flagellate* (<10 µ)	Unknown Phyla	4.29%	9.83%
Achnanthes exigua var. heterovalva Krasske	Diatoms	5.04%	9.20%
Anabaena oscillarioides Bory	Blue-green algae	2.49%	3.67%
Placoneis elginensis (Greg.) Cox	Diatoms	0.11%	1.37%
Capartogramma crucicula (Grun. ex Cl.) Ross	Diatoms	0.03%	1.25%
Planothidium lanceolatum	Diatoms	0.25%	1.10%
Glenodinium sp.	Dinoflagellates	0.20%	0.91%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Psammothidium bioretii (Germ.) Bukht. et Round	Diatoms	0.03%	0.89%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	6.78%	0.74%
Navicula submuralis Hust.	Diatoms	0.66%	0.74%
Eunotia exigua (Bréb. ex Kütz.) Rabh.	Diatoms	0.17%	0.71%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	0.39%	0.49%
Achnanthes oblongella Østrup	Diatoms	0.13%	0.35%
Cymbella affinis Kütz.	Diatoms	0.02%	0.27%
Nitzschia sinuata var. tabellaria (Grun.) Grun. in V.H.	Diatoms	0.02%	0.13%
Synedra rumpens Kütz.	Diatoms	0.01%	0.03%
Totals (cell density and biovolume)		1,175,777	51,765,896
TM-4 9/13/2000 Subsample Identifier B			
Scenedesmus acutus Meyen	Green algae	70.45%	54.73%
Anabaena oscillarioides Bory	Blue-green algae	13.31%	17.32%
Chlamydomonas sp.	Green algae	1.46%	11.00%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	7.47%	5.37%
Unknown *alga flagellate* (<10 µ)	Unknown Phyla	2.19%	4.45%
Achnanthes exigua var. heterovalva Krasske	Diatoms	1.60%	2.58%
Caloneis amphisbaena (Bory) Cleve	Diatoms	0.01%	1.91%
Euglena sp.	Euglenoids	0.08%	1.11%
Navicula submuralis Hust.	Diatoms	0.49%	0.49%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	2.60%	0.25%
Eunotia exigua (Bréb. ex Kütz.) Rabh.	Diatoms	0.05%	0.17%
Planothidium lanceolatum	Diatoms	0.04%	0.15%
Capartogramma crucicula (Grun. ex Cl.) Ross	Diatoms	0.00%	0.13%
Navicula arvensis Hust.	Diatoms	0.07%	0.11%
Cryptomonas sp.	Cryptophytes	0.08%	0.09%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	0.07%	0.08%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.00%	0.02%
Neidium alpinum Hust.	Diatoms	0.01%	0.02%
Achnanthes oblongella Østrup	Diatoms	0.01%	0.02%
Totals (cell density and biovolume)		1,356,704	67,515,569

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
TM-4 9/13/2000 Subsample Identifier C			
Scenedesmus acutus Meyen	Green algae	51.93%	36.19%
Achnanthes exigua var. heterovalva Krasske	Diatoms	13.06%	18.91%
Anabaena oscillarioides Bory	Blue-green algae	6.13%	7.16%
Planothidium lanceolatum	Diatoms	1.81%	6.29%
Unknown *alga flagellate* (<10 µ)	Unknown Phyla	3.14%	5.71%
Neidium ampliatum (Ehr.) Kramm.	Diatoms	0.04%	4.68%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	5.71%	3.68%
Capartogramma crucicula (Grun. ex Cl.) Ross	Diatoms	0.11%	3.08%
Chlamydomonas sp.	Green algae	0.43%	2.89%
Navicula submuralis Hust.	Diatoms	3.23%	2.88%
Navicula arvensis Hust.	Diatoms	1.88%	2.52%
Eunotia exigua (Bréb. ex Kütz.) Rabh.	Diatoms	0.57%	1.87%
Placoneis elginensis (Greg.) Cox	Diatoms	0.14%	1.35%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	10.27%	0.90%
Cryptomonas sp.	Cryptophytes	0.86%	0.85%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	0.46%	0.46%
Neidium alpinum Hust.	Diatoms	0.14%	0.33%
Achnanthes oblongella Østrup	Diatoms	0.11%	0.24%
Totals (cell density and biovolume)		896,326	49,709,706
CEN 9/14/2000 Subsample Identifier A			
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	59.48%	45.20%
Achnanthes exigua var. heterovalva Krasske	Diatoms	9.11%	23.92%
Nitzschia amphibia Grun.	Diatoms	1.56%	8.74%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	17.04%	6.79%
Lyngbya sp. 1 ANS FWA	Blue-green algae	9.88%	5.43%
Gomphonema augur var. turris (Ehr.) Lange-Bert.	Diatoms	0.07%	2.38%
Scenedesmus acutus Meyen	Green algae	0.94%	2.10%
Scenedesmus acuminatus (Lagerh.) Chod.	Green algae	0.75%	2.07%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.15%	0.81%
Diadesmis confervacea Kütz.	Diatoms	0.11%	0.79%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	0.19%	0.53%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Scenedesmus ecornis (Ralfs) Chod.	Green algae	0.56%	0.37%
Gomphonema minutum (Ag.) Ag.	Diatoms	0.04%	0.36%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.04%	0.29%
Navicula seminulum Grun.	Diatoms	0.07%	0.23%
Totals (cell density and biovolume)		4203371	171092275
CEN 9/14/2000 Subsample Identifier B			
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	63.59%	41.78%
Achnanthes exigua var. heterovalva Krasske	Diatoms	14.03%	31.87%
Nitzschia amphibia Grun.	Diatoms	1.04%	5.01%
Lyngbya sp. 1 ANS FWA	Blue-green algae	9.83%	4.67%
Hydrocoleum brebissonii Kütz.	Blue-green algae	1.70%	3.77%
Scenedesmus acutus Meyen	Green algae	1.70%	3.28%
Gomphonema augur var. turris (Ehr.) Lange-Bert.	Diatoms	0.10%	2.86%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	6.67%	2.30%
Scenedesmus acuminatus (Lagerh.) Chod.	Green algae	0.73%	1.73%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.16%	0.73%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.05%	0.60%
Scenedesmus quadricauda (Turp.) Bréb.	Green algae	0.24%	0.59%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.05%	0.35%
Diadesmis confervacea Kütz.	Diatoms	0.05%	0.32%
Navicula seminulum Grun.	Diatoms	0.05%	0.14%
Totals (cell density and biovolume)		2,561,002	120,548,665
CEN 9/14/2000 Subsample Identifier C			
Amphithrix janthina (Mont.) Born. and Flah.	Blue-green algae	66.92%	40.93%
Hydrocoleum brebissonii Kütz.	Blue-green algae	9.68%	19.97%
Achnanthes exigua var. heterovalva Krasske	Diatoms	6.73%	14.23%
Mougeotia sp.	Green algae	0.10%	9.78%
Scenedesmus acutus Meyen	Green algae	3.24%	5.82%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	9.73%	3.12%
Nitzschia amphibia Grun.	Diatoms	0.49%	2.22%
Scenedesmus acuminatus (Lagerh.) Chod.	Green algae	0.61%	1.34%
Lyngbya sp. 1 ANS FWA	Blue-green algae	2.13%	0.94%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
Gomphonema augur var. turris (Ehr.) Lange-Bert.	Diatoms	0.02%	0.63%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	0.07%	0.46%
Sellaphora pupula (Kütz.) Meresckowsky	Diatoms	0.02%	0.27%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.02%	0.11%
Scenedesmus ecornis (Ralfs) Chod.	Green algae	0.20%	0.11%
Navicula seminulum Grun.	Diatoms	0.02%	0.06%
Totals (cell density and biovolume)		5,360,029	271,030,705
TSB 9/13/2000 Subsample Identifier A			
Diadesmis confervacea Kütz.	Diatoms	13.09%	32.77%
Hydrocoleum brebissonii Kütz.	Blue-green algae	28.15%	25.46%
Nitzschia amphibia Grun.	Diatoms	6.55%	12.92%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	2.22%	6.07%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	31.74%	4.46%
Achnanthes exigua var. heterovalva Krasske	Diatoms	3.46%	3.20%
Gomphonema patrickii Kociolek & Stoermer	Diatoms	0.25%	2.79%
Navicula minima Grun.	Diatoms	4.94%	2.23%
Euglena sp.	Euglenoids	0.13%	1.73%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	0.86%	1.66%
Gomphonema augur var. turris (Ehr.) Lange-Bert.	Diatoms	0.12%	1.39%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	2.10%	1.29%
Scenedesmus acuminatus (Lagerh.) Chod.	Green algae	1.06%	1.03%
Navicula laevissima Kütz.	Diatoms	0.12%	0.77%
Navicula seminulum Grun.	Diatoms	0.49%	0.54%
Caloneis bacillum (Grun.) Cl.	Diatoms	0.12%	0.46%
Scenedesmus ecornis (Ralfs) Chod.	Green algae	1.86%	0.43%
Navicula cryptocephala Kütz.	Diatoms	0.12%	0.41%
Nitzschia fonticola Grun.	Diatoms	0.37%	0.31%
Cyclotella atomus Hust.	Diatoms	0.12%	0.09%
Nitzschia archibaldii Lange-Bertalot	Diatoms	2.10%	0.00%
Totals (cell density and biovolume)		4,586,021	529,338,921

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample	
		Cell density (cells/cm^2)	Biovolume (µm^3/cm^2)
TSB 9/13/2000 Subsample Identifier B			
Diadesmis confervacea Kütz.	Diatoms	23.46%	44.14%
Nitzschia amphibia Grun.	Diatoms	8.60%	12.76%
Pinnularia brebissonii (Kütz.) Rabh.	Diatoms	0.18%	8.75%
Hydrocoleum brebissonii Kütz.	Blue-green algae	9.37%	6.37%
Scenedesmus acuminatus (Lagerh.) Chod.	Green algae	6.88%	5.01%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	3.22%	4.65%
Nitzschia palea (Kütz.) W. Sm.	Diatoms	1.97%	4.04%
Achnanthes exigua var. heterovalva Krasske	Diatoms	4.84%	3.37%
Navicula minima Grun.	Diatoms	7.52%	2.55%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	21.41%	2.26%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	0.18%	1.74%
Navicula seminulum Grun.	Diatoms	1.07%	0.89%
Cyclotella meneghiniana Kütz.	Diatoms	0.18%	0.88%
Lyngbya sp. 1 ANS FWA	Blue-green algae	5.54%	0.81%
Scenedesmus ecornis (Ralfs) Chod.	Green algae	3.06%	0.54%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	0.90%	0.41%
Navicula subminuscula Mang.	Diatoms	0.72%	0.34%
Encyonema minutum (Hilse) Mann	Diatoms	0.18%	0.27%
Gomphonema kobayasii Kociolek & Kingston	Diatoms	0.18%	0.12%
Nitzschia fonticola Grun.	Diatoms	0.18%	0.11%
Nitzschia archibaldii Lange-Bertalot	Diatoms	0.36%	0.00%
Totals (cell density and biovolume)		2069048	317681960
TSB 9/13/2000 Subsample Identifier C			
Oedogonium sp.	Green algae	2.41%	86.09%
Diadesmis confervacea Kütz.	Diatoms	28.40%	7.14%
Hydrocoleum brebissonii Kütz.	Blue-green algae	19.66%	1.79%
Nitzschia amphibia Grun.	Diatoms	8.65%	1.72%
Euglena sp.	Euglenoids	0.34%	0.45%
Navicula clementis Grun.	Diatoms	0.16%	0.45%
Oscillatoria sp. 1 ANS FWA	Blue-green algae	24.48%	0.35%
Scenedesmus acuminatus (Lagerh.) Chod.	Green algae	3.45%	0.34%

Appendix table 3-2. Periphyton taxa and cell density and biovolume by taxon for samples from selected sites in the Threemile Creek basin, Mobile, Alabama, 2000–2002.—Continued

[cells/cm^2, cells per square centimeter; µm^3/cm^2, cubic micrometers per square centimeter; µm,micrometer]

Scientific name	Algae group	Percentage of sample: Cell density (cells/cm^2)	Percentage of sample: Biovolume (µm^3/cm^2)
Nitzschia palea (Kütz.) W. Sm.	Diatoms	1.14%	0.31%
Achnanthes exigua var. heterovalva Krasske	Diatoms	3.26%	0.30%
Nitzschia intermedia Hantz. ex Cl. et Grun.	Diatoms	0.33%	0.26%
Gomphonema parvulum (Kütz.) Kütz.	Diatoms	1.14%	0.22%
Achnanthes lanceolata var. rostrata Hust.	Diatoms	0.16%	0.21%
Navicula minima Grun.	Diatoms	2.94%	0.13%
Navicula seminulum Grun.	Diatoms	0.98%	0.11%
Achnanthidium minutissimum (Kütz.) Czarnecki	Diatoms	0.82%	0.05%
Nitzschia fonticola Grun.	Diatoms	0.49%	0.04%
Navicula subminuscula Mang.	Diatoms	0.49%	0.03%
Scenedesmus ecornis (Ralfs) Chod.	Green algae	0.69%	0.02%
Totals (cell density and biovolume)		2,929,878	3,366,457,014

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