TECHNICAL REPORT

An Impervious Surface Study over Three Regimes: Three Mile Creek, Fly Creek, and Bay Minette Creek Subwatersheds

March 2004

Alabama Department of Environmental Management
Mobile Branch
2204 Perimeter Road, Mobile, Alabama 36615

An Impervious Surface Study over Three Regimes: Three Mile Creek, Fly Creek, and Bay Minette Creek Subwatersheds

An Examination of Water and Sediment Quality in Relation to Impervious Surface Cover and a Report on the Characteristics, History, and Current Land Uses for the Individual Basins.

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EXECUTIVE SUMMARY

Starting in January 2003, and continuing through December 2003, the Mobile Branch of the Department's Field Operations Division conducted a survey of three subwatersheds located in the coastal area of Alabama. These were the Three Mile Creek subwatershed, located in eastern Mobile County, and the Bay Minette Creek and Fly Creek subwatersheds, located in western Baldwin County. The subwatersheds were chosen based on their degree of impervious surface cover as determined by the Geological Survey of Alabama. The survey endeavored to assess water quality within the three subwatersheds and compare those data across impervious surface regimes representing high, moderate and low levels of development. From highest to lowest level of development the subwatersheds were: Three Mile Creek with an estimated 34% impervious surface cover, Fly Creek with 5.4% impervious surface cover, and Bay Minette Creek with an estimated 1% impervious surface cover.

The Bay Minette Creek subwatershed is, for the larger part of its basin, rural with concentrated population centers largely restricted to the northeast section of the subwatershed near the Town of Bay Minette. The Fly Creek subwatershed has concentrated population centers in the cities of Daphne, Fairhope, and Point Clear. The Three Mile Creek subwatershed has a dense population in comparison with the other two subwatersheds and is industrial, commercial, and urban for most of its coverage. With its many roads, parking lots, driveways, and roof tops, storm water runoff within the Three Mile Creek subwatershed must travel over significant amounts of impervious surface.

Apart from analytical data for parameters such as ammonia, pH, water temperature, and five of eight sediment metals, it proved difficult to distinguish a clear delineation among the three subject watersheds. The watershed demonstrating the greatest degree of water quality degradation was, predictably, Three Mile Creek. However, showing a causal relationship between that subwatershed's degradation and the amount of its impervious surface cover is problematic insofar that, although it did have the most impervious surface cover, the Three Mile Creek subwatershed also had the greatest concentration of industry, commerce, and population. The increased impervious surface coverage only compounded the potential for NPS pollution. Conversely, the Bay Minette Creek subwatershed, representing the study's subject for low level development, had the lowest population and virtually no industry or commerce, yet did not display substantially better water quality than either of the other two subject subwatersheds with greater impervious surface cover.

INTRODUCTION

As water drains off the land, it can introduce an array of pollutants into the receiving stream. Recognizing this is important to effectively monitor and protect water resources. The Alabama Department of Environmental Management (ADEM) adopted the watershed assessment strategy in 1996 as an integrated, holistic strategy for more effectively restoring and protecting aquatic ecosystems by examining water resources and the land from which water drains to those resources (ADEM. 2000). By defining a geographical region's drainage pathways and focusing on the individual basins, the ADEM is provided an objective, targeted approach toward meaningful water quality monitoring, assessment, and implementation of control activities. Over the past decade the ADEM has conducted watershed surveys in the coastal areas of Mobile and Baldwin counties as part of its "Water Quality and Natural Resource Monitoring Strategy for Coastal Alabama." These studies have included Dog River, Bon Secour River, Chickasaw Creek, Little Lagoon, and Bayou Sara. Each of the watershed studies attempts to define potential pollutant sources and explore potential avenues toward improving the water quality.

Throughout the watershed studies, it has been demonstrated that economic development and growth in the Alabama coastal zone continues with each passing year and is characterized by the transformation of woodlands, pasture, and crop land into residences, subdivisions, condominiums, schools, and shopping centers. One of the more serious consequences of this growth has been decreased stream clarity from increased stream siltation and loss of aquatic habitat caused by erosion from land disturbance activities (ADEM. 1997). With the continued growth comes increased impervious surface cover. Impervious surfaces are any surfaces that inhibit or prevent altogether the infiltration of water to the soil. They include rooftops, roads, parking lots, and sidewalks. In the United States recent studies of the effects of impervious surfaces upon surface water quality have concluded that the percent of impervious surface in a watershed is a good indicator of potential water quality impacts. The streams in watersheds with greater than 10% impervious cover have been determined to be at greater risk of experiencing impacted water quality. The concept is easily grasped when the amount of impervious surface is a direct measure of a watershed's degree of urbanization. Areas with more impervious surfaces are likely to generate more runoff during rain events, which increases the potential for contaminating and warming stream waters. Further, the increased runoff rate presents a greater potential for degrading stream channels and banks.

In 2002, the Geological Survey of Alabama conducted an impervious surface mapping project for Mobile and Baldwin counties. The purpose of the project was to determine and map the extent of impervious surfaces within Mobile and Baldwin Counties. Using 1995 and 2000 LandSat multi-spectral imagery, the GSA mapped the two counties to a subwatershed level at a 5-acre scale. Within three subwatersheds representing high, moderate and low levels of development, impervious surfaces were mapped using conventional aerial photography to validate the imagery classification. All products were formatted in a manner suitable for use in a geographic information system, GIS, environment. This project was funded or partially funded by the National Oceanic and Atmospheric Administration, the Department of Environmental Management, and the Geological Survey of Alabama (GSA. 2003).

Percentage of Impervious Surface per Subwatershed

Three Mile Creek	34.0
Fly Creek	5.4
Bay Minette Creek	1.0

(GSA. 2003)

In 2003, as a second phase of this project, the three subwatersheds selected to represent high, moderate, and low levels of development were studied. The subwatershed representing high development, with an estimated impervious surface cover of 34%, was the Three Mile Creek subwatershed (HUC 03160204 060) located in Mobile County. This subwatershed drains an area that is largely urban with a substantial amount of industry, numerous commercial enterprises, and concentrated population centers. The subwatershed selected to represent moderate levels of development was the Fly Creek subwatershed (HUC 03160205 040) located in Baldwin County. The Fly Creek subwatershed had an estimated impervious surface cover of 5.4%. Although the Fly Creek subwatershed possessed population concentrations, industry and commercial sites, the density of these was substantially less than that encountered in the Three Mile Creek subwatershed. The subwatershed representing low level development, at 1% estimated impervious surface cover, was the Bay Minette Creek subwatershed (HUC 03160204 040) also located in Baldwin County. The area within this drainage basin was, for the most part, exclusively rural and forested with virtually no industry or commercial activity.

Beginning in January 2003, and continuing through December 2003, personnel from the Alabama Department of Environmental Management monitored the water quality of the surface waters within the three selected subwatersheds in accordance with the protocols outlined in the ADEM Technical Report, *Methodology For Coastal Watershed Assessments* (2001). Seven sampling stations within each subwatershed were chosen through topographic map review and field observation. The selected stations were monitored, at least monthly, for dissolved oxygen, pH, salinity, conductivity, temperature, total suspended solids, total dissolved solids, turbidity, fecal coliform bacteria, ammonia, nitrates/nitrites, total Kjehldahl nitrogen, and total phosphorous. Selected stations were also sampled for sediment metals concentrations.

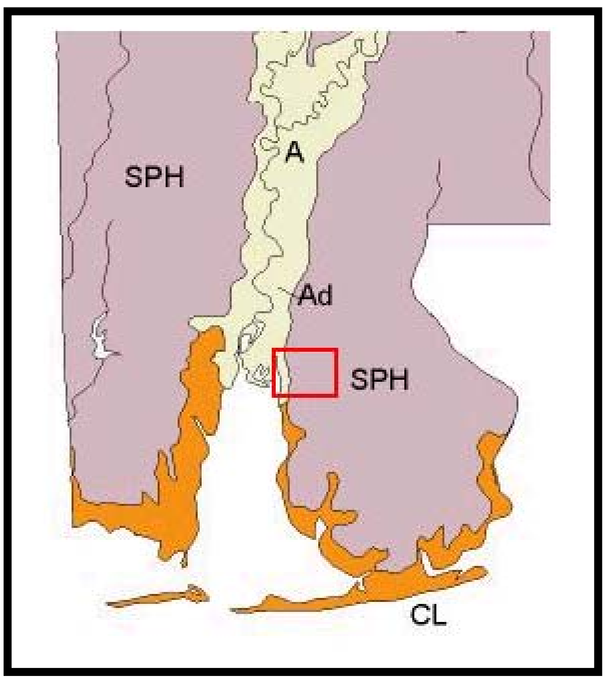
The Three Mile Creek and Bay Minette Creek subwatersheds are contributors to the Mobile-Tensaw Delta watershed. The Fly Creek subwatershed empties directly into the Mobile Bay. Areas immediately surrounding the streams of all three subwatersheds studied fall within the 100 year flood plain (Federal Emergency Management Agency. Flood Insurance Rate Map. 1985. 1998).

In presenting the water quality data derived from the study, stations are represented in groups and by individual station. Graphs are used to facilitate comparison between subwatersheds. Average values recorded are an arithmetic mean of the total determinations made throughout the study period. These average values are, unless otherwise specified, inclusive of all monitored levels along the water column.

PHYSICAL CHARACTERISTICS

GENERAL DESCRIPTION

Bay Minette Creek Subwatershed
HUC 03160204 040

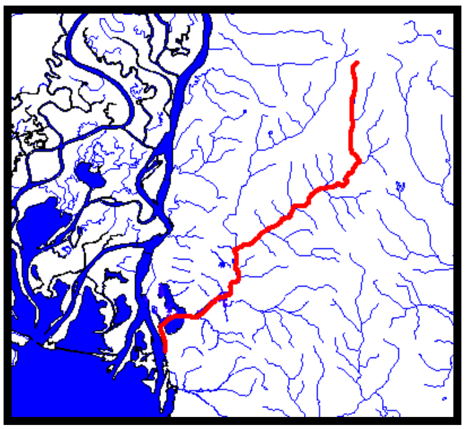


Baldwin County is situated in extreme lower Alabama. The Bay Minette Creek subwatershed lies entirely within and along the western edge of Baldwin County and represents a large portion of the Lower Tensaw River subwatershed. The Lower Tensaw River subwatershed comprises a total land area of greater than 112,000 acres. The physiographic regions represented in the Bay Minette Creek subwatershed are the Southern Pine Hills (SPH) and the Alluvial-Deltic Plain (A, Ad). The Southern Pine Hills, comprising the majority of the subwatershed, are underlain by terrigenous sediments. The Alluvial-Deltic Plain exhibits very little topographic relief and consists of alluvial and terrace deposits from rivers. It is located along the extreme western edge of the subwatershed.

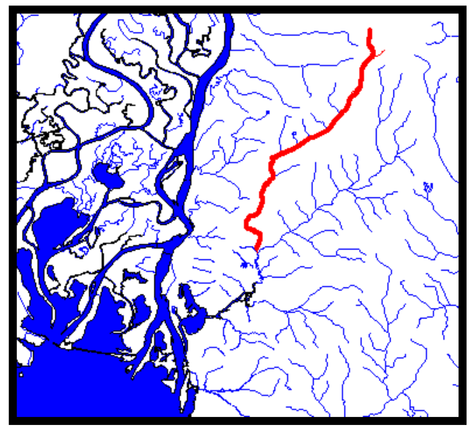
An estimated two percent of the Bay Minette Creek subwatershed is pasture land, ten percent is crop land, fifteen percent is urban land, and fifty-four percent is forested. There are fewer than seven hundred cattle in the subwatershed. Seven hundred and twenty septic tank systems have been identified within the basin (Soil and Water Conservation District. 1998.) Bay Minette Creek appears on the Department's 2000 303(d) listing of impaired streams as a result of excessive mercury concentrations.

Originating southwest of Bay Minette, in north central Baldwin County, Bay Minette Creek flows south and east for approximately 17 miles to its discharge into Bay Minette and, ultimately, Blakely River and the Mobile Bay. From its origin to its confluence with Bay Minette, Bay Minette Creek falls less than 50 feet. This represents a vertical fall of about 2.5 feet for every mile. Geographical relief present in the southwest portion of the subwatershed is greater than that demonstrated elsewhere within the drainage basin. In this section of the subwatershed, the Saluda Ridge, which runs south and west to north and east, exhibits elevations approaching 180 feet above mean sea level. This represents elevations about 100 feet greater than are observed in the remainder of the study area.

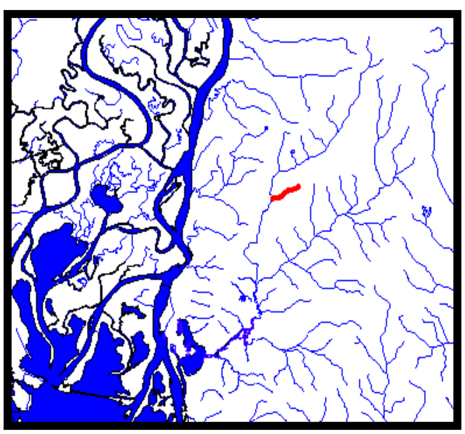
BAY MINETTE CREEK



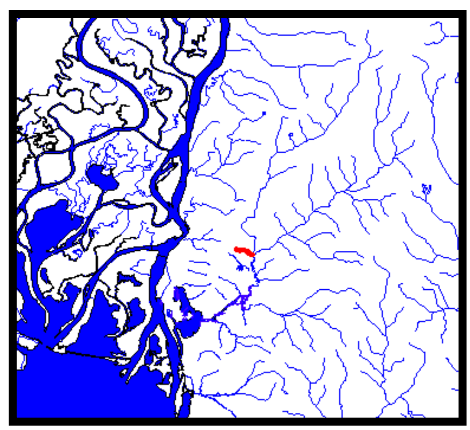
WHITEHOUSE CREEK



LONG BRANCH



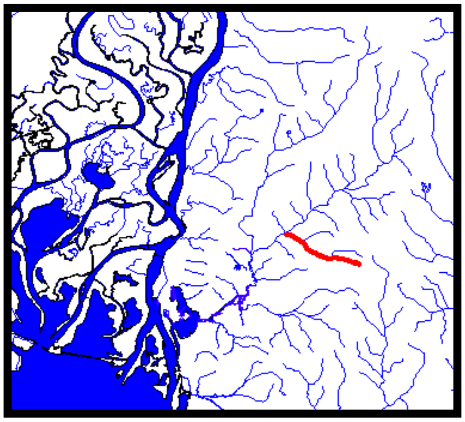
FOOTLOG BRANCH



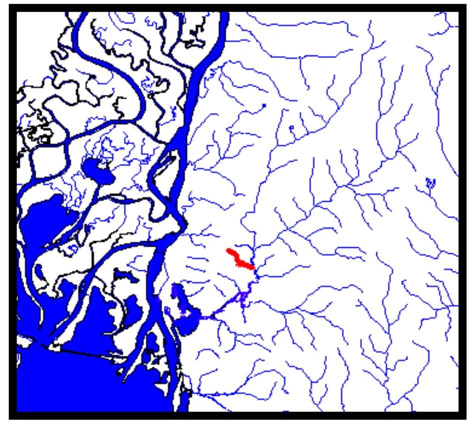
Whitehouse Creek is Bay Minette Creek's largest tributary. Its origin lies north and slightly west of that of Bay Minette Creek. From its origin to its confluence with Bay Minette Creek, Whitehouse Creek travels approximately 14 miles. Along the way, Whitehouse Creek is joined by several tributaries. Only two of these tributaries are named. One of these, Long Branch, travels about 1 mile in a southwestern direction and joins Whitehouse Creek approximately 3 miles upstream of that creek's confluence with Bay Minette Creek. The other named tributary to Whitehouse Creek is Footlog Branch.

This tributary travels south and east for a distance of less than 0.5 mile and joins Whitehouse Creek immediately upstream of that creek's confluence with Bay Minette Creek.

WILSON CREEK

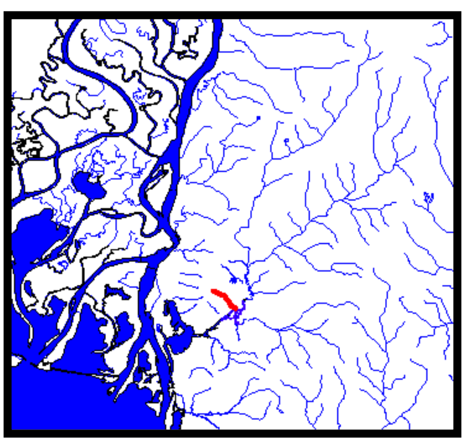


BLAKELY BRANCH

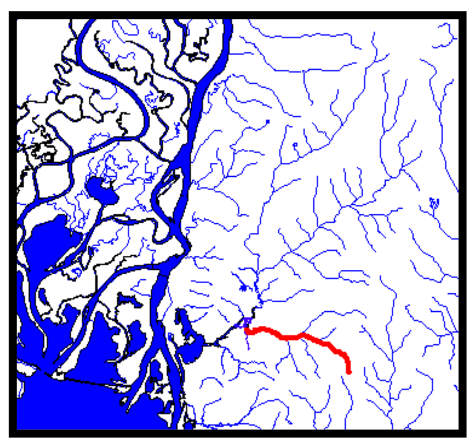


Bay Minette Creek is joined by numerous tributaries along its course. Like those of Whitehouse Creek, only a few tributaries of these have received names. The furthermost upstream named tributary is Wilson Creek. Wilson Creek travels north and west for approximately 3 miles before emptying into Bay Minette Creek a little over a mile upstream of the confluence of Bay Minette Creek and Whitehouse Creek. Further downstream, Blakely Branch travels south and east for approximately 1 mile and joins Bay Minette Creek about 0.5 mile below the confluence of Bay Minette Creek and Whitehouse Creek. Wilkins Creek also travels south and east, roughly parallel to Blakely

WILKINS CREEK

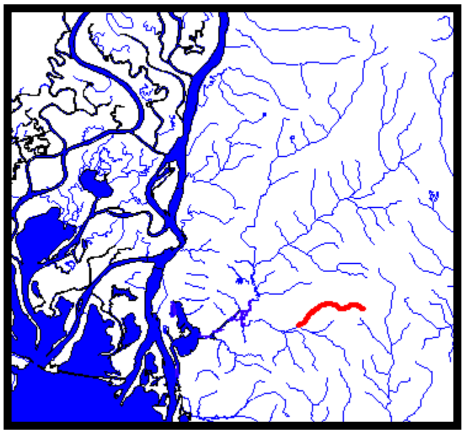


SIBLEY CREEK

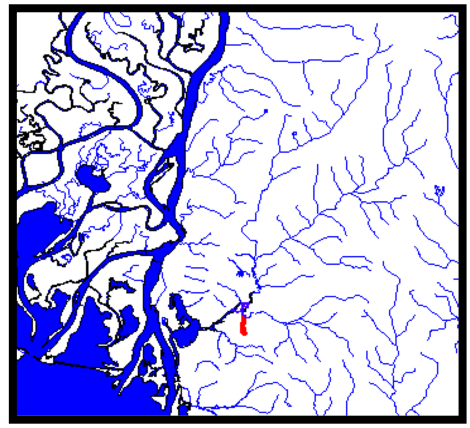


Branch's course, for about a mile and empties into Bay Minette Creek approximately 1 mile below Blakely Creek. Sibley Creek travels north and west for approximately 3.5 miles and joins Bay Minette Creek just downstream of the Wilkins Creek and Bay

HUNAWELL CREEK

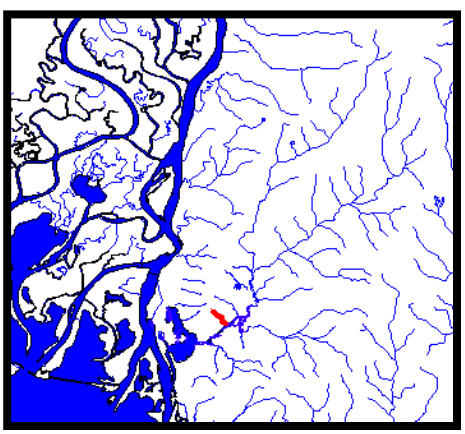


FICKLING BRANCH

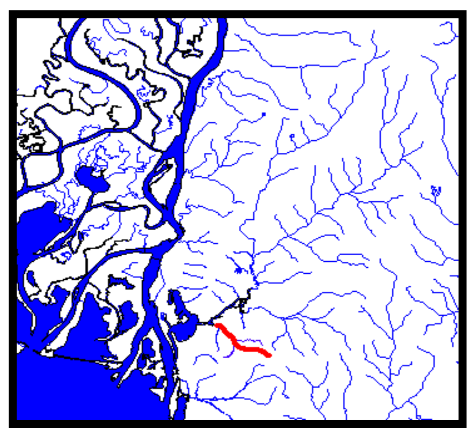


Minette Creek confluence. Hunawell Creek travels south and west and empties into Sibley Creek about 2 miles upstream of that creek's junction with Bay Minette Creek.

MUDDY BRANCH



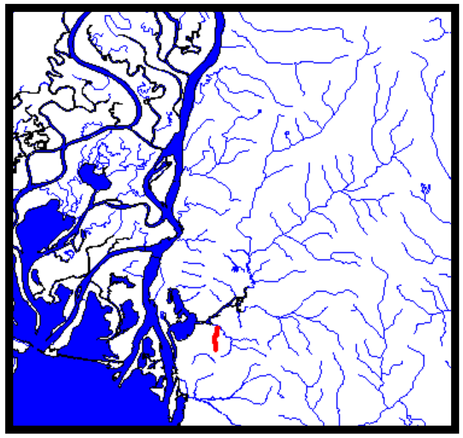
BOGGY BRANCH

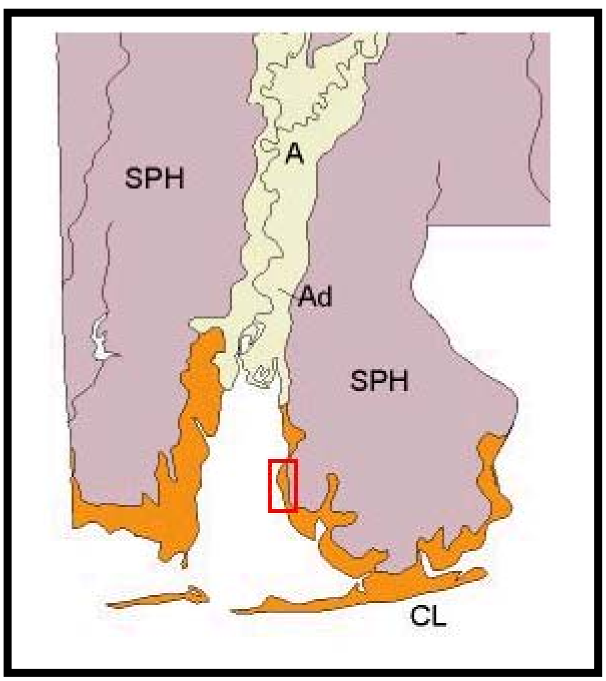


Fickling Branch travels north and west for about 0.75 mile and empties into Sibley Creek just upstream of the confluence of Sibley Creek and Bay Minette Creek. Muddy Branch travels south and east for about 0.75 mile and empties into Bay Minette Creek about 0.5 mile downstream of Wilkins Creek. Boggy Branch originates in the southwest portion of the subwatershed and flows north and west for a distance of about 2 miles before emptying into Bay Minette Creek approximately 0.5 mile upstream of Bay Minette Creek's confluence with Bay Minette. Coleman Spring Branch is a tributary to Boggy

Branch that originates north and west of Boggy Branch's origin and flows about 1 mile before meeting Boggy Branch.

COLEMAN SPRING BRANCH





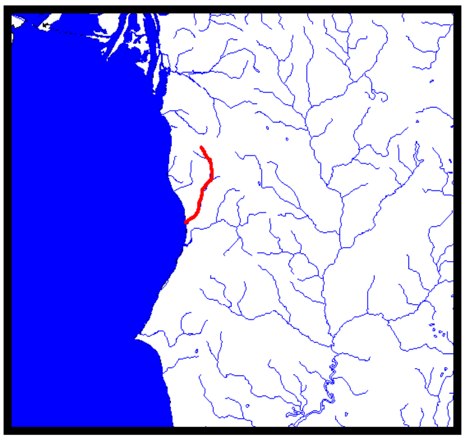
Fly Creek Subwatershed
HUC 03160205 040

The Fly Creek subwatershed lies entirely within and along the western edge of Baldwin County and comprises a total land area of greater than 23,000 acres. The physiographic regions represented in the Fly Creek subwatershed are the Southern Pine Hills (SPH) and the Coastal Lowlands (CL). The Coastal Lowlands are the principal physiographic region represented within the Fly Creek subwatershed and are characterized by flat to gently undulating, locally swampy plains underlain by terrigenous deposits of Holocene and late Pleistocene age. The Southern Pine Hills, present in a small portion of the easternmost reaches of the subwatershed, are underlain by terrigenous sediments.

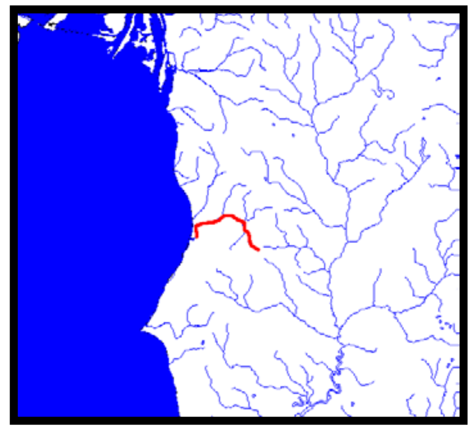
An estimated seven percent of the subwatershed is pasture land, twenty-five percent is crop land, thirty-eight percent is urban land, and twenty-nine percent is forested. There are greater than two thousand five hundred cattle in the subwatershed. Three thousand two hundred and sixty-six septic tank systems have been identified within the basin (Soil and Water Conservation District. 1998.)

Rock Creek originates in the northern portion of the subwatershed and flows south and west for about 3 miles before emptying into Mobile Bay. Originating in east central Baldwin County, Fly Creek flows west for approximately 3 miles to its discharge into the Mobile Bay. From its origin to its confluence with the Mobile Bay, Fly Mile Creek falls approximately 120 feet. This represents a vertical fall of about 40 feet for every mile.

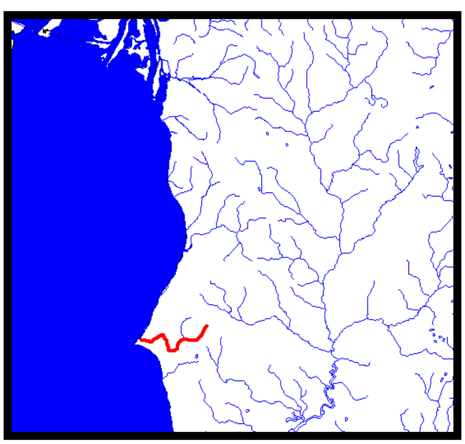
ROCK CREEK



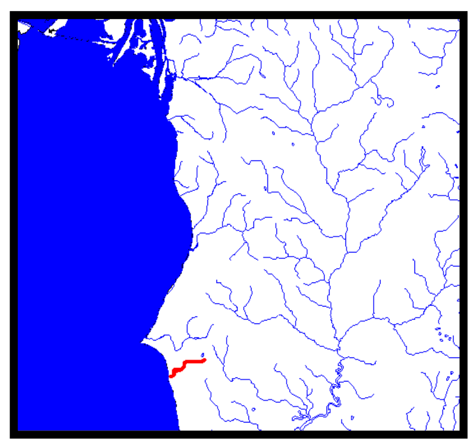
FLY CREEK



POINT CLEAR CREEK

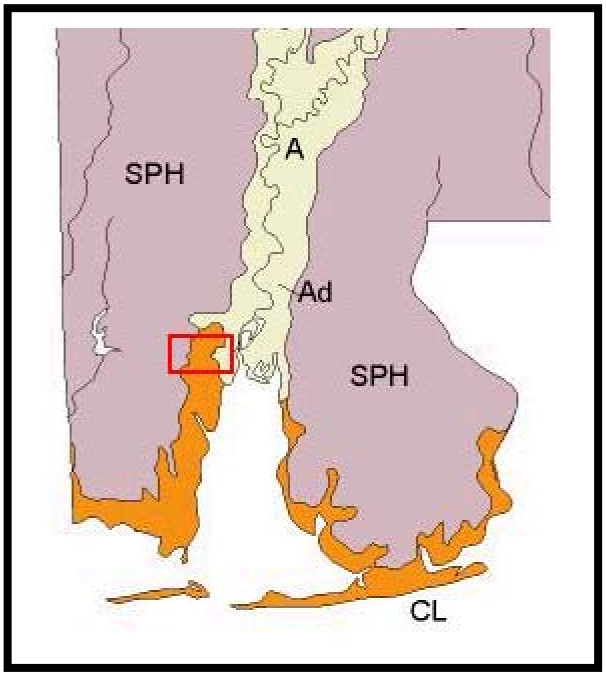


BAILEY CREEK



Point Clear Creek originates in the central portion of the subwatershed, east of Point Clear and travels about 1.5 miles west and empties into the Mobile Bay. Bailey Creek originates about 0.5 mile south of Point Clear Creek and travels about 1 mile south and west to empty into the Mobile Bay. The lower western one-third of the watershed is mostly marshlands.

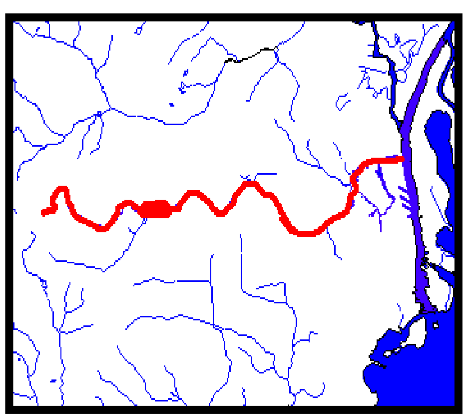
Three Mile Creek Subwatershed
HUC 03160204 060



The Three Mile Creek subwatershed lies entirely within and along the eastern edge of Mobile County and comprises a total land area of greater than 27,600 acres. The physiographic regions represented in the Three Mile Creek subwatershed are the Southern Pine Hills (SPH), the Coastal Lowlands (CL) and the Alluvial-Deltic Plain (A, Ad). The Southern Pine Hills are underlain by terrigenous sediments and make up the western most portion of the subwatershed. In the central portion of the subwatershed, the Coastal Lowlands are the principal physiographic region and are characterized by flat to gently undulating, locally swampy plains underlain by terrigenous deposits of Holocene and late Pleistocene age. The Alluvial-Deltic Plain, present at the easternmost reaches of the subwatershed, exhibits very little topographic relief and consists of alluvial and terrace deposits from rivers.

An estimated five percent of the Three Mile Creek subwatershed is forested. Ninety-one percent of the subwatershed is urban land. There are no crop lands or pasture lands within

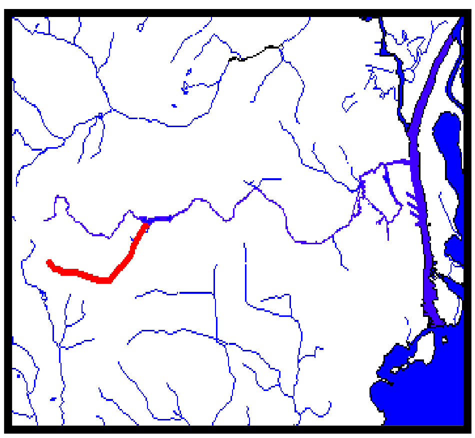
THREE MILE CREEK



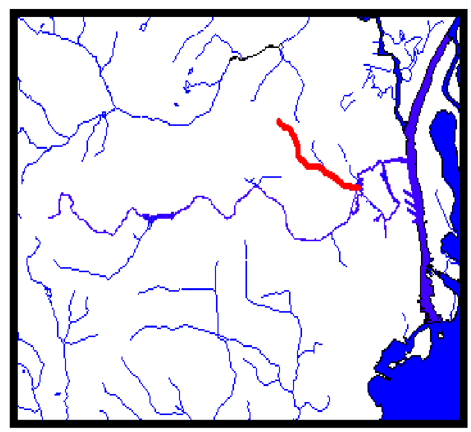
the basin. No cattle were observed in the subwatershed. Three hundred and three septic tank systems have been identified (Soil and Water Conservation District. 1998.) Three Mile Creek appears on the Department's 2000 303(d) list of impaired streams for chlordane concentrations, over enrichment, and depressed dissolved oxygen levels.

Originating in central Mobile County, Three Mile Creek flows east for approximately 30 miles to its discharge into the Mobile River. From its origin to its confluence with the Mobile River, Three Mile Creek falls less than 50 feet. This represents a vertical fall of about 2.5 feet for every mile. Twelve Mile Creek originates south and west of the intersection of Cody Road and Tanner Williams Road in the extreme western portion of the subwatershed and travels a little over 3 miles north and east to empty into Three Mile Creek. Toulmins Spring Branch originates in the northeastern portion of the subwatershed in the Whistler community just north and east of the Interstate 65/ U.S. Highway 45 junction. This tributary travels approximately 2.5 miles to its confluence with Three Mile Creek.

TWELVE MILE CREEK

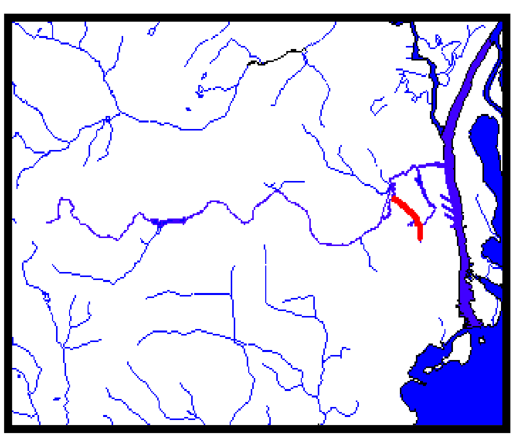


TOULMINS SPRING BRANCH

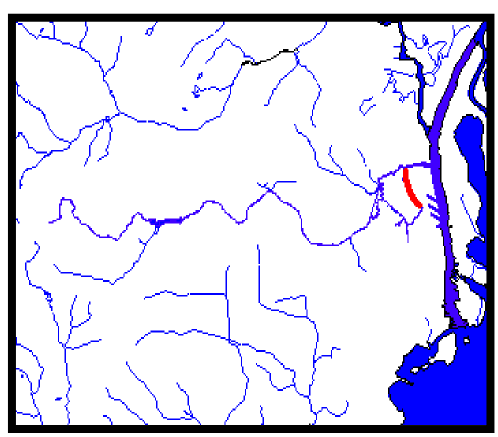


Originating in the northeast corner of the City of Mobile, One Mile Creek travels north and east for a little over 0.25 mile before entering a man-made channel. The channelized

ONE MILE CREEK



INDUSTRIAL CANAL



One Mile Creek travels north and west for about a mile and empties into Three Mile Creek very near the confluence of Toulmins Spring Branch and Three Mile Creek.

The Three Mile Creek Industrial Canal originates in the extreme eastern portion of the subwatershed and is a channelized canal, a little over 1 mile in length, emptying northward into Three Mile Creek about 0.5 mile upstream of the confluence of Three Mile Creek and the Mobile River.

GEOLOGIC UNITS, SOILS, AND HYDROGEOLOGY

Each of the subwatersheds studied are underlain by the same geologic units. These were the Citronelle formation, underlain by the Miocene Series undifferentiated, followed by the Eocene and Oligocene Series undifferentiated. The Citronelle formation is confined to the areas of higher elevation since, near streams and along Mobile Bay, the layer has been eroded to expose the underlying Miocene undifferentiated. Citronelle sediments consist of nonfossiliferous moderate-reddish brown fine to very coarse quartz sand, light-gray, orange, and brown sandy clay, and clayey gravel of nonmarine origin. The sediment type often changes abruptly over short distances. The Miocene Series undifferentiated consists of clastic sedimentary deposits of marine and estuarine origin. Its width ranges from approximately 100 feet in northern Baldwin County to about 3,400 feet in southern Mobile County. The Eocene Series undifferentiated include interbedded sand, silt, clay, and some limestone. The Oligocene Series undifferentiated is comprised of Red Bluff Clay, Forest Hill Sand, Marianna Limestone, Byram Formation, and Chickasawhay Limestone.

The principal soil types encountered in the Bay Minette Creek subwatershed are Bowie fine sandy loam, Bowie fine sandy loam (thin solum), Bowie, Lakeland, and Cuthbert soils, Carnegie very fine sandy loam, Cuthbert fine sandy loam, Cuthbert, Bowie, and Sunsweet soil, Eustis loamy fine sand, Faceville fine sandy loam, Greenville loam, Hyde and Bayboro soils and muck, Kalmia fine sandy loam, Lakeland loamy fine sand, Local alluvial land, Marlboro very fine sandy loam, Norfolk fine sandy loam, Orangeburg fine sandy loam, Plummer loamy sand, Ruston fine sandy loam, Sunsweet fine sandy loam, Tifton very fine sandy loam, and Wet loamy alluvial land. The principal soil types underlying the sample stations were the Hyde and Bayboro soils and muck and Wet loamy alluvial land. The majority of the soil types are of the Bowie-Lakeland-Cuthbert association or the Bowie-Tifton-Sunsweet association (U.S. Dept. of Agriculture. Soil Conservation Service. 1964.)

The principal soil types encountered in the Fly Creek subwatershed are Bibb and Mantachie soils, Bowie, Lakeland, and Cuthbert soils, Carnegie very fine sandy loam, Cuthbert fine sandy loam, Eustis loamy fine sand, Greenville loam, Hyde and Bayboro soils and muck, Lakeland loamy fine sand, Marlboro very fine sandy loam, Norfolk fine sandy loam, Orangeburg fine sandy loam, Ruston fine sandy loam, Tifton very fine sandy loam, and Wet loamy alluvial land. The principal soil type underlying the sample stations was the Hyde and Bayboro soils. The majority of the soil types are of the Marlboro-Faceville-Greenville association (U.S. Dept. of Agriculture. Soil Conservation Service. 1964.)

The principal soil types encountered in the Three Mile Creek subwatershed are Bama sandy loam, Bayou-Escambia association, Benndale sandy loam, Benndale-Urban land complex, Dorovan-Levy association, Duckston sand, Escambia sandy loam, Grady loam, Harleston-Urban land complex, Heidel sandy loam, Johnston-Pamlico association, Malbis sandy loam, Notcher sandy loam, Pits, Saucier sandy loam, Shubuta-Troop association, Smithton-Urban land complex, Troop-Urban land complex, and Urban land. The principal soil types underlying the sample stations were the Smithton-Urban and the Troop-Urban land complexes (U.S. Dept. of Agriculture. Soil Conservation Service. 1980.)

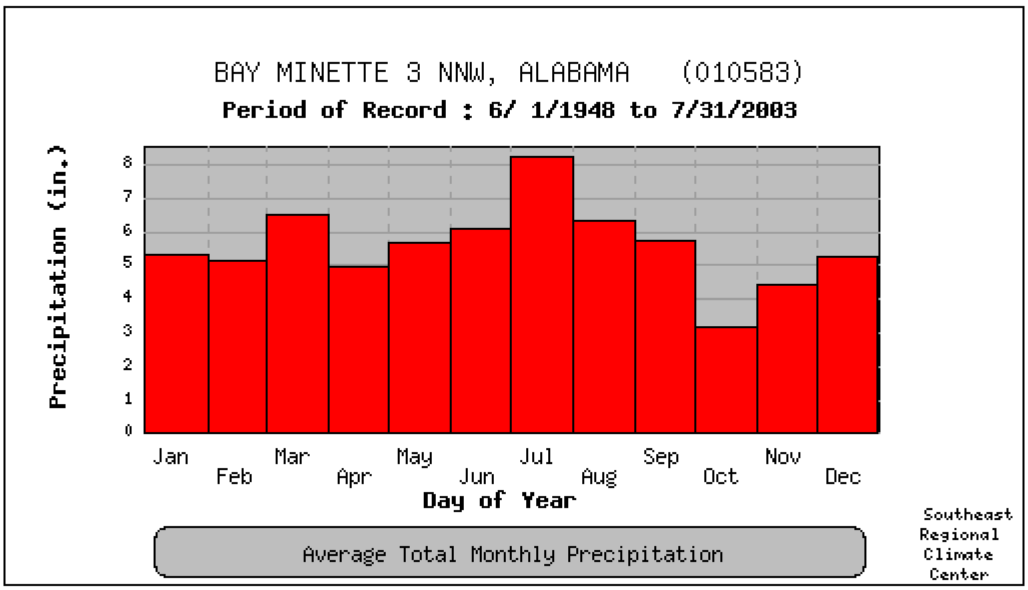
The principal aquifers within the study area are the Miocene-Pliocene Aquifer and the Watercourse Aquifer. The Miocene-Pliocene Aquifer consists of the Citronelle Formation and the Miocene Series undifferentiated and is represented by beds of sand, gravel, and clay. Wells completed in this aquifer yield from 0.5 to 2.5 million gallons per day. The Watercourse Aquifer consists of alluvial, coastal, and low terrace deposits represented by interbedded sand, gravel, and clay. Where the sand is sufficiently thick, wells may yield 0.5 to 1.0 million gallons per day. The sand and gravel channels, surrounded by silty and clayey sediments, do not yield significant amounts of water but do allow the slow infiltration of recharge water. Both the Miocene-Pliocene and the Watercourse Aquifers are hydraulically connected to one another and the land's surface and, as such, are unconfined and vulnerable to contamination from runoff (Geological Survey of Alabama. 2000).

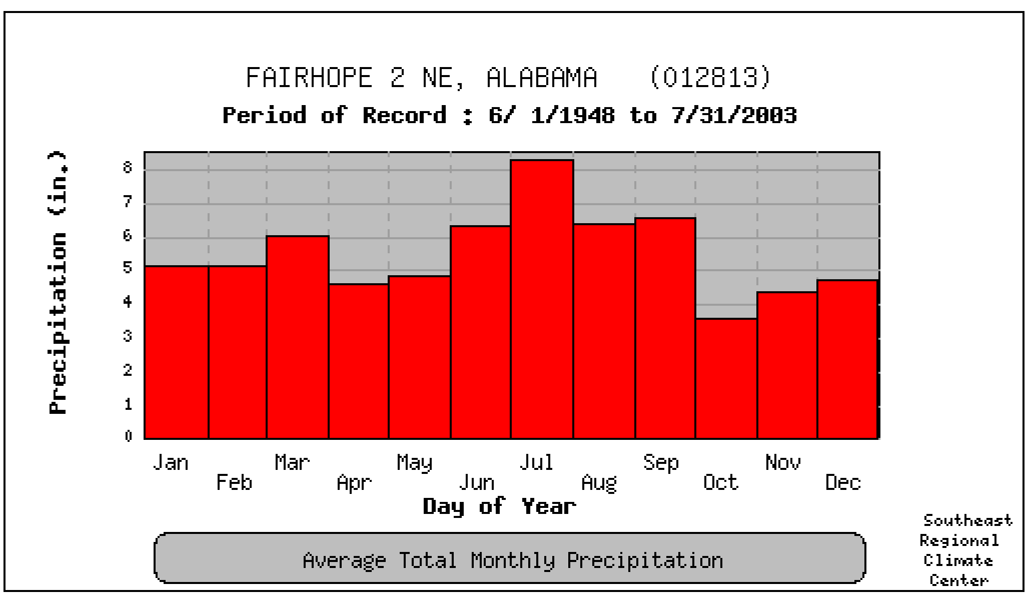
CLIMATE

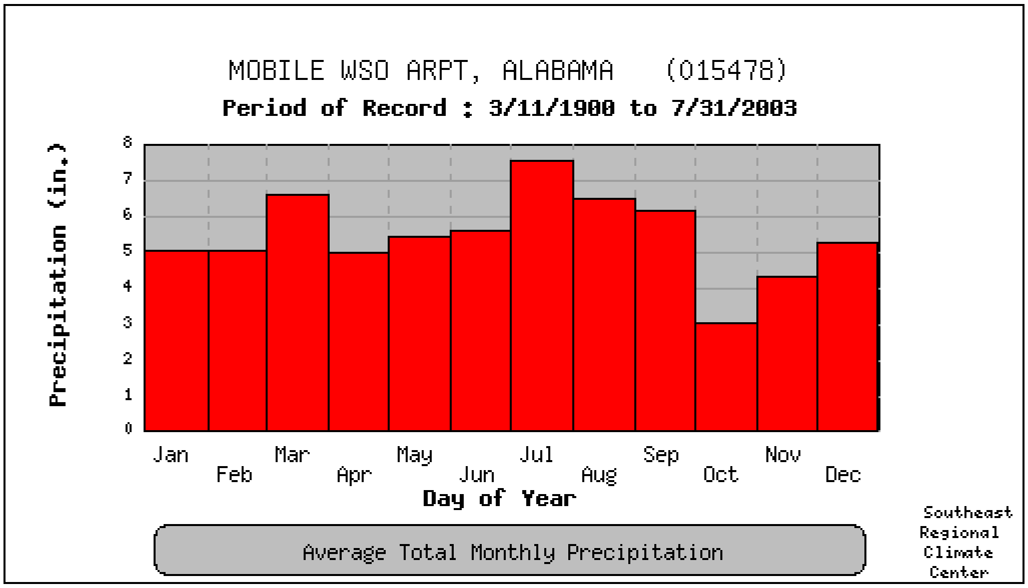
Summers in the subject subwatersheds are typically hot and humid with an average temperature of 81^0 F, and an average daily maximum temperature of 91^0 F. Winters are mild, with an average temperature of 53^0 F, and an average daily minimum temperature of 43^0 F. The lowest temperature on record, 7^0 F, occurred on January 1, 1963. The highest temperature, 104^0 F, was recorded on July 25, 1952. Rain occurs year round, with the heaviest rainfall occurring in April through September. Total average yearly rainfall is approximately 64 inches. Relative humidity is high in the area, averaging about 60 percent in mid afternoon. The highest relative humidity readings are, typically, at night, with measurements of about 90 percent not uncommon in the dawn hours (U.S. Geological Survey).

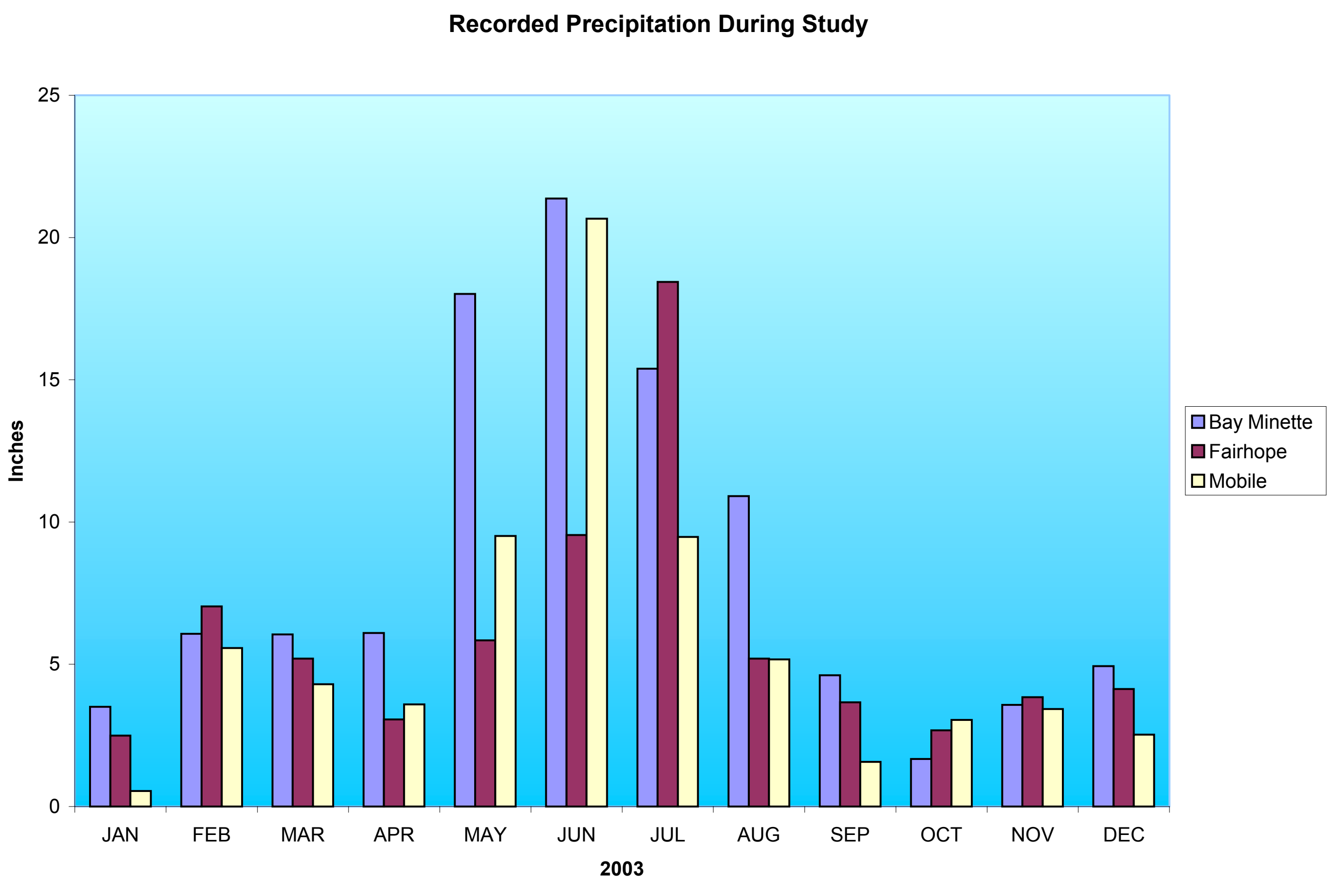
As may be seen in the statewide precipitation graphic, the study areas experience a normal annual rainfall that is higher than elsewhere in Alabama and is among the highest in the United States. This may be attributed to the area's close proximity to the Gulf of Mexico. Rainfall is usually of the shower type with long periods of continuous rain being rare. Precipitation is usually greatest in the summer and least in the fall. Thunderstorms may occur at any time of the year, regardless of season.

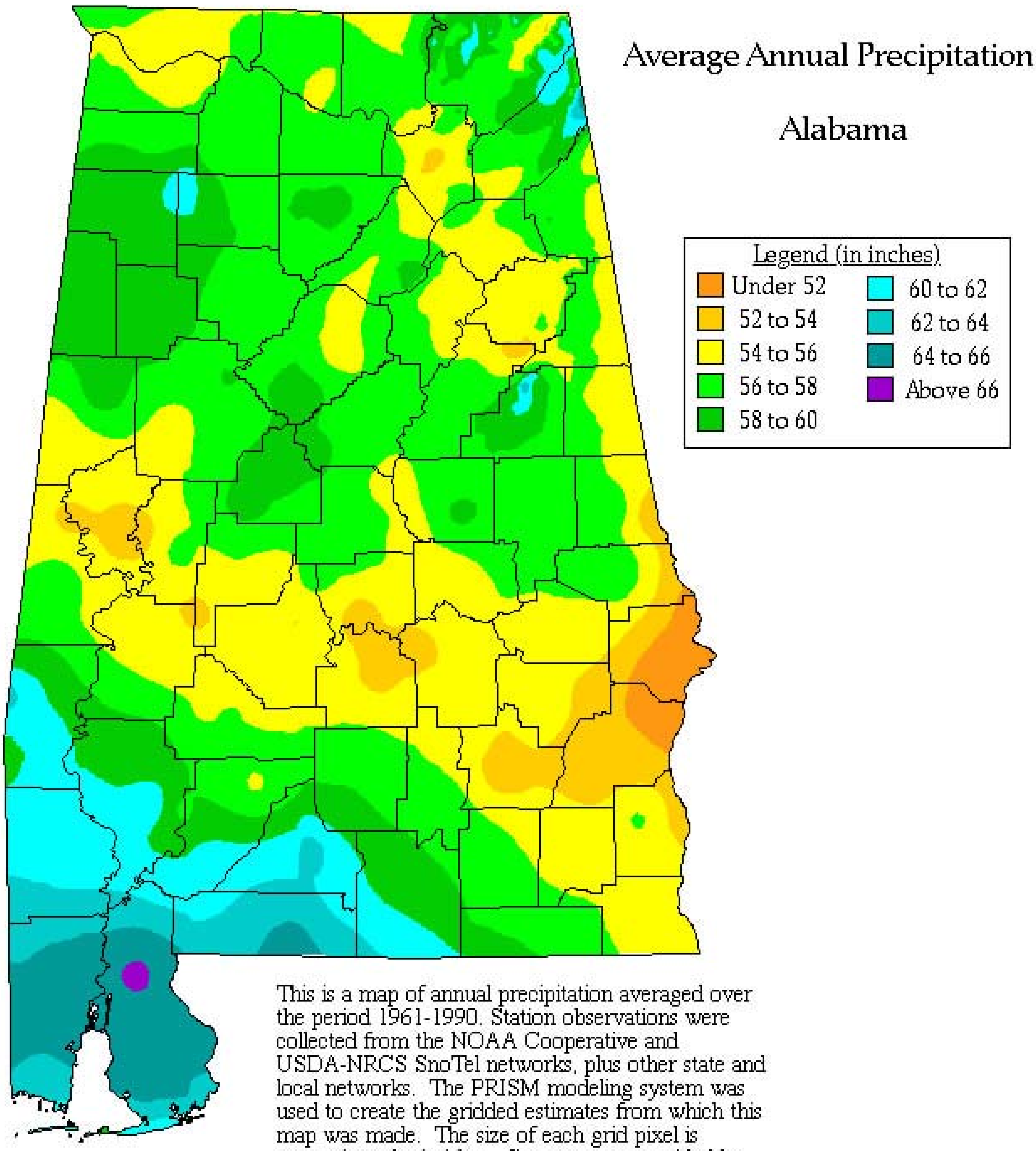
The inserted charts illustrate the normal average rainfall by month for the subject areas and the recorded amounts of rainfall during the study period. The average rainfall during the Study period appeared to be substantially greater than the historical average. The general trend in rainfall averages appeared to follow that of the historical data with the summer months experiencing the greatest amount of rainfall and the fall months experiencing the least. Increased rainfall amounts during the early spring were observed in both the historical record and in the record produced during the study period.






MOBILE WSO ARPT, ALABAMA (015478)
Period of Record : 3/11/1900 to 7/31/2003
Precipitation (in.)
0
1
2
3
4
5
6
7
8
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Day of Year
Average Total Monthly Precipitation
Southeast Regional Climate Center


Recorded Precipitation During Study
Inches
0
5
10
15
20
25
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2003
Bay Minette
Fairhope
Mobile



Average Annual Precipitation

Alabama

This is a map of annual precipitation averaged over the period 1961-1990. Station observations were collected from the NOAA Cooperative and USDA-NRCS SnoTel networks, plus other state and local networks. The PRISM modeling system was used to create the gridded estimates from which this map was made. The size of each grid pixel is approximately 4x4 km. Support was provided by the NRCS Water and Climate Center.

USE CLASSIFICATION

Rule 335-6-11-.02(9) establishes a Use Classification of Agriculture and Industry for Three Mile Creek from its source to the Mobile River. Bay Minette Creek and Fly Creek carry Use Classifications of Fish and Wildlife from their source to Mobile Bay. In addition, Fly Creek carries a Use Classification of Swimming from its source to Mobile Bay.

For those water bodies with a use classification of swimming and other whole body water contact sports, the following water quality criteria apply:

Criteria	**Limit**
pH	6.0 to 8.5 s.u.
Water Temperature	$\geq 90^0$ F
Dissolved Oxygen	≤ 5.0 mg/l
Fecal Coliform Bacteria	≥ 100 colonies/100 ml (geometric mean)
Turbidity	> 50 ntu above background

For those water bodies with a use classification fish and wildlife, the following water quality criteria apply:

Criteria		**Limit**
pH		6.0 to 8.5 s.u.
Water Temperature		$\geq 90^0$ F
Dissolved Oxygen		≤ 5.0 mg/l
Fecal Coliform Bacteria	June – September	≥ 100 colonies/100 ml (geometric mean)
	October - May	≥ 1000 colonies/100 ml (geometric mean)
		≥ 2000 colonies/100 ml (single sample)
Turbidity		> 50 ntu above background

(ADEM Admin. Code R. 335-6-10-.09.)

ECONOMIC DEVELOPMENT AND LAND USE

HISTORY

As a result of its proximity to the Gulf of Mexico, European explorers first discovered Mobile, Alabama in the early 16th century. It was not until the early 18th century, however, that French, Spanish, English, Swedish, and Russian immigrants began to set up residence in the area. The arrival of these settlers eventually drove the land's original denizens, the Native Americans, away. Mobile dates back to 1702 as the earliest successful French royal settlement on the upper Gulf Coast, predating New Orleans. During its history, Mobile has been part of many nations, including France, Britain, Spain, the United States, and the Confederate States of America. The present city of Mobile was founded in 1711 and is the oldest of all Alabama cities.

In the early years of its history, trappers from all over the southern United States sold their furs in Mobile. As a port city Mobile came to rely heavily on the cotton trade. The advent of the Civil War disrupted the cotton flow and almost destroyed the city economically. In the years following that conflict little money was expended to upgrade Mobile's industry. It was not until the time of World War I that Mobile's port facilities were rebuilt to accommodate ocean going vessels. With the advent of World War II, Mobile experienced tremendous growth, especially along its waterfront. Local shipyards were inundated with shipbuilding orders. By the end of the war Mobile shipyards had produced more than 3,000 Navy and Merchant Marine vessels and employed more than 40,000 people. The completion of the Tennessee-Tombigbee Waterway in 1985 connected the Port of Mobile with Appalachian coal fields and Midwest grain fields and made the city the seaport for the second-largest river system in the country. In recent years, the docks of Mobile have handled more wood pulp than any other port in the United States (Mobile Chamber of Commerce. 2003.)

Until the final years of the 19th century, Mobile was the largest population center in the state. By the year 1820, 2,672 people had settled in the area now known as Mobile County. In 1900, that number had grown to 62,740. In the year 2000, the population of Mobile County was 399,843 (U.S. Census Bureau. 2002).

Baldwin County is one of the fastest growing counties in Alabama and one of the largest counties east of the Mississippi River. It was first organized as county in 1809, ten years before Alabama's statehood. The county is named after Abraham Baldwin, a State of Georgia Legislator from Connecticut who founded the first state university, The University of Georgia, and never stepped foot in Alabama. Baldwin County's first inhabitants were the Native Americans who were drawn to the area by the abundance of its natural resources and the incredible range of its navigable waters. Recorded history denotes Baldwin County's discovery at the time of the Spanish explorers in the early sixteenth century. There is, however, a small amount of evidence to suggest that Baldwin County may have been discovered as early as the 12th century by Welsh explorers. This evidence includes archaeological remains of an ancient fort, Indian legend, and personal accounts of Daniel Boone, George Rogers Clark, and a former Governor of Tennessee. At any rate, the Spanish were well represented in the county throughout the 17th Century. Towards the end of the 17th Century, Spanish interests in the area were replaced by the French. The area fell under British control as a result of the French-Indian War. For a short period during the American Revolution, the Spanish reestablished supremacy in the area.

The earliest documented settlers of Baldwin County included persons from France, Greece, Germany, Yugoslavia, Russia, Sweden, Czechoslovakia, and Africa. These settlers built Baldwin County's agricultural, commercial, manufacturing, tourism and fishing industries. Around the turn of the 20th century, immigrants from many regions of the United States and from other countries began populating Baldwin County. Italians settled in Daphne, Scandinavians in Silverhill, Germans in Elberta, Poles in Summerdale, Greeks in Malbis Plantation, Quakers in Fairhope, Amish in Bay Minette, and Bohemians in Robertsdale, Summerdale, and Silverhill. At the present time, retirees from northern states continue to migrate to Baldwin County.

Bay Minette, Baldwin County's County Seat, was named for the bay, which was named after a surveyor with Jean Baptiste Le Moyne, founder of New Orleans.

The population for the selected watersheds, as of the 2000 census is as follows:

Bay Minette Creek Subwatershed	
Bay Minette	7,820
Spanish Fort	5,423
Fly Creek Subwatershed	
Daphne	16,581
Fairhope	12,480
Point Clear	1,876
Three Mile Creek Subwatershed	
Mobile	198,915

Permitted Facilities

At the time of the study, only one of the subject subwatersheds, Three Mile Creek, had NPDES permitted facilities discharging into its surface water. There were three permitted dischargers to Three Mile Creek. These were: Cavenham Forest Industries, Incorporated (AL0001104), located at the south end of Herbert Street in Mobile, Alabama, Carlos A. Morris WWTP (AL0023205), located on Grover Street in Prichard, Alabama, and the Wright Smith Jr. WWTP (AL0023094), located on Conception Street in Mobile, Alabama.

Cavenham Forest Industries' permit, effective October 1, 2001 through September 30, 2006, is for the discharge of treated groundwater and contaminated storm water from groundwater and soil remediation operations. No limit is established in the permit for flow. The pH of the discharge is limited to between 6.0 and 8.5 standard units and total phenols may not exceed 0.1 parts per million. An NPDES Compliance Inspection conducted by the ADEM in May, 1997, noted no significant violations at the facility.

The Carlos A. Morris WWTP permit, effective September 25, 1999, through September 30, 2004, establishes a daily flow limit of 4.0 million gallons.

Carlos A. Morris WWTP Permit Limits

	Monthly Average	Daily Minimum	Daily Maximum
BOD	15.0 ppm		
TSS	30.0 ppm		
TKN	5.0 ppm		
pH		6.0 s.u.	9.0 s.u.
DO		5.0 ppm	
TRC (after chlorination)		0.5 ppm	
TRC (after dechlorination)			0.04 ppm

An NPDES Compliance Sampling Inspection conducted at the Carlos A. Morris WWTP by the ADEM in January of 2002 did not reveal any substantial violations.

The Wright Smith Jr. WWTP permit, effective February 15, 1999, through February 29, 2004, establishes a daily flow limit of 12.8 million gallons.

Wright Smith Jr. WWTP Permit Limits

	Monthly Average	Daily Minimum	Daily Maximum
BOD	20.0 ppm		
TSS	30.0 ppm		
TKN	5.0 ppm		
pH		6.0 s.u.	9.0 s.u.
DO		5.0 ppm	
TRC (after chlorination)		0.5 ppm	
TRC (after dechlorination)			0.01 ppm
Fecal Coliform	200 colonies/100 ml		2000 colonies/100 ml

An NPDES Compliance Sampling Inspection conducted at the Wright Smith Jr. WWTP by the ADEM in April of 2002 did not reveal any substantial violations.

Threatened and Endangered Species

All three of the subject subwatersheds exhibited a diverse and prolific array of flora and fauna. The Bay Minette Creek subwatershed appeared to offer the best habitat among the three watersheds. The Fly Creek subwatershed offered the second best habitat and the Three Mile Creek subwatershed followed last in this area. Anthropogenic activities were probably the primary causative factor in this rating scale. Population pressures were virtually non existent in the Bay Minette Creek subwatershed. These pressures were substantially increased in the Fly Creek subwatershed and were pronounced in the Three Mile Creek subwatershed. Wading birds such as the Great Blue Heron, *Ardea herodias*, Great Egret, *Casmerodius albus*, Green Heron, *Butorides virescens*, American Bittern, *Botaurus lentiginosus*, and others were ubiquitous during field patrols in each of the selected subwatersheds. It has been generally accepted that the presence or absence of such wading birds is indicative of environmental trends within an area (Geological Survey of Alabama. 1983). Also prevalent within the subject subwatersheds were varying Hawk species, the Osprey, *Pandion haliaetus*, Kingfisher, *Ceryle alcyon*, and Turkey Vulture, *Cathartes aura*. All of which are indicators of ample food supply and acceptable habitat.

Below is a current Federal listing of threatened and endangered species for the study areas.

THREATENED -	Piping plover *Charadrius melodus*
THREATENED -	Eastern indigo snake *Drymarchon corais couperi*
THREATENED -	Gopher tortoise *Gopherus polyphemus*
THREATENED -	Loggerhead sea turtle *Caretta caretta*
THREATENED -	Green sea turtle *Chelonia mydas*
THREATENED -	Gulf sturgeon *Acipenser oxyrinchus desotoi*
THREATENED -	Flatwoods salamander *Ambystoma cingulatum*
ENDANGERED -	Louisiana quillwort *Isoetes louisianensis*
ENDANGERED -	Red-cockaded woodpecker *Picoides borealis*
ENDANGERED -	Least tern *Sterna antillarum*
ENDANGERED -	Alabama red-bellied turtle *Pseudemys alabamensis*
ENDANGERED -	Kemp's ridley sea turtle *Lepidochelys kempii*
CANDIDATE SPECIES -	Black pine snake *Pituophis melanoleucus lodingi*

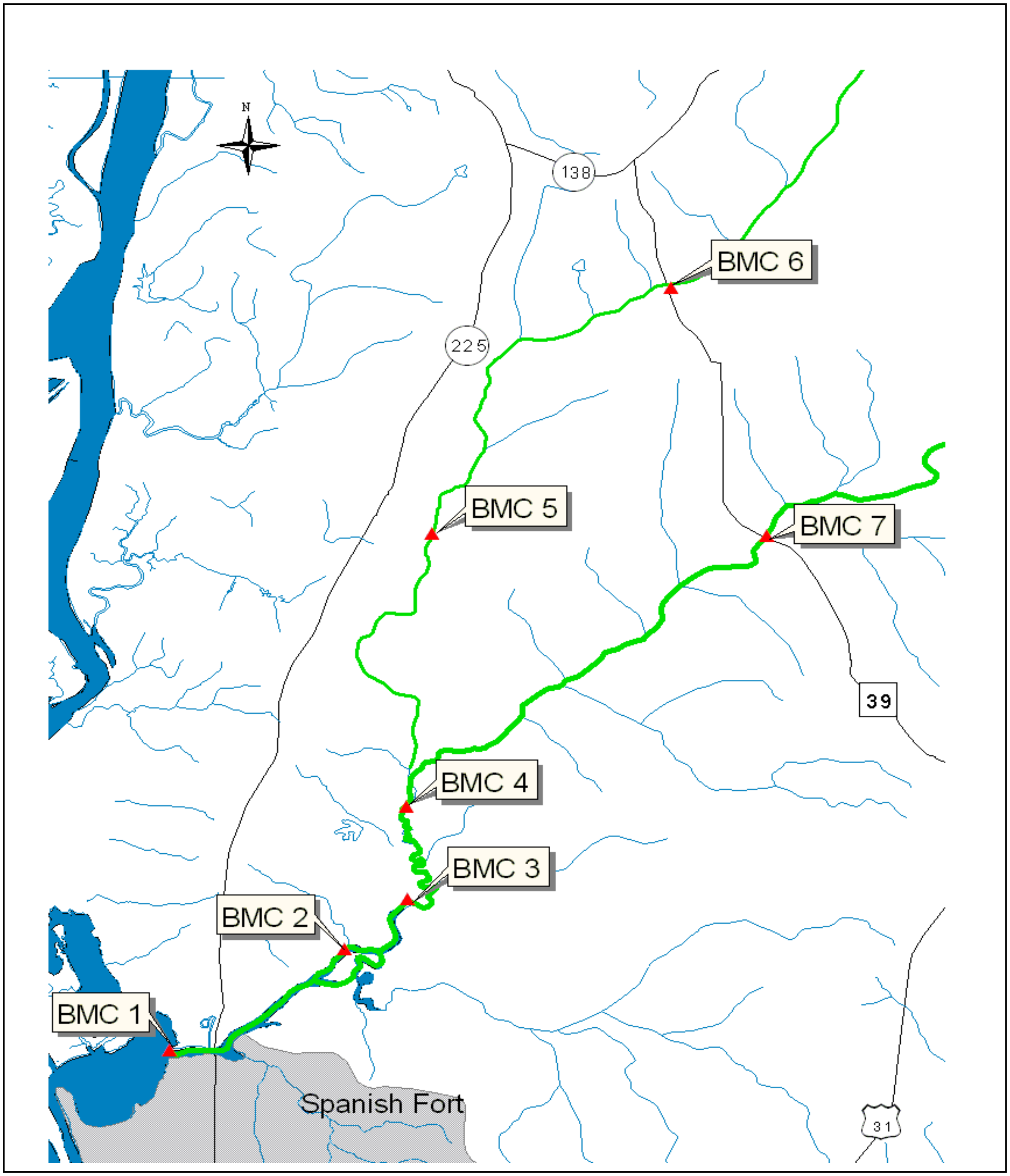
(Daphne Ecological Services Field Office. 2002.)

BROWNFIELD STUDY

In April of 2003, the ADEM took a series of surface water samples on Three Mile Creek and its tributaries in the easternmost portion of the watershed. These samples were taken in support of a Mobile targeted Brownfield assessment. The samples, retrieved from 11 stations, were analyzed for volatiles, semi-volatiles, and total levels of arsenic, cadmium, lead, and mercury. Of the 11 stations, constituent concentrations above the laboratory method detection limit were only observed in three. Two of the three stations were located on the upper reaches of One Mile Creek, a stream draining a densely urbanized area within metropolitan Mobile. Station SW-OC-13, near the origin of One Mile Creek, exhibited a 107.75 parts per billion concentration of acetone. Station SW-11-1M, located at the point One Mile Creek becomes channelized, exhibited a 5.13 parts per billion total concentration of lead. The third station, SW-09-3M, was located on Three Mile Creek a few hundred feet downstream of that stream's confluence with One Mile Creek. Samples retrieved at this station revealed a trace amounts of 2, 4—D, 0.109 parts per billion concentration of Malathion, and a 2.94 parts per billion total concentration of lead. Based on the land use surrounding the area covered under this study, the presence of the observed constituents in the concentrations noted is not alarming. The study area was bounded to the north, south, and west by concentrated, urban population centers and to the east lay an abundance of industry. Given the potential for NPS pollutants in such an environment, trends monitoring of the same stations would likely reveal a variety of constituent concerns over time.

Sample Stations

Bay Minette Creek Subwatershed
03160204 040



BMC 1 - **Bay Minette Creek West Of Highway 225 Bridge** **30^0 42' 00"**
87^0 54' 30"

BMC 1 was located just upstream of Bay Minette, about 300 yards downstream of the U.S. Highway 225 Bridge, just north of Spanish Fort, Alabama. This station was accessible only by boat. Land use in the vicinity of BMC 1 was swamp forest, forest, and marsh. No substantial impervious surface area was observed bordering this station. No disturbances of the riparian zone on either bank were observed. The bottom substrate of BMC 1 consisted of fine organic muck, silt, sand, and detritus. The stream here was about 100 yards wide and as a result had no canopy cover except directly along the banks. Aquatic vegetation was abundant along both banks. Bank height averaged about one foot. Obvious high water marks of about 1.5 feet were visible on trees and other vegetation lining the banks. The photo is facing upstream across the station and toward the Highway 225 bridge.

BMC 2 - **Bay Minette Creek Downstream of Whitehouse Creek** **30^0 42' 54"**
87^0 53' 02"

BMC 2 was located on Bay Minette Creek approximately 200 yards downstream of the confluence of Wilkins Creek and Bay Minette Creek. This station was accessible only by boat. The stream's width was approximately 50 yards at this station. Land use on both banks was forest. No substantial impervious surface area was observed. No disturbances of the riparian zones of either bank were observed. No canopy cover existed for this station except along the banks. The bottom substrate consisted of fine organic muck, silt, sand, and detritus. Aquatic vegetation was abundant along both banks. Bank height was about one foot. Obvious high water marks of about 1.5 feet were visible on trees and other vegetation lining the banks. The photo is facing upstream across the station and toward Wilkins Creek.

BMC 3 - Bay Minette Creek at Power Line Crossing **30^0 43' 21"**
87^0 52' 31"

BMC 3 was located at the power line crossing several hundred yards upstream of the confluence of Wilkins Creek and Bay Minette Creek. This station was accessible only by boat. The width of the stream at this station was about 30 yards. Land use on both banks was forest with a power line corridor. No substantial impervious surface area was observed around this station. Vegetation within the power line corridor was cut back periodically. Apart from this, no disturbances of the riparian zones of either bank were observed. No canopy cover existed for this station except along the banks upstream and downstream of the power line corridor. The bottom substrate consisted of fine organic muck, silt, sand, and detritus. Aquatic vegetation was abundant along both banks. A pitcher plant, *Sarracenia purpurea*, was present along the right bank, adjacent the power line corridor. Bank height was about one foot. Obvious high water marks of about 1.5 feet were visible on trees and other vegetation lining the banks. The photo is facing downstream across the station.

BMC 4 - Bay Minette Creek **30^0 44' 11"**
87^0 52' 22"

BMC 4 was the uppermost station accessed by boat. It was located on Bay Minette Creek about ½ mile upstream of BMC 3 and ½ mile downstream of the confluence of Bay Minette Creek and Whitehouse Creek. The stream was about 40 feet wide at this station. Land use on both banks was forest. No substantial impervious surface area was observed around this station. No disturbances of the riparian zones of either bank were observed. Canopy cover was an estimated 5%. The bottom substrate at this station consisted of mostly sand with a small amount of CPOM and detritus. Aquatic vegetation was abundant along both banks. Bank height was about one foot. Obvious high water marks of about 1.5 feet were visible on trees and other vegetation lining the banks. The photo is facing upstream toward the station.

BMC 5 Whitehouse Creek at County Road 40 **30^0 46' 37" 87^0 52' 19"**

BMC 5 was located on Whitehouse Creek about 100 feet upstream of the bridge on Baldwin County Road 40. The stream width at this station was typically around 15 feet. Land use on the right bank was rural/residential with one house and outbuildings. Land use on the left bank was swamp forest. The most significant impervious surface observed was County Road 40 and the bridge. No disturbances of the riparian zone were observed on the left bank. The vegetation of the right bank was cut periodically. Canopy cover was estimated to be about 40 percent. The bottom substrate at this station consisted of sand, silt, CPOM and detritus. Aquatic vegetation was present in small sections. Bank height on the left bank was less than a foot. Bank height on the right bank was closer to two feet. High water evidence exceeding 3 feet was observed. The photo is facing upstream across the station.

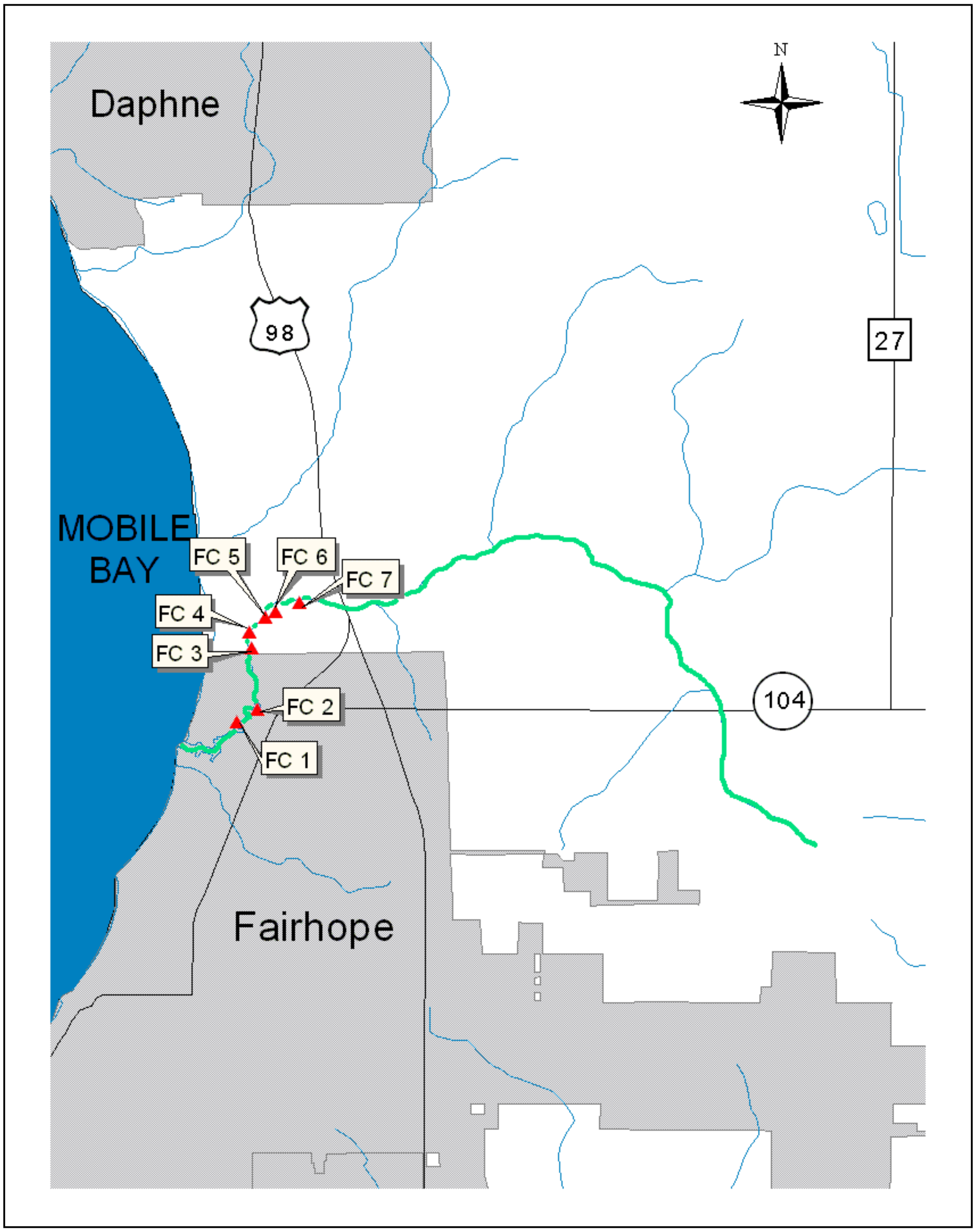
BMC 6 Whitehouse Creek at County Road 39 **30^0 48' 49" 87^0 50' 19"**

BMC 6 was located on Whitehouse Creek about 200 feet upstream of the bridge on Baldwin County Road 39. The stream width at this station was typically around 15 feet. Land use on both banks was swamp forest. The most significant impervious surface observed was County Road 39 and the bridge. No disturbances of the riparian zones of either bank were observed. Canopy cover was estimated to be about 50 percent. The bottom substrate at this station consisted of sand, silt, CPOM, and detritus. The bottom was also strewn with natural rock, boulder and cobble sized, driftwood, and old glass bottles. Aquatic vegetation was present in small sections. Bank height was about 1.5 feet. High water evidence was observed in excess of 3 feet. The photo is facing upstream across the station.

BMC 7 - Bay Minette Creek at County Road 39 30^0 46' 36" 87^0 49' 31"

BMC 7 was located on Bay Minette Creek about 150 feet upstream of the bridge on Baldwin County Road 39. The stream width at this station was typically around 20 feet. Land use on both banks was swamp forest. The most significant impervious surface observed was County Road 39 and the bridge. No disturbances of the riparian zones of either bank were observed. Canopy cover was estimated to be about 40 percent. The bottom substrate at this station consisted of sand, silt, CPOM, and detritus. Aquatic vegetation was present in small patches. Bank height on the left bank was about 2 feet. Bank height on the right bank was about 1.5 feet. Flood level evidence was observed greater than 3 feet above bank height. The photo is facing upstream across the station.

Fly Creek Subwatershed
03160205 040



FC 1 - Fly Creek Upstream of Marinas **30^0 32’ 40”**
87^0 53’ 59”

FC 1 was located on Fly Creek upstream of that creek’s marinas. All of the Fly Creek stations were reached by boat. The stream width at FC 1 was typically around 80 feet. Land use on the right bank was residential. The left bank was swamp forest. Impervious surface was estimated to be less than 10 percent. No disturbances of the riparian zone were observed on the left bank. Vegetation on the right bank was cut periodically. Canopy cover was estimated to be about 5 percent. The bottom substrate at this station consisted of sand, silt, CPOM and detritus. Aquatic vegetation was abundant along both banks. Bank height was about one foot. The photo is facing downstream across station.

FC 2 - Fly Creek **30^0 32’ 43”**
87^0 53’ 54”

FC 2 was located on Fly Creek about 300 yards upstream of FC 1. The stream width at this station was typically greater than 100 feet. Land use on the right bank was residential. The left bank was swamp forest. Impervious surface was estimated to be less than 10 percent. No disturbances of the riparian zone on the left bank were observed. Vegetation along portions of the right bank were cut periodically. Canopy cover was estimated to be less than 5 percent. The bottom substrate at this station consisted of sand, silt, CPOM and detritus. Aquatic vegetation was abundant along both banks. The photo was taken facing downstream across the station.

FC 3 - **Fly Creek** **30^0 32' 59"**
87^0 53' 56"

FC 3 was located on Fly Creek about 300 yards downstream of the bridge on Scenic U.S. Highway 98. The stream width at this station was typically about 50 feet. Land use on both banks was residential. Impervious surface was estimated to be less than 10 percent. Disturbances of the riparian zones of both banks were observed. Canopy cover was estimated to be about 5 percent. The bottom substrate at this station consisted of sand, silt, CPOM and detritus. Aquatic vegetation was abundant along both banks. Bank height was about one foot. The photo was taken facing downstream toward the station.

FC 4 - **Fly Creek Downstream of Highway 98 Bridge** **30^0 33' 03"**
87^0 53' 56"

FC 4 was located on Fly Creek about 200 feet downstream of the bridge on Scenic U.S. Highway 98. The stream width at this station was typically around 30 feet. Land use on both banks was residential. Impervious surface was estimated to be about 10 percent. No disturbances of the riparian zone were observed on the left bank. Some disturbance of the vegetation on the right bank was observed. Canopy cover was estimated to be about 10 percent. The bottom substrate at this station consisted of mostly sand with some silt, CPOM and detritus. Aquatic vegetation was abundant along both banks. Bank height at the left bank was about 3 feet. At the right bank the bank height was gradually sloping. The photo was taken facing downstream across the station.

FC 5 - Fly Creek Upstream of Highway 98 Bridge **30^0 33' 07"**
87^0 53' 52"

FC 5 was located on Fly Creek about 200 feet upstream of the bridge on Scenic U.S. Highway 98. The stream width at this station was typically around 30 feet. Land use on both banks was swamp forest. Impervious surface was estimated to be less than 10 percent. No disturbances of the riparian zones of either bank were observed. Canopy cover was estimated to be about 40 percent. The bottom substrate at this station consisted of mostly sand with some silt, CPOM and detritus. Aquatic vegetation was abundant along both banks. Bank height was about 1.5 feet. The photo was taken facing downstream across the station.

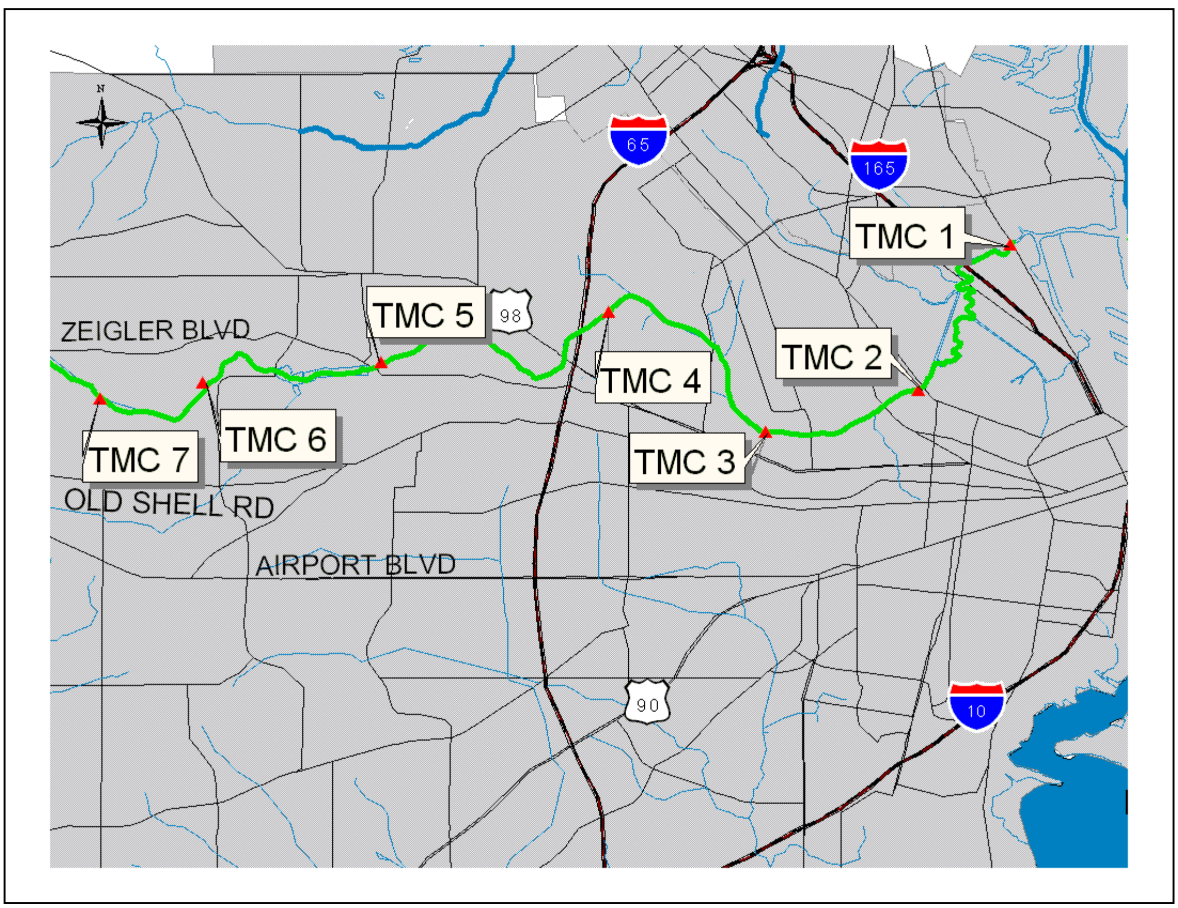
FC 6 - Fly Creek Upstream of FC 5 **30^0 33' 09"**
87^0 53' 49"

FC 6 was located on Fly Creek about 200 yards upstream of FC 5, just above the 1st island observed. The stream width at this station ranged from 20 feet to 50 feet depending on tide and flow conditions. Land use on both banks was forest. Impervious surface was estimated to be less than 10 percent. No disturbances of the riparian zones of either bank were observed. Canopy cover was estimated to be about 40 percent. The bottom substrate at this station consisted of mostly sand with some silt, CPOM and detritus. Aquatic vegetation was present in small patches. Bank height was about one foot. The photo was taken facing downstream across the station.

FC 7 - **Fly Creek** **30^0 33' 11"**
87^0 53' 43"

FC 7 was located on Fly Creek about 200 yards upstream of FC 6. The stream width at this station was typically around 25 feet. Land use on both banks was residential/forest. Impervious surface was estimated to be less than 10 percent. No disturbances to the riparian zone of the right bank were observed. The left bank demonstrated minor disturbances of the riparian zone. The station appeared to be a swimming spot for persons unknown. Canopy cover was estimated to be around 50 percent. The bottom substrate at this station consisted of mostly sand with some silt, CPOM and detritus. Aquatic vegetation was present in small patches. Bank height was about one foot. The photo was taken facing downstream across the station.

Three Mile Creek Subwatershed
03160204 060



TMC 1 - Three Mile Creek Upstream of Industrial Canal **30^0 43' 27"**
88^0 03' 32"

TMC 1 was located on Three Mile Creek approximately ¼ mile upstream of the Three Mile Creek Industrial Canal and immediately upstream of the Telegraph Road bridge. This site is a Mobile Delta Trend site designated TM -1. Water quality data has been collected on a regular basis at this site since March of 1978. The stream width at this station was typically about 60 feet. Land use on both banks was industrial. Impervious surface was estimated to be greater than 50 percent. Substantial disturbances of the riparian zones of both banks were observed. Natural canopy cover was not observed. Artificial canopy cover, rail and road bridges, was present. The bottom substrate consisted of mostly silt with some sand, muck, CPOM and detritus. Aquatic vegetation was abundant along both banks. The photo was taken from the left bank facing slightly downstream across the station to the right bank.

TMC 2 - Three Mile Creek at Stone Street **30^0 42' 12"**
88^0 04' 21"

TMC 2 was located on Three Mile Creek about 100 feet upstream of the bridge on Stone Street. The stream width at this station was typically greater than 100 feet. Land use on both banks was primarily urban. Impervious surface was estimated to be about 20 percent. Substantial disturbances of the riparian zone on both banks were observed. Canopy cover was not observed. The bottom substrate at this station consisted of mostly silt with some sand, muck, CPOM, and detritus. Aquatic vegetation was abundant along both banks. The photo was taken from the right bank facing slightly downstream across the station to the left bank.

TMC 3 - Three Mile Creek at Levert Drive **30^0 41’ 51” 88^0 05’ 40”**

TMC 3 was located on Three Mile Creek off of Levert Drive North. The stream width at this station was typically about 60 feet. Land use on both banks was residential although the houses were set well away from the stream banks. Impervious surface was estimated to be less than 10 percent. Substantial disturbances of the riparian zone on both banks were observed. Canopy cover was not observed. The bottom substrate at this station consisted of mostly silt with some sand, silt, CPOM and detritus. Aquatic vegetation was abundant along both banks. The photo was taken facing downstream across the station.

TMC 4 - Three Mile Creek at Armour Avenue **30^0 42’ 52” 88^0 07’ 03”**

TMC 4 was located on Three Mile Creek east of Interstate 65 off of Armour Avenue. The stream width at this station was typically around 50 feet and channelized. Land use on both banks was commercial. Impervious surface was estimated to be about 10 percent. Substantial disturbances of the riparian zone on both banks were observed. Canopy cover was not observed. The bottom substrate at this station consisted of mostly sand with some silt, CPOM and detritus. Aquatic vegetation was present in patches. The photo was taken from the left bank facing slightly upstream across the station to the right bank.

TMC 5 - Three Mile Creek Downstream of Ziegler Blvd. 30^0 42’ 26” 88^0 09’ 01”

TMC 5 was located on Three Mile Creek about 300 feet downstream of the bridge on Ziegler Boulevard adjacent the old State Fish Hatchery. The stream width at this station was typically around 20 feet. Land use on both banks urban forest. Impervious surface was estimated to be less than 10 percent. No disturbances of the riparian zone on either bank were observed. Canopy cover was estimated to be about 10 percent. The bottom substrate at this station consisted of mostly sand with some silt, CPOM and detritus. Aquatic vegetation was present in patches. Of all study stations, TMC 5 demonstrated the most substantial erosion. During periods of heavy rainfall the water level at this station rises dramatically. High water evidence existed as high as 8 to 10 feet above bank height. The photo was taken facing downstream toward the station.

TMC 6 - Three Mile Creek Upstream of University Blvd. 30^0 42’ 15” 88^0 10’ 33”

TMC 6 was located on Three Mile Creek west of University Boulevard off of Health Services Drive. The stream width at this station was typically about 7 feet. Land use on both banks was urban forest. Impervious surface was estimated to be less than 10 percent. No disturbances of the riparian zone on either bank were observed. Canopy cover was estimated to be about 70 percent. The bottom substrate at this station consisted of mostly sand with some silt, CPOM and detritus. Aquatic vegetation was present in patches. The photo was taken facing upstream across the station.

TMC 7 - Three Mile Creek near Origin **30^0 42' 07"**
88^0 11' 27"

TMC 7 was located on Three Mile Creek near the Hillsdale community, just north of Middle Ring Road. The stream width at this station was typically about 5 feet. Land use on both banks was urban forest. Impervious surface was estimated to be less than 10 percent. No disturbances of the riparian zones of either bank were observed. Canopy cover was estimated to be greater than 80 percent. The bottom substrate at this station consisted of mostly sand with some silt, CPOM and detritus. Aquatic vegetation was present in patches. The photo was taken facing upstream across the station.

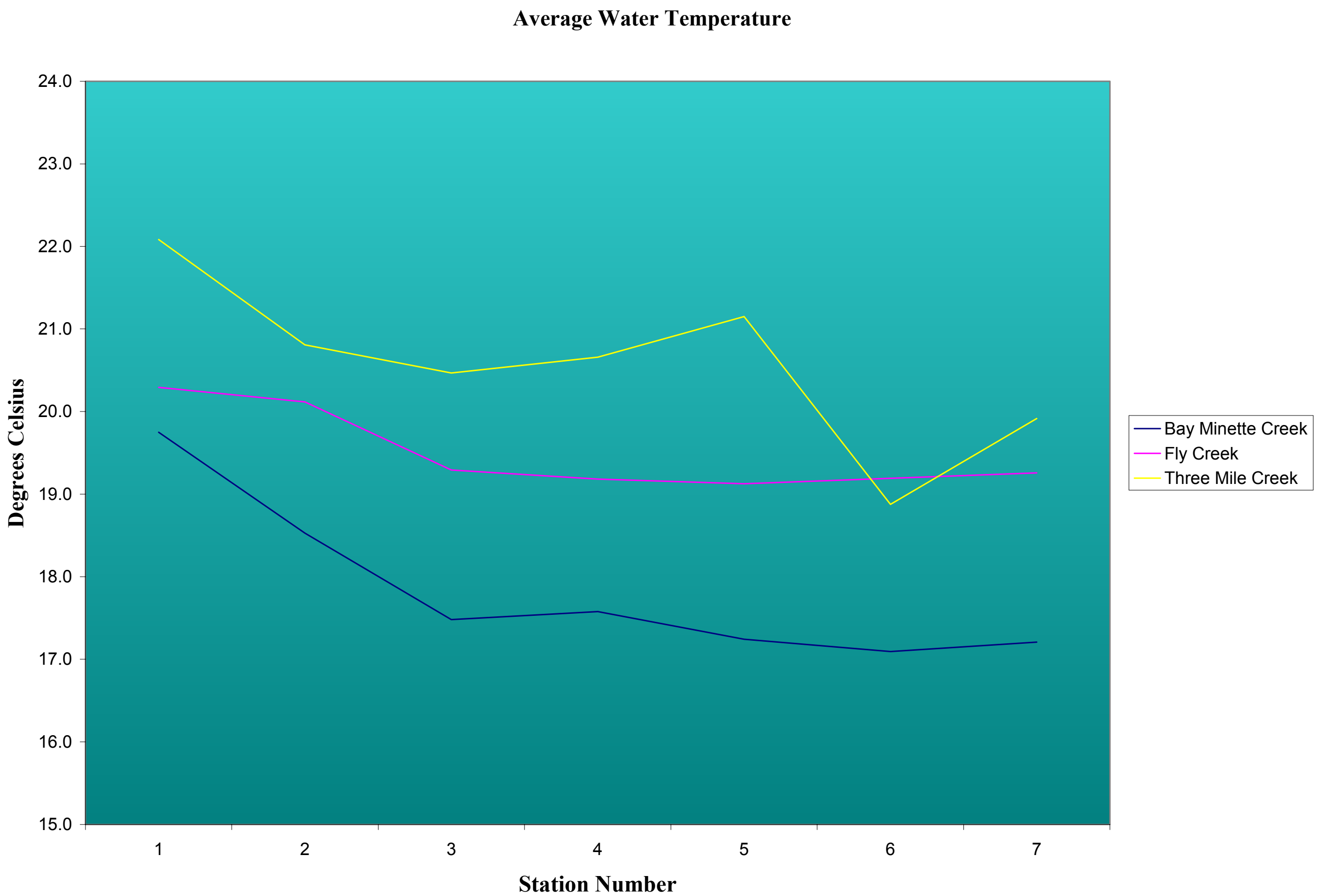
WATER QUALITY

FIELD PARAMETERS

Water Temperature

In an aquatic ecosystem, water temperature can influence dissolved oxygen concentrations, photosynthesis rates, and the metabolic processes of aquatic organisms. A number of factors contribute to the warming of a water body. These factors include, but are not limited to, ambient air temperature, runoff, man made discharges, and suspended solids concentrations. Elevated water temperatures generally result in decreased dissolved oxygen concentrations (NCSU. 1994). As discussed previously, Division 6 of the Department's Administrative Code provides that no state water with the use designation of Fish and Wildlife, or Swimming and other Whole Body Water Contact Sports shall have a temperature exceeding 90^0 F. In the course of this study, no station exhibited a water temperature in excess of 90^0 F.

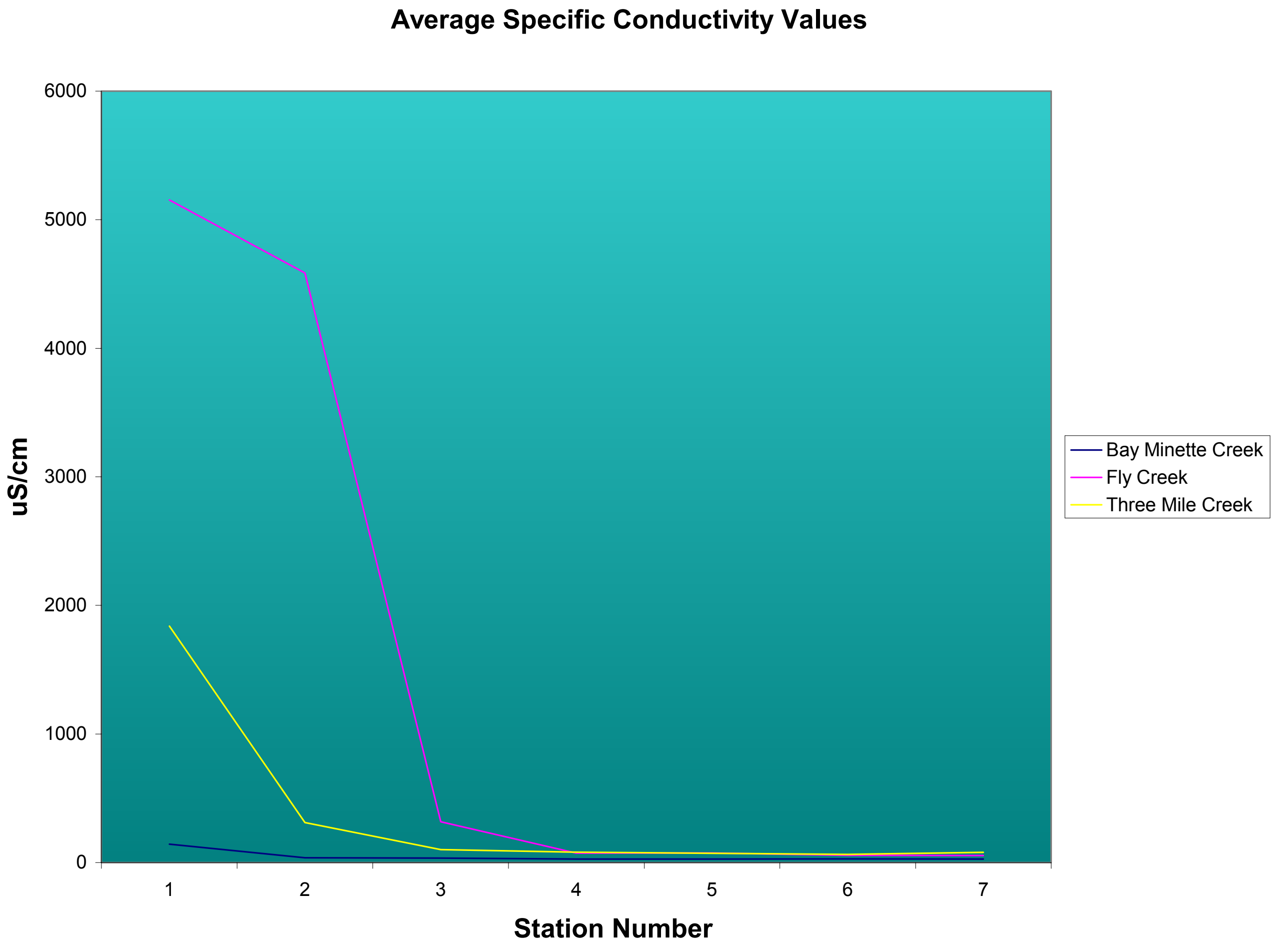
Water temperature was one of the measured parameters that demonstrated a graphical difference between the three subwatersheds. The highest average water temperature was observed in the subwatershed with the highest level of development and the subwatershed with the lowest level of development exhibited the lowest water temperature. The Three Mile Creek subwatershed average water temperature for the entire study period was 20.3^0 C. The Fly Creek subwatershed's average water temperature was 19.5^0 C and the Bay Minette Creek subwatershed's average water temperature was 17.8^0 C. The observed values follow the expected trend across the three impervious surface regimes. That is, watersheds with increased impervious surface cover would be expected to exhibit elevated water temperatures in relation to watersheds with less impervious surface



coverage. In all three subwatersheds water temperatures appeared to increase in a downstream direction. This gradient was more pronounced in the Three Mile Creek and Bay Minette Creek subwatersheds than in the Fly Creek subwatershed.

Specific Conductivity

Conductivity is a measure of water's ability to conduct electricity. More specifically, it is a measure of the ionic activity and content within water. Generally, the higher the ionic concentration within water, the higher the conductivity. Temperature, however, has a pronounced effect upon conductivity values. For this reason, specific conductivity (conductivity normalized to a temperature of 25^0 C) is often used in comparative water quality studies. Specific conductivity can be a good measure of total dissolved solids and salinity. It can not, however, provide information on the type of or individual concentrations of ions present. The list of ionic forms that may be present in water and which effect water's conductivity is a long one. The list includes such ions as calcium, magnesium, sodium, potassium, sulfate, chloride, bicarbonate, nitrogen, phosphorous, iron and others. Specific conductivity values are useful as indicators of potential water quality problems. Low values generally indicate low nutrient, high quality waters, while high values suggest nutrient rich waters. Also, sudden changes in specific conductance values may be an indicator of a pollutant discharge. It should be observed, however, that



higher specific conductance values are the norm in tidally influenced waters and are not, necessarily, indicators of pollutant stress, but, rather, reflect the increased ionic activity associated with saline inflow.

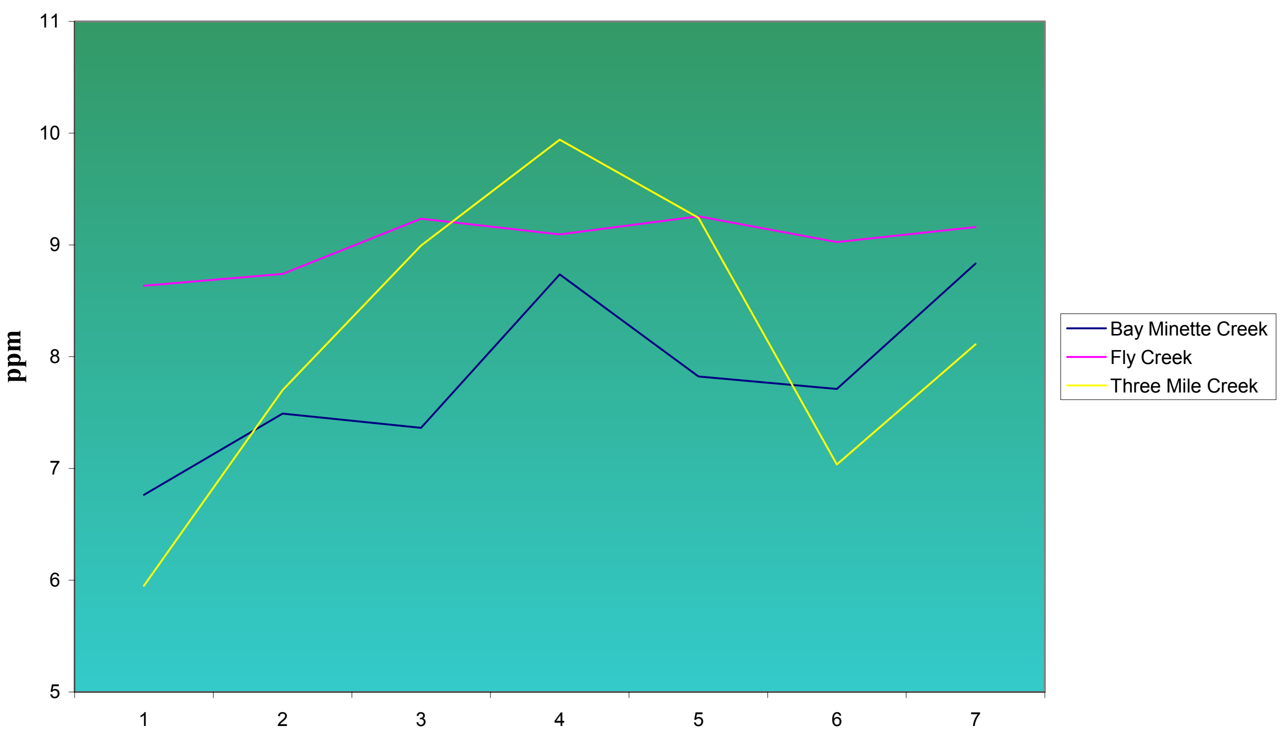
The inserted graph presents the average values for specific conductivity for all stations. With the exception of the tidally influenced stations BMC 1, BMC 2, FC 1, FC 2, FC 3, TMC 1, and TMC 2, the specific conductivity values for all three subwatersheds were comparable. Fly Creek demonstrated the largest specific conductivity values with an average of 1473 uS/cm for the entire study period. This was anticipated as a result of this watershed's direct connection to the Mobile Bay. The Three Mile Creek subwatershed had the second highest average specific conductivity value for the entire study at 118 uS/cm. The Bay Minette Creek subwatershed had a total average specific conductivity of

46 uS/cm. Naturally, specific conductivity was greatest at those stations in the most downstream portions of the subject subwatersheds. Rising specific conductivity values correlated positively with the salinity values observed during the study.

Dissolved Oxygen

Adequate dissolved oxygen is essential in aquatic systems for the growth and survival of biota. Dissolved oxygen levels in aquatic systems can range from 0-18 parts per million, but most natural water systems require 5-6 parts per million to support a diverse population (NCSU. 1994). Dissolved oxygen in aquatic systems is necessary for plants and animals to carry on respiration. Dissolved oxygen is defined as the amount of free molecular oxygen, O_2, dissolved in an aqueous solution. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a waste product

Average Dissolved Oxygen Concentrations



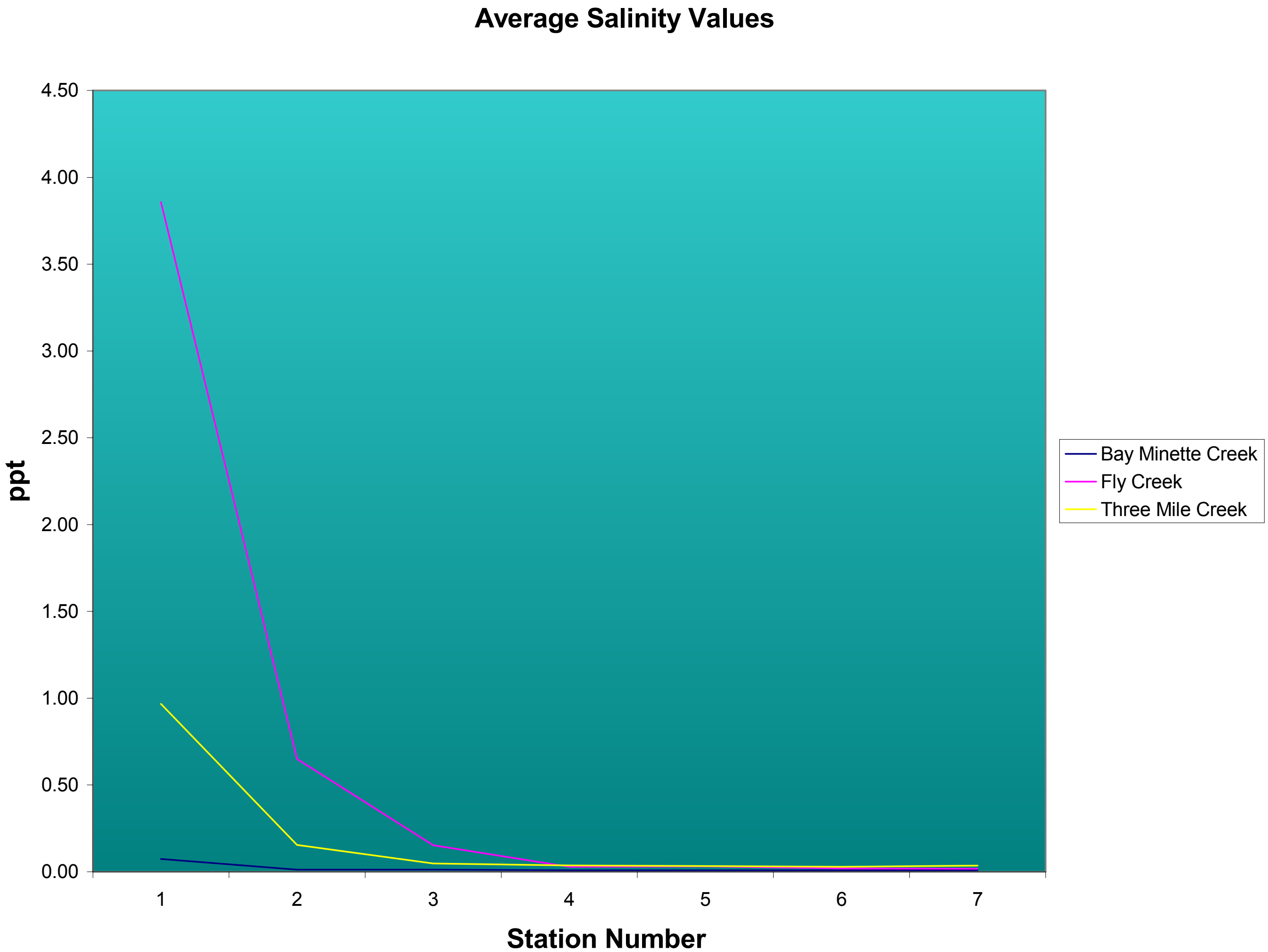
of photosynthesis. Regardless of its vehicle of introduction, the dissolved oxygen content in a water body may be considered one of the most important and principal measurements of water quality and indicator of a water body's ability to support aquatic life. Dissolved oxygen levels above 5 milligrams per liter (mg O_2/L) are considered optimal. Levels below 1 milligrams per liter are considered *hypoxic* (oxygen deficient). When O_2 is totally absent, the system is considered *anoxic*. Some bacteria consume oxygen during the process of decomposition. Decreases in the dissolved oxygen levels can cause changes in the types and numbers of aquatic macroinvertebrates, which live in a water ecosystem. Some organisms, like mayflies, stone flies, caddis flies, and aquatic beetles, require high dissolved oxygen levels to survive. Worms and fly larvae, which can survive in low dissolved oxygen environments, can be indicators of an unhealthy water body (NCSU. 1994).

Dissolved oxygen concentrations were, generally, higher in the upper reaches of all three subwatersheds than they were at the most downstream stations. On average, the Fly Creek stations exhibited higher dissolved oxygen concentrations than did the Three Mile Creek stations. Likewise, the Three Mile Creek stations exhibited higher concentrations than did the Bay Minette Creek stations. For the entire study period the Fly Creek subwatershed demonstrated an average dissolved oxygen concentration of 9.02 parts per million. The second highest average concentration was that of the Three Mile Creek subwatershed at 8.5 parts per million. The Bay Minette Creek subwatershed had an average dissolved oxygen concentration of 7.82 parts per million. Greater variation in dissolved oxygen concentrations were evident in the Three Mile Creek and Bay Minette Creek subwatersheds than those recorded in the Fly Creek subwatershed. This variation may be attributed to the relative distance between stations, with that distance being much smaller in the Fly Creek subwatershed.

Salinity

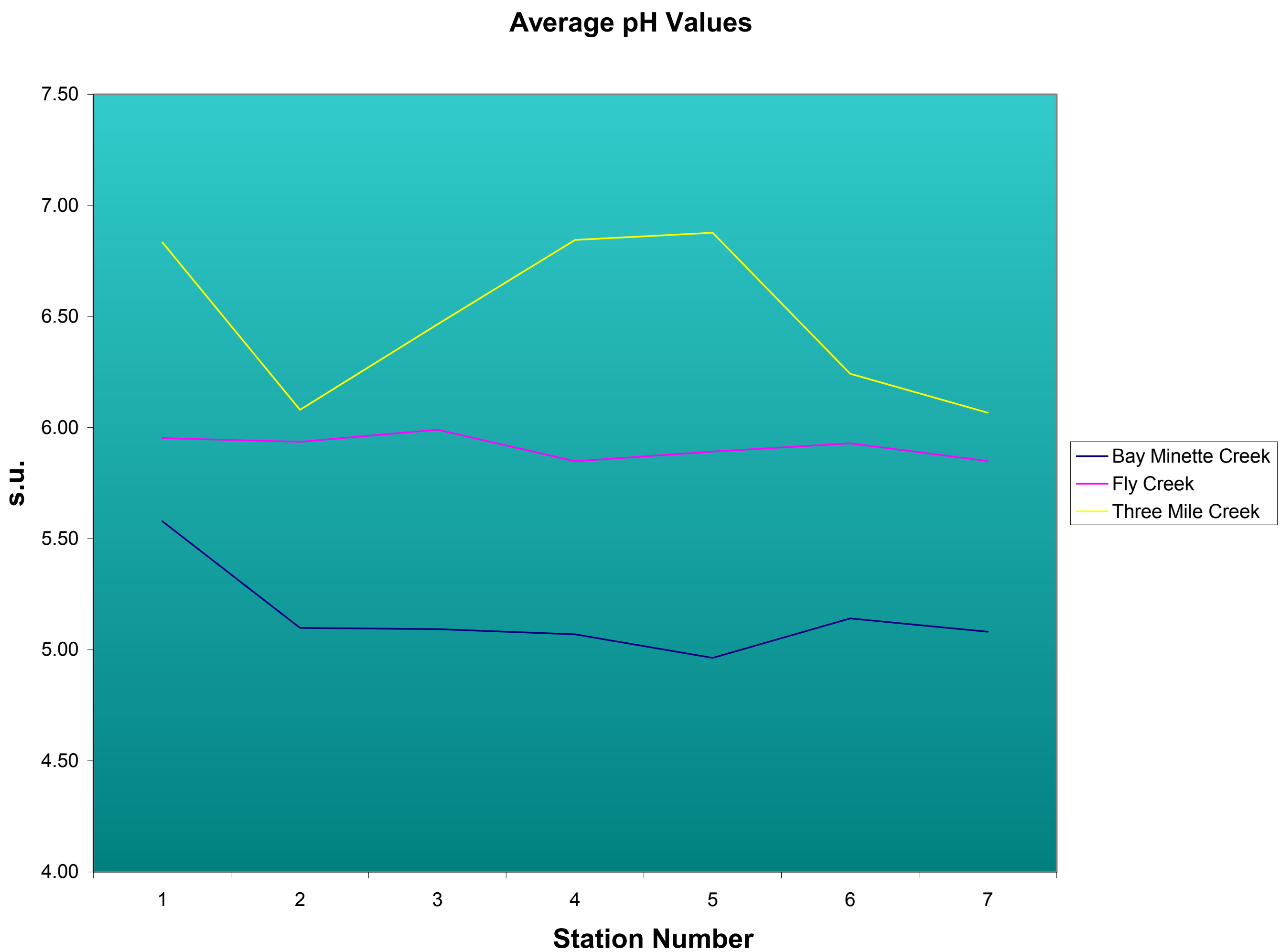
Salinity is the total amount of dissolved salts present in water. Salt concentrations play a significant role in plant and animal habitat and water quality. Salinity affects dissolved oxygen concentrations, pH, and conductivity. The average salinity of world oceans is around 35 ppt. Freshwater, conversely, is expected to have a salinity approaching zero ppt (NOAA. 2001).

The most downstream stations of all three subwatersheds exhibited the highest average salinity values, as would be anticipated with tidally influenced water bodies. Those stations in the upper reaches of the three subwatersheds consistently demonstrated salinity concentrations around 0.01 ppt. The Fly Creek subwatershed exhibited the highest salinity values, probably as a result of its direct connection to the Mobile Bay. The average salinity for this subwatershed for the entire study period was 38 parts per thousand. The Three Mile Creek subwatershed exhibited the second highest average salinity concentration at 0.06 parts per thousand. The Bay Minette Creek subwatershed average salinity concentration was 0.02 parts per thousand.



pH

A measure of a solution's acidity is termed pH. This measure is based upon the concentration of positively charged hydrogen atoms (hydrogen ions) in a solution. For the purposes of this study, pH may be defined as the negative logarithm of the concentration of hydronium ions in solution. Hydronium ions are chosen because hydrogen ions readily associate with water molecules to form hydronium ions. In pure water, hydronium and hydroxyl ions exist in equal quantities which results in a neutral solution. Neutral solutions have a pH of 7. When hydronium ion concentrations exceed the concentration of hydroxyl ions, the solution becomes acidic. As a result, pH values falling below 7 are considered acidic solutions. Conversely, when hydroxyl ion concentrations are greater than hydronium ion concentrations, the solution is considered basic and the pH values range from greater than 7 to 14 (NCSU. 1994).

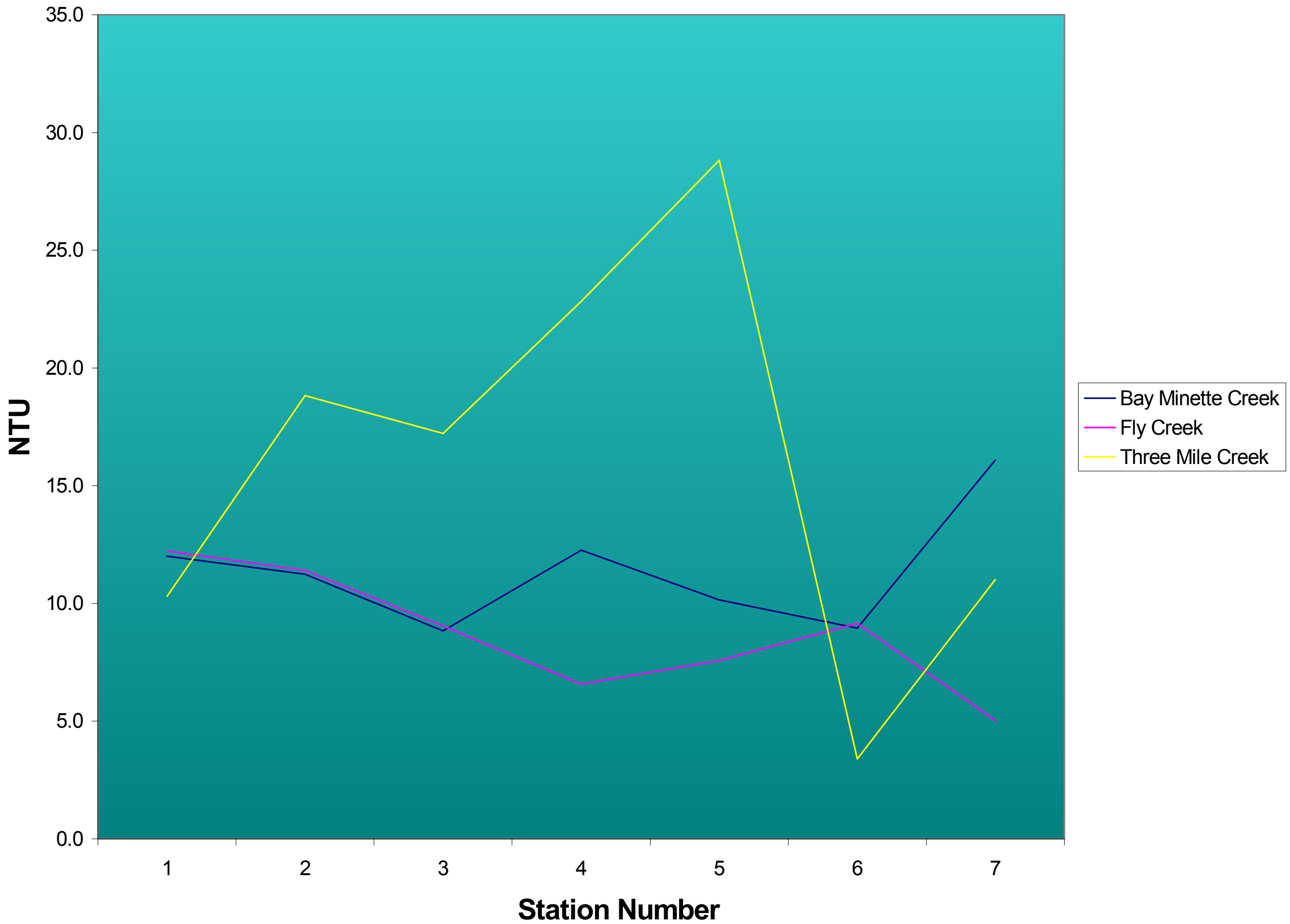


As can be seen in this section's graph, pH was one of the parameters demonstrating clear delineation among the subject subwatersheds. The Three Mile Creek subwatershed demonstrated the highest average pH values. The average pH for the Three Mile Creek subwatershed for the entire study period was 6.43 s.u. The Fly Creek subwatershed exhibited the second highest average pH value at 5.91 s.u. The Bay Minette Creek subwatershed average pH value was 5.15 s.u. The recorded values for pH were generally lower in the upstream stations of all the subject subwatersheds than those recorded in the downstream stations. The stations of the Three Mile Creek subwatershed exhibited the greatest variation in pH values. The Fly Creek subwatershed demonstrated comparable pH values from station to station.

Turbidity

Turbidity may be described as a function of total suspended solids. But, whereas, total suspended solids are determined by weight per unit volume, turbidity is measured as the amount of light scattered from a sample, making it a measure of cloudiness or murkiness in water. Turbidity reduces the amount of light that penetrates the water. Since aquatic plants require light for growth, a reduction in the amount of available light may impair plant growth. Fish or other aquatic organisms that depend on such plants for survival, be it for food or shelter, are also impacted. Further, since aquatic plants also provide oxygen to the water body, a reduction in the number of plants results in less oxygen being

Average Turbidity Values



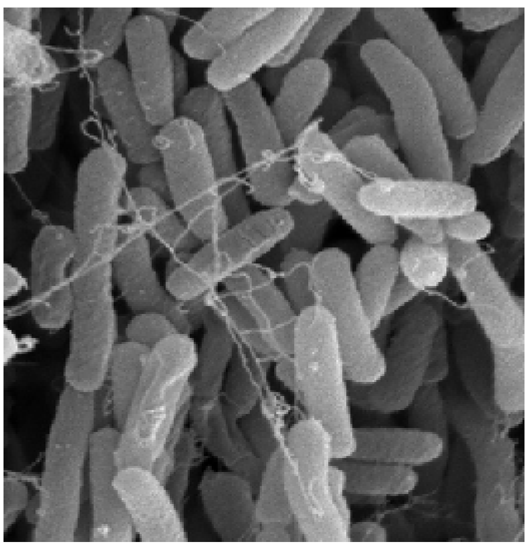
introduced to the aquatic system. Compounding this problem, turbid waters are generally warmer than non-turbid waters as a result of the suspended particles absorbing the sun's electromagnetic radiation. Increases in the water's temperature decreases the amount of available dissolved oxygen. Depleted oxygen, in turn, results in fewer aquatic invertebrates and fish (NCSU. 1994).

Apart from its impact on light penetration, turbidity offers other complications in the aquatic environment. The suspended particles that contribute to the turbidity can affect the way aquatic invertebrates and fish feed and breathe. Filter feeders are particularly impacted as their feeding mechanisms become choked by increased amounts of suspended particles. Likewise, fish can also experience clogging and damage of gills. Excessive suspended particles may also decrease aquatic organisms' disease resistance, reduce growth rates, interfere with reproductive development, or, simply, smother eggs and larvae. Turbidity can be caused by any number of sources. The most common causes are erosion, runoff, waste discharges, algal activity, and stirring of the bottom sediments (NCSU. 1994).

Average turbidity values were generally highest among the Three Mile Creek subwatershed stations. The average turbidity for this subwatershed for duration of the study was 17 nephelometric turbidity units (ntu). The Bay Minette Creek subwatershed stations demonstrated an average turbidity value of 11.4 ntu. The Fly Creek subwatershed exhibited the lowest average turbidity for the study at 8.7 ntu. All of the subwatersheds showed significant variation in average turbidity values from station to station. The variation observed in the Three Mile Creek subwatershed was greater than that observed in the Bay Minette Creek subwatershed. The Fly Creek subwatershed's variation in average turbidity values was less than that of the other two subwatersheds.

LABORATORY ANALYSES

Fecal Coliform Bacteria



electron micrograph of *E. coli*.

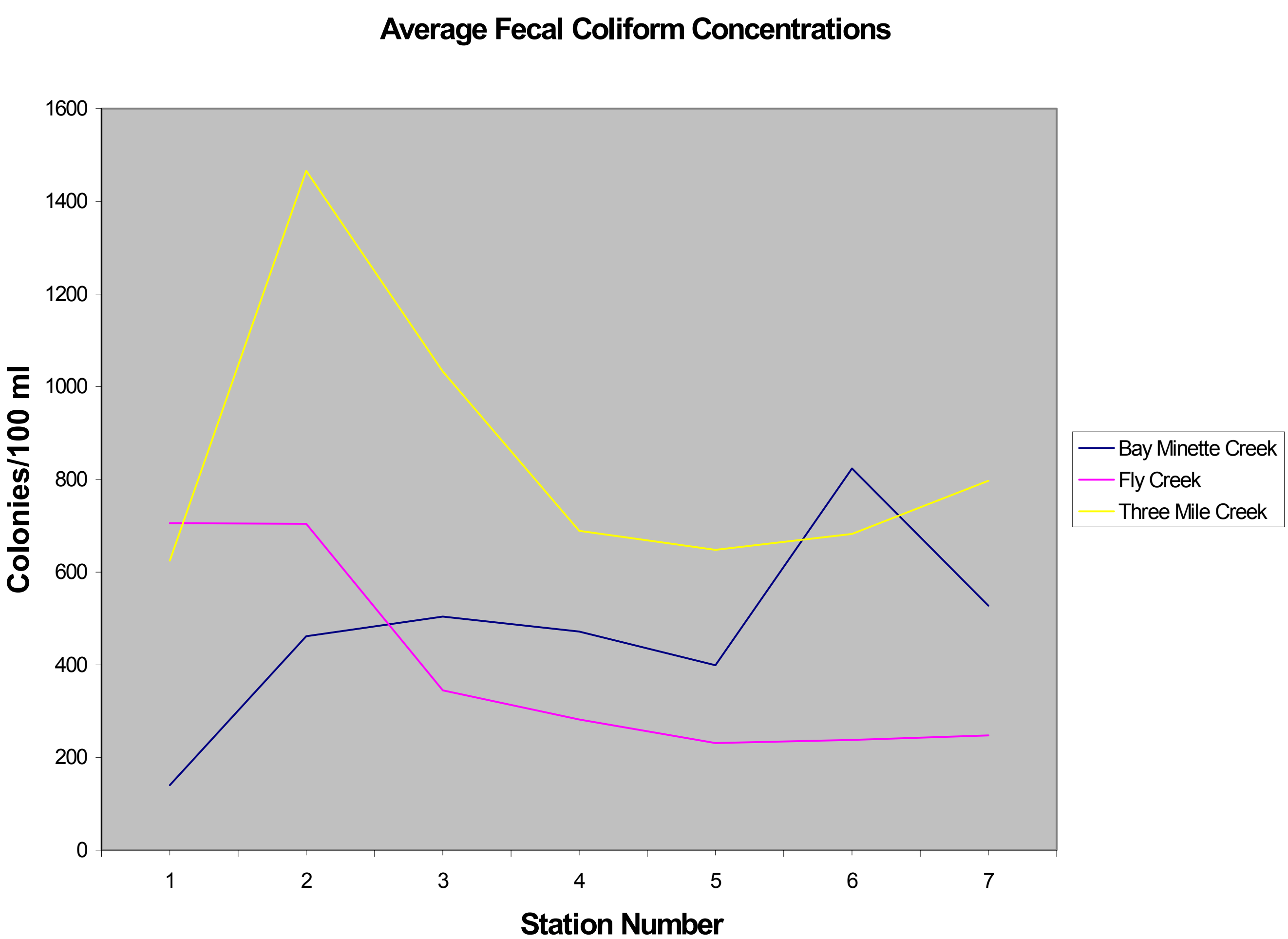
Bacteria are prokaryotes of the Kingdom Monera. Monerans are the most numerous and the most ubiquitous organisms in the environment. Coliform bacteria are a collection of relatively harmless microorganisms that live in large numbers in the intestines of man and warm and cold-blooded animals. These bacteria are essential for the digestion of certain foods. One of the total coliform bacteria subgroups is the fecal coliform bacteria. Of this subgroup, the most common member is *Escherichia coli.* Coliform bacteria are not considered to be pathogenic organisms, having been demonstrated to be only mildly infectious.

Fecal coliform bacteria serve as a group of indicator organisms, i.e., their presence indicates recent fecal pollution by animals or man, and the possible presence of other disease causing organisms that may potentially infect those that come into contact with the water. It is generally accepted that the presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. Substantial numbers of these organisms in an aquatic environment gives rise to concern that pathogenic organisms, also present in fecal matter, may be present. As such, the presence of fecal coliform bacteria is an indicator that a potential health risk exists for individuals exposed to this water. Such health risks include ear infections, dysentery, typhoid fever, viral and bacterial gastroenteritis and hepatitis A. It should also be noted that the presence of fecal coliform tends to affect humans more than it does aquatic creatures.

Fecal coliform bacteria can enter surface water through direct discharge of waste from mammals and birds, from agricultural and storm runoff, and from untreated human sewage. Individual home septic systems can become overloaded during rain events and allow untreated human wastes to flow into drainage ditches and nearby waters. Agricultural practices also may contribute to bacterial contamination through such practices as allowing animal wastes to wash into nearby streams, spreading manure and fertilizer on fields during rainy periods, and allowing livestock to water in streams.

The highest average concentrations of fecal coliform bacteria were encountered in the Three Mile Creek subwatershed with an average fecal coliform bacteria concentration for the entire study of 849 colonies per 100 milliliters (col/100 ml). The Fly Creek subwatershed exhibited the lowest total average fecal coliform concentration at 393 col/100 ml. The average fecal coliform concentration for the Bay Minette Creek subwatershed stations was 476 col/100 ml. The highest concentrations of fecal coliform bacteria were observed in samples retrieved during or following substantial rain events, at times when tremendous volumes of runoff were being introduced to the streams.

On several occasions, in sections of stream with a water use classification of Fish and Wildlife, fecal coliform concentrations exceeded the established ADEM water use criteria of 2,000 colonies/100ml. On May 21, 2003, station BMC 6 exhibited a fecal



count of 5,100 colonies/100ml. On July 28, 2003, stations BMC 2 and BMC 6 had fecal counts greater than 2,000 colonies/100ml. On August 21, 2003, stations BMC 3 – 7 had fecal counts greater than 2,000 colonies/100ml. Fly Creek exhibited fecal counts greater than 2,000 colonies/100ml at stations FC 1 and FC 2 on May 20, 2003, and again on November 19, 2003.

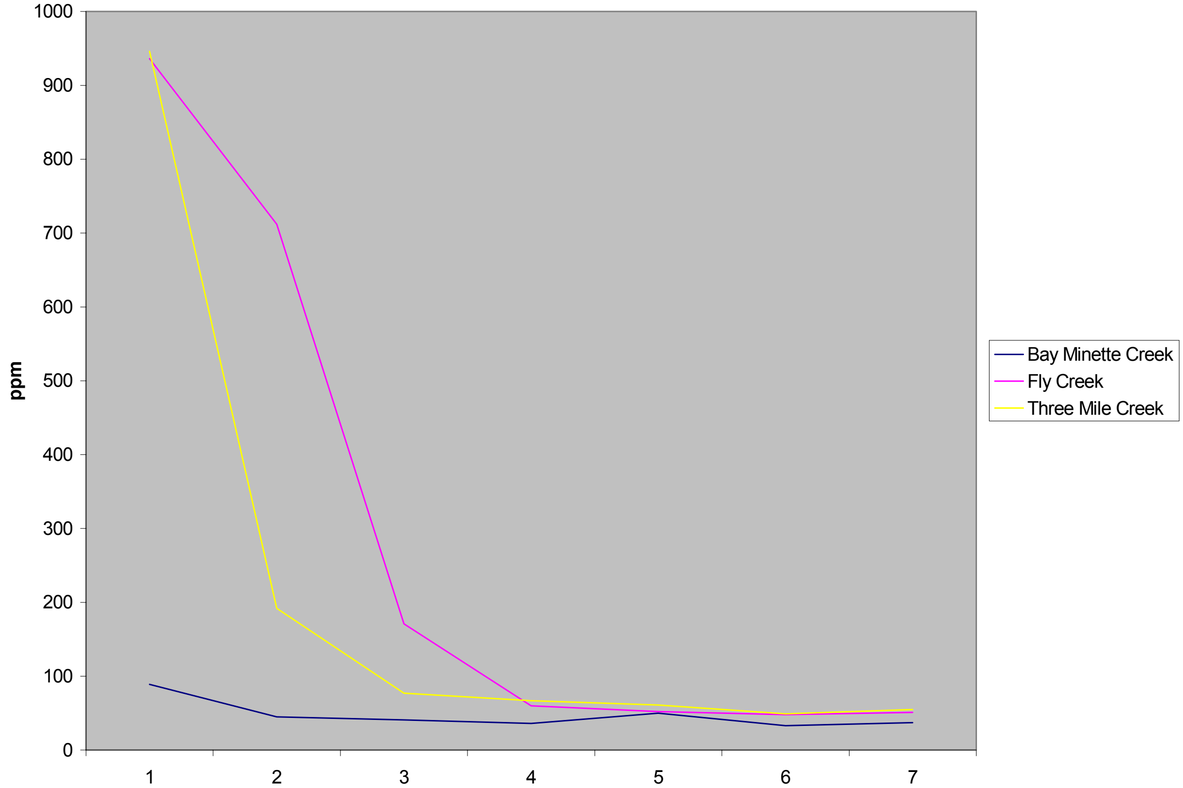
On January 7, 2003, and February 25, 2003, fecal counts greater than 2,000 colonies/100 ml were observed at TMC 1. Such elevated counts were also observed on May 19, 2003, at TMC 2-5, and at TMC 7. On July 22, 2003, fecal counts greater than 2,000 colonies/100ml were recorded at stations TMC 2-5, and TMC 7. On August 20, 2003, and September 8, 2003, fecal counts greater than 2,000 colonies/100ml were recorded at station TMC 2. On November 18, 2003, fecal counts greater than 2,000 colonies/100ml were recorded at stations TMC 2 and TMC 3. As no geometric mean sampling was included in this study, the water quality criteria established for those waters carrying a use classification of swimming and other whole body water contact sports is not applicable in terms of comparison to the data presented.

Total Dissolved Solids

Total Dissolved Solids is a measure of the amount of material dissolved in water, or the concentration of solids in water that can pass through a filter. These solids typically include nitrate, calcium, magnesium, sodium, carbonate, bicarbonate, chloride, sulfate, phosphate, organic ions, and other ions. A certain level of these ions in water is necessary for aquatic life. Their presence effects the density of the surrounding solution. And, since density is directly correlated to the osmotic potential of water with relation to the metabolic processes of aquatic organisms, changes in total dissolved solids concentrations may have a profound effect upon those organisms. Excessively high or low total dissolved solids concentrations may even lead to impaired growth or death. High concentrations of total dissolved solids may also reduce water clarity, contribute to a decrease in photosynthesis, and serve to increase the water's temperature, thereby depleting the available dissolved oxygen (NCSU. 1994).

Dissolved solids concentrations tended to increase with each downstream station among the three subwatersheds. The most downstream stations consistently yielded the greatest total dissolved solids concentrations in each of the subject subwatersheds. The Bay Minette Creek subwatershed exhibited the lowest average dissolved solids concentrations for the study at 47 parts per million. The Fly Creek subwatershed had the greatest average dissolved solids concentration among the subject subwatersheds at 290 parts per million. The Three Mile Creek subwatershed demonstrated an average dissolved solids concentration of 290 parts per million. Little variation in dissolved solids concentrations was observed in those stations not influenced by tides.

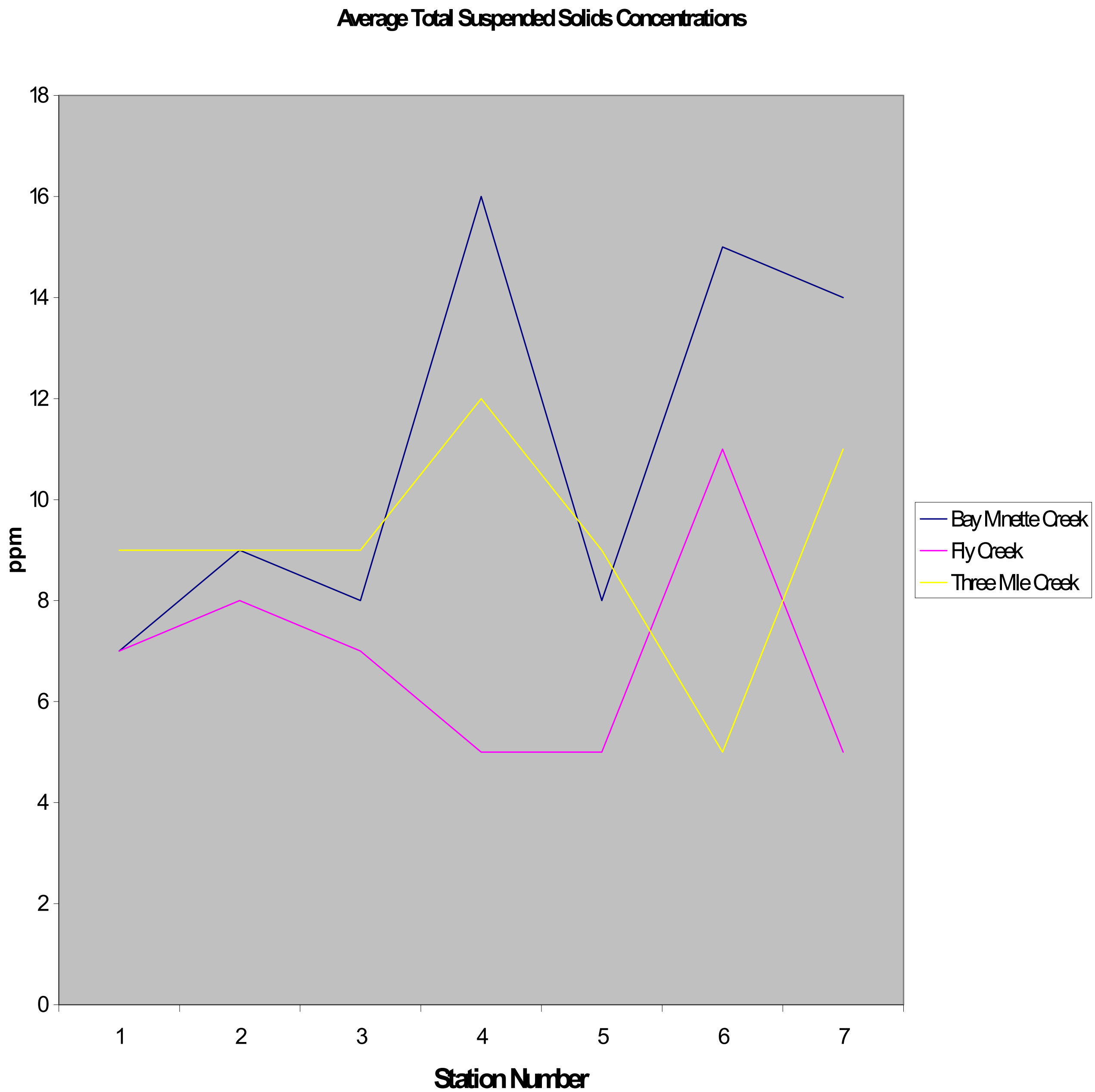
Average Total Dissolved Solids Concentrations



Total Suspended Solids

Total suspended solids (TSS) concentration is a measure of suspended solids per volume of water. The measured solids are those that can be captured by a filter. These solids include a varied assortment of materials, either mineral or organic, including, but not limited to, sand and silt, decaying plant and animal matter, and waste particulates. High concentrations of suspended solids may cause many problems for water quality. Apart from diminishing the available light, increased siltation may alter a stream's dynamics as well as destroy existing habitat. Suspended particles also serve as substrates for other pollutants such as pathogens and some heavy metals. Suspended solids, therefore, effect the aquatic system both physically and biochemically. Geology and land use are the primary factors influencing suspended solids concentrations. As watersheds develop, there is an increase in disturbed areas, a decrease in vegetation, and an increase in impervious surface area, all of which reduce the watershed's ability to filter runoff. This contributes to increases in erosion, loading of particulate matter, nutrients, and pollutants. Such overloading leads to increased algal growth among other complications, which ultimately leads to decreased dissolved oxygen levels. Further, suspended solids can also clog fish gills, reduce growth rates, decrease resistance to disease, and prevent egg and larval development (NCSU. 1994).

The values for loading presented in the table appearing below represent calculated estimates of total suspended solids loading for each of the subject subwatersheds. Although total suspended solids concentrations were analyzed for each sample event conducted during the study and are presented separately, only those data collected at times when actual stream flow could be measured were used in the calculation of daily



total suspended solids loading. The averaged flow measurement used in arriving at the value appearing in the table were acquired by taking the arithmetic mean of the measured flow for all stations within the individual subwatershed.

AVERAGED SUSPENDED SEDIMENT LOADING

Subwatershed	Flow (MGD)	TSS (ppm)	Load (ppd)
Bay Minette Creek	19.9	< 5.3	< 880.15
Fly Creek	10.2	< 5.8	< 493.69
Three Mile Creek	9.2	< 6.9	< 529.74

Loads, given in pounds per day units, were estimated using the following equation:

$$W = C * Q * 8.345 \text{ lbs}$$

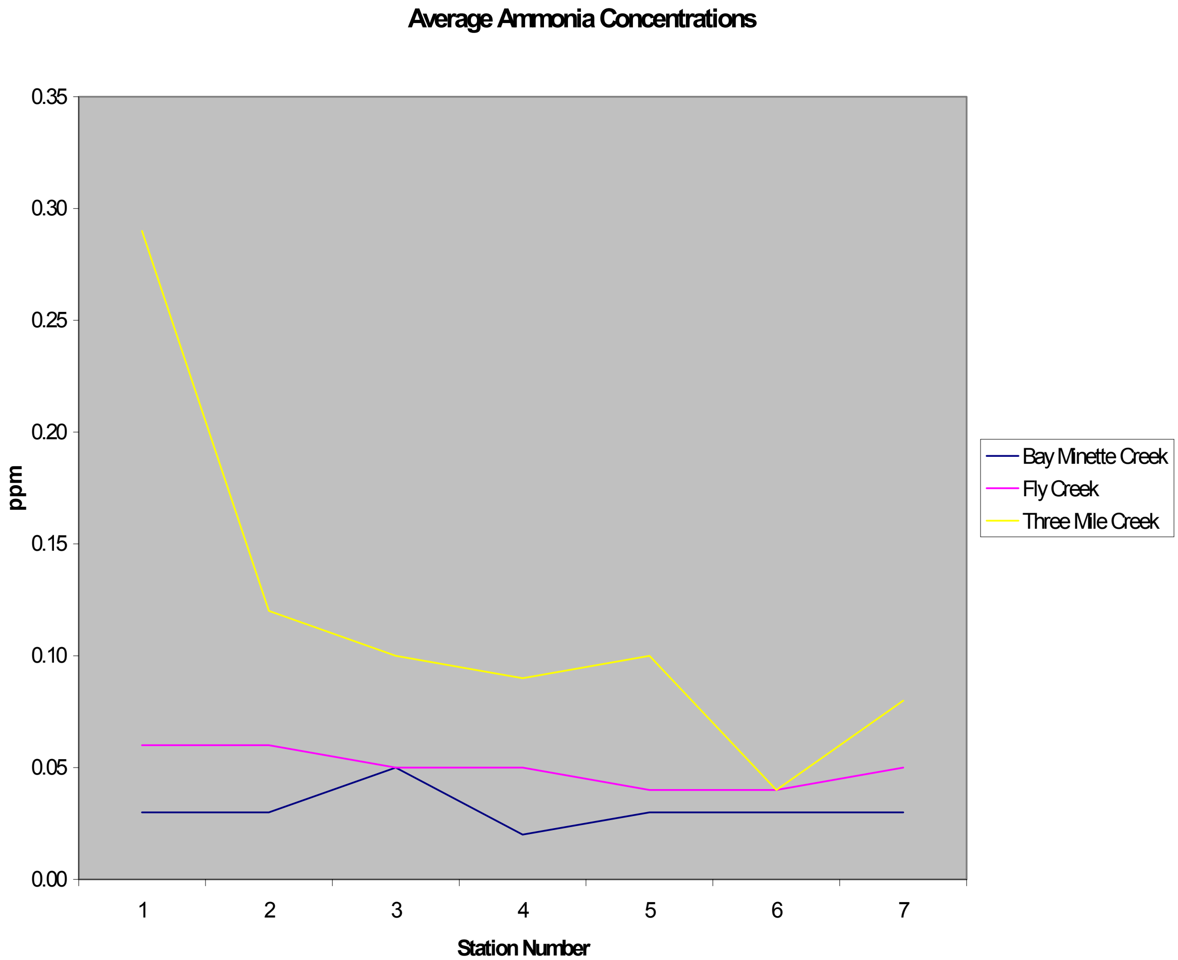
where:
W = load in pounds per day
C = measured concentration in parts per million
Q = flow in millions of gallons per day (MGD)*
8.345 lbs = weight of 1 gallon of water

*Flow was converted to MGD by multiplying the value in cubic feet per second by a factor of 0.6463169 (the dimensional equivalent in gallons per day of cubic feet per second divided by a factor of $1.0 * 10^6$)

For the greater part of the study, total suspended solids concentrations were less than five parts per million at all stations. For this reason, the recorded values appearing in the table are preceded by the ‘ < ’ symbol. Concentrations of suspended solids were the highest during the summer months for all of the subject subwatersheds. The subwatershed with the lowest level of development, the Bay Minette Creek subwatershed, demonstrated the greatest concentration of suspended solids at just under 15 parts per million. The subwatershed representing moderate levels of development, the Fly Creek subwatershed, exhibited the lowest suspended solids concentration – less than 7 parts per million. The Three Mile Creek subwatershed, representing the high level of development, had an average total suspended solids concentration of less than 9 parts per million. All of the subwatersheds exhibited considerable variation in TSS values from station to station. The average TSS concentrations for the Bay Minette Creek subwatershed were substantially lower at the most downstream station than those recorded at the most upstream station. This was also the case with the Three Mile Creek subwatershed, although the drop in value was not so pronounced as observed in the Bay Minette Creek subwatershed. The case was reversed in the instance of the Fly Creek subwatershed, where the average TSS concentrations of the most upstream station were lower than the concentrations recorded in the most downstream station.

Ammonia

Ammonia is an important source of nitrogen for plants and animals. It is a colorless gas that may be found in water, soil, and air. Ammonia is suspected to remain in the atmosphere less than two weeks, depending on weather and other factors, before being deposited or chemically altered. It is recycled naturally by a substantial number of plants and microscopic organisms that rapidly take up ammonia. Most of the ammonia in the environment comes from the natural breakdown of organic matter, like feces, and dead



plants and animals. The amount of ammonia produced by man is very small compared to that produced by nature every year. The majority of man-made ammonia goes toward the manufacture of fertilizer. Ammonia is also used to manufacture synthetic fibers, plastics, and explosives (Microsoft® Encarta® Online Encyclopedia 2002).

Ammonia may be introduced to a watershed through surface water runoff, direct discharge, or directly from the atmosphere. When too much ammonia becomes available, free ammonia may accumulate in body tissues. This accumulation can lead to metabolism alterations or increases in internal pH. Factors which influence ammonia's toxicity in an aquatic environment include; dissolved oxygen concentrations, historical ammonia loading, carbon dioxide concentrations, and the presence of other toxic compounds. Generally, the total percentage of ammonia in water is expected to increase with temperature and pH. Concentrations of the principal form of toxic ammonia (NH_3), of less than half a part per million, may be toxic to some aquatic organisms. Such toxicity is directly correlated with both temperature and pH (Grimwood, M.J. & Dixon, E. 1997). Plants appear to be more tolerant of ammonia than are animals. Invertebrates also appear to demonstrate a greater ammonia tolerance than do higher life forms (NCSU Water Quality Group. August, 1994).

The stations exhibiting the greatest average values for ammonia concentrations during the study were those located in the Three Mile Creek subwatershed. The average ammonia concentration for this watershed for the entire study was less than 0.09 parts per million. With the exception of TMC 6, ammonia concentrations at the Three Mile Creek stations were consistently higher than the concentrations encountered in the stations of the remaining two subwatersheds. As is demonstrated in this section's graph, ammonia concentrations were greater in the downstream stations than those recorded in the upper reaches of the subwatershed. The concentrations observed in the Fly Creek and Bay Minette Creek subwatersheds remained somewhat constant from station to station. The average ammonia concentrations recorded in the Fly Creek stations, with the exception of FC 3, were higher than those observed in each of the Bay Minette Creek stations. The Fly Creek subwatershed had an average ammonia concentration of less than 0.05 parts per million for the entire study period, and the Bay Minette Creek subwatershed's average concentration for the same period was less than 0.03 parts per million.

OBSERVED AMMONIA CONCENTRATIONS

	BMC 1	BMC 2	BMC 3	BMC 4	BMC 5	BMC 6	BMC 7
Average	< 0.03	< 0.03	< 0.05	< 0.02	< 0.03	< 0.03	< 0.03
Maximum	0.07	0.09	0.4	0.06	0.06	0.07	0.09
Minimum	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

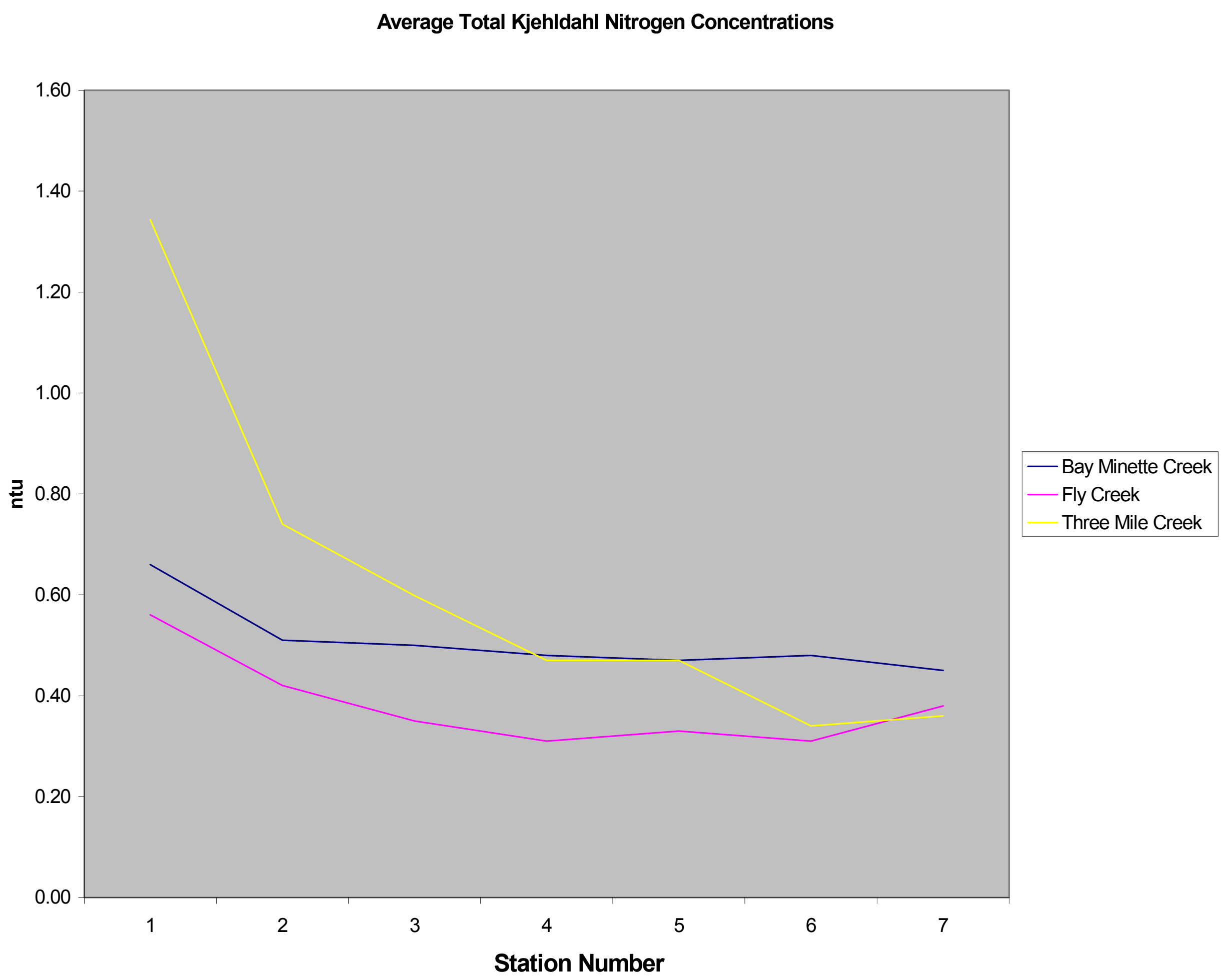
	FC 1	FC 2	FC 3	FC 4	FC 5	FC 6	FC 7
Average	0.06	< 0.06	< 0.05	< 0.05	< 0.04	< 0.04	< 0.05
Maximum	0.15	0.13	0.12	0.18	0.1	0.12	0.12
Minimum	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

	TMC 1	TMC 2	TMC 3	TMC 4	TMC 5	TMC 6	TMC 7
Average	0.29	< 0.12	< 0.1	< 0.09	< 0.1	< 0.04	< 0.08
Maximum	0.6	0.3	0.21	0.26	0.28	0.09	0.18
Minimum	0.05	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

The highest ammonia concentrations observed for all stations were encountered following substantial rain events. Excessive ammonia concentrations were not observed at any station during the study.

Total Kjehldahl Nitrogen

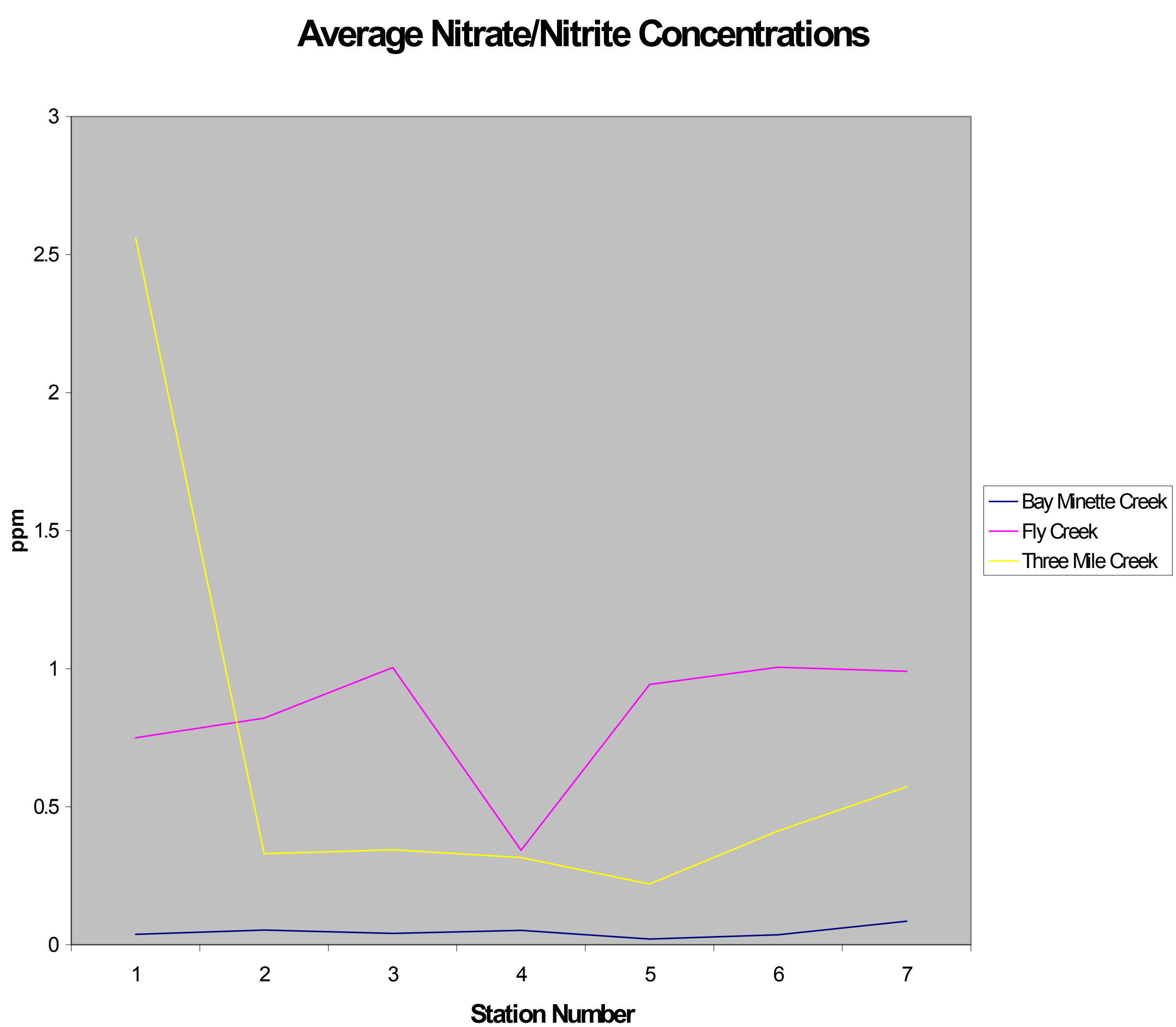
It has been well established that Nitrogen is a very important nutrient to a stream ecology and that, while some nitrogen is necessary as a nutrient for aquatic plant growth, too much nitrogen adversely affects that ecology. Since the nitrogen cycle is very complex, and nitrogen can exist in so many forms simultaneously, the Total Kjehldahl Nitrogen (TKN) test was developed using digestion and distillation to determine the sum concentration of the various nitrogen compounds. Kjehldahl nitrogen, therefore, refers to the total of organically bound nitrogen and ammonia nitrogen. Typically, high Total Kjehldahl Nitrogen values are indicative of pollution in an aquatic system.



For the entire study period, the Bay Minette Creek subwatershed exhibited an average TKN value of 0.51 parts per million. This represented the highest average value for this parameter among the subject subwatersheds. The Three Mile Creek subwatershed's average TKN value of 0.49 parts per million was only slightly lower. The Fly Creek subwatershed had the lowest average observed TKN value at less than 0.38 parts per million. TMC 1 recorded the largest average TKN concentrations among all stations sampled. In the upper reaches of the watershed, the Three Mile Creek subwatershed's TKN concentrations were comparable with those of the Bay Minette Creek and Fly Creek subwatersheds. In all of the subject subwatersheds, TKN values were greatest at the tidally influenced stations.

Nitrate/Nitrite

Nitrogen (N_2) is a principal component of our atmosphere and one of the planet's most abundant elements. The air we breath is composed of approximately eighty percent nitrogen. Nitrogen is found in the cells of all living things and is an essential component



of proteins. Inorganic nitrogen exists in nature in the free state as a gas (N_2), or as nitrate (NO_3-), nitrite (NO_2-), or ammonia (NH_3+). Nitrogen enters the water body via runoff (animal wastes and septic tanks), municipal and industrial wastewater, and even discharges from car exhausts. In aquatic environments, nitrogen-containing compounds act as nutrients. Aquatic plants and animals continually recycle available nitrogen. Depending on the predominant form, too much or too little nitrogen in an aquatic system may have deleterious effects. Too little nitrogen and the biota experience deprivation, too much and the algae, plants that are fed by nutrients, thrive and rapidly overpopulate. Such algal blooms pose a number of problems to an aquatic system. They may contribute to turbidity and substantially reduce the amount of light penetrating the water. Although algae produce oxygen as a by product of photosynthetic activity, the amount of dissolved oxygen they contribute to the aquatic system is not sufficient to overcome the oxygen demand created by their subsequent decay. The bacteria feeding upon decaying algae quickly convert nitrites to nitrates. Nitrate reactions in aquatic environments can cause oxygen depletion. The sum effect of eutrophication on aquatic systems is decreased dissolved oxygen levels. Decreased dissolved oxygen levels, in turn, lead to hypoxic or even anoxic conditions (NCSU. 1984).

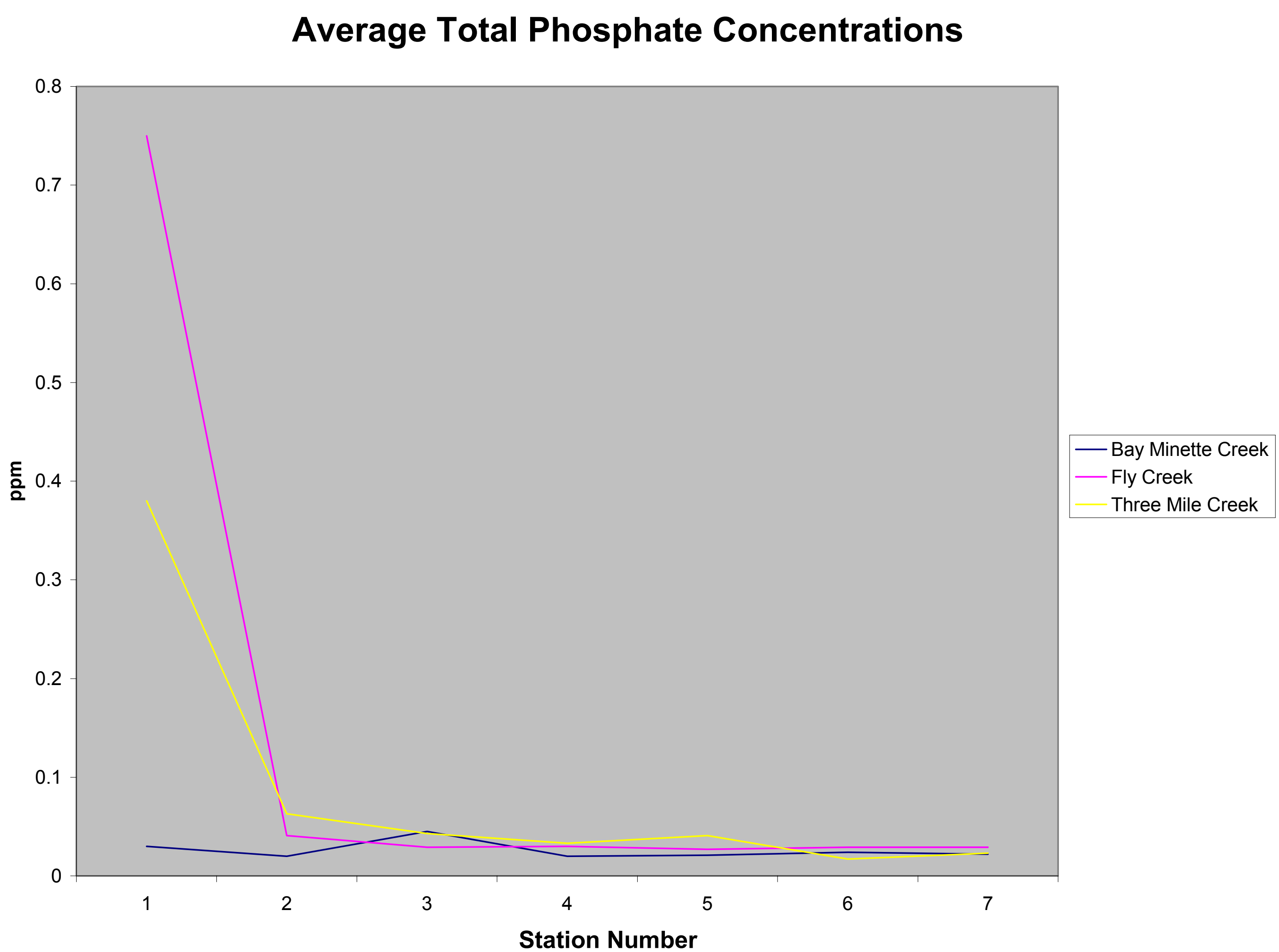
The highest average nitrate/nitrite concentrations were observed in the Fly Creek subwatershed. For the entire study period, this subwatershed had an average nitrate/nitrite concentration of 0.942 parts per million. The second highest average concentration, 0.67 parts per million, was recorded in the Three Mile Creek subwatershed. The lowest average nitrate/nitrite concentrations were observed in the Bay Minette Creek subwatershed. This subwatershed's total average nitrate/nitrite concentrations for the entire study period was less than 0.05 parts per million. Little variation in nitrate/nitrite concentrations was observed in the Bay Minette Creek subwatershed stations. This variation was more pronounced in the remaining two subwatersheds. Nitrate/nitrite concentrations were slightly lower in the most downstream stations of the Bay Minette Creek and Fly Creek subwatersheds than those recorded in the most upstream stations. In the Three Mile Creek subwatershed, the nitrate/nitrite concentrations were much greater at the most downstream station than those at the most upstream station.

Phosphate

Total phosphate is a measure of both suspended and dissolved phosphates. Of high nutritive value to plants and animals, phosphates are used in fertilizers and as animal feed supplements. They are also used in the manufacture of numerous industrial chemicals. Phosphorous is a major nutritional and structural component of biota. It is also the least abundant of biota's required components. It occurs in aquatic systems almost exclusively as phosphates. There are several classifications of phosphates: ortho phosphates, condensed phosphates, and organically bound phosphates. Phosphates occur in solution, in detritus, or in the bodies of aquatic organisms. The forms of phosphate are introduced via a variety of sources including wastewater discharge, fertilizer runoff, and runoff from sewage. Phosphorus is found in the Earth's rocks primarily as the ion ortho phosphate (PO_4^{3-}), which is the most significant form of inorganic phosphorus in aquatic systems.

The phosphorous cycle is very complex, but the majority of phosphate in aquatic systems is bound up in the particulate phase as living biota such as bacteria and plants, effectively removing it from the primary productive zone. With the algae/bacteria interaction comes a colloidal substance, through which some phosphorous is lost to the sediment, while still more is lost through hydrolyzation and conversion to ortho phosphate. Ortho phosphate, since it is soluble, is quickly taken up by macrophytes and algae. The colloidal and particulate forms of phosphorus must be replaced by regeneration of solubilized phosphorus from decomposition, precipitation, and runoff (NCSU. 1984).

Although phosphates in the aquatic environment are usually poly-phosphates or organically bound, all will degrade to ortho phosphates (reactive) with time. Overloading of phosphate concentrations may result in the proliferation of algae or other aquatic plant life. As previously discussed, such eutrophication causes decreased dissolved oxygen levels in the water due to the accelerated decay of organic matter. Excessive ortho phosphate concentrations are an indicator of such overloading (NCSU. 1984).



With the exception of the most downstream stations, total average phosphate concentrations among the three subwatersheds were comparable. The Fly Creek subwatershed exhibited a total average phosphate concentration of 0.134 parts per million for the entire study period. This was the highest average among the subject subwatersheds. The Three Mile Creek subwatershed was second with a total average phosphate concentration of less than 0.042 parts per million. The Bay Minette Creek subwatershed demonstrated the lowest a total average phosphate concentration at less than 0.022 parts per million. The highest total phosphate concentrations were observed in the tidally influenced stations of all three subwatersheds.

Sediment Metals

Sediments represent a temporally integrated record of chemical conditions in a watershed. Since many contaminants entering a watershed become sequestered in the sediment, examining sediment metal concentrations provide insight into past and current conditions (ADEM, 1997). The objective of the sediment metal study was to determine the concentrations of metals contained in the sediment of the three subwatersheds and compare those values across the three impervious surface regimes. The data gathered were compared to "Ecological Response" levels developed by Long et al., 1995 that establish three ranges in a given contaminant's concentration where detrimental effects are rare, occasional, and frequent. The three ranges are defined by two threshold concentrations known as Effects Range – Low (ER-L) and Effects Range – Moderate (ER-M). Values below ER-L rarely result in detrimental effects. Values exceeding ER-L, but below ER-M, result in occasional detrimental effects. Values exceeding ER-M are likely to result in detrimental effects (ADEM, 2000).

Threshold in Parts Per Million

Metal	ER – L	ER – M
Arsenic	8.2	70.0
Cadmium	1.2	9.6
Chromium	81.0	370.0
Copper	34.0	270.0
Lead	46.7	218.0
Mercury	0.15	0.71
Nickel	20.9	51.6
Zinc	150.0	410.0

(Long, 1995)

Excessive levels of arsenic in surface water may have devastating effects upon aquatic life. In significant concentrations, it is a potent poison. Arsenic may enter the surface water in a number of ways, not all anthropogenic. As may be observed in the table appearing in this section, low levels of arsenic were detected in sediment samples for stations BMC 1, BMC 3, FC 3, FC 4, TMC 1, and TMC 5. Of these stations, only TMC 1 exhibited arsenic concentrations in excess of the ER – L. At 11.7 parts per million, however, this station's observed value was below the ER - M of 70 parts per million for arsenic.

Cadmium is not usually found in its free elemental state, but rather combined with other elements. It is a common substance suspected to be present in all soils and rocks. It is also a persistent element that does not break down readily in the environment. It has been recognized as a probable carcinogen, especially when inhaled. Low levels of cadmium were detected in the sediment at stations BMC1, BMC 2, BMC 3, FC 4, and TMC 1. The highest concentration of cadmium observed was at station BMC 3 which exhibited a total cadmium level of 0.11 parts per million. None of the observed concentrations exceeded the ER – L of 1.2 parts per million.

SEDIMENT METALS CONCENTRATIONS IN PARTS PER MILLION

Station	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
BMC 1	1.4	0.09	14	3.9	8.8	0.09	8.6	21
BMC 2	< 0.5	0.03	5.2	1	2.9	< 0.05	5.9	6.2
BMC 3	1.8	0.11	24	4.9	8.6	0.11	7	30
BMC 4	< 0.5	< 0.025	1.3	< 0.5	< 1.0	< 0.05	8	2.3
BMC 5	< 0.5	< 0.025	1.9	< 0.5	1.1	< 0.05	4.1	2.9
BMC 6	< 0.5	< 0.025	1.9	< 0.5	1.4	< 0.05	< 1.0	2
BMC 7	< 0.5	< 0.025	1.8	< 0.5	< 0.5	< 0.05	1.9	1.7
FC 1								
FC 2								
FC 3	1.6	< 0.025	10	< 0.5	5.1	0.05	3.4	8
FC 4	1.7	0.03	< 0.5	< 0.5	6.3	0.06	4	12
FC 5	< 0.5	< 0.025	2.4	< 0.5	1.2	< 0.05	9.4	1.5
FC 6	< 0.5	< 0.025	4.4	< 0.5	2	< 0.05	5.3	4
FC 7	< 0.5	< 0.025	3.8	2	1	< 0.05	5.2	2.2
TMC 1	11.7	0.8	43.26	69.18	63			
TMC 2								
TMC 3								
TMC 4	< 0.5	< 0.025	3	< 0.5	1.4	< 0.05	4.8	5
TMC 5	1	< 0.025	7.1	< 0.5	4.3	< 0.05	3.6	6
TMC 6	< 0.5	< 0.025	3.5	< 0.5	3.2	< 0.05	2.3	7
TMC 7	< 0.5	< 0.025	8.3	< 0.5	4	0.05	3.6	11

Chromium occurs naturally in rocks, soil, air, and water. It normally appears in either trivalent or hexavalent form, depending on pH. It is a necessary trace element for the support of life functions, but, as is the case with many substances, excessive concentrations may lead to complications, i.e. acute toxicity to plants and animals. This is especially true with the hexavalent species of the element. Chromium was detected in low levels in each of the stations studied with the exception of FC 4. None of the observed concentrations, however, exceeded the ER – L of 81 parts per million. Station TMC 1 exhibited the greatest concentration of sediment chromium at 43.26 parts per million.

Copper is a metal that is often found in its elemental form. It was likely the first metal ever used in production by mankind. It is an essential element for normal growth and reproduction in higher plants and animals, as well as being a primary factor in the development of collagen and protective nerve coatings. Although excessive levels of copper may produce nausea and other adverse effects, deficiencies in copper are believed to be more calamitous than excess concentrations. The greatest concentrations of copper in sediment were observed at station TMC 1. The copper concentration at this station, 69.18 parts per million, exceeded the ER – L for copper of 34 parts per million, but was below the ER – M value of 270 parts per million. Four other stations, BMC 1, BMC 2, BMC 3, and FC 7 also exhibited measurable concentrations of copper.

Lead, in sufficient concentrations, is a toxic metal to both plant and animals. This toxicity is correlated to the lead's solubility, which depends on pH and water hardness. Lead finds its way to water bodies through runoff, industrial discharge, or, even through precipitation. Station TMC 1 exhibited the highest concentration of lead in sediment. The 63 parts per million total concentration of lead observed at this station exceed the ER – L for lead, 46.7 parts per million, but was below the ER – M, 218 parts per million. Stations BMC 1, BMC 2, BMC 3, BMC 5, BMC 6, and FC 3 through FC 7 also exhibited measurable concentrations of lead.

Mercury is a toxic metal. It is not usually found in its free elemental state, but rather combined with other elements. Many of these mercury combinations are beneficial, but benefits aside, mercury has been identified as a bioaccumulative poison. Mercury's toxicity is dependent on its chemical form and the route of exposure. It is particularly pernicious in its methylated form. It is suspected that atmospheric deposition of mercury is the major route of that substance into the water. Mercury was not detected in concentrations exceeding the ER – L of 0.15 parts per million at any of the stations. Low levels of mercury were detected at stations BMC 1, BMC 3, FC 3, and FC 4. Station BMC 3 exhibited the greatest mercury concentrations encountered at 0.11 parts per million.

Nickel is a hard, corrosion resistant metal that shares many properties in common with iron and cobalt. It occurs naturally in the earth's crust, generally coupled with other elements. It is also present in meteorites. Certain nickel species produce deleterious health effects in living organisms and some of the nickel forms are suspected carcinogens. Nickel was not detected in concentrations exceeding the ER – L of 20.9 parts per million at any of the stations. The greatest concentration of nickel observed in sediment samples was at station FC 5, 9.4 parts per million. Of all the stations, only BMC 6 did not have measurable concentrations of nickel.

Zinc is a metal used in the production of a number of useful alloys. It is found in many minerals. It is an essential element for many organisms. Zinc is not considered very toxic to humans or other organisms. It may be present in a water body naturally or through deposition from discharge or runoff. Since it is used in the vulcanization of rubber, high concentrations of zinc are not uncommon around roadways. Zinc was detected at every station. None of the observed concentrations exceeded zinc's ER – L of 150.0 parts per million. The highest concentration of total zinc was observed at station TMC 7 with 11.0 parts per million.

MATERIALS AND METHODS

This study was conducted in accordance with the ADEM *Methodology for Coastal Subwatershed Assessments, 2001* and executed under the requirements established in the ADEM *Standard Operating Procedures and Quality Control Assurance Manual*.

The three subwatersheds were delineated using U.S. Department of the Interior Geological Survey 7.5 Minute Series topographic maps. The quadrangles: Bay Minette, Bridgehead, Stapleton, Daphne, Point Clear, Siverhill, Spring Hill, and Mobile were used in mapping the contour lines to determine the extent of the basins and to select sampling stations.

Sampling stations were selected to represent a cross section of the individual subwatersheds. Land use determinations were obtained from the Alabama Soil and Water Conservation needs Assessment Unit. Station accessibility was a significant factor in the final designation of stations. Seven stations were selected for each subwatershed. Station one was the furthermost downstream location, while station seven was the furthermost upstream location. At those stations accessible only by boat, field parameters were taken at the surface, mid depth, and bottom. At stations accessible by wading, parameters were retrieved from the surface and mid depth. All samples were retrieved at a depth of 15 to 30 cm below the water's surface.

Each of the stations were visited, at least monthly, and monitored for; dissolved oxygen, pH, salinity, specific conductivity, flow, and temperature, as well as sampled for total suspended solids, total dissolved solids, turbidity, fecal coliform bacteria, ammonia, nitrates/nitrites, total Kjehldahl nitrogen, and total phosphorous. Stations were also sampled, on a one time basis, for metals concentrations in the sediment. Field parameters for all stations were taken *in-situ* using the YSI 600XLM® and the YSI 650 MDS®.

Flow measurements were obtained using the Pygmy Flow Meter. The Department's Microsoft Excel Stream Flow Calculation Worksheet was used to calculate flow based on measurements obtained using a Price vertical axis current meter, pygmy type, mounted on a top setting rod. Runoff during and immediately following significant rain events quickly impacted the drainage paths of all three subwatersheds. Significant rain events transformed typically wadeable streams into swollen streams too deep and/or swift for safe flow measurement.

REVIEW AND CONCLUSIONS

Data collected in this study, while less than definitive, do suggest that increased impervious surface coverage within a watershed is a detriment to water quality. Increasing impervious surface area within a drainage basin correspondingly decreases the amount of area in that basin over which water may infiltrate the soil, thereby creating greater volumes of runoff. Greater volumes of runoff increase the probability of pollutants entering the streams draining that basin. Sufficient stress from NPS pollutants will quickly degrade water quality. No obvious sources of pollutants, apart from sewage system overflows and roadside trash/debris were identified during the course of the study.

The field analyses and laboratory results demonstrate that the subwatershed, Three Mile Creek, with the highest level of development had the highest average water temperature and turbidity, the greatest average concentration of ammonia and fecal coliform bacteria. These findings may be attributed to the subwatershed's estimated 34% impervious surface coverage, but more than likely are a combination of the impervious surface coverage and the land use upon which those impervious surfaces rest. The Three Mile Creek subwatershed, in comparison to the Bay Minette Creek and Fly Creek subwatersheds, is the most populated watershed. It has the most industry and the most commercial enterprises. More traffic travels the roads in the Three Mile Creek subwatershed than in the other two subject subwatersheds combined. These factors make it difficult to investigate correlation between water quality impacts and impervious surface cover alone.

The subwatershed with the moderate level of development, Fly Creek, had the highest average specific conductivity and salinity and the highest average concentration of dissolved oxygen, total dissolved solids, nitrate/nitrites, and phosphate. This watershed also demonstrated the lowest average turbidity and lowest average concentrations of fecal coliform bacteria, total suspended solids, and total Kjehldahl nitrogen. The Bay Minette Creek subwatershed with its estimated 1% impervious surface cover had the lowest average concentrations of total dissolved solids, ammonia, nitrate/nitrite, and phosphate, but it also had the highest average concentrations of total suspended solids and total Kjehldahl nitrogen and lowest average values for pH and dissolved oxygen.

The lack of clear delineation between the data from the three separate subwatersheds may be a factor related to the precipitation levels encountered throughout this study. Rain events were heavy and significantly greater than the historical average for the study areas. Most sampling events were conducted during or following substantial rain events. This is of particular importance in the instance of the Three Mile Creek subwatershed as upsets from the Mobile Area Water and Sewer System (MAWSS) sanitary sewers are common during substantial rain events. Records of reported releases by the MAWSS demonstrate that substantial amounts of untreated sewage overflow into the subwatershed on a frequent basis. Given enough rainfall, regardless of surface conditions (i.e. impervious or porous), the earth is quickly saturated to an extent that any more rain is prevented from infiltrating the soil. Under such conditions correlation between varying impervious surface regimes is difficult to assess.

Were the land uses and population pressures in the three subject subwatersheds substantially similar, the data collected would have been more useful in forming definitive conclusions about the impact of impervious surface coverage on water quality. Inasmuch as the land uses and population numbers differed greatly, the data are open to wider interpretation.

LIST OF ACRONYMS AND ABBREVIATIONS

ADEM -	Alabama Department of Environmental Management
BOD_5 -	5 day biochemical oxygen demand
BSW –	Bayou Sara Watershed
^0C –	degrees Celsius/centigrade
CBOD -	carbonaceous biochemical oxygen demand
cfs –	cubic feet per second
DO –	dissolved oxygen
EPA -	Environmental Protection Agency
^0F -	degrees Fahrenheit
GIS -	geographic information system
mgd/MGD –	million gallons per day
mg/kg -	milligrams per kilogram
mg/l –	milligrams per liter
NPDES -	National Pollutant Discharge Elimination System
NPS -	non point source

NTU -	Nephelometric turbidity unit
P -	phosphate
POTW -	publicly owned treatment works
ppb -	parts per billion
ppd -	pounds per day
ppm -	parts per million
ppt -	parts per thousand
s.u. –	standard units
TKN -	total Kjehldahl nitrogen
TRC -	total residual chlorine
USEPA –	United States Environmental Protection Agency
USGS –	United States Geological Survey
ug/g -	micrograms per gram
uS/cm -	micro Siemens per centimeter
WWTP -	wastewater treatment plant

DEFINITIONS OF TERMINOLOGY

Aquifer -	a water bearing stratum of sand, gravel, or permeable rock
Impervious surface -	any material that prevents the infiltration of water into the soil
Non-point source -	pollutant introduction from spatially separate origins such as pollution arising from runoff during rain events
Point source -	pollutant introduction from a specific outlet
Potentiometric surface -	a surface of potential, or hydraulic head, for an aquifer

Sample –	physical evidence collected from a facility, site, or from the environment
Terrigenous -	relating to ocean sediment derived directly from the destruction of rocks on the earth's surface
Watershed -	a geographical area from which water drains along common paths. The area is bounded by topographical or other features that contain or otherwise direct the flow of water falling within the watershed.

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Field Parameters

BMC 1
30^0 41.994'
87^0 54.507'

FD = Field Duplicate

Date dd/mm/yy	Time	H_20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Depth feet	Secchi Depth m	Turbidity ntu
1/9/03	1330	11.6	19	61	9.45	0.00	5.28	surface	1.4	5.9
		11.4	19	59	9.39	0.00	5.25	5.0		
		10.2	19	56	9.46	0.00	5.51	10.0		
2/4/03	920	13.9	13	148	9.39	0.10	6.26	surface	1.4	6.19
		13.8	13	141	9.75	0.10	6.19	5		
		13.8	13	130	9.93	0.10	6.1	10.0		
2/27/03	1105	13.9	17	35	8.04	0.02	4.76	surface	1.2	6.3
		13.8	17	35	7.43	0.02	4.73	5.5		
		13.6	17	39	2.7	0.02	4.84	11.0		
3/18/03	1115	18.5	30	38	7.06	0.10	4.44	surface	1.0	10.62
		18.1	30	31	6.16	0.10	4.22	7.0		
		18	30	32	6.92	0.10	4.31	14.0		
3/27/03	1210	21.7	29	58	7.92	0.03	5.65	surface	0.8	9.9
		21.5	29	61	7	0.03	5.69	5.8		
		21.2	29	65	7.06	0.03	5.69	11.5		
4/14/03	940	18.4	25	106	7.66	0.05	4.5	surface	0.8	10.8
		17.4	25	106	7.45	0.05	4.67	4.1		
		16.2	25	101	1.6	0.05	4.82	8.2		
4/29/03	1125	23.5	31	82	6.9	0.04	5.46	surface	0.9	7.9
		22.8	31	88	6.45	0.04	5.56	5.0		
		21.8	31	116	2.05	0.05	5.69	10		
5/3/03	1205	28.5	29	77	6.92	0.03	5.62	surface	0.5	6.4
		27.4	29	86	3.18	0.04	5.97	6.0		
		26.2	29	151	1.14	0.07	5.94	12		
5/21/03	1110	22.9	29	24	5.79	0.01	4.5	surface	0.4	27.3
		22.5	29	25	5.12	0.01	4.52	5.0		
		22.1	29	29	6.57	0.01	4.56	10		

BMC 1

Date dd/mm/yy	Time	H_20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Depth feet	Secchi Depth m	Turbidity ntu
6/24/03	1135	28.7	31	27	5.74	0.01	4.91	surface	0.6	12.2
		26.4	31	28	4.42	0.01	4.95	5.0		
		24.3	31	26	4.91	0.01	4.82	10		
7/28/03	1000	27.1	31	40	6.4	0.02	6.14	surface	0.6	18.5
		25.1	31	27	5.8	0.01	5.58	6.0		
		24.9	31	25	5.94	0.01	5.42	12		
8/21/03	1105	28.1	32	33	7.41	0.01	5.86	surface	0.7	12.6
		27.8	32	33	7.15	0.01	5.86	4.4		
		27	32	60	0.7	0.03	6.28	8.9		
9/16/03	925	25.8	25	107	6.37	0.05	6.38	surface	0.7	13.4
		25.6	25	97	5.84	0.04	6.23	4.8		
		24.3	25	49	2.71	0.02	6.28	9.5		
10/23/03	1240	23	28	1180	8.11	0.58	6.57	surface	1	8.1
		22.1	28	1200	7.98	0.60	6.53	5.4		
		21.7	28	1103	7.7	0.55	6.45	10.8		
11/25/03	1205	16.7	15	205	7.42	0.10	6.23	surface	0.8	12
		16	15	285	7.32	0.14	6.35	4.1		
		16	15	376	8.02	0.20	6.37	8.1		
12/4/03	1215	15	19	115	8.31	0.05	6.01	surface	0.7	19.4
		12.9	19	63	7.93	0.03	6.00	5.0		
		13	19	60	8.83	0.03	6.02	10.1		
12/18/03	1145	10.3	15	48	10.44	0.02	6.15	surface	0.7	16.6
		10.4	15	48	10.13	0.02	6.22	3.8		
		10.3	15	51	10.8	0.02	6.13	7.6		

BMC 2
30^0 42.901'
87^0 53.048'

Date dd/mm/yy	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Depth feet	Secchi Depth m	Turbidity ntu
37630	1315	11.07	19	51	9.49	0	5.11	surface	2.5	3.4
		9.83	19	43	9.56	0	5.1	9.6		
		9.63	19	45	10.7	0	5.21	19.1		
2/4/03	950	12.8	14	89	8.74	0	5.38	surface	2.2	3.53
		12.7	14	75	8.81	0	5.35	10.9		
		12.7	14	75	9.28	0	5.38	22.1		
2/27/03	1135	13.6	17	27	8.67	0.01	4.76	surface	0.8	10.3
		13.5	17	27	8.72	0.01	4.82	7.9		
		13.5	17	27	8.83	0.01	4.95	15.8		
3/18/03	1135	18.4	29	27	7.61	0.01	4.34	surface	1.2	8.46
		18	29	27	7.64	0.01	4.22	8.0		
		17.4	29	27	7.45	0.01	4.19	16.0		
3/27/03	1240	21.5	29	30	7.17	0.01	4.9	surface	1.2	4.6
		19.1	29	30	7.07	0.01	4.91	7.0		
		17.4	29	27	7.38	0.01	4.91	14.0		
4/14/03	1005	20.7	25	33	7.56	0.01	4.36	surface	1.2	5.6
		16	25	29	7.87	0.01	4.24	8.3		
		15.64	25	30	7.4	0.01	4.28	16.5		
4/29/03	1140	24.1	32	34	6.75	0.01	4.91	surface	0.8	6.2
		19.9	32	29	6.24	0.01	4.7	9.5		
		19.8	32	29	6.22	0.01	4.81	19.0		
5/13/03	1230	28.2	30	84	5.22	0.04	5.33	surface	0.9	4.5
		24.4	30	76	3.98	0.03	4.97	8.0		
		23.5	30	117	2.44	0.05	5.52	16.0		
5/21/03	1140	21.8	29	22	6.54	0.01	4.34	surface	0.4	27.4
		21.7	29	22	6.59	0.01	4.34	8.0		

		21.7	29	21	6.74	0.01	4.35	15.5		

BMC 2

Date dd/mm/yy	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Depth feet	Secchi Depth m	Turbidity ntu
6/24/03	1155	25.9	31	24	6.3	0.01	4.77	surface	0.5	23.9
		24	31	23	6.64	0.01	4.74	8.0		
		23.9	31	23	6.78	0.01	4.78	16.0		
7/28/03	1025	25.3	31	19	6.06	0.01	5.02	surface	0.5	26.8
		24.2	31	19	6.14	0.01	5.02	9.5		
		24.2	31	19	5.86	0.01	5.04	19.0		
8/21/03	1125	26.3	31	24	7.44	0.01	5.41	surface	0.8	8.1
		25.3	31	23	7.51	0.01	5.38	8.8		
		25	31	23	7.6	0.01	5.38	17.6		
9/16/03	950	23.6	25	25	5.84	0.01	5.3	surface	0.4	36.5
		23.5	25	25	5.84	0.01	5.3	7.9		
		23.4	25	24	6.48	0.01	5.49	15.8		
10/23/03	1255	23.2	28	97	7.34	0.04	5.71	surface	1.4	4.9
		18.5	28	26	7.33	0.01	5.69	8.7		
		17.4	28	35	7.51	0.02	6.04	17.4		
11/25/03	1225	16	16	30	7.09	0.01	5.64	surface	1	5
		14.7	16	29	7.15	0.01	5.67	7.7		
		14.8	16	30	7.3	0.01	5.87	15.4		
12/4/03	1235	13.5	20	30	9.3	0.01	5.44	surface	0.9	5.6
		11.7	20	29	9.66	0.01	5.45	8.7		
		11.8	20	70	9.92	0.03	6.72	17.3		
12/18/03	1200	10.5	17	25	10.05	0.01	5.5	surface	1.6	6.4
		10.08	17	25	10.08	0.01	5.49	8.6		
		10.03	17	25	10.1	0.01	5.5	17.2		

BMC 3

30^0 43.356'

87^0 52.514'

Date dd/mm/yy	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Depth feet	Secchi Depth m	Turbidity ntu
1/9/03	1300	10.7	18	48	9.72	0	5.03	surface	2.4	2.8
		10.14	18	46	9.85	0	4.99	7.6		
		9.67	18	49	10.12	0	5.17	15.5		
2/4/2003/FD	1010	12.7/12.6	14/14	79/79	8.86/9.01	0/0	5.32/5..6	surface	2.6/2.6	3.01/3.1
		12.5/12.5	14/14	72/72	8.91/8.86	0/0	5.27/5.25	6.3		
		12.1/12	14/14	69/68	9.35/9.01	0/0	5.44/5.21	12.9		
2/27/03	1155	14.3	20	27	8.34	0.01	4.62	surface	0.7	12.5
		13.8	20	27	7.2	0.01	4.68	8.5		
		13.8	20	34	5.82	0.02	5.34	17.0		
3/18/03	1145	17.2	29	25	7.99	0.01	3.82	surface	1	9.46
		17.5	29	25	8.11	0.01	3.94	9.0		
		17.9	29	30	1.74	0.01	4.31	18.0		
3/27/03	1310	20.6	29	26	7.31	0.01	4.79	surface	1.1	4.3
		16.7	29	24	7.69	0.01	4.85	8.5		
		16.6	29	35	6.61	0.02	5.06	17.0		
4/14/03	1030	18.4	26	25	8.02	0.01	4.46	surface	0.9	4.7
		15.8	26	24	8.27	0.01	4.48	8.3		
		15.1	26	28	7.1	0.01	4.51	16.5		
4/29/03	1150	23.4	32	29	6.98	0.01	4.71	surface	0.65	6.6
		19.6	32	27	6.02	0.01	4.76	6.5		
		19.2	32	34	6.12	0.02	5.01	13		
5/13/03	1245	28.6	31	46	5.34	0.02	5.07	surface	0.7	3.7
		23.9	31	28	5.21	0.01	4.91	9.5		F.D. 4.0
		19.6	31	59	1.17	0.03	5.46	19		
5/21/03	1200	21.6	29	22	6.69	0.01	4.34	surface	0.5	25.5

		21.6	29	22	6.74	0.01	4.34	8		
		21.6	29	22	7.05	0.01	4.37	16		

BMC 3

Date dd/mm/yy	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Depth feet	Secchi Depth m	Turbidity ntu
6/24/03	1210	24.9	30	23	6.32	0.01	4.59	surface	0.5	24.3
		23.9	30	23	6.47	0.01	4.53	8		
		23.9	30	23	6.68	0.01	4.56	16		
8/21/03	1150	24.8	33	22	8.21	0.01	5.3	surface	0.8	11.9
		23.9	33	22	8.24	0.01	5.29	10		
		23.8	33	22	7.16	0.01	5.62	20		
9/16/03	1000	23.7	26	25	6.06	0.01	5.25	surface	0.7	17
		23.1	26	25	6.12	0.01	5.25	8.1		
		23	26	28	6.54	0.01	5.6	16.2		
10/23/03	1310	22.6	28	35	7.42	0.01	5.94	surface	1.5	3.6
		17.8	28	23	7.87	0.01	6.13	9		
		17.9	28	170	1.96	0.08	6.78	18		
11/25/03	1245	15.9	16	23	7.77	0.01	5.59	surface	1.3	3.5
		14.7	16	22	7.8	0.01	5.59	9		
		14.6	16	25	7.87	0.01	5.75	18		
12/4/03	1250	14.4	21	27	9.51	0.01	5.3	surface	1.6	4.8
		12.1	21	26	9.96	0.01	5.59	9.3		
		12.1	21	31	10.54	0.02	5.67	18.5		
12/18/03	1215	11	17	23	9.66	0.01	5.57	surface	2.2	3.7
		10.5	17	23	8.68	0.01	5.84	9.3		
		10.5	17	34	10.31	0.01	5.67	18.6		

BMC 4
30^0 44.186'
87^0 52.527'

Date dd/mm/yy	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Depth feet	Secchi Depth m	Turbidity ntu
1/9/03	1230	10.1	18	47	10.51	0	5.14	surface	1.5	2.5
		10	18	45	10.05	0	5.16	2.3		
		10.1	18	43	10.16	0	5.16	4.9		
2/4/03	1040	13.6	15	72	8.89	0	5.38	surface	1.1	2.84
		13.6	15	68	9.04	0	5.38	1.7		
		13.6	15	67	9.94	0	5.4	3.6		
2/27/03	1230	14	22	27	8.79	0.01	4.37	surface	0.7	14.8
		14	22	27	8.82	0.01	4.34	2.6		
		14	22	27	8.99	0.01	4.39	5.2		
3/18/03	1210	17.12	29	24	8.41	0.01	4.2	surface	1.1	9.39
		17.12	29	24	8.44	0.01	4.16	4.5		
		17.12	29	24	8.48	0.01	4.1	9		
3/27/03	1330	19.7	29	22	8.43	0.01	4.91	surface	1.6	3.5
		17.4	29	22	8.7	0.01	5.03	3.5		
		17.4	29	22	8.92	0.01	5.16	7		
4/14/03	1100	16.7	28	23	8.69	0.01	4.7	surface	1.3	3.7
		16.4	28	23	8.77	0.01	4.74	2.5		
		16.4	28	23	8.87	0.01	5.02	5		
4/29/03	1230	21.2	33	24	8.51	0.01	4.98	surface	1.5	3.5
		18.4	33	24	8.87	0.01	5.03	3.2		
		18.2	33	23	9	0.01	5.19	6.5		
5/13/2003/FD	1325	22.1/22.2	32/32	25/25	8/8.03	0.01/0.01	5.06/5.05	surface	0.8	6.3
		21.4/21.4	32/32	25/25	7.95/8.03	0.01/0.01	5.27/5.27	3		
		21.5/21.5	32/32	25/25	7.92/8.10	0.01/0.01	5.65/5.64	6		

BMC 4

Date dd/mm/yy	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Depth feet	Secchi Depth m	Turbidity ntu
5/21/03	1225	21.7	29	22	6.73	0.01	4.23	surface	0.4	25.9
		21.7	29	22	6.8	0.01	4.29	3		
		21.7	29	22	7.13	0.01	4.32	6		
6/24/03	1230	23.8	31	23	6.62	0.01	4.45	surface	0.5	33.1
		23.8	31	23	6.7	0.01	4.42	2.5		
		23.8	31	23	7.32	0.01	4.45	5		
8/21/03	1220	23.7	33	22	8.47	0.01	5.08	surface	0.2	68
		23.7	33	22	8.53	0.01	5.08	3.3		
		23.7	33	22	8.87	0.01	5.06	6.5		
9/16/03	1025	21.8	26	22	7.53	0.01	5.45	surface	1.1	8
		21.8	26	22	7.59	0.01	5.46	4		
		21.8	26	22	8.07	0.01	5.44	8		
10/23/03	1340	19.4	29	22	8.35	0.01	5.82	surface	1.7	3.4
		18.5	29	22	8.44	0.01	5.94	3.3		
		18.3	29	30	8.74	0.01	6.09	6.6		
11/25/03	1320	13	16	22	8.99	0.01	5.72	surface	1.2	3.3
		13	16	21	8.97	0.01	5.72	2.8		
		13	16	22	9.53	0.01	5.68	5.6		
12/4/03	1310	14	23	27	9.71	0.01	5.29	surface	1.6	4.8
		14	23	27	9.72	0.01	5.33	3.7		
		14	23	27	9.84	0.01	5.38	7.3		
12/18/03	1235	9.96	18	21	10.99	0.01	5.55	surface	1.6	3.2
		9.94	18	21	11.02	0.01	5.52	2.8		
		10.1	18	22	11.52	0.01	5.64	5.5		

BMC 5
30^0 46.623'
87^0 52.310'

Date dd/mm/yy	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Flow cfs	Depth feet	Turbidity ntu
1/9/03	1105	8.44	20	49	10.51	0	4.94	19	2	1.3
2/4/03	1200	12.7	16	74	9.12	0	5.59	19.6	1.9	2.4
2/27/03	1025	13.9	19	25	7.58	0.01	4.2			6.8
field dup.		13.9	19	25	7.56	0.01	4.2			6.8
3/18/03	1020	17.5	26	25	7.82	0.01	4.09	55.4	3.5	4.7
3/27/03	1115	18.3	28	22	8.14	0.01	4.4	22.7	1.7	2.9
4/8/03	1040	18.6	21	19	6.98	0.01	4.8			5
4/29/03	1045	18.7	27	17	8.41	0.01	4.41	14.2	1.7	3.3
5/13/03	1115	21.6	28	28	7.99	0.01	4.65	11.7	1.5	7.2
5/21/03	1030	21.5	27	21	5.56	0.01	4.47			16.8
6/24/03	1050	23.8	28	21	6.4	0.01	4.46			33.4
7/23/2003/FD	1100	23.4/23.2	22/22	21/21	5.07/5.14	0.01/0.01	5.29/5.31			41.8/41.7
8/21/03	1035	24	33	19	6.8	0.01	4.93			32.1
9/16/03	1125	21.5	29	23	7.49	0.01	5.43	28.1	1.9	4
10/23/03	1140	17.6	22	24	8.49	0.01	5.84	15.4	1.6	3.4
11/25/03	1105	11	10	22	9.23	0.01	5.8	18	1.5	2.2
12/4/03	1105	12.8	20	27	9.84	0.01	5.48	46.5	2.8	3.4
12/18/03	1055	7.8	15	22	11.04	0.01	5.61	21.9	1.7	1.8

BMC 6

30^0 48.824'

87^0 50.319'

Date dd/mm/yy	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Flow cfs	Depth feet	Turbidity ntu
1/9/03	1020	8.4	18	46	9.63	0	5.24	17.3	1.9	1.8
2/4/2003/FD	1245	13/12.8	16/16	78/76	9.01/8.86	0/0	5.63/5.70	25.8	2.3	1.8/1.6
2/27/03	1000	13.9	20	27	8.49	0.01	4.26			12.4
3/18/03	940	17.3	24	26	7	0.01	5.9	33.1	3	5.9
3/27/03	1035	17.7	26	24	7.73	0.01	4.56	22.5	2.1	2.3
4/8/03	1015	18.5	21	21	7.06	0.01	4.27			7
4/29/03	1020	18	28	27	7.18	0.01	4.43	17.4	1.9	4.7
5/13/03	1020	20.5	25	29	6.02	0.01	4.53	13.4	2	3
5/21/03	1005	21.6	27	16	6.61	0.01	4.46			30.4
6/24/03	1030	23.8	29	24	5.81	0.01	4.83			8.1
7/28/03	1025	23	23	20	5.57	0.01	5.43			37.5
8/21/03	1005	23.6	32	21	7.86	0.01	5.59			22.6
9/16/03	1220	22.3	30	24	6.82	0.01	5.63	24.2	2.3	4.5
10/23/03	1050	17.7	21	25	8.06	0.01	5.68	16.8	2.3	2.8
11/25/03	1020	10.4	10	23	8.33	0.01	5.73	16.7	2.8	2.4
12/4/03	1015	13.5	18	28	9.02	0.01	5.57	36.8	3.2	2.9
12/18/03	1010	7.4	13	23	10.9	0.01	5.65	22.8	2.5	2

BMC 7
30^0 46.599'
87^0 49.524'

Date dd/mm/yy	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Flow cfs	Depth feet	Turbidity ntu
1/9/03	940	10.2	15	44	9.86	0	5.21	37.2	2.6	2.8
2/4/03	1330	14.2	16	75	9.68	0	5.62	34.6	2.4	3.12
2/27/03	935	14	20	25	9.12	0.01	3.91			17.9
3/18/03	905	16.6	20	22	8.93	0.01	6.02	75.4	3.4	8.6
3/27/03	940	16.9	26	21	9.35	0.01	5.84	48.8	2.5	2.7
4/8/03	935	18.5	21	20	8.27	0.01	4.13			25.5
4/29/03	945	18	25	22	9.6	0.01	4.5	29.5	2.3	4
5/13/03	925	19.6	25	23	8.91	0.01	4.5	33.2	2.1	5.3
5/21/03	935	21.3	28	24	5.58	0.01	3.85			70.1
6/24/03	945	22.6	27	22	7.76	0.01	4.42	110.9	4.2	17.3
7/28/03	945	22.9	24	22	5.96	0.01	5.14			43.7
8/21/03	940	23.1	31	21	9.3	0.01	5.27			43.2
9/16/03	1310	21.2	31	21	8.22	0.01	5.63	53.5	3.2	7
10/23/03	1005	17.6	21	22	9.18	0.01	5.56	36.6	2.6	4.3
11/25/03	920	12	5	21	9.7	0.01	6.33	38.5	2.6	3
12/4/03	940	14	19	26	9.74	0.01	5.15			11.6
12/18/03	910	9.8	9	20	11.01	0.01	5.31	42.9	3	3.4

FC 1 30^0 32.659', 87^0 53.991'

FD = Field Duplicate

Date dd/mm/yy	Time	H_20 Temp. ^0C	Air Temp. ^0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Turbidity ntu
1/8/03	1340	13.1	16	190	8.86	0.1	6.01	4.83
2/26/03	940	15.5	21	928	8.73	0.46	6.16	9.7
3/20/2003/FD	945	19.7/19.6	26/26	232/238	10.44/10.39	0.11/0.11	5.3/5.33	7.5/7.4
4/10/03	1240	17	18	93	9.5	0.04	5.49	8.8
5/20/03	920	23.2	29	65	6.6	0.03	5.08	32.9
6/11/03	935	28.8	30	534	11.53	0.26	6.2	7.8
7/24/03	950	24.9	27	47	8.11	0.02	6.32	40.8
8/19/03	1000	26.6	32	169	9.08	0.08	6.22	7.8
9/10/03	940	23.3	29	1598	6.82	38	6.14	4.5
10/29/03	905	18	21	4026	8.52	2.13	6.27	3.2
11/19/03	935	19.4	18	5086	6.6	2.41	6.24	13.3
12/16/03	930	14	22	48880	8.83	2.64	6.00	5.6

FC 2 30^0 32.710', 87^0 53.905'

Date dd/mm/yy	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Turbidity ntu
1/8/03	1325	13.2	15	112	9.87	0	6.03	4.26
2/26/03	950	15.7	22	167	8.52	0.08	5.78	8.4
3/20/03	955	20.4	26	88	10.01	0.04	5.27	6.4
4/10/03	1015	15	13	80	8.61	0.04	5.04	5.5
5/20/03	935	23.5	29	60	6.65	0.03	5.18	26.7
6/11/03	945	28.3	30	449	11.66	0.21	6.23	7.3
7/24/03	1010	25	29	47	8.65	0.02	6.41	49.4
8/19/03	1010	25.8	33	73	8.5	0.03	6.17	6.4
9/10/03	955	22.9	29	960	7.2	0.47	6.03	3.2
10/29/03	915	18.2	21	4406	8.87	2.36	6.39	3.2
11/19/03	950	19.3	18	3924	7.64	2.07	6.34	11.6
12/16/03	945	14.1	20	44660	8.71	2.44	6.36	4.5

FC 3 30^0 32.980', 87^0 53.928'

Date dd/mm/yy	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Turbidity ntu
1/8/03	1255	13.2	15	96	9.17	0	5.99	4.48
2/26/03	1005	15.6	20	93	9.58	0.04	5.61	4.9
3/20/03	1010	18.5	28	60	10.71	0.03	5.42	8.6
4/10/03	1025	15	14	58	9.84	0.03	5.31	4.2
5/20/2003/FD	1140	22.7/22.6	30/30	53/53	8.98/9.10	0.02/0.02	5.54/5.56	10.2/10.0
6/11/03	1000	23.8	30	63	8.7	0.03	5.49	5.6
7/24/03	1040	25	28	47	9.22	0.02	6.49	51.9
8/19/03	1030	24	33	57	8.8	0.03	6.2	3.9
9/10/03	1015	22.5	29	1841	7.48	0.92	6.14	3.9
10/29/03	935	17.5	20	947	9.89	0.48	6.53	2.1
11/19/03	1005	19.1	20	430	8.48	0.2	6.62	6.7
12/16/03	1000	14.6	21	60	9.96	0.03	6.54	2

FC 4 30^0 33.052', 87^0 53.937'

Date dd/mm/yy	Time	H20 Temp. ^{0C}	Air Temp. ^{0C}	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Turbidity ntu
1/8/03	1230	12.9	16	97	9.35	0	5.99	3.58
2/26/03	1050	15.7	20	58	9.73	0.03	5.71	5.3
3/20/03	1030	18.9	28	58	10.66	0.03	5.44	4.9
4/10/03	1040	15	15	55	10.01	0.02	5.33	4.2
5/20/03	1000	22.2	29	52	8.16	0.02	5.55	10.1
6/11/03	1010	23.3	28	57	8.71	0.03	5.42	4.4
7/24/03	1055	25	27	48	7.01	0.02	6.49	30.8
8/19/03	1040	23.9	32	56	9.23	0.02	6.22	3.8
9/10/03	1025	22.2	29	55	8.09	0.02	6.31	2.8
10/29/03	945	17.5	20	190	10.14	0.09	5.49	2.1
11/19/03	1015	18.9	20	106	7.95	0.05	6.16	5
12/16/03	1015	14.7	20	55	10.08	0.02	6.07	1.9

FC 5 30^0 33.118', 87^0 53.868'

Date dd/mm/yy	Time	H20 Temp. ^{0C}	Air Temp. ^{0C}	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Turbidity ntu
1/8/03	1150	12.5	15	86	9.62	0	5.9	3.52
2/26/03	1130	15.7	18	56	9.38	0.03	5.68	5.3
3/20/03	1045	18.8	26	58	11.26	0.03	5.52	6.7
4/10/03	1100	15	19	50	10.95	0.02	5.6	4.2
5/20/03	1020	22	29	52	8.47	0.02	5.53	8.6
6/11/03	1020	23.2	27	56	8.6	0.03	5.52	4.7
7/24/03	1125	25	27	44	7.89	0.02	6.48	41.7
8/19/03	1050	23.9	30	56	8.9	0.02	6.22	4.1
9/10/03	1035	22.1	29	53	8.62	0.02	6.18	2.9
10/29/03	1015	17.5	18	252	9.23	0.12	6.15	2.3
11/19/03	1025	18.9	18	73	8.03	0.04	6.01	4.8
12/16/03	1100	14.9	18	53	10.13	0.02	5.91	2.1

FC 6 30^0 33.144', 87^0 53.822'

Date dd/mm/yy	Time	H20 Temp. ^{0C}	Air Temp. ^{0C}	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Turbidity ntu
1/8/03	1135	12.4	15	87	8.73	0	5.87	4.64
2/26/03	1200	15.6	17	55	9.27	0.02	5.56	15.2
3/20/03	1105	18.9	26	56	10.93	0.02	5.55	5.66
4/10/03	1120	15.7	18	52	10.08	0.02	5.42	4
5/20/03	1035	22.1	29	52	7.98	0.02	5.57	8.9
6/11/03	1040	23.1	26	56	8.9	0.03	5.42	4.3
7/24/03	1150	25.1	28	37	7.04	0.02	6.47	51.4
8/19/03	1110	23.9	31	55	8.79	0.02	6.25	4.2
9/10/03	1050	22.2	29	53	8.3	0.02	6.98	2.9
10/29/03	1045	17.4	19	51	9.7	0.02	6.2	2.3
11/19/03	1045	18.8	16	54	8.37	0.02	5.97	4.4
l2/16/2003/FI	1125	15.1/15	18/18	52/52	10.21/10.18	0.02/0.02	5.89/5.88	1.9/1.7

FC 7 30^0 33.183', 87^0 53.718'

Date dd/mm/yy	Time	H20 Temp. ^{0}C	Air Temp. ^{0}C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Turbidity ntu
1/8/03	1115	12.5	14	82	10.9	0	5.84	3.3
2/26/03	1230	15.5	17	59	9.21	0.02	5.67	9.6
3/20/03	1120	18.9	26	57	11.06	0.03	5.55	4.6
4/10/03	1200	16	15	49	9.46	0.02	5.36	4.5
5/20/03	1100	22	29	51	8.04	0.02	5.48	7.4
6/11/03	1115	23.3	28	56	8.95	0.02	5.44	3.9
7/24/03	1215	25.2	28	33	7.17	0.01	6.47	12.4
8/19/03	1125	24	31	55	8.75	0.02	6.26	3
9/10/03	1120	22.3	29	53	7.97	0.02	6.04	3.4
10/29/03	1120	17.5	20	51	9.6	0.02	6.14	2.1
11/19/03	1130	18.8	15	54	8.65	0.02	5.99	4.1
12/16/03	1155	15.1	18	52	10.17	0.02	5.95	2.1

TMC 2 30^0 42.192', 88^0 04.340'

FD = Field Duplicate

Date	Time	H_20 Temp. ^0C	Air Temp. ^0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Turbidity ntu
1/8/03	915	10.5	8	160	9.9	0.08	5.3	24.3
2/25/03	845	14.5	11	174	7.11	0.08	5.68	17.7
3/19/03	850	20.8	23	186	8.42	0.09	5.51	21.1
4/9/03	855	16.4	15	118	6.83	0.06	5.81	11.8
5/19/03	900	22.4	25	91	6.34	0.04	5.76	68.8
6/9/03	920	28.4	29	112	8.88	0.05	5.79	12.7
7/22/03	945	25.8	28	116	7.56	0.05	6.83	39.8
8/20/03	855	29.3	31	164	8.78	0.08	6.65	8.9
9/8/03	900	26.6	25	132	7.88	0.06	6.59	4.3
10/16/03	950	21.1	24	102	4.6	0.05	6.2	9.3
11/18/03	1235	22.1	25	2118	7.96	1.1	6.5	2.8
12/15/03	905	11.8	6	245	8.14	0.12	6.33	4.4

TMC 3 30^0 41.838', 88^0 05.672'

Date	Time	H_20 Temp. ^0C	Air Temp. ^0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Turbidity ntu
1/8/03	1000	10.8	8	127	10.7	0.06	6.08	20.2
2/25/03	910	16.1	11	112	8.52	0.05	6.28	17.3
3/19/2003/FD	925	21/21	25/25	114/114	9.38/9.26	0.05/0.05	6.14/6.18	20.1/19.8
4/9/03	915	17.2	15	70	9.53	0.04	6.2	15.9
5/19/03	920	22	26	78	8.44	0.04	6	60.7
6/9/03	940	26	30	112	8.83	0.05	5.91	16.3
7/22/03	1010	24.8	29	78	7.93	0.04	6.72	38.2
8/20/03	920	28.6	32	113	8.1	0.05	6.67	5.1
9/8/03	930	26.1	27	101	7.38	0.05	6.68	3.8
10/16/03	1020	20.6	26	96	8.3	0.04	6.6	2.8
11/18/03	1215	21.9	25	108	8.42	0.05	6.97	2.8
12/15/03	930	10.5	10	98	12.4	0.05	7.33	3.5

TMC 4 30^0 42.867', 88^0 07.037'

Date	Time	H20 Temp. ^{0}C	Air Temp. ^{0}C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Flow cfs	Depth feet	Turbidity ntu
1/8/03	1025	11	10	105	11.3	0.05	6.47	18.1	1.2	31.4
2/25/03	935	14.8	12	90	9.96	0.04	6.49	17.6	1.2	24.9
3/19/03	950	21.4	25	95	10.18	0.04	6.57	26.3	1	25.6
4/9/03	935	17.7	15	76	9.35	0.03	6.5	38	1.8	24.3
5/19/03	940	23	27	70	8.66	0.03	6.27	57.8	1.9	88.1
6/9/03	1000	27.1	32	84	8.69	0.04	6.35	30.9	1.8	18.2
7/22/03	1030	25.2	31	47	8.87	0.02	7.07	68	1.8	44.6
8/20/03	940	28.7	32	64	10.54	0.03	7.37	26.4	1.5	4.7
9/8/03	945	26.3	27	97	8.33	0.04	7.41	17.9	1.3	3.9
10/16/03	1040	20.8	26	66	10.2	0.03	7.2	16.1	1.5	3.5
11/18/2003/FD	1140	21.7/21.7	25/25	102/99	9.92/9.86	0.05/0.05	7.24/7.25	11.7	1.3	1.9/2.0
12/15/03	955	10.2	10	84	13.3	0.04	7.19	17.7	1.8	2.9

TMC 5 30^0 42.433', 88^0 09.002'

Date	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Flow cfs	Depth feet	Turbidity ntu
1/8/03	1120	11.3	14	92	10.8	0.04	6.54	13.1	2.5	38.2
2/25/03	1015	14.9	15	71	9.52	0.03	6.25	12.2	2.5	38.3
3/19/03	1040	22.1	30	66	9.03	0.03	6.75	16.7	2.7	32.9
4/9/03	1020	18.3	15	63	9.08	0.03	6.54	24.3	3.1	30.9
5/19/03	1020	23	27	56	8.24	0.03	6.43			107.7
6/9/03	1030	28.2	32	57	8.03	0.03	6.59	17.3	2.6	25.5
7/22/03	1115	25.6	32	41	8.81	0.02	7			53.8
8/20/03	1035	29.5	33	84	9.47	0.04	7.34	17.1	2.7	3.4
9/8/03	1035	27.2	27	86	7.45	0.04	7.44	12.8	2.7	4.1
10/16/03	1150	22.2	25	78	8.6	0.04	7.4	11.1	2.6	3.9
11/18/03	1105	20.7	25	84	9.27	0.04	6.95	11.8	2.7	2
12/15/03	1050	10.8	11	73	12.63	0.03	7.3	13.7	2.6	5.2

TMC 6 30^0 42.251', 88^0 10.553'

Date	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Flow cfs	Depth feet	Turbidity ntu
1/8/03	1220	10.7	12	64	6.94	0.03	5.56			2.8
2/25/03	1100	14.1	15	64	7.18	0.03	6.25			1.5
3/19/03	1130	20.3	30	71	7.21	0.03	5.87	0.3	0.8	2.6
4/9/03	1100	16	16	69	6.16	0.03	5.78			2.3
5/19/03	1045	21.9	27	62	6.84	0.03	5.74			3.6
6/9/03	1110	23.6	32	68	6.33	0.03	5.75	0.3	0.4	1.6
7/22/03	1130	23.8	34	69	8.32	0.03	6.48	1.3	0.6	19.3
8/20/03	1120	24.8	33	44	7.73	0.02	6.4	1.1	0.5	0.3
9/8/03	1110	23	28	63	6.44	0.03	6.89			1.3
10/16/03	1215	17.5	25	64	7.2	0.03	6.7			0.9
11/18/03	1015	20.8	25	68	6.49	0.03	6.35			1.2
12/15/2003/FD	1140	10	10	60/63	10.23/10.11	0.03/0.03	7.14/7.13			3.1/2.9

TMC 7 30^0 42.115', 88^0 11.450'

Date	Time	H20 Temp. 0C	Air Temp. 0C	Sp. Cond. uS/cm	D.O. ppm	Salinity ppt	pH s.u.	Flow cfs	Depth feet	Turbidity ntu
1/8/03	1245	14.4	16	97	10.17	0.05	5.97	2.6	0.8	9.4
2/25/03	1130	15.9	17	82	8.8	0.04	6	1.6	0.7	7.3
3/19/03	1215	22.3	32	86	8.49	0.04	5.87	1.2	0.6	5.6
4/9/03	1125	15.9	15	64	6.57	0.03	5.74	1.1	0.5	13
5/19/03	1120	22.6	28	77	7.36	0.03	5.09	1.1	0.6	29.3
6/9/03	1140	23.3	32	82	7.57	0.04	5.02	1.1	0.5	16.2
7/22/03	1225	24.2	34	88	7.88	0.04	6.44	2.6	0.7	25.6
8/20/03	1155	23	34	83	9.63	0.04	6.59	1.3	0.5	3.4
9/8/03	1135	22.4	30	73	6.73	0.03	6.63	1.7	0.6	4.7
10/16/03	1235	20	26	73	7.9	0.03	6.6	1.3	0.4	3
11/18/03	930	20.9	26	76	7.13	0.03	6.21	1.1	0.4	3.7
12/15/03	1210	14.1	14	67	9.12	0.03	6.64	0.4	0.3	2.4

FLOW MEASUREMENTS IN CUBIC FEET PER SECOND

DATE	BMC 5	BMC 6	BMC 7	FC 3	FC 4	FC 5	FC 6	FC 7	TMC 4	TMC 5	TMC 6	TMC 7
1/7/03									18.1	13.1		2.6
1/8/03				19.0	10.5	9.4	12.1					
1/9/03	19.0	17.3	37.2									
2/4/03	19.6	25.8	34.6									
2/25/03									17.6	12.2		1.6
2/26/03				18.2	26.1	9.8	12.7	11.5				
3/18/03	55.4	33.1	75.4									
3/19/03									26.3	16.7	0.3	1.2
3/27/03	22.7	22.5	48.8									
4/9/03									38.0	24.3		1.1
4/10/03					11.0	11.5	10.1	11.6				
4/14/03	14.2	17.4	29.5									
5/13/03	11.7	13.4	33.2									
5/19/03									57.8			1.1
5/20/03							18.4	14.8				
6/9/03									30.9	17.3	0.3	1.1
6/11/03								9.0				
6/24/03			110.9									
7/22/03									68.0		1.5	2.6
7/24/03					57.5	52.6	44.4	11.0				
8/19/03							13.3	13.1				
8/20/03									26.4	17.1	1.1	1.3
9/8/03									17.9	12.8		1.7
9/10/03							10.4	11.4				
9/16/03	28.1	24.2	53.5									
10/16/03									16.1	11.1		1.3
10/23/03	15.4	19.8	36.6									
10/29/03					10.8	19.2	11.6	12.2				
11/18/03									11.7	11.8		1.1
11/19/03							16.8	11.2				
11/25/03	18.0	16.7	38.5									
12/4/03		36.8	46.5									
12/15/03									17.7	13.7		0.4
12/16/03					10.5	12.6	11.2	11.2				
12/18/03	21.9	22.8	42.9									

Laboratory Analyses

BMC 1

30^0 41.994'

87^0 54.507'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm	Ortho-P ppm
1/9/03	1335	< 2	< 5.0	36	0.01	0.3	0.013	0.018	0.005
2/4/03	925	32	< 5.0	53	0.04	0.59	0.067	0.02	< 0.005
2/27/03	1105	120	< 5.0	36	< 0.01	0.41	0.041	< 0.005	0.015
Field Duplicate	1105	90	< 5.0	37	0.01	0.54	0.042	0.016	< 0.005
3/18/03	1120	52	< 5.0	39	0.01	0.45	0.036	0.062	0.005
3/27/03	1215	10	8	55	0.02	0.69	0.026	0.033	0.008
4/14/03	945	14	5	47	0.02	0.47	0.018	0.033	< 0.005
4/29/03	1130	20	< 5.0	55	0.02	0.71	0.029	0.039	
5/13/03	1210	12	5	58	0.05	0.88	0.013	0.039	0.007
5/21/03	1115	640	10	55	0.07	0.66	0.039	0.039	< 0.005
6/24/03	1140	180	9	50	0.01	0.47	0.036	0.015	< 0.005
7/28/03	1005	560	6	52	0.03	0.46	0.017	0.007	0.033
8/21/03	1110	91	9	107	0.02	0.59	0.028	0.007	0.022
9/16/03	930	91	6	81	< 0.01	0.55	0.032	0.043	0.009
10/23/03	1245	10	< 5.0	564	< 0.01	2.10	0.052	0.022	0.016
11/25/03	1210	170	8	120	< 0.01	0.49	0.095	0.04	0.04
12/4/03	1220	140	8	71	< 0.01	0.83	0.061	0.046	0.02
12/18/03	1150	95	9	46	0.01	0.66	0.058	0.027	

BMC 2

30^0 42.901'

87^0 53.048'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm	Ortho-P ppm
1/9/03	1320	8	< 5.0	28	0.01	0.27	0.058	0.015	< 0.005
2/4/03	955	42	< 5.0	26	0.04	0.37	0.078	0.01	< 0.005
2/27/03	1135	210	< 5.0	30	0.01	0.44	0.057	0.01	< 0.005
3/18/03	1140	120	< 5.0	37	0.01	0.37	0.043	0.025	0.005
3/27/03	1245	24	< 5.0	41	< 0.01	0.56	0.02	0.014	< 0.005
4/14/03	1010	8	< 5.0	38	0.01	0.43	0.017	0.021	< 0.005
4/29/03	1145	24	< 5.0	42	0.01	0.54	0.031	0.027	
5/13/03	1235	4	< 5.0	49	0.06	1.1	0.02	0.034	0.009
5/21/03	1145	1200	10	49	0.06	0.7	0.03	0.033	< 0.005
6/24/03	1200	520	11	48	0.02	0.44	0.057	0.005	0.017
7/28/03	1030	3000	9	43	0.09	0.43	0.028	0.007	0.025
8/21/03	1130	280	9	106	0.02	0.47	0.057	0.009	0.014
9/16/03	955	1800	10	56	0.02	0.53	0.103	0.041	0.007
10/23/03	1300	18	< 5.0	74	< 0.01	0.51	0.04	0.019	0.048
11/25/03	1230	98	6	30	< 0.01	0.41	0.14	0.028	0.05
12/4/03	1240	40	< 5.0	26	< 0.01	0.54	0.061	< 0.005	0.02
12/18/03	1205	34	< 5.0	30	< 0.01	0.23	0.048	0.021	

BMC 3

30^0 43.356'

87^0 52.514'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm	Ortho-P ppm
1/9/03	1305	10	< 5.0	26	< 0.01	0.3	0.065	0.015	< 0.005
2/4/03	1015	38	< 5.0	29	0.4	0.4	0.073	0.009	< 0.005
2/27/03	1200	520	< 5.0	33	0.01	0.53	0.044	0.011	< 0.005
3/18/03	1150	240	< 5.0	34	0.01	0.41	0.039	0.011	0.005
3/27/03	1315	20	< 5.0	36	0.02	0.49	0.026	0.013	0.005
4/14/03	1035	20	< 5.0	31	0.01	0.35	0.03	0.017	< 0.005
4/29/03	1155	30	< 5.0	45	0.01	0.63	0.026	0.021	
5/13/03	1250	8	< 5.0	41	0.05	0.86	0.018	0.031	0.006
Field Duplicate		<2	< 5.0	51	0.04	0.75	0.017	0.029	0.007
5/21/03	1205	1900	9	55	0.05	0.56	0.027	0.033	0.005
6/24/03	1215	1100	10	45	0.01	0.44	0.045	0.021	< 0.005
7/28/03	1055	300	6	37	0.03	0.46	0.03	0.007	0.01
8/28/03	1155	3000	10	101	0.02	0.5	0.07	0.01	
9/16/03	1050	760	5	45	0.02	0.56	0.027	0.03	0.007
10/23/03	1315	16	< 5.0	42	< 0.01	0.54	0.032	0.016	0.046
11/25/03	1250	48	< 5.0	14	< 0.01	0.33	0.061	0.026	0.04
12/4/03	1255	54	< 5.0	30	< 0.01	0.46	0.064	0.023	0.021
12/18/03	1220	14	< 5.0	24	0.01	0.17	0.058	0.016	

BMC 4
30^0 44.186'
87^0 52.527'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm	Ortho-P ppm
1/9/03	1235	30	< 5.0	27	0.01	0.25	0.069	0.014	< 0.005
2/4/03	1045	18	< 5.0	20	0.04	0.51	0.082	0.009	< 0.005
2/27/03	1235	700	9	34	0.01	0.59	0.032	0.015	0.014
3/18/03	1215	98	< 5.0	33	< 0.01	0.31	0.036	0.011	0.005
3/27/03	1335	14	< 5.0	35	0.01	0.29	0.053	0.01	< 0.005
4/14/03	1105	88	< 5.0	30	0.01	0.37	0.042	0.015	< 0.005
4/29/03	1235	24	< 5.0	36	0.01	0.43	0.059	0.019	
5/13/03	1330	190	< 5.0	34	0.03	0.79	0.05	0.027	0.005
5/21/03	1230	1200	10	49	0.06	0.65	0.025	0.032	0.005
6/24/03	1235	740	12	51	0.01	0.53	0.033	0.029	< 0.005
7/28/03	1115	560	13	38	0.03	0.5	0.029	0.017	0.008
8/21/03	1225	> 3000	41	45	0.02	0.78	0.087	0.031	0.78
9/16/03	1030	240	< 5.0	38	< 0.01	0.36	0.029	0.019	0.006
10/23/03	1345	39	< 5.0	38	< 0.01	0.36	0.089	0.012	0.026
11/25/03	1325	56	< 5.0	30	< 0.01	0.32	0.06	0.026	0.059
12/4/03	1315	560	9	34	< 0.01	0.61	0.062	0.028	0.03
12/18/03	1240	30	< 5.0	23	0.02	0.22	0.072	0.015	

BMC 5

30^0 46.623'

87^0 52.310'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm	Ortho-P ppm
1/9/03	1110	30	< 5.0	28	0.01	0.019	0.019	0.013	< 0.005
2/4/03	1210	34	< 5.0	23	0.04	0.36	0.02	0.009	< 0.005
2/27/03	1025	270	< 5.0	25	0.01	0.56	0.014	0.011	< 0.005
3/18/03	1025	86	< 5.0	31	< 0.01	0.55	0.018	0.009	0.005
3/27/03	1120	24	< 5.0	38	< 0.01	0.38	< 0.005	0.011	< 0.005
4/8/03	1045	360	6	26	0.02	0.34	0.008	0.015	< 0.005
4/29/03	1050	52	< 5.0	43	0.01	0.58	0.01	0.021	
5/13/03	1120	58	6	40	0.05	0.63	0.015	0.03	0.007
5/21/03	1035	210	< 5.0	40	0.04	0.47	0.011	0.021	0.005
6/24/03	1055	740	10	49	< 0.01	0.48	0.024	0.024	< 0.005
7/23/03	1105	1200	9	45	0.06	0.61	0.016	0.048	0.008
8/21/03	1040	> 3000	11	45	0.01	0.77	0.073	0.042	0.009
9/16/03	1130	160	< 5.0	36	< 0.01	0.49	< 0.005	0.017	0.006
10/23/03	1145	46	< 5.0	41	< 0.01	0.43	0.032	0.01	0.038
11/25/03	1110	36	< 5.0	274	< 0.01	0.41	0.012	0.027	0.051
12/4/03	1110	75	< 5.0	23	< 0.01	0.48	0.027	0.021	0.023
12/18/03	1100	8	< 5.0	24	0.02	0.17	0.029	0.014	

BMC 6
30^0 48.824'
87^0 50.319'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm	Ortho-P ppm
1/9/03	1025	34	< 5.0	27	0.01	0.33	0.039	0.014	< 0.005
2/4/03	1255	10	< 5.0	25	0.04	0.29	0.043	0.009	< 0.005
2/27/03	1000	700	< 5.0	37	< 0.005	0.68	0.029	0.022	0.007
3/18/03	945	54	< 5.0	34	< 0.01	0.32	0.03	0.012	0.005
3/27/03	1040	52	< 5.0	39	< 0.01	0.37	0.014	0.01	< 0.005
4/8/03	1020	300	5	28	0.02	0.33	0.018	0.017	0.005
4/29/03	1025	24	< 5.0	1	0.01	0.53	0.026	0.019	
5/13/03	1025	36	< 5.0	37	0.04	0.54	0.021	0.022	0.006
5/21/03	1010	5100	7	44	0.06	0.79	0.037	0.055	0.007
6/24/03	1030	120	< 5.0	39	0.02	0.45	0.033	0.019	< 0.005
7/23/03	1030	3400	37	37	0.07	0.68	0.042	0.065	0.007
8/21/03	1010	> 3000	9	44	0.01	0.59	0.073	0.04	0.007
9/16/03	1225	100	< 5.0	40	0.01	0.41	0.04	0.021	0.007
10/23/03	1055	100	< 5.0	38	< 0.01	0.36	0.053	0.009	0.035
11/25/03	1025	38	< 5.0	29	< 0.01	0.4	0.032	0.027	0.055
12/4/03	1020	110	< 5.0	28	< 0.01	0.65	0.049	0.021	0.024
12/18/03	1015	80	< 5.0	26	< 0.01	0.19	0.06	0.015	

BMC 7

30^0 46.599'

87^0 49.524'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm	Ortho-P ppm
1/9/03	945	78	< 5.0	23	0.01	0.26	0.133	0.013	< 0.005
2/4/03	1340	120	< 5.0	24	0.05	0.6	0.12	0.008	< 0.005
2/27/03	935	900	7	41	0.02	0.62	0.042	0.023	< 0.005
3/18/03	910	100	< 5.0	30	0.01	0.3	0.098	0.011	< 0.005
3/27/03	945	78	< 5.0	27	0.01	0.53	0.093	0.009	0.005
4/8/03	940	700	24	31	0.03	0.41	0.055	0.025	0.005
4/29/03	950	260	< 5.0	32	0.01	0.41	0.095	0.017	
5/13/03	930	50	< 5.0	28	0.03	0.66	0.089	0.019	< 0.005
5/21/03	940	1100	11	79	0.09	0.77	0.046	0.05	0.007
6/24/03	945	280	11	36	0.02	0.37	0.079	0.01	< 0.005
7/23/03	950	800	27	51	0.08	0.64	0.058	0.048	0.006
8/21/03	945	> 3000	20	62	0.01	0.59	0.082	0.034	0.01
9/16/03	1315	360	5	35	< 0.01	0.35	0.045	0.019	0.007
10/23/03	1010	33	< 5.0	32	< 0.01	0.34	0.132	0.013	0.048
11/25/03	925	96	< 5.0	25	< 0.01	0.29	0.115	0.028	0.045
12/4/03	945	500	8	32	< 0.01	0.08	0.083	0.023	0.031
12/18/03	915	52	5	26	0.01	0.19	0.119	0.015	

FC 1 30^0 32.659', 87^0 53.991'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/8/03	1345	50	< 5.0	93	0.05	0.11	1.29	0.023
2/26/03	945	140	6	479	0.06	0.78	0.966	0.057
3/20/03	950	170	< 5.0	135	0.05	0.71	0.31	0.04
4/10/03	1245	140	< 5.0	71	0.06	0.45	0.928	0.035
5/20/03	925	> 3000	6	64	0.15	1.10	0.593	0.121
6/11/03	940	120	12	268	0.04	0.78	0.294	0.08
7/24/03	955	940	9	38	0.07	0.80	0.237	0.109
8/19/03	1005	380	< 5.0	97	0.01	0.45	0.885	0.024
9/10/03	945	290	5	2200	0.06	0.34	0.95	0.019
10/29/03	905	160	< 5.0	2410	0.04	0.32	0.974	0.023
11/19/03	940	> 3000	6	2650	0.01	0.57	0.823	0.042
12/16/03	935	76	5	2730	0.08	0.30		0.022

FC 2 30^0 32.170', 87^0 53.905'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/8/03	1330	56	< 5.0	52	0.05	0.16	1.31	0.019
2/26/03	955	140	< 5.0	82	0.04	0.38	1.04	0.027
3/20/03	1000	150	< 5.0	66	0.04	0.27	0.342	0.028
4/10/03	1020	64	< 5.0	57	0.06	0.31	1	0.021
5/20/03	940	> 3000	< 5.0	56	0.13	0.89	0.622	0.124
6/11/03	950	80	10	305	0.05	0.64	0.393	0.06
7/24/03	1015	780	10	50	0.07	0.64	0.239	0.084
8/19/03	1015	720	< 5.0	45	0.01	0.33	0.883	0.027
9/10/03	1000	230	< 5.0	604	0.03	0.27	1.13	0.016
10/29/03	915	150	< 5.0	2650	0.05	0.39	0.962	0.021
11/19/03	955	> 3000	5	2010	< 0.01	0.59	0.929	0.04
12/16/03	950	80		2570	0.1	0.2	1	0.023

FC 3 30^0 32.980', 87^0 53.928'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/8/03	1300	46	< 5.0	47	0.04	0.23	1.35	0.018
2/26/03	1010	120	< 5.0	49	0.02	0.27	1.04	0.017
3/20/03	1015	140	< 5.0	46	0.03	0.32	0.834	0.031
4/10/03	1030	76	< 5.0	51	0.05	0.23	1.04	0.015
5/20/03	1145	540	< 5.0	48	0.12	0.78	0.717	0.089
6/11/03	1005	360	5	162	0.06	0.33	1.04	0.019
7/24/03	1045	430	8	45	0.07	0.66	0.27	0.074
8/19/03	1035	120	< 5.0	38	0.01	0.2	1.12	0.013
9/10/03	1020	130	< 5.0	916	0.04	0.31	1.02	0.019
10/29/03	935	95	< 5.0	374	0.02	0.28	1.29	0.009
11/19/03	1010	2000	< 5.0	228	< 0.01	0.48	1	0.032
12/16/03	1005	84	< 5.0	47	0.04	0.13	1.33	0.014

FC 4 30^0 33.052', 87^0 53.937'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/8/03	1245	34	< 5.0	47	0.05	0.11	1.34	0.016
2/26/03	1055	110	< 5.0	38	0.02	0.37	1.07	0.02
Field Duplicate		84	< 5.0	37	0.02	0.26	1.41	0.018
3/20/03	1035	100	< 5.0	48	0.03	0.21	0.693	0.019
4/10/03	1045	42	< 5.0	49	0.04	0.26	1.03	0.016
5/20/03	1005	640	< 5.0	48	0.18	0.6	0.711	0.089
Field Duplicate		840	< 5.0	57	0.12	0.7	0.723	0.089
6/11/03	1015	220	< 5.0	146	0.07	0.15	1.31	0.008
7/24/03	1100	260	9	53	0.06	0.62	0.265	0.069
8/19/03	1045	80	< 5.0	42	0.02	0.23	1.1	0.012
9/10/03	1030	140	< 5.0	48	0.01	0.18	1.13	0.014
10/29/03	945	56	< 5.0	120	0.02	0.19	1.26	0.011
11/19/03	1020	1300	< 5.0	69	< 0.01	0.28	0.986	0.03
12/16/03	1020	44	< 5.0	44	0.03	0.11	1.31	0.014

FC 5 30^0 33.118', 87^0 53.868'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/8/03	1155	36	< 5.0	42	0.04	< 0.1	1.4	0.016
2/26/03	1135	76	5	39	0.02	0.34	1.07	0.015
3/20/03	1050	120	< 5.0	47	0.01	0.21	0.356	0.02
4/10/03	1105	38	< 5.0	48	0.05	0.27	1.04	0.019
5/20/03	1025	560	< 5.0	46	0.1	0.8	0.106	0.083
6/11/03	1025	120	6	86	0.07	0.16	1.3	0.01
7/24/03	1130	350	8	49	0.06	0.6	0.235	0.087
8/19/03	1055	90	< 5.0	45	0.02	< 0.1	1.11	0.007
9/10/03	1040	120	< 5.0	50	0.02	0.2	1.08	0.015
10/29/03	1015	87	< 5.0	76	0.02	0.23	1.32	0.012
11/19/03	1030	1100	< 5.0	56	< 0.01	0.31	0.98	0.03
12/16/03	1105	78	< 5.0	44	0.03	0.15	1.32	0.014

FC 6 30^0 33.144', 87^0 53.822'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/8/03	1140	68	< 5.0	40	0.05	0.14	1.37	0.017
2/26/03	1205	260	22	41	0.03	0.47	1.04	0.026
3/20/03	1110	93	< 5.0	46	0.03	0.27	0.959	0.019
4/10/03	1125	120	< 5.0	47	0.05	0.32	1.04	0.017
5/20/03	1040	640	< 5.0	45	0.12	0.62	0.736	0.087
6/11/03	1045	140	5	92	0.06	0.14	1.3	0.011
7/24/03	1155	240	5	50	0.06	0.78	0.227	0.075
8/19/03	1115	80	< 5.0	43	0.02	0.13	1.17	0.017
9/10/03	1055	70	< 5.0	48	0.01	0.17	1.1	0.015
10/29/03	1045	92	< 5.0	39	0.02	0.22	0.843	0.019
11/19/03	1050	1000	< 5.0	45	< 0.01	0.31	0.972	0.03
12/16/03	1130	50	< 5.0	44	0.03	0.15	1.32	0.014

FC 7 30^0 33.183', 87^0 53.718'

Date dd/mm/yy	Time	F. Coli. colonies/100mL	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/8/03	1120	86	< 5.0	37	< 0.01	< 0.1	1.76	0.016
2/26/03	1235	130	5	37	0.03	0.4	1.03	0.017
3/20/03	1125	64	< 5.0	47	0.03	0.34	0.828	0.022
4/10/03	1205	130	< 5.0	46	0.04	0.32	1.05	0.018
5/20/03	1105	480	< 5.0	57	0.12	0.65	0.192	0.082
6/11/03	1120	74	< 5.0	107	0.06	0.09	1.29	0.012
7/24/03	1220	480	< 5.0	50	0.07	0.8	0.208	0.079
8/19/03	1130	350	< 5.0	47	0.02	< 0.1	1.18	0.007
9/10/03	1125	74	< 5.0	62	0.01	0.18	1.08	0.013
10/29/03	1120	100	< 5.0	42	0.09	0.23	1.3	0.02
11/19/03	1135	970	< 5.0	41	< 0.01	0.35	0.97	0.028
12/16/03	1200	32	< 5.0	40	0.04	0.43	1.5	0.015

TMC 2 30^0 42.192', 88^0 04.340'

Date	Time	F. Coli. colonies/100ml	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/7/03	930	140	< 5.0	94	0.13	1.6	0.524	0.036
2/25/03	855	780	< 5.0	124	0.11	0.57	0.376	0.046
3/19/03	855	680	6	91	0.12	0.74	0.301	0.082
4/9/03	900	720	< 5.0	84	0.2	0.82	0.246	0.065
5/19/03	905	> 3000	15	99	0.3	1.30	0.422	0.133
6/9/03	925	440	20	85	0.06	0.75	0.275	0.062
7/22/03	950	> 3000	5	80	0.11	0.68	0.172	0.096
8/20/03	900	> 3000	5	99	0.02	0.52	0.217	0.049
9/8/03	905	2200	< 5.0	87	0.04	0.43	0.213	0.039
10/16/03	955	500	< 5.0	134	< 0.01	0.31	0.516	0.017
11/18/03	1240	> 3000	5	1240	< 0.01	0.66	0.368	0.08
12/15/03	910	130	< 5.0	83	0.06	0.53		0.053

TMC 3 30^0 41.838', 88^0 05.672'

Date	Time	F. Coli. colonies/100ml	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/7/03	1010	52	< 5.0	91	0.09	0.43	0.538	< 0.005
2/25/03	915	82	< 5.0	102	0.05	0.52	0.38	0.03
3/19/03	930	150	< 5.0	86	0.05	0.5	0.321	0.032
4/9/03	920	640	< 5.0	67	0.09	0.63	0.246	0.035
5/19/03	925	> 3000	14	76	0.21	1.2	0.481	0.088
Field Duplicate		> 3000	12	85	0.21	1.3	0.476	0.087
6/9/03	945	360	6	83	0.1	0.69	0.334	0.029
7/22/03	1015	2600	6	69	0.09	0.65	0.221	0.095
8/20/03	925	140	< 5.0	78	< 0.01	0.43	0.161	0.02
9/8/03	935	210	< 5.0	74	0.03	0.36	0.22	0.022
10/16/03	1025	50	< 5.0	63	< 0.01	0.53	0.199	0.01
11/18/03	1220	> 3000	< 5.0	65	< 0.01	0.6	0.204	0.052
12/15/03	935	140	< 5.0	64	0.05	0.42		0.019

TMC 4 30^0 42.867', 88^0 07.037'

Date	Time	F. Coli. colonies/100ml	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/7/03	1030	80	< 5.0	82	0.1	0.52	0.569	< 0.005
2/25/03	940	140	< 5.0	86	0.08	0.46	0.36	0.03
3/19/03	955	210	< 5.0	72	0.06	0.39	0.368	0.031
4/9/03	940	660	< 5.0	55	0.08	0.51	0.214	0.035
5/19/03	945	> 3000	17	81	0.26	1.1	0.433	0.1
6/9/03	1005	170	< 5.0	63	0.09	0.41	0.319	0.022
7/22/03	1035	> 3000	7	64	0.09	0.6	0.239	0.078
8/20/03	945	170	< 5.0	70	0.03	0.34	0.21	0.008
9/8/03	950	160	< 5.0	69	0.04	0.35	0.222	0.018
10/16/03	1045	82	< 5.0	54	< 0.01	0.34	0.217	0.01
11/18/03	1145	420	< 5.0	52	< 0.01	0.36	0.247	0.019
12/15/03	1000	170	< 5.0	54	0.03	0.31	0.395	0.015

TMC 5 30^0 42.433', 88^0 09.002'

Date	Time	F. Coli. colonies/100ml	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/7/03	1125	30	< 5.0	73	0.11	0.41	0.363	0.043
2/25/03	1020	94	< 5.0	80	0.12	0.66	0.237	0.039
3/19/03	1045	250	< 5.0	65	0.06	0.43	0.206	0.051
4/9/03	1025	1100	6	53	0.08	0.49	0.147	0.041
5/19/03	1025	> 3000	17	82	0.28	1.2	0.328	0.122
6/9/03	1035	120	9	49	0.04	0.43	0.103	0.026
7/22/03	1120	3000	10	68	0.1	0.45	0.184	0.09
8/20/03	1040	34	< 5.0	61	0.08	0.35	0.128	0.014
9/8/03	1040	45	< 5.0	53	0.05	0.3	0.154	0.019
10/16/03	1155	34	5	55	< 0.01	0.34	0.197	0.014
11/18/03	1110	10	< 5.0	51	< 0.01	0.32	0.219	0.019
12/15/03	1055	56	< 5.0	45	0.03	0.31	0.375	0.015

TMC 6 30^0 42.251', 88^0 10.553'

Date	Time	F. Coli. colonies/100ml	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/7/03	1230	70	< 5.0	39	< 0.01	0.25	0.558	0.019
2/25/03	1110	110	< 5.0	62	0.01	0.4	0.314	0.012
ield Duplicate		110	< 5.0	60	0.01	0.38	0.317	0.012
3/19/03	1135	660	< 5.0	46	0.01	0.32	0.318	0.015
4/9/03	1105	620	< 5.0	53	0.05	0.5	0.275	0.024
5/19/03	1050	1400	< 5.0	44	0.09	0.6	0.333	0.027
6/9/03	1115	1200	< 5.0	49	0.08	0.31	0.333	0.011
7/22/03	1135	1800	< 5.0	55	0.05	0.46	0.251	0.017
8/20/03	1125	780	< 5.0	44	0.03	0.3	0.476	< 0.005
9/8/03	1115	680	< 5.0	53	0.03	0.14	0.422	0.012
10/16/03	1220	300	< 5.0	47	< 0.01	0.22	0.491	< 0.005
11/18/03	1020	290	< 5.0	43	< 0.01	0.33	0.451	0.023
12/15/03	1145	280	< 5.0	40	0.01	0.25	0.472	0.012

TMC 7 30^0 42.115', 88^0 11.450'

Date	Time	F. Coli. colonies/100ml	TSS ppm	TDS ppm	NH3 ppm	TKN ppm	Nitrate/Nitrite ppm	Total-P ppm
1/7/03	1250	130	16	54	0.06	0.23	0.613	0.022
2/25/03	1140	170	14	68	0.03	0.24	0.562	0.015
3/19/03	1220	220	< 5	51	0.03	0.24	0.352	0.013
4/9/03	1130	640	23	53	0.09	0.52	0.473	0.036
5/19/03	1125	2600	11	63	0.12	0.67	0.492	0.046
6/9/03	1145	1200	6	53	0.09	0.34	0.555	0.011
7/22/03	1230	> 3000	10	66	0.18	0.65	0.337	0.049
8/20/03	1200	210	< 5	55	0.05	0.17	0.768	0.005
9/8/03	1140	520	5	58	0.04	0.22	0.604	0.016
10/16/03	1240	210	< 5	50	< 0.01	0.15	0.705	0.012
11/18/03	935	560	6	42	0.03	0.42	0.721	0.029
12/15/03	1215	100	< 5	44	0.14	0.43	0.678	0.024

TM-1 Trends Station Data

TMC 1 (TM-1) TREND STATION 30^0 43.450', 88^0 03.540'

DATE	TIME	Air ^0C	H_2O ^0C	pH s.u.	Conductivity umho@ 25^0C	Turbidity NTU	D.O. mg/L	Salinity ppt
January 15, 2003	11:00	9	11	6.6	457	7.7	8.7	0.2
February 12, 2003	9:45	15	14	6.5	933	5.7	8.8	0.5
March 24, 2003	10:05	25	20	6.9	572	8.7	5.6	0.3
April 3, 2003	9:30	23	20	6.8	572	5.5	6.8	0.3
May 28, 2003	10:20	28	25	6.8	374	16.1	4.8	0.2
June 23, 2003	10:05	32	28	6.7	405	30.4	4.6	0.2
July 29, 2003	10:15	34	29	6.8	1188	7.9	5	0.6
August 12, 2003	10:05	26	29	6.9	1151	21.6	4.4	0.6
September 25, 2003	10:30	28	28	7.1	5133	8.9	4.7	2.8
October 9, 2003	10:25	25	25	6.8	3657	2.8	4	1.9
November 4, 2003	10:20	26	23	7.2	6908	4.3	6.5	3.7
December 11, 2003	9:50		13	6.9	700	4	7.5	0.3

DATE	TIME	TDS mg/L	TSS mg/L	NH3-N mg/L	NO3-N mg/L	TKN mg/L	PO4-P mg/L	F. Coli col/100 ml
January 15, 2003	11:00	215	5	0.6	2.92	1.4	0.356	2500
February 12, 2003	9:45	448	<5	0.6	3.8	2	0.534	210
March 24, 2003	10:05	273	7	0.42	3.28	1.2	0.388	>3000
April 3, 2003	9:30	307	7	0.48	5.78	2.3	0.779	52
May 28, 2003	10:20	155	13	0.28	1.43	1.3	0.332	1200
June 23, 2003	10:05	109	10	0.26	1.38	1.1	0.247	960
July 29, 2003	10:15	819	7	0.16	0.834	0.71	0.18	290
August 12, 2003	10:05	714	13	0.21	1.22	1.3	0.092	140
September 25, 2003	10:30	3390	10	0.09	0.601	0.66	0.141	280
October 9, 2003	10:25	2180	<5	0.18	4.35	1.3	0.743	270
November 4, 2003	10:20	2370	<5	0.05	2.56	2.2	0.359	170
December 11, 2003	9:50	373	<5	0.12	2.54	0.92	0.364	800

Sediment Metals

TMC 1 (TM-1) Sediment Metals Concentrations

Date	Ag mg/kg	As mg/kg	Cd mg/kg	Cr^{t} mg/kg	Cu mg/kg	Fe mg/kg	Hg mg/kg	Mn mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
12-Aug-98		27	0.71	74	78	30000		180	26	50	310
20-Oct-99		7.04	0.85	63	85	22700	0.386	232	18	77	365
28-Jun-00	5.95	7.27	1.54	36	120	23000	1.7	160	19	102	530
3-Oct-01	0.24	<1	0.1	6.3	7.9	2600	0.072	25	1.6	11	40
17-Oct-02	2.4	5.5	0.7	37	55	12000	0.78	120	14	74	270
9-Oct-03	3.9	35	1.7	62	110	34000	0.74	180	22	140	470

BMC, FC, and TMC Sediment Metals Concentrations

3/27/03	Al ug/g	Sb ug/g	As ug/g	Cd ug/g	Cr ug/g	Cu ug/g	Fe ug/g	Pb ug/g	Mn ug/g	Ni ug/g	Se ug/g
BMC 1	20000	< 0.75	1.4	0.09	14	3.9	8900	8.8	80	8.6	< 0.75
BMC 2	9200	< 0.75	< 0.5	0.03	5.2	1	2800	2.9	22	5.9	< 0.75
BMC 3	66000	< 0.75	1.8	0.11	24	4.9	14000	8.6	55	7	< 0.75
BMC 4	8200	< 0.75	< 0.5	< 0.025	1.3	< 0.5	290	< 1.0	3	8	< 0.75
BMC 5	5300	< 0.75	< 0.5	< 0.025	1.9	< 0.5	390	1.1	5	4.1	< 0.75
BMC 6	840	< 0.75	< 0.5	< 0.025	1.9	< 0.5	860	1.4	11	< 1.0	< 0.75
BMC 7	2700	< 0.75	< 0.5	< 0.025	1.8	< 0.5	430	< 0.5	4.1	1.9	< 0.75

	Ag ug/g	Sn ug/g	Zn ug/g	Hg ug/g
BMC 1	< 0.075	1.5	21	0.09
BMC 2	< 0.075	< 0.75	6.2	< 0.05
BMC 3	< 0.075	2.4	30	0.11
BMC 4	< 0.075	< 0.75	2.3	< 0.05
BMC 5	< 0.075	< 0.75	2.9	< 0.05
BMC 6	< 0.075	< 0.75	2	< 0.05
BMC 7	< 0.075	< 0.75	1.7	< 0.05

BMC, FC, and TMC Sediment Metals Concentrations (continued)

3/20/03	Al ug/g	Sb ug/g	As ug/g	Cd ug/g	Cr ug/g	Cu ug/g	Fe ug/g	Pb ug/g	Mn ug/g	Ni ug/g	Se ug/g
FC 3	6800	< 0.75	1.6	< 0.025	10	< 0.5	3800	5.1	150	3.4	< 0.75
FC 4	9900	< 0.75	1.7	0.03	< 0.5	< 0.5	5300	6.3	140	4	< 0.75
FC 5	8100	< 0.75	< 0.5	< 0.025	2.4	< 0.5	1600	1.2	19	9.4	< 0.75
FC 6	5700	< 0.75	< 0.5	< 0.025	4.4	< 0.5	1300	2	27	5.3	< 0.75
FC 7	6300	< 0.75	< 0.5	< 0.025	3.8	2	1100	1	10	5.2	< 0.75

	Ag ug/g	Sn ug/g	Zn ug/g	Hg ug/g
FC 3	< 0.075	0.9	8	0.05
FC 4	< 0.075	1.4	12	0.06
FC 5	< 0.075	< 0.75	1.5	< 0.05
FC 6	< 0.075	< 0.75	4	< 0.05
FC 7	< 0.075	< 0.75	2.2	< 0.05

3/19/03	Al ug/g	Sb ug/g	As ug/g	Cd ug/g	Cr ug/g	Cu ug/g	Fe ug/g	Pb ug/g	Mn ug/g	Ni ug/g	Se ug/g
TMC 1			11.7	0.8	43.26	69.18	18060	63			
TMC 4	5400	< 0.75	< 0.5	< 0.025	3	< 0.5	630	1.4	15	4.8	< 0.75
TMC 5	4400	< 0.75	1	< 0.025	7.1	< 0.5	2100	4.3	36	3.6	< 0.75
TMC 6	1600	< 0.75	< 0.5	< 0.025	3.5	< 0.5	770	3.2	8	2.3	< 0.75
TMC 7	6000	< 0.75	< 0.5	< 0.025	8.3	< 0.5	2800	4	30	3.6	< 0.75

	Ag ug/g	Sn ug/g	Zn ug/g	Hg ug/g
TMC 1	2.9			
TMC 4	< 0.075	< 0.75	5	< 0.05
TMC 5	< 0.075	1.9	6	< 0.05
TMC 6	< 0.075	< 0.75	7	< 0.05
TMC 7	< 0.075	0.8	11	0.05