Water Quality Report For Selected Lakes and Streams

Leon County Public Works

Division of Engineering Services

Prepared Under the Direction of
Johnny Richardson
Water Resource Scientist

October 2010

(Water Quality Data collected through December of 2009)

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

No project such as this can be done alone, so I would like to extend my appreciation to all agencies and individuals that contributed to the creation of this report and allowed the representatives and contractors of Leon County access to the lakes and streams sampled. I would like to thank:

Scott Zengel and staff at PBS&J
David Evans and staff at Water Air and Research
Elva Peppers and staff at Florida Environmental and Land Services, Inc.
Pace Laboratories' staff
Test America laboratory staff
Leon County Public Works Engineering Services staff

For their personal and individual assistance, I would like to thank (in no particular order):

Shannon Gerardi, Thomas Frick, Ken Espy, Julie Espy, Maosen Hu, Elizabeth Miller, and Lori Wolfe.

1. INTRODUCTION

Leon County is laced with miles of lakes, rivers, streams, and springs. These waterbodies are an integral part of the County as well as our world's ecosystem and provide various recreational and esthetic opportunities including: fishing, bird watching, hunting, boating, and swimming. These waterbodies serve as stopping off points for migratory wildfowl as well as providing food and habitat for fish, amphibians, aquatic insects, mammals, and reptiles. Some waterbodies eventually drain into sinks and enter the groundwater, which is a primary source of drinking water for much of the state. And in the case of Lake Talquin they are used for hydro-electric power generation. For these reasons as well as others, it's very important to protect these waterbodies for our physical, mental, and economic health, as well as the health of future generations.

Surface waters are affected by natural events as well as human activities within the drainage area. Natural event examples include drought, flooding, and sinkhole development. Human activities are not limited to the obvious draining of wetlands and stream channelization, but also include large-scale vegetation changes (eg. silviculture), introduction of exotic/invasive plants or animals, pollution, illegal dumping and site development.

The growing awareness and concern for development impacts on local lakes motivated the initial Ecology of the Lakes sampling in 1991. The initial focus on water chemistry within major lakes provided a snapshot of a lake. The monitoring program now includes biological conditions that help reflect long term influences, and stream sampling to identify stream water quality conditions as well as determine loadings to lakes and rivers.

This report helps answer the question of, how healthy are Leon County's lakes, streams, and rivers? The river, stream, and lake ratings that are given for each waterbody in this document are based on water quality and biological results, as well as habitat assessments, land use in the watershed/basin, Total Maximum Daily Load (TMDL) and verified water body listings, fish consumption advisories, algal blooms and best professional judgment from Leon County staff.

Data used in this report has been generated by Leon County or its contractors. Data is being used as reported by contract laboratories or field personnel with any exceptions being noted in the individual waterbody reports. To access the data used in this report please go to the Tallahassee Leon County Wateratlas website (http://www.tlc.wateratlas.usf.edu/) where data generated by the County and its consultants as well as other entities can be downloaded and viewed.

The data collected is used to establish water quality conditions; identify lakes, rivers, and streams with potential water quality problems; and to monitor water quality trends. The data is also used by the Florida Department of Environmental Protection (FDEP) and the United States Environmental Protection Agency (EPA) to determine if a waterbody is considered impaired. As data continues to be collected, Leon County can continue to monitor the effectiveness of current stormwater and growth management practices and can help direct future efforts.

I. Lakes, Streams and Rivers

Leon County currently monitors 13 lakes, 26 streams, and two rivers in Leon County (Figure 1-1 and Table 1-1).

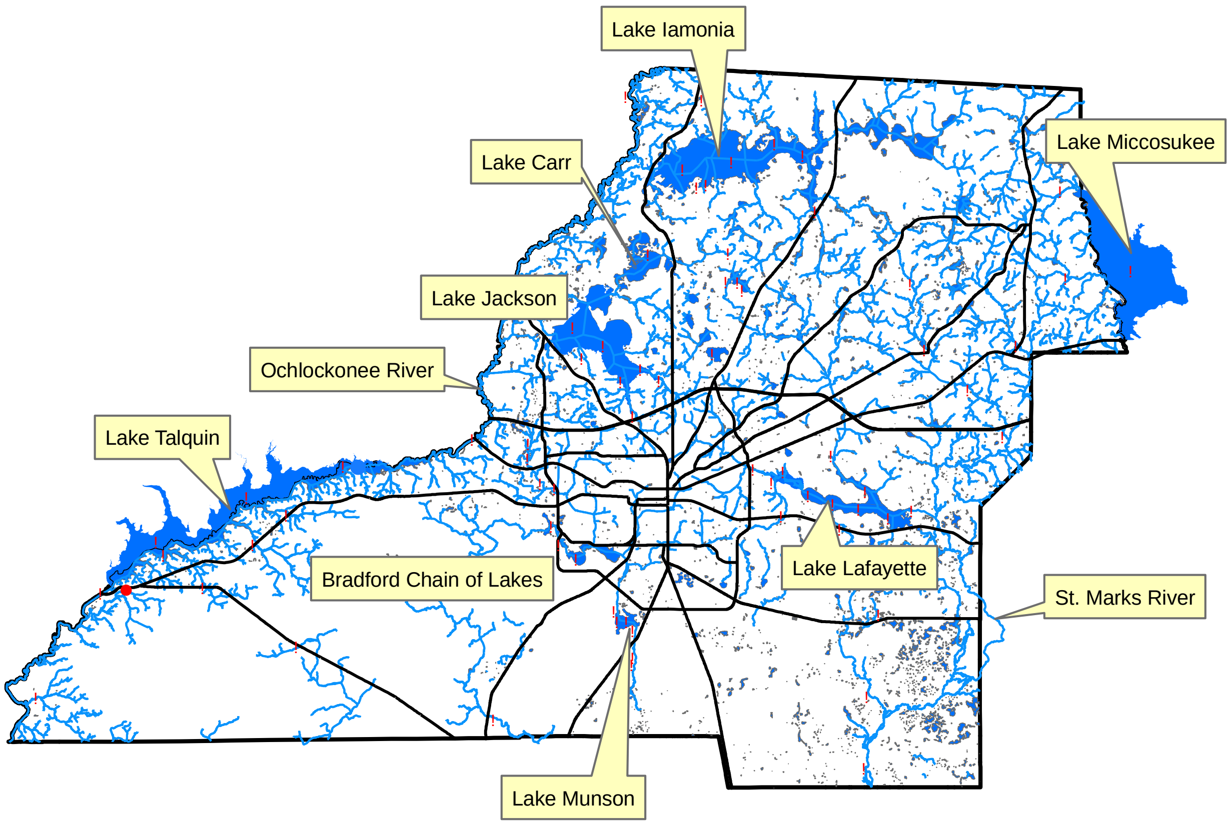


FIG. 1-1. Locations of Leon County water quality sampling stations. Red markers represent current stations.

TABLE 1-1. Leon County waterbodies currently being sampled.

Lakes
Lake Bradford
Lake Carr
Lake Cascade
Lake Hall
Lake Hiawatha
Lake Iamonia
Lake Jackson
Lake Lafayette
Lake McBride
Lake Miccosukee
Lake Munson
Lake Talquin
Lake Weeks

Rivers
Ochlockonee River
St. Marks River

Streams
Alford Arm Tributary
Chicken Branch
Dry Creek
Fisher Creek
Freeman Creek
Gum Creek
Harvey Creek
Jackson Heights Creek
Lafayette Creek
Lexington Tributary
Lost Creek
Meginnis Creek
Munson Slough
Northeast Black Creek
Northeast Drainage Ditch
Panther Creek
Patty Sink Drain
Plantation Tributary
Polk Creek
Soapstone Creek
Summer Creek @ Bannerman Rd
Tall Timbers Creek 1
Unnamed Stream 3 @ Apalachee Parkway
Unnamed Stream 5 @ Apalachee Parkway

Unnamed Stream @ Chaires Road
West Black Creek

2. WATER QUALITY STANDARDS AND CLASSIFICATION OF SURFACE WATERS

The Federal Clean Water Act (CWA) is the cornerstone of surface water quality protection of the United States and requires that surface waters of each state be classified according to designated uses. Florida has six classes with associated designated uses, which are arranged in order of degree of protection required:

Class I – Potable Water Supplies

Class II – Shellfish Propagation or Harvesting

Class III – Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife (majority of surface waters fall under this category)

Class III-Limited – Fish Consumption; Recreation or Limited Recreation; and/or Propagation and Maintenance of a Limited Population of Fish and Wildlife (established June, 2010)

Class IV – Agricultural Water Supplies

Class V – Navigation, Utility and Industrial Use.

The surface waters of the state are Class III unless described differently in rule 62-302.400 F.A.C. All surface waters in Leon County are Class III.

Each class has scientifically established thresholds for contaminants and ecological conditions to assure that public health and aquatic life are protected. These standards are contained in rule 62-302 Florida Administrative Code (F.A.C.). If the designated use of surface water is not being met and maintained, the cause of the water quality degradation ("impairment") must be identified and fixed. The State programs established to identify problems and restore water quality are Total Maximum Daily Loads (TMDLs) and Basin Management Action Planning (BMAP). This document utilizes these standards when discussing waterbody conditions.

3. METHODOLOGIES AND PARAMETERS

Combinations of chemical and biological parameters were used to evaluate the health of these waterbodies since a single indicator is inadequate for proper evaluation. Also note that the direct comparison between different waterbodies of any parameter is usually inappropriate due to the amount and variety of waterbodies monitored and the parameters measured. The evaluation parameters and goals are explained on the following pages.

I. The Concept of Eutrophication, Biological Productivity and Nutrients

For Florida lakes, three interrelated measurements are often used as a starting point to evaluate lake health. These measurements are: the level of eutrophication, biological productivity and the Trophic State Index (TSI).

A. Eutrophication

Natural eutrophication is a gradual process by which lakes age and become more productive as the lake builds up concentrations of plant nutrients. This occurs when production and consumption within the lake become unbalanced and the lake slowly becomes overladen with nutrients. While not rare in nature, natural eutrophication normally takes thousands of years to progress **(Figure 3-1)**.

Cultural (or anthropogenic) eutrophication is caused by human activities accelerating eutrophication by increasing the rate at which nutrients enter the water **(Figure 3-2)**. Increased levels of nutrients cause vascular plants (macrophytes) and algae to speed up their growth. The increased plants and algae increase oxygen output during the day, but utilize oxygen at night. If there are enough plants and algae in the lake, oxygen levels can be decreased to levels that will kill fish and other aquatic animals. As algae and plants die, they are decomposed by bacteria which release a portion of nutrients into the water. These bacteria also utilize oxygen in the water, which depresses oxygen levels in or directly above the sediment. The nocturnal use of oxygen by plants and algae in addition to excessive bacterial decomposition contributes to aquatic animal kills. As part of the decomposition process, plants and algae sink to the bottom of the lake and become part of the sediment. Eventually the lake starts to fill with sediment and in extreme cases will completely disappear **(Figure 3-2)**.

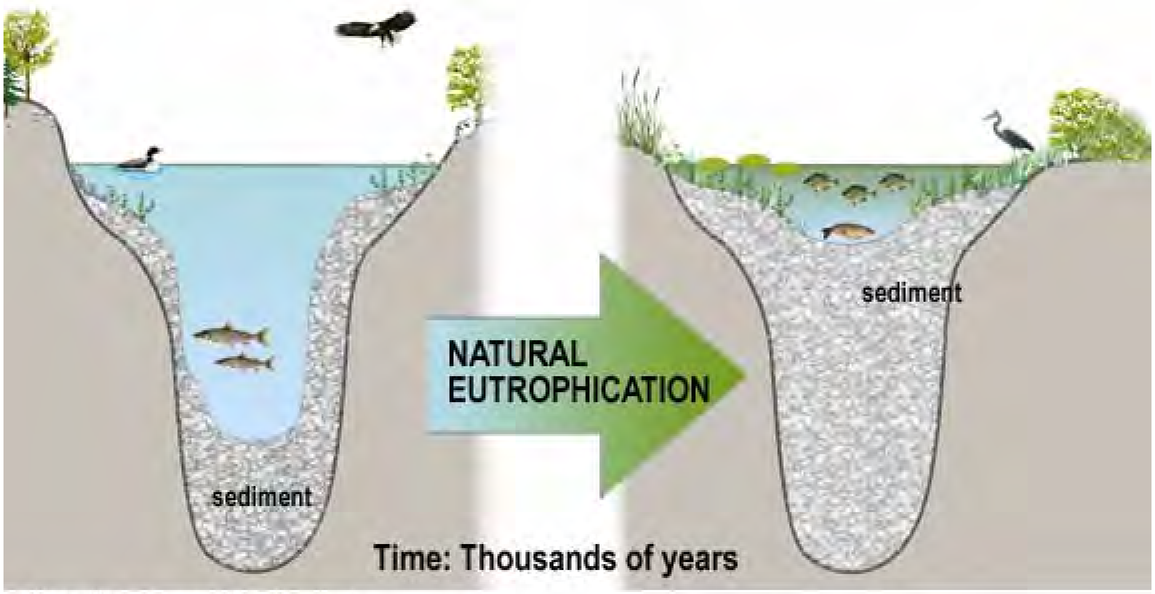


FIG. 3-1. An example of natural eutrophication.

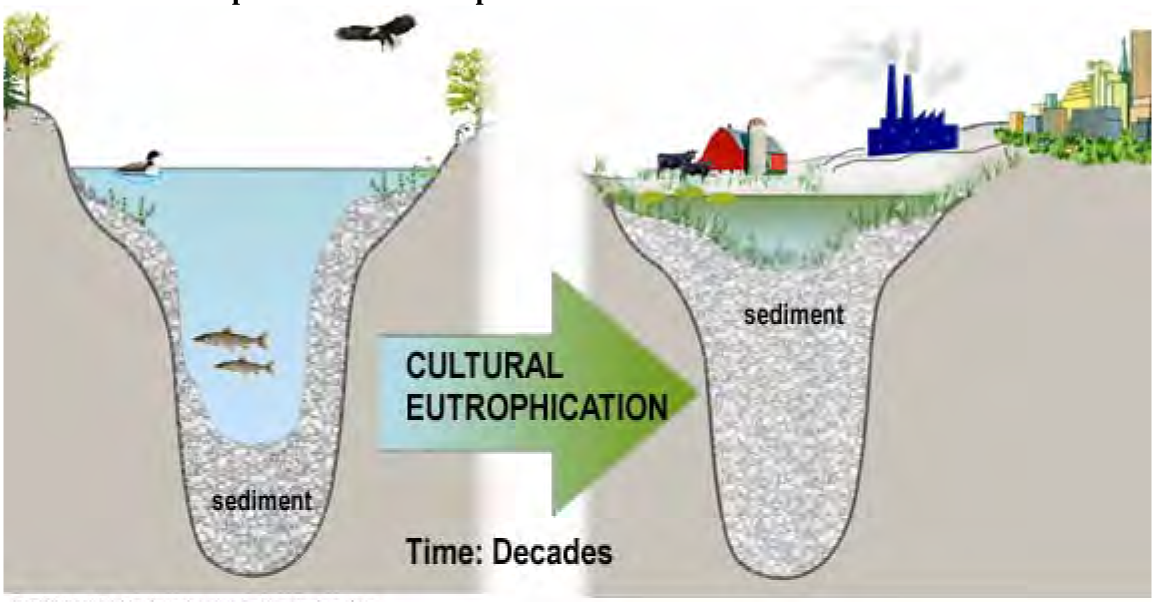


FIG. 3-2. An example of cultural eutrophication.

One way that eutrophication can be measured is by biological productivity.

B. Biological Productivity

Biological productivity is defined as the ability of a waterbody to support aquatic life. The amount of biological productivity (amount of algae, vascular plants, fish, etc.) that a waterbody can produce and sustain is defined as the trophic state. Waterbodies are generally classified into four groups according to their level of biological productivity and are as follows.

Oligotrophic – Nutrients tend to be in short supply so oligotrophic lakes typically have less aquatic vascular plants and algae and have high water clarity. Low levels of fish and wildlife are supported.

Mesotrophic – Nutrients are in moderate supply and the lake is capable of producing and supporting moderate levels of macrophytes, fish, and wildlife.

Eutrophic – Nutrients are in sufficient amounts to support the abundant growth of algae and/or abundant macrophytes. Eutrophic lakes are more biologically productive than oligotrophic and mesotrophic lakes and usually support large populations of fish.

Hypereutrophic – Extremely high nutrient concentrations can support either an abundant population of algae or abundant population of macrophytes and sometimes both. Hypereutrophic waterbodies can support large numbers of fish. Typically the bottom of these waterbodies will have thick layers of organic sediments as the decaying plant and/or algal debris accumulates. Oxygen depletion due to algal blooms/decaying plant/algal material may be a common cause of fish kills in these waterbodies.

The parameters most often used to help determine biological productivity are chlorophyll, total nitrogen and total phosphorus. The Forsberg and Ryding (1980) criteria for classifying lakes into trophic states are based on four water chemistry parameters (chlorophyll, total phosphorus, total nitrogen and water clarity) (http://lakewatch.ifas.ufl.edu/circpdffolder/trophic2.pdf) and is utilized by Leon County the Florida LAKEWATCH program and the City of Tallahassee. An introduction to the previously mentioned water chemistry parameters as well as the Forsberg and Ryding criteria are below.

C. Nutrients

Nutrient pollution, especially from nitrogen and phosphorus, has consistently ranked as one of the top causes of degradation in some U.S. waters for more than a decade (http://www.epa.gov/waterscience/criteria/nutrient/). While nitrogen and phosphorus are essential for plant growth, excessive amounts entering waterbodies can lead to significant water quality problems including harmful algal blooms, hypoxia and declines in wildlife and wildlife habitat. Based on waters assessed and reported in the 2008 Integrated Water Quality Assessment for Florida, nutrient pollution has contributed to approximately 1,000 miles of rivers and streams, 350,000 acres of lakes, and 900 square miles of estuaries to be considered impaired by the State (FDEP staff, 2008).

D. Phosphorus

Phosphorus plays a major role in biological activity. In comparison to other macronutrients required by plants and animals, phosphorus is oftentimes the least abundant and commonly is the first element to limit biological productivity (Wetzel, 2001). When phosphorus is supplied, plant growth is stimulated. In rivers, streams and lakes, phosphorus can cause problems by stimulating excess plant growth and reducing the quality of the water. Under certain conditions, excess phosphorus can contribute to excessive aquatic plant growth, algae blooms, low dissolved oxygen levels, fish kills and loss of biodiversity. Nonpoint source pollution is a major source of phosphorus to surface waters in the United States (Carpenter, et al, 1998).

Phosphorus can enter freshwater from atmospheric precipitation and from groundwater and surface runoff. The loading rates vary greatly with patterns of land use, geology and morphology of the drainage basin, soil productivity, human activities, pollution and other factors (Wetzel, 2001).

Phosphorus in rivers, lakes, and streams occur in many forms, but has widely differing availability for biological growth. Aquatic plants take in dissolved inorganic phosphorus and convert it to organic phosphorus as it becomes part of their tissues. Animals get the organic phosphorus they need by eating either aquatic plants, other animals, or decomposing plant and animal material. As plants and animals excrete wastes or die, the organic phosphorus they contain sinks to the bottom, where bacterial decomposition converts it back to inorganic phosphorus, both dissolved and attached to particles. This inorganic phosphorus gets back into the water column when the bottom is stirred up by animals, human activity, chemical interactions, or water currents. Then it is taken up by plants and the cycle begins again (EPA, 1997).

A large proportion of phosphorus in freshwater occurs as organic phosphates and cellular constituents in the biota or is adsorbed to inorganic and dead particulate matter. Orthophosphate (PO_4^{3-}) is the soluble form that can be directly utilized by algae and macrophytic vegetation (aquatic plants). Other forms would be considered temporarily unavailable.

Trophic state distribution with regards to total phosphorus is shown in **Table 3-1**. Because of the rapid cycling of phosphorus, total phosphorus is normally measured, rather than the individual compounds (in a waterbody).

TABLE 3-1. Lake trophic states established with the following total phosphorus distribution.

Total Phosphorus	
Oligotrophic	< 15 µg/L
Mesotrophic	Between 15 – 25 µg/L
Eutrophic	Between 25 and 100 µg/L
Hypereutrophic	> 100 µg/L

Figures 3-3 and 3-4 show the 2009 yearly average for total phosphorus for the County's sampled streams, rivers and lakes. As previously mentioned, direct comparisons between different waterbodies of any parameter is usually inappropriate due to the amount and variety of waterbodies monitored and the parameters measured.

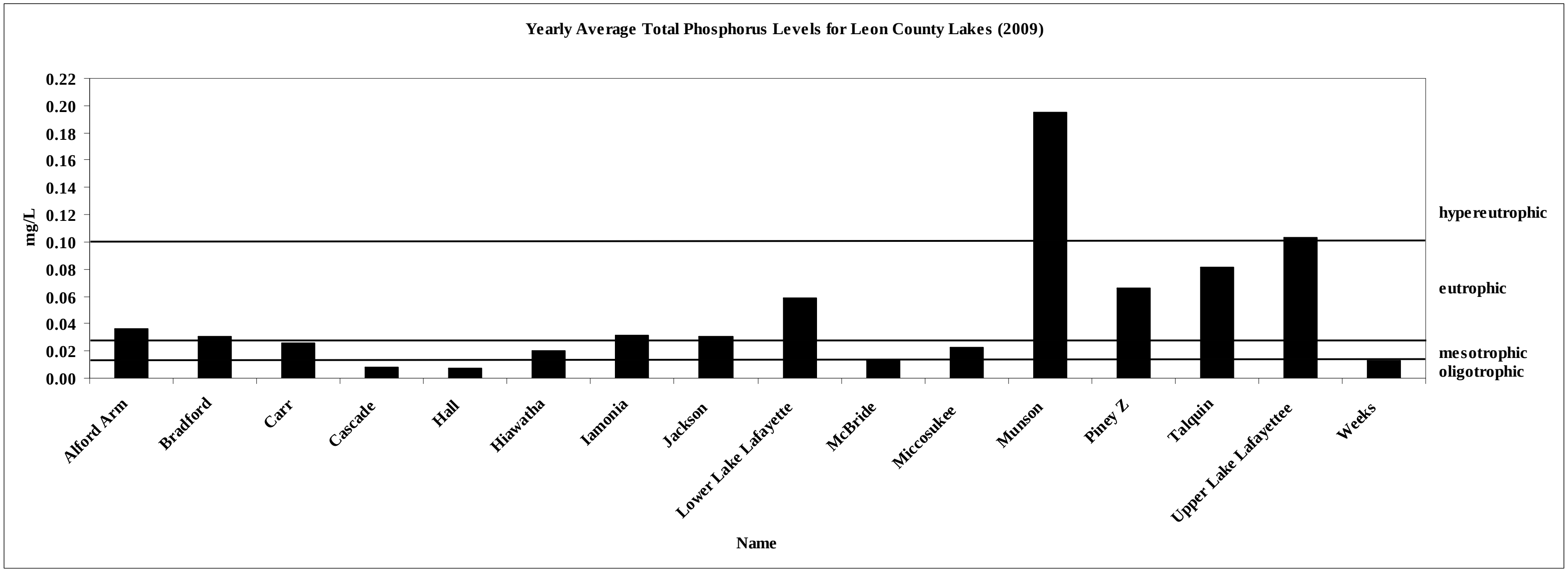


FIG. 3-3. Yearly average (2009) for sampled lakes in Leon County. Note that the Lake Lafayette sections are Alford Arm, Lower Lake Piney Z, and Upper Lake Lafayette.

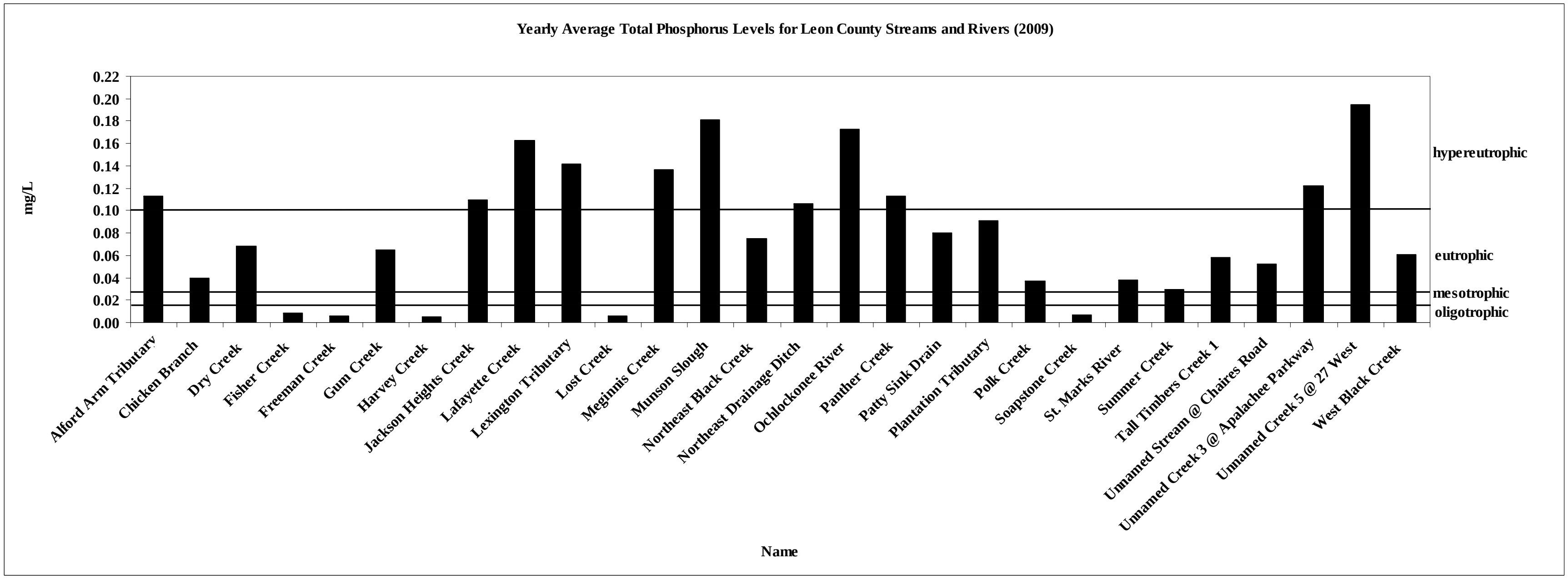


FIG. 3-4. Yearly average (2009) for sampled streams and rivers in Leon County.

E. Nitrogen

Nitrogen, like phosphorus, is a nutrient necessary to all forms of life, and the supply of nitrogen available to plants and animals has historically been quite limited. Also, nitrogen, like phosphorus, occurs in many forms.

Although nitrogen is the most abundant element in the atmosphere, nitrogen from the air cannot be used by plants until it is chemically transformed, or fixed, into ammonium or nitrate compounds that plants can metabolize. In nature, only certain bacteria and algae (and, to a lesser extent, lightning) have this ability to fix atmospheric nitrogen, and the amount that they make available to plants is comparatively small. Other bacteria break down nitrogen compounds in dead matter and release it to the atmosphere again (World Resources Institute, et al, 1998). The forms of nitrogen considered most bioavailable are nitrate (NO_3^-) and ionized ammonia (NH_4^+).

Only two forms of nitrogen can be considered directly toxic to aquatic organisms. Nitrite (NO_2^-) is rarely detected in the water column because it is easily oxidized to nitrate, while unionized ammonia (NH_3) is strongly pH dependent and usually does not occur in high enough concentrations to constitute a problem to aquatic organisms.

Indirectly, however, elevated nitrogen levels can have serious effects on aquatic ecosystems. Due to increases of fertilizer use, improper disposal of sewage, burning of fossil fuels and land clearing/deforestation, the amount of nitrogen available for uptake has increased substantially. In the case of waterbodies, excess nitrogen (like excess phosphorus) can contribute to excessive aquatic plant growth, algae blooms, low dissolved oxygen levels, fish kills and loss of biodiversity.

Since nitrogen can quickly cycle from one state to the next, total nitrogen measurements includes the sum of all forms of nitrogen. When total nitrogen is in low supply, and other factors necessary for plant and animal growth are present in sufficient amounts, low biological productivity can be expected. Like phosphorus, nitrogen can be a limiting nutrient (Florida LAKEWATCH, 2000B).

Trophic state distribution with regards to total nitrogen is shown in **Table 3-2**.

TABLE 3-2. Lake trophic states established with the following total nitrogen distribution.

Total Nitrogen	
Oligotrophic	< 400 µg/L
Mesotrophic	Between 400 – 600 µg/L
Eutrophic	Between 600 and 1500 µg/L
Hypereutrophic	> 1500 µg/L

Figures 3-5 and 3-6 show the 2009 yearly average for total nitrogen for the County's sampled streams, rivers and lakes. As previously mentioned, direct comparisons between different waterbodies of any parameter is usually inappropriate due to the amount and variety of waterbodies monitored and the parameters measured.

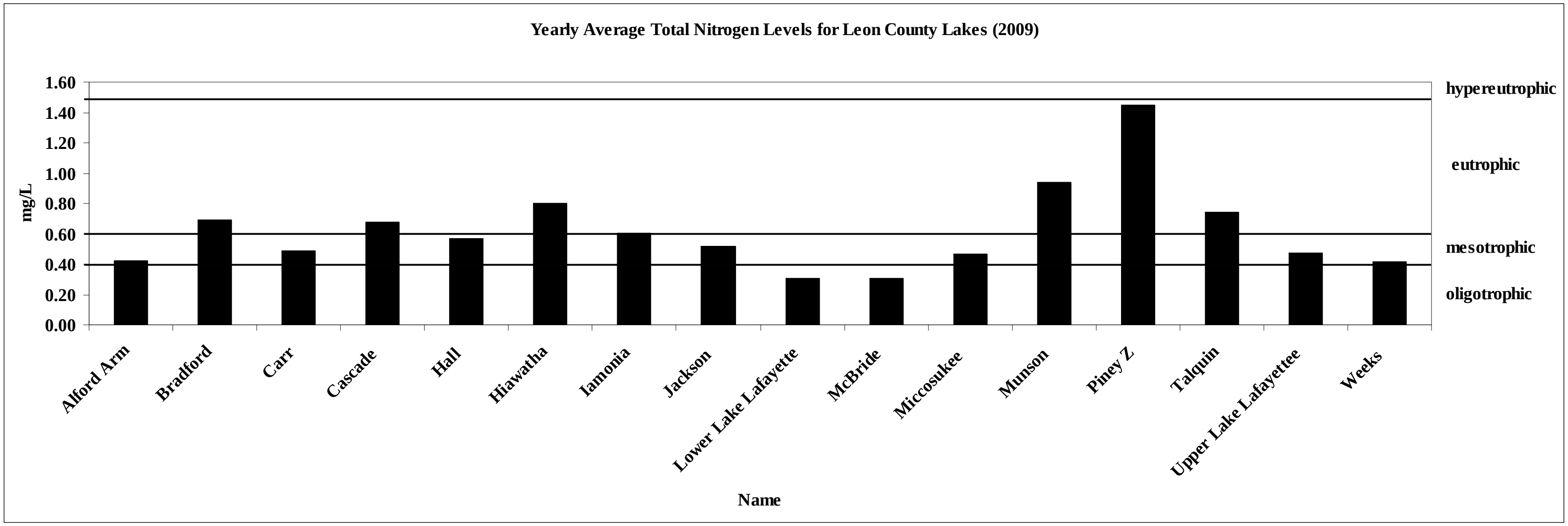


FIG. 3-5. Yearly average (2009) for sampled lakes in Leon County. Note that the Lake Lafayette sections are Alford Arm, Lower Lake Piney Z, and Upper Lake Lafayette.

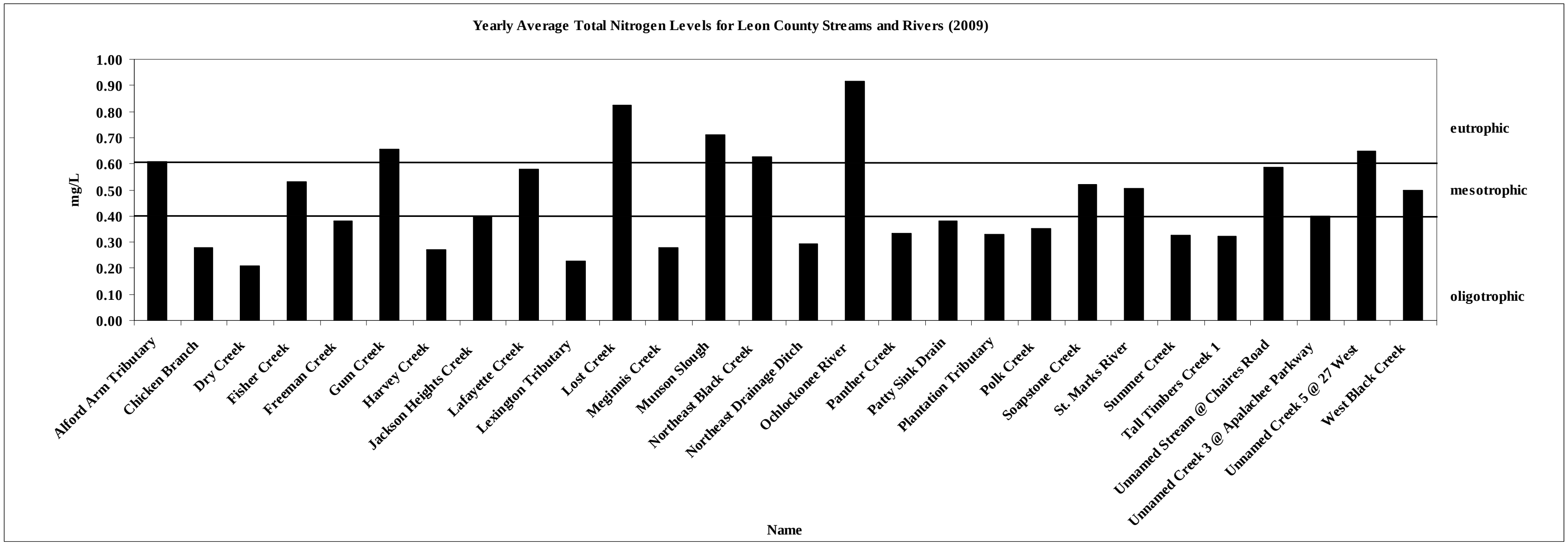


FIG. 3-6. Yearly average (2009) for sampled streams and rivers in Leon County.

F. Chlorophyll *a*

Chlorophyll is a green pigment that allows plants to convert sunlight into organic compounds during photosynthesis, and its abundance is a good indicator of the amount of algae in lakes, rivers and streams. Chlorophyll levels can be an effective measure of trophic status, are potential indicators of maximum photosynthetic rate and are a commonly used measure of water quality. High levels often indicate poor water quality and low levels often suggest good water quality conditions. However, elevated chlorophyll concentrations are not necessarily harmful. It is the long-term persistence of elevated levels that is a problem.

Long-term elevated quantities of chlorophyll can indicate the presence of algae blooms. These usually consist of a single species of algae, typically a species undesirable for fish and other predators to consume. Unconsumed algae sink to the bottom and decay, using up the oxygen required by other plants and benthic organisms to survive. Furthermore, the presence of too many nutrients, such as nitrogen and phosphorus, can stimulate algal blooms and result in reduced water clarity.

It is natural for chlorophyll levels to fluctuate over time. Chlorophyll concentrations are often higher after rainfall, particularly if the rain has flushed nutrients into the water. Higher chlorophyll levels are also common during the summer months when increased water temperatures and light levels lead to greater phytoplankton numbers.

Chlorophyll *a* is the predominant type of chlorophyll found in algae and cyanobacteria (blue-green algae) and is the form of chlorophyll that is most often analyzed for water quality testing. Starting in late 2003, Leon County began analyzing water samples for chlorophyll *a* (corrected). Previously, samples were analyzed for uncorrected chlorophyll *a* values which can be misleading because pheophytin, a natural degradation product of chlorophyll *a*, can be present in the sample and inflate the concentration value.

Trophic state distribution with regards to chlorophyll *a* is shown in **Table 3-3**.

TABLE 3-3. Lake trophic states established with the following chlorophyll *a* distribution.

Chlorophyll *a*	
Oligotrophic	< 3 µg/L
Mesotrophic	Between 3 - 7µg/L
Eutrophic	Between 7 and 40 µg/L
Hypereutrophic	> 40 µg/L

Figures 3-7 and 3-8 show the 2009 yearly average for chlorophyll for the County's sampled streams, rivers and lakes. As previously mentioned, direct comparisons between different waterbodies of any parameter is usually inappropriate due to the amount and variety of waterbodies monitored and the parameters measured.

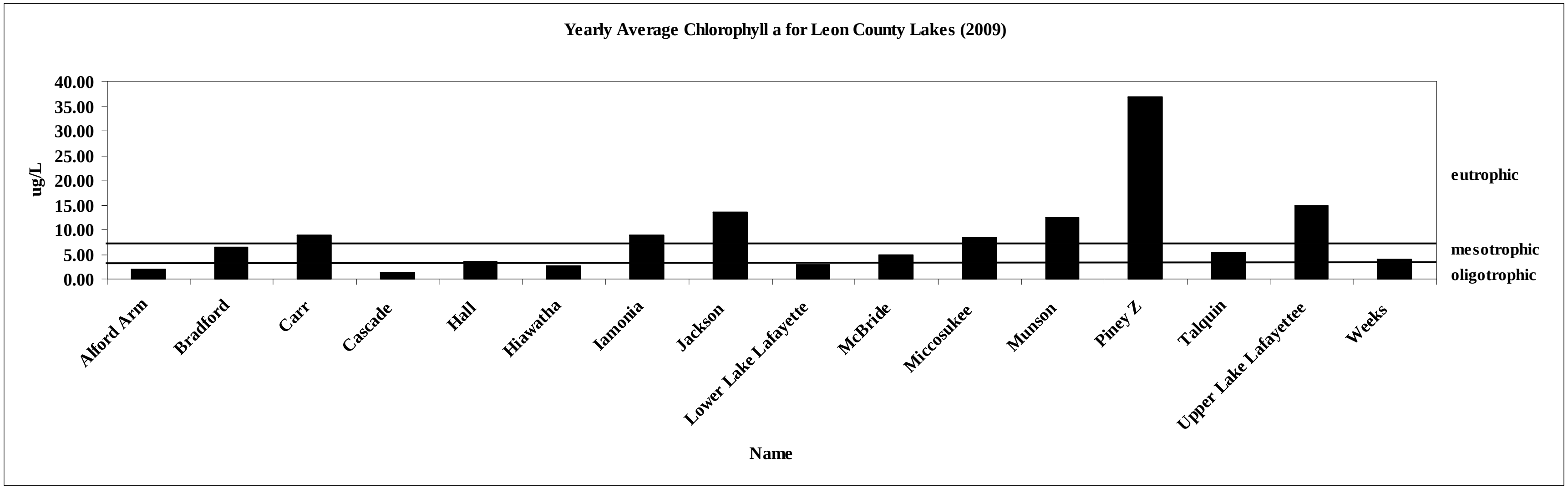


FIG. 3-7. Yearly average (2009) for sampled lakes in Leon County. Note that the Lake Lafayette sections are Alford Arm, Lower Lake Piney Z, and Upper Lake Lafayette.

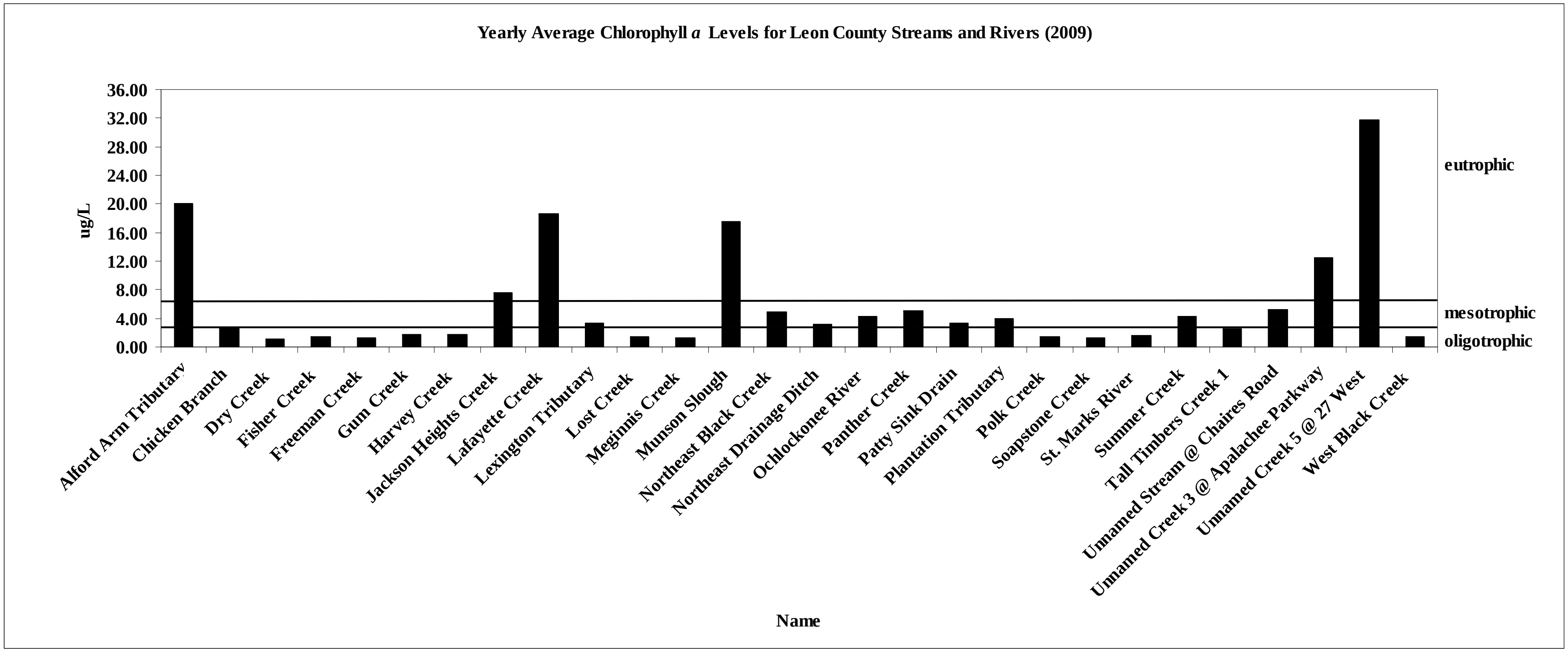


FIG. 3-8. Yearly average (2009) for sampled streams and rivers in Leon County.

While biological productivity using nutrients and chlorophyll is a useful tool, it can sometimes be difficult to assign a trophic state. The individual levels of nitrogen, phosphorus and chlorophyll *a* in a waterbody can be at levels that suggest multiple trophic states for one waterbody.

G. Limiting Nutrient

A limiting nutrient is a nutrient that influences plant growth but is available in quantities smaller than needed for algae and aquatic plants to increase their abundance. Once the limiting nutrient is exhausted, algae stop growing. If more of the limiting nutrient is added, larger algal populations will result until the nutrient is again exhausted or growth is stopped by some other limiting factor.

In most Florida lakes, the limiting nutrient is believed to be phosphorus. However, in watersheds with an abundance of phosphorus deposits in the soil as in Leon County, nitrogen can be the limiting nutrient.

The TN/TP ratio is used to determine nutrient limitation in Florida waters. Florida waterbodies are loosely divided into three groups:

- When the TN/TP ratio is less than 10, a waterbody is nitrogen-limited;
- When the TN/TP ratio is between 10 and 30, either nitrogen or phosphorus could be limiting;
- When the TN/TP ratio is greater than 30, a waterbody is considered phosphorus-limited.

Different agencies sometimes divide these three groups differently. The above values are used by the Florida Department of Environmental Protection (FDEP) when calculating the Trophic State Index.

II. Trophic State Index

In determining impairment for the Total Maximum Daily Load (TMDL) program, the FDEP usually assesses lakes using the Trophic State Index (TSI). The TSI is a scale from 1 to 100 used to indicate the relative trophic state of a waterbody (http://plants.ifas.ufl.edu/guide/tsi.html). Low TSI values indicate lower levels of biological productivity, and higher TSI values indicate higher levels of productivity. The Florida TSI was developed by FDEP following protocols that uses the below mathematical formula that takes into account the measurements of total phosphorus, total nitrogen, and total chlorophyll *a* (corrected) and limiting nutrient considerations (62-303 F.A.C., 2007). To calculate an annual TSI, at least one sample must be collected during each calendar quarter to adequately reflect the seasonal water chemistry changes.

The following protocols are used.

If TN/TP ratio >30, the $NUTR_{TSI} = TP2_{TSI}$
IF TN/TP ratio < 10, then $NUTR_{TSI} = TN2_{TSI}$
If TN/TP ratio > 10 and < 30, then $NUTR_{TSI} = (TN_{TSI} + TP_{TSI})/2$

TSI values are calculated using the following equations.

Chlor *a* $(corr.)_{TSI} = 16.8 + [14.4 * LN(Chlor\ a)]$
$TN_{TSI} = 56 + [19.8 * LN(TN)]$
$TN2_{TSI} = 10*[5.96 + 2.15*LN(TN + 0.0001)]$
$TP_{TSI} = [18.6*LN(TP*1000)] – 18.4$
$TP2_{TSI} = 10*[2.36*LN(TP*1000) – 2.38]$

LN equals the Natural Log.

Then an average TSI score is calculated using the equation below.

$TSI = (Chlor\ a_{TSI} + Nut_{TSI})/2$

According to FDEP a "clear" lake (average mean color less than or equal to 40 platinum cobalt units) may be considered impaired if the yearly TSI exceeds 40. Lakes that have a mean color greater than 40 platinum cobalt units may be considered impaired if the mean TSI exceeds 60. In addition, any lake may be considered impaired if the annual mean TSIs have increased over the assessment period, as indicated by a positive slope in the mean plotted versus time, or the annual mean TSI has increased by more than 10 units over historical values (62-303.352(1), (2), (3) F.A.C., 2007).

However, a high TSI means there is a high level of productivity in a lake so there is a capacity for the lake to support abundant populations of fish and wildlife despite the fact that it may not be considered ideal for swimming or diving. So if you like to fish or observe wildlife, a more productive lake (up to a point) would furnish more fish and support more wildlife.

4. OTHER PARAMETERS

Other important parameters that are used to evaluate the health of our area's lakes, streams, and rivers are explained below.

A. Dissolved Oxygen

Dissolved oxygen (DO) is the amount of oxygen present in the water. It is measured in terms of milligrams per liter (mg/L). Oxygen gets into water by diffusion from the surrounding air, by physical aeration (rapid movement), and as a byproduct of photosynthesis.

Large daily variations of DO concentrations naturally occur throughout the day and night. Because photosynthesis requires light, it can only occur during daylight hours and is offset by the constant loss of oxygen used during normal respiration of living organisms and the decomposition of dead plant material and other organisms. This can cause the DO concentration to steadily decline at night. The DO concentration is lowest just before dawn when photosynthesis resumes.

Other influences on DO include the weather, depth of water and the temperature. Cold water can hold more oxygen, as well as other gases, than warmer water. DO levels tend to be lower at the bottom of a waterbody due to lack of water/air interaction and the oxygen utilization by aerobic bacteria on the sediment. Cloudy weather inhibits photosynthesis, causing plants to respire and lowering DO levels on cloudy days.

Pollution also disrupts the natural levels of DO. Pollution can affect the DO levels by contributing oxygen-demanding organic matter (sewage, lawn clippings, soils from streambank and lakeshore erosion, and from agricultural runoff) or by contributing nutrients that stimulate growth of bacteria and algae. As these materials enter a waterbody, bacterial growth is stimulated and the population increases rapidly, consuming the available oxygen as it does so. Normally biological activities are balanced concerning oxygen production and consumption. However, in lakes where a large portion of the organic matter is brought in from outside the lake, oxygen production and oxygen consumption are not balanced and low DO may become a serious problem.

FDEP rule states that DO "shall not be less than 5.0 mg/L. Normal daily and seasonal fluctuations above these levels shall be maintained" (62-302.530(30) F.A.C., 2006).

Where possible, DO concentrations are recorded at surface, mid and bottom depths.

B. Dissolved Oxygen Percent Saturation

Oxygen saturation is the relative measure of oxygen that is dissolved in water.

High dissolved gas concentrations in water (>110%) can be caused by excess oxygen production by aquatic plants (enhanced by excess nutrients associated with pollution), solar heating, hydroelectric and impoundment dams and can be harmful to aquatic life. Fish in waters containing excessive dissolved gases may suffer from Gas Bubble Disease (GBD). This disease is caused when supersaturated gases in the water escape from the water into the body fluids of the fish (effects that are similar to the "bends" that scuba divers sometimes experience). Aquatic invertebrates are also affected by gas bubble disease but at DO levels higher than those lethal to fish.

Rule 62-302.530(66) FAC, notes that Total Dissolved Gases (TDG) shall not be greater than 110%. This translates into a requirement for the DO% portion of TDG to be less than about 150%.

C. Biological Oxygen Demand

The degree of oxygen consumption by microbially-mediated oxidation of contaminants in water is called the biochemical (or biological) oxygen demand (BOD) (Manahan, 1991).

BOD directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD, the more rapidly oxygen is depleted in the stream by microbial organisms. This means less oxygen is available to higher forms of aquatic life. Lower dissolved oxygen levels mean higher level aquatic organisms (fishes) become stressed or die.

Sources of increased BOD include: fertilizers, wastewater, feedlots, dead plants and animals and stormwater runoff.

Florida's BOD criteria for Class III water states that BOD shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case, shall it be great enough to produce nuisance conditions (62-302.530(11) F.A.C., 2007).

D. Specific Conductance

Specific conductance is a measure of how well water can conduct an electrical current and is measured as µmhos/cm. A higher value of conductance is the result of increases of salts in the water allowing the water to become a better electrical conductor. Because human waste, fertilizers, and runoff from feedlots and roads contain salts, specific conductance can be used to measure for contamination. But it's important to remember that elevated conductance measurements may have various causes and do not prove by themselves there is contamination from human wastes (Florida LAKEWATCH, 1999). For example, groundwater tends to have higher conductivity levels than surface waters due to mineral content.

Florida's specific criterion for Class III water states that levels shall not be increased more than 50% above background or to 1275 µmhos/cm, whichever is greater (62-302.530(22) F.A.C., 2006).

E. pH

The pH value is the measure of the acidity or alkalinity of a solution. The measurement (measured in SU or Standard Units) ranges from 0 (acidic) to 14 (alkaline) with neutral being 7.

The pH of a particular waterbody is often influenced by basin location and the vegetation characteristics of that basin. For example, oligotrophic cypress rimmed lakes will tend to have lower pH values than other lakes in the same region because when cypress needles fall and decay in the water they make the water more acidic. However, highly eutrophic lakes (even cypress rimmed lakes) will have higher pH values due to algae reducing carbon dioxide in the water column. Rainfall can also influence pH. Airborne pollutants such as nitrogen dioxide (NO_2) and sulfur trioxide (SO_3) can interact with water and form acids. This then precipitates to the ground as acid rain. This may change the pH of the streams, lakes, or rivers that receive this rainfall.

Changes in pH cause problems because plants and animals are adapted to survive in water at a certain pH. When pH is raised or lowered, the organisms in and around the water may become stressed or die. The pH of the water also affects the solubility and thus the bioavailability of other substances. As the pH falls, water becomes more acidic and many substances become more soluble and available for absorption.

Florida's pH criterion for Class III water states that counts shall not be lowered to less than 6.5 SU or raised above 8.5 SU unless natural levels are above or below those limits. If the natural background is below 6.5 SU, the pH shall not vary below natural background, or if the natural level is higher than 8.5 SU, the pH shall not vary above that level (62-302.530(51) (c) F.A.C., 2006).

F. Alkalinity

Alkalinity is a measure of the buffering capacity of the carbonate system in water or the capacity of water to neutralize acids. Alkalinity in water results from any dissolved species, usually weak acid anions that can accept and neutralize protons. Because carbon dioxide (CO_2) is quite soluble and relatively abundant in water and carbonates are common as primary minerals over much of the earth, the property of alkalinity of most freshwaters are mostly made up of bicarbonates and carbonates (Wetzel, 2001).

Alkalinity is important for aquatic life because it protects or buffers against rapid pH changes. Buffering capacity resistance to changes in pH is increased when alkalinity levels are higher. The presence of buffering materials in water also helps to neutralize acids as they get added to the water through rainfall or discharges.

Florida's alkalinity criteria for Class III water states that alkalinity levels shall not be depressed below 20 mg/L (62-302.530(1) F.A.C., 2006).

G. Color

Color in natural water may be caused by grains of rock forming minerals such as quartz, clay mineral particles, detrital organic material, virus particles and living cells of bacteria and algae (Davis-Colley, et al, 2003). Water color is usually the direct result of where the water flows from. Water that drains from swamps or a lake that is surrounded by a cypress rim will often be reddish brown (tea-colored) or almost black, hence the term; "blackwater". Photosynthesis is often inhibited in such systems since the water color inhibits transmission of certain wavelengths of light. In aquatic environments with high light transparency the phytoplankton populations are strongly correlated to the supply of nutrients, but in blackwater systems light availability can be a major limiting factor for primary production (Phlips, et al, 2000).

H. Bacteriological

To monitor water routinely for the presence of pathogens is a difficult undertaking. Instead, indicator bacteria are used to indicate the probable presence of pathogenic bacteria that is associated with fecal pollution. These bacteria normally do not cause illness but their presence can indicate possible fecal contamination, and/or disease-causing pathogens. Fecal coliforms, a subset of the total coliform group, have historically been used to determine if a waterbody has been contaminated. These are bacteria that live in the lower intestines of warm-blooded animals, including wildlife, farm animals, pets and humans. Sources of fecal contamination can include direct deposition by wildlife or pets; wastewater treatment outfalls; septic tank runoff; or diffuse sources such as runoff from fields where livestock waste has been applied.

Florida's fecal coliform criterion for Class III water states that counts shall not exceed a monthly geometric average of 200, nor exceed 400 in 10% of the samples nor exceed 800 on any one day (62-302.530(6) F.A.C., 2007).

I. Temperature

Temperature impacts both the chemical and biological characteristics of surface water. Plant and animal metabolism, growth, emergence, and reproduction are directly related to temperature, whereas food availability, (both quantity and quality) may be indirectly related through associated microbial activity (Anderson and Cummins, 1979). Temperature changes as the result of human activities can be detrimental to the environment.

Thermal pollution is the introduction of water that is warmer than the body of water into which it flows. Thermal pollution is typically associated with manufacturing or power plants. These industries discharge hot water, that has been used to cool equipment, directly into streams. Another source of thermal pollution is urban runoff. This is water that has been heated as it flowed over parking lots, streets and sidewalks. The removal of the forest canopy during construction or agricultural activities near streams also contributes to thermal pollution by decreasing shade, thereby increasing solar heating of the water's surface. In addition to increasing the amount of solar radiation reaching the water's surface, removal of vegetation near streams often results in increased erosion and increased amounts of sediments in the water. The sediments absorb heat from sunlight rather than reflect it. This heats the water further.

As many aquatic organisms are directly affected by temperature, this particular environmental impact is significant. Warm water is less capable of holding dissolved oxygen and the problem is magnified by the fact that biological activity increases as water temperature rises, increasing oxygen demand. Decreases in oxygen levels and increases in metabolic activity of the aquatic animals can alter ecosystems by stressing animals and increasing the probability of disease; causing food shortages (increased metabolism means more food is needed); killing juvenile fish that are more affected by increased water temperature, and increasing the probability of large scale fish kills.

Where possible, temperature readings are collected at surface, mid and bottom depths and is measured as ºC.

J. Turbidity

Turbidity is the amount of particulate matter that is suspended in water. Turbidity measures the scattering effect that suspended solids have on light - the higher the intensity of scattered light, the higher the turbidity. Material that causes water to be turbid includes clay, silt, finely divided organic compounds, plankton, and other microscopic organisms.

Excessive levels of turbidity can have numerous effects on water quality and the biological activities of fish and wildlife. Turbidity can inhibit photosynthesis, reducing aquatic plant and algae growth. Turbid water can reduce visibility for fish and other animals when seeking prey. It can also act as an irritant to their gills and generally increases stress on the animal. When particles settle "out" of the water column, the particles will buildup on the lake or stream bottom and on top of animal habitat (aquatic plants, downed logs, leaf litter, etc.). This reduces habitat, food sources and breeding areas for fish, aquatic invertebrates, amphibians and other aquatic animals.

Florida's turbidity criteria for Class III water states that levels shall be less than or equal to 29 Nephelometric Turbidity Units (NTU) above background conditions (62-302.530(69) F.A.C., 2007).

K. Total Suspended and Total Dissolved Solids

Total Suspended Solids (TSS) are solids in water than can be trapped by a filter (usually with a pore size of 0.45 micrometers) while Total Dissolved Solids (TDS) are solids that pass through the filter.

TSS can include a variety of material, including silt, decaying plant and animal material, or sewage. High TSS can reduce water clarity and inhibit photosynthesis, increase water temperature, clog fish gills, affect prey/predator interactions, and smother eggs and aquatic insects and their habitat.

TDS can include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. A certain level of these ions in water is necessary for aquatic life. Changes in TDS concentrations can be harmful because the density of the water determines the flow of water into and out of an organism's cells. High TDS concentrations can also have effects similar to TSS.

5. BIOLOGICAL MONITORING

In addition to the above parameters, biological indices are being used to evaluate the health of selected Leon County streams.

A. Biological Indices

The widespread use of assessing water quality by using living organisms has been a fairly recent approach in North America and the United Kingdom. The former countries have historically relied mainly on chemical and physical measures, even though water pollution is essentially a biological problem. One problem of relying solely on chemical and physical measurements to evaluate water quality is that they provide data that primarily reflect conditions that exist when the sample is taken. Chemical and physical measurements provide a "snapshot" of water quality conditions. In contrast, biological monitoring gives an indication of past conditions as well as current conditions. Biological data provides an integrated "moving picture" of the past (Resh, et al., 1996). However, physical/chemical measurements and biomonitoring are not mutually exclusive; an optimal water quality monitoring program involves both approaches (Rosenberg and Resh, 1996).

To successfully manage ecosystems and protect water resources, a basic understanding of the system's biological components is mandatory. The biota responds to a wide variety of cumulative factors, both natural and anthropogenic **(Figure 5-1)**. As the organisms integrate these factors over time, a characteristic community structure emerges.

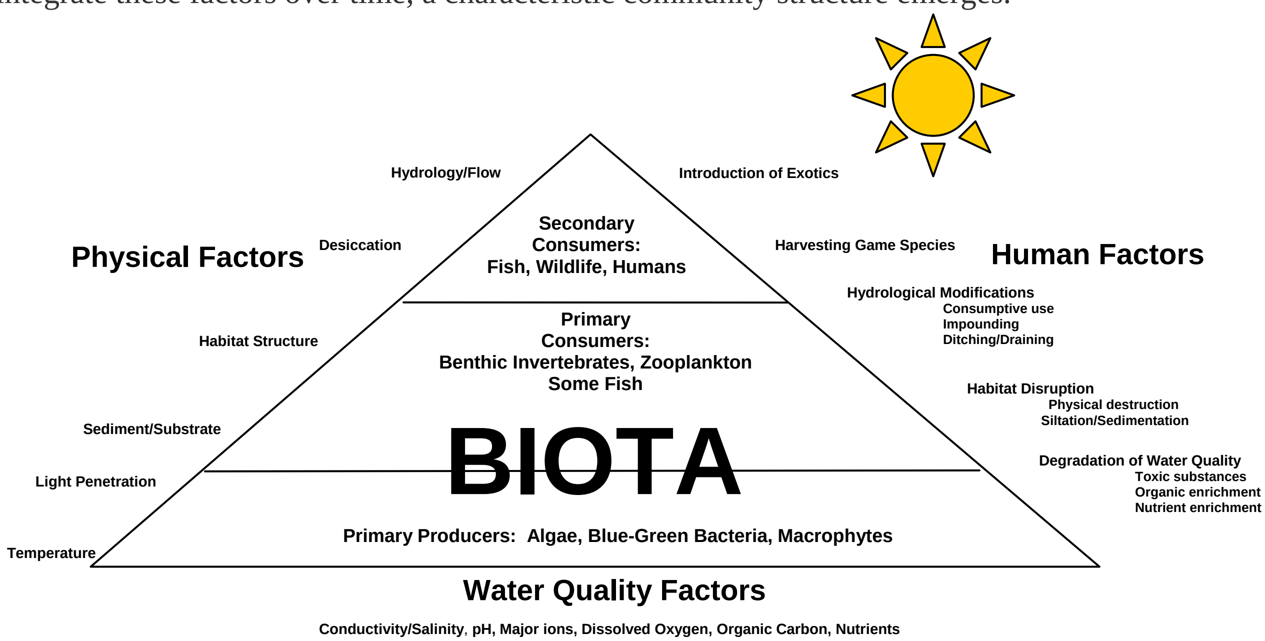


FIG. 5-1. Biota are influenced by a variety of factors. Modified from: Sampling and Application of the Stream Condition Index (Presentation).

When human actions adversely affect a system, the biological population will change, leading to an imbalanced community. As **Figure 5-2** shows, pollution sensitive animals will disappear, other types and numbers of animals usually decrease, food webs are disturbed, and undesirable nuisance species may dominate http://www.dep.state.fl.us/labs/biology/baintro.htm).

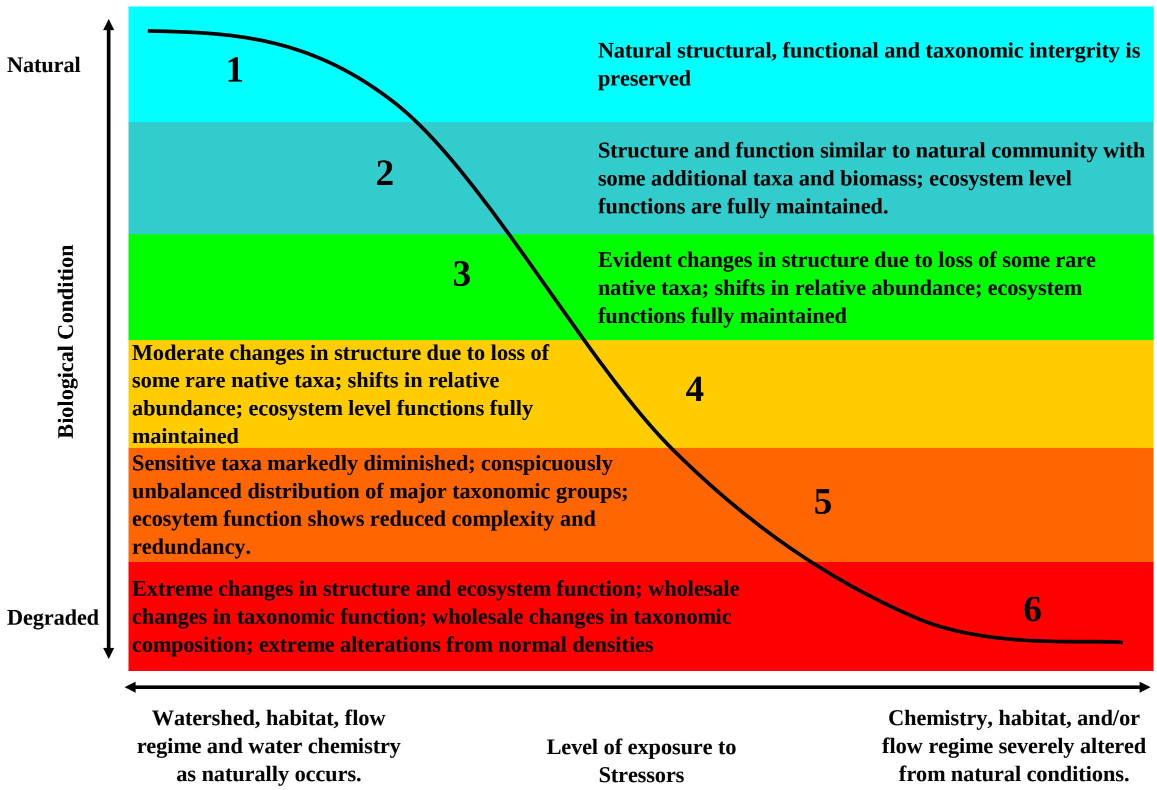


FIG. 5-2. The Biological Condition Gradient and summaries of biological tiers. Modified from Davies and Jackson (2006).

The biota most often used as indicators are benthic macroinvertebrates (aquatic invertebrates). Benthic macroinvertebrates are good indicators of stream health because they:

- Have limited mobility
- Stay in areas suitable for their survival
- Are relatively easy to collect
- Differ in their tolerance to amount and types of pollution
- Are relatively easy to identify in a laboratory
- Often live in the water for more than one year
- Are integrators of environmental conditions

Several different measurements of benthic macroinvertebrate community health are routinely employed to determine the status of a system. These are:

- Taxa richness: the number of different types of organisms present in a system.
- Shannon-Weaver diversity: an index which is specified in the Florida Administrative Code as a measure of biological integrity.
- Percent contribution of the dominant taxon: related to diversity, used for analysis of qualitative samples.

- Numbers of pollution sensitive taxa: several different invertebrate indices based on this principle, including the Florida Index and the Lake Condition Index.
- Ephemeroptera/Plecoptera/Trichoptera Index: an index which sums the number of these kinds of organisms present. A related parameter, the Ephemeroptera/Plecoptera/Odonata Index, is also sometimes used.
- Community structure: measurements of shifts in proportions of major groups of organisms, compared to reference conditions.
- Trophic composition/feeding guilds: determination of shifts in the feeding strategies of invertebrates.
- The Stream Condition Index for Florida: a composite macroinvertebrate index made up of several of the measurements listed above.
- Habitat Assessment: quality of the local environment with respect to the needs of the organisms investigated.

The above measurements, as well as others, can help determine the health of a water body. **Figure 5-3** shows representative macroinvertebrates that are used to evaluate the health of a waterbody.

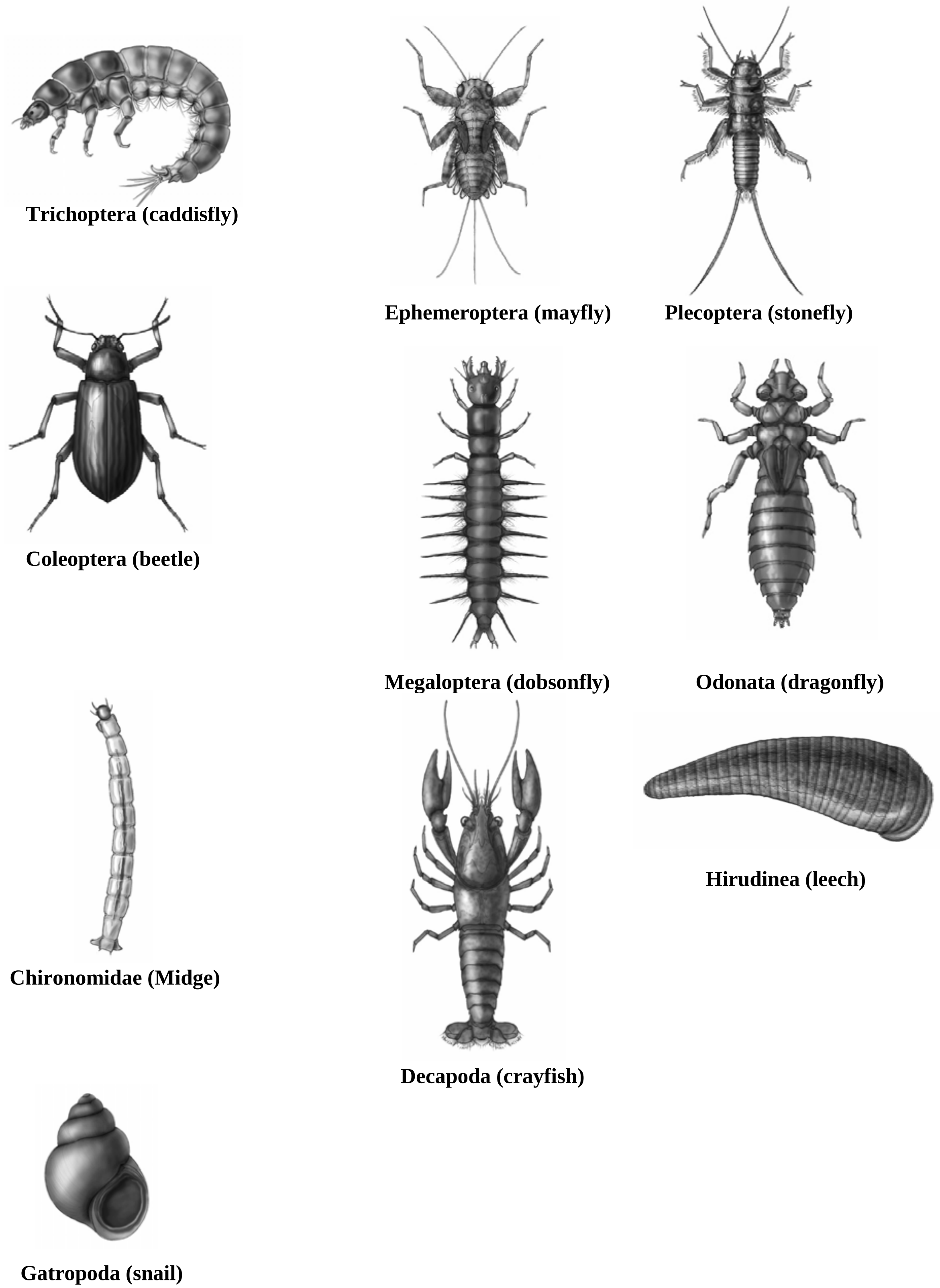


FIG. 5-3. Examples of macroinvertebrates found in Southeastern lakes, streams and rivers. Illustrations from: Aquatic Macroinvertebrate Field Guide for Georgia's Streams, 2006.

Leon County uses the Florida Stream Condition Index as well as the Florida Habitat Assessment to help determine the health of the area streams.

B. Florida Stream Condition Index

The Stream Condition Index (SCI) is a multimetric index that assesses the biological health of stream ecosystems by the evaluation of the population and diversity of macroinvertebrates that are found in a 100 meter stream reach. Several anthropogenic factors including sedimentation, nutrient enrichment, habitat loss, hydrologic stream channel alteration, and riparian zone alteration adversely influence biological health of stream ecosystems **(Table 5-1)**. The bioassessment procedures, along with standardized habitat assessments provide evidence to determine the ecological health of a stream.

TABLE 5-1. Principal mechanisms by which land use influences stream ecosystems (modified from Allen, 2004).

Environmental Factor	Effects
Sedimentation	Increases turbidity, scouring and abrasion; impairs substrate suitability for periphyton and biofilm production; decreases primary production and food quality causing bottom-up effects through food webs; in-filling of interstitial habitat harms crevice-occupying invertebrates and gravel-spawning fishes; coats gill and respiratory surfaces; reduces stream depth heterogeneneity, leading to decrease in pool species
Nutrient enrichment	Increases autotrophic biomass and production, resulting in changes to assemblage composition, including proliferation of filamentous algae, particularly if light also increases; accelerates litter breakdown rates and may cause decreases in dissolved oxygen and a shift from sensitive species to more tolerant, often non-native species
Contaminant pollution	Increases heavy metals, synthetics, and toxic organics in suspension associated with sediments and in tissues; increases deformities; increases mortality rates and impacts to abundance, drift, and emergence in invertebrates; depresses growth, reproduction, condition, and survival among fishes; disrupts endocrine system; physical avoidance
Hydrologic alteration	Alters runoff-evapotranspiration balance,

	causing increases in flood magnitude and frequency, and often lowers base flow; contributes to altered channel dynamic, including increased erosion from channel and surroundings and less-frequent overbank flooding; runoff more efficiently transports nutrients, sediments, and contaminants, thus further degrading in-stream habitat. Strong effects from impervious surfaces and stormwater conveyance in urban catchments and from drainage systems and soil compaction in agricultural catchments
Riparian clearing/canopy opening	Reduces shading, causing increases in stream temperatures, light penetration, and plant growth; decreases bank stability, inputs of litter and wood, and retention of nutrients and contaminants; reduces sediment trapping and increases bank and channel erosion; alters quantity and character of dissolved organic carbon reaching streams; lowers retention of benthic organic matter owing to loss of direct input and retention structures; alters trophic structure
Loss of large woody debris	Reduces substrate for feeding, attachment, and cover; causes loss of sediment and organic material storage; reduces energy dissipation; alters flow hydraulics and therefore distribution of habitats; reduces bank stability; influences invertebrates and fish diversity and community function

The SCI method consists of collecting 20 D-frame dipnet sweeps (0.5 m in length) of the most productive habitats in a 100 m reach of stream. The organisms are sub-sampled, sorted, and identified to the lowest practical taxonomic level. The resulting data is used to calculate the SCI which is based on ten measurements of invertebrate health **(Table 5-2)**. The calculated data is then compared with the expectations within a particular ecoregion to determine the health of the system **(Table 5-3)**.

TABLE 5-2. Description of SCI metrics and expected effects of human disturbance

SCI Metric	Description and expected effects due to human disturbance
Total taxa	Represents a general measure of the biological complexity found at a site. Widely applied in biomonitoring programs because of its consistent decline with human disturbance for stream invertebrates.
Ephemeroptera taxa	Ephemeroptera are considered pollution sensitive so numbers and taxa will decline as human disturbance increases.
Trichoptera taxa	Trichoptera are considered pollution sensitive so numbers and taxa will decline as human disturbance increases.
% Filterer	Feed on fine particulate matter that they filter out of the water. Are expected to decline in response to disturbance because of the increase in sediment and silt that can damage or clog nets or filtering structures.
Long-lived taxa	Taxa that spend at least one year of their lives in an aquatic habitat. Long-lived taxa are expected to decline as human disturbance alters naturally flow regime, because these taxa require water in the channel year round. Pollution events of short duration may also eliminate these taxa, while other taxa may colonize from unaffected sites.
Clinger taxa	Clingers have morphological and behavioral adaptations that allow them to cling to objects in fast water. Human development near stream sites in FL often translates into eroding sand that can smother habitat and eliminate taxa.
% Dominance	Percentage dominance of the most abdundant taxon increases with disturbance as the natural taxonomic diversity declines and very tolerant taxa dominant samples.
% Tanytarsini	Members of the family Chrionomidae. Generally sensitive to human disturbance.
Sensitive taxa	Historically documented taxa that are considered sensitive to human disturbance in FL.
% Very tolerant	Historically documented taxa that are considered very tolerant to human disturbance in FL.

TABLE 5-3. Category names, ranges of values for SCI, and example descriptions of biological conditions typically found for that category. Narrative metric descriptions are not used to score metrics, rather they describe values associated with a range of index values (from DEP-SOP-002/01 Table LT 7200-2).

SCI Category	SCI Range	Example Description
Category 1 ("exceptional")	71 - 100	Higher diversity of taxa than for Category 2, particularly for Ephemeroptera and Trichoptera; several more clinger and sensitive taxa than found in Category 2; high proportion for Tanytarsini; few individuals in the dominant taxon; very tolerant individuals make up a very small percentage of the assemblage.
Category 2 ("healthy")	35-70	Diverse assemblages with 30 different species found on average; several different taxa each of Ephemeroptera, Trichoptera, and long-lived and on average, 5 unique clinger and 6 sensitive taxa routinely found; small increase in dominance by a single taxon relative to Category 1; very tolerant taxa represent a small percentage of individuals, but noticeably increased from Category 1.
Category 3 ("impaired")	0-34	Notable loss of taxonomic diversity; Ephemeroptera, Trichoptera, long-lived, clinger, and sensitive taxa uncommon or rare; half the number of filterers than expected; assemblage dominated by a tolerant taxon; very tolerant individuals represent a large proportion of the individuals collected.

C. Habitat Assessment

Eight attributes known to have potential effects on the stream biota are evaluated and scored, including the categories of substrate diversity, substrate availability, water velocity, habitat smothering, artificial channelization, bank stability, riparian buffer zone width, and riparian zone vegetation quality. Based on the sum of these individual scores, overall habitat quality is assigned to one of four categories: Optimal, Suboptimal, Marginal, or Poor **(Table 5-4)**.

TABLE 5-4. Habitat Categories and Scoring Ranges.

Habitat Assessment Category	Score Range
Optimal	124-160
Sub Optimal	81-123
Marginal	44-80
Poor	11-43

D. Lake Vegetation Index

Because of the complications in assessing human disturbance in lakes using the invertebrate community, FDEP developed a method involving the lake aquatic plant community. The Lake Vegetation Index (LVI) is a multi-metric index that evaluates how closely a lake's plant community resembles one which would be expected in a condition of minimal human disturbance. It is based on a rapid field assessment of aquatic and wetland plants as indicators of various effects of human disturbance over time. Plants respond to physical disturbances such as introduction of exotic species or lakeshore alterations, and chemical disturbance such as introduction of excess nutrients, particulates, or herbicides from the surrounding land uses. Four metrics comprise the index **(Table 5-5)**.

TABLE 5-5. Description of LVI metrics and expected effects of human disturbance

LVI Metric	Description and expected effects due to human disturbance
% Native taxa	Native taxa are those whose natural range included FL at the time of European contact (1500 AD)
% Invasive exotic taxa	Exotics that that have increased in abundance or frequency and/or are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives
Coefficient of Conservatism (C of C)	The coefficient of conservatism is a number from 0 to 10 that indicates how broad or narrow a taxon's ecological niche is, as determined by expert botanists. Exotic and ubiquitous weedy native taxa have low C of C scores, and taxa that display fidelity to a particular community and are sensitive to disturbance have high C of C scores
% Sensitive taxa (C of C > 7)	Taxa that display fidelity to a particular community and are sensitive to disturbance have high C of C scores

The LVI method is performed from a boat, so it is intended for use in lakes and ponds that can be accessed by boat. The method involves dividing a lake into 12 units and identifying plants in 4 of the 12 units **(Figure 5-4)**.

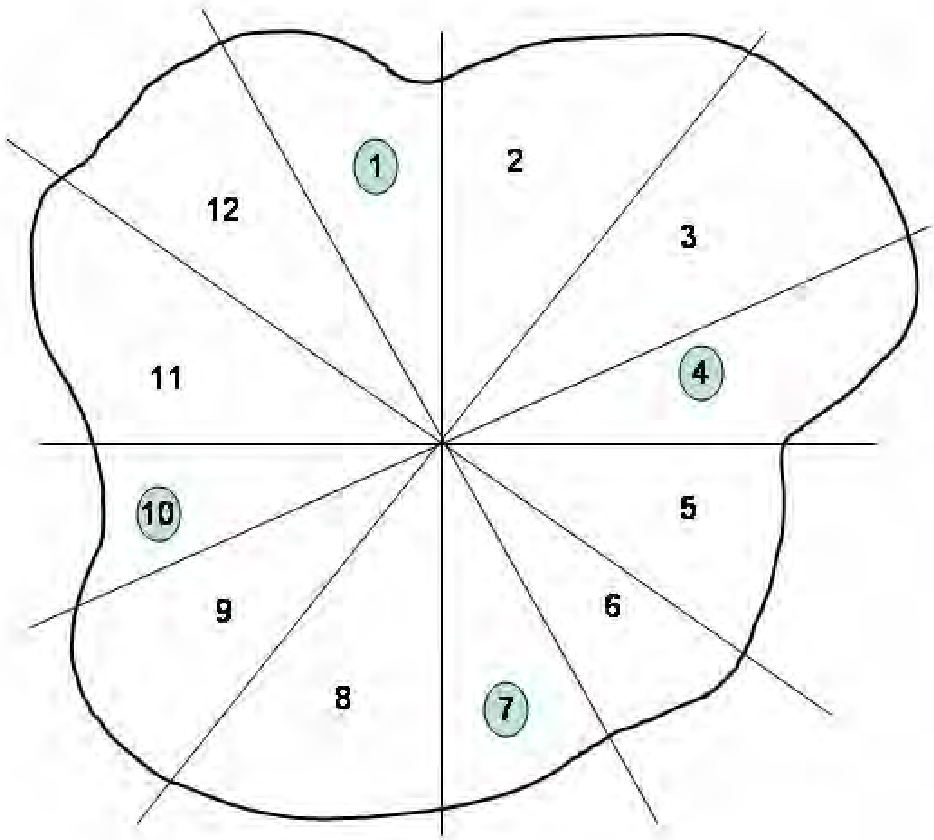


FIG. 5-4. Example of lake being divided into 12 units. Section 1, 2, or 3 is randomly selected as a starting section, and then every third section is sampled after that. In this example, section 1 was selected as the starting section.

Plants are identified in each unit by a visual boat "drive by" and also via a transect approach followed by the deployment of a type of sampling equipment known as the frodus **(Figure 5-5)**. Dominance or co-dominance in the plant community is also determined. The resulting data is used to calculate the LVI and is evaluated according to the scoring system in **Table 5-6**.

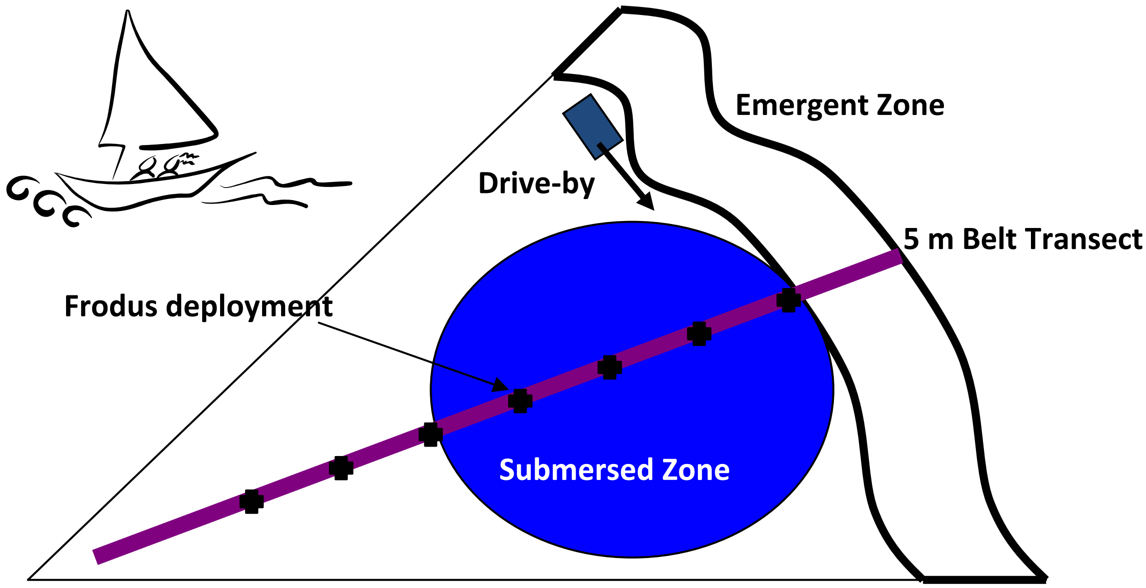


FIG. 5-5. For a given lake section, the sampling team conducts a drive-by survey of plant taxa, and then examines a 5 meter stretch of shoreline, followed by five frodus throws toward the lake center. Source: Sampling and Use of the Lake Vegetation Index (LVI) for Assessing Lake Plant Communities in Florida: A Primer
ftp://ftp.dep.state.fl.us/pub/labs/assessment/sopdoc/lvi_primer.pdf

TABLE 5-6. Category names, ranges of values for LVI, and example descriptions of biological conditions typically found for that category. Narrative metric descriptions are not used to score metrics, rather they describe values associated with a range of index values (from DEP-SOP-002/01 Table LT 7500).

Aquatic life use category	LVI Range	Description
Category 1 “exceptional”	78–100	Nearly every macrophyte present is a species native to Florida, invasive taxa typically not found. About 30% of taxa present are identified as sensitive to disturbance and most taxa have C of C values >5.
Category 2 “healthy”	38–77	About 85% of macrophyte taxa are native to Florida; invasive taxa present. Sensitive taxa have declined to about 15% and C of C values average about 5.
Category 3 “impaired”	0–37	About 70% of macrophyte taxa are native to Florida. Invasive taxa may represent up to 1/3 of total taxa. Less that 10% of the taxa are sensitive and C of C values of most taxa are <4.

E. Lake Habitat Assessment

Seven attributes known to have potential effects on the lake biota are evaluated and scored, including the categories of secchi depth, vegetation quality, stormwater inputs, bottom substrate quality, lakeside adverse human alterations, upland buffer zone, and adverse watershed land use. Based on the sum of these individual scores, overall habitat quality is assigned to one of four categories: Optimal, Suboptimal, Marginal, or Poor **(Table 5-7)**.

TABLE 5-7. Habitat Categories and Scoring Ranges.

Habitat Assessment Category	Score Range
Optimal	106-140
Sub Optimal	71-105
Marginal	36-70
Poor	7-35

Staff performed the LVI on lakes Carr, Miccosukee and Munson in 2009. In addition, staff assisted the City of Tallahassee staff with their lake sampling during the 2008 season and was able to complete LVI evaluations on lakes Hall, Bradford and Hiawatha. Both the 2008 and 2009 results are included in the Basins discussion of this report. In the future, more Leon County lakes will be evaluated using the LVI.

6. MISCELLANEOUS WATER QUALITY INFLUENCES

A. Leon County Fish Consumption Advisories

Mercury is a toxic metal that can cause learning and memory problems to children. Mercury can be naturally found in the environment or may occur due to pollution from electric power plants, mining and other industrial sources. Most Florida fish have low to medium levels of mercury. Another industrial toxin found in fish are polychlorinated biphenols (PCBs), which have been known to cause cancer and can negatively effect the immune system, reproductive system, nervous system, and endocrine system of animals including humans (http://www.epa.gov/pcb/pubs/effects.htm). To lower the risk of harm from mercury (or other contaminants) found in fish caught in Florida, the Florida Department of Health (FDOH) developed a set of guidelines based on tests of various freshwater waterbodies to allow people to determine the amount of fish to eat or avoid. The guidelines for Leon County waterbodies are shown in **Table 6-1**. For further information please visit FDOH's Fish Consumption Advisory webpage at:http://www.doh.state.fl.us/environment/medicine/fishconsumptionadvisories/index.html.

TABLE 6-1. Eating Guidelines for Leon County freshwater fish, 2009. Unless noted, mercury is the contaminant of concern. Modified from; Your Guide to eating fish caught in Florida, 2008.

Water Body	Species	Women of childbearing age, young children (# of meals)*	All Other Individuals (# of meals)*
Lake Iamonia	Bluegill, Redear sunfish	One per week	**Two per week**
	Largemouth bass, Bowfin, Gar	One per month	**One per week**
Lake Miccosukee	Bluegill	Two per week	**Two per week**
	Largemouth bass, Bowfin, Gar	One per month	**Two per week**
Lake Munson (PCBs)	Largemouth bass 19 inches or more	One per month	**One per month**
Lake Munson	Redear sunfish	One per week	**One per week**
	Black crappie, Largemouth bass, Bowfin, Gar	One per month	**One per week**
Lake Talquin	Bluegill	One per week	**Two per week**
	Redear sunfish	One per month	**Two per week**
	Black crappie	One per month	**One per week**
	Largemouth bass, Bowfin, Gar	One per month	**One per month**
Lake Tom John	Largemouth bass, Bowfin, Gar	One per month	**One per week**
Moore Lake	Largemouth bass, Bowfin, Gar	One per month	**One per month**
Ochlockonee River south of Lake Talquin Dam	Bluegill, Redbreast sunfish	One per month	**One per week**
	Redear sunfish, Warmouth	One per month	**One per month**
	Largemouth bass, Bowfin, Gar	**Do not eat**	**One per month**
Ochlockonee River north of US 90 bridge	Bluegill, Redbreast sunfish, Redear sunfish, Spotted sunfish, Warmouth	One per month	**One per week**
	Black crappie	One per month	**One per month**
	Largemouth bass, Bowfin, Gar	**Do not eat**	**One per month**
Piney Z Lake	Redear sunfish, Warmouth	Two per week	**Two per week**
	Bluegill, Brown Bullhead	One per week	**Two per week**

*All Other Individuals should eat no more than one six ounce meal per week of Largemouth Bass, Bowfin, or Gar from freshwater bodies in Florida.

B. Algal Blooms

Algae occur naturally all over the world and are part of the food chain. However, under suitable conditions, algae can proliferate (especially blue-green algae or cyanobacteria) to levels that adversely affect natural resources or humans. This is called an algal bloom. These blooms are not a new phenomenon, having been documented as early as the 19^{th} century in Florida, but the relatively recent boom in human population and land use alteration has made algal blooms more prevalent in recent years (**Figures 6-1 and 6-2)**.

Warm and calm waters with high levels of nutrients and low levels of turbidity and color are prime candidates for a bloom. These blooms can last weeks or months and turn the water bright green and can sometimes cause water to take on the appearance of green antifreeze. In most cases, blooms are most prevalent during the summer months and die back during the cold winter months.

FIG. 6-1. Lake Munson in a non algal bloom condition.

FIG. 6-2 Lake Munson algal bloom.

Algal blooms cause multiple detrimental effects to waterbodies. During daylight hours when algae produce oxygen, supersaturated oxygen levels can occur and can lead to a condition in fish known as Gas Bubble Disease (GBD) that can cause fish to die. On the other end of the spectrum, night time respiration of algae can cause oxygen supplies to be depleted in the water column, causing organisms relying on oxygen to die. Blooms can also interfere with vegetation in the water by blocking sunlight from the plants, which hinders photosynthesis and alters water temperature, causing plants to die. Blooms can also contribute to increases of unionized ammonia to levels that can harm fish.

Prolonged algal blooms also affect the foodchain. Microscopic animals, known as zooplankton, normally eat phytoplankton. Small fish eat the zooplankton, and then larger fish and other larger animals eat the smaller fish, etc. However, algal blooms are normally composed of blue-green algae. Blue-green algae are often difficult to eat or are of poor nutritional value for zooplankton. This resultant decline of zooplankton is followed by declines in small fish and then of larger fish and replacement of game fish with rough fish (St Johns Water Management District, 2005).

Another concern with algal blooms is the possibility of toxin production. Certain blue-green algae release toxins when the cells die or are ingested. There are about 20 species or groups of freshwater or freshwater-estuarine blue-green algae that are toxic or potentially toxic occurring in Florida waters. Some species isolates are not toxic, but potentially toxic cyanobacteria that are known to bloom frequently in Florida waters include *Microcystis aeruginosa, Anabaena circinalis, A. flos-aquae, Aphanizonenon flos-aquae, Cylindrospermopsis raciborskii*, and *Lyngbya wollei* (Steidinger, et al, 1999). Depending on the type of toxin produced, health effects can range from gastroenteritis, asthma or eye irritation to liver damage, paralysis, or death. For further information please refer to; http://research.myfwc.com/features/category_main.asp?id=1884 or http://www.who.int/water_sanitation_health/dwq/cyanobactox/en/index.html.

During 2009, algal blooms were reported in Lakes Munson, Talquin, Jackson, and Weeks.

C. Rainfall

The low amounts of rainfall over the past several years have led to several lakes and streams going dry. While rainfall levels are still below average, several heavy rain events including Tropical Storm Fay (2008) and heavy rain events in April and December of 2009 returned lake and stream water levels to a level that could be sampled on a regular basis.

As shown in **Figure 6-3**, the Tallahassee area has had dryer than normal conditions for seven of the last ten years. Rainfall for 2009 measured 58.21 inches (5.00 inches below normal) (National Weather Service). The wettest month was December with 10.92 inches of rain, followed closely by April with 10.18 inches of rain. The driest month was January with only 1.27 inches of rain recorded.

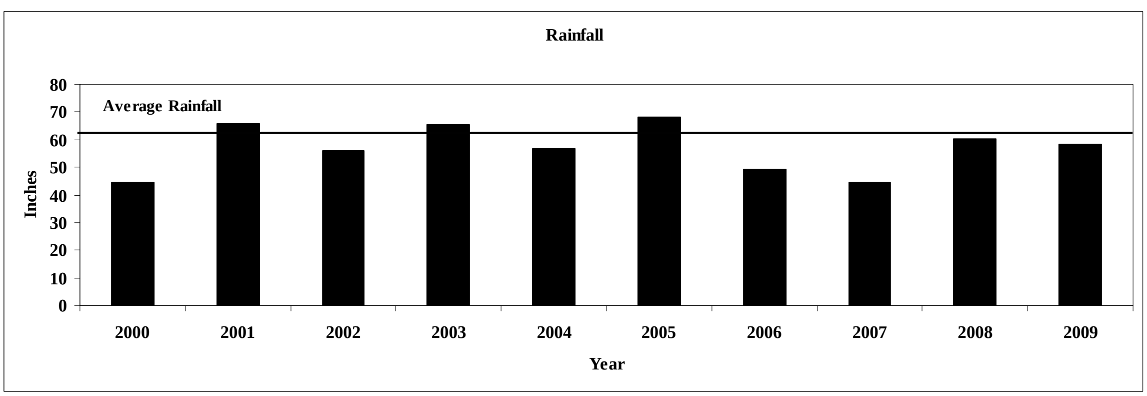


FIG. 6-3. 2000-2008 Tallahassee accumulated precipitation by year. Source: National Weather Service.

D. Land Use

One of the most important factors that affect water quality is watershed land use. Rain falling on undeveloped "natural" land normally soaks into the vegetation and soil, flows through the soil and feeds streams, lakes and aquifers. When land is developed, and vegetation cleared, soil is compacted or covered by impervious areas. Water, instead of soaking into the ground or vegetation, flows off rooftops, parking lots and roads. As the water flows, whatever lies on the surface is picked up, including fertilizers and pesticides from lawns, oil and gasoline that leak from vehicles, etc. This runoff then flows into stormwater conveyances, stormwater ponds or directly into streams or lakes. Increased impervious area and more efficient transport of stormwater runoff via pipe can cause hydrological, chemical, stream morphology, biological, and nutrient processing changes to streams and lakes **(Table 6-2)**.

TABLE 6-2. Problems generally associated with urban streams (modified from Walsh et al, 2005). Responses are those that have been observed to increase (↑) or decrease (↓) with increased urbanization.

Feature	Response
Hydrology	↑ Frequency of overland flow
	↑ Frequency of erosive flow
	↑ Magnitude of high flow
	↓ Lag time to peak flow
	↑ Rise and flow of storm hydrograph
Water Chemistry	↑ Nutrients
	↑ Toxicants
	↑ Temperature
Channel Morphology	↑ Channel Width
	↑ Pool depth
	↑ Scour
	↑ Channel complexity
Organic Matter	↓ Water Retention
Fishes	↓ Sensitive Fishes
Invertebrates	↑ Tolerant Invertebrates
	↓ Sensitive Invertebrates
Algae	↑ Eutrophic diatoms
	↓ Oligotrophic diatoms
Ecosystem Processes	↓ Nutrient uptake

In determining possible sources and causes of water quality and biological issues, land use tables were created in the fall of 2006 from utilizing the Tallahassee Leon County (TLC) - Planning Department's Existing Landuse 2003 data set, Florida Fish and Wildlife Commission's Habitat and Landuse 2003 data set, and Leon County Property Appraisers' Parnal data set. These tables are included in each waterbody summary page with the exception of waterbody basins/watersheds that extended outside Leon County information.

Unfortunately, Leon County's GIS coverage does not extend beyond Leon County, so accurate land use is not readily available for areas outside the county. This limitation affects the Ochlockonee River, St. Marks River, Lake Talquin, Lake Iamonia, and Lake Miccosukee. Because of this limitation, land use tables are not provided for these waterbodies.

7. THE TOTAL MAXIMUM DAILY LOAD PROGRAM

A Total Maximum Daily Load (TMDL) is a calculation that specifies the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and allocates pollutant loadings among point and nonpoint pollutant sources. Under Section 303(d) of the federal Clean Water Act and the Florida Watershed Restoration Act, TMDLs must be developed for all waters that are not meeting their designated uses and, consequently, are defined as "impaired waters". If a state, territory, or authorized tribe submission is inadequate, EPA must establish the list or the TMDL (www.epa.gov/owow/tmdl/intro.html), (http://www.dep.state.fl.us/water/tmdl/index.htm).

The TMDL program is important since over 40% of assessed waters in the United States still do not meet the water quality standards that states, territories, and authorized tribes have set for them. This amounts to over 20,000 individual river segments, lakes, and estuaries. These impaired waters include approximately 300,000 miles of rivers and shorelines and approximately 5 million acres of lakes -- polluted mostly by sediments, excess nutrients, and harmful microorganisms. An overwhelming majority of the population - 218 million people – live within ten miles of polluted water (www.epa.gov/owow/tmdl/intro.html).

The Florida Department of Environmental Protection (FDEP) manages the TMDL program for the state of Florida and develops, allocates, and implements the program through a watershed-based management phased approach that addresses the 52 major hydrologic basins throughout the state. These basins are placed in five groups and undergo a five phase cycle on a rotating schedule. Leon County is included with the Group 1 basins. The following descriptions of each particular phase are taken in part from: http://www.dep.state.fl.us/water/tmdl/docs/TMDL_Program_Overview.pdf.

I. TMDL Procedure

A. Phase 1

FDEP conducts an initial water quality assessment in the basin and determines information required, accepted methods of data collection and analysis and quality control/quality assurance requirements. Planning lists are then developed; highlighting waters that are potentially impaired and then developing strategic monitoring plans for further data collection.

B. Phase 2

During Phase 2, FDEP, with close coordination with local monitoring entities, conducts strategic monitoring to meet priority information needs; conducts integrated monitoring assessment using EPA guidance; derives a revised planning list and a draft verified list of impaired waters for public comment; adopts Group-specific verified list of impaired waters by rule for submittal to EPA as 303(d) waters for which TMDLs will be established.

C. Phase 3

For waterbodies or segments on the adopted verified list of impaired list waters, FDEP will develop and adopt TMDLs with input from stakeholders. During Phase 3, FDEP establishes TMDLs for waterbodies or water segments verified as impaired.

D. Phase 4

Stakeholders affected by TMDLs will work with FDEP and other affected agencies to reach consensus on load reduction allocations and strategies, leading to development of a Basin Management Action Plan (B-MAP). Since pollutants can enter waterbodies through point source discharges (generally from a specific facility) or nonpoint discharges (stormwater runoff, etc.), all contributors to these discharges will be asked to share the responsibility of attaining TMDLs through load allocations (the amount of specified pollutant allotted for discharge) that are based on an established TMDL.

E. Phase 5

FDEP will take the lead in coordinating the implementation of TMDLs, which may be carried out through non-regulatory and existing water quality protection programs. Implementation will involve local government National Pollutant Discharge Elimination System (NPDES) stormwater programs, local restoration projects, private sector partnerships, Best Management Practices (BMPs), etc., as provided in the B-MAP.

II. Status of TMDLs in Leon County

Currently, FDEP verified lists are available at: http://www.dep.state.fl.us/water/watersheds/assessment/adopted_gp1-c2.htm. Planning lists are not available on-line at this time. **Table 7-1** lists EPA and FDEP TMDL sites, pollutant of concern and percentage reduction needed for compliance with the TMDLs established. Since the City of Tallahassee has water quality sampling programs already in place, Leon County normally does not sample inside the City limits; therefore, Godby, Central, East Drainage Ditch as well as St. Augustine Branch are not currently being sampled by the County.

Table 7-1. TMDL listings, pollutants of concern and % reduction needed for compliance for TMDLs that are inside Leon County's borders.

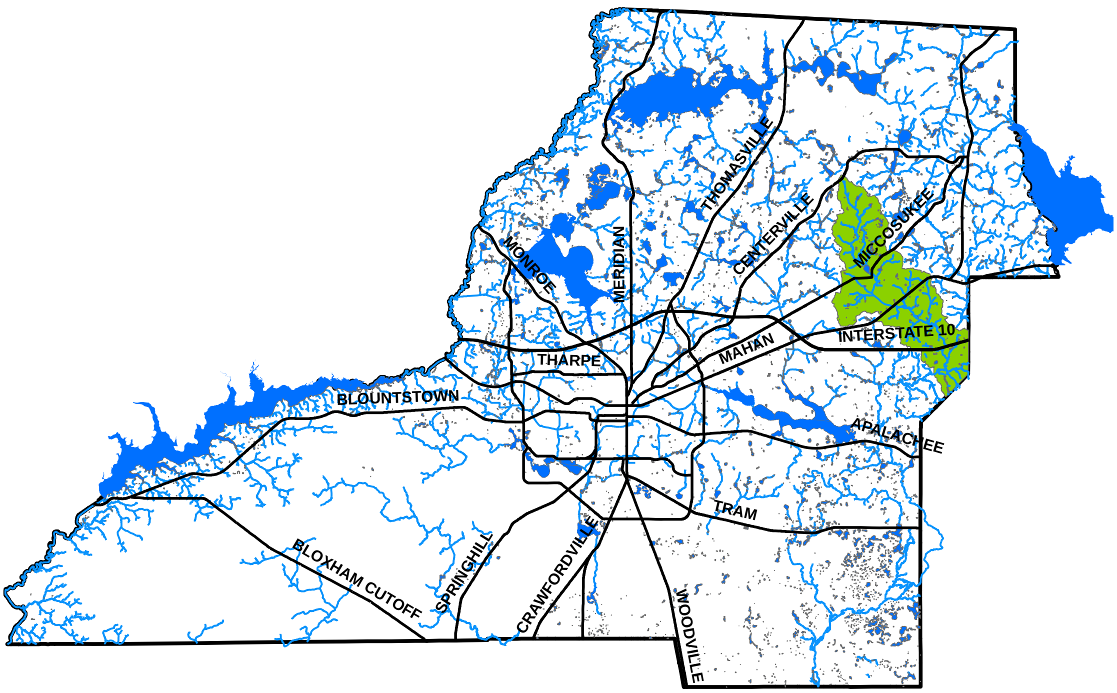
Water Body	Parameter of Concern	Existing Load	TMDL Target	% Reduction
Northeast Drainage Ditch	Fecal Coliform	*	400	63%
Northeast Drainage Ditch	Total Coliform	*	2400	52%
Harbinwood Estates	Total Phosphorus	0.23 mg/L	0.15 mg/L	35%
Godby Ditch	Total Phosphorus	0.16 mg/L	0.15 mg/L	6%
Central Drainage Ditch	Total Nitrogen	0.73 mg/L	0.72 mg/L	1%
Central Drainage Ditch	Fecal Coliform	900	400	56%
Central Drainage Ditch	Total Coliform	33500	2400	93%
St. Augustine Branch	Total Nitrogen	1.03 mg/L	0.72 mg/L	30%
St. Augustine Branch	Fecal Coliform	1601	400	75%
St. Augustine Branch	Total Coliform	12250	2400	80%
East Drainage Ditch	Fecal Coliform	2350	400	83%
East Drainage Ditch	Total Coliform	4050	2400	41%
Munson Slough (upstream of Lake Munson)**	BOD_5	*	2.00 mg/L	50.0%
Munson Slough (upstream of Lake Munson)	Total Nitrogen	*	0.72 mg/L	8.35%
Munson Slough (upstream of Lake Munson)**	Total Phosphorus	*	0.15 mg/L	17.53%
Lake Munson**	Total Nitrogen	*	95074 lbs/yr	46%
Lake Munson **	Total Phosphorus	*	5439 lbs/yr	82%
Lake Munson **	BOD_5	*	2.00 mg/L	50.0%
Lake Munson**	Turbidity	*	31	31.9%
Munson Slough (downstream of Lake Munson)**	NH_3N	*	0.32 mg/L	33.30%
Munson Slough (downstream of Lake Munson)**	BOD_5	*	2.00 mg/L	52.94%
Munson Slough at Roberts Ave.	Fecal Coliform	*	400	47%
Munson Slough at Springhill Rd.	Fecal Coliform	*	400	97%
Munson Slough at Capital Circle	Fecal Coliform	*	400	73%
West Black Creek	Fecal Coliform	*	400	40%

* Existing loads were not included in the original report.

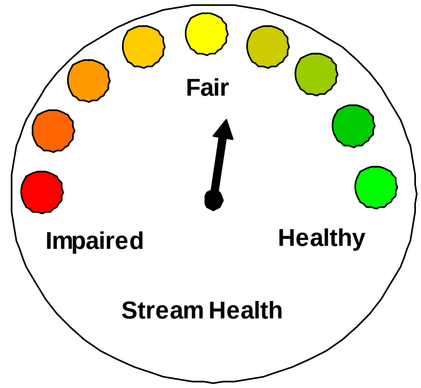
** Proposed TMDL

8. BASINS

8.1. Bird Sink Basin



A. Northeast Black Creek



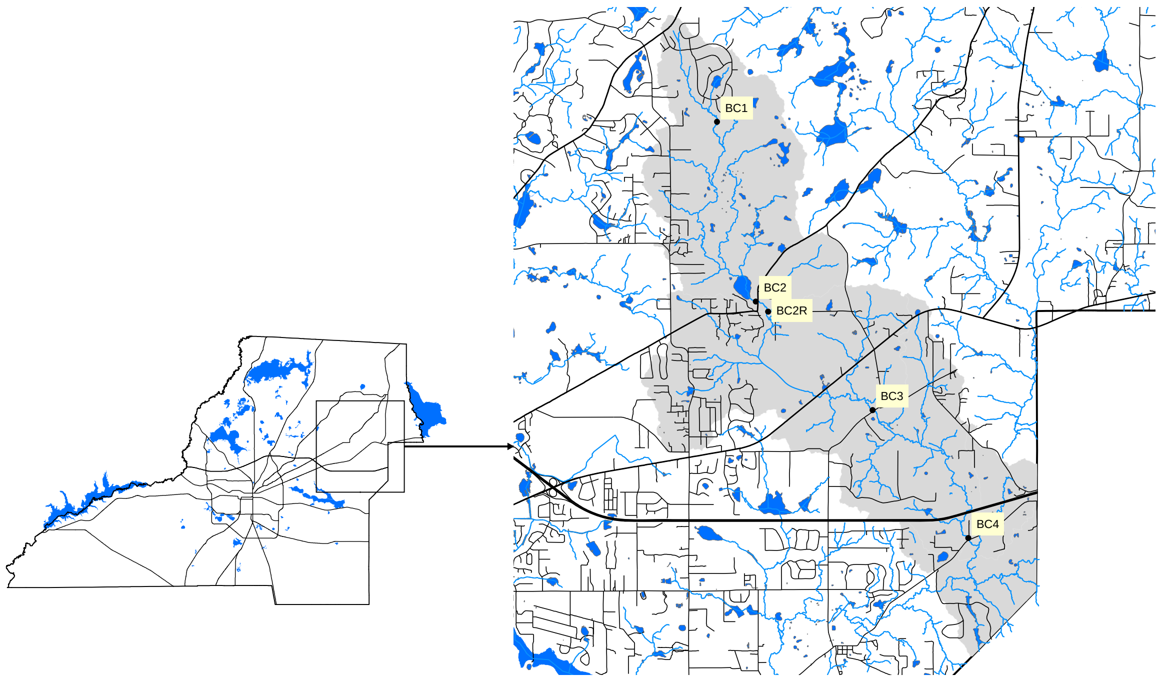


FIG. 8.1-1. Overview Map of the Northeast Black Creek Watershed.

Northeast Black Creek is a tannic, acidic predominantly nitrogen-limited stream located in northeast Leon County **(Figure 8.1-1)**. The stream forms near Centerville Road and the Chemonie Plantation subdivision flows southeast through the Miccosukee Land Cooperation before crossing under Capitola Road. Black Creek then turns northeast to join Still Creek and then flows into Bird Sink.

As shown in **Figure 8.1-2**, approximately 33% of the Northeast Black Creek watershed is comprised of residential, agriculture, and transportation land uses. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses. The developed land in the watershed creates a greater increase in storm flow following rain events. This results in greater than normal erosion and sediment transfer; increasing nutrients in the water column as well as degrading habitat used by aquatic organisms.

Due to past drought, several stations were dry during the sampling period. When viewing figures, the absence of station bars mean no samples were collected due to lack of water in the stream. Station BC2 was dropped in 2009 and replaced with Station BC2M for access reasons.

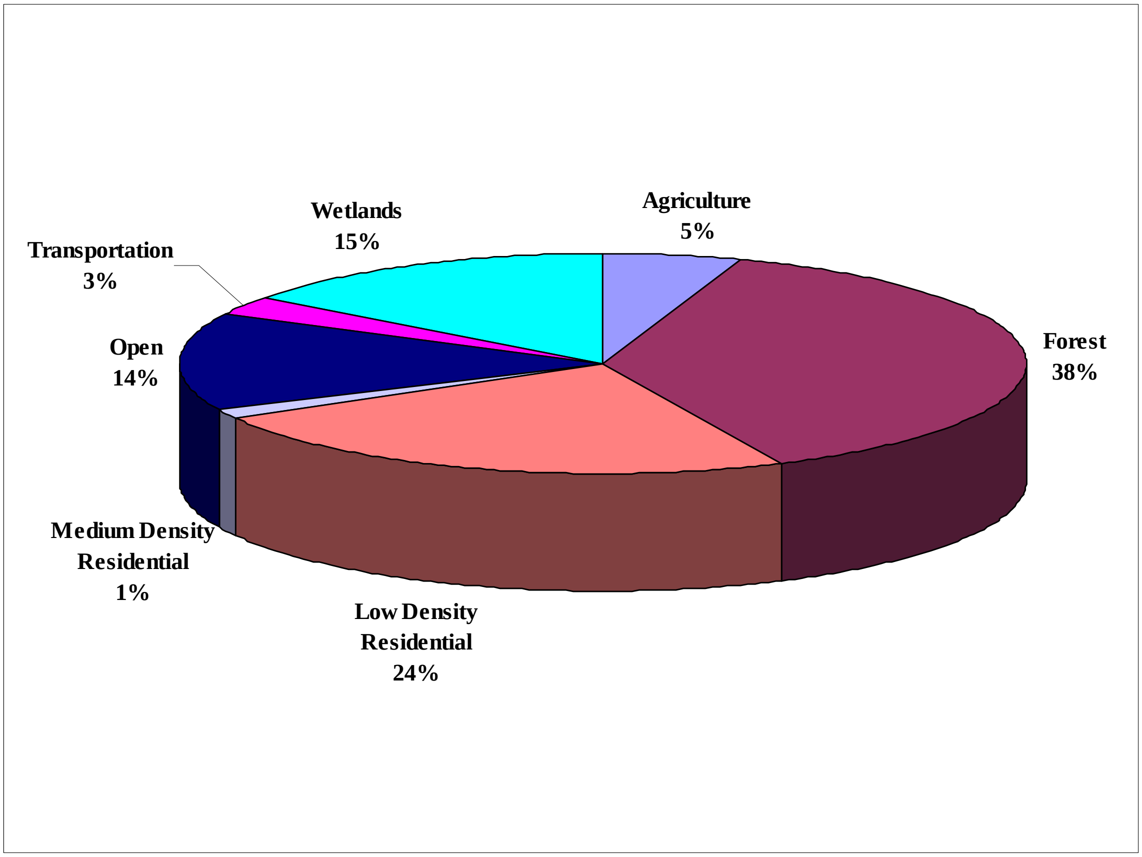


FIG. 8.1-2. Land use in the Northeast Black Creek watershed (11,868 acres).

At times, fecal coliform levels were elevated above the 800 maximum exceedance Class III water quality standards at stations BC1, BC3 and BC4 **(Figure 8.1-3)**. DO levels did not meet Class III water quality standards during some sampling events **(Figure 8.1-4)**. Although low gradient tannic streams naturally have low DO levels, elevated BOD levels during some sampling events showed that elevated biological activity may be contributing to low DO **(Figure 8.1-5)**. The elevated 4th quarter 2009 BOD levels cannot be linked to elevated nutrients or depressed DO levels. Elevated TKN levels at stations BC2, BC3, and BC4 during the May 2008 sampling event (BC3 values were higher than levels found in 80% of Florida streams) and elevated nitrate + nitrite levels during the same time period demonstrate that ammonia, organic nitrogen, and nitrate + nitrite may have contributed to the low DO problem during that sampling event **(Figures 8.1-6 and 8.1-7)**. Residential development in the watershed could result in elevated nutrient levels and incidence of fecal coliforms (due to improperly functioning septic tanks) in the naturally shallow stream. Other causes could be wild animals and agriculture.

Elevated ammonia levels during the last two quarters of 2009 can be attributed to a change in the laboratory detection limits. Total and ortho-phosphorus levels were cyclic in nature due to increased biological activity during the warmer parts of the year **(Figures 8.1-8 and 8.1-9)**. Fertilizer application during the warmer spring and summer months could be a factor in the phosphorus levels.

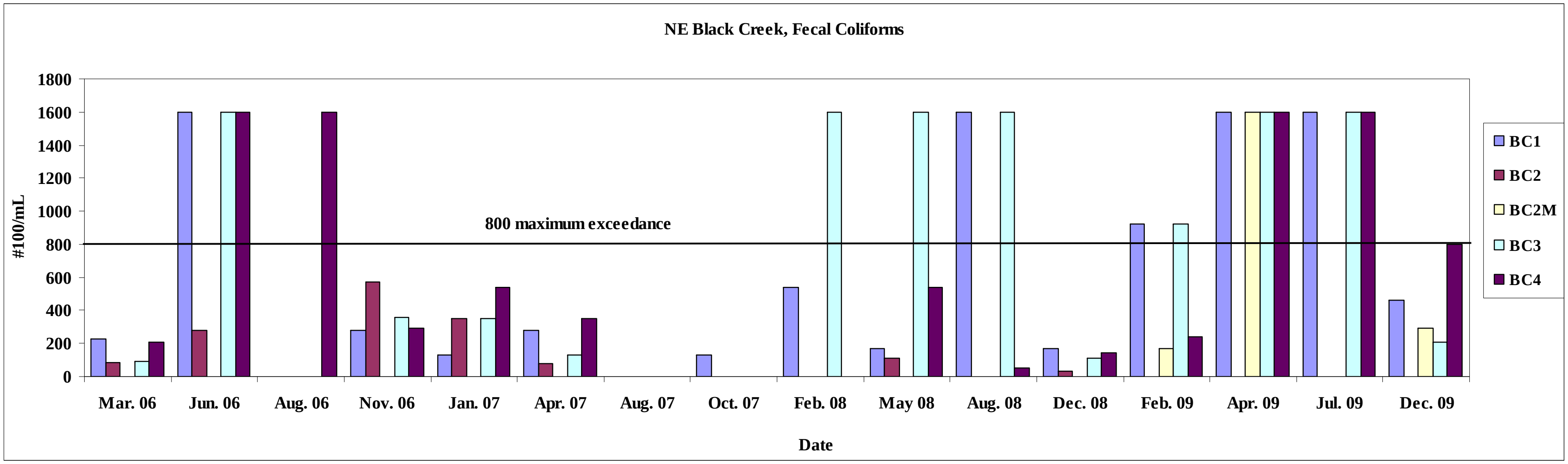


FIG. 8.1-3. Parameter of concern.

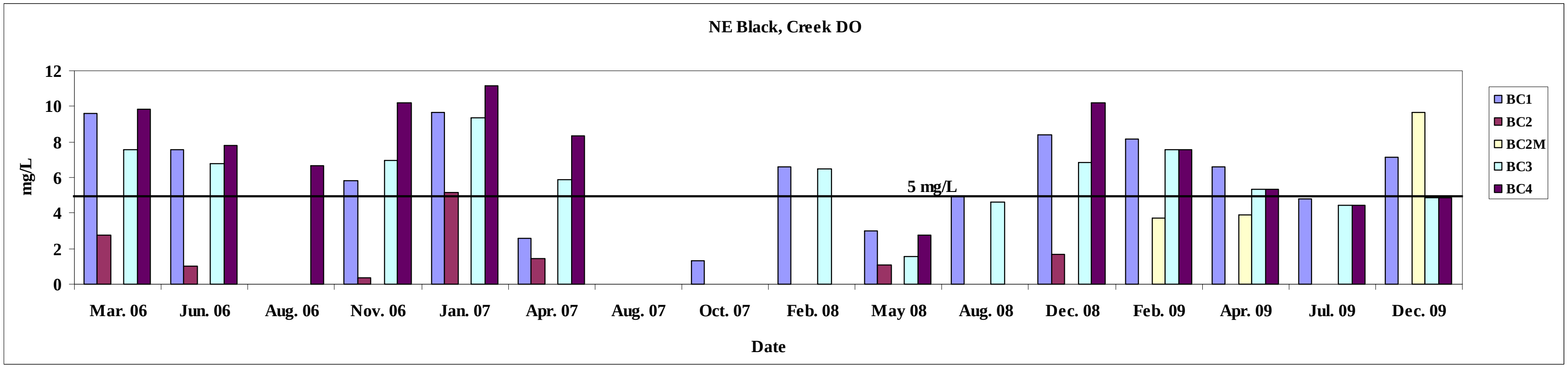


FIG. 8.1-4. Parameter of concern.

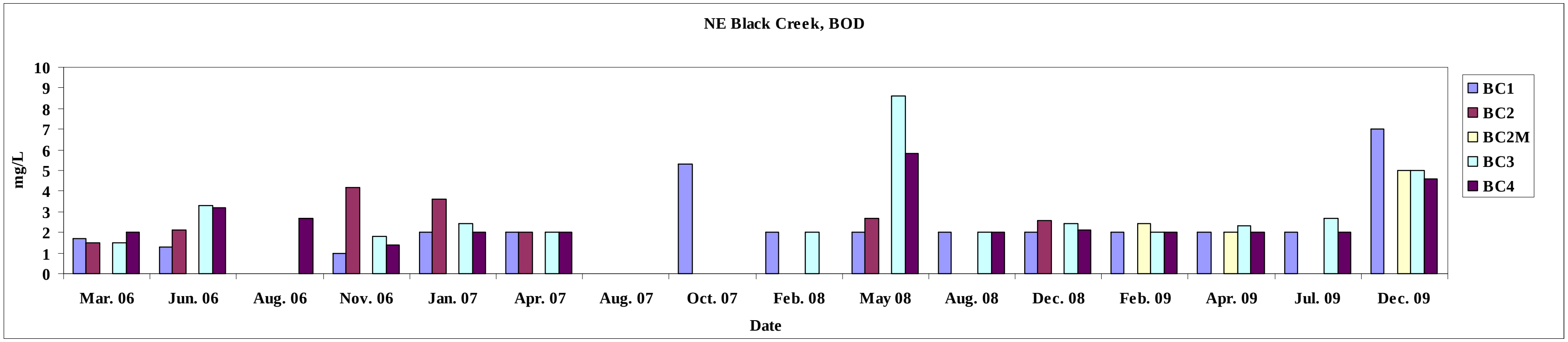


FIG. 8.1.5. Parameter of concern.

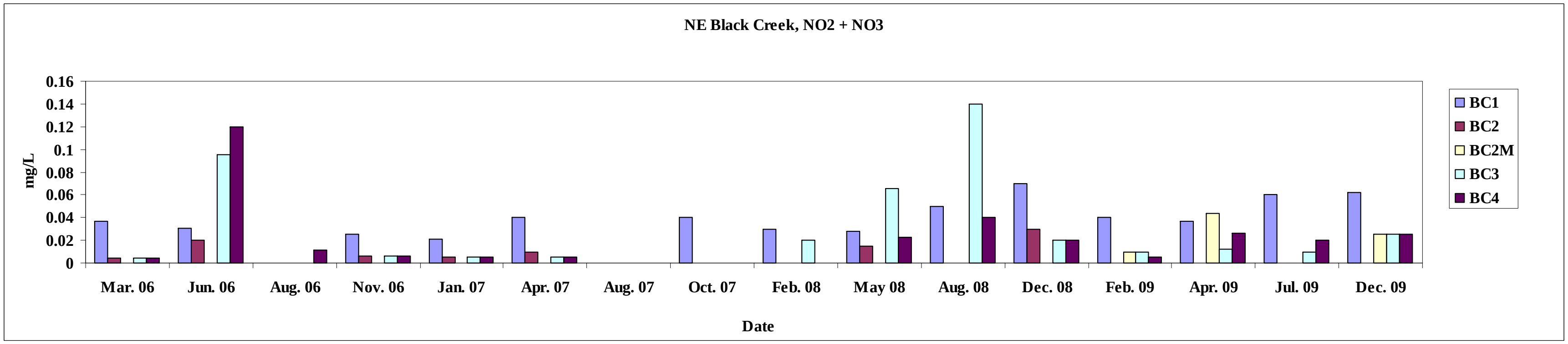


FIG. 8.1-6. Parameter of concern.

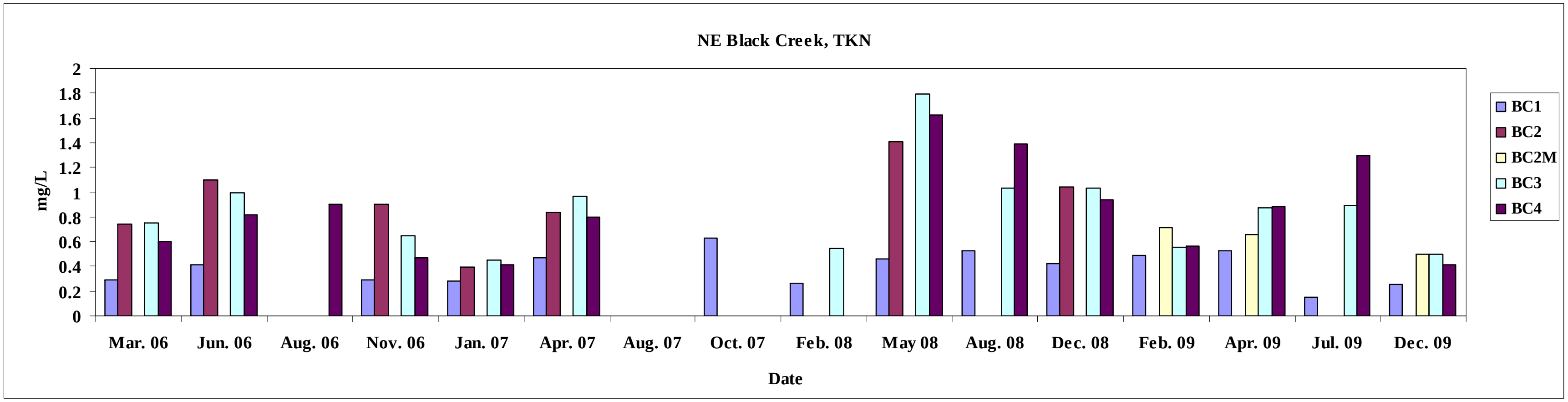


FIG. 8.1-7. Parameter of concern.

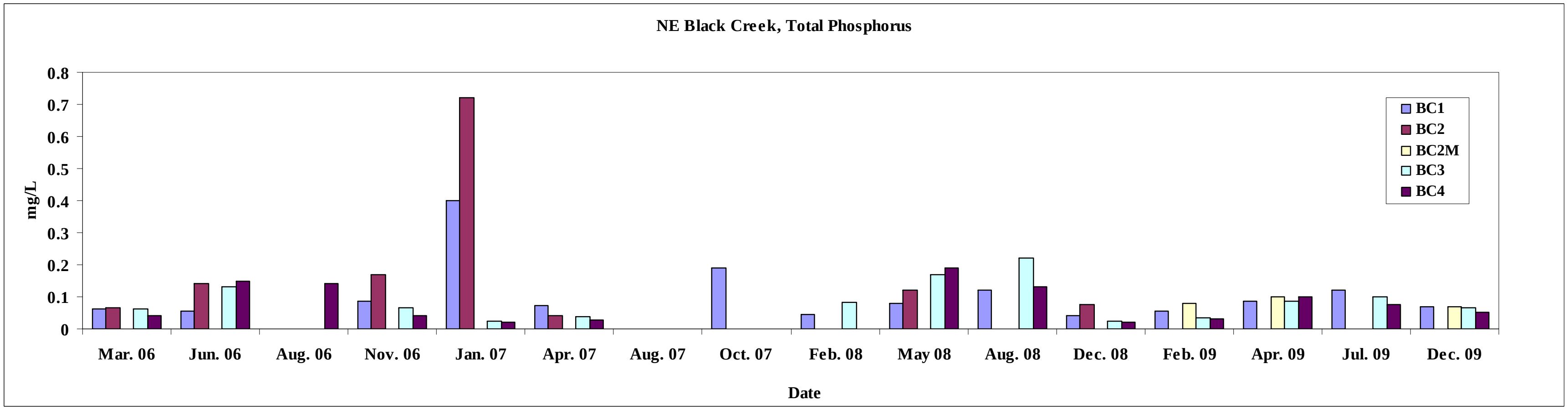


FIG. 8.1-8. Parameter of concern.

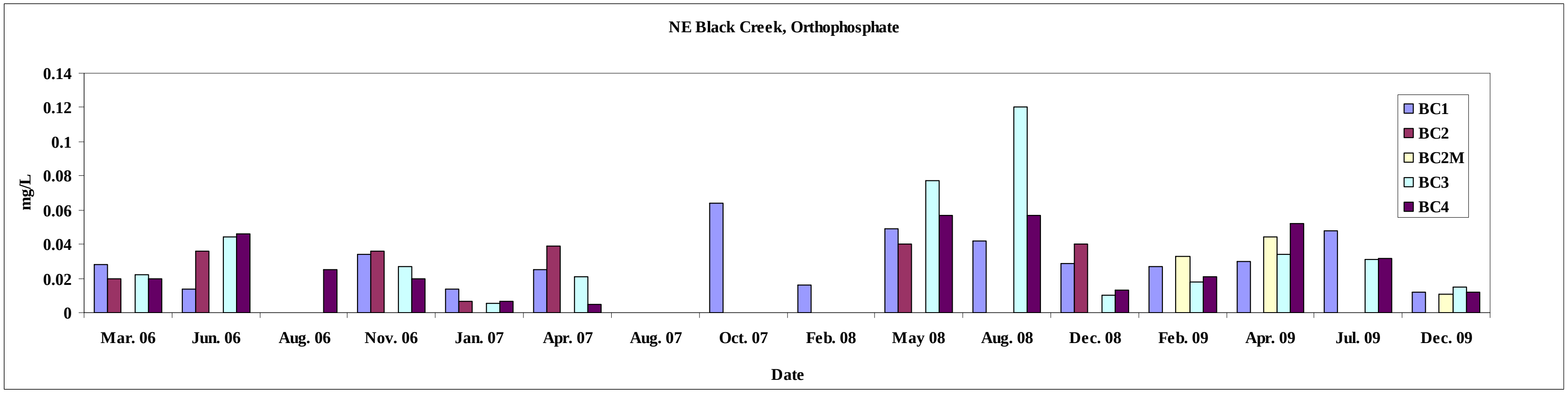


FIG. 8.1-9. Parameter of concern.

B. Stream Condition Index

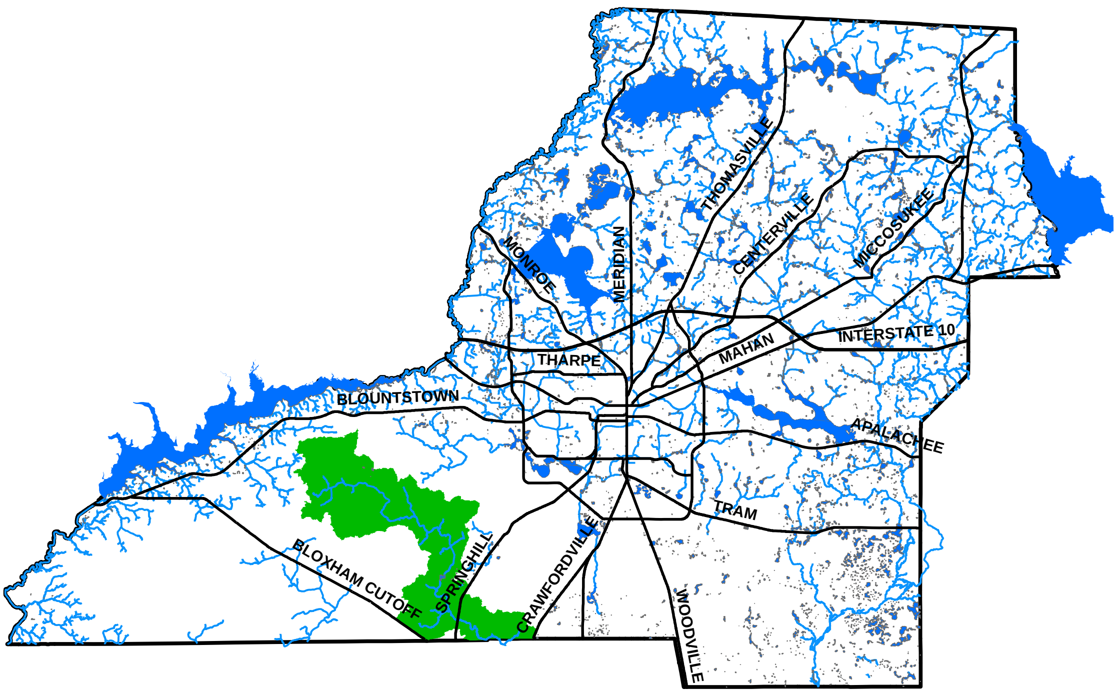
The SCI scores for BC1 (53), BC3 (44) and BC4 (42) were all in the healthy range while the habitat assessment scores for BC1 (120) and BC4 (123) were in the upper range of the sub optimal category while BC4's score (124) was in the optimal category **(Table 8.1-1)**.

The habitat assessment showed that bank stability, riparian zone width and vegetation quality, and bank stability at all stations were in the optimal or sub-optimal category. Substrate diversity and availability were in the marginal or poor category at stations BC1 and BC3 while BC4's substrate diversity and availability were in the sub-optimal and poor category.

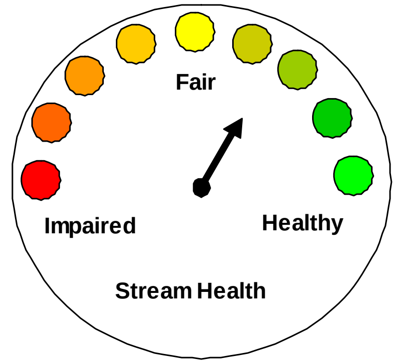
TABLE 8.1-1. SCI and Habitat Assessment scores and interpretation.

Black Creek	**BC1 Dup 1**	**BC1 Dup 2**	**BC3 Dup 1**	**BC3 Dup 2**	**BC4 Dup 1**	**BC4 Dup 2**
SCI Metric						
Total Taxa	41	32	27	23	31	25
Ephemeroptera Taxa	1	1	1	0	2	2
Trichoptera Taxa	1	2	1	1	1	1
% Filterer	36.45	39.35	61.7	58.45	54.6	61.35
Long-lived Taxa	2	2	0	1	0	1
Clinger Taxa	3	3	3	3	4	6
% Dominance	12.7	13.5	24.1	24.7	40	44.7
% Tanytarsini	22.8	16.9	17.7	25.4	10	12.7
Sensitive Taxa	5	4	5	3	4	8
% Very Tolerant Taxa	11.2	11.4	4.2	11.3	11.4	5.3
Total SCI Score	**54.61**	**52.04**	**45.58**	**41.74**	**39.10**	**44.88**
Average of two aliquots	**53**		**44**		**42**	
Score Interpretation	**Healthy**		**Healthy**		**Healthy**	
Habitat Assessment Score	**120**		**123**		**124**	
Score Interpretation	**Sub Optimal**		**Sub Optimal**		**Optimal**	

8.2. Fisher Creek Basin



A. Fisher Creek



Fisher Creek is a phosphorus limited tannic stream located in the Apalachicola National Forest in southwestern Leon County **(Figure 8.2-1)**. The stream flows north to southeast and eventually enters the Floridian aquifer via a sink. Dye trace studies have linked the flow of water in Fisher Creek to Wakulla Springs.

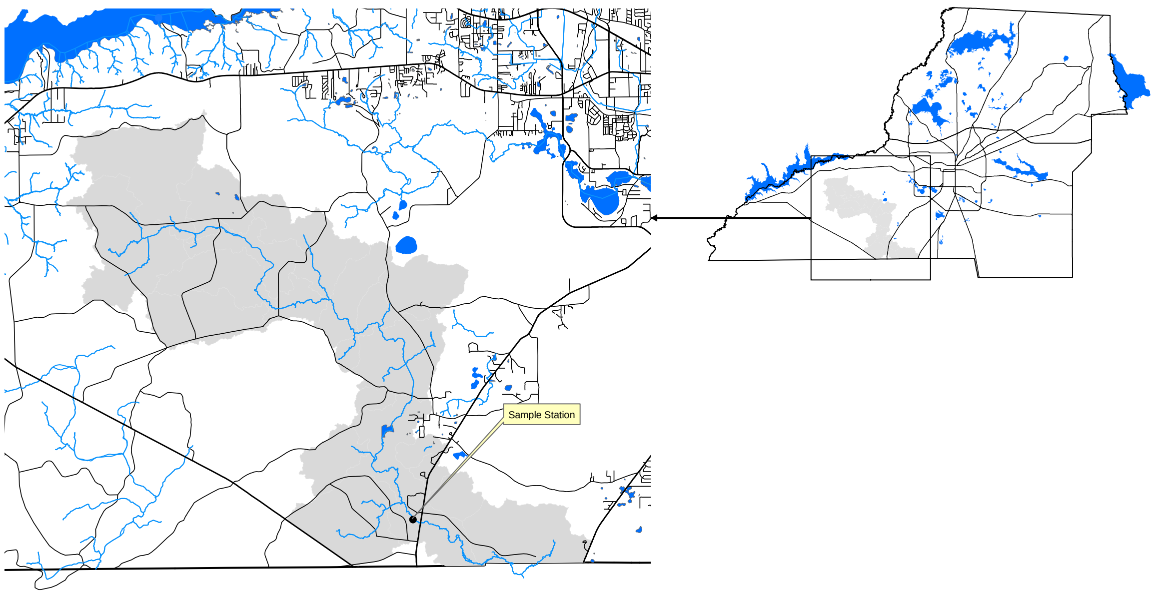


Figure 8.2-1. Overview Map of Fisher Creek Basin.

Figure 8.2-2 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Residential and transportation uses make up approximately 2% of the watershed.

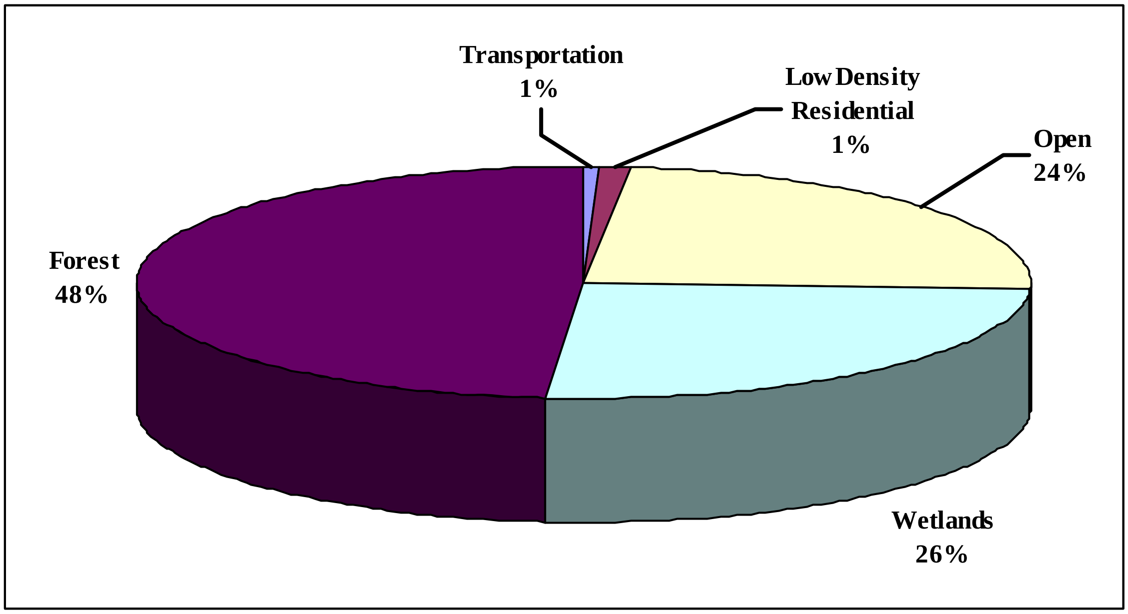


FIG. 8.2-2. Land use in the Fisher Creek watershed (20,083 acres).

With the exception of elevated TKN levels **(Figure 8.2-3)** during the August 2008 sampling period, nutrients were low when compared to other Florida streams. The elevated TKN level can be attributed to the high levels of organic nitrogen that were washed into Fisher Creek during the Tropical Storm Fay event. Elevated BOD levels during the May 2008 and February 2009 sampling events **(Figure 8.2-4)** can not readily be explained. Elevated color levels during the June and December 2009 sampling events can be attributed to tannin laden runoff associated with heavy rains in the area **(Figure 8.2-5)**. Dissolved oxygen and fecal coliform levels complied with Class III water quality standards.

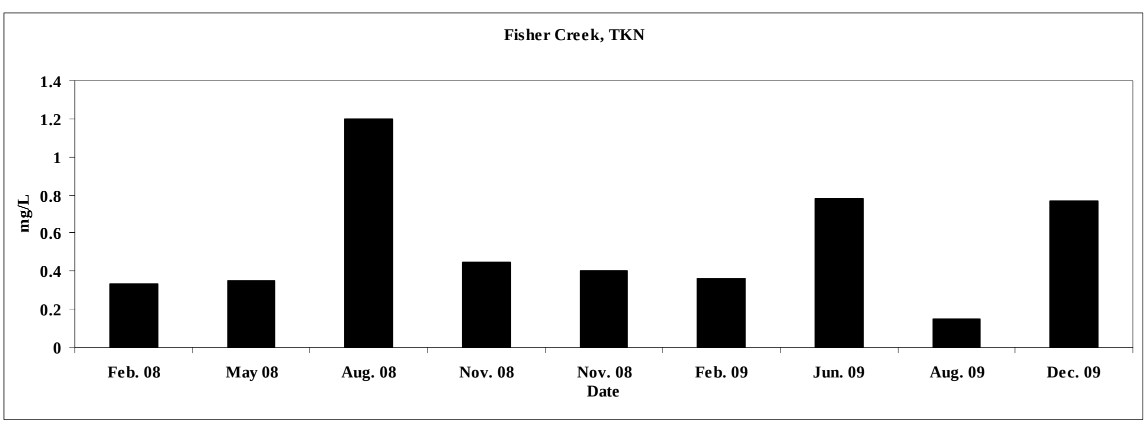


FIG. 8.2-3. Parameter of interest.

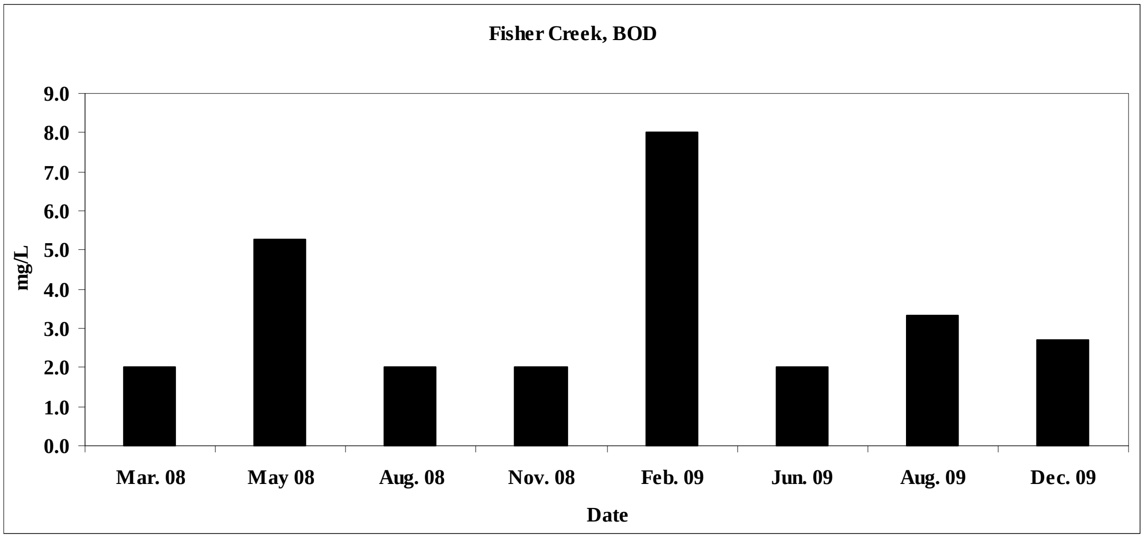


FIG. 8.2-4. Parameter of concern.

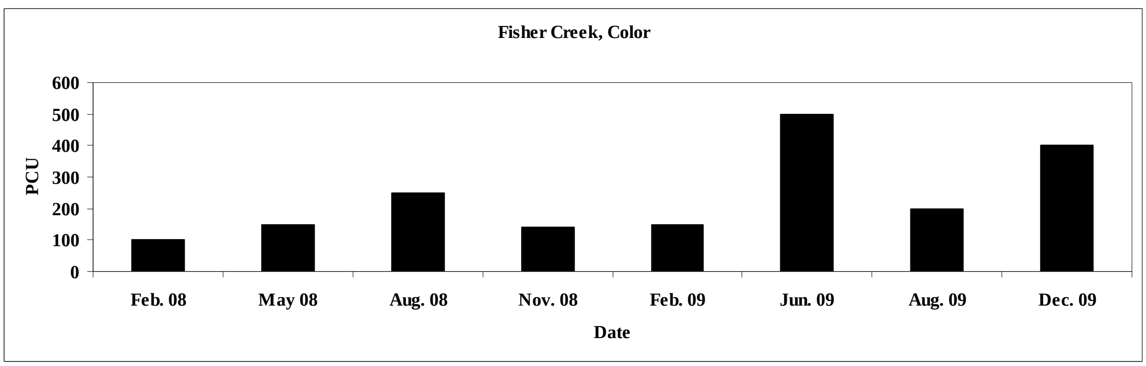
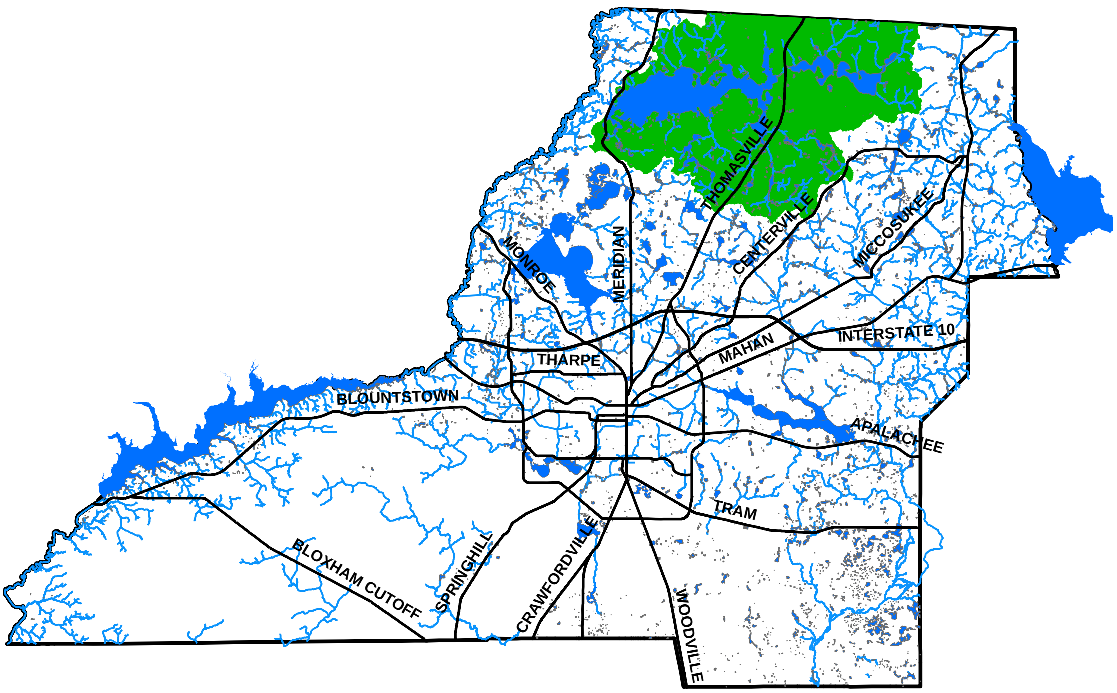
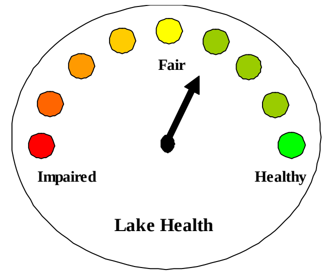


FIG. 8.2-5. Parameter of interest.

8.3. Lake Iamonia Basin



A. Lake Iamonia



The largest waterbody in the county, Lake Iamonia is an approximately a 5,554 acre, shallow, flat-bottomed, phosphorus limited, prairie lake located in northern Leon County **(Figure 8.3-1)**. Drastic water level fluctuations occur from discharge to the sinkhole and receiving floodwaters from the Ochlockonee River. Various control structures were constructed in order to attempt to control water level fluctuations.

Starting in the early 1900's, various management practices, especially water-level stabilization and changes in land use, have led to the overabundance of aquatic plants and the accumulation of organic sediment in Lake Iamonia which impede recreational usage and threaten its fish, wildlife, and ecosystem integrity (Camp, et al, 1991). One of the largest modifications occurred in 1939, when an earthern dam was constructed to isolate the 20-acre sink basin from the lake. Other modifications continued with the latest being the removal of two gates that were formerly used to control water level. Prior to their removal (2007), the gates had been locked open since 1980, due to the fact that the Northwest Florida Water Management District deemed the dam to be unsafe for impounding water (Hill, 2007). These latest modifications have been performed in order to protect the public and to allow the lake to have more naturally fluctuating water levels. Water quality monitoring is continuing to be used to evaluate the long term health of the lake.

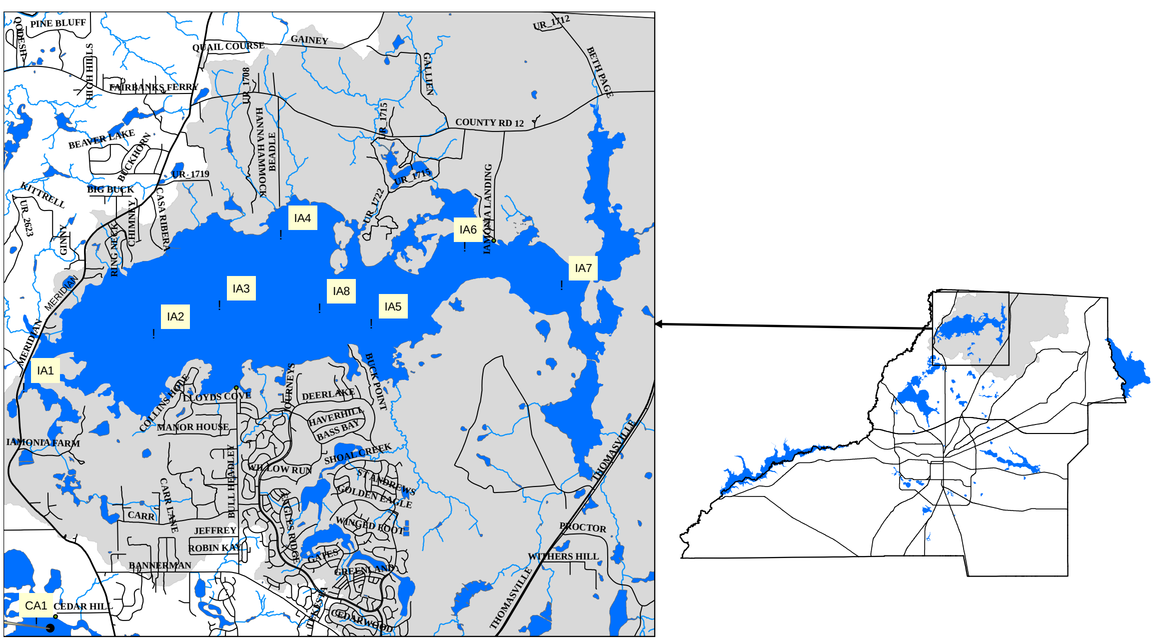


FIG. 8.3-1. Lake Iamonia basin with locations of Lake Iamonia water quality sampling stations shown.

Unfortunately, low water levels caused by drought meant certain water quality stations could not be sampled during some months**.** Conversely, substantial inflow from the

Ochlockonee River due to Tropical Storm Fay and subsequent flooding of Lake Talquin probably had an impact on water quality.

Figures 8.3-2 and **8.3-3** represents the Lake Iamonia's trophic state utilizing the FDEP Trophic State Index. Seasonal and yearly averages show that Lake Iamonia did not exceed the 60 threshold and would not be considered impaired according to FDEP standards.

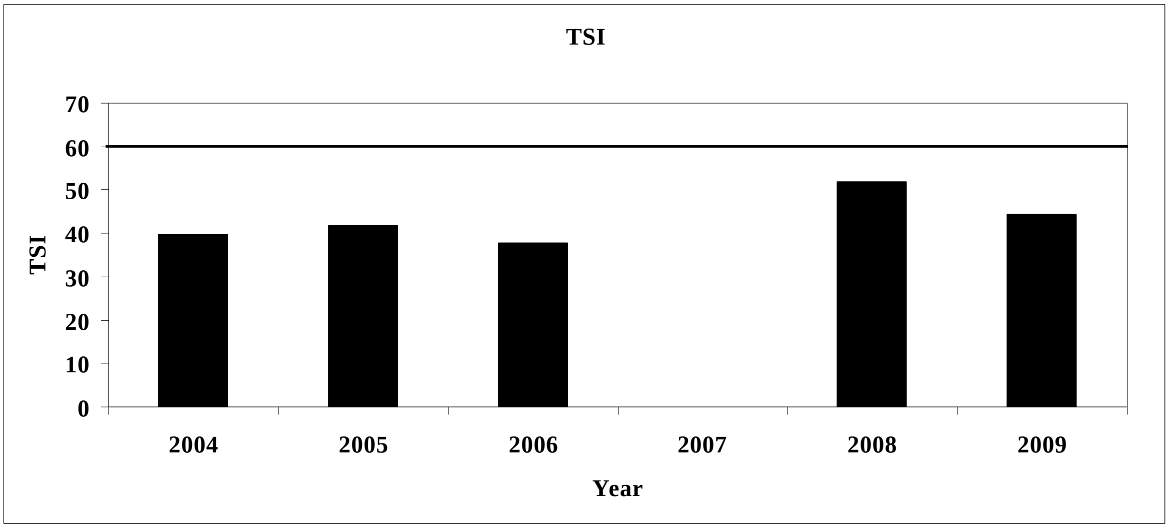


FIG. 8.3-2. Lake Iamonia trophic state index (yearly average). Bars exceeding a TSI of 60 indicate impairment. Yearly TSI score for 2007 was not calculated due to lack of 4th quarter data.

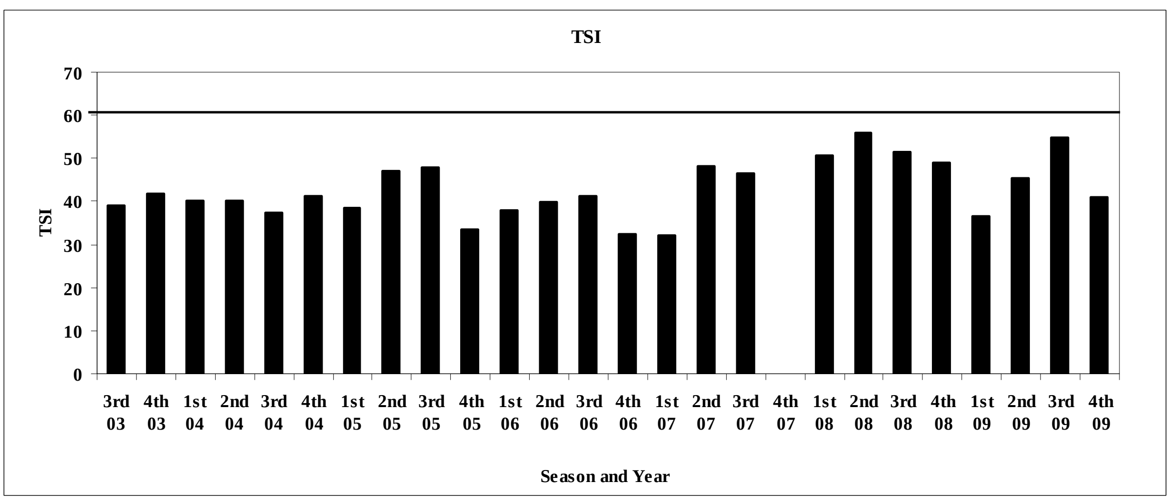


FIG. 8.3-3. Lake Iamonia trophic state index (seasonal average). Bars exceeding a TSI of 60 would indicate impairment.

Dissolved oxygen levels have consistently been low during summer months and frequently did not meet Class III water quality standards **(Figure 8.3-4)**. This could be due to aquatic plant growth covering the surface of the lake, suppressing any algal photosynthetic activities in the water column. Another factor is the increasing biological activity during the warmer months utilizing more oxygen than can be replaced. Contributing to lower oxygen levels during the warmer months is the water's inability to hold higher levels of oxygen, due to decreased oxygen solubility at higher water temperatures.

Leon County Public Works staff and the Department of Health were notified about a possible illicit discharge from a septic tank pump-out vehicle at the Bull Headley boat ramp that occurred sometime in December of 2009. Subsequent fecal coliforms levels at that station showed coliform levels (900/100 mL) exceeding the FDEP's 800 #/100 mL limit. Fecal coliforms levels at station IA7 (920/100mL) also exceeded FDEP's 800 #/100 mL limit during the October 2009 sampling event.

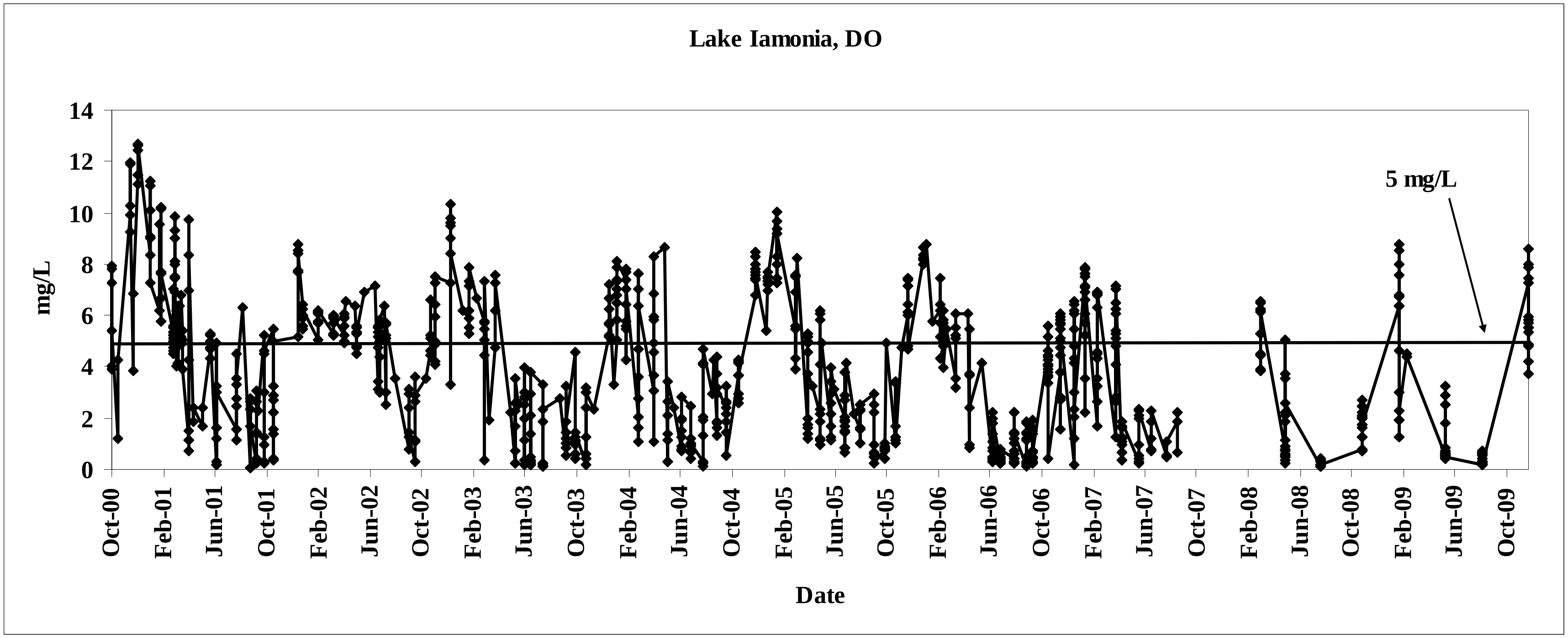
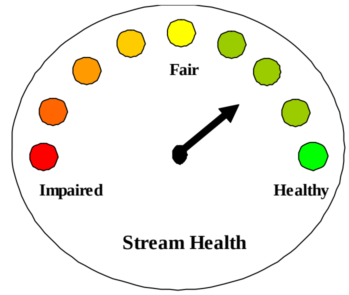


FIG. 8.3-4. Parameter of concern. Markers represent individual measurements. Starting in June 2006, top, mid-depth, and bottom DO measurements were taken where appropriate.

B. Tall Timbers Creek # 1



Tall Timbers Creek #1 is a tannic stream located in northwest Leon County **(Figure 8.3-5).** The stream flows south under County Road 12 through the Tall Timbers Research Station and Land Conservancy, eventually entering Lake Iamonia.

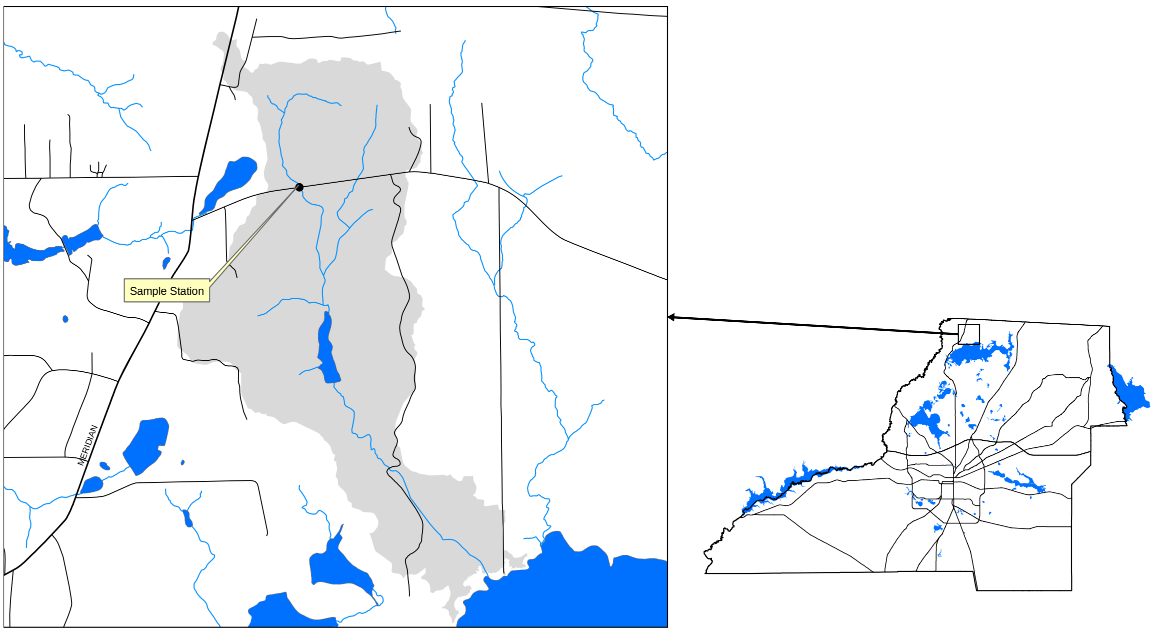


FIG. 8.3-5. Overview Map of Tall Timbers Creek #1 watershed.

As shown in **Figure 8.3-6**, approximately 16% of land use in the Tall Timbers Creek watershed is residential, agriculture, or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

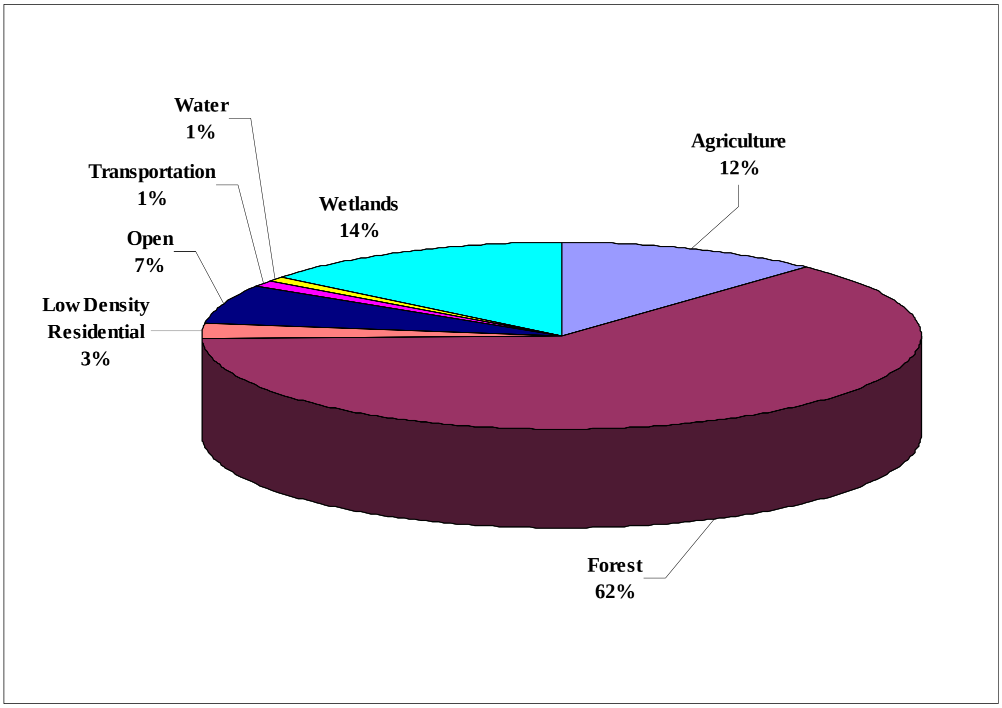


FIG. 8.3-6. Land use in the Tall Timbers Creek watershed (574 acres).

Dissolved oxygen values were below the 5 mg/L Class III water quality standard during several sampling dates **(Figure 8.3-7)**. Low gradient, tannic streams typically have low DO levels, so this may be a natural occurrence. Fecal coliforms exceeded FDEP's 800 #/100 mL limit several times over the sampling period **(Figure 8.3-8)**. Agriculture/animal shelters located upstream of the sampling site may have contributed to the elevated fecal coliform values. Total phosphorus, TKN and nitrite + nitrate values were relatively low when compared to other Florida streams.

Elevated turbidity (**Figure 8.3-9)**, total suspended solids, nitrogen, and phosphorus levels during the December 2009 sampling event were attributed to overland runoff associated with the 1.7 inch rainfall that occurred the day of the sampling event. Turbidity exceeded Class III water quality standards for the same event. Significant slopes directing runoff to the stream are susceptible to erosion during high intensity rain events. This appeared to contribute to the isolated high turbidity values reported.

The 2009 SCI score (58) was in the healthy range **(Table 8.3-1)**. The habitat assessment score total (130) for Tall Timbers Creek #1 was in the optimal category and showed low substrate diversity, sub-optimal water velocity and riparian zone vegetation quality.

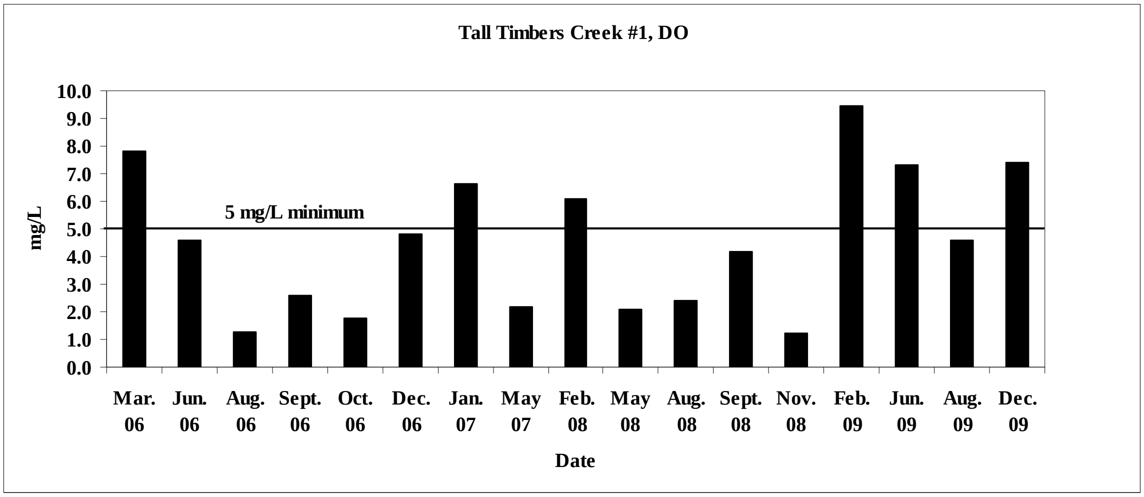


FIG. 8.3-7. Parameter of concern.

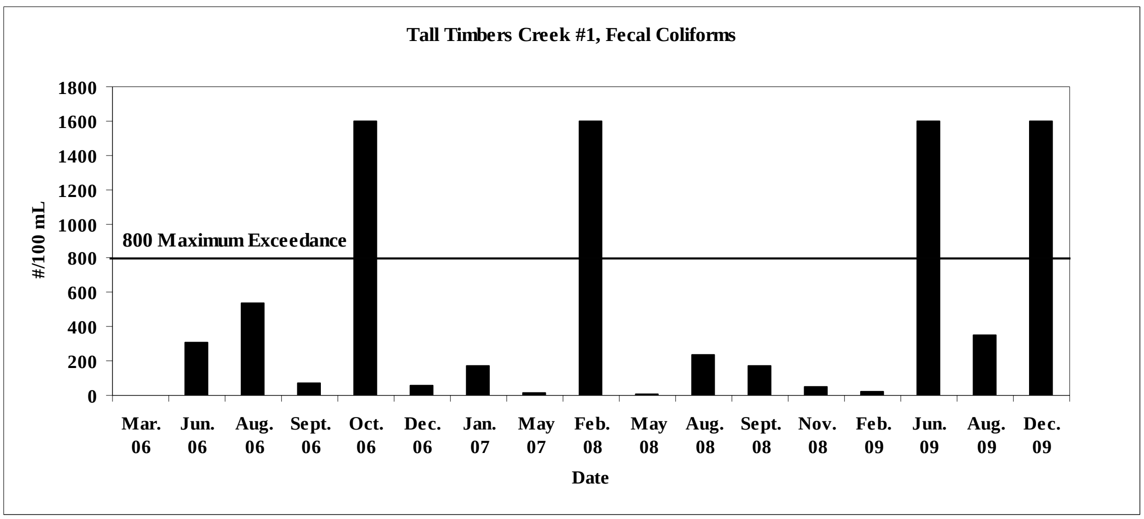


FIG. 8.3-8. Parameter of concern.

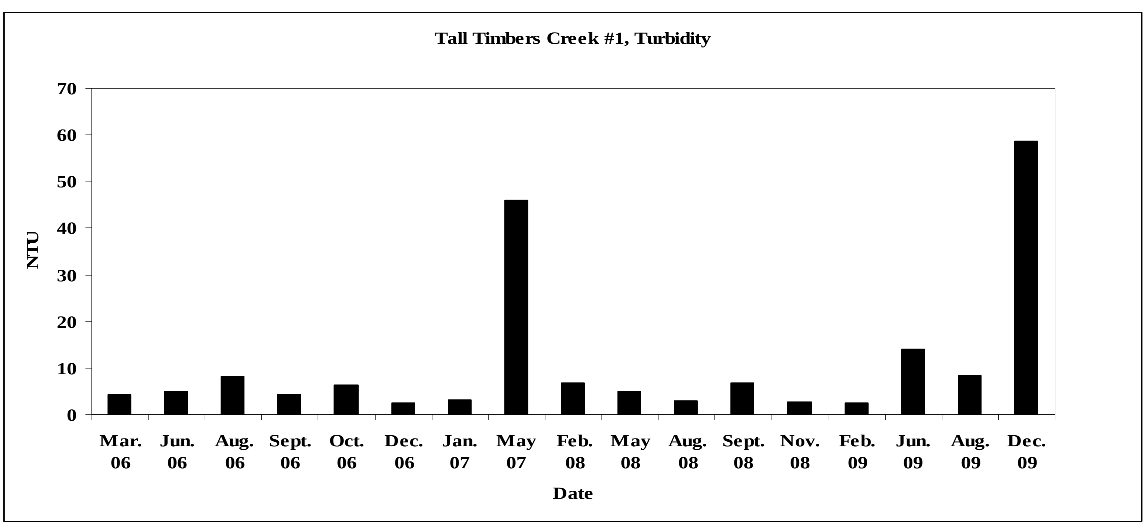
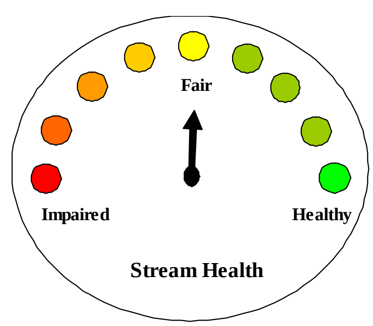


FIG. 8.3-9. Parameter of concern.

TABLE 8.3-1. SCI and Habitat Assessment scores and interpretation.

Tall Timbers Creek 1 @ 12	Dup 1 2009	Dup 2 2009
SCI Metric		
Total Taxa	42	35
Ephemeroptera Taxa	1	0
Trichoptera Taxa	3	3
% Filterer	11.3	10.85
Long-lived Taxa	5	5
Clinger Taxa	6	4
% Dominance	9.2	11.9
% Tanytarsini	10.6	7.7
Sensitive Taxa	9	8
% Very Tolerant Taxa	9.9	11.2
Total SCI Score	**61.76**	**53.46**
Average of two aliquots	**58**	
Score Interpretation	**Healthy**	
Habitat Assessment Score	**130**	
Score Interpretation	**Optimal**	

C. Plantation Stream at Thomasville Highway



Plantation Stream is the discharge from the Centerville watershed, essentially bounded by Proctor Road and Pisgah Church Road at Centerville Road, then flowing west; going under Thomasville Highway to Lake Iamonia at its southeast end **(Figure 8.3-10)**. The Centerville Conservation Community and Baker Place Subdivisions are located within the watershed. Most of the waterbodies are former farm ponds used for dairy and other agriculture practices.

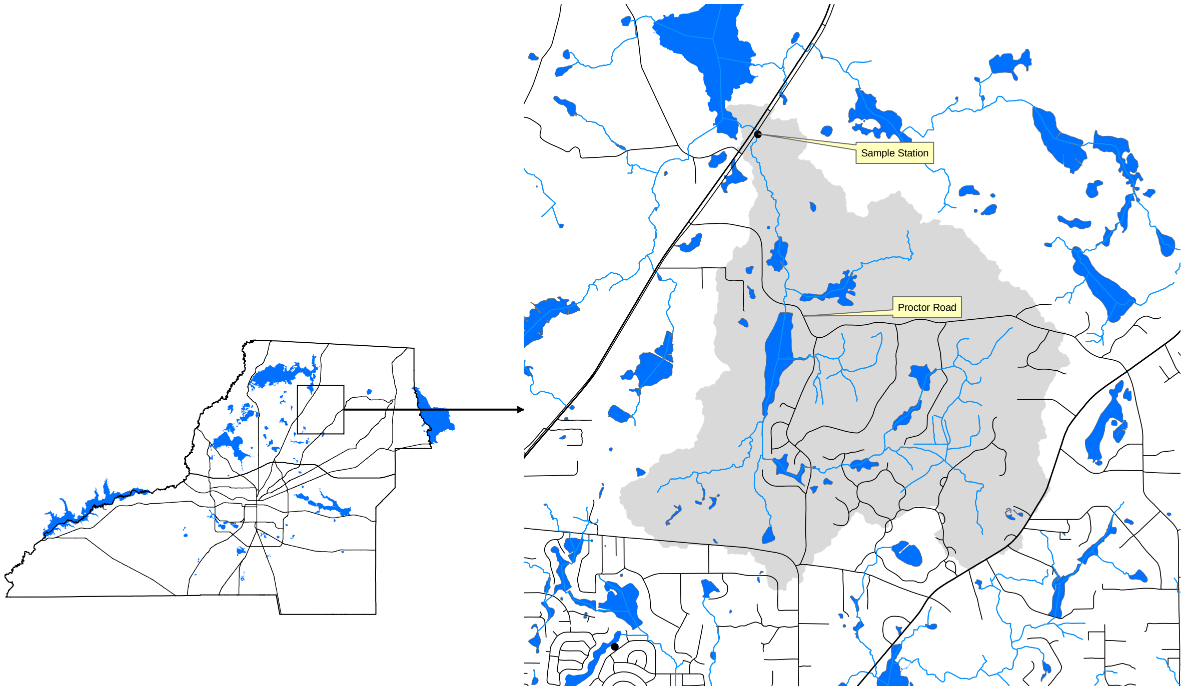


FIG. 8.3-10. Overview Map of the Plantation Stream watershed.

As shown in **Figure 8.3-11**, approximately 13% of land use in the watershed is residential, agriculture, or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

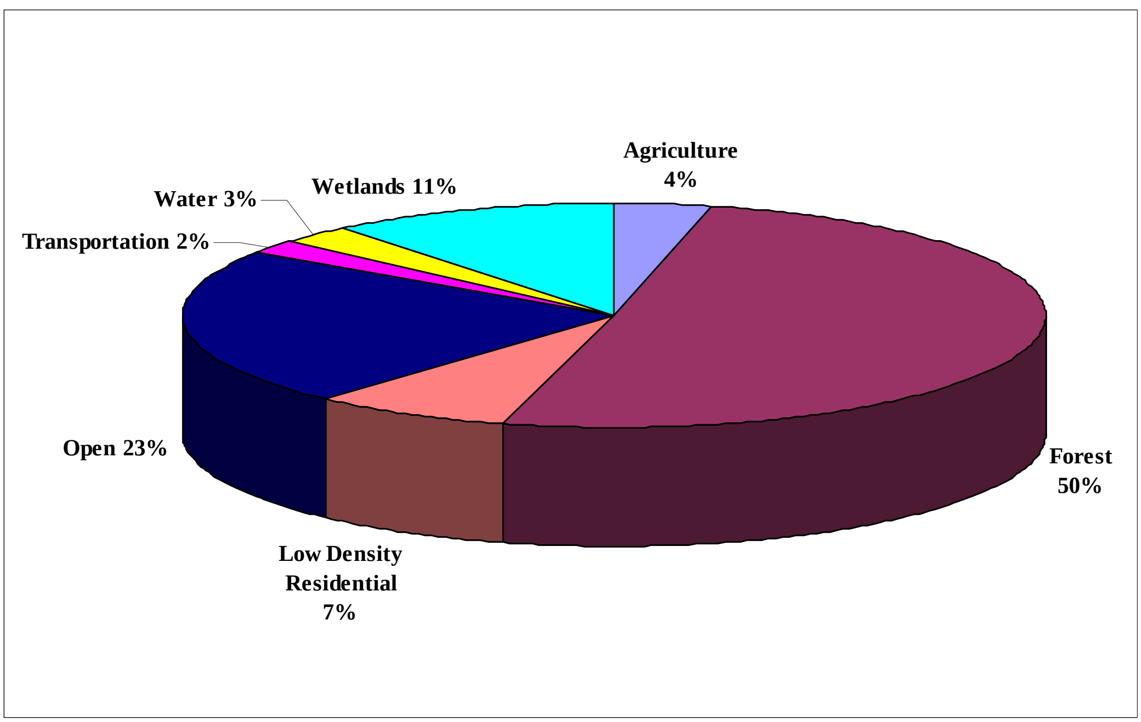


FIG. 8.3-11. Land use in the Plantation Stream watershed (4,047 acres).

Dissolved oxygen did not meet acceptable criteria for Class III water bodies for several sampling events **(Figures 8.3-12)**. These levels could be the result of low flow conditions rather than anthropogenic sources. There were several instances where fecal coliforms did not meet acceptable criteria for Class III waterbodies **(Figure 8.3-13)** but those exceedances may be related to wildlife. Turbidity, total suspended solids and BOD levels were elevated during the August 2008 sampling event **(Figure 8.3-14 – 8.3-16)** as a result of runoff generated by Tropical Storm Fay. Elevated turbidity, BOD, total suspended solids and phosphorus levels **(Figure 8.3-17)** during the December 2009 sampling event were attributed to overland runoff associated with the 1.7 inch rainfall that occurred the day of the sampling event. Turbidity levels exceeded Class III water quality standards for the same event. The above elevated levels are likely caused by runoff from Proctor Road, a dirt road located directly upstream of the sampling site. While there has been some past success in road stabilization, more work remains to be done. Proper stabilization of the road will prevent erosion, thus preventing suspended solids along with the resultant turbidity plumes and nutrients from entering the stream.

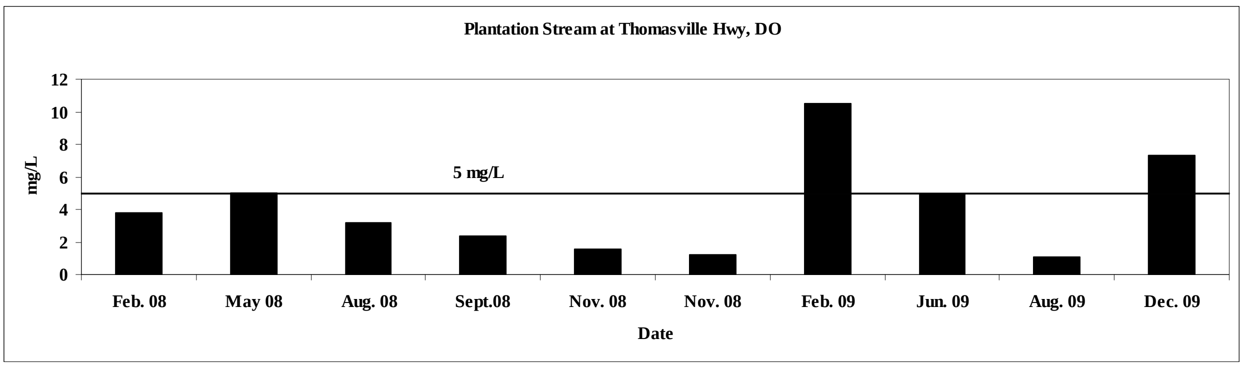


FIG. 8.3-12. Parameter of concern.

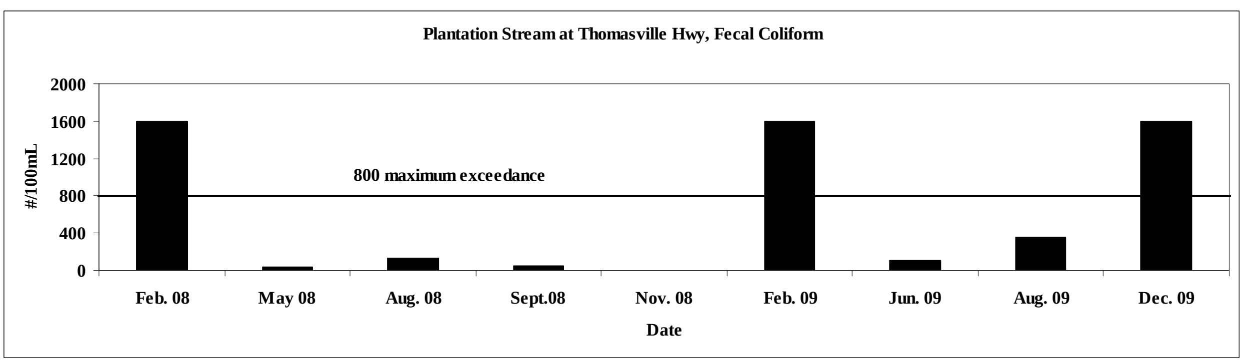


FIG. 8.3-13. Parameter of concern.

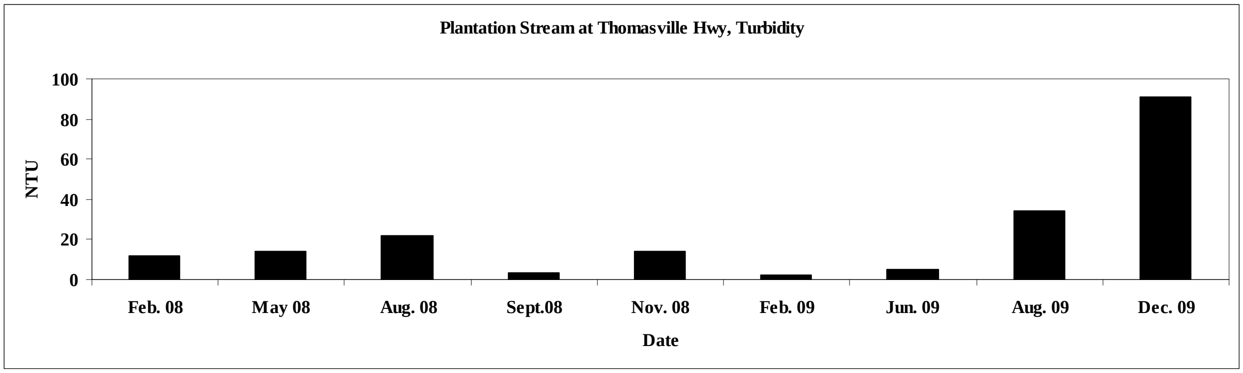


FIG. 8.3-14. Parameter of concern.

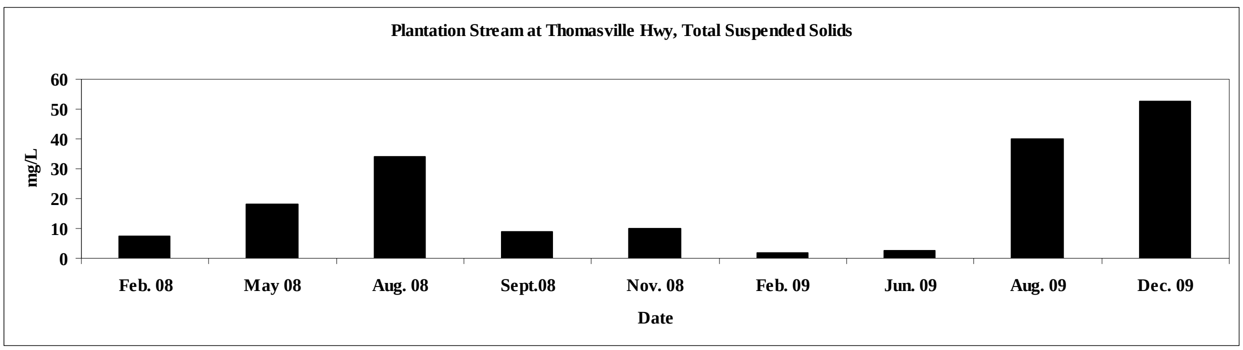


FIG. 8.3-15. Parameter of concern.

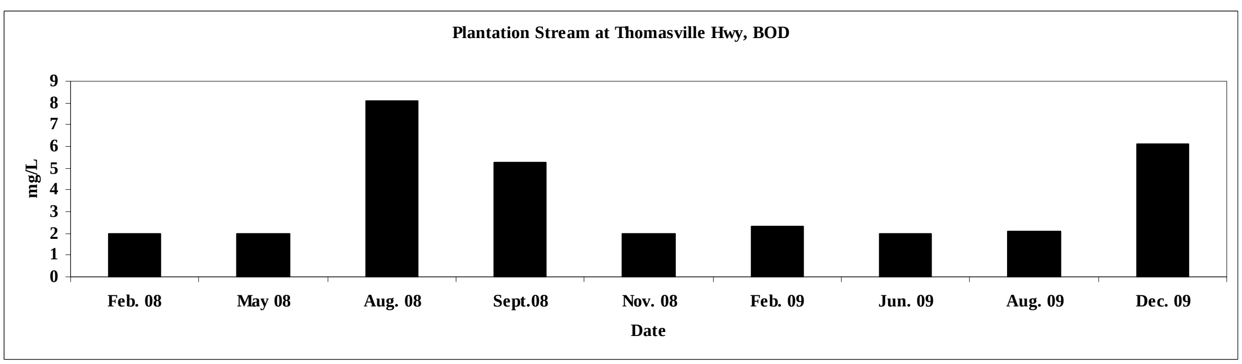


FIG. 8.3-16. Parameter of concern.

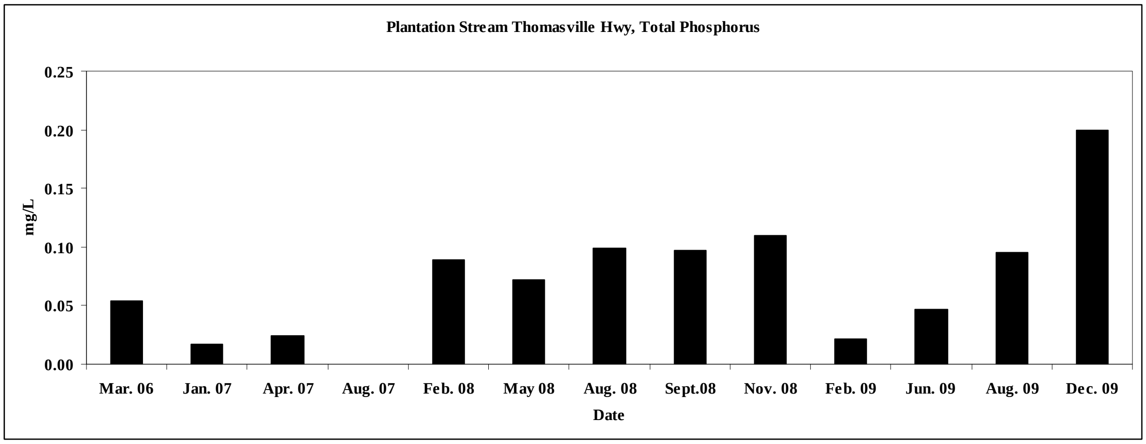
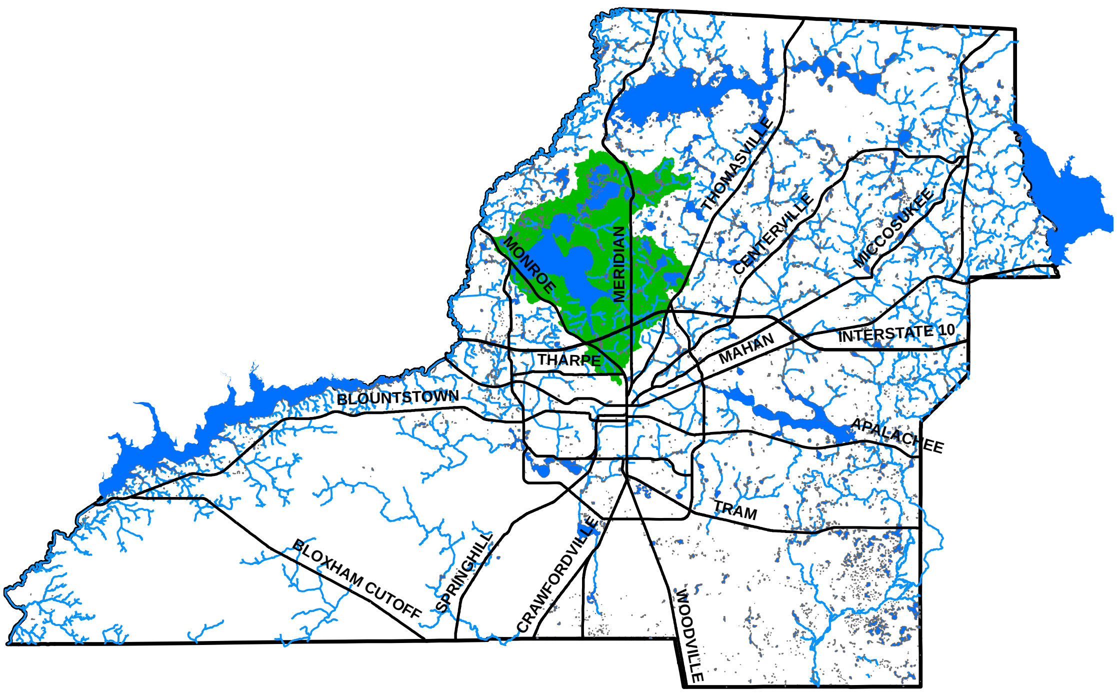
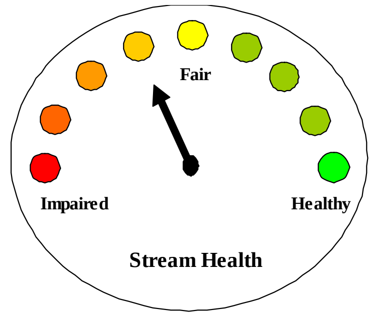


FIG. 8.3-17. Parameter of concern.

8.4. Lake Jackson Basin



A. Jackson Heights Creek



Jackson Heights Creek is a heavily altered stream located off of Hwy 27 in northern Leon County **(Figure 8.4-1)**. The stream receives runoff from the Parkhill and Greenwood Hills subdivisions, then flows north through Lake Jackson Heights and Harbinwood and eventually enters Lake Jackson. This watershed, with residential development dating from the 1950's, displays impacts from channelized flow and aging septic tanks. Sampling was intermittent from February 2007 through October 2008, due to low flow conditions and stormwater facility construction in the channel. The stormwater facility, intended to mitigate the development impacts, should prove beneficial to both the creek and Lake Jackson.

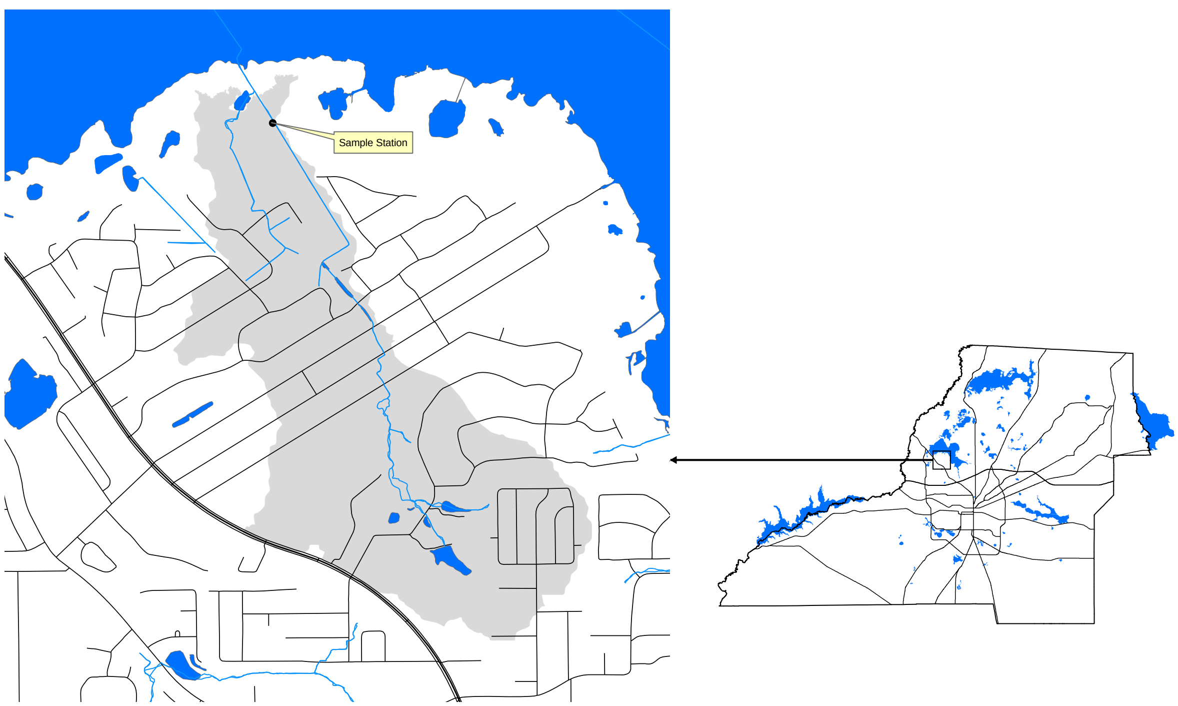


FIG. 8.4-1. Overview Map of Jackson Heights Creek watershed.

Figure 8.4-2 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Residential, commercial, and transportation uses make up approximately 79% of the watershed.

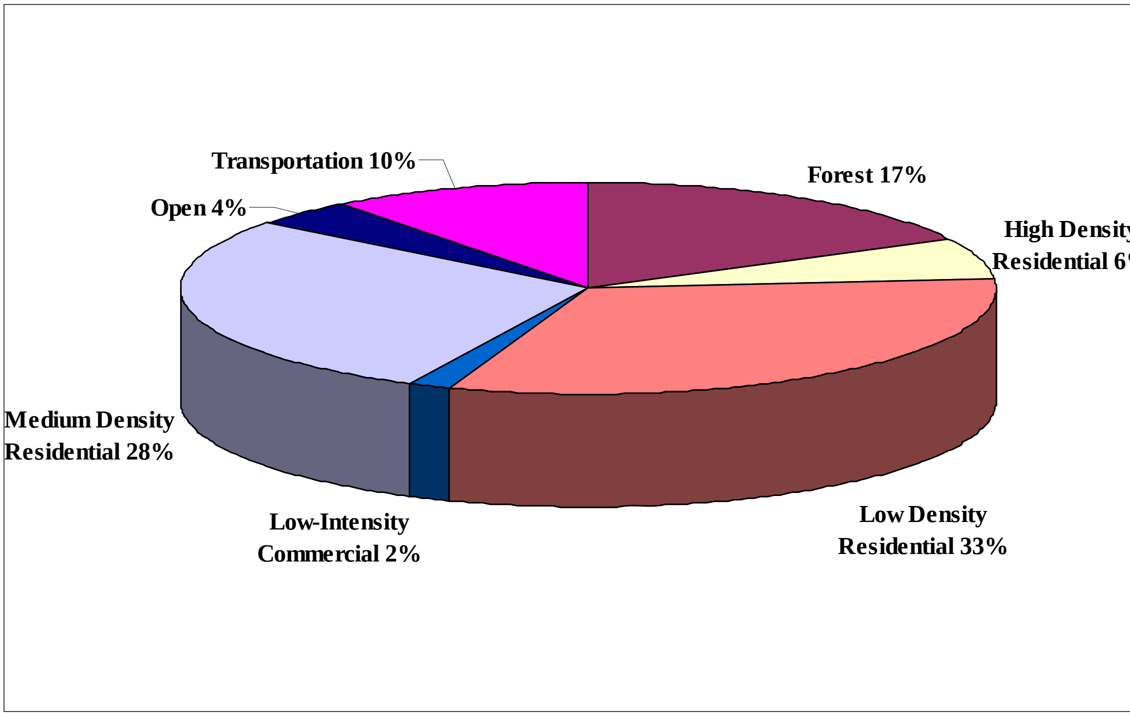


FIG. 8.4-2. Land use in the Jackson Heights Creek watershed (445 acres).

In late 2006, USEPA set a TMDL target for total phosphorus of 0.15 mg/L, a 35% reduction of the previous existing concentration of 0.23 mg/L. Current total phosphorus concentrations ranged from 0.036 mg/L to 0.29 mg/L **(Figure 8.4-3)**, with an average of 0.13 mg/L. Even though 0.29 mg/L exceeds the 70th percentile of Florida streams, there appears to be an overall phosphorus reduction. High intensity storms during December 2009 likely eroded the channel, contributing to the elevated phosphorus level. Dissolved oxygen levels did not meet Class III water quality standards during several sampling events **(Figure 8.4-4)**. Fecal coliforms exceeded FDEP's 800/100 mL limit during two sampling events **(Figure 8.4-5)**.

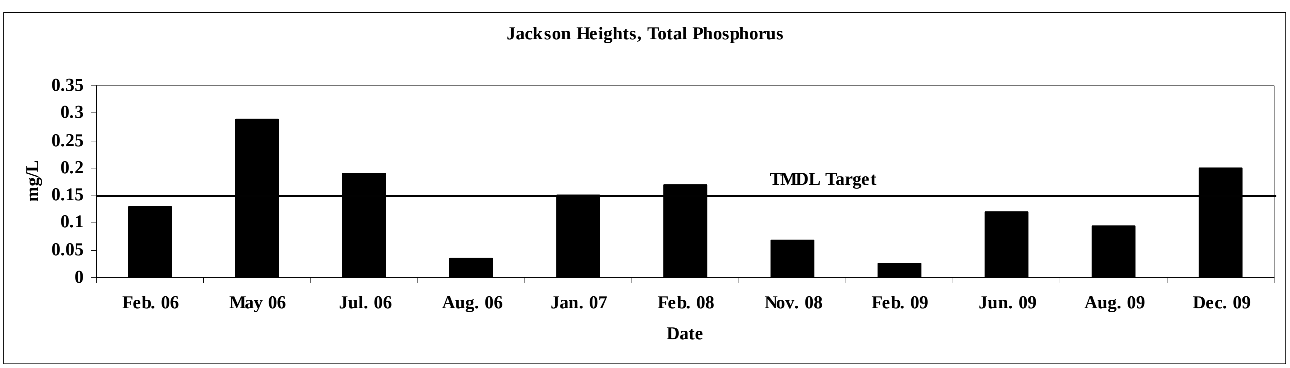


FIG. 8.4-3. Parameter of concern.

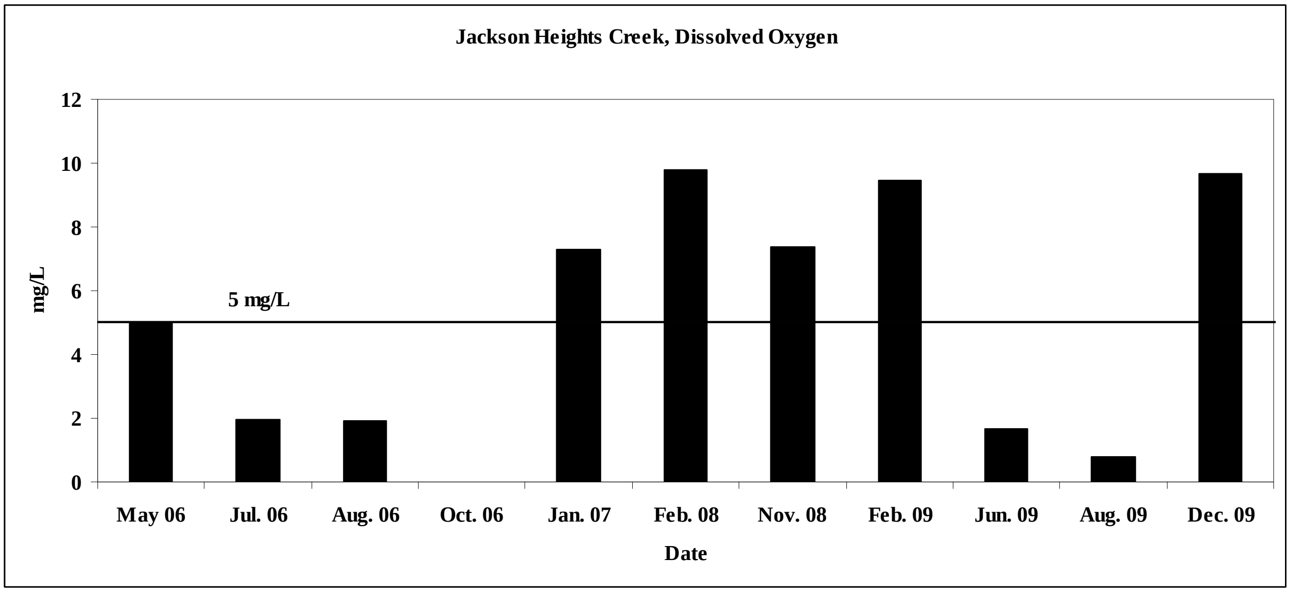


FIG. 8.4-4. Parameter of concern.

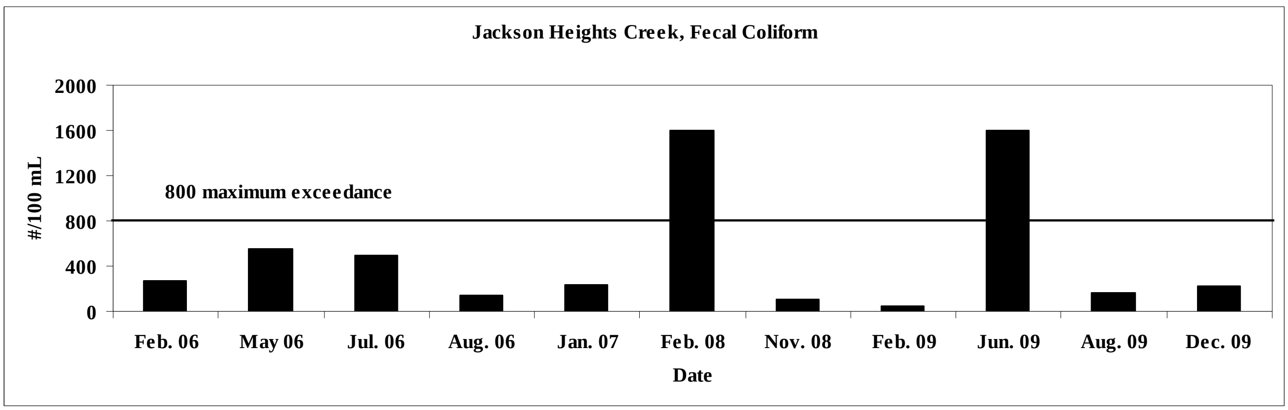


FIG. 8.4-5. Parameter of concern.

1. Stream Condition Index

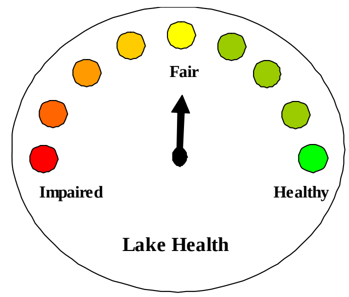
The habitat assessment score total (64) for Jackson Heights Creek was in the marginal category, while the SCI score (34) was in the impaired range **(Table 8.4-1)**. The habitat assessment showed poor substrate diversity, habitat smothering issues, stream channelization, poor riparian zone width and poor vegetation quality. Of the limited habitat present, wild taro, (*Colocasia esculenta*) a Category I Invasive Exotic and alligator weed (*Alternanthera philoxeroides*) a Category II Invasive Exotic were two of the three plants that were considered habitat for aquatic invertebrates. Pennywort (*Hydrocotyle* sp.) was the only native plant that was determined to provide some habitat.

TABLE 8.4-1. SCI and Habitat Assessment scores and interpretation.

Jackson Heights Creek	Dup 1	Dup 2
SCI Metric		
Total Taxa	34	30
Ephemeroptera Taxa	1	1
Trichoptera Taxa	1	2
% Filterer	21.75	18.6
Long-lived Taxa	0	0
Clinger Taxa	3	2
% Dominance	24.5	19.4
% Tanytarsini	18.9	17.4
Sensitive Taxa	0	0
% Very Tolerant Taxa	29.3	32.1
Total SCI Score	**33.78**	**33.69**
Average of two aliquots	**34**	
Score Interpretation	**Impaired**	
Habitat Assessment Score	**64**	
Score Interpretation	**Marginal**	

While progress has been made upstream with reducing pollutant loadings by the construction of stormwater facilities, further progress needs to be made regarding aquatic invertebrate populations. Returning the stream to a more natural condition by increasing stream sinuosity, removal of exotic plant species in the stream and the riparian corridor, and reducing habitat smothering, would help improve habitat and promote a more balanced ecosystem.

B. Lake Carr



Lake Carr is an approximately 880 acre, primarily phosphorus limited, shallow lake located north of Lake Jackson **(Figure 8.4-6)** and is essentially surrounded by two property owners: Ayavalla Land Company and Orchard Pond LLC. Like Lake Jackson and Mallard Pond, Lake Carr is a valuable biological, aesthetic and recreational resource of Leon County and was designated as an Aquatic Preserve in 1973 for the primary purpose of preserving and maintaining the biological resources in their natural condition (Gardner, 1991).

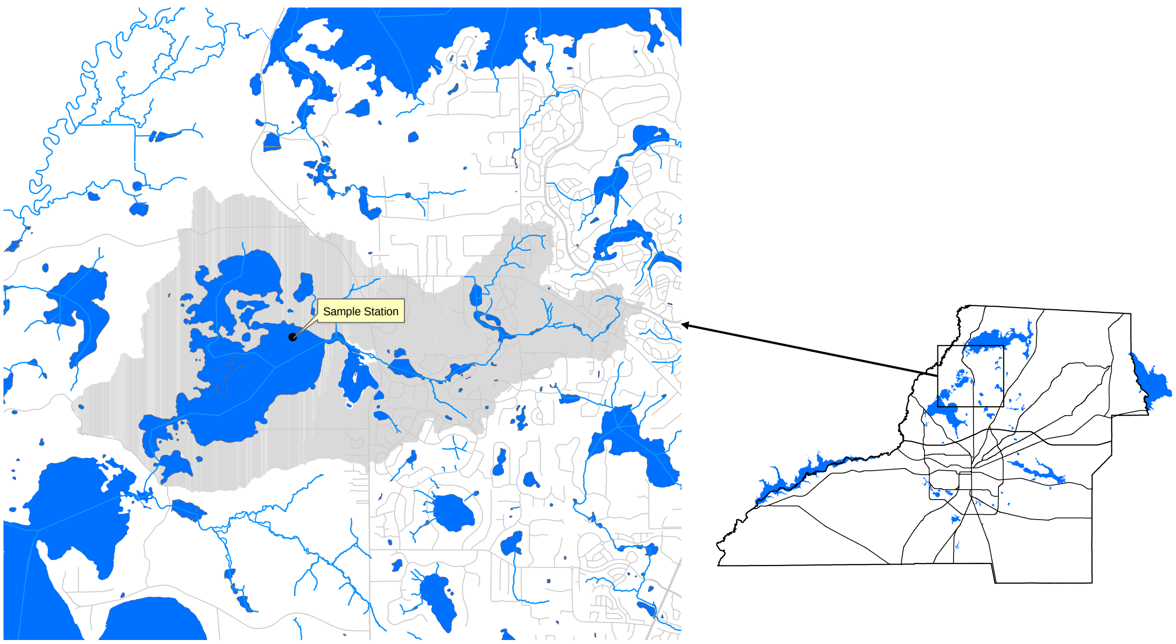


Figure 8.4-6. Overview map of Lake Carr watershed and water quality sampling station.

As shown in **Figure 8.4-7**, 28% of land use in the Lake Carr watershed is commercial, residential, agricultural, or transportation. The lake receives direct runoff from the surrounding agricultural property as well as flow from the residential areas east of Meridian Road (Summerbrooke and Ox Bottom Manor). Water bodies in the residential areas are modified farm ponds serving as stormwater facilities dedicated to the respective homeowners associations for maintenance. The Summerbrooke Golf Club (157 acres) also lies in this watershed.

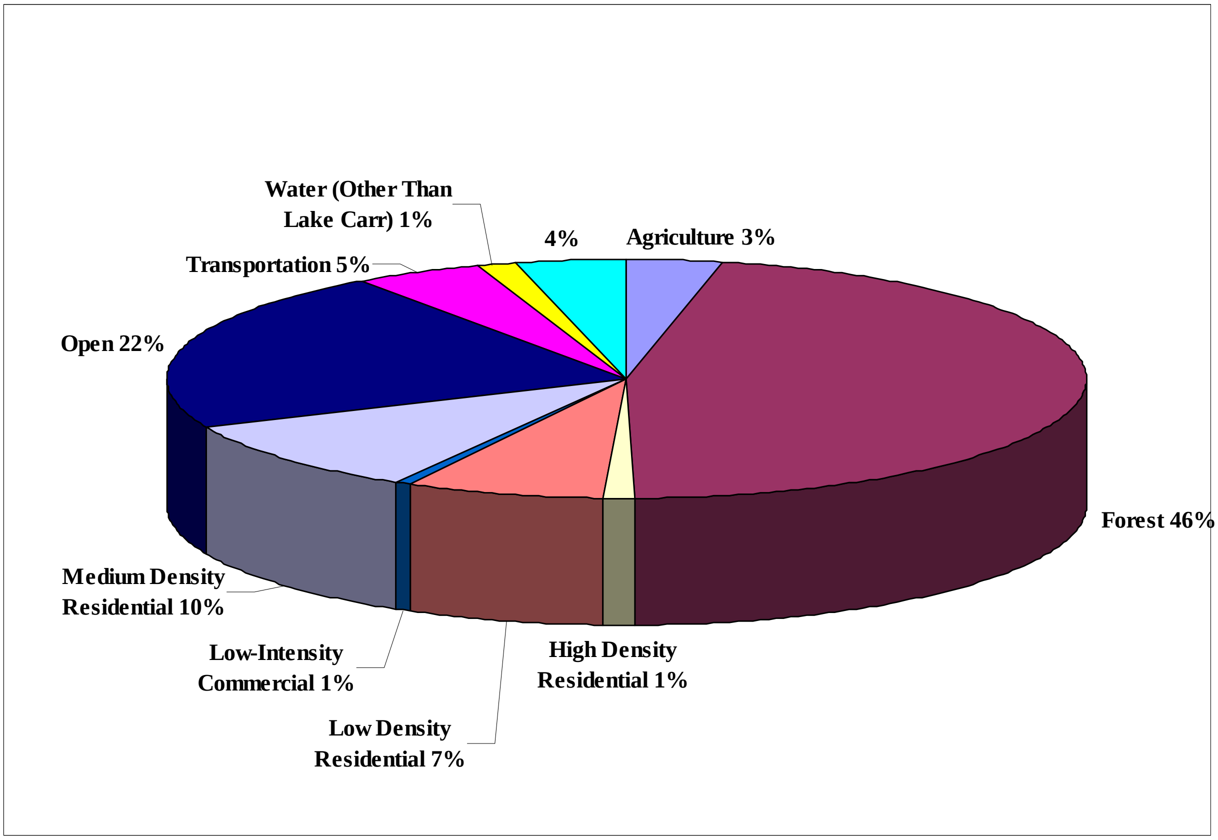


FIG. 8.4-7. Land use in the Lake Carr watershed (4,865 acres).

Figures 8.4-8 and **8.4-9** represents Lake Carr's trophic state utilizing the FDEP Trophic State Index. Yearly averages show that Lake Carr exceeded the TSI threshold of 40 in 2008 and 2009, while seasonal averages also show some exceedances above the 40 threshold. Total nitrogen (0.47 mg/L), phosphorus (0.02 mg/L) and chlorophyll *a* (4.64 µg/L) placed Lake Carr in the mesotrophic category. However, there appears to be a gradual increase in the amounts of total phosphorus and nitrogen over the entire sampling period and a substantial increase of chlorophyll *a* levels in 2008, with a consequent decline in 2009 **(Figures 8.4-10 – 8.4-12)**. Lake Carr's increased nutrient concentrations suggests that the lake may be moving toward a more eutrophic state. Dissolved oxygen levels have been consistently low since early 2006, failing in several instances to meet Class III water quality standards **(Figure 8.4-13**). This is undoubtedly due to the aquatic plant growth covering large portions of the lake's surface.

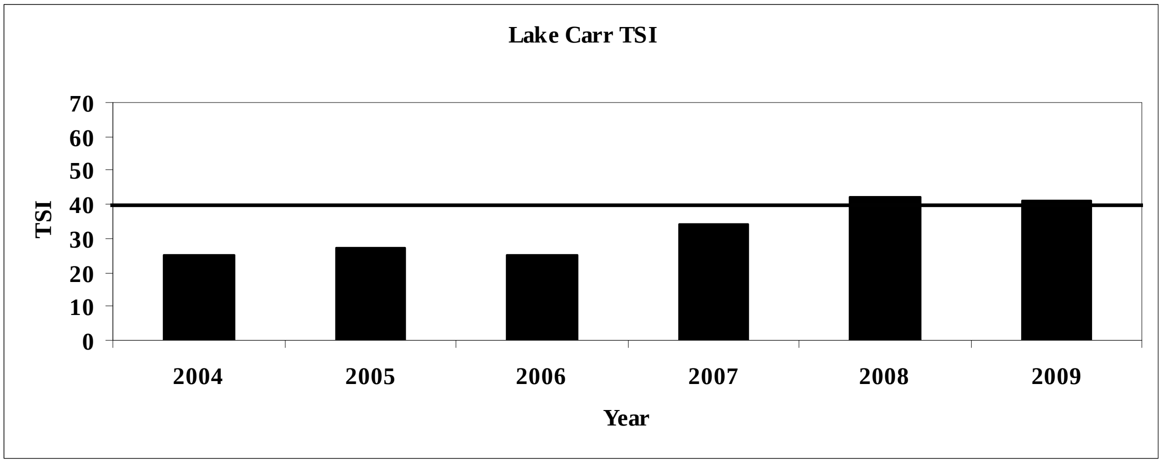


FIG. 8.4-8. Lake Carr trophic state index (yearly average). Bars exceeding a TSI of 40 would indicate impairment.

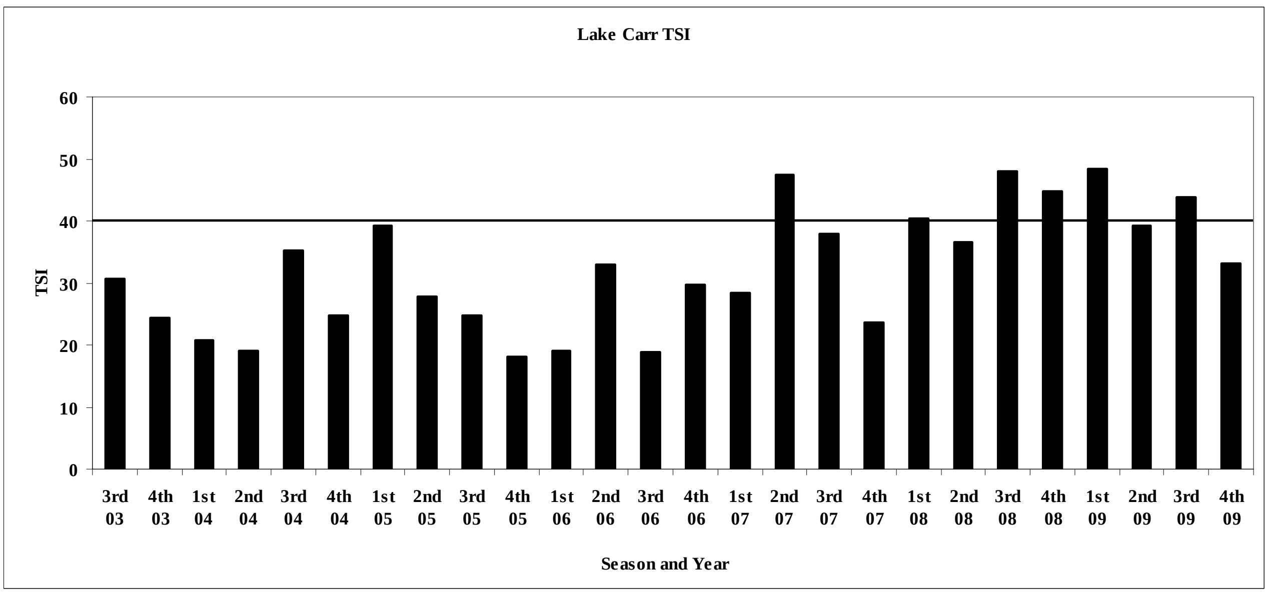


FIG. 8.4-9. Lake Carr trophic state index (seasonal average). Bars exceeding a TSI of 40 indicate impairment.

1. Lake Vegetation Index

The LVI score for Lake Carr was 67 placing the lake in the "Healthy" category.

Lake Carr, being a shallow clear lake had a plethora of vegetation throughout the lake's water column. The native species water lily (*Nymphaea odorata*) and fanwort (*Cabomba caroliniana*) dominated the lake followed by water shield (*Braseina schreberi*), buttonbush (Ceratophyllum demersum), american lotus (*Nelumbo lutea*), and bladderwort (*Utriculara foliosa*).

Unfortunately, water hyacinth (*Eichnoria crassipes*) and hydrilla (*Hydrilla verticillata*) both listed as Category I Invasive Exotics by the Florida Exotic Pest Control Council are two invasive exotics that are a concern in Lake Carr. Alligator weed (*Alternanthera philoxeroides*) a Category II Invasive Exotic was also present in Lake Carr. Due to FDEP's occasional herbicide treatment, the invasive exotic plant species appear to be under control.

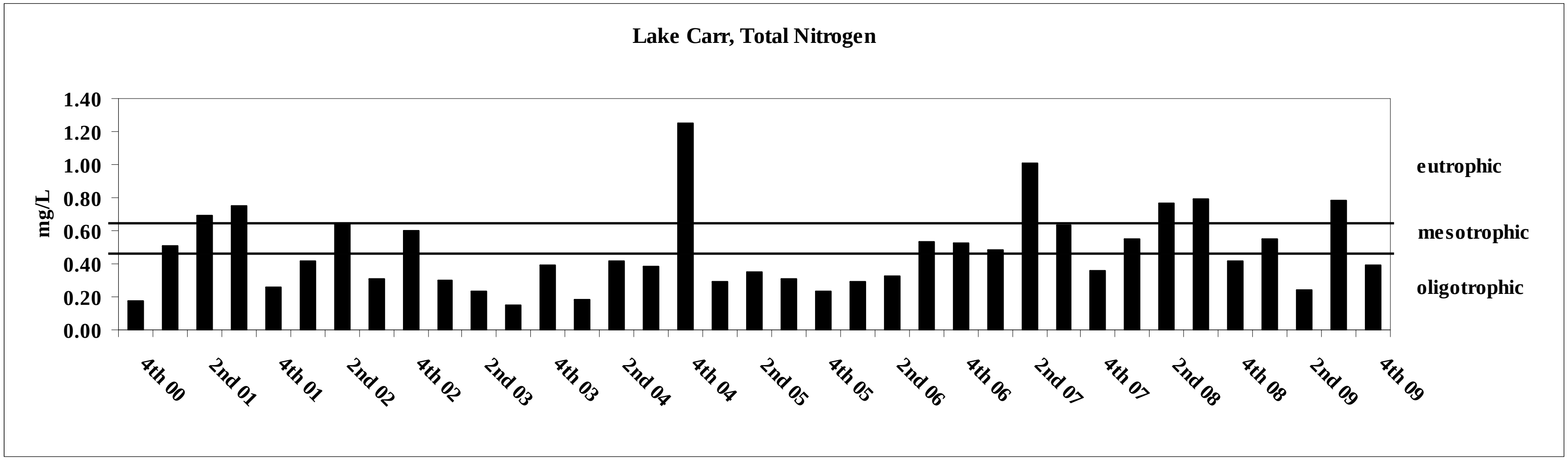


FIG. 8.4-10. Lake Carr total nitrogen. Each bar represents the seasonal average.

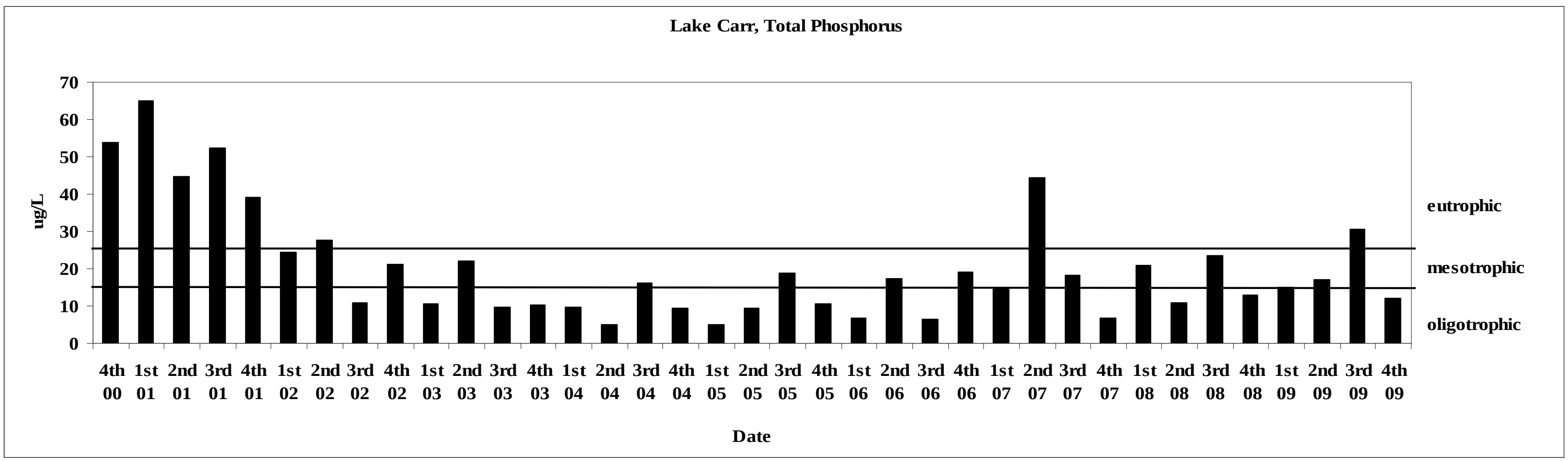


FIG. 8.4-11. Lake Carr total phosphorus.

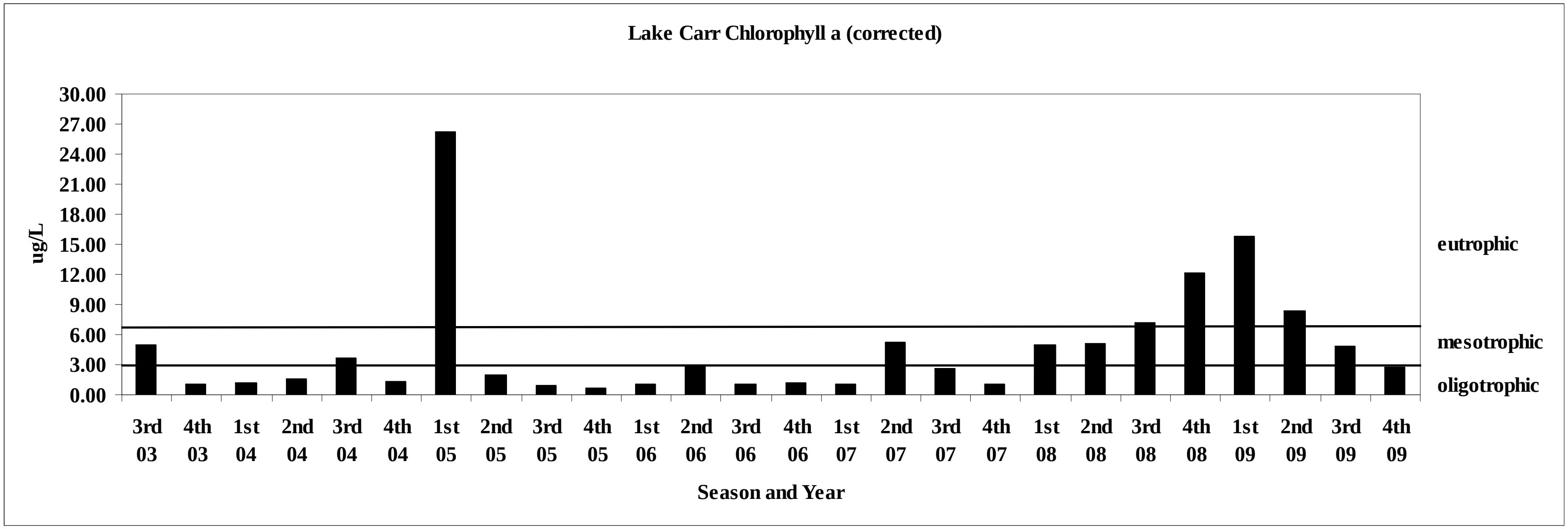


FIG. 8.4-12. Lake Carr chlorophyll *a* levels.

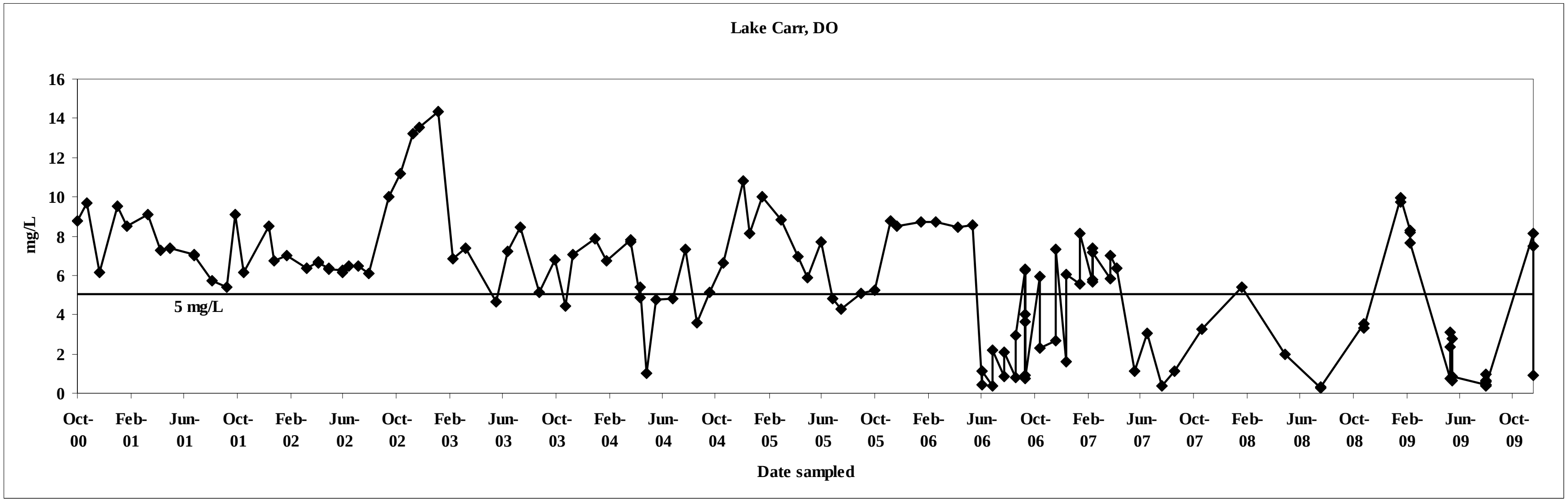
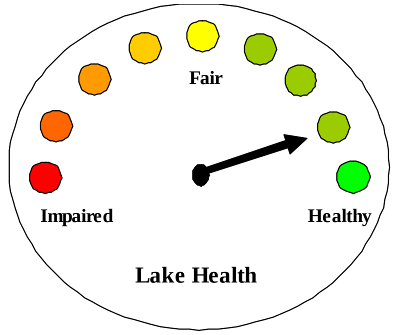


FIG. 8.4-13. Parameter of concern. Markers represent individual measurements. Starting in June 2006, top, mid-depth, and bottom DO measurements were taken where appropriate.

C. Lake Hall



Lake Hall is an approximately 182 acre lake located in northern Leon County just north of Interstate 10 and slightly west of U.S. Highway 19 and is part of the Alfred B. Maclay State Gardens State Park, a state recreation area and botanical gardens **(Figure 8.4-14)**. FDEP considers this lake to be an "Outstanding Florida Waters" (62-302.700(9) (d) F.A.C., 2006).

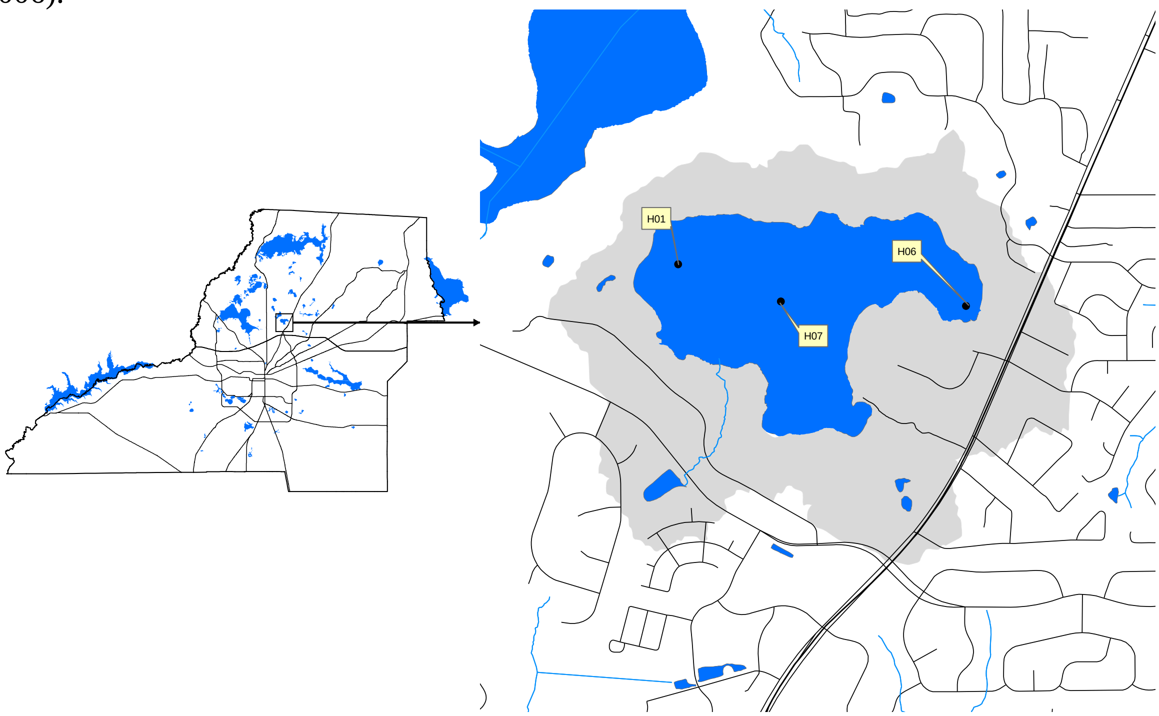


FIG. 8.4-14. Overview map of Lake Hall watershed and water quality sampling stations.

As shown in **Figure 8.4-15**, approximately 35% of land use in the Lake Hall watershed is residential, commercial, or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

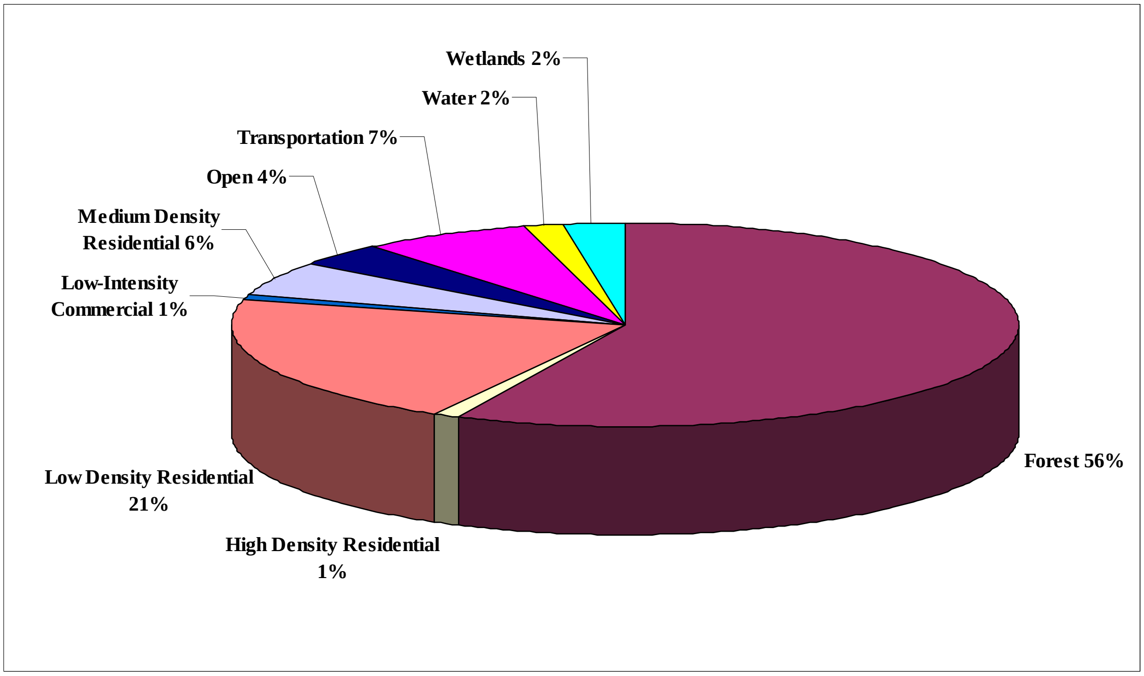


FIG. 8.4-15. Land use in the Lake Hall watershed (464 acres).

Figures 8.4-16 and **8.4-17** represents the Lake Hall's trophic state utilizing the FDEP Trophic State Index. Yearly and seasonal averages show that Lake Hall did not exceed the 40 threshold and would not be considered impaired according to FDEP standards. Other parameters appear to be within normal limits for Florida Lakes.

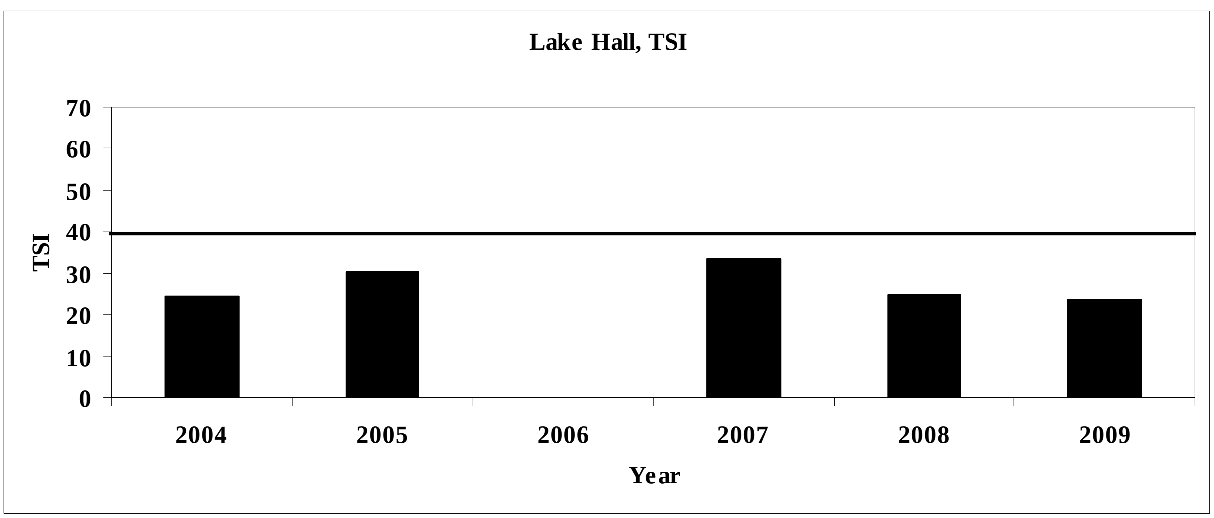


FIG. 8.4-16. Lake Hall trophic state index (yearly average). Bars exceeding a TSI of 40 would indicate impairment. The yearly TSI score for 2006 was not calculated due to lack of 3rd and 4th quarter data.

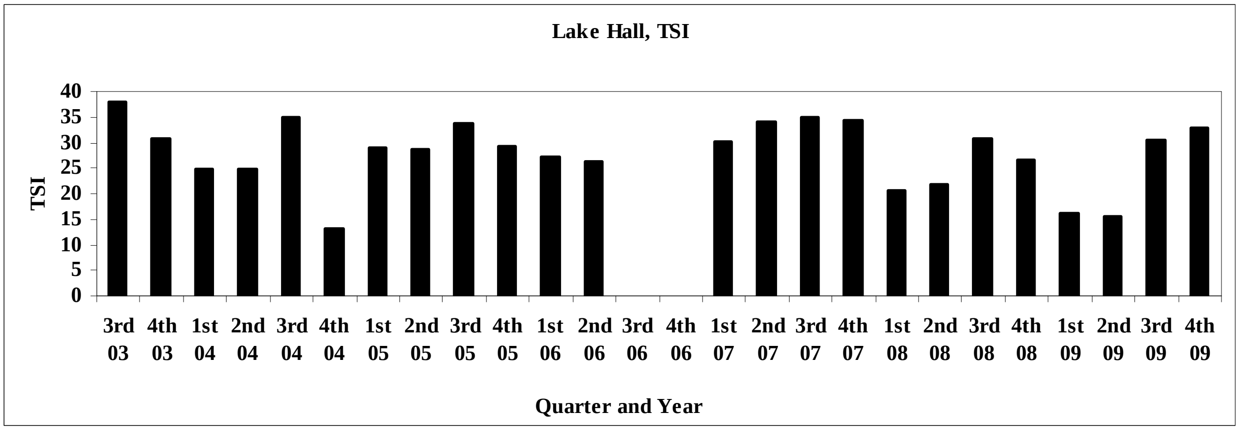


FIG. 8.4-17. Lake Hall trophic state index (seasonal average). Bars exceeding a TSI of 40 indicate impairment. Lake samples were not collected during the 3rd and 4th quarters of 2006.

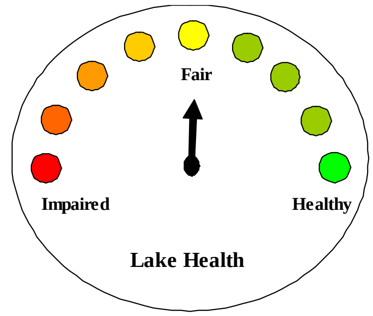
1. Lake Vegetation Index

The LVI score for Lake Hall was 77 placing the lake in the "Healthy" category.

The native species, water shield (*Brasenia schreberi*), fragrant waterlily (*Nymphaea odorata*), and american cupscale grass (*Sacciolepis striata*) dominated the shoreline area of Lake Hall and were the most dominant species in the lake. Because Lake Hall is a deep lake, rooted plants cannot grow in the center of the lake, but fanwort (*Cabomba caroliniana*), banana lily (*Nymphoides aquatica*), american lotus (*Nelumbo lutea*), and coontail (*Ceratophyllum demersum*), all native species, were found in the shallower areas.

Water hyacinth (*Eichnoria crassipes*) and hydrilla (*Hydrilla verticillata*), both listed as Category I Invasive Exotics by the Florida Exotic Pest Control Council are two invasive exotics that are a concern in Lake Hall. Fortunately, due to FDEP's occasional herbicide treatment and the addition of grass carp, hydrilla and water hyacinth appear to be under control. Alligator weed (*Alternanthera philoxeroides*) a Category II Invasive Exotic was also present along the shoreline of the Lake Hall. In the 1960's three South American insects were released to control alligator weed with devastating effects to the weed. Even though alligator weed is still present in more than 80% of Florida waters, levels are low, so it is rarely necessary to control with other means (IFAS, 2010).

D. Lake Jackson



Lake Jackson is an approximately 4000 acre shallow flat bottomed prairie lake with two major sinkholes and is located north of the City of Tallahassee **(Figure 8.4-18)**. Lake Jackson is a valuable biological, aesthetic and recreational resource of Leon County and was designated (along with the neighboring Lake Carr and Mallard Pond) as an Aquatic Preserve in 1973 for the primary purpose of preserving and maintaining the biological resources in their natural condition (Gardner, 1991).

The aforementioned sinkholes are the source of extreme water loss in the lake over the past several decades. Normally the sinkholes are plugged with sediments, but will collapse when groundwater levels drop, allowing lake water to enter the aquifer, and often dramatically lowering the water level as was the case in 1999 and more recently in 2007.

Over the past three decades, the water quality and ecological functioning of Lake Jackson has declined as a result of nonpoint source pollution. When the lake drained in 1999, a massive restoration effort was taken to remove organic rich sediments from the lake bottom. This project was completed in 2001 and resulted in over 2,000,000 cubic yards of sediment removed from the lake bottom. Water quality monitoring is continuing to be used to evaluate the long term health of the lake and the effects of the restoration.

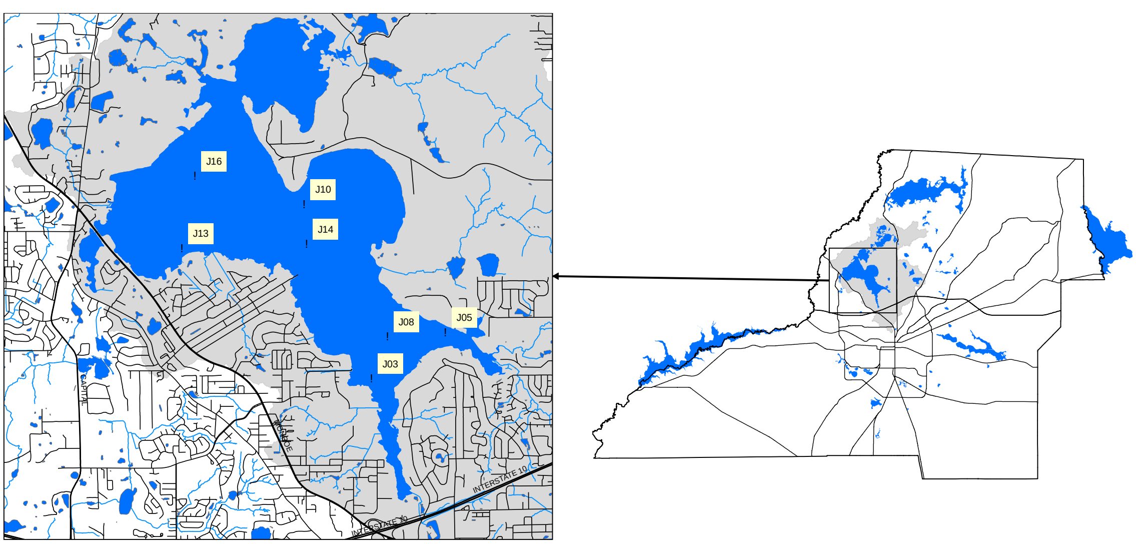


FIG. 8.4-18. Lake Jackson Basin with locations of Lake Jackson water quality sampling stations shown.

Unfortunately, the low water levels caused by drought and sinkhole activity meant certain water quality stations could not be sampled during some months. After Tropical Storm Fay (August 2008), Lake Jackson water levels have reached full pool conditions. Objective criteria of nutrient concentration continued to be skewed by this water level fluctuation. The effects of reflooding will be documented and are expected to resolve as the lake continues to stabilize.

As shown in **Table 8.4-19**, approximately 33% of land use in the Lake Jackson Basin is residential, commercial, agriculture or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

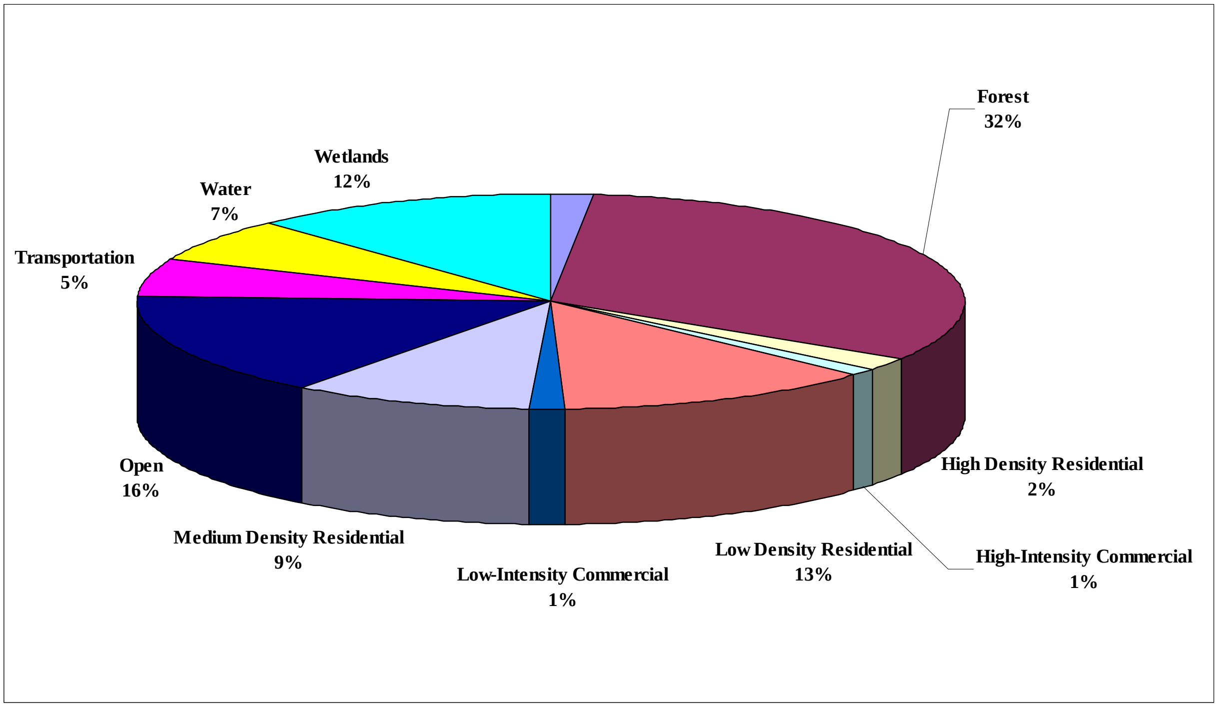


FIG. 8.4-19. Land use in the Lake Jackson watershed (27,262 acres).

1. TSI and Color

As mentioned in Chapter 3, color determines the TSI threshold; darker lakes (≥ 40 PCU) use the 60 threshold while lighter lakes use the 40 threshold. As **Table 8.4-2** shows, over the entire sampling period (1991-2009) Lake Jackson's average color levels exceeded 40 PCU, meaning the higher TSI threshold (60) would be used to determine impairment. However, due to changes in runoff characteristics, land use practices, better stormwater controls, and other unknown factors, color gradually decreased over the sampling period. The TSI calculation requires the use of corrected chlorophyll, which wasn't collected until 2004, so it was decided to use color data from the 2004-2009 period to determine which TSI threshold to use. During the 2004-2009 time period, lake color decreased and color data indicated that Lake Jackson would be considered impaired if the TSI exceeded 40.

TABLE 8.4-2. Lake Lafayette color levels and TSI thresholds over time.

Lake	1991-2009 Color	Past TSI Threshold	2004-2009 Color	Current TSI Threshold
Lake Jackson	47	60	24	40

Figures 8.4-20 and **8.4-21** represents Lake Jackson's trophic state utilizing the FDEP Trophic State Index. Seasonal and yearly averages showed that Lake Jackson exceeded the 40 threshold in 2006, 2008 and 2009 and would be considered impaired according to FDEP standards. Color levels continue to be below the 40 PCU threshold, so the lower TSI threshold may become the norm for Lake Jackson. Because of the dynamic nature of the lake and the recent drought, staff would hesitate to utilize the FDEP's TSI to determine impairment.

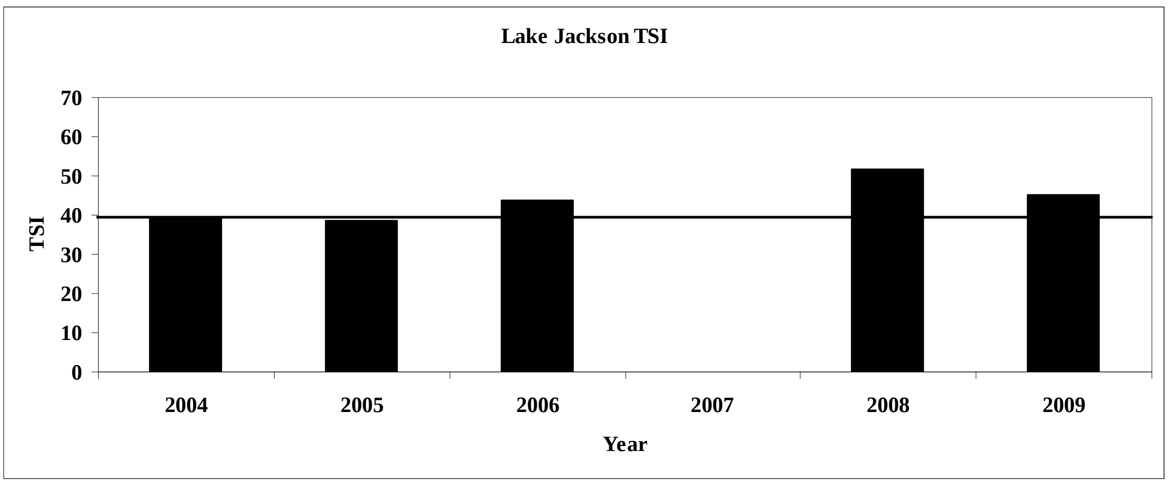


FIG. 8.4-20. Lake Jackson trophic state index (yearly average). Bars exceeding a TSI of 40 indicate impairment. Yearly TSI score for 2007 was not calculated due to lack of 4th quarter data.

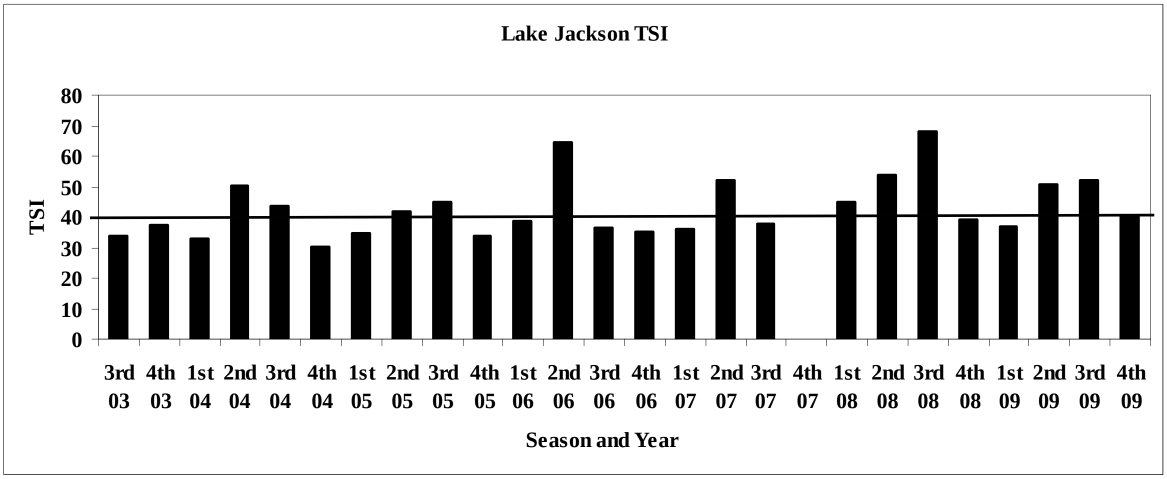


FIG. 8.4-21. Lake Jackson trophic state index (seasonal average). Bars exceeding a TSI of 40 indicate impairment.

Looking at the three different TSI parameters independently showed varying results. Immediately after Tropical Storm Fay, there was a substantial increase in both phosphorus and chlorophyll, as well as a small increase in nitrogen **(Figures 8.4-22 – 8.4-23)**. The seasonal average chlorophyll *a* value during the 2003-2009 sampling period was 10.54 µg/L placing Lake Jackson in the lower eutrophic range. The seasonal average for total nitrogen and total phosphorus during the 1991-2009 sampling period was 0.89 mg/L and 0.07 mg/L respectively, placing the lake in the eutrophic range. Both nitrogen and phosphorus followed a similar pattern throughout the sampling period **(Figures 8.4-23 and 8.4-24)**, showing large increases during the 4th quarter of 1999 through the end of 2000 undoubtedly due to the restoration efforts that occurred during that time period. After the restoration was complete and the lake gradually filled with water, both nutrients gradually dropped in concentration. When the lake started going dry in late 2006, nutrients began increasing again. These increased concentrations may reflect the relative effect of dilution. Other possibilities include nutrient recycling from sediment or perhaps and more likely increasing concentrations in the water column due to algal uptake. Now that the lake has filled again, vegetation that has grown in the lake bottom during the lake's dry period has continued to die and decompose, releasing nutrients into the water column, resulting in a nutrient increase as well as algal blooms. As the lake shifts from a terrestrial/wet prairie community, it is hoped that as nutrients are assimilated by aquatic vegetation, water column nutrient and chlorophyll *a* values will decline over time. Overall, phosphorus, nitrogen and chlorophyll *a* declined in 2009, and it is hoped that these values will continue to decline.

Fecal coliform levels exceeded Class III water quality standards during the August 2009 sampling event. At times, Lake Jackson showed DO levels that did not meet Class III water quality standards **(Figure 8.4-25)**. The DO levels could be related to the death and decay of the vegetation that was drowned during the lake's transition from a wetland prairie to a "true" lake. Staff will continue to evaluate this incredibly dynamic lake.

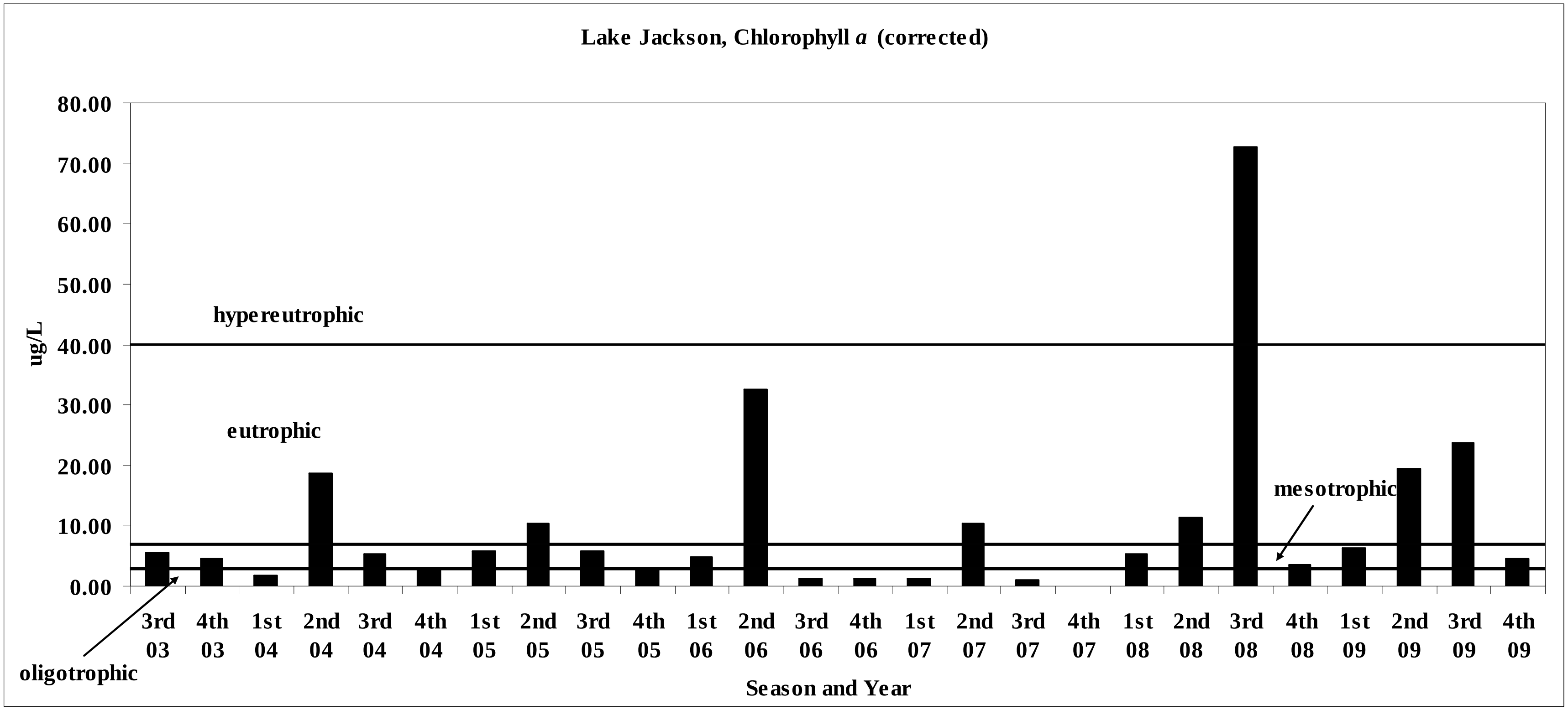


FIG. 8.4-22. Lake Jackson chlorophyll a (corrected).

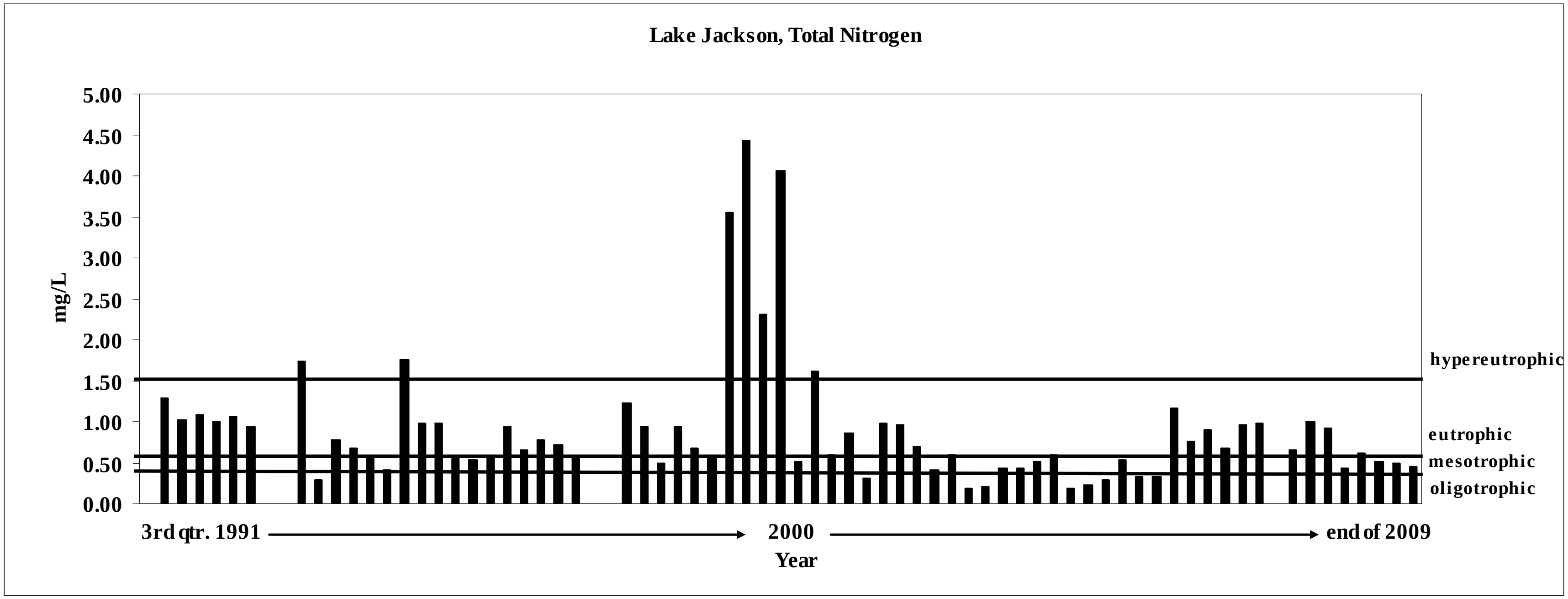


FIG. 8.4-23. Lake Jackson total nitrogen. Each bar represents the seasonal average.

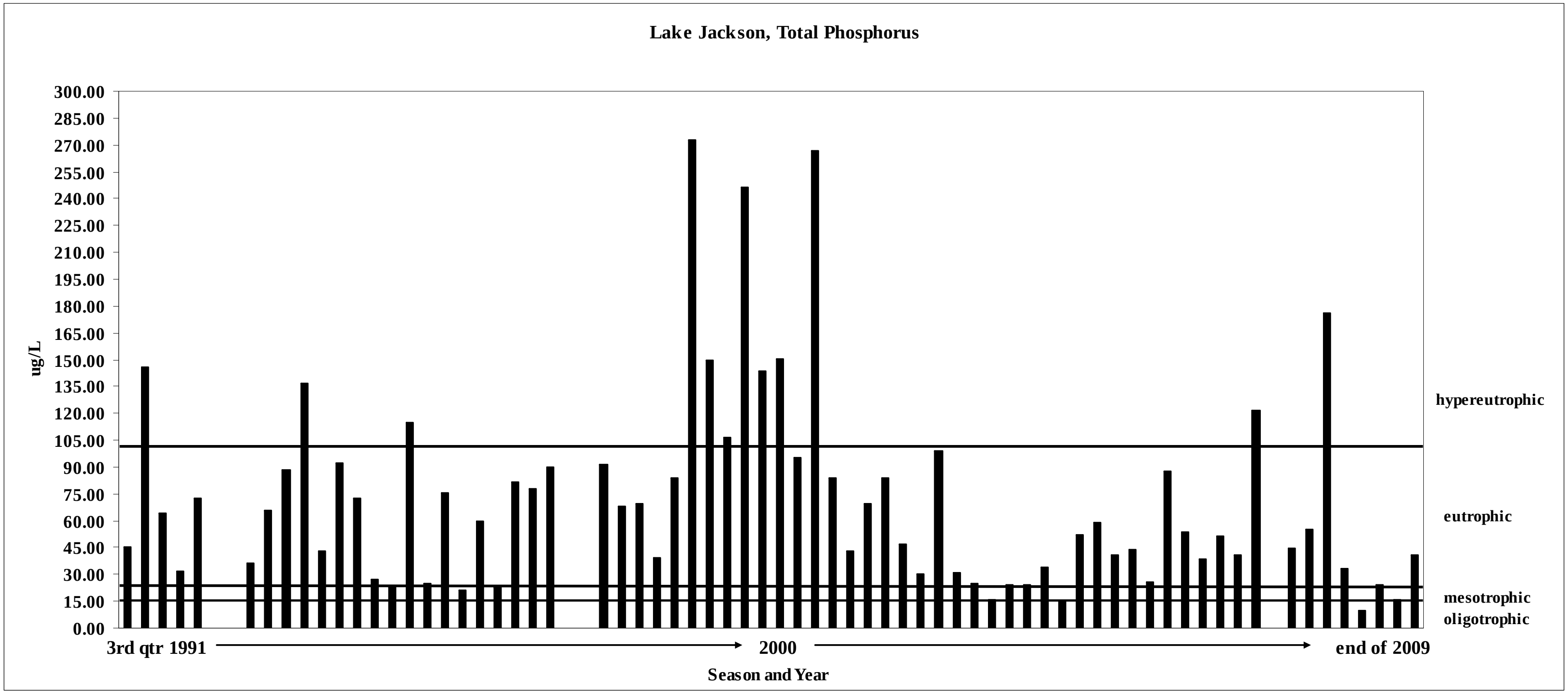


FIG. 8.4-24. Lake Jackson total phosphorus. Each bar represents the seasonal average.

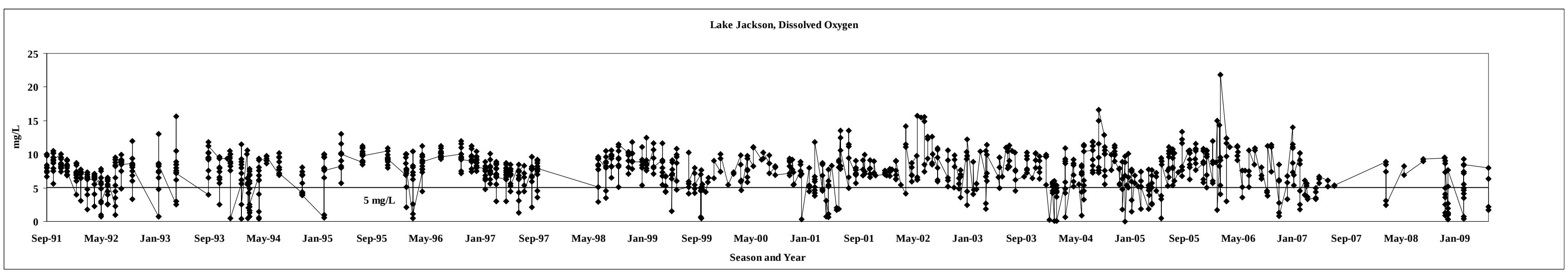
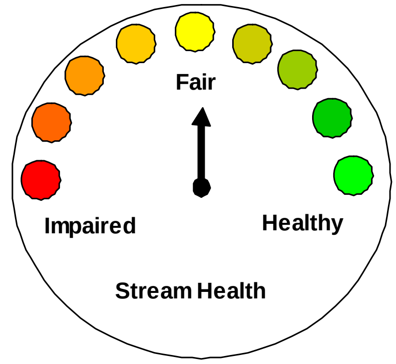


FIG. 8.4-25. Parameter of concern.

E. Lexington Tributary at Timberlane Road



Lexington Tributary is a moderately altered stream located in the northern part of Tallahassee and drains into Fords Arm of Lake Jackson **(Figure 8.4-26)**. The watershed reaches to Thomasville Road at I-10 on the east, and is bounded by Maclay Road and Live Oak Plantation Road on the north and south, respectively.

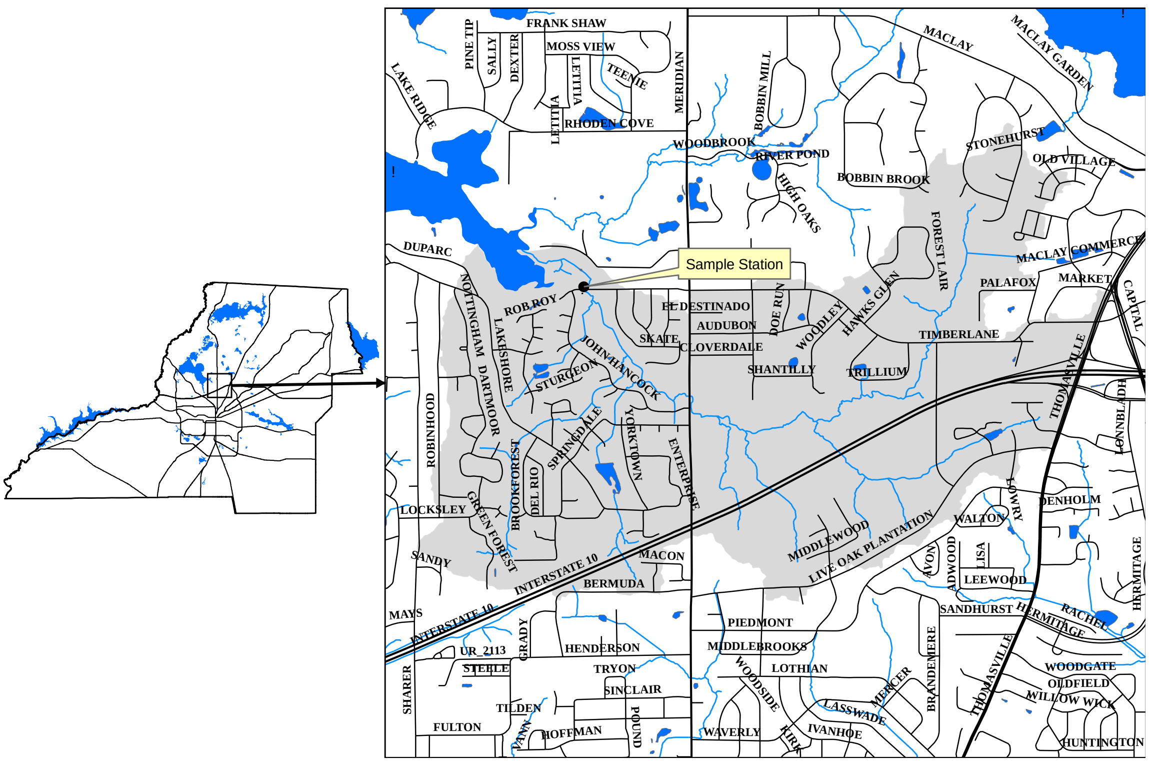


FIG. 8.4-26. Overview Map of the Lexington Tributary watershed.

Figure 8.4-27 shows land use in the watershed. Residential, commercial, and transportation uses make up approximately 68% of the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed.

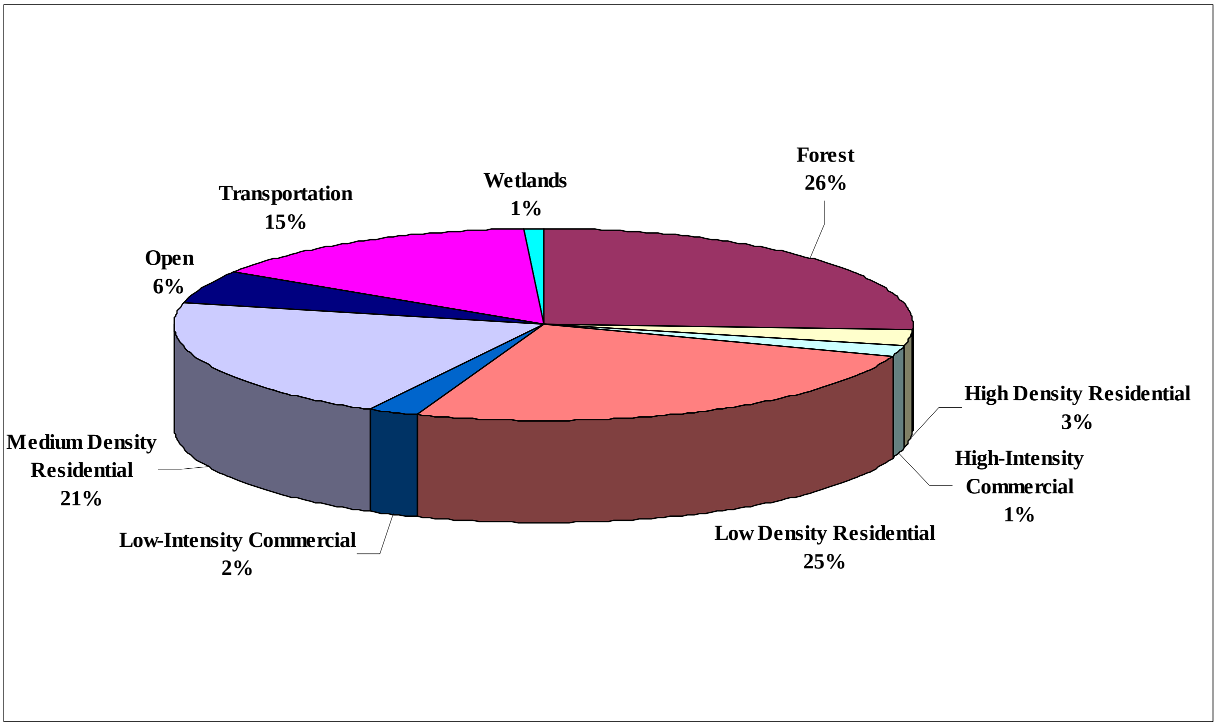


FIG. 8.4-27. Land use in the Lexington Tributary watershed (1,803 acres).

Fecal coliform bacteria exceeded the Class III water quality standard of 800 colonies/100 mL several times during the sampling period **(Figure 8.4-28)**. Total phosphorus values were slightly elevated throughout the sampling period **(Figure 8.4-29)**, at times exceeding the 60th percentile of Florida streams.

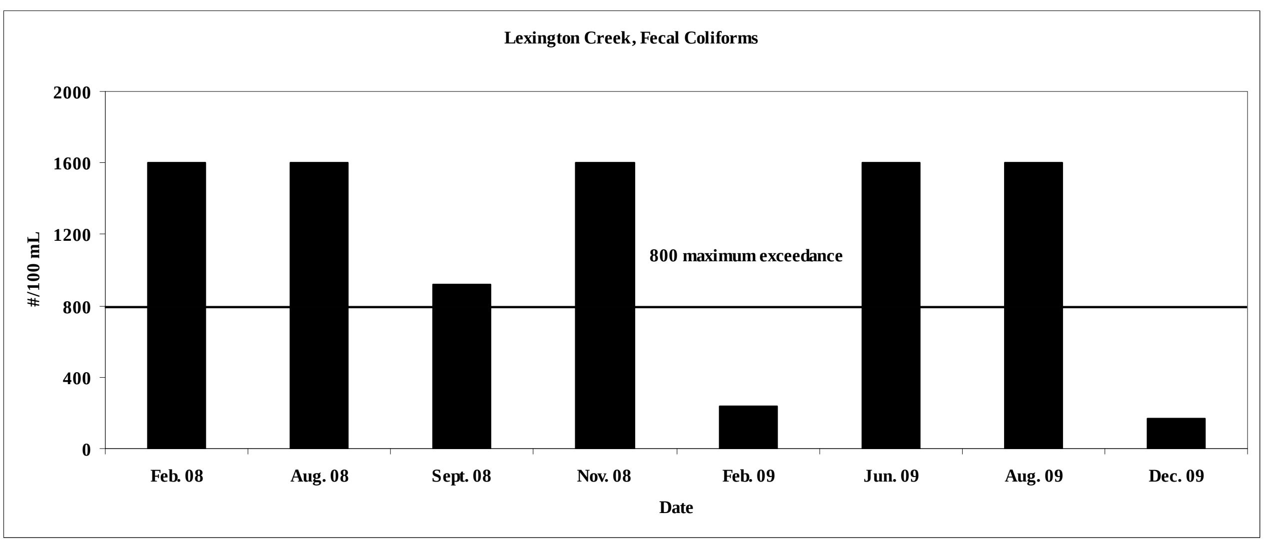


FIG. 8.4-28. Parameter of concern.

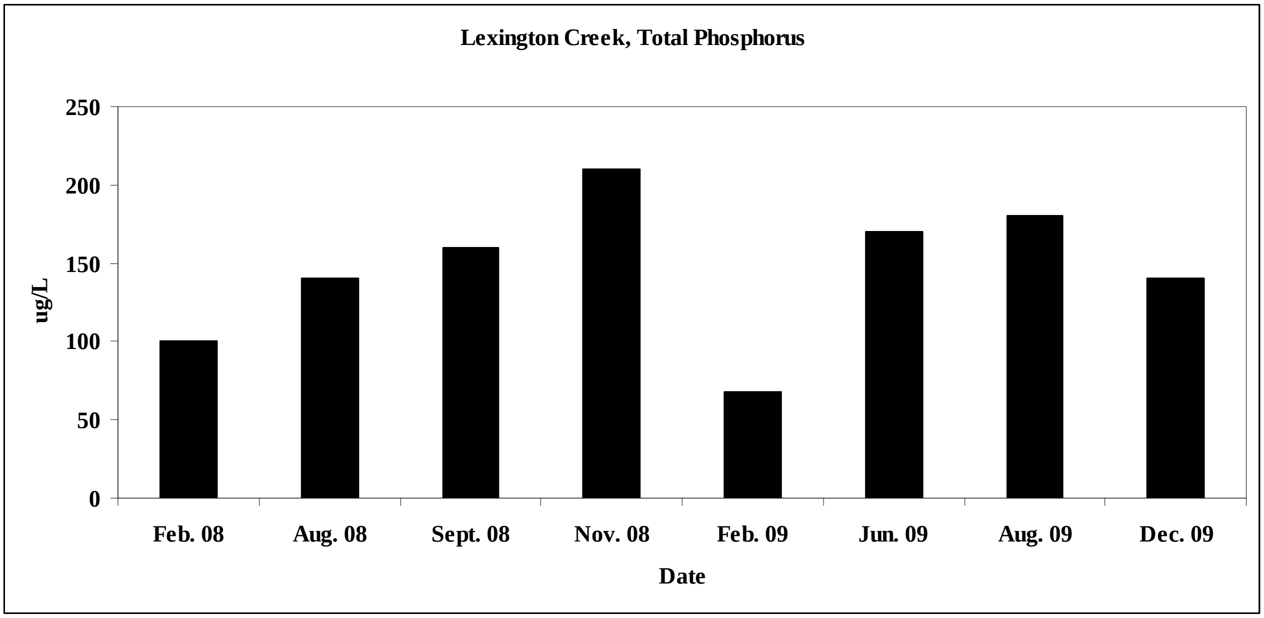


FIG. 8.4-29. Parameter of concern.

1. Stream Condition Index

The SCI score for Lexington Tributary's SCI (44) was in the healthy range while the habitat assessment score total (98) was in the sub-optimal category **(Table 8.4-3)**.

The habitat assessment showed that bank stability and substrate availability were in the marginal category, while habitat smothering was in the poor category. Excess silt and sand smother aquatic habitat and are often caused by excessive erosion and increased storm runoff in the watershed. Marginal bank stability is further evidence of excessive erosion. While the riparian zone width in this area is greater than 18 meters, the riparian vegetation quality has been degraded due to the exotic plant community that makes up a portion of the understory vegetation. Removal of the invasive exotic plant community and reducing excessive runoff from upstream areas will improve the riparian zone vegetation quality and reduce habitat smothering in the stream.

TABLE 8.4-3. SCI and Habitat Assessment scores and interpretation.

Lexington Trib @ Timberlane Rd.	**Dup 1**	**Dup 2**
SCI Metric		
Total Taxa	24	26
Ephemeroptera Taxa	2	2
Trichoptera Taxa	2	1
% Filterer	35.6	45.45
Long-lived Taxa	0	0
Clinger Taxa	6	5
% Dominance	25.3	31
% Tanytarsini	6.9	15.8
Sensitive Taxa	5	3
% Very Tolerant Taxa	6.2	5.5
Total SCI Score	**43.46**	**43.99**
Average of two aliquots	**44**	
Score Interpretation	**Healthy**	
Habitat Assessment Score	**98**	
Score Interpretation	**Sub Optimal**	

F. Meginnis Creek

Meginnis Creek is a substantially altered, nitrogen limited stream located in the northern part of Tallahassee and drains into Lake Jackson **(Figure 8.4-30)**.

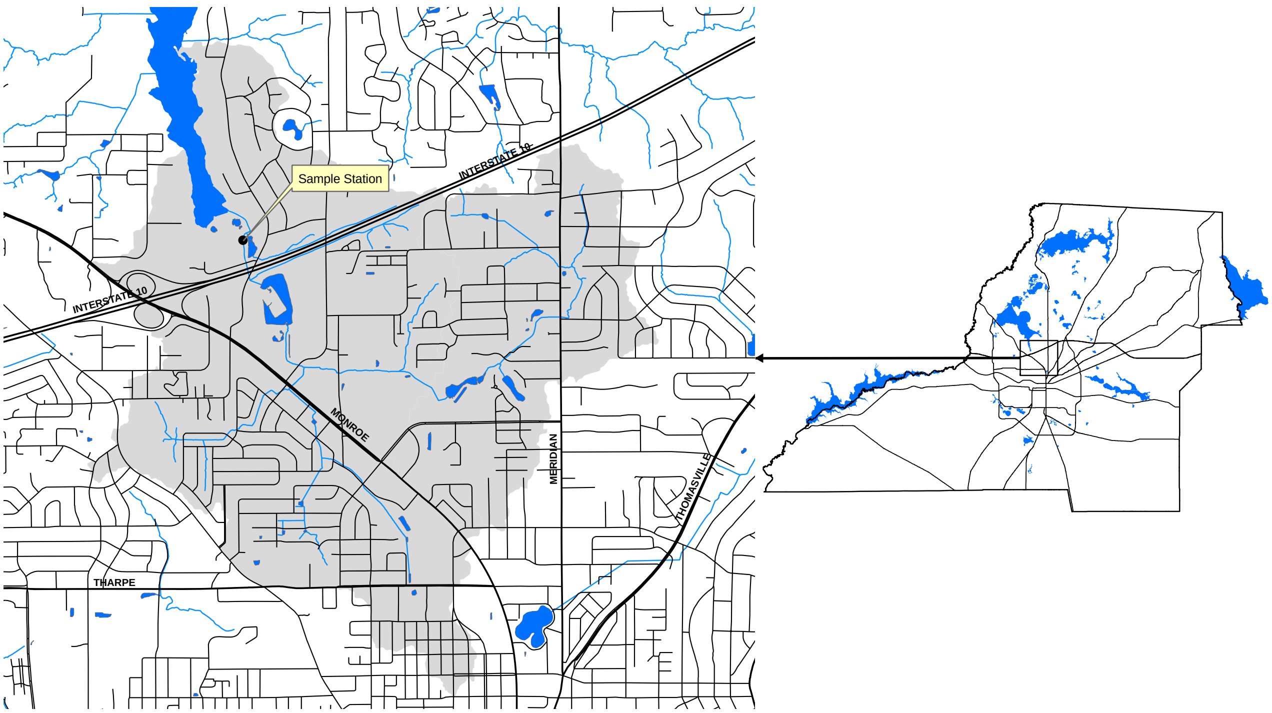


FIG. 8.4-30. Overview Map of the Meginnis Creek Stream watershed.

Figure 8.4-31 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Residential, commercial, and transportation uses make up approximately 81% of the watershed.

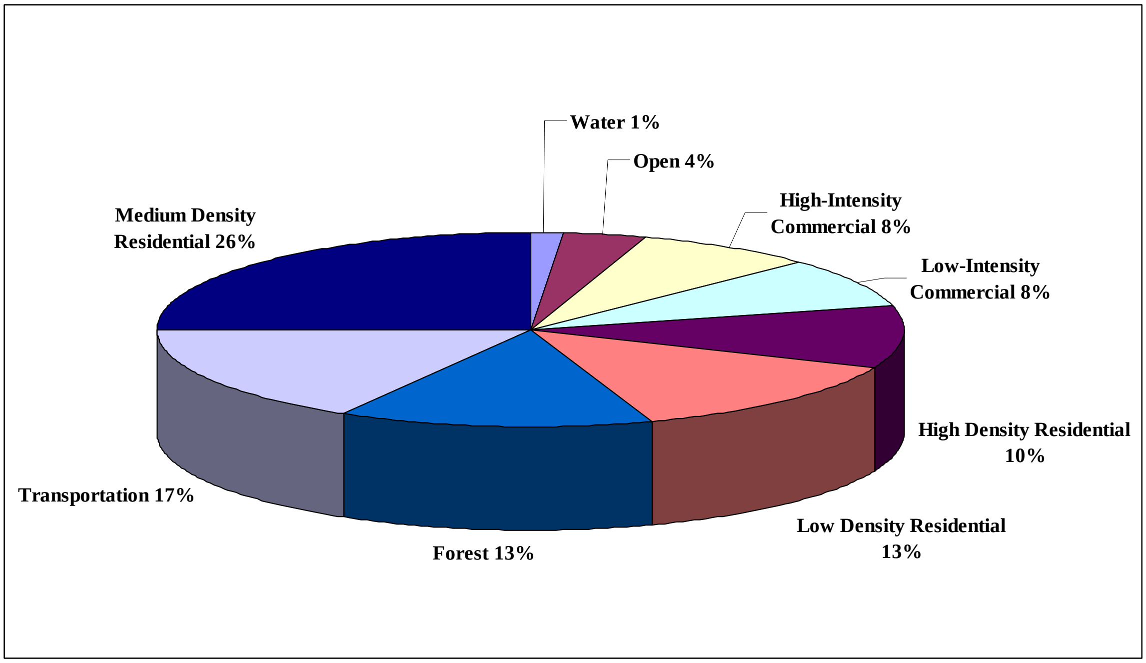
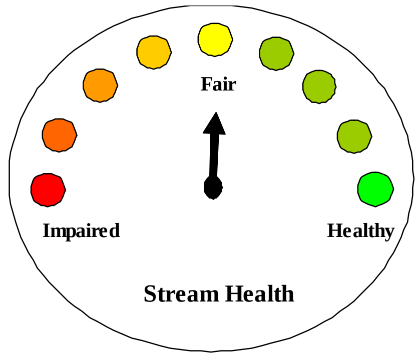


FIG. 8.4-31. Land use in the Meginnis Creek watershed (2,510 acres).

Low water levels prevented sampling during the 2nd and 3rd quarters of 2009. In December 2009, staff was unable to collect from Meginnis Creek due to a portion of the water being directed to the Water Management District's constructed wetland and a water flow restriction to the creek itself due to a series of stop logs blocking stream flow. This flow pattern was completely contrary to past flow regimes and the objectives of sampling this particular creek. Since the water re-distribution will probably become commonplace (wetland has recently been replanted and is being used for treatment), staff deactivated the existing station and established another station (established in 2010) that is located further downstream below all water treatment. The new station will allow staff to collect samples below all treatment associated with the Meginnis Creek water so as to better determine what potential pollutants are reaching Lake Jackson.

G. Summer Creek at Bannerman (formerly known as Unnamed Stream at Bannerman)



Summer Creek at Bannerman is a slightly tannic stream located in northwest Leon County **(Figure 8.4-32)** discharging to Lake Carr (Section B).

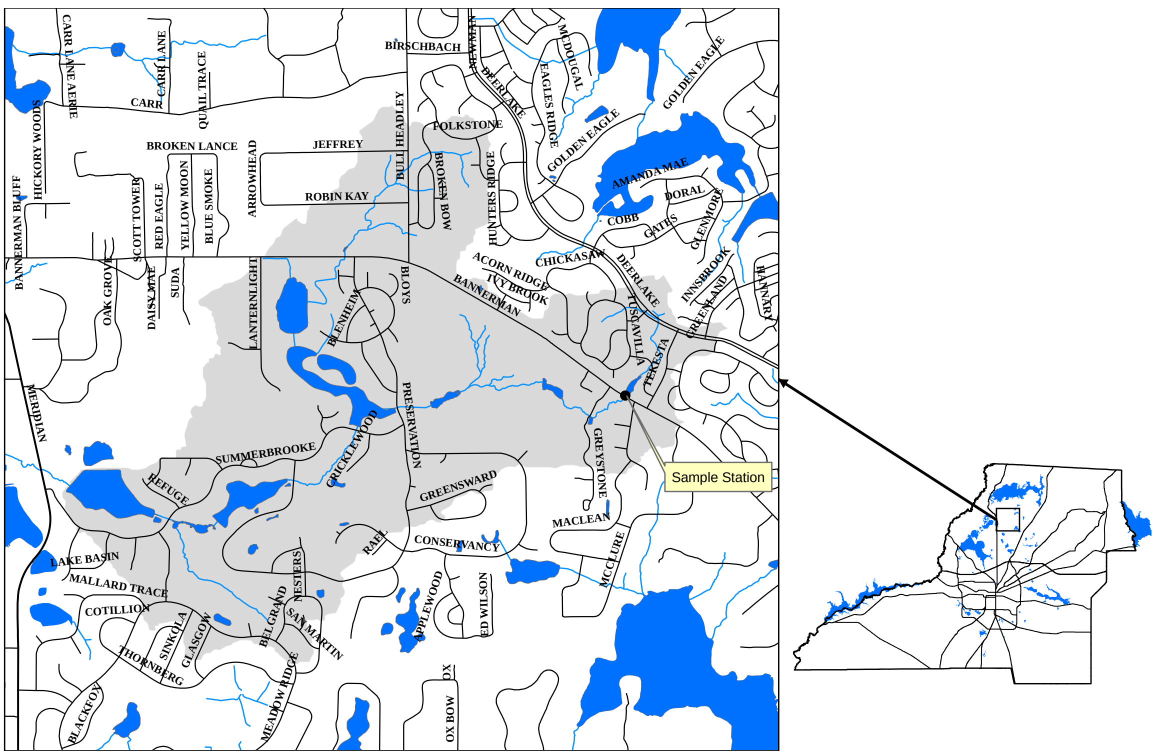


FIG. 8.4342. Overview Map of Summer Creek at Bannerman watershed.

As shown in **Figure 8.4-33**, approximately 61% of land use in the watershed is residential, commercial, agriculture, industrial, or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

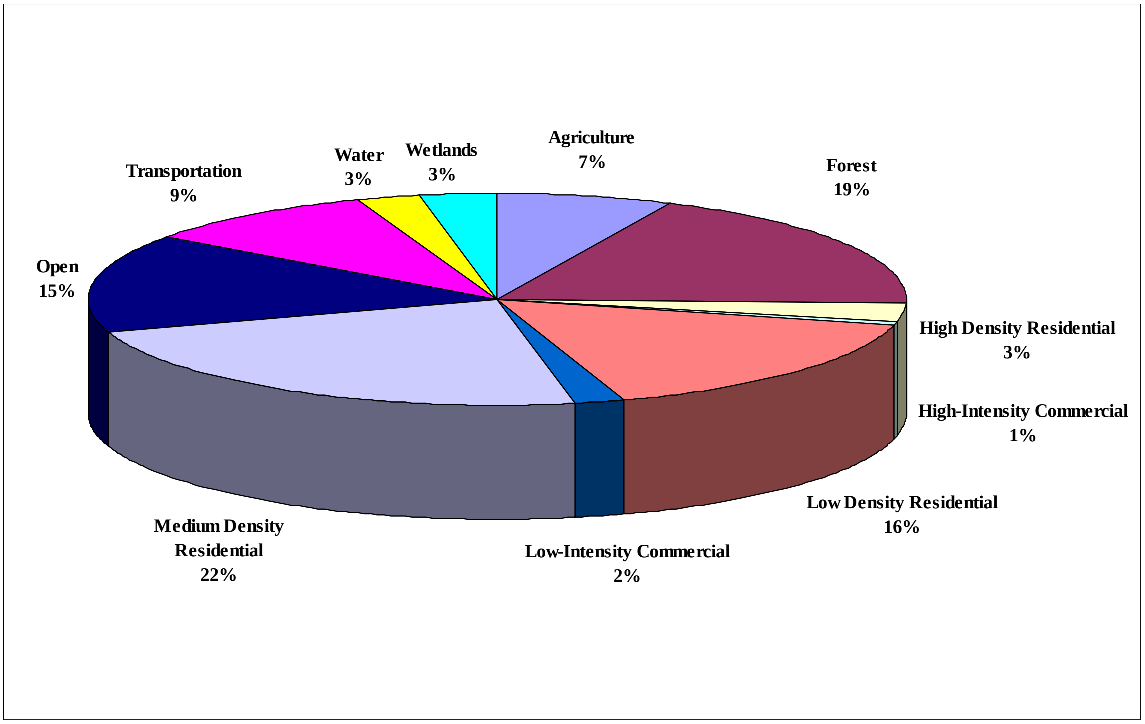


FIG. 8.4-33. Land use in the Summer Creek watershed (1,546 acres).

Fecal coliforms exceeded Class III water quality standards during several sampling events **(Figure 8.4-34)**. With the exception of the December 2009 nitrate + nitrite value, nutrients were low in Summer Creek, with total phosphorus levels ranked in the 10th percentile of streams in Florida. The December 2009 nitrate + nitrite value (0.26 mg/L) was higher than 70% of streams in Florida. Other nitrate + nitrite values were at levels below the detection limit of the analysis.

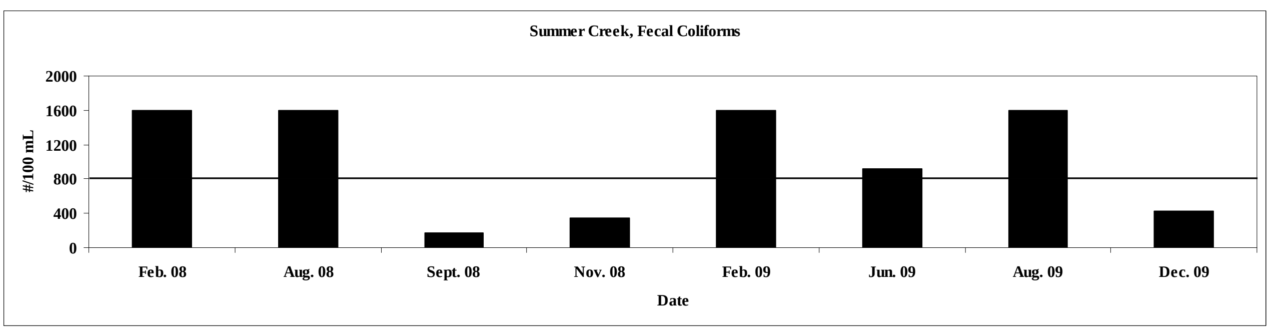
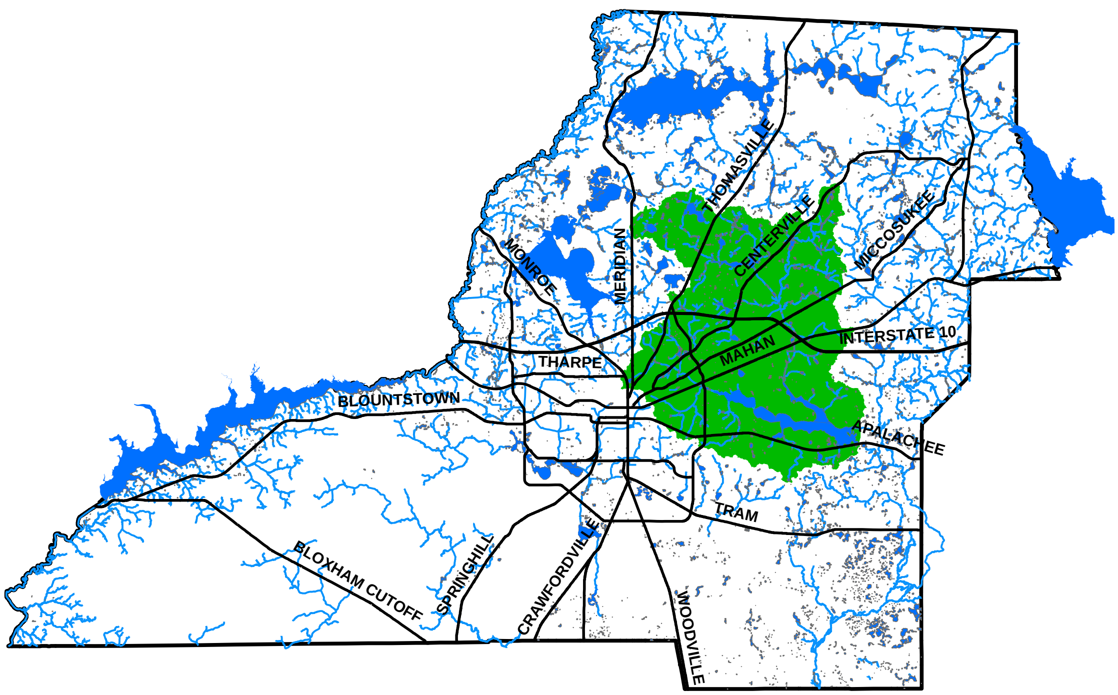
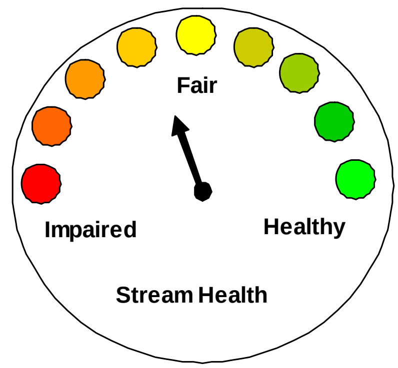


FIG. 8.4-34. Parameter of concern.

8.5. Lake Lafayette Basin



A. Alford Arm Tributary



The Alford Arm tributary is a moderately altered, nitrogen limited stream located in the northeast part of Leon County **(Figure 8.5-1)**. The tributary flows from Lake McBride in the Bradfordville area and receives runoff from the heavily developed Killearn Estates and Killearn Acres neighborhoods. Many of the water-bodies are former agriculture ponds, most notably the Velda Dairy impoundments, that are now seen as residential amenities. The zoning designation south of the Centerville Road and US 90 remains agricultural.

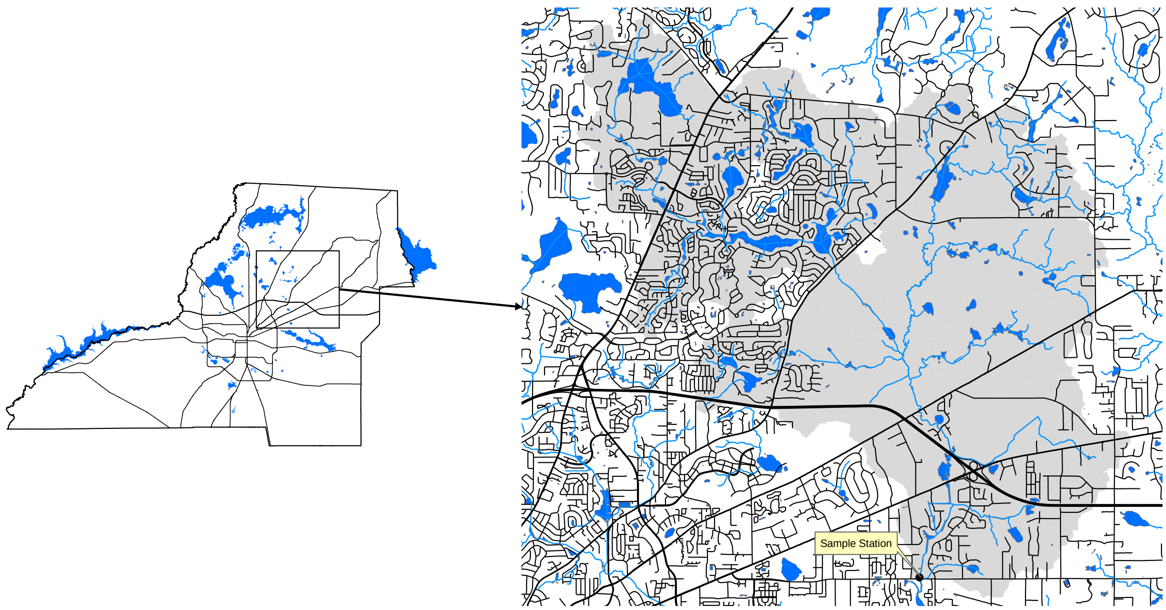


FIG.8.5-1. Overview Map of the Alford Arm Tributary watershed.

Figure 8.5-2 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Residential, agricultural, commercial, and transportation uses make up approximately 52% of the watershed.

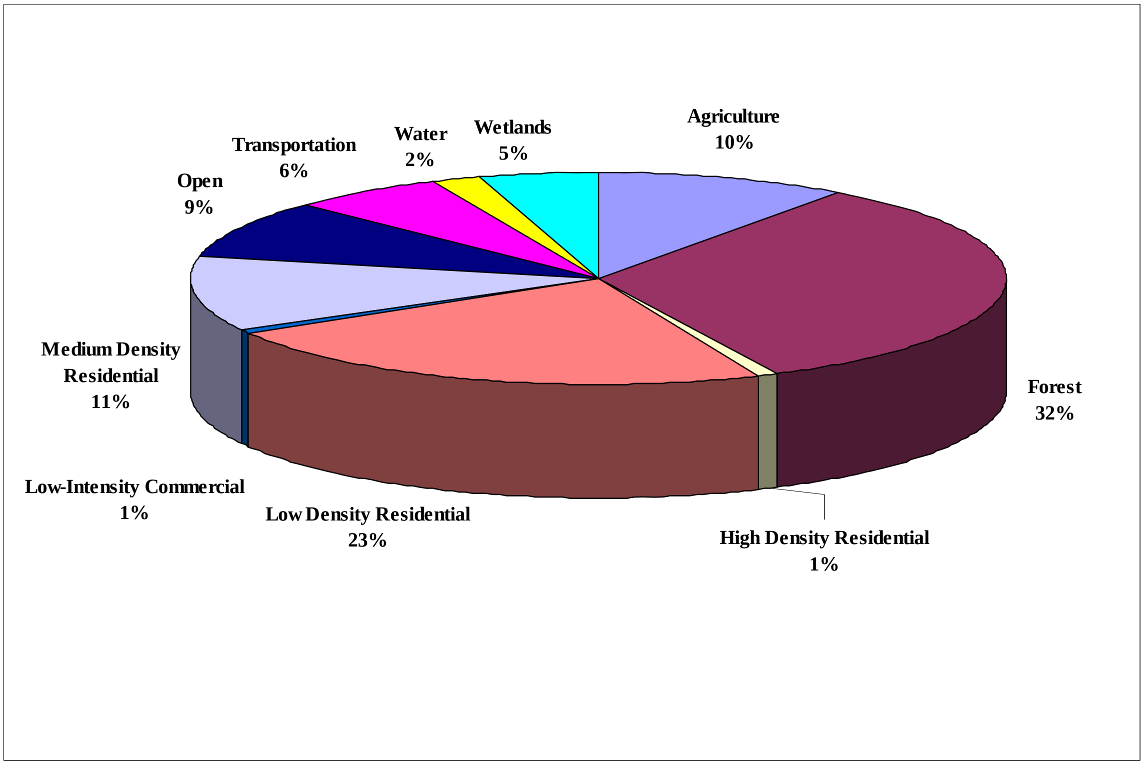


FIG. 8.5-2. Land use in the Alford Arm tributary watershed (22,603 acres).

Dissolved oxygen levels did not meet the Class III water quality standard of 5 mg/L for two of the three sampling events **(Figure 8.5-3)**. The fecal coliform value for the December 2009 sampling event exceeded Class III water quality standards **(Figure 8.5-4)**. The total phosphorus value (0.19 mg/L) for the December 2009 sampling event ranked in the 60th percentile of streams in Florida. Chlorophyll *a* values were elevated in 2009, ranking in the 70th percentile of streams in Florida for the June and December 2009 sampling events, and ranked in the 90th percentile for the August 2009 event **(Figure 8.5-5)**. The December sampling event showed an elevated turbidity value (14.8 NTU) when compared to the other 2009 sampling events **(Figure 8.5-6)**. Significant grades remain in the developed areas of the watershed. High intensity rainfall would have a greater likelihood of eroding these soils and generating increased turbidity.

FIG. 8.5-3. Parameter of concern.

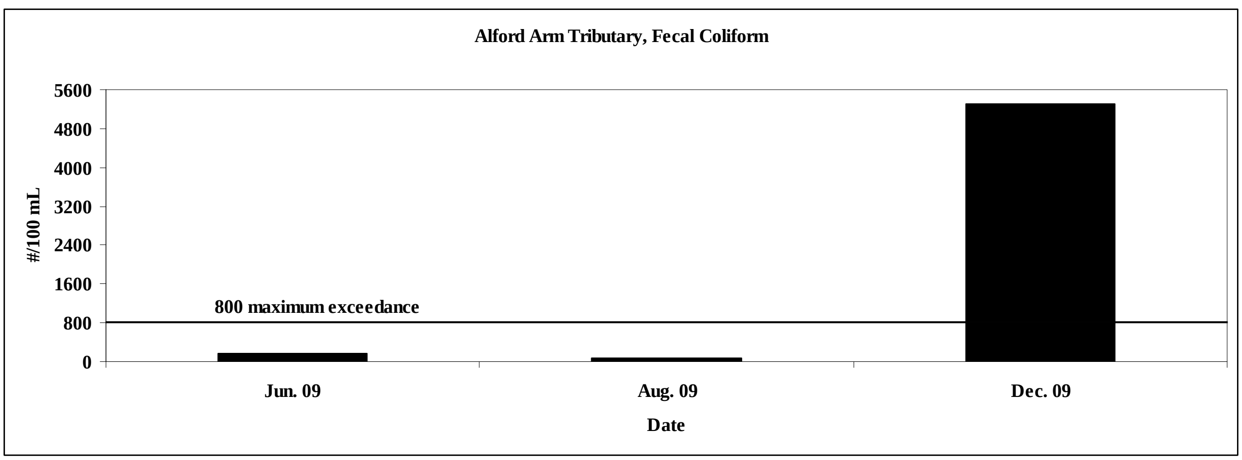


FIG. 8.5-4. Parameter of concern.

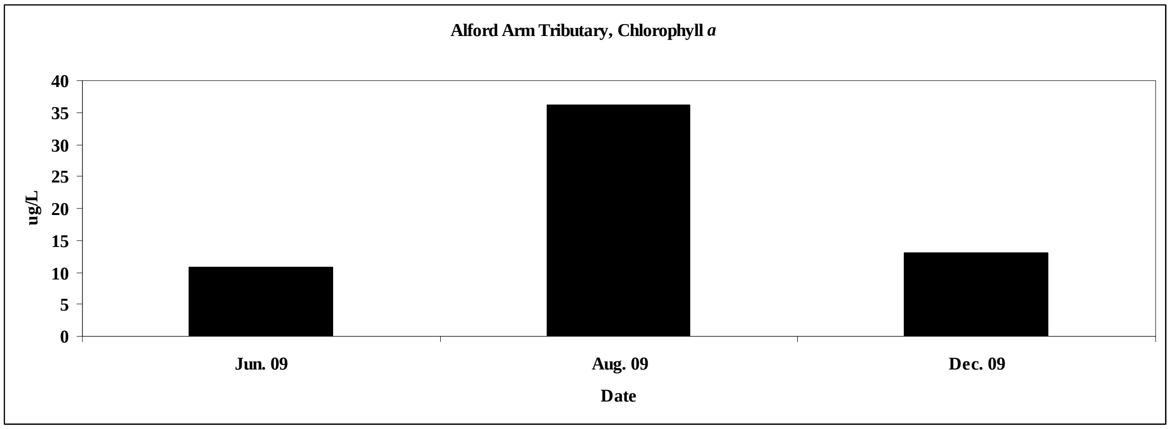


FIG. 8.5-5. Parameter of concern.

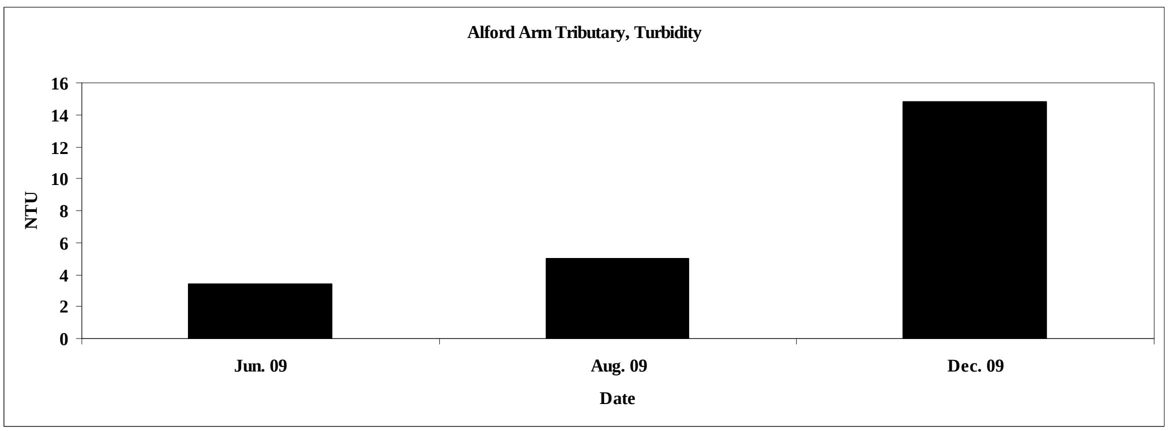
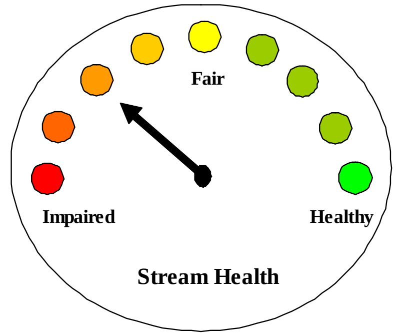


FIG. 8.5-6. Parameter of concern

B. Lafayette Creek



Lafayette Creek is a slightly tannic stream that flows north and drains into Upper Lake Lafayette **(Figure 8.5-7)**. Two stations, one located on Apalachee Parkway, the other located further downstream where Lafayette Creek enters into Upper Lake Lafayette were sampled during the sampling record timeframe. Unfortunately, low water conditions hindered any but the most tentative direct connections between the two stations so comparisons of water chemistry were not made at this time.

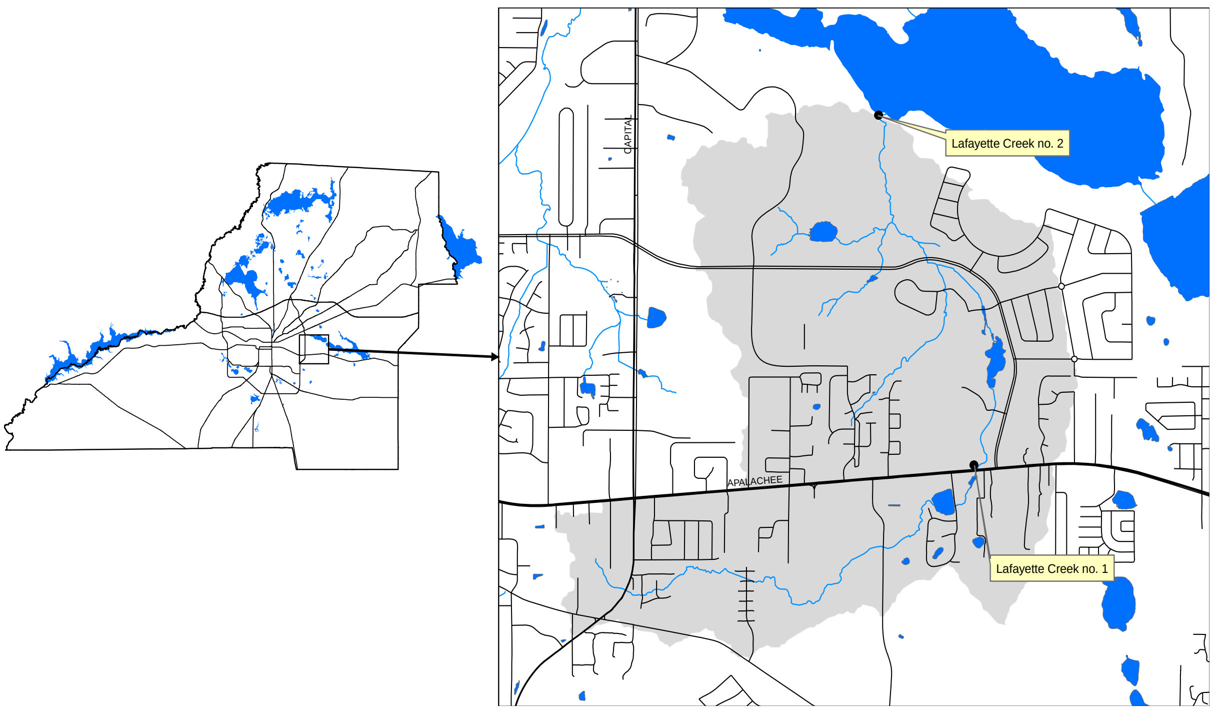


FIG.8.5-7. Overview Map of Lafayette Creek at Apalachee Parkway watershed.

As shown in **Figure 8.5-8**, approximately 57% of land use in the Lafayette Creek watershed is residential, commercial, agriculture, industrial, or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

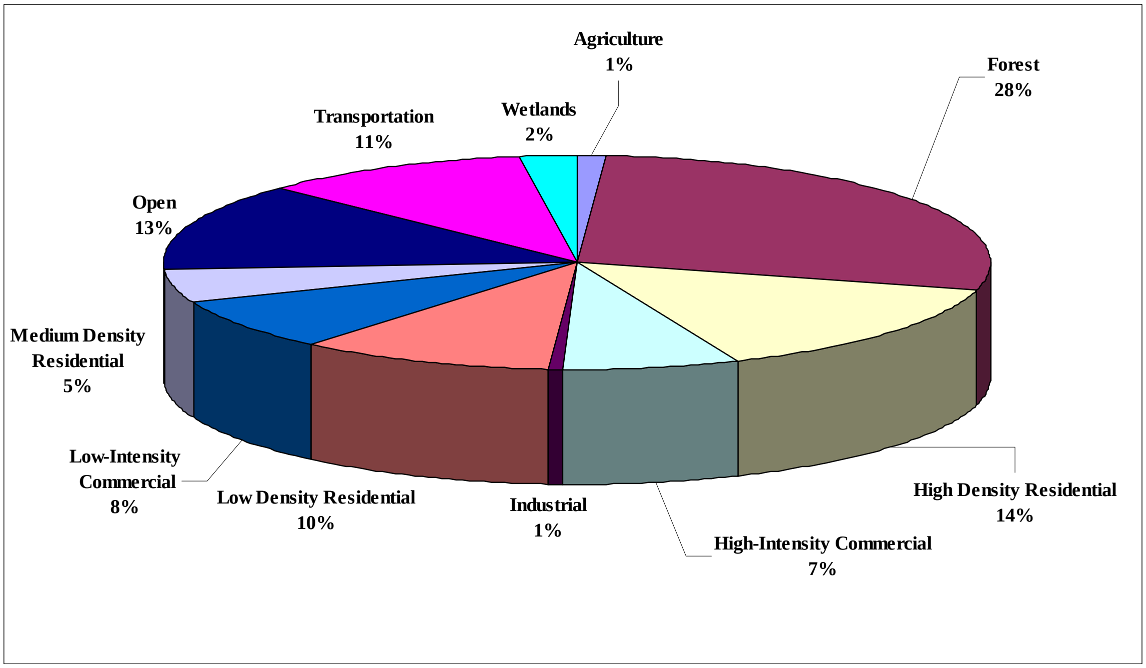


FIG. 8.5-8. Land use in the Lafayette Creek watershed (1,699 acres).

1. Lafayette Creek Station 1 (Apalachee Parkway)

The August 2009 sampling event DO value (4.03 mg/L) was below the 5 mg/L Class III water quality standard. Fecal coliforms exceeded FDEP's 800/100mL limit during the August and December 2009 sampling events **(Figure 8.5-9)**. Elevated turbidity levels during the February and December 2009 sampling events exceeded Class III water quality standards **(Figure 8.5-10)**.

Nutrient values continue to be elevated in this stream. The December 2009 total phosphorus level exceeded levels found in 70% of Florida streams **(Figure 8.5-11)**. The August 2006 and November 2007 ammonia values exceeded values found in 95% of Florida streams; data from other sampling dates exceeded values found in 90% of streams in Florida **(Figure 8.5-12)**. Nitrite + nitrate values exceeded 80% of other Florida streams during the October 2006 and January 2007 sampling events but have dropped in 2008-2009 **(Figure 8.5-13)** with a relatively slight increase during the December 2009 event**.** Elevated chlorophyll *a* levels in 2009 would place Lafayette Creek on FDEP's planning list due to the annual mean chlorophyll *a* concentrations being greater than 20 µg/L **(Figure 8.5-14)**. The extraordinarily high nutrient and chlorophyll levels indicate a significant impairment to the creek water chemistry.

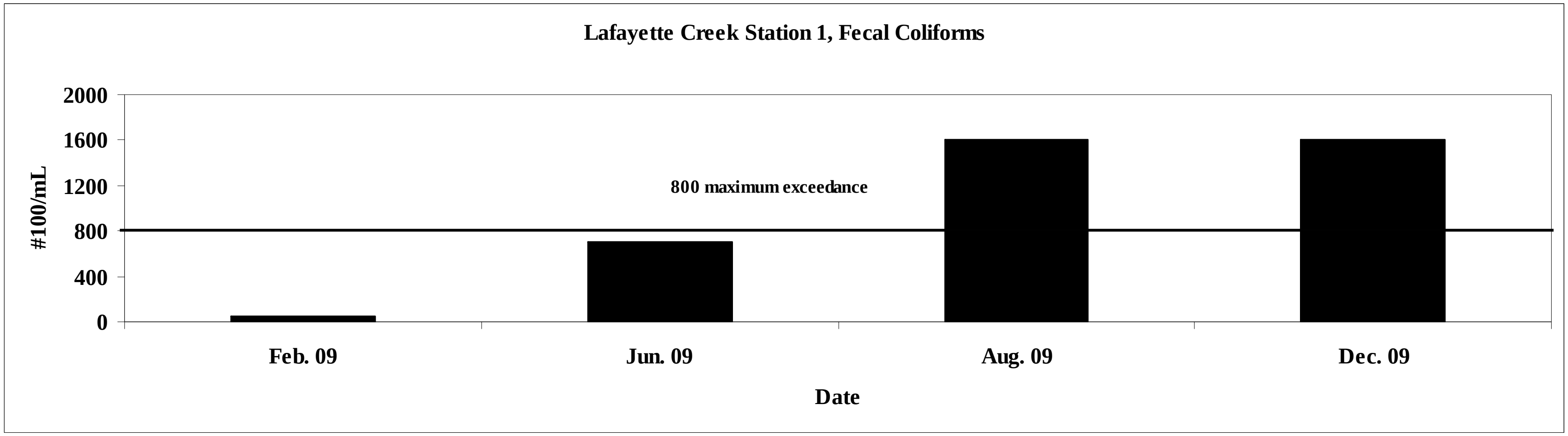


FIG. 8.5-9. Parameter of concern.

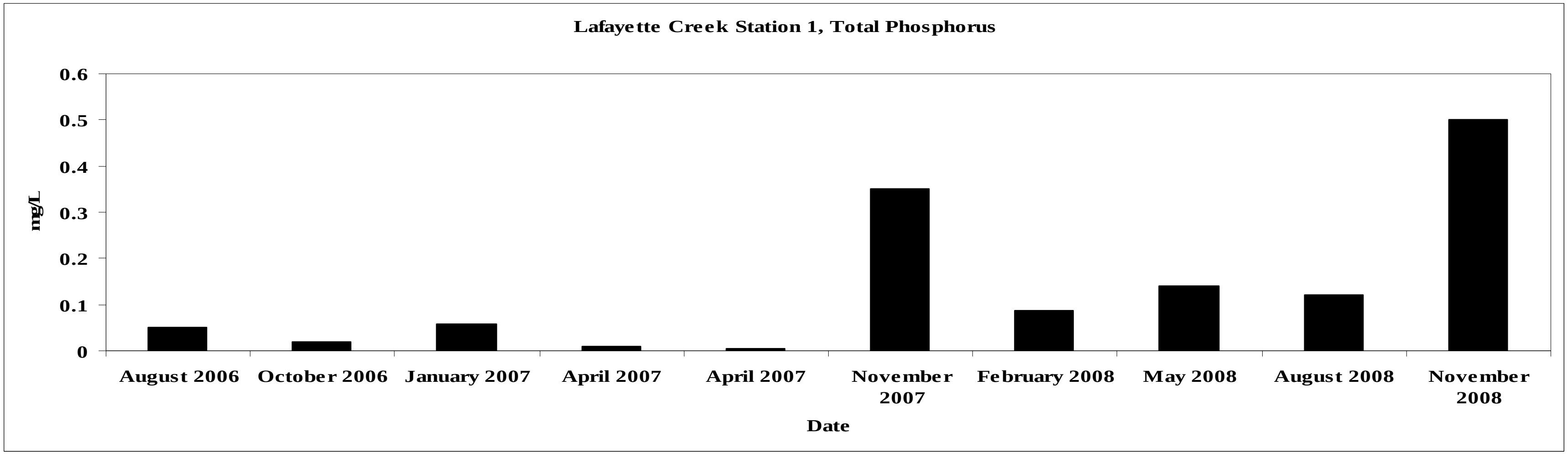


FIG. 8.5-10. Parameter of concern.

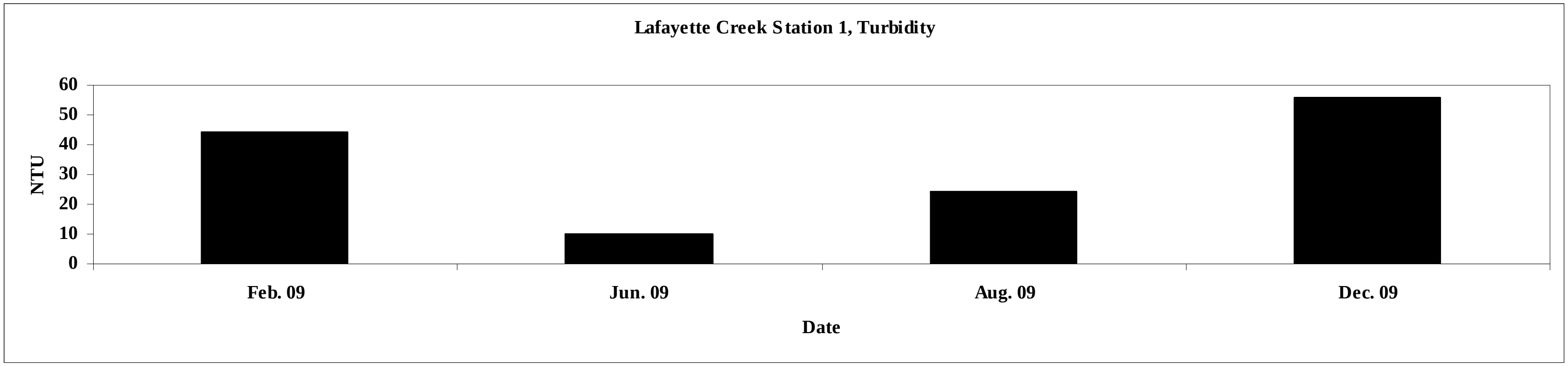


FIG. 8.5-11. Parameter of concern.

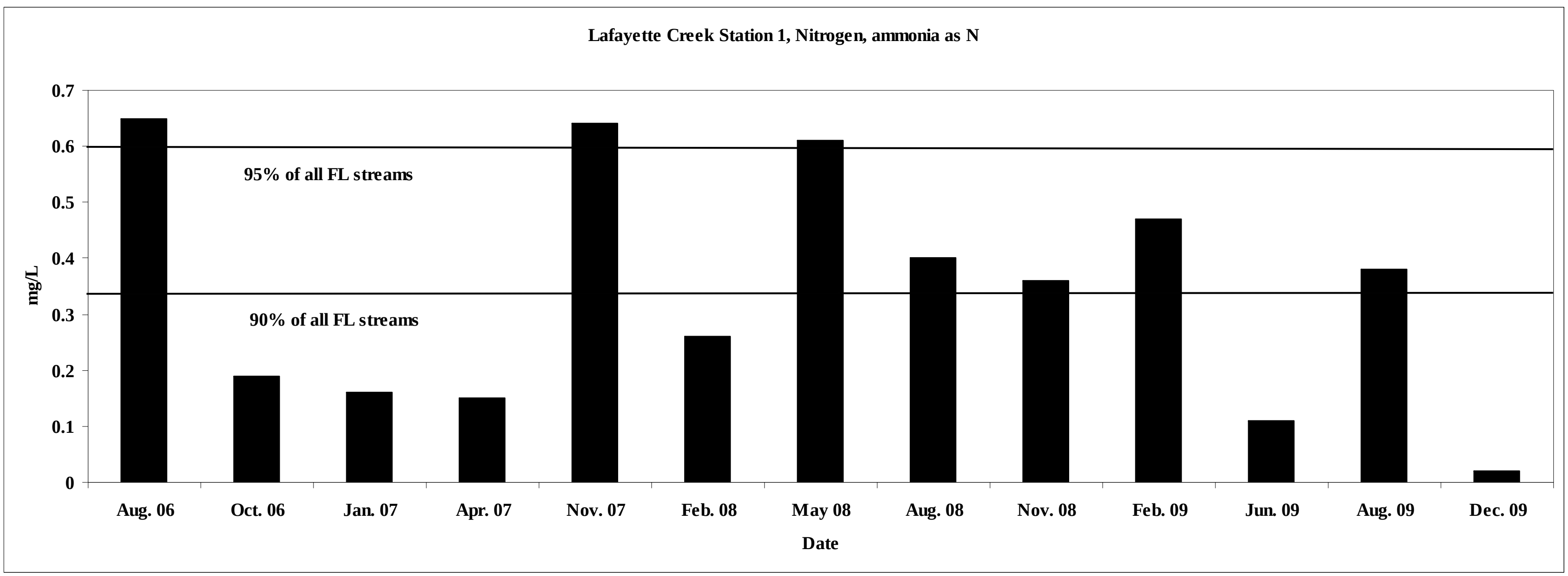


FIG. 8.5-12. Parameter of concern.

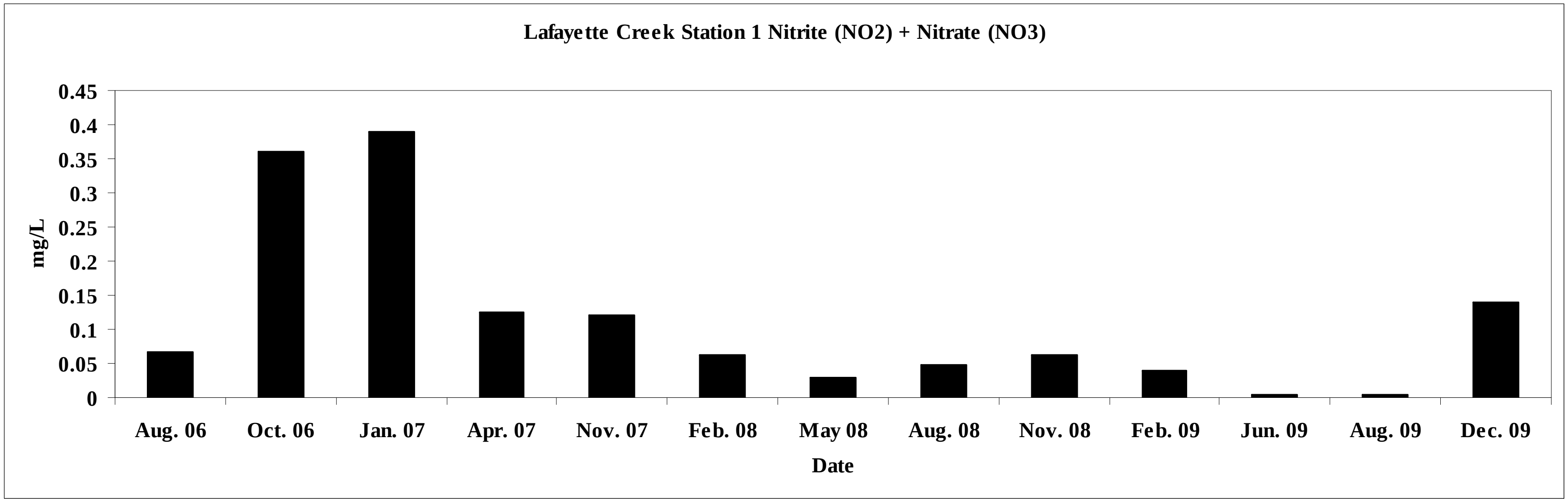


FIG. 8.5-13. Parameter of concern.

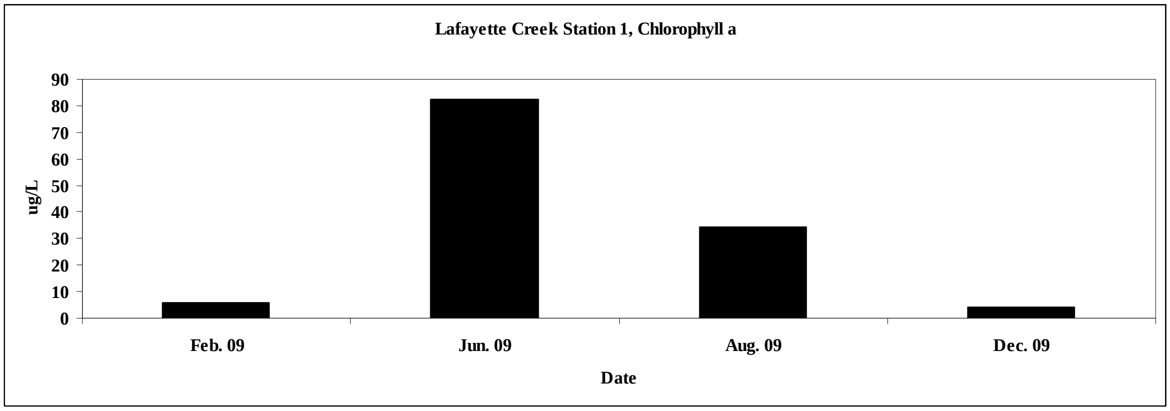


FIG. 8.5-14. Parameter of concern.

2. Lafayette Creek Station 2 (near Upper Lake Lafayette)

Low water conditions prevented sample collection for the 1st quarter of 2009. The fecal coliform values for the August and December 2009 sampling events and the DO for the August 2009 event did not meet Class III water quality standards **(Figures 8.5-15 – 8.5-16)**. Total phosphorus and turbidity values were elevated in the 4th quarter of 2009 **(Figures 8.5-17 – 8.5-18)** while chlorophyll *a* values were elevated in the 2nd quarter of 2009 **(Figures 8.5-19)**.

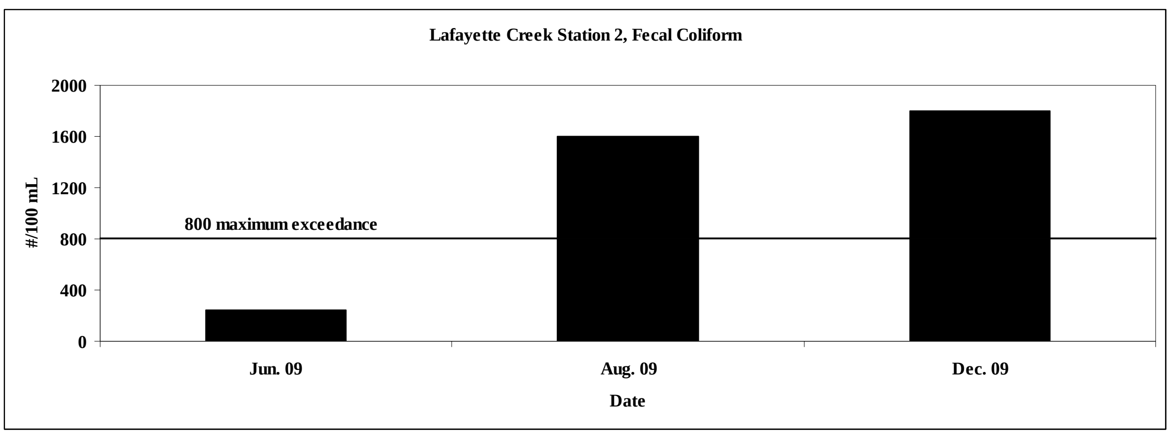


FIG. 8.5-15. Parameter of concern.

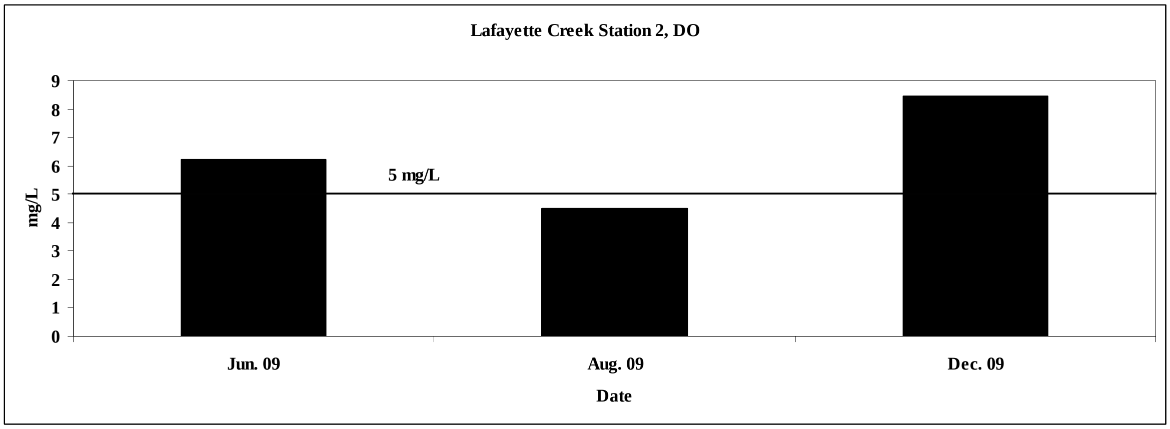


Fig. 8.5-16. Parameter of concern.

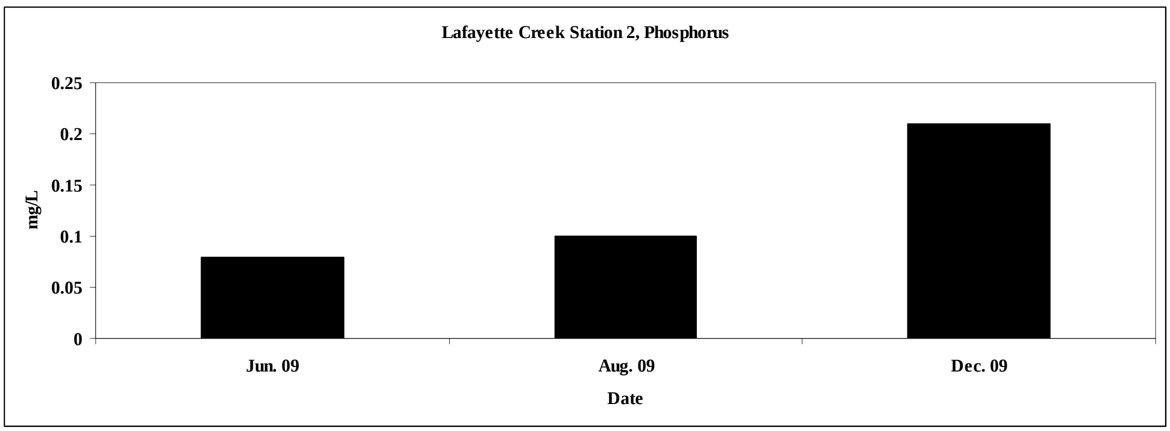


Fig. 8.5-17. Parameter of concern.

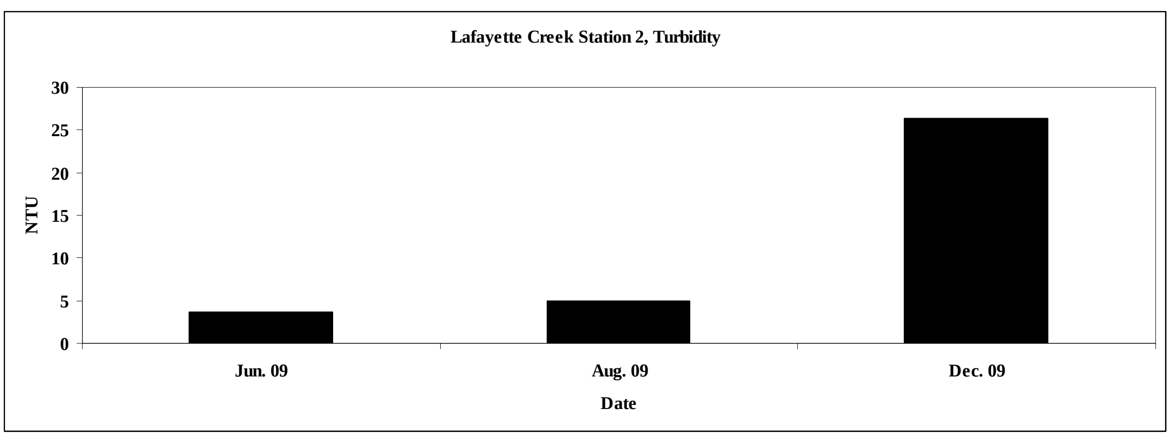


Fig. 8.5-18. Parameter of concern.

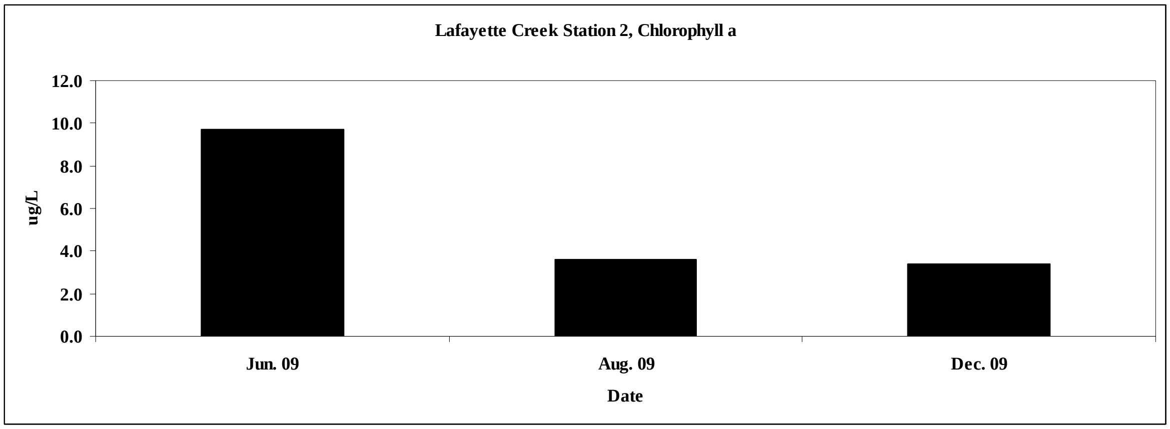


FIG. 8.5-19. Parameter of concern.

C. Lake Lafayette

Lake Lafayette was historically a meandering, wetland/prairie lake system located in eastern Leon County **(Figure 8.5-20)**, but land alterations in the mid 1900s separated the lake into four distinct sections, known as Upper Lake Lafayette, Lake Piney Z, Alford Arm, and Lower Lake Lafayette. Limited hydraulic connectivity occurs between the various sections, much of which is present only during high water elevations (Harper and Baker, 2005). Because of the compartmentalization of the four sections, each section is treated as a separate "lake".

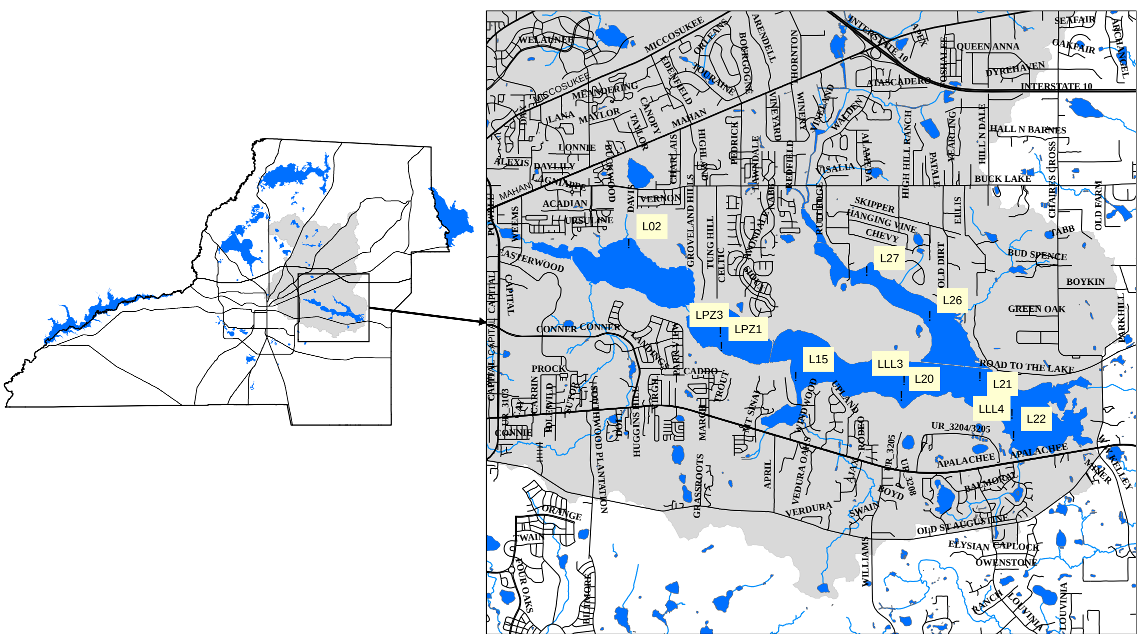


FIG. 8.5-20. Lake Lafayette with the locations of water quality sampling stations shown.

Figure 8.5-21 shows land use in the Lake Lafayette Basin. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Commercial, residential, agriculture and transportation uses make up approximately 58% of the Lake Lafayette Basin.

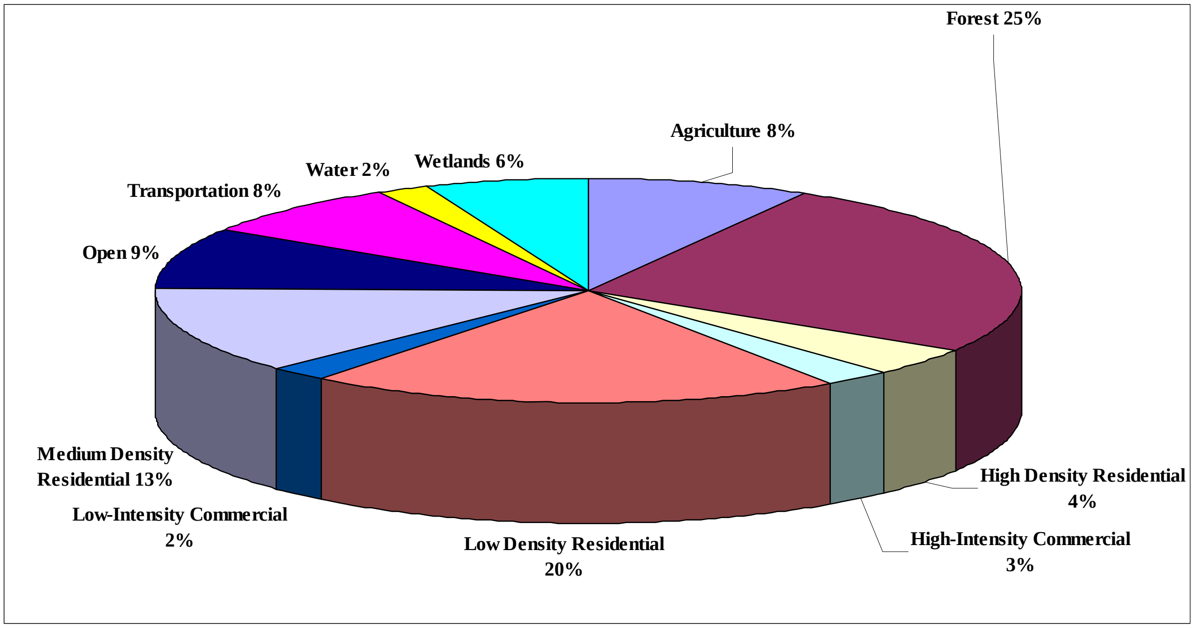


FIG. 8.5-21. Land use in the Lake Lafayette Basin (53,907 acres).

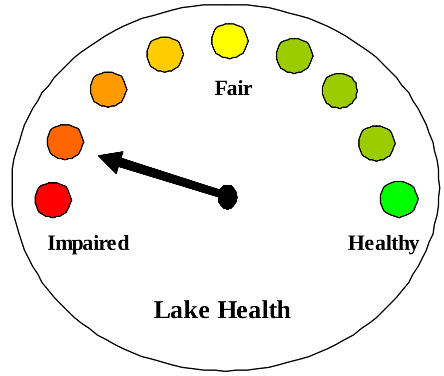
1. TSI and Color

As mentioned in Chapter 3, color determines the TSI threshold; darker lakes (≥ 40 PCU) use the 60 threshold while lighter lakes use the 40 threshold. As **Table 8.5-1** shows, over the entire Lake Lafayette sampling period (1991-2009) the four sections of Lake Lafayette had color levels exceeding 40 PCU, meaning the higher TSI threshold (60) would be used to determine impairment. However, due to changes in runoff characteristics, land use practices, better stormwater controls, and other unknown factors, color gradually decreased over the sampling period. The TSI calculation requires the use of corrected chlorophyll, which wasn't collected until 2004, so it was decided to use color data from the 2004-2009 period to determine which TSI threshold to use. During the 2004-2009 time periods, lake color decreased in all sections and color data indicated that two sections (Upper Lake Lafayette and Lake Piney Z) would be considered impaired if the TSI exceeded 40.

TABLE. 8.5-1. Lake Lafayette color levels and TSI thresholds over time.

Lake Section	1991-2009 Color	Historical TSI Threshold	2004-2009 Color	Current TSI Threshold
Upper Lake Lafayette	50	60	28	40
Piney Z	49	60	33	40
Alford Arm	57	60	45	60
Lower Lake Lafayette	121	60	103	60

a. Upper Lake Lafayette



The typically phosphorus limited Upper Lake Lafayette is the westernmost lake in this system **(Fig 8.5-22)**. The most dominant feature of Upper Lake Lafayette is the sinkhole (Lafayette Sink) that is located in the northeastern portion of the lake and is thought to drain into the Floridan Aquifer. The majority of the water entering Upper Lake Lafayette ultimately discharges into the sink area. As a result, the area and volume of the lake is highly variable. During typical rainfall periods, the area around Lafayette Sink becomes a 300 acre lake, but following dry periods, the lake bed can drain completely (ATM, 2004). The heavily urbanized Northeast Drainage Ditch and Lafayette Creek are the primary sources of water for the lake. Three other minor contributing sources are two small tributaries to the north of the lake and Lake Piney Z.

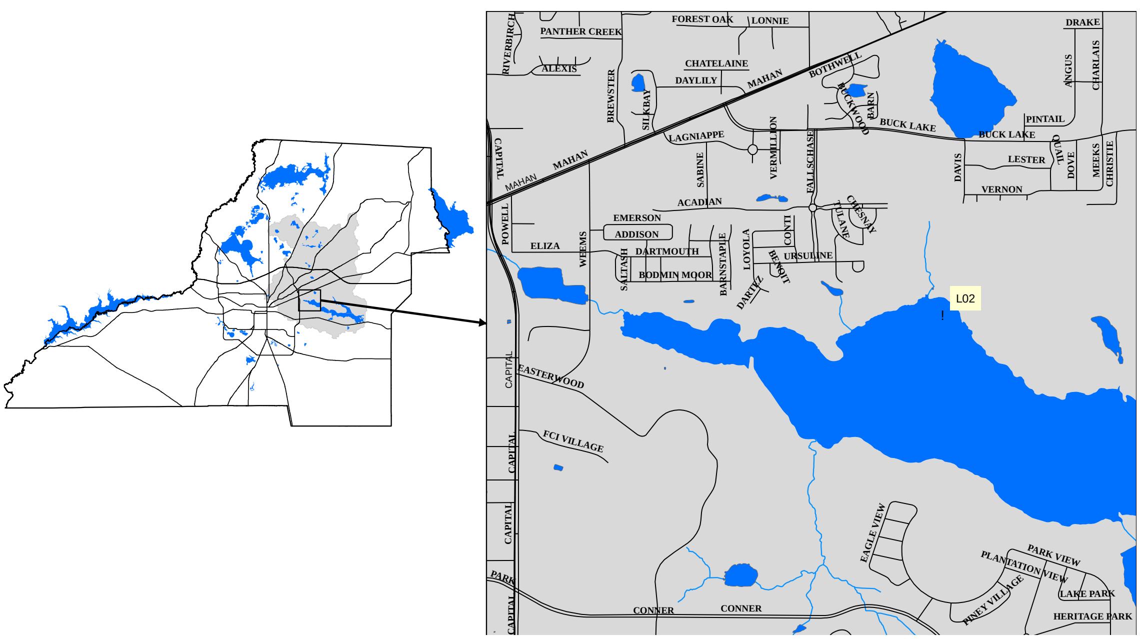


FIG. 8.5-22. Upper Lake Lafayette with the locations of water quality sampling stations shown.

Figures 8.5-23 and **8.5-24** represents Upper Lake Lafayette's trophic state utilizing the FDEP Trophic State Index. Seasonal and yearly averages show that Upper Lake Lafayette exceeded the 40 threshold in most seasons and all years and would be considered impaired according to FDEP standards.

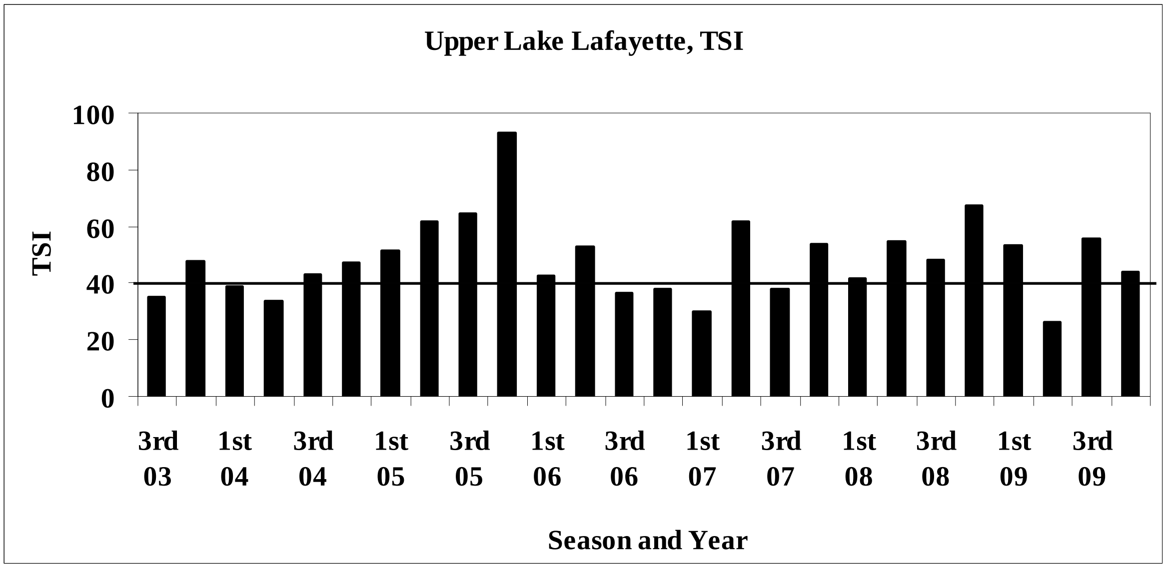


FIG. 8.5-23. Upper Lake Lafayette trophic state index (seasonal average).

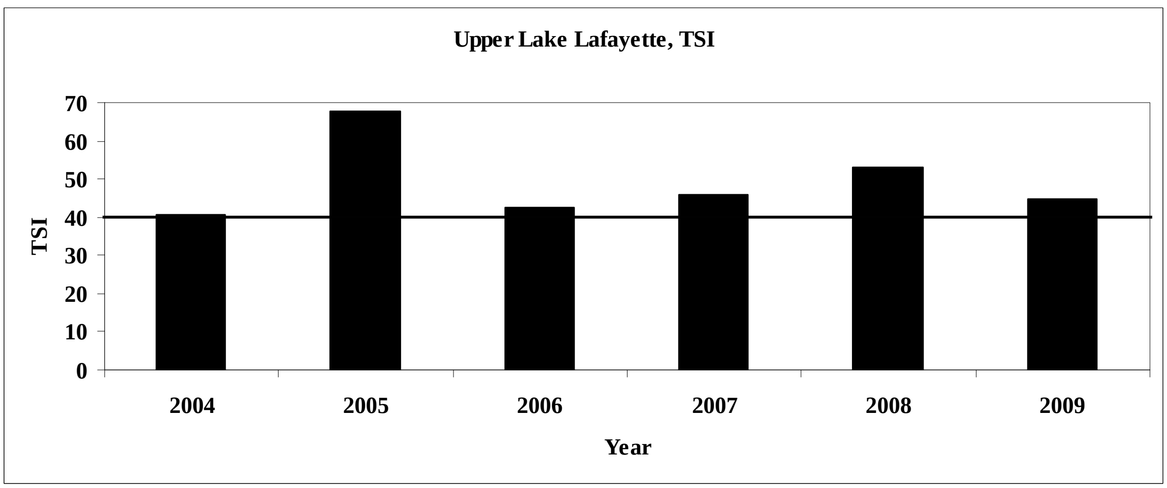
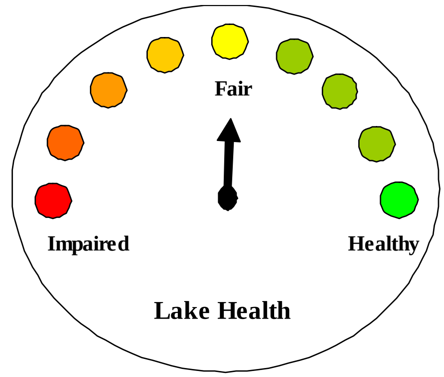


FIG. 8.5-24. Upper Lake Lafayette trophic state index (yearly average).

Elevated nutrient levels in Upper Lake Lafayette may occur due to the urbanized inflow streams combined with the fluctuating lake volume. The reduced volume concentrates incoming pollutants, reducing the lake's ability to assimilate the incoming nutrients.

Dissolved oxygen and fecal coliform levels met acceptable criteria in 2009 for Class III waterbodies.

b. Lake Piney Z



Lake Piney Z is a 228 acre waterbody located between Upper Lake Lafayette and Lower Lake Lafayette which consists primarily of an open water system, although substantial stands of vegetation are present within the lake **(Figure 8.5-25)** (Harper and Baker, 2005).

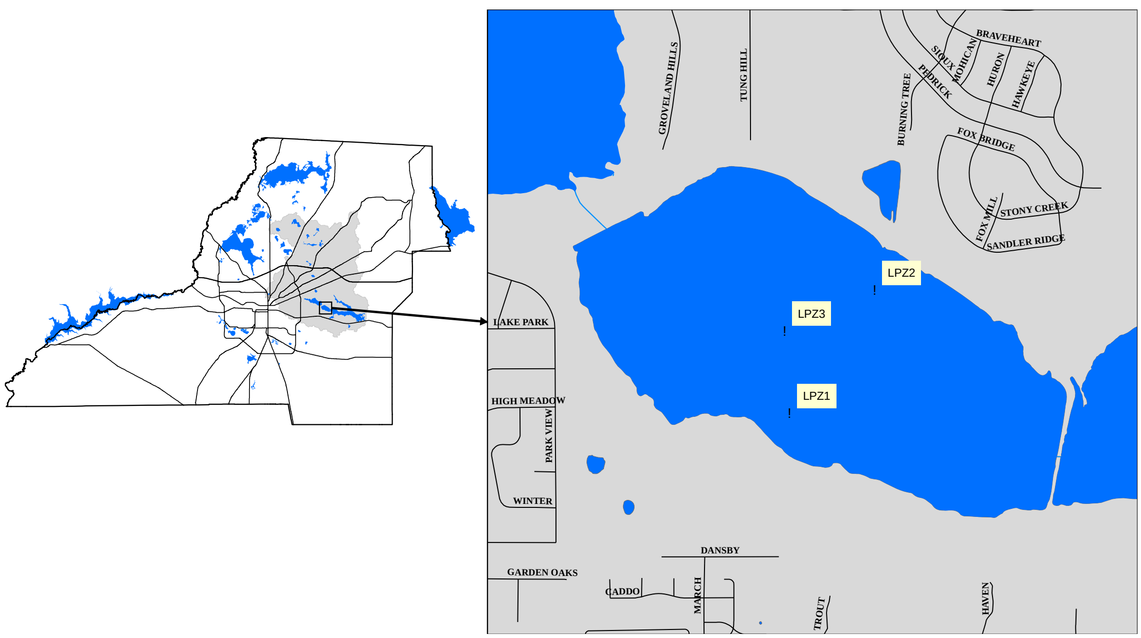


FIG. 8.5-25. Lake Piney Z with the locations of water quality sampling stations shown.

Discharges to Lower Lake Lafayette can occur via two outfalls located on the east side of Lake Piney Z and discharges to Upper Lake Lafayette can occur via a ditch located on the west side of the lake. Pipe blockage due to vegetation and damage to the pipes themselves suggest that the discharges are being limited. Lake Piney Z receives stormwater inflow from the Piney Z Plantation development and the Swift Creek Middle School stormwater pond on its northern shore, from a few holding ponds near the southern portion of the lake and also from the dirt road that rings the lake (City of Tallahassee Stormwater Management Division, 2007).

In 1997 Lake Piney Z was drawn down and organic matter was scraped from the bottom and used to construct fishing fingers extending north from the southern bank. Restocking of game fish commenced and currently Florida Fish and Wildlife Conservation Commission, in cooperation with the City of Tallahassee, manages Piney Z as a Fish Management Area.

Figures 8.5-26 and **8.5-27** represents Lake Piney Z's trophic state utilizing the FDEP Trophic State Index. Seasonal and yearly averages show that Lake Piney Z exceeds the 40 threshold and would be considered impaired according to FDEP standards.

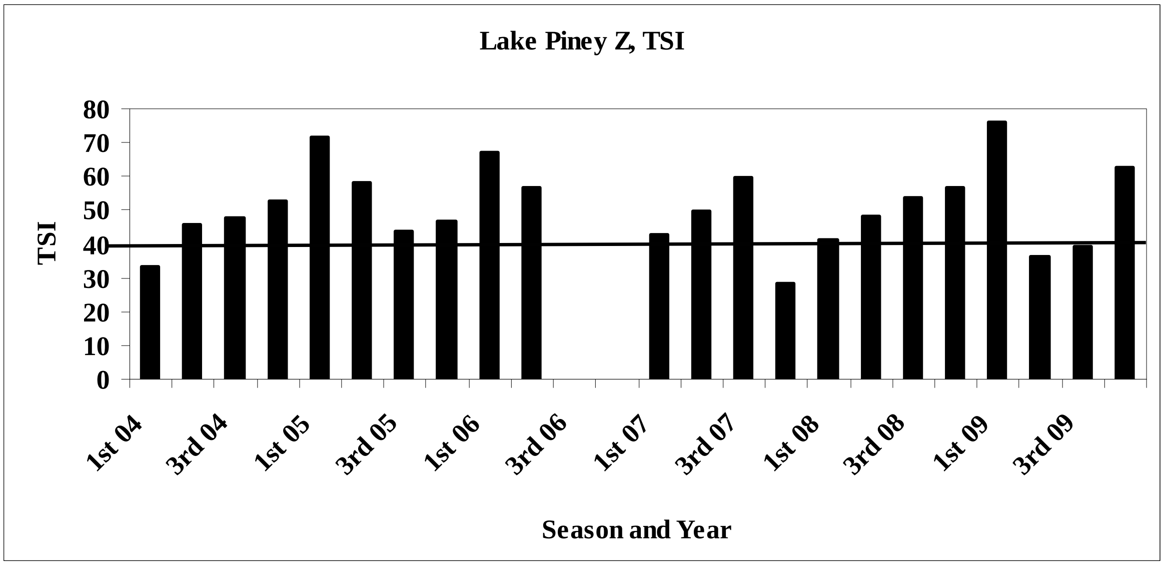


FIG. 8.5-26. Lake Piney Z trophic state index (seasonal average). Seasons not represented mean samples were not collected for all four seasons.

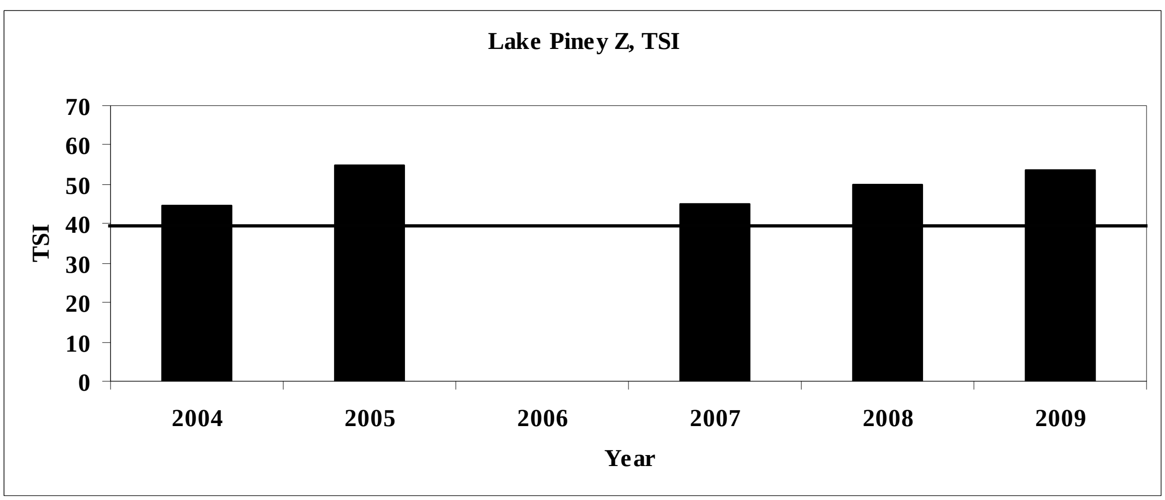


FIG. 8.5-27. Lake Piney Z trophic state index (yearly average based on seasonal averaging of the data). Years not represented mean samples were not collected for all four seasons.

Dissolved oxygen levels fluctuated and at times did not meet Class III water quality standards **(Figure 8.5-28)**. This occurred more frequently in the mid to latter part of 2007, suggesting that drought conditions had an effect on Lake Piney Z. Fecal coliform levels (920/100 mL) exceeded Class III water quality standards during the August 2008 sampling event.

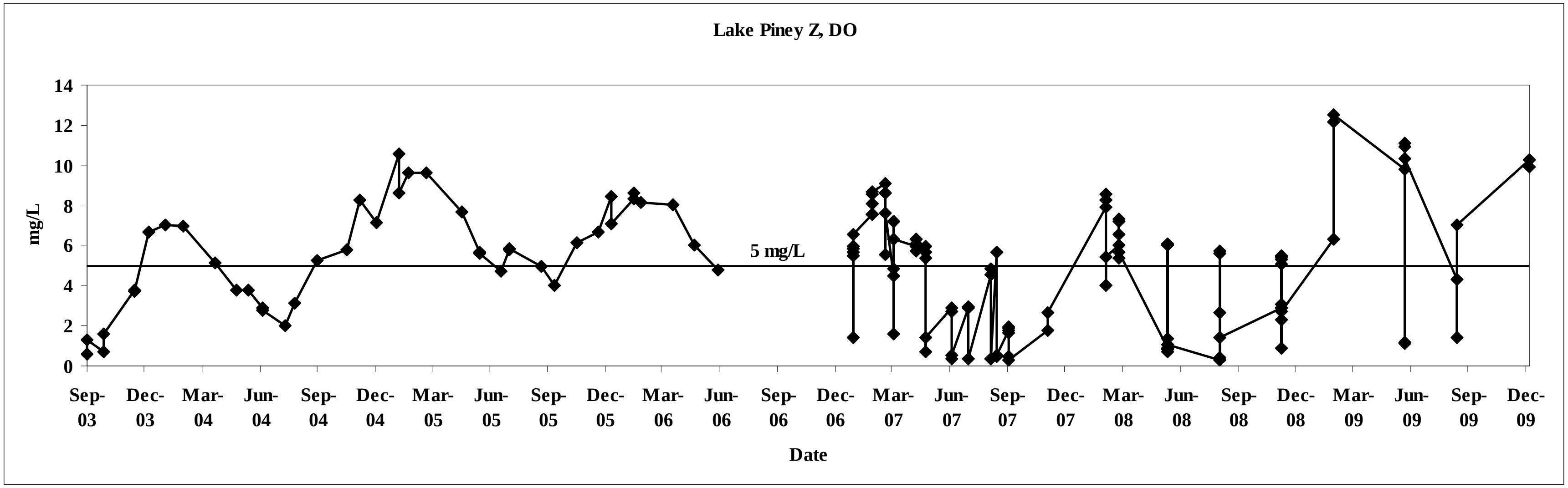
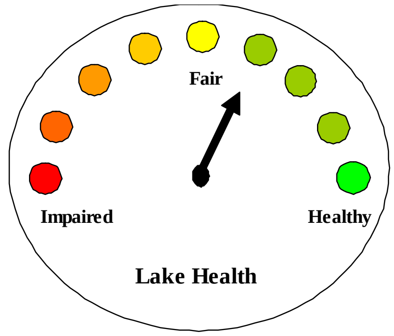


FIG. 8.5-28. Parameter of concern. Markers represent individual measurements. Starting in January 2007, top, mid-depth, and bottom DO measurements were taken where appropriate.

c. Alford Arm



Alford Arm is a 231 acre waterbody which was separated from Lower Lake Lafayette by construction of the CSX Railroad **(Figure 8.5-29)** and receives flow from the greatest area with natural cover, including the Welaunee Plantations, the Miccosukee Greenway and the Alford Arm Greenway. The substantial storage along the channel intercepted most flows during the year due to the extended drought. Although Alford Arm contains areas of standing water, the vast majority is covered by dense stands of both submergent and emergent wetland vegetation (Harper and Baker, 2005). Because of the dense vegetation and low water conditions, samples could not be collected for the last two quarters of 2008 and the 1st quarter of 2009.

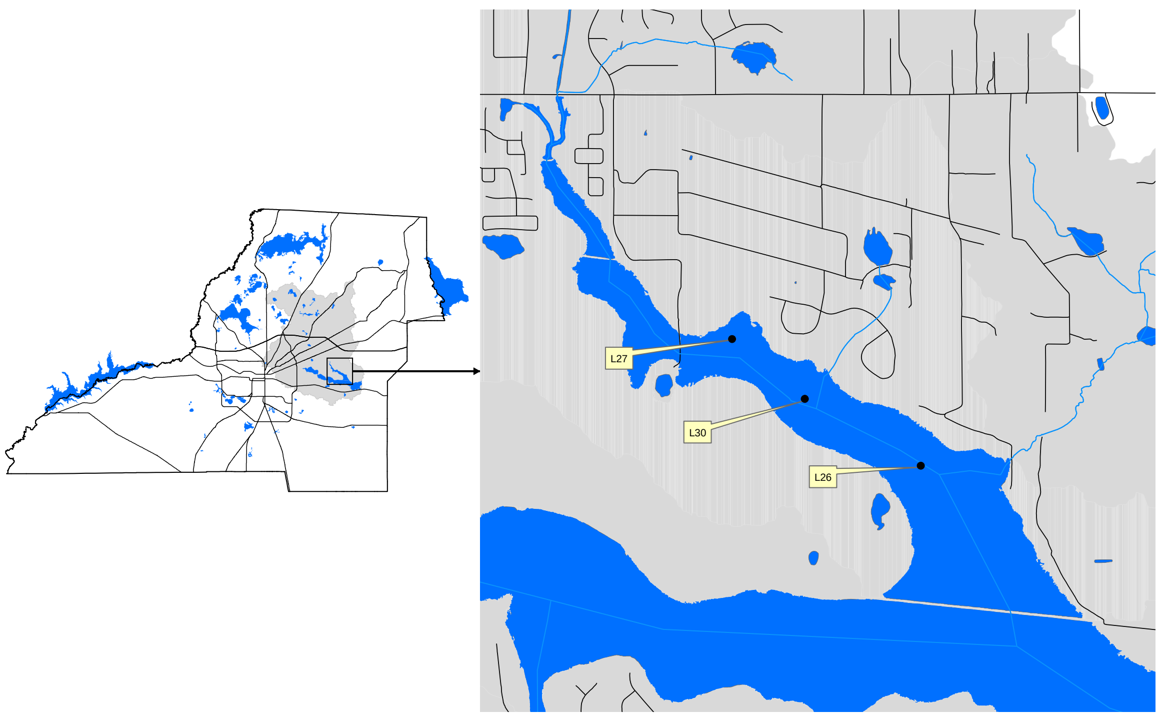


FIG. 8.5-29. Alford Arm with the locations of water quality sampling stations shown.

Figures 8.5-30 and **8.5-31** represents Alford Arm's trophic state utilizing the FDEP Trophic State Index. Seasonal and yearly averages show that Alford Arm does not exceed the 60 threshold and would not be considered impaired according to FDEP standards.

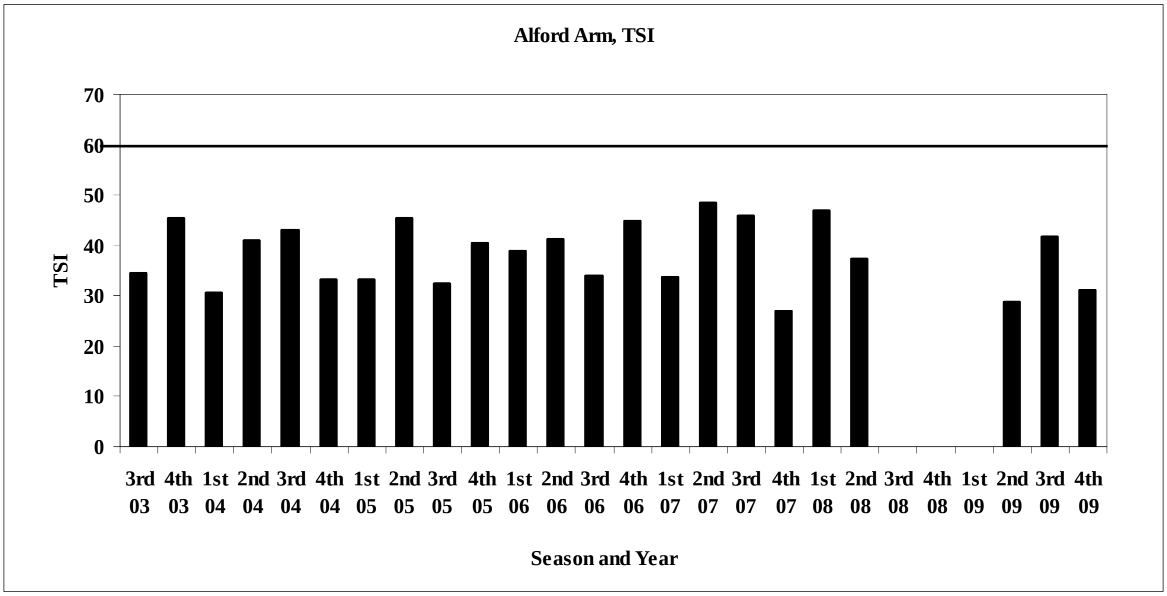


FIG. 8.5-30. Alford Arm trophic state index (seasonal average).

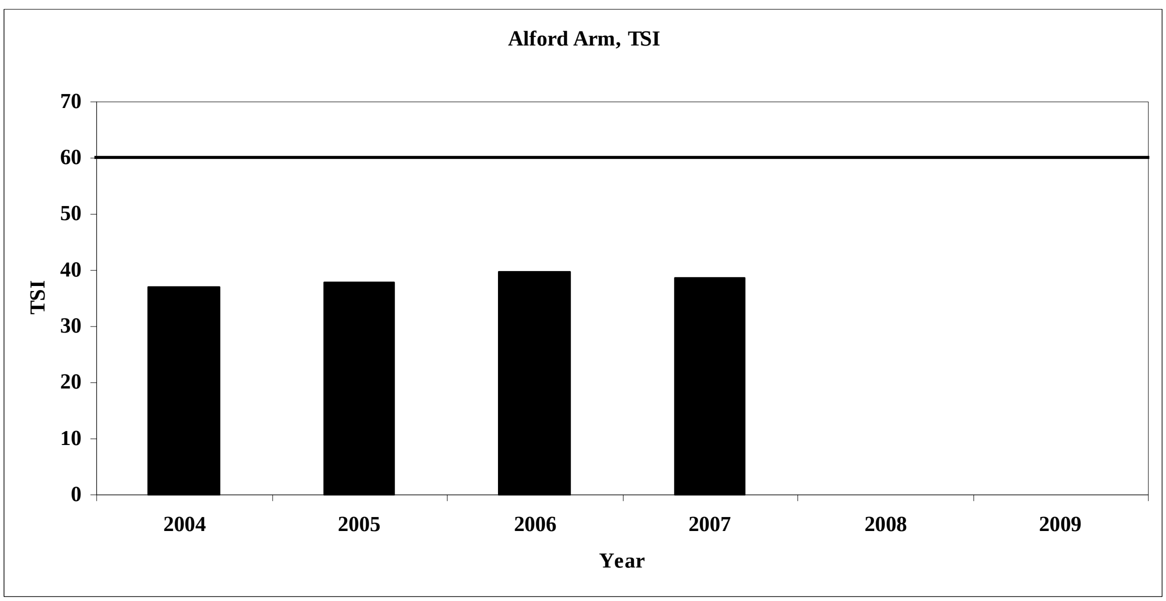


FIG. 8.5-31. Alford Arm trophic state index (yearly average based on seasonal averaging of the data). Yearly TSI scores for 2008 and 2009 were not calculated due to the lack of seasonal data.

Dissolved oxygen levels fluctuated and at times did not meet Class III water quality standards **(Figure 8.5-32)**. This occurred more frequently in late 2006 to the latter part of 2007 suggesting that drought conditions had an effect on Alford Arm. Another probable cause was a change in sampling. Where possible, multiple DO readings were taken throughout the water column to determine oxygen levels at varying depths. In highly organic sediments, sediment oxygen demand can play a role in low DO readings near the bottom of a waterbody. That appears to be the case with Alford Arm. In 2008, DO levels rose to levels that appear to be more typical of historic readings; however levels dropped again in 2009.

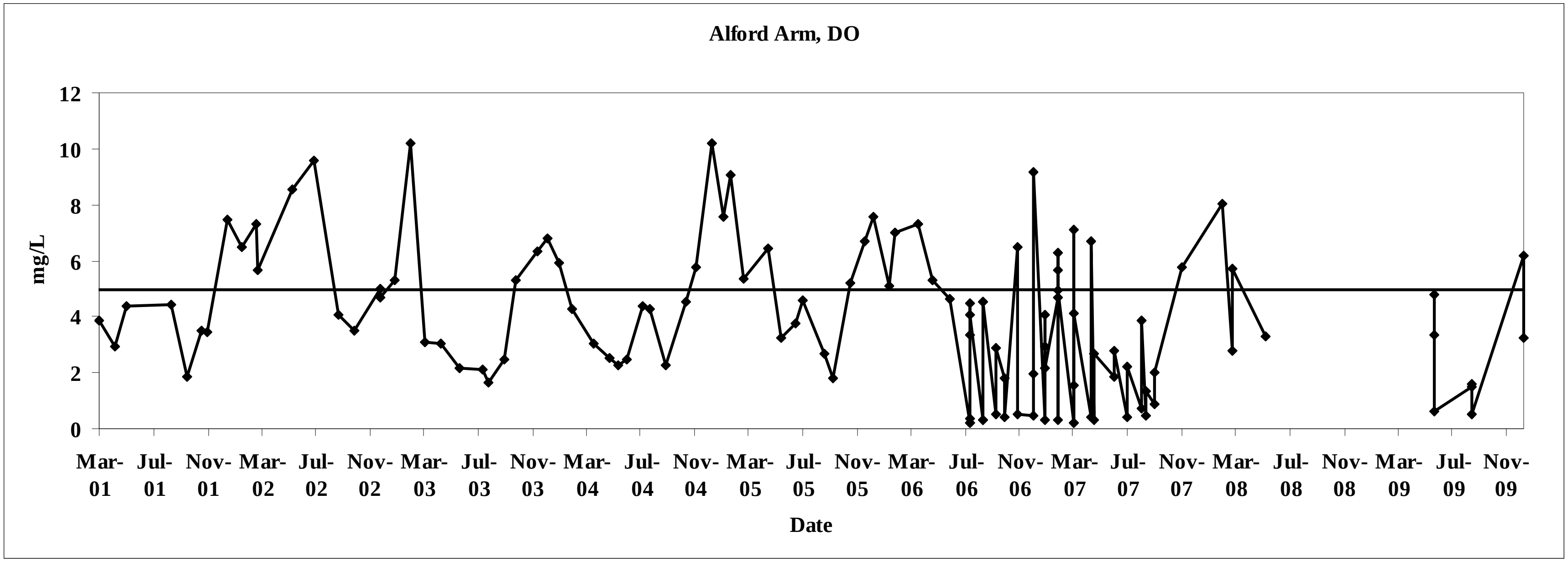
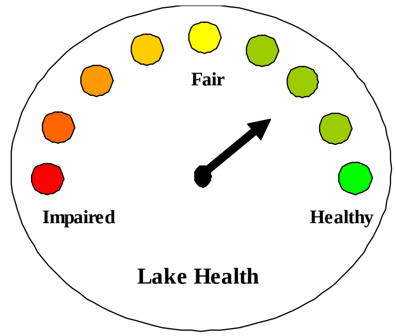


FIG. 8.5-32. Parameter of concern. Markers represent individual measurements. Starting in June of 2006, top, mid-depth, and bottom DO measurements were taken where appropriate.

d. Lower Lake Lafayette



Lower Lake Lafayette is the largest of the four lake compartments, covering an area of 1006 acres and bordered by the Leon County Solid Waste Facility, Talquin Electric Sewage Treatment Plant and various residential and commercial developments **(Figure 8.5-33).**

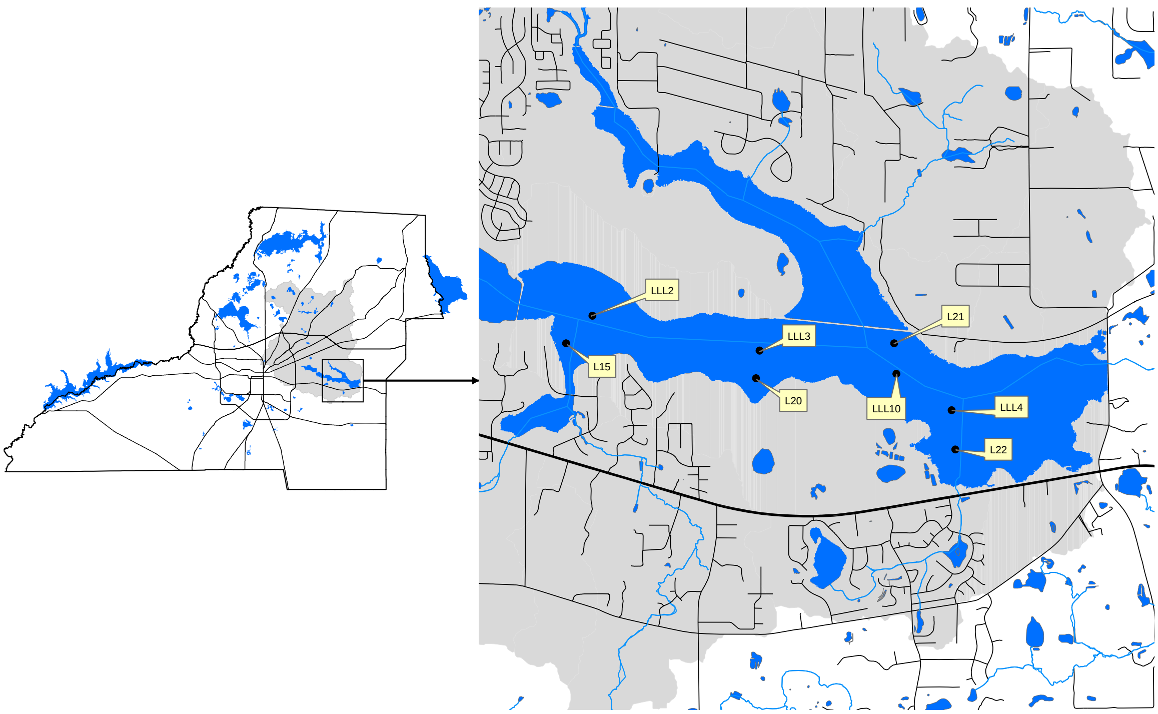


FIG. 8.5-33. Lower Lake Lafayette with the locations of water quality sampling stations shown.

Although pockets of open water are scattered throughout Lower Lake Lafayette, the vast majority of the area is covered by dense growths of emergent vegetation and trees (Harper and Baker, 2005). Water from Alford Arm enters Lower Lake Lafayette via pipes located under the CSX railroad track. Discharges from Lower Lake Lafayette occur through an earthen channel on the eastern end of the lake and passes under Chaires Cross Road and enters wetland systems associated with the St. Marks River (Harper and Baker, 2005). The extended drought caused low water levels in this section, which prevented water sampling during several quarters of 2007 and 2008.

Figures 8.5-34 and **8.5-35** represents Lower Lake Lafayette's trophic state utilizing the FDEP Trophic State Index. Seasonal and yearly averages show that Lower Lake Lafayette does not exceed the 60 threshold and would not be considered impaired according to FDEP standards. Lower Lake Lafayette often functions more like a wetland than a lake and it is thought that the massive amounts of vegetation act as a nutrient sink for any nutrients entering the lake.

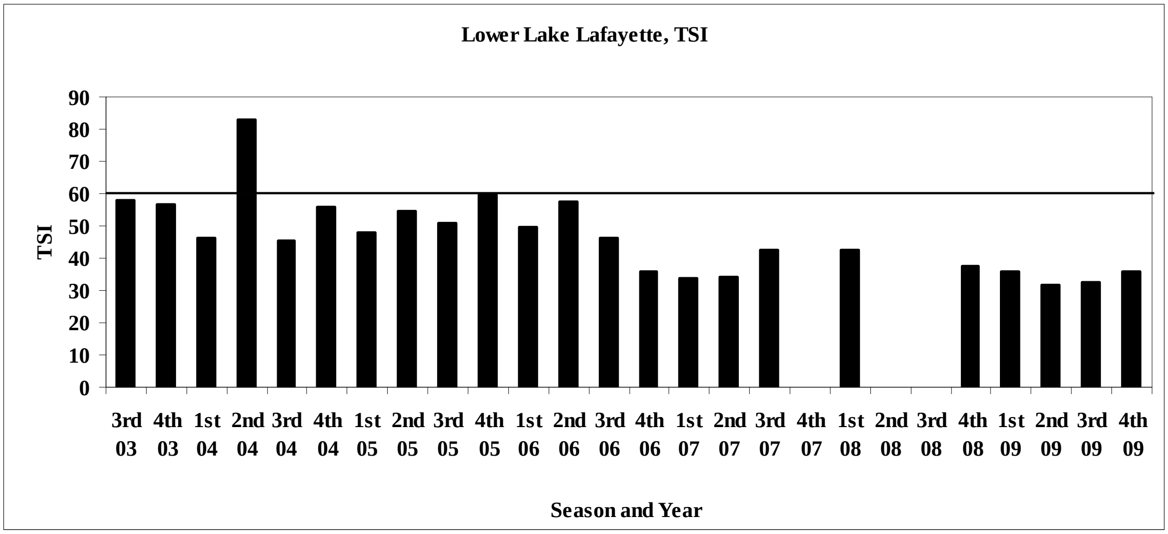


FIG. 8.5-34. Lower Lake Lafayette trophic state index (seasonal average). Due to low water the 2007 4th, 2008 2nd and 3rd quarter sampling could not be done.

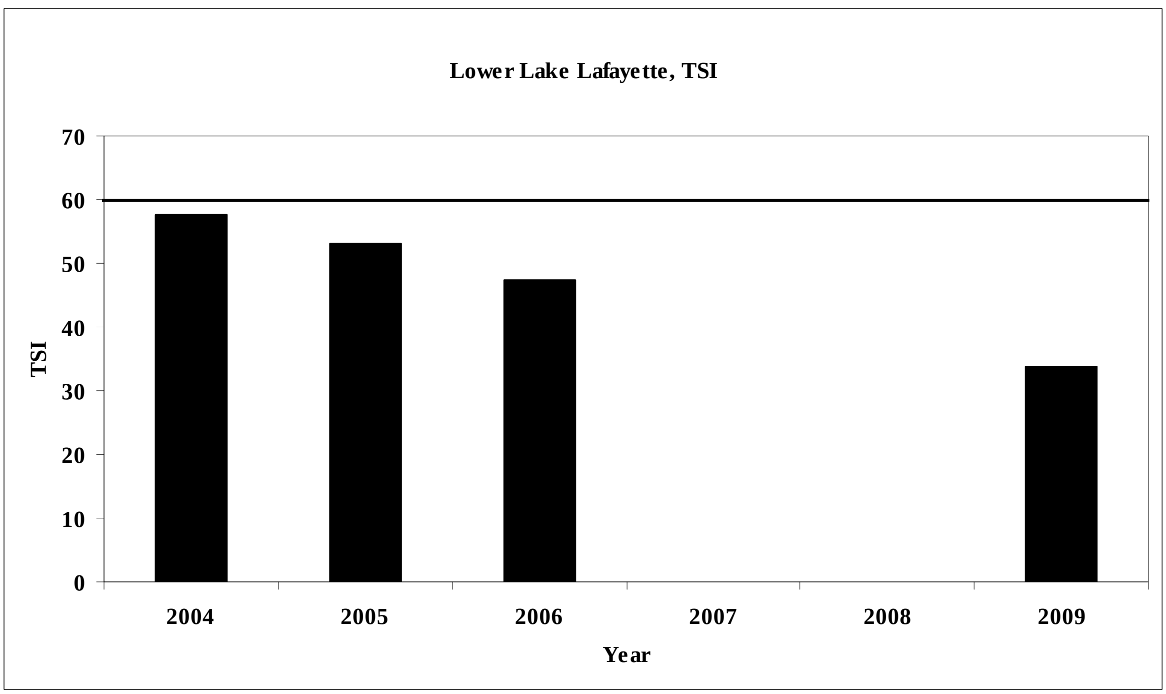


FIG. 8.5-35. Lower Lake Lafayette trophic state index (yearly average based on seasonal averaging of the data). Years not represented mean samples were not collected for all four seasons.

Like the other Lafayette lakes, DO levels fluctuated and at times did not meet Class III water quality standards **(Figure 8.5-36)**. It was thought that since this occurred more frequently in late 2006 to the latter part of 2007, that drought conditions had an effect on Lower Lake Lafayette. But since the fluctuations continued through 2009, it's more likely that the cause was a change in sampling technique. Where possible, multiple DO readings were taken throughout the water column to determine oxygen levels at varying depths. In highly organic sediments, sediment oxygen demand can play a role in low DO readings near the bottom of a waterbody. That appears to be the case with Lower Lake Lafayette.

Class III water quality standards were exceeded for fecal coliforms in August 2009 at station LLL2 (1600/100 mL) and LLL4 (920/100 mL).

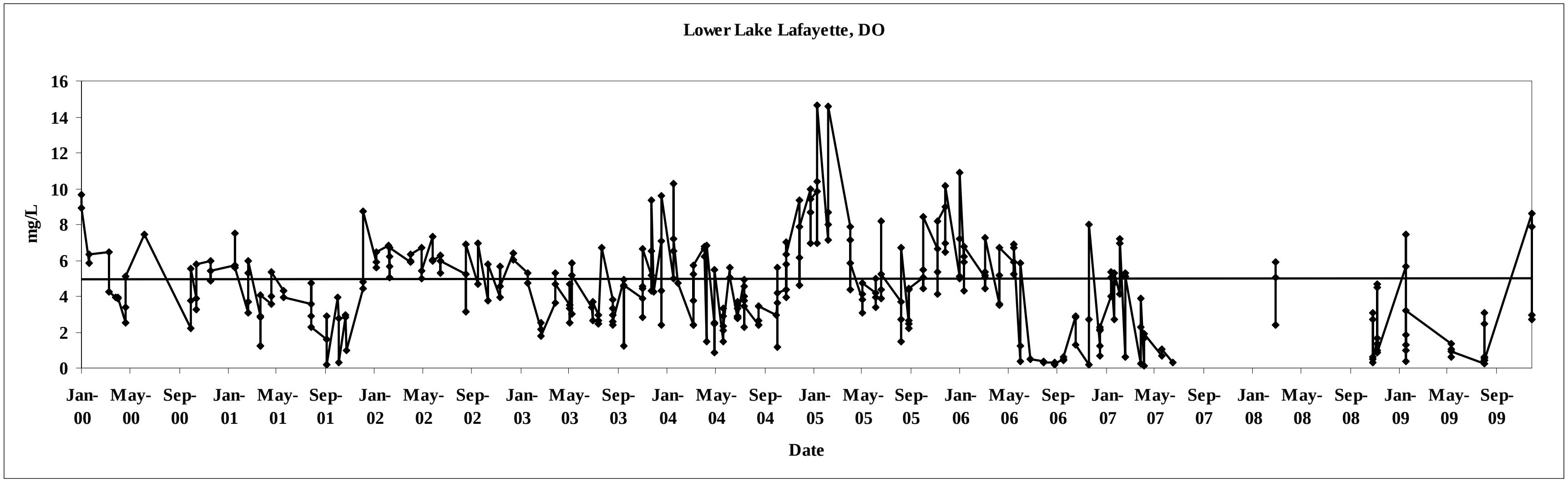
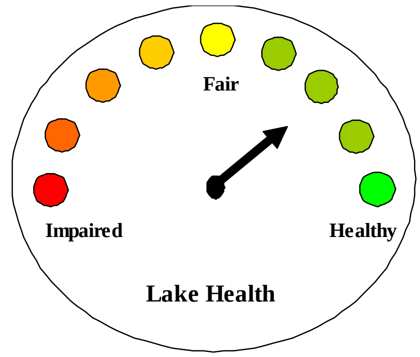


FIG. 8.5-36. Parameter of concern. Markers represent individual measurements. Starting in June of 2006, top, mid-depth, and bottom DO measurements were taken where appropriate.

D. Lake McBride



Lake McBride is a 183 acre lake located in the northern Leon County **(Figure 8.5-37)**.

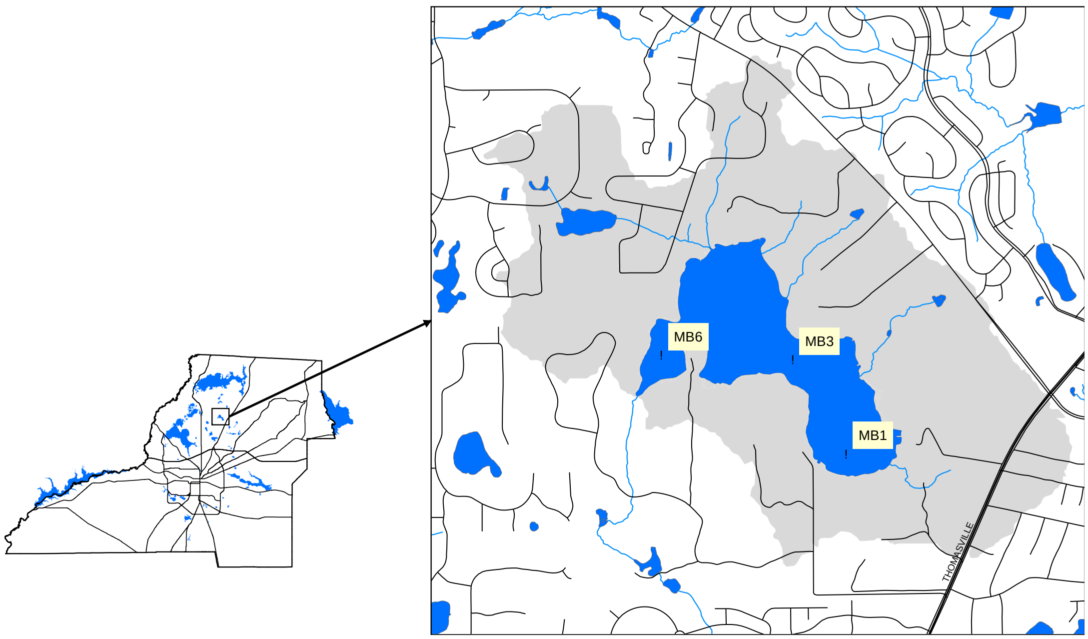


FIG. 8.5-37. Lake McBride watershed with the locations of water quality sampling stations shown.

As shown in **Figure 8.5-38**, approximately 57% of land use in the Lake McBride watershed is agricultural, residential, or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

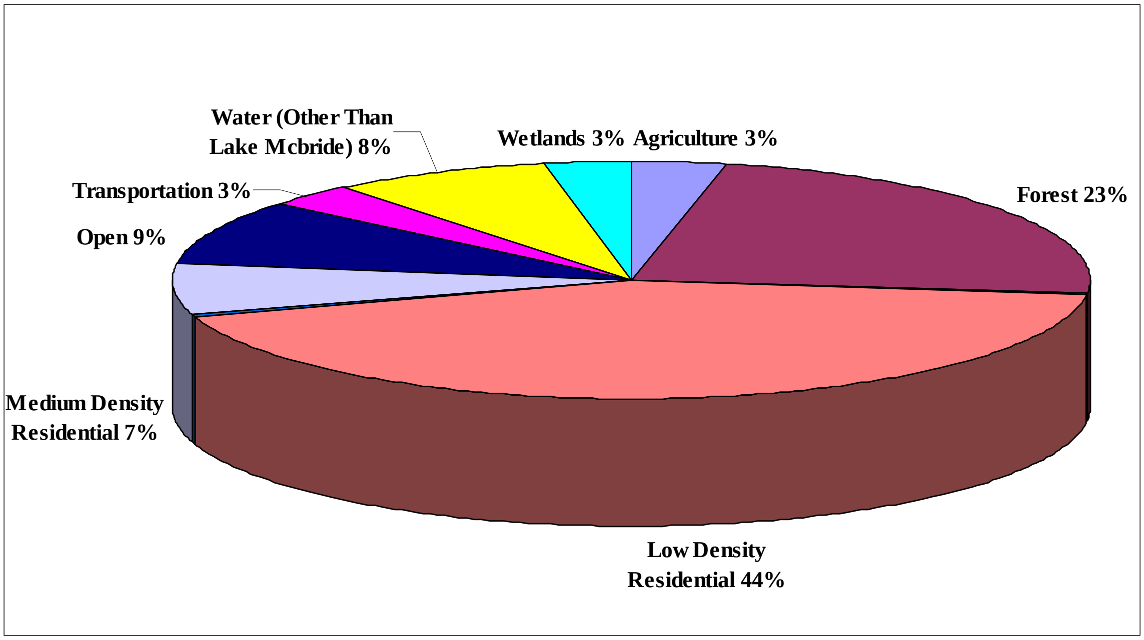


FIG. 8.5-38. Land use in the Lake McBride watershed (1,210 acres).

Figures 8.5-39 and **8.5-40** represent Lake McBride's trophic state utilizing the FDEP Trophic State Index. Yearly averages show that Lake McBride did not exceed the 40 threshold and would not be considered impaired according to FDEP standards. However seasonal averages did show minor exceedances above the 40 threshold.

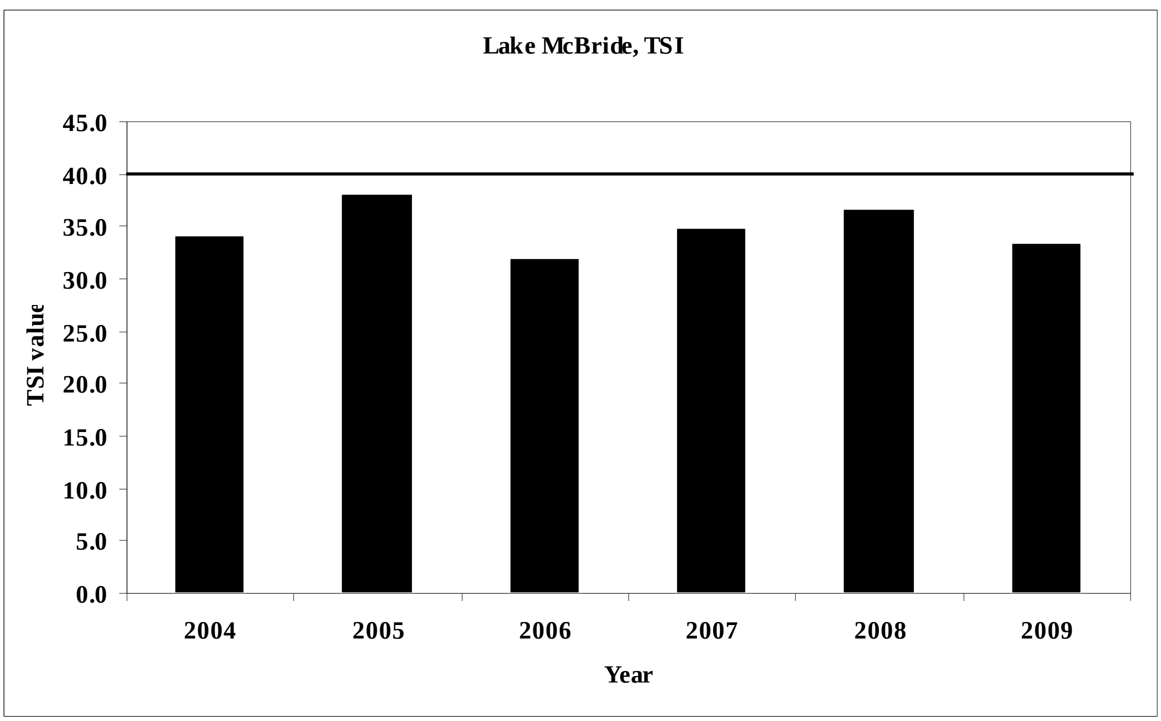


FIG. 8.5-39. Lake McBride trophic state index (yearly average).

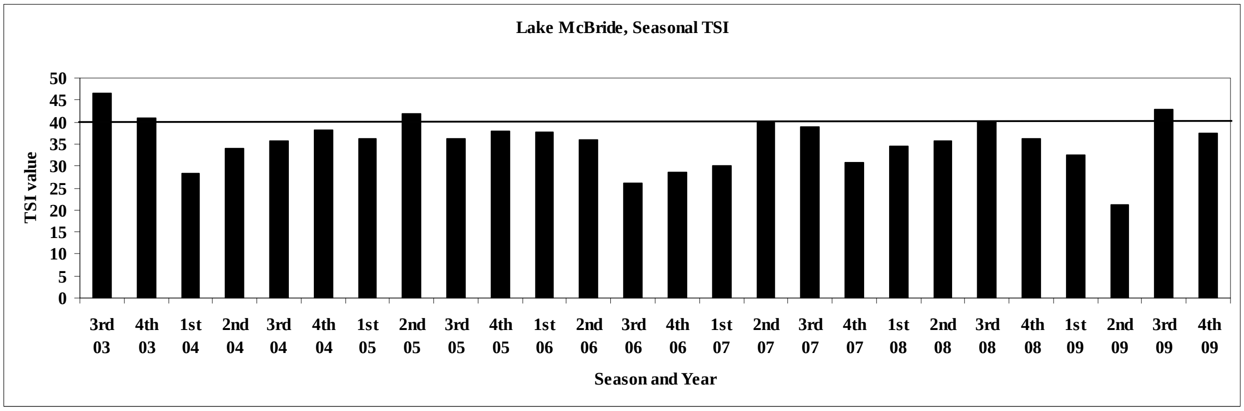


FIG. 8.5-40. Lake McBride trophic state index (seasonal average). Bars exceeding a TSI of 40 indicate impairment.

Dissolved oxygen levels have consistently been low during summer months and frequently did not meet the 5 mg/L Class III water quality standard **(Figure 8.5-41)**. Increasing biological activity during the warmer months can utilize more oxygen than can be replaced. Contributing to lower oxygen levels during the warmer months is the water's inability to hold higher levels of oxygen, due to decreased oxygen solubility at higher water temperatures. Other water quality parameters were in the normal range for water bodies of this type.

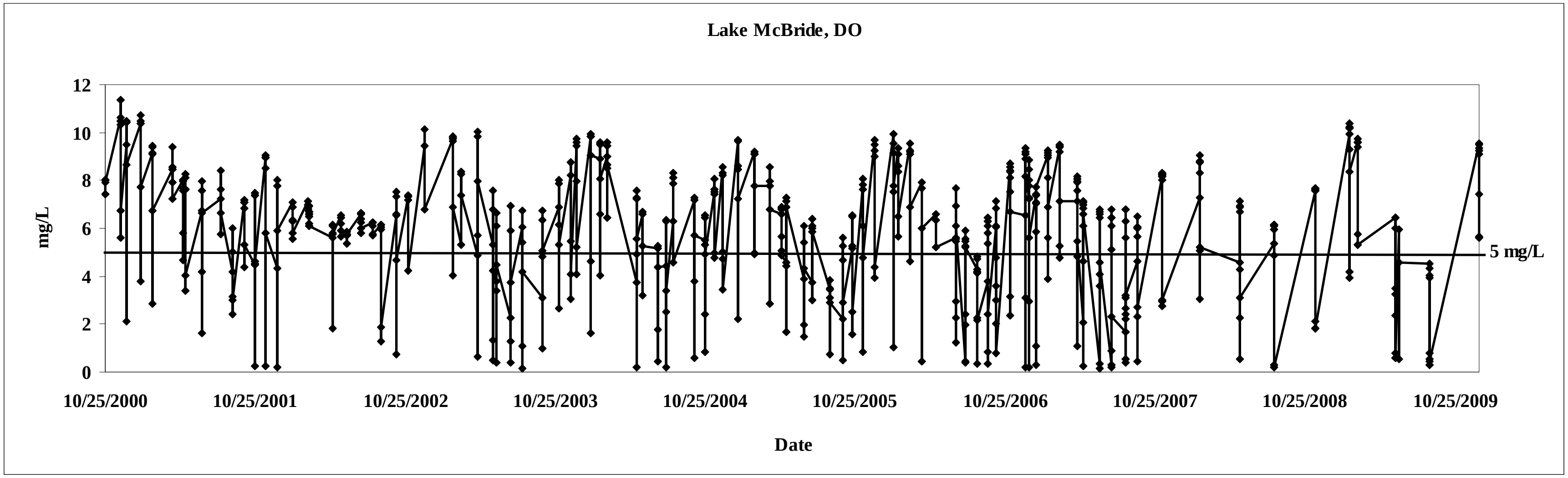
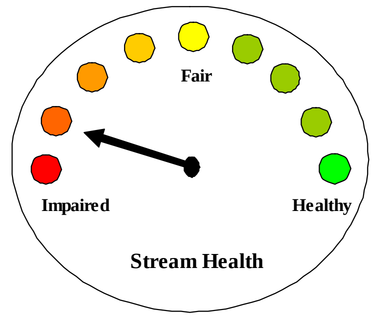


FIG. 8.5-41. Parameter of concern.

E. Northeast Drainage Ditch



Northeast Drainage Ditch is a heavily urbanized stream located within the City of Tallahassee **(Figure 8.5-42)**. The stream flows east and eventually enters Upper Lake Lafayette.

The Northeast Drainage Ditch west of Weems Road was historically altered in areas for mosquito control and/or drainage purposes. The greatly altered flow conditions create channel scour during storms but contribute to low base flow east of Weems Road. This physically unaltered segment reflects the hydraulic impacts with poor biology.

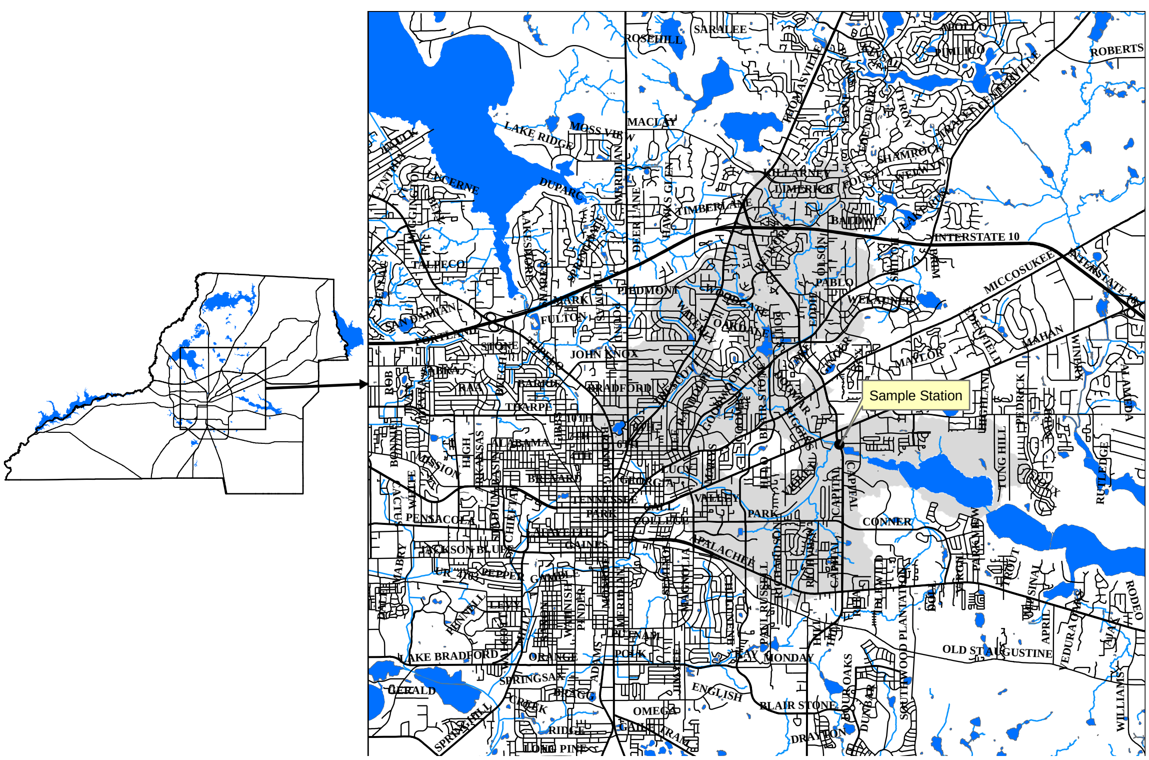


FIG. 8.5-42. Overview Map of Northeast Drainage Ditch watershed.

Figure 8.5-43 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Residential, industrial, commercial, agricultural and transportation uses make up approximately 71% of the watershed.

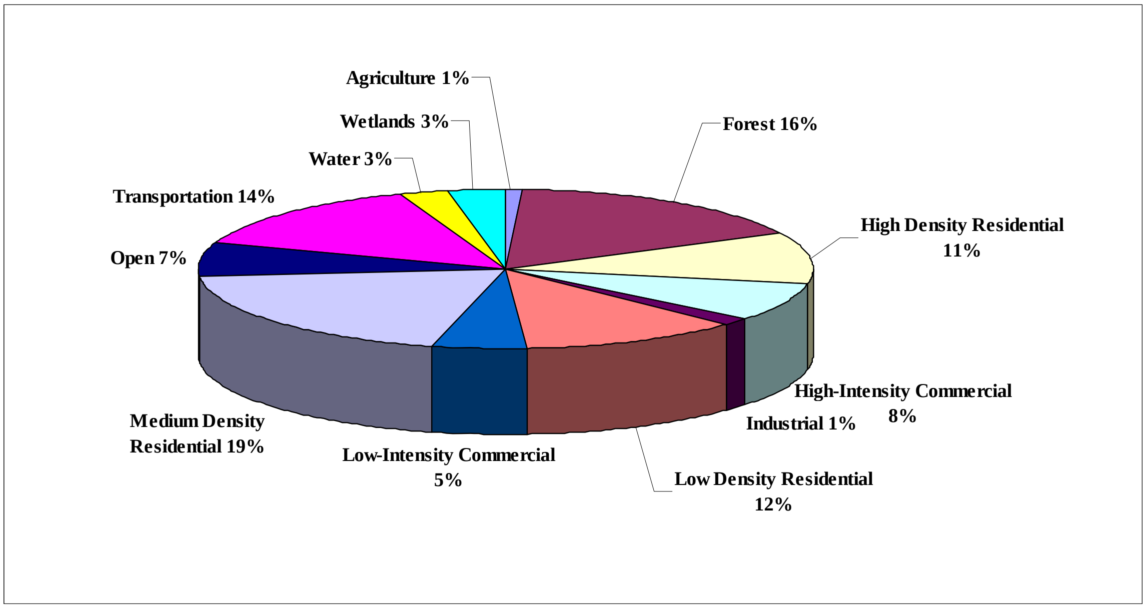


FIG. 8.5-43. Land use in the Northeast Drainage Ditch watershed.

At times, dissolved oxygen did not meet acceptable criteria for Class III water bodies **(Figure 8.5-44)**. Total phosphorus was elevated during the May 2008 and December 2009 sampling events **(Figure 8.5-45)**, but other nutrients appear to not be elevated beyond what is typically found in Florida streams. Turbidity exceeded Class III water quality standards during the December 2009 sampling event (**Fig. 8.5-46)**. The elevated turbidity and phosphorus levels were the result of 4.55 inches of rain falling in the area one day before the sampling event.

In late 2006, USEPA set a TMDL target for fecal coliforms of 400 #100mL, a 63% reduction of the previous existing load. Fecal colforms exceeded the TMDL target twice in 2009 (**Fig. 8.5-47)**.

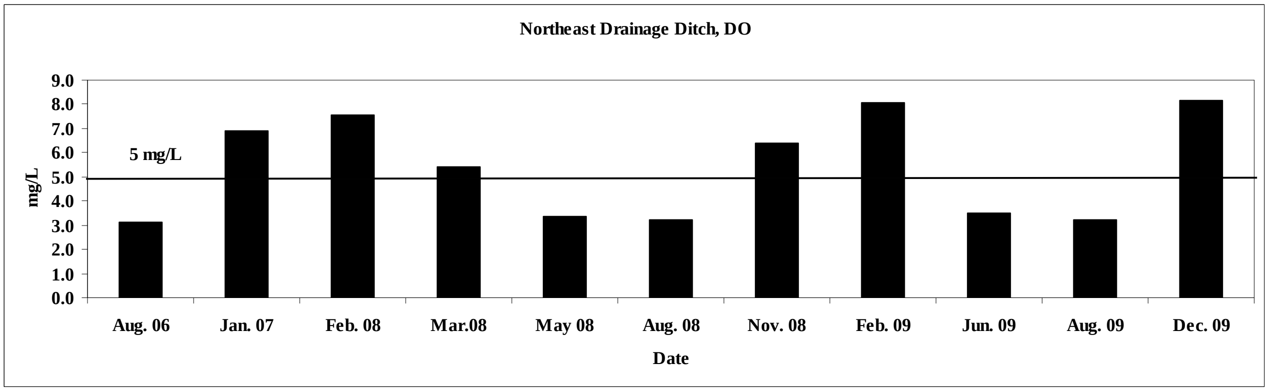


FIG. 8.5-44. Parameter of concern.

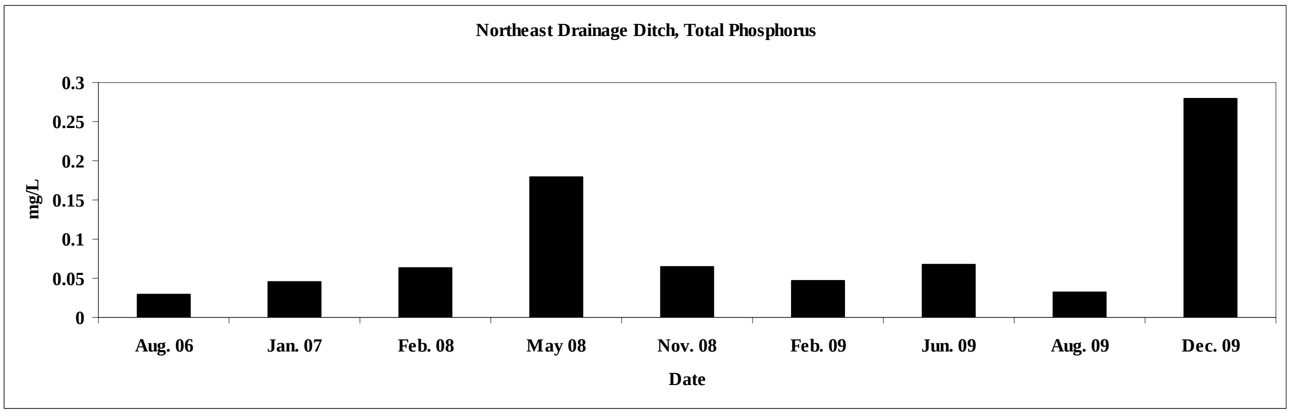


FIG. 8.5-45. Parameter of concern.

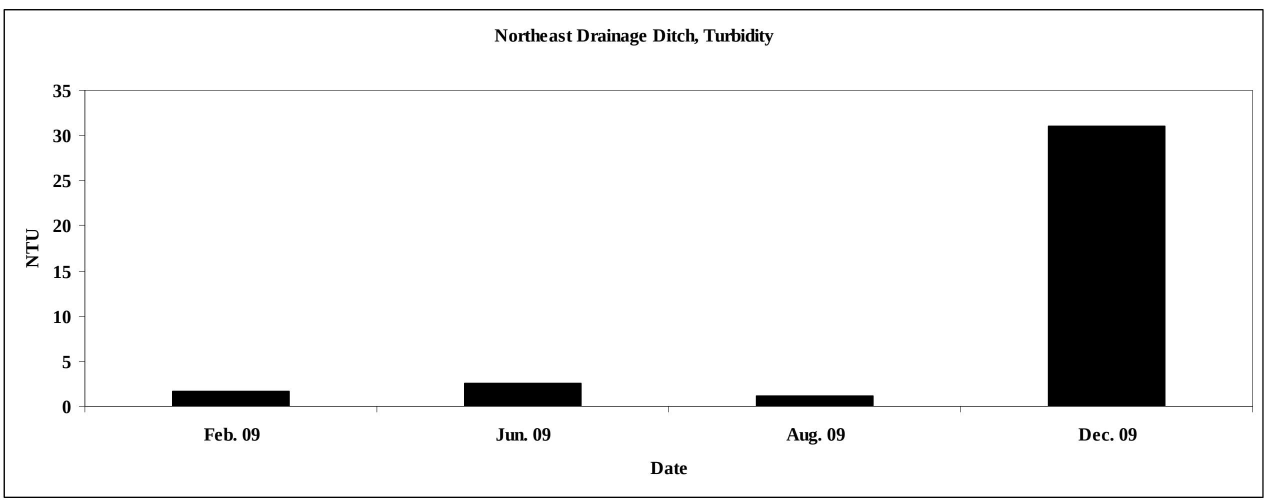


FIG. 8.5-46. Parameter of concern.

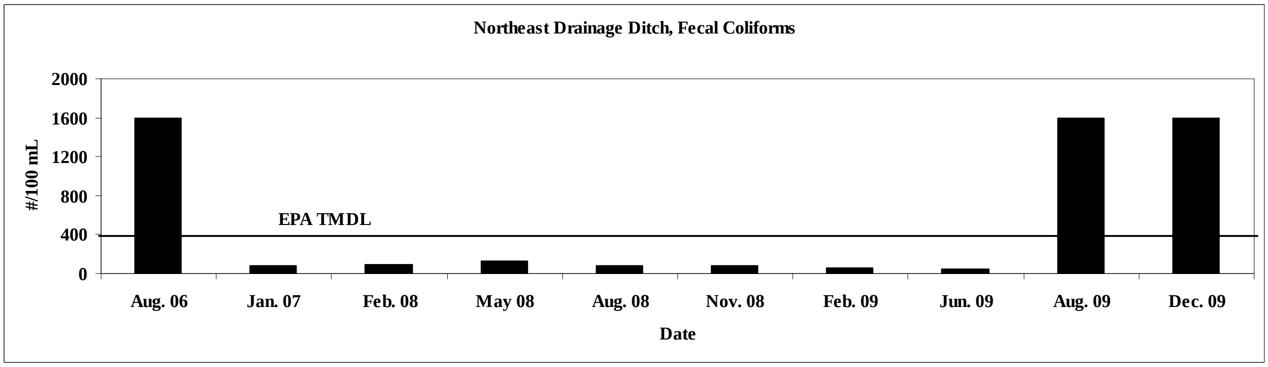


FIG. 8.5-47. Parameter of concern.

1. Stream Condition Index

The habitat assessment score total (91) for Northeast Drainage Ditch was in the suboptimal category, while the SCI score (12) was in the impaired range **(Table 8.5-2)**. The habitat assessment showed marginal substrate availability, habitat smothering, water velocity, bank stability, and riparian zone vegetation quality.

TABLE 8.5-2. SCI and Habitat Assessment scores and interpretation.

NE Ditch/Weems Rd.	**Dup 1 2009**	**Dup 2 2009**
SCI Metric		
Total Taxa	32	17
Ephemeroptera Taxa	0	0
Trichoptera Taxa	1	0
% Filterer	5.1	0.7
Long-lived Taxa	1	0
Clinger Taxa	1	0
% Dominance	54	57.9
% Tanytarsini	5.5	1.4
Sensitive Taxa	0	1
% Very Tolerant Taxa	24.1	22.8
Total SCI Score	**18.42**	**5.20**
Average of two aliquots	**12**	
Score Interpretation	**Impaired**	
Habitat Assessment Score	**91**	
Score Interpretation	**Sub Optimal**	

2. Habitat Smothering

A stream's equilibrium and stability are controlled by sediment load and hydrology. Since stream channels are dynamic systems, they are constantly adjusting in an attempt to maintain equilibrium with their flow regime and surroundings. Urbanization of a watershed can contribute large volumes of sediment to stream channels during storm events and can exceed the stream's finite capacity to transport the excess sediment. When the transport capacity is exceeded, sediment begins to accumulate in the channel filling pools and covering up existing habitat. In response to the increased load of sediment, the stream channel will become straighter, and the banks will become more incised. The additional sediment to the system increases the erosion of the stream bed and banks and further degrades the habitat for the local biotic population. Urbanization also contributes to the volume of runoff during storm events due to the increase of impervious surfaces. In order to improve the biological integrity of the system, storm event runoff must be controlled so that peak flows are significantly reduced (rate control), and proper best management practices should be utilized during construction to prevent the initial sediment loads from entering the streams.

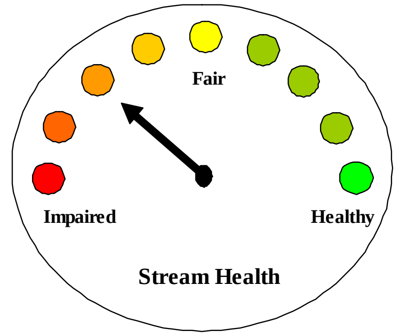
3. Low Flow

Impervious surfaces diminish groundwater recharge, so water is flushed away downstream instead of resupplying the water table. This flushing of water increases the severity of flood events while decreasing the base flow of urban streams by "starving" the stream of its groundwater recharge. This has serious implications for habitat quality.

4. Habitat Quality and Availability

Historically, any impediment to stream flow in an urban stream is considered detrimental to the stream's perceived function, which is to move water from one point to another. While removing flow obstructions such as sand bars addresses public concerns about flooding and mosquito control, the practice removes biotic habitat from the stream as well as contributes to the further destabilization of the stream's bank and stream bed. A compromise can be reached to allow habitat substrate to accumulate in certain areas of a stream or purposely create areas of habitat in a specific area of the stream, thus promoting increased biota richness and allowing the stream to function more naturally. This is a practice recommended by the U.S. Environmental Protection Agency.

F. Unnamed Stream at Chaires Crossroad



Unnamed Stream at Chaires Crossroad is a highly altered stream/ditch draining Alford Arm and Lower Lake Lafayette and is located in eastern Leon County **(Figure 8.5-48)**.

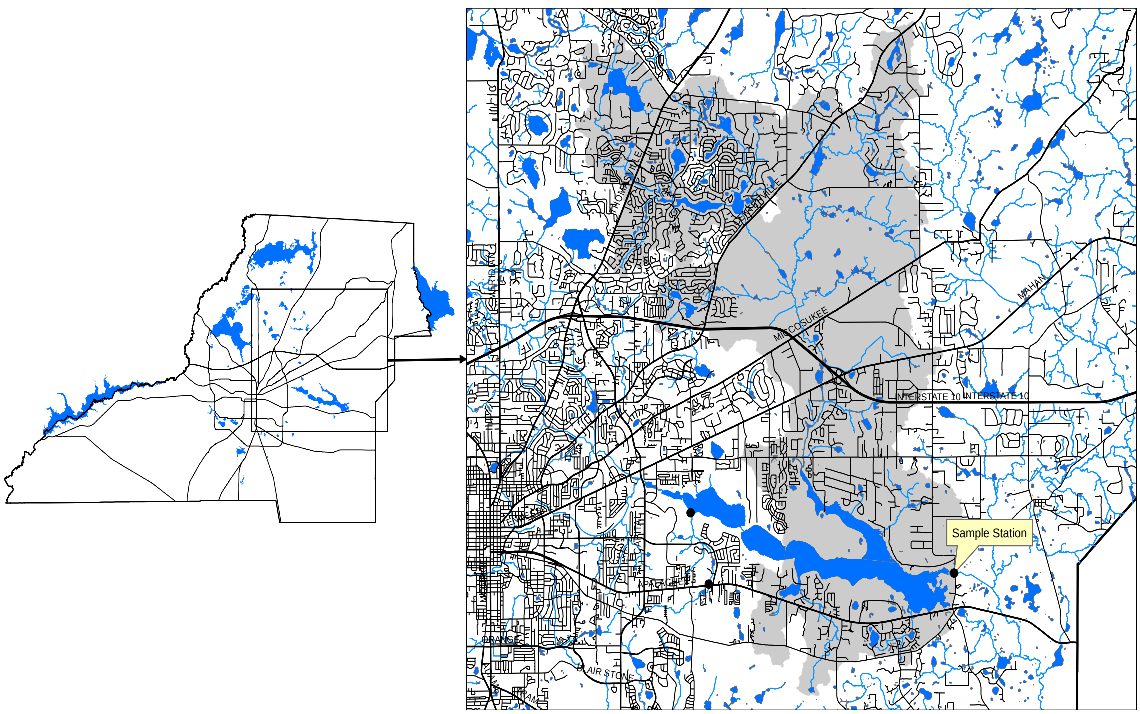


FIG. 8.5-48. Overview Map of Unnamed Stream at Chaires watershed.

As shown in **Figure 8.5-49**, approximately 51% of land use in the watershed is residential, commercial, agriculture, or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

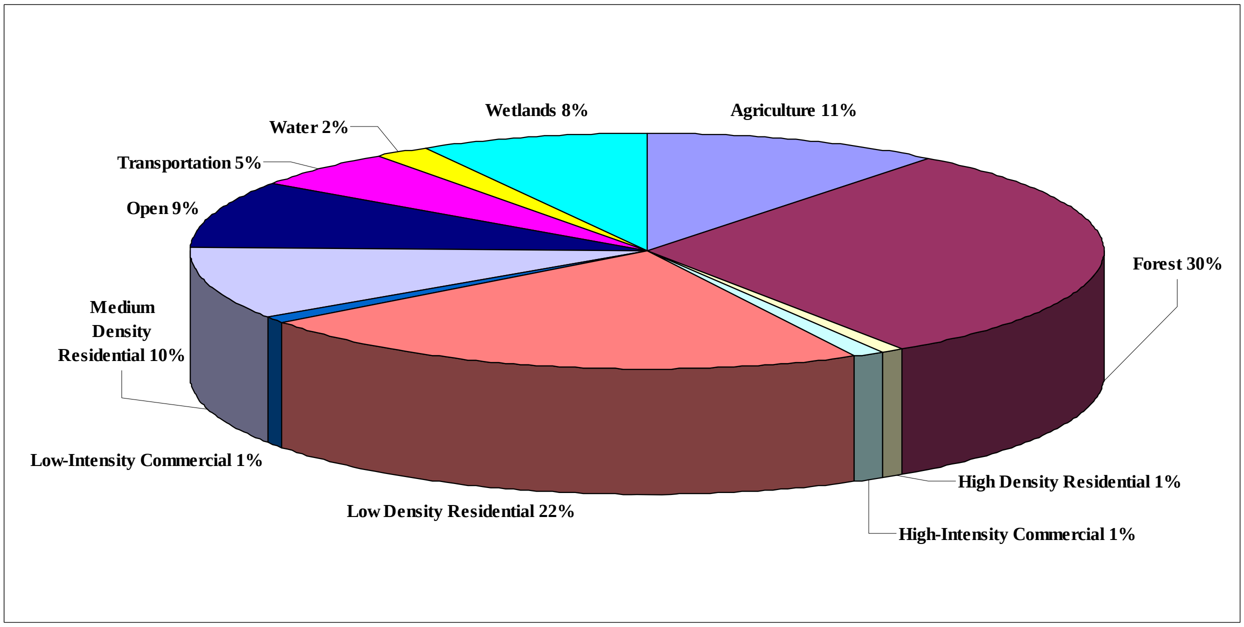


FIG. 8.5-49. Land use in the Unnamed Stream at Chaires watershed (32,021 acres).

Dissolved oxygen did not meet acceptable criteria for Class III water bodies in 2009 **(Figure 8.5-50).** Fecal coliforms levels exceeded Class III water quality standards during the August and December 2009 sampling events **(Figure 8.5-51)**. Biological oxygen demand levels were elevated during all sampling events **(Figure 8.5-52)**.

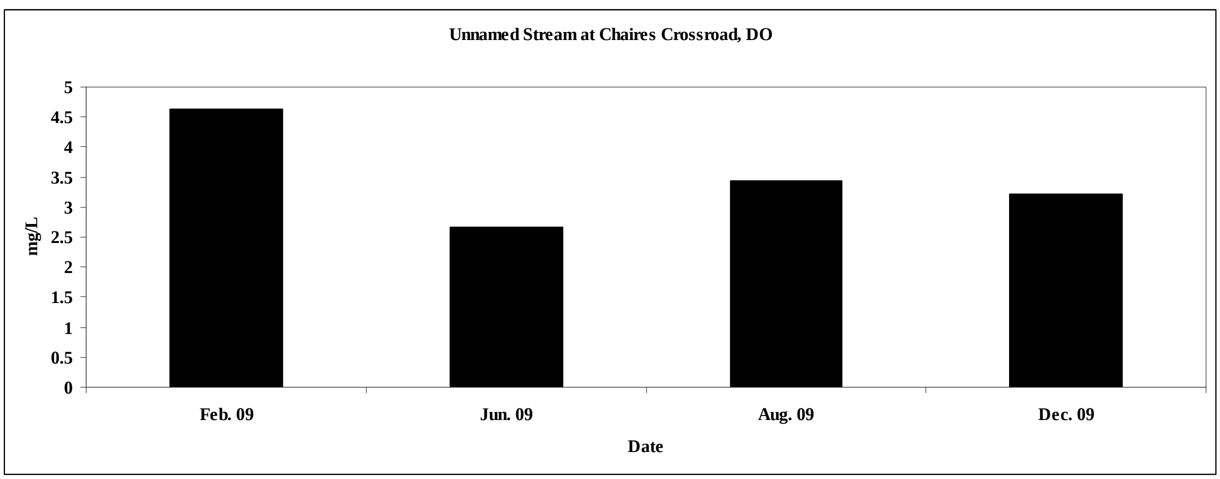


FIG. 8.5-50. Parameter of concern.

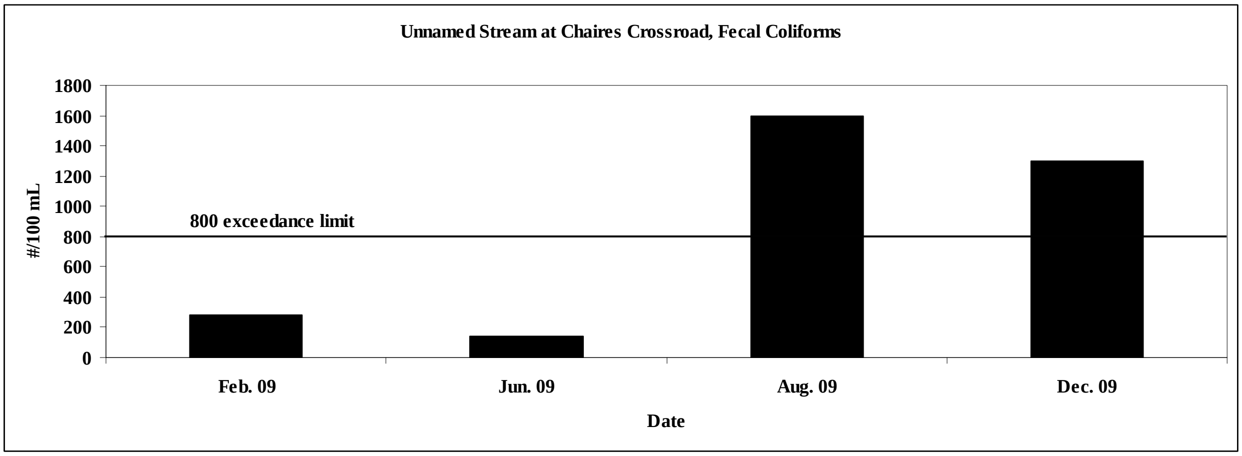


FIG. 8.5-51. Parameter of concern.

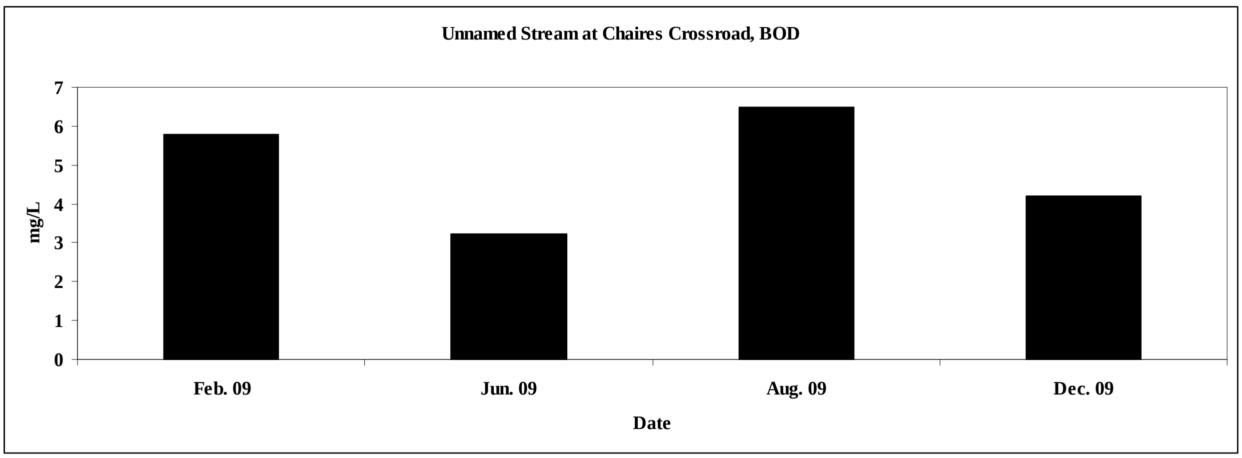


FIG. 8.5-52. Parameter of concern.

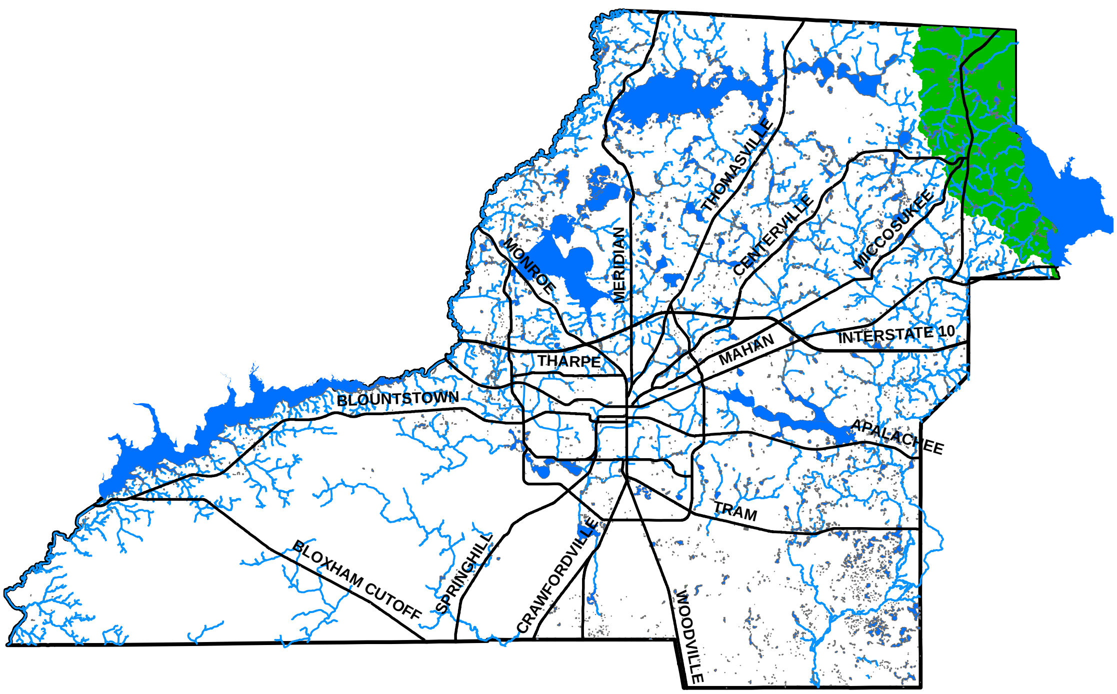
1. Stream Condition Index

The habitat assessment score total (86) for Unnamed Creek at Chaires was in the suboptimal category, while the SCI score (25) was in the impaired range **(Table 8.5-3)**. The habitat assessment showed marginal substrate diversity, and poor water velocity, habitat smothering, and stream channelization. Since this system is the product of dredging efforts in the 1940's it is not surprising that macroinvertebrate communities do not do well here.

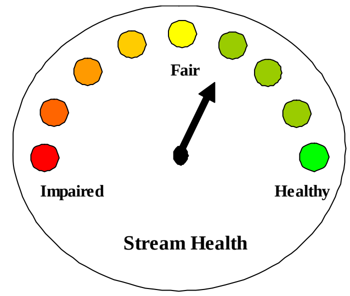
TABLE 8.5-3. SCI and Habitat Assessment scores and interpretation.

Unnamed Creek @ Chaires Rd.	**Dup 1**	**Dup 2**
SCI Metric		
Total Taxa	30	27
Ephemeroptera Taxa	0	0
Trichoptera Taxa	0	1
% Filterer	5	3.85
Long-lived Taxa	0	0
Clinger Taxa	0	0
% Dominance	10.7	13.9
% Tanytarsini	10	7
Sensitive Taxa	2	1
% Very Tolerant Taxa	50.1	48
Total SCI Score	**25.84**	**23.40**
Average of two aliquots	**25**	
Score Interpretation	**Impaired**	
Habitat Assessment Score	**86**	
Score Interpretation	**Sub Optimal**	

8.6. Lake Miccosukee Basin



A. Dry Creek



Dry Creek is located in northeastern Leon County and flows into Lake Miccosukee **(Figure 8.6-1).**

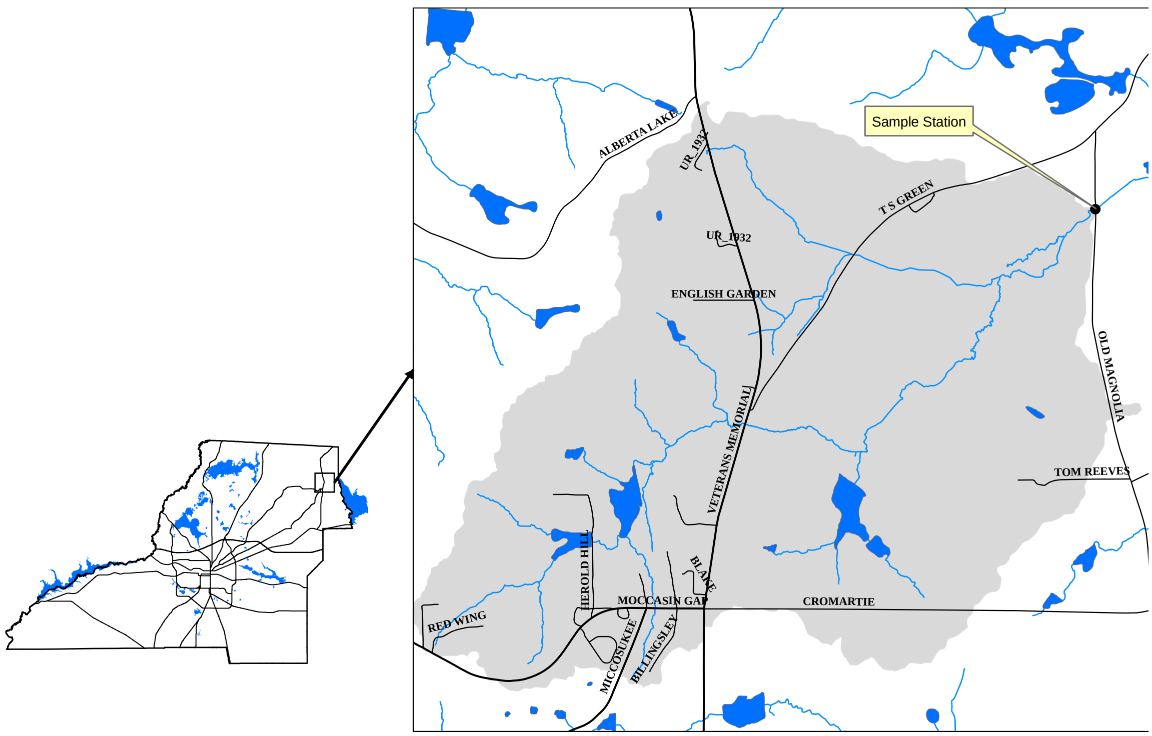


Fig. 8.6-1. Overview Map of Dry Creek Watershed.

Figure 8.6-2 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Residential, agriculture and transportation uses make up approximately 24% of the watershed.

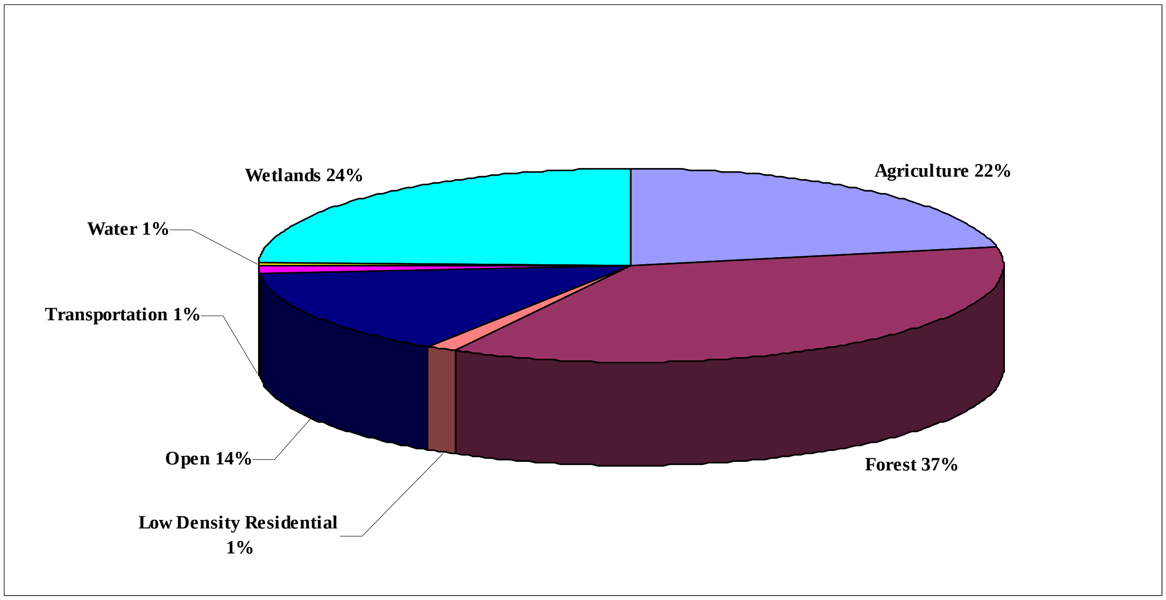


FIG. 8.6-2. Land use in the Dry Creek watershed (2,580 acres).

Due to low water conditions only two samples were collected in 2009. Nitrogen and phosphorus concentrations were low when compared to other streams in Florida. Dissolved oxygen levels during the August 2009 sampling event (2.53 mg/L) did not meet the 5 mg/L criteria for Class III water bodies. Fecal coliform levels during the June (920/100 mL) or the August (920/100 mL) exceeded the Class III maximum daily value (800 #100mL).

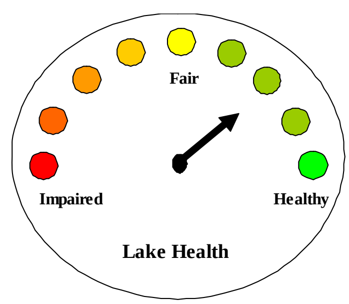
1. Stream Condition Index

The habitat assessment score total (119) for Dry Creek was in the sub-optimal category and showed marginal bank stability and marginal productive habitat. The SCI score (32) showed that Dry Creek was in the impaired range **(Table 8.6-1)**. The possible ephemeral nature of this stream may have contributed to the low SCI score, but it is more likely that the lack of habitat and poor stream bank stability led to the low score. Another factor could be the lack of recruitment from downstream areas. Approximately 10 meters downstream from the SCI station, the stream begins flowing through an open cattle pasture, where there is no riparian zone, little to no productive habitat or substrate diversity. This is in sharp contrast to the upstream station. While insect recruitment usually happens via downstream drift, there remains the possibility that upstream transport via aquatic invertebrates moving upstream against the current or adult insects flying upstream to deposit eggs would occur if the downstream portions of the stream were more natural.

Table 8.6-1. SCI and Habitat Assessment scores and interpretation.

Dry Creek @ Old Magnolia Road	**Dup 1**	**Dup 2**
SCI Metric		
Total Taxa	27	28
Ephemeroptera Taxa	2	1
Trichoptera Taxa	3	3
% Filterer	19.5	8.6
Long-lived Taxa	0	0
Clinger Taxa	6	4
% Dominance	30.9	27.6
% Tanytarsini	6.8	6.6
Sensitive Taxa	4	4
% Very Tolerant Taxa	47.7	45.4
Total SCI Score	**34.47**	**29.82**
Average of two aliquots	**32**	
Score Interpretation	**Impaired**	
Habitat Assessment Score	**119**	
Score Interpretation	**Sub Optimal**	

B. Lake Miccosukee



Lake Miccosukee is a 6,257 acre phosphorus limited lake that forms the northeast border of Leon County **(Figure 8.6-4)**. Like Lakes Jackson, Lafayette, and Iamonia, Lake Miccosukee is considered a shallow prairie lake. Like the above lakes, Lake Miccosukee historically drained via sinkholes becoming nearly dry in the process. The result of the natural drawdowns is a large reduction in the amount of organic matter content of the bottom sediments.

In 1954, a control structure was constructed around the northern sinkhole and a wooden weir constructed at the southern end of the lake to stabilize water levels (Chen, et al, 1994). Water level stabilization led to increased emergent vegetation in the lake, so much so that vegetation covered as much as 80% of the lake's surface. By taking up space and decreasing oxygen levels, the increased vegetation also contributed to the diminishment of the fish population.

Because of rising concerns about the health of the lake, the control structure gate was opened during the 1999 drought, allowing part of the lake to drain into the aquifer. Several areas of the lake were excavated and part of the lake bottom was burned during the drawdown. The burning and excavation led to increased lake volume and removed a portion of the organic rich sediment. After the 2001 tropical storms Allison and Barry passed through the area, Lake Miccosukee filled and is returning to a more natural system. As time passes, there is expected to be more scheduled drawdowns to allow the organic rich sediment to oxidize and help provide good fisheries habitat.

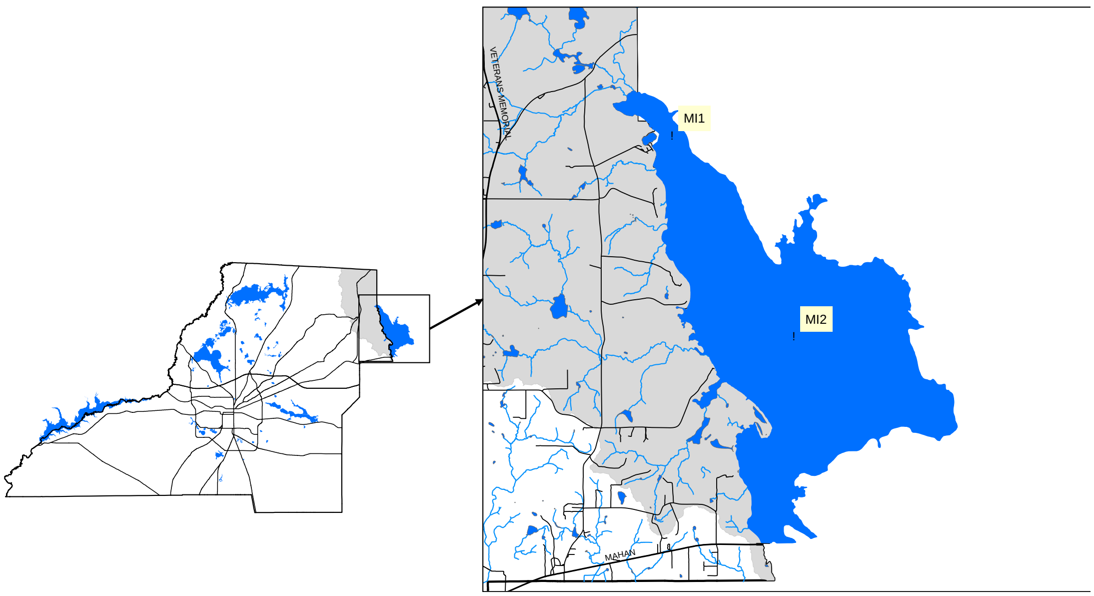


FIG. 8.6-4. Lake Miccosukee Basin with locations of Lake Miccosukee water quality sampling stations shown.

Figures 8.6-5 and **8.6-6** represents Lake Miccosukee's trophic state utilizing the FDEP Trophic State Index. TSI levels decreased in 2008 but levels appeared to be rising back to 2006-2007 levels. Seasonal and yearly averages showing that Lake Miccosukee did not exceed the 60 TSI threshold and would not be considered impaired according to FDEP standards. Elevated chlorophyll *a* levels accounted for the higher TSI levels in 2009 **(Figures 8.6-7)**.

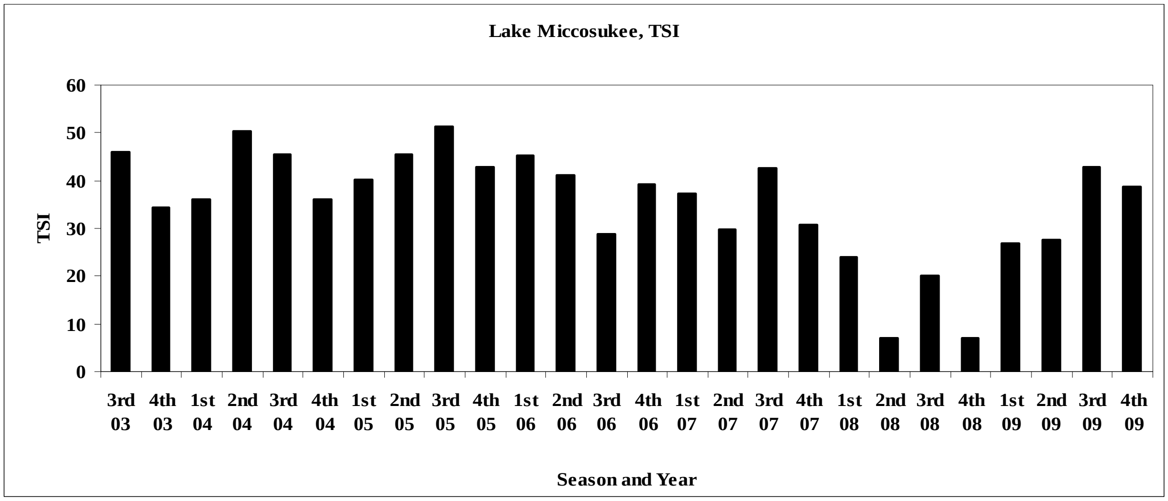


FIG. 8.6-5. Lake Miccosukee trophic state index (seasonal average).

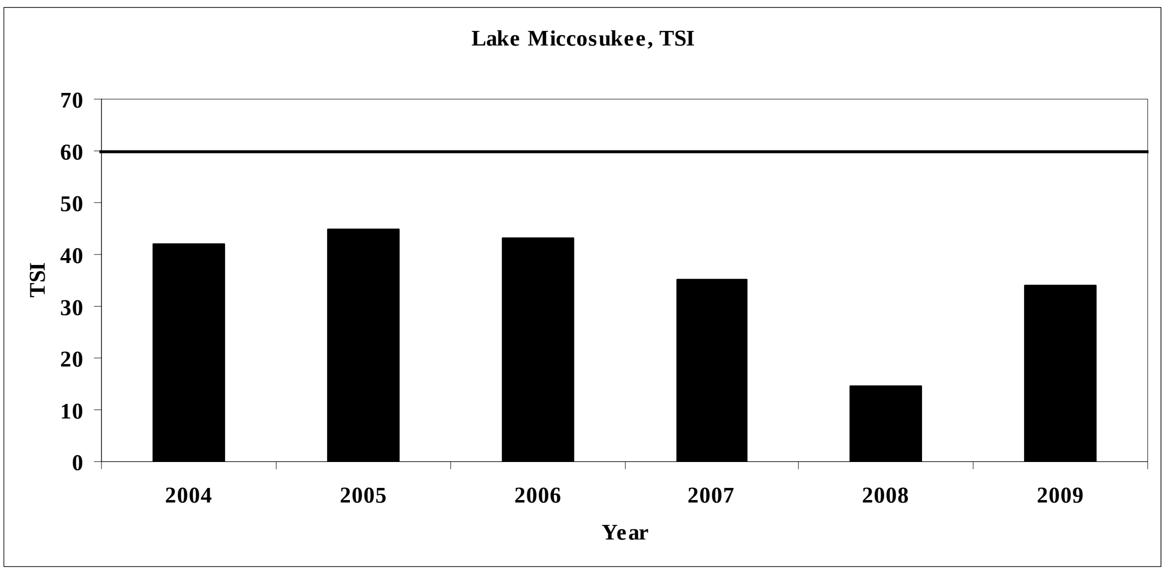


FIG. 8.6-6. Lake Miccosukee trophic state index (yearly average).

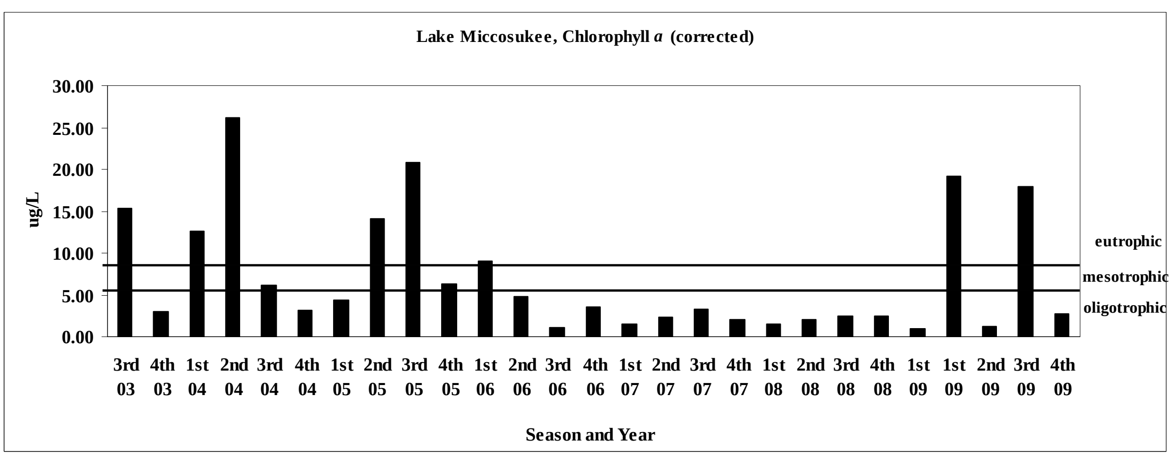


FIG. 8.6-7. Lake Miccosukee chlorophyll *a* levels.

Dissolved oxygen levels have consistently been very low during the sampling period, and frequently did not meet Class III water quality standards **(Figure 8.6-8)**. This could be due to aquatic plant growth covering the surface of the lake, suppressing algal photosynthetic activities in the water column; organic sediments depleting the water column oxygen levels; or as a result of elevated microbial activity, as evidenced by the BOD results of the third (4.78 mg/L) and fourth (6.70 mg/L) quarter data

.

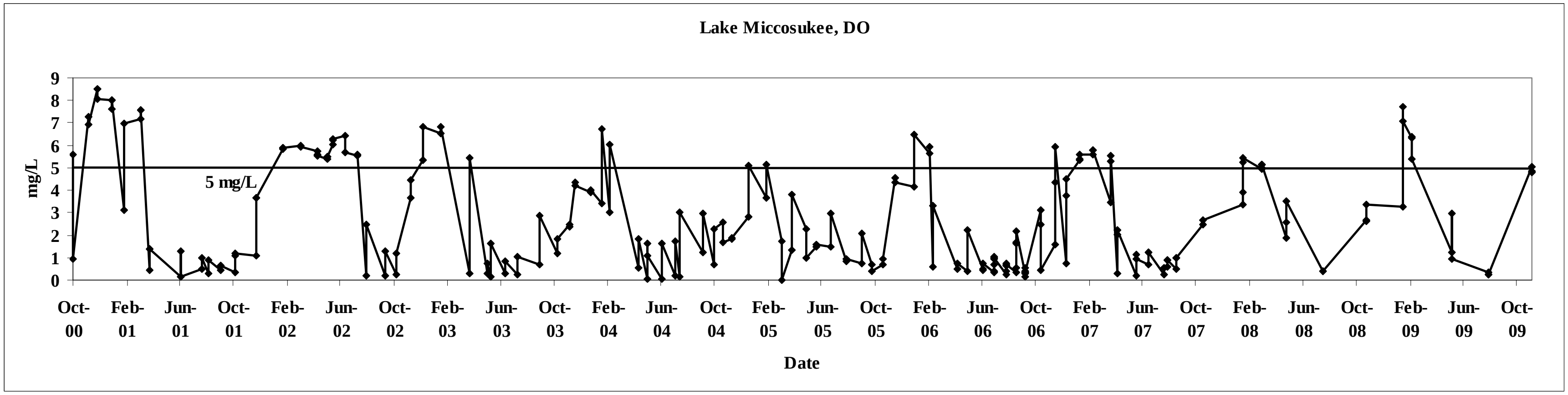
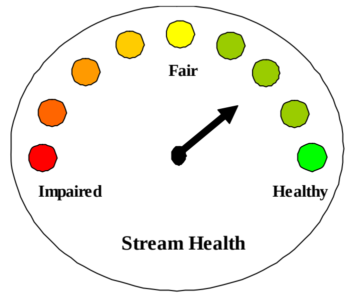


FIG. 8.6-8. Parameter of concern. Markers represent individual measurements. Starting in June 2006, top, mid-depth, and bottom DO measurements were taken were appropriate.

C. Panther Creek



Panther Creek is a tannic, nitrogen-limited stream that flows southeast and eventually drains into Lake Miccosukee **(Figure 8.6-9)**.

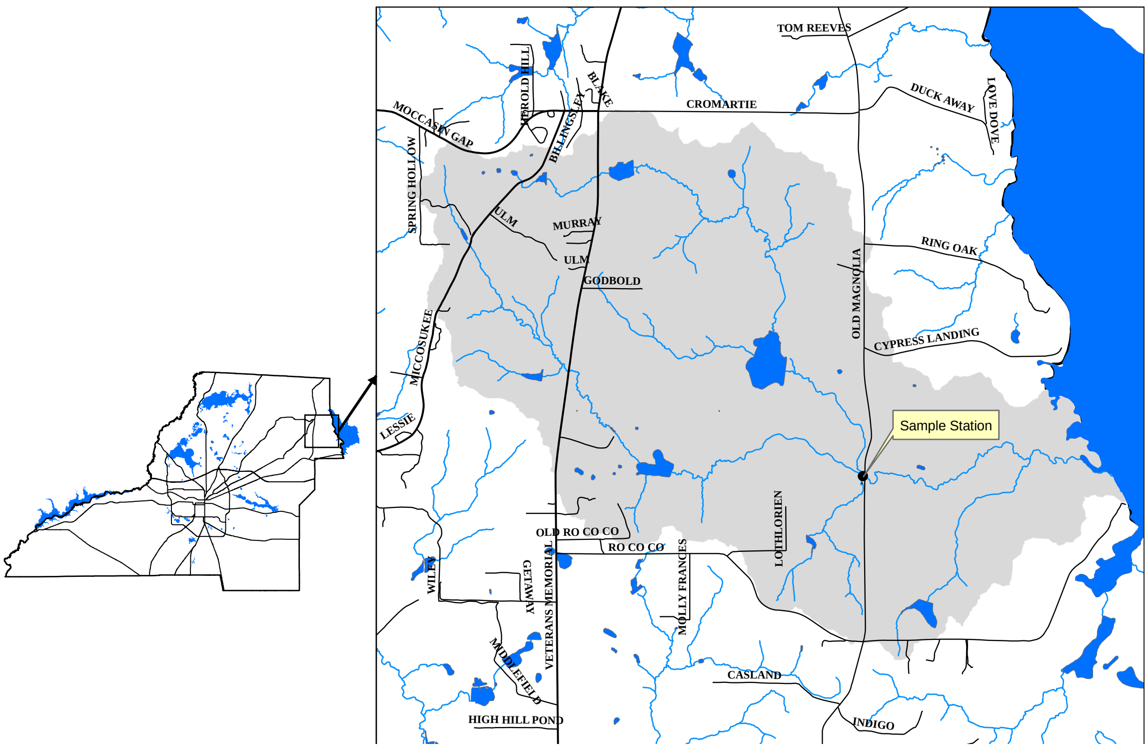


FIG. 8.6-9. Overview Map of the Panther Creek watershed 303 (acres).

Figure 8.6-10 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Residential, commercial, industrial, and transportation uses make up approximately 59% of the watershed.

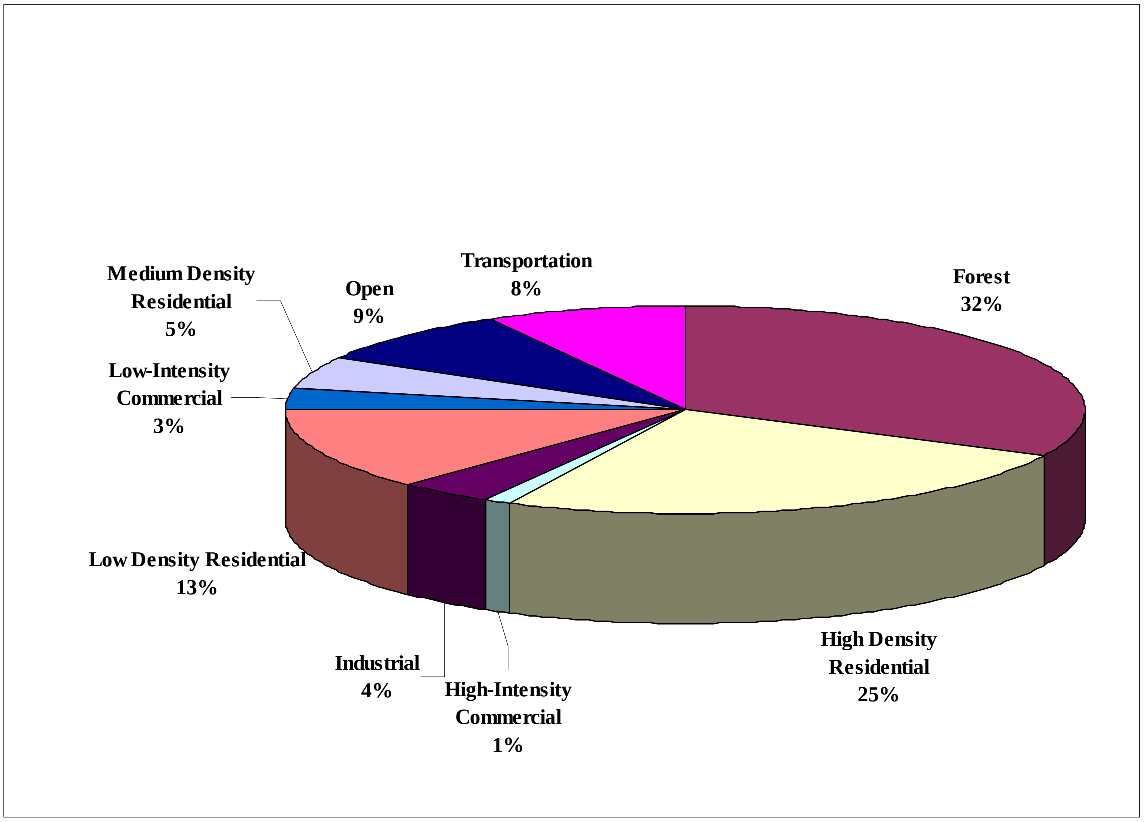


FIG. 8.6-10. Land use in the Panther Creek watershed.

Fecal coliforms levels exceeded the 800/100 mL maximum exceedance level during the August and December 2009 sampling events **(Figure 8.6-11)**. Total and ortho-phosphorus levels increased throughout 2008 with the November levels exceeding levels found in 70% of Florida streams **(Figures 8.6-12 – 8.6-13)**. Other water quality parameters appeared normal when compared to other streams in Florida.

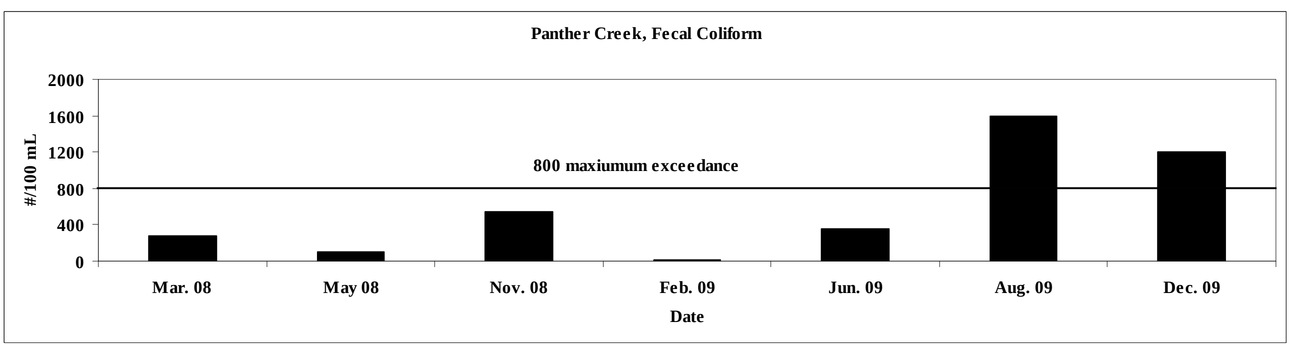


FIG. 8.6-11. Parameter of concern.

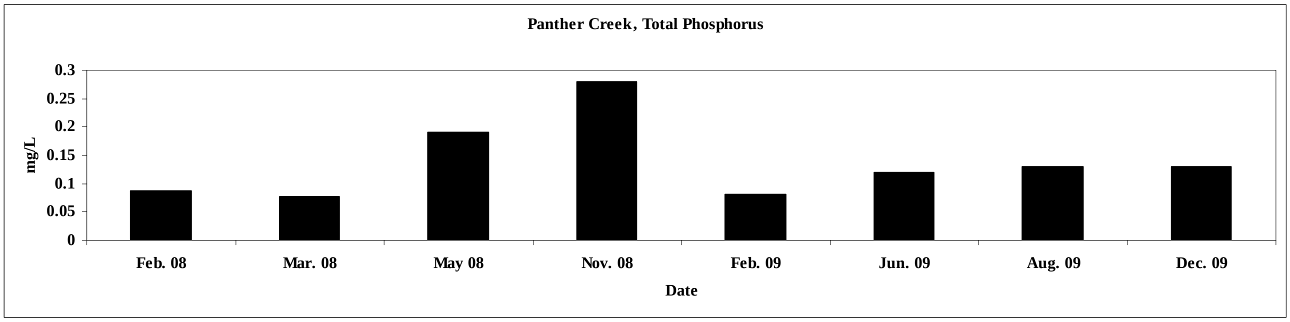


FIG. 8.6-12. Parameter of concern.

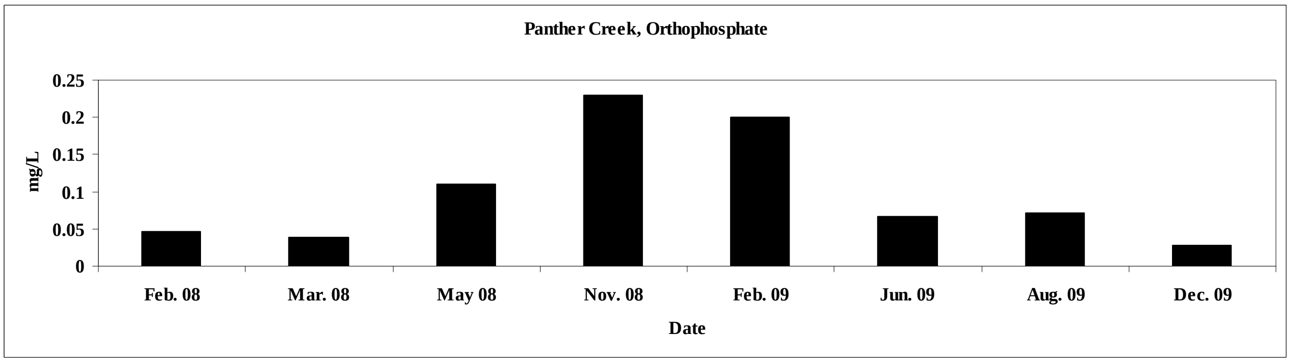


FIG. 8.6-13. Parameter of concern.

1. Stream Condition Index

The SCI score for Panther Creek (57) was in the healthy range while the habitat assessment score total (121) was in the suboptimal category **(Table 8.6-2)**.

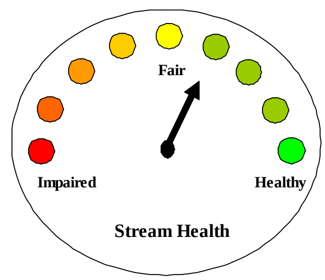
The habitat assessment showed that habitat smothering and riparian buffer zone width on the right bank was in the marginal category. Substrate availability and habitat smothering were at the bottom of the suboptimal category.

TABLE 8.6-2. SCI and Habitat Assessment scores and interpretation.

Panther Creek @ Old Magnolia Rd.	**Dup 1 2009**	**Dup 2 2009**
SCI Metric	A1	A2
Total Taxa	35	24
Ephemeroptera Taxa	3	2
Trichoptera Taxa	2	3
% Filterer	64.05	55.9
Long-lived Taxa	1	0
Clinger Taxa	5	6
% Dominance	36.2	21.6
% Tanytarsini	24.8	27.5

Sensitive Taxa	8	6
% Very Tolerant Taxa	2.7	2
Total SCI Score	**57.04**	**56.11**
Average of two aliquots	**57**	
Score Interpretation	**Healthy**	
Habitat Assessment Score	**121**	

D. Patty Sink Drain



Patty Sink Drain is a slightly tannic, nitrogen-limited stream that flows south and eventually drains into Patty Sink **(Figure 8.6-14)**.

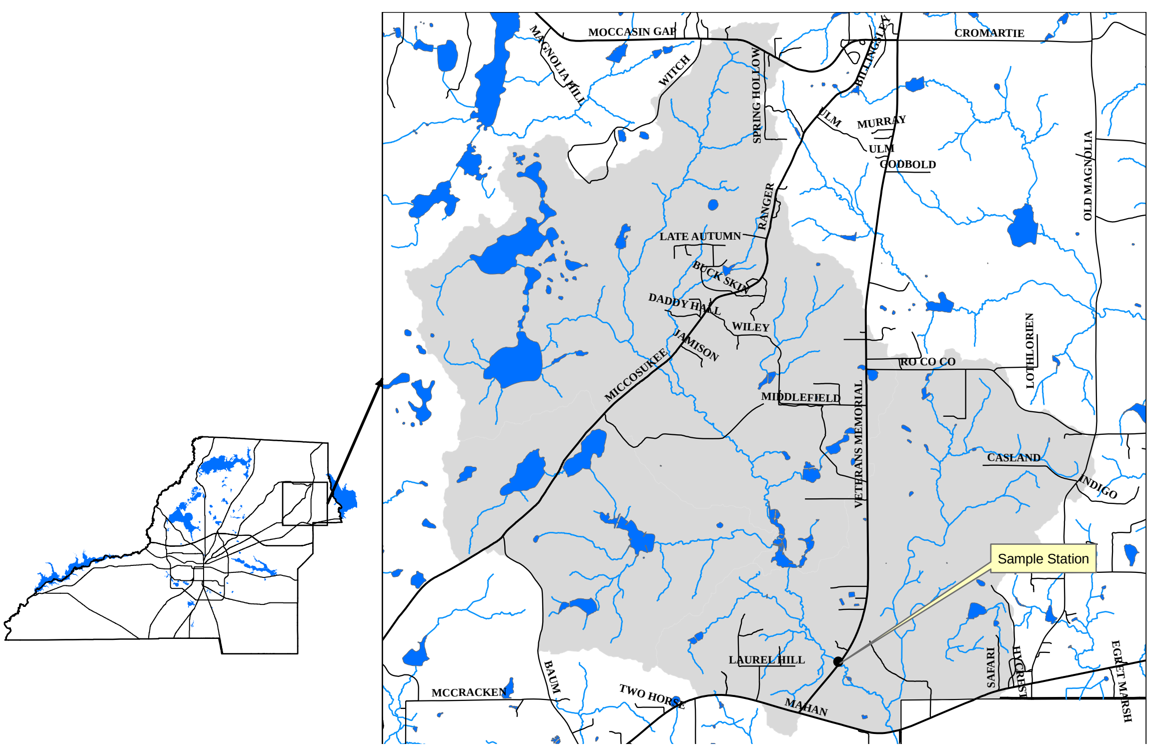


FIG. 8.6-14. Overview Map of the Patty Sink Drain watershed.

Figure 8.6-15 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Residential, agricultural, industrial and transportation uses make up approximately 26% of the watershed.

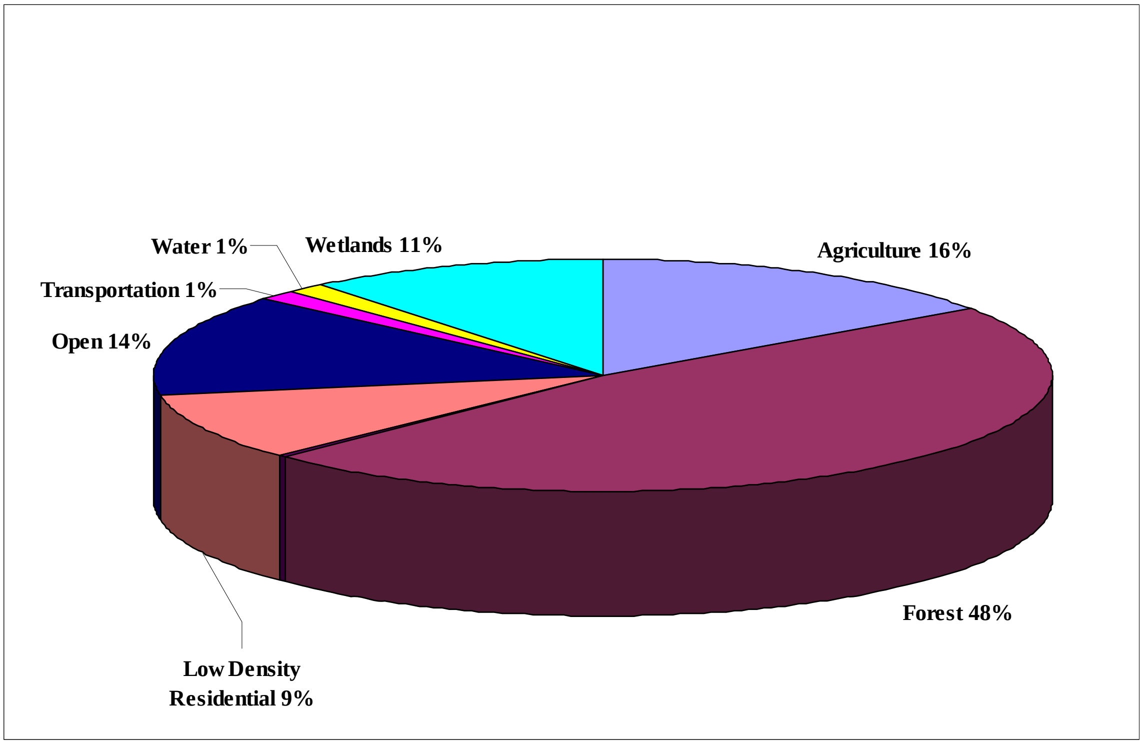


FIG. 8.6-15. Land use in the Patty Sink Drain watershed (10,167 acres).

Fecal coliforms (2800/100 mL) exceeded Class III water quality standards during the December 2009 sampling event. December BOD values (4.0 mg/L) and chlorophyll values (7.9 µg/L) were elevated as well. The probable source of the high BOD and coliform values is the runoff associated with the cattle located in an adjacent field. Other water quality parameters appeared normal when compared to other streams in Florida.

1. Stream Condition Index

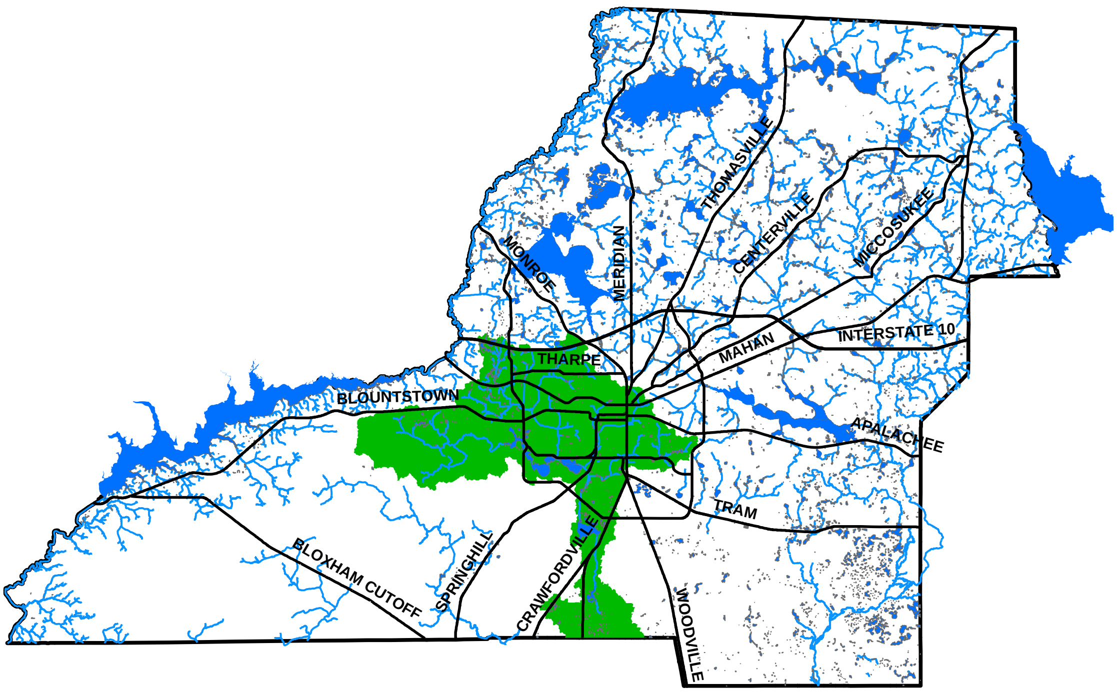
The SCI score (53) for Patty Sink Drain's was in the healthy range while the habitat assessment score total (129) was in the optimal category **(Table 8.6-3)**.

The habitat assessment showed that bank stability, riparian zone width and vegetation quality, water velocity and bank stability where in the optimal category; substrate diversity was in the suboptimal category; and substrate availability was in the marginal category.

TABLE 8.6-3. SCI and Habitat Assessment scores and interpretation.

Patty Sink Drain @ Veterans Memorial	**Dup 1**	**Dup 2**
SCI Metric		
Total Taxa	26	24
Ephemeroptera Taxa	2	0
Trichoptera Taxa	3	3
% Filterer	64.7	72
Long-lived Taxa	0	0
Clinger Taxa	5	6
% Dominance	25.5	24
% Tanytarsini	30	28.7
Sensitive Taxa	7	8
% Very Tolerant Taxa	5.7	2.7
Total SCI Score	**52.87**	**52.13**
Average of two aliquots	**53**	
Score Interpretation	**Healthy**	
Habitat Assessment Score	**129**	
Score Interpretation	**Optimal**	

8.7 Lake Munson Basin



I. Bradford Brook Chain of Lakes

The Bradford Brook Chain of Lakes is composed of the cypress rimmed Lakes Bradford, Hiawatha and Cascade and is located in western Leon County **(Figure 8.7-1)**. Water typically flows east via Bradford Brook into Lake Cascade. Lake Hiawatha receives flow from Lake Cascade via a culvert beneath Capital Circle Southwest. Much of the water entering Lake Bradford is via Lake Hiawatha, though at times Grassy Lake flows into Lake Bradford. On occasion, flow is occasionally reversed and Lake Bradford flows into Lake Hiawatha which then flows into Lake Cascade. In addition groundwater sources of flow are possible.

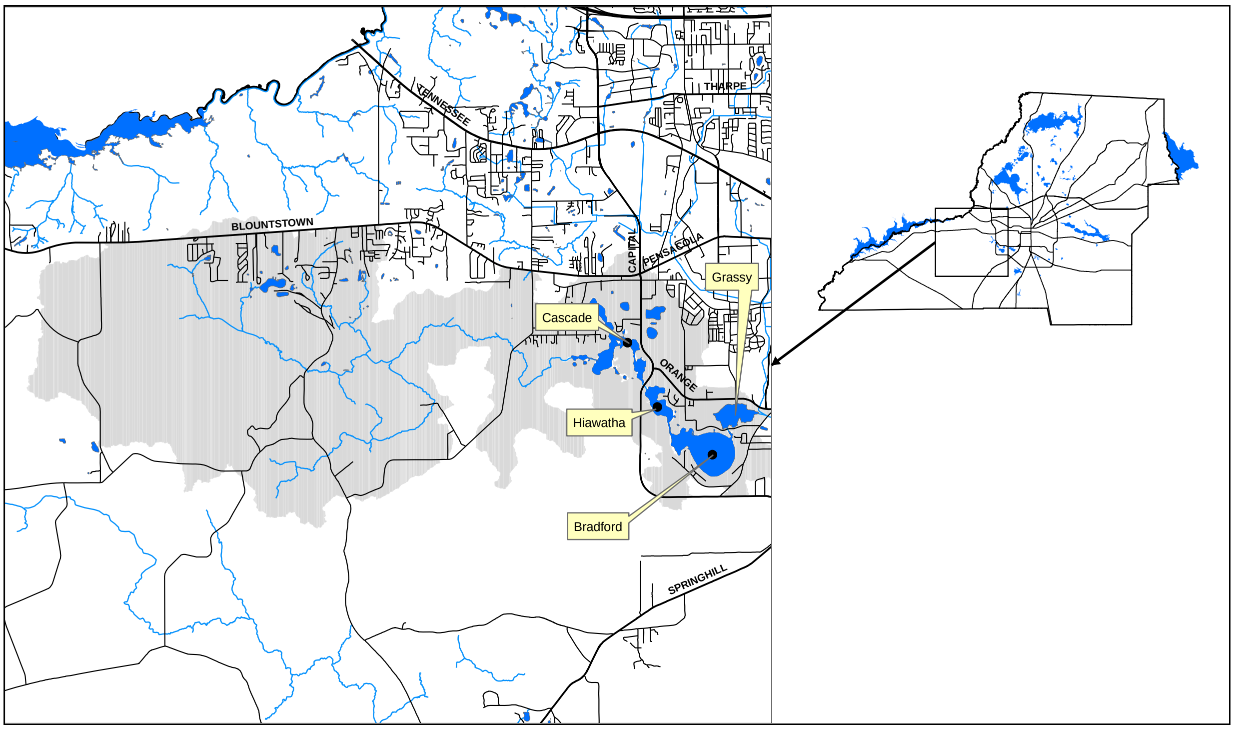


FIG. 8.7-1. Bradford Brook Chain of Lakes watershed with the locations of water quality sampling stations shown.

Table 8.7-2 shows land use in the Bradford Brook watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Commercial, agricultural, residential, industrial, and transportation uses make up approximately 16% of the Bradford Brook watershed.

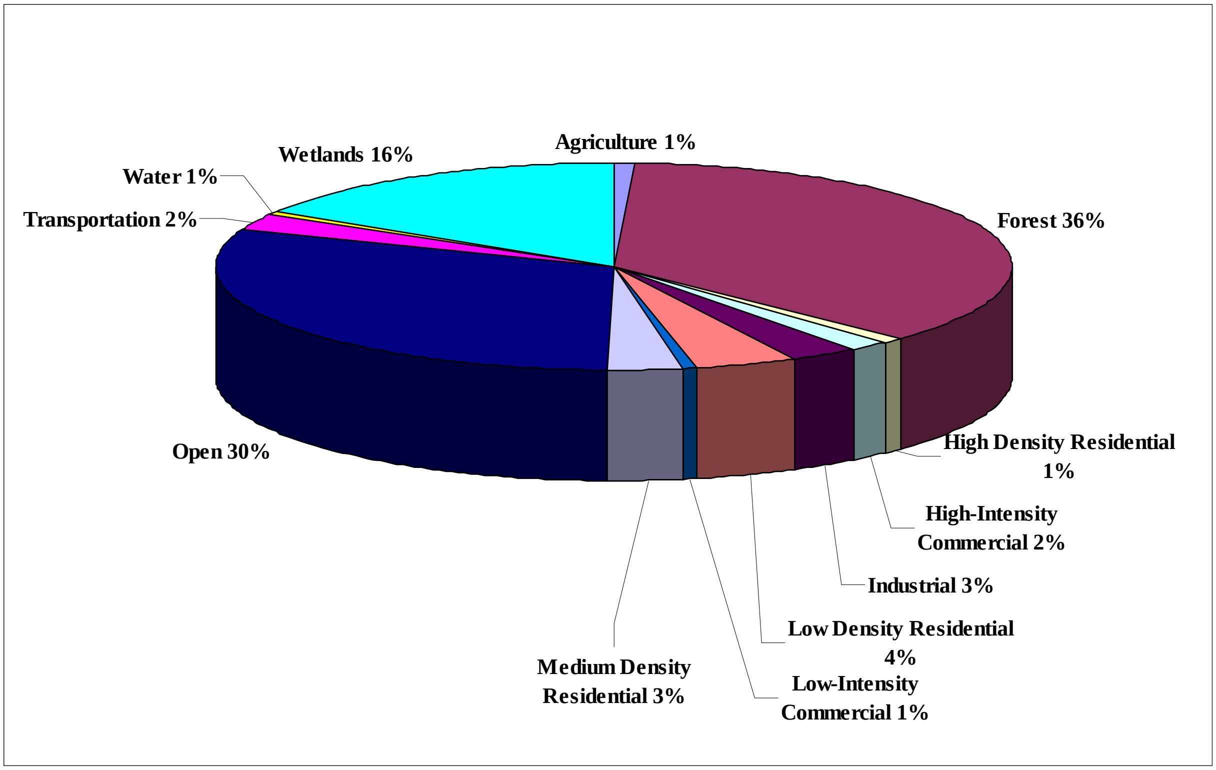
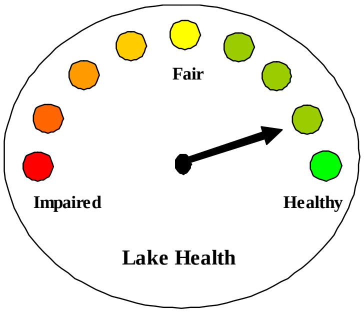


FIG. 8.7-2. Land use in the Bradford Brook Chain of Lakes watershed (11,148 acres).

Typical for blackwater systems, the Bradford Brook Chain of Lakes is subject to a greater degree of natural stresses than many non-blackwater systems. The three lakes have lower levels of DO, low pH, poor sunlight penetration due to the high color, low alkalinity, low assimilative capacities, and organic detritus is often acidic and difficult to break down. While the DO, alkalinity and pH parameters did not always meet Class III water quality standards, the low values would be considered natural and would not require further action.

A. Lake Bradford



Figures 8.7-3 and **8.7-4** represents Lake Bradford's trophic state utilizing the FDEP Trophic State Index. Seasonal and yearly averages show that Lake Bradford does not exceed the 60 threshold and would not be considered impaired according to FDEP standards.

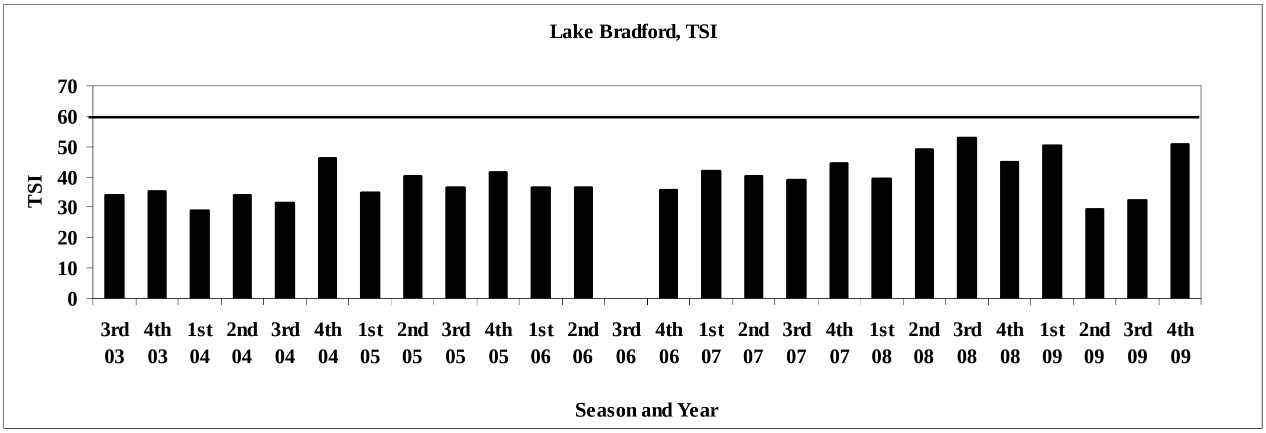


FIG. 8.7-3. Lake Bradford trophic state index (by season).

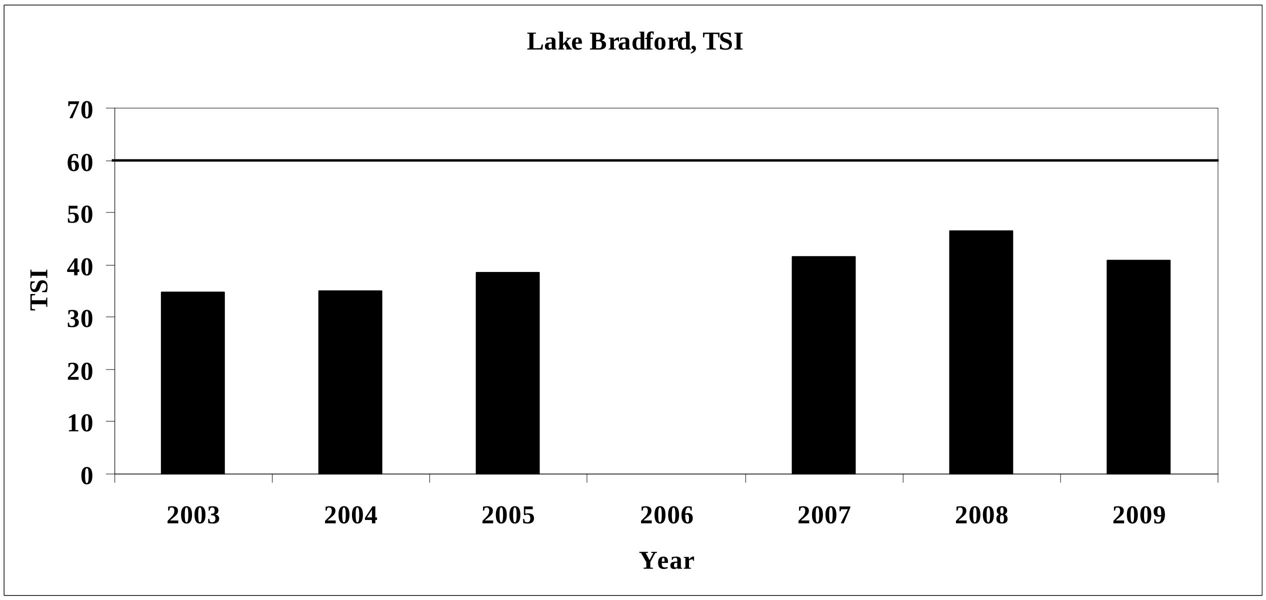


FIG. 8.7-4. Lake Bradford trophic state index (yearly average). Years not represented mean samples were not collected for all four seasons.

The mean chlorophyll *a* value during the sampling period was 5.94 µg/L placing Lake Bradford in the mesotrophic range. However, Lake Bradford fluctuated between an oligotrophic and mesotrophic state with some values reaching eutrophic levels in 2007 through 2009 **(Figure 8.7-5)**. It is thought that the excess runoff, leading to increased nitrogen and phosphorus concentrations, from Tropical Storm Fay contributed to the high chlorophyll *a* levels in the latter part of 2008 and the early part of 2009. Runoff from a localized storm probably contributed to high chlorophyll and phosphorus levels in the 4th quarter of 2009 **(Figures 8.7-6 and 8.7-7)**.

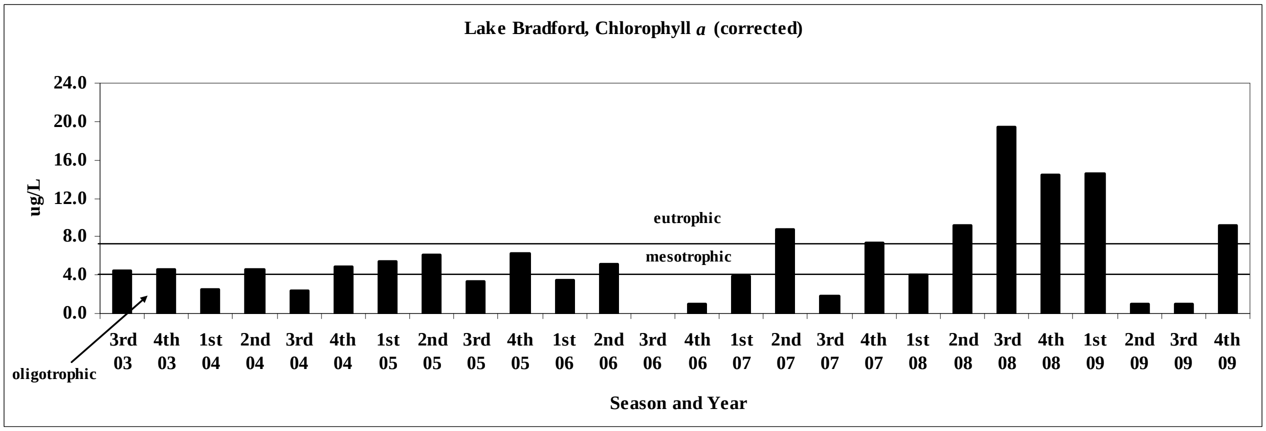


FIG. 8.7-5. Lake Bradford chlorophyll *a* values.

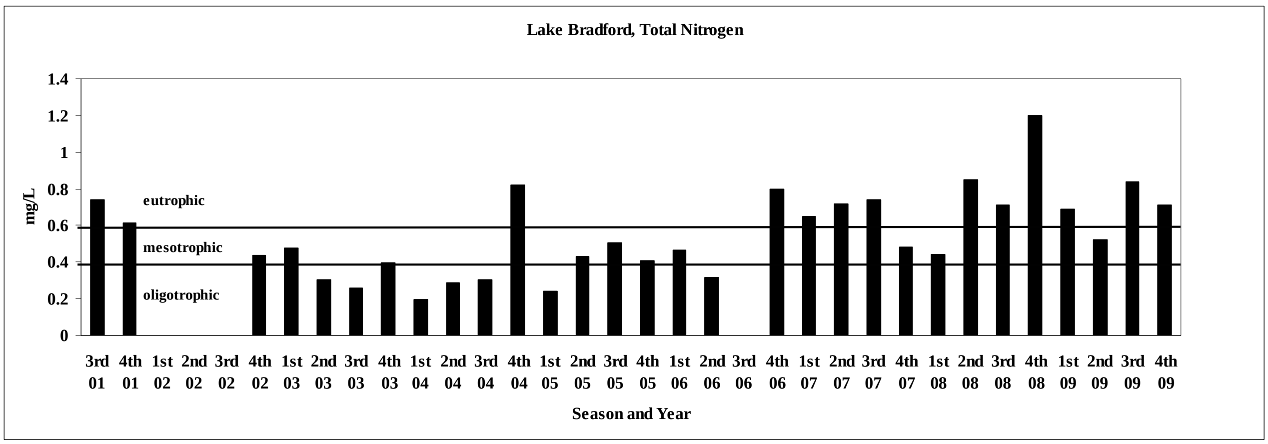


FIG. 8.7-6. Lake Bradford total nitrogen values.

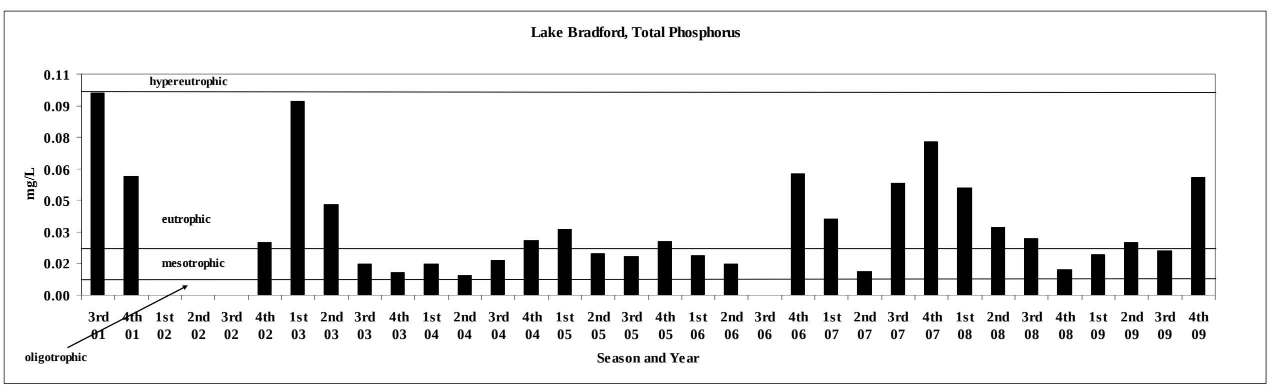


FIG. 8.7-7. Lake Bradford total phosphorus values.

1. Lake Vegetation Index

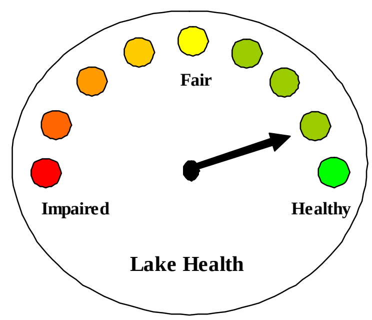
The LVI score for Lake Bradford was 62 placing the lake in the "Healthy" category.

The native species, pond cypress (*Taxodium ascendens*) and dog fennel (*Eupatorium leptophyllum*) dominated the shoreline area of Lake Bradford and were the most dominant species in the lake. Other native shoreline vegetation included; red maple (*Acer rubrum*), buttonbush (*Cephalanthus occidentalis*) and titi (*Cyrilla racemiflora*). Due to the blackwater nature of the Lake Bradford Chain of Lakes, there was limited aquatic vegetation in the water.

Torpedograss (*Panicum repens*), and Chinese tallow (*Sapium sebiferum*), both listed as Category I Invasive Exotics by the Florida Exotic Pest Control Council are two invasive exotics that are a concern in Lake Bradford.

Alligator weed (*Alternanthera philoxeroides*) a Category II Invasive Exotic was also present along the shoreline of the Lake Bradford. In the 1960's three South American insects were released to control alligator weed with devastating effects to the weed. Even though alligator weed is still present in more than 80% of Florida waters, levels are low, so it is rarely necessary to control with other means. (IFAS, 2010).

B. Lake Hiawatha



Figures 8.7-8 and **8.7-9** represents Lake Hiawatha's trophic state utilizing the FDEP Trophic State Index. Unfortunately, due to drought conditions, the last two quarters of 2007 and the first three quarters of 2008 data could not be collected. Seasonal and yearly averages show that Lake Hiawatha does not exceed the 60 threshold and would not be considered impaired according to FDEP standards.

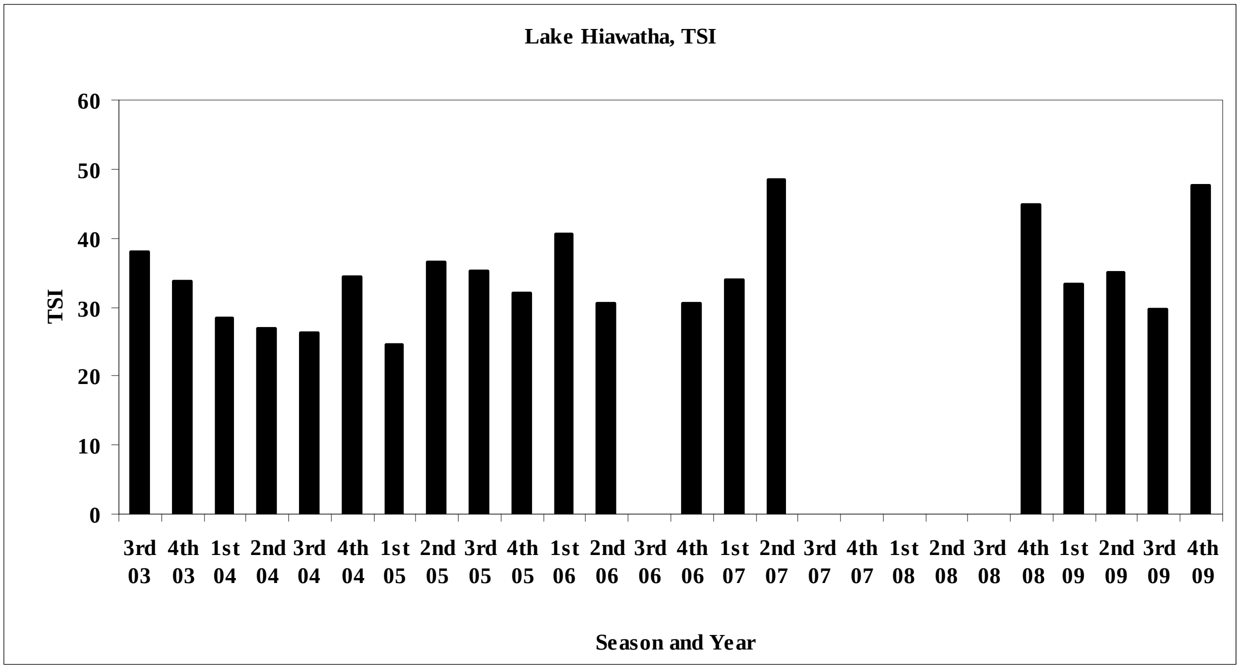


FIG. 8.7-8. Lake Hiawatha trophic state index (by season).

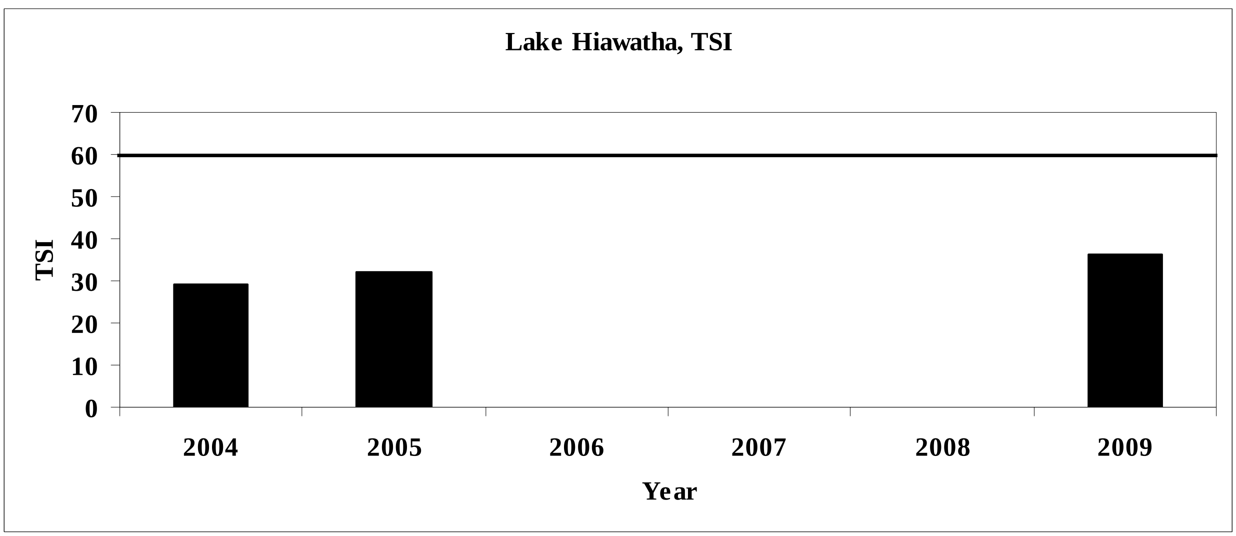


FIG. 8.7-9. Lake Hiawatha trophic state index (yearly average). Years not represented mean samples were not collected for all four seasons.

Total nitrogen values appear to be slightly elevated in 2009, when compared to previous years **(Figure 8.7-10)**. The mean chlorophyll *a* value during the sampling period was 3.7 µg/L, placing Lake Hiawatha in the oligotrophic range. However, Lake Hiawatha fluctuated between an oligotrophic and mesotrophic state **(Figure 8.7-11)**. The high level of water color (average was 163 PCU over the entire sampling period) undoubtedly inhibited chlorophyll production.

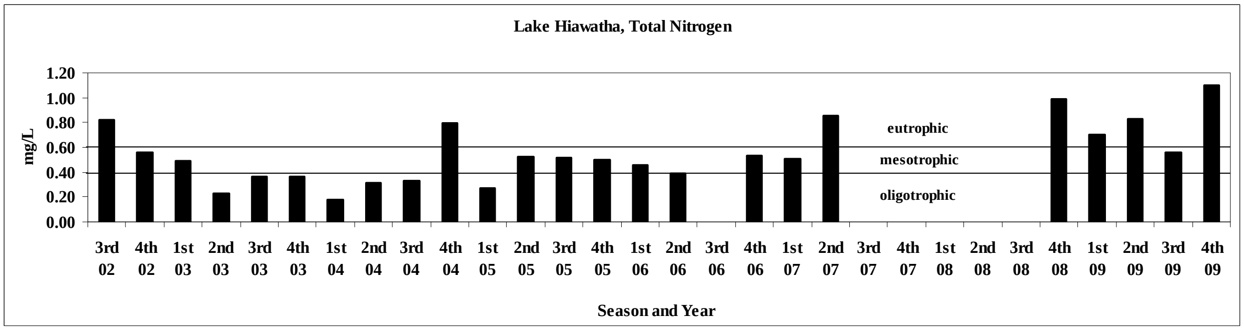


FIG. 8.7-10. Lake Hiawatha total nitrogen values.

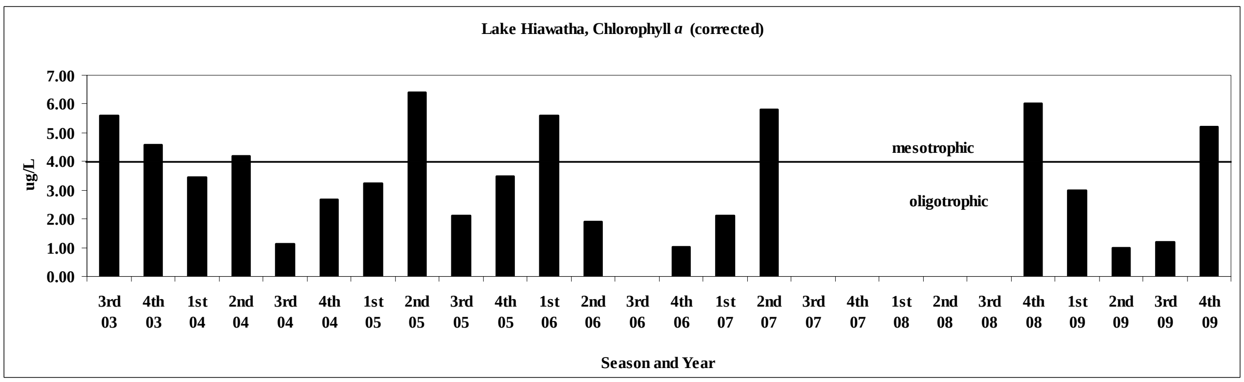


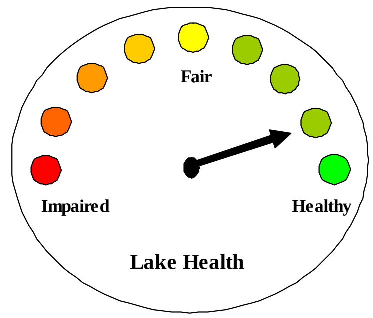
FIG. 8.7-11. Lake Hiawatha chlorophyll *a* values.

1. Lake Vegetation Index

The LVI score for Lake Hiawatha's was 90 placing the lake in the "Exceptional" category.

The native species, maidencane (*Panicum hemitomon*) and dog fennel (*Eupatorium leptophyllum*) dominated the shoreline area of Lake Hiawatha and were the most dominant species in the lake. Other native shoreline vegetation includes; swamp tupelo (*Nyssa sylvatica biflora*), pond cypress (*Taxodium ascendens*), red maple (*Acer rubrum*), buttonbush (*Cephalanthus occidentalis*) and titi (*Cyrilla racemiflora*). Due to the blackwater nature of the Lake Bradford Chain of Lakes there is limited aquatic vegetation in the water. No invasive exotic plants were noted at the time of sampling.

C. Lake Cascade



Figures 8.7-12 and **8.7-13** represents Lake Cascade's trophic state utilizing the FDEP Trophic State Index. Unfortunately, due to drought conditions, the last two quarters of 2006, all four quarters of 2007 and the first three quarters of 2008 data could not be collected. Water samples could not be collected in the fourth quarter of 2009 due to low water levels. Seasonal and yearly averages show that Lake Cascade does not exceed the 60 threshold and would not be considered impaired according to FDEP standards.

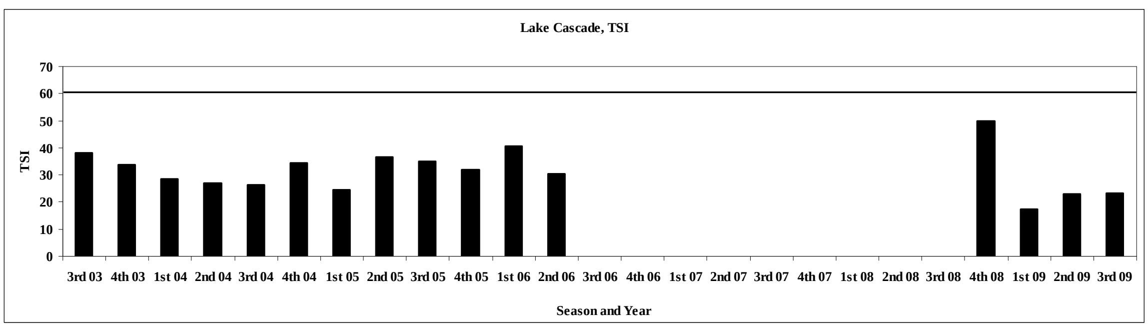


FIG. 8.7-12. Lake Cascade trophic state index.

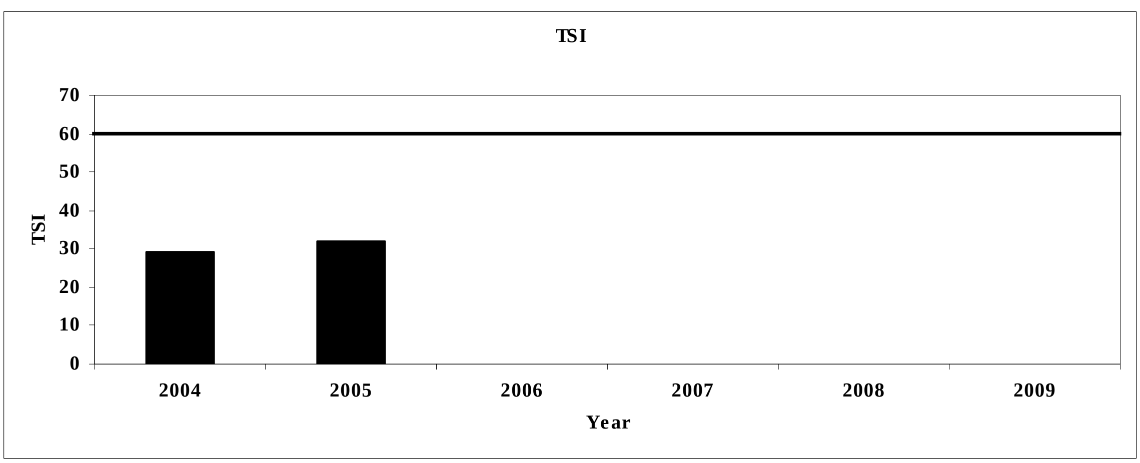
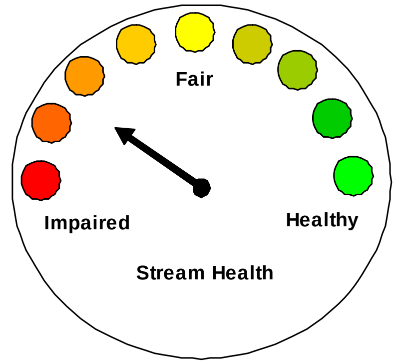


FIG. 8.7-13. Lake Cascade trophic state index (yearly average based on seasonal averaging of the data). Years not represented mean samples were not collected for all four seasons.

D. Gum Creek



The urbanized Gum Creek system is located in central Leon County **(Figure 8.7-14)**. Gum Creek meanders south through several wetlands, and eventually flows into Munson Slough.

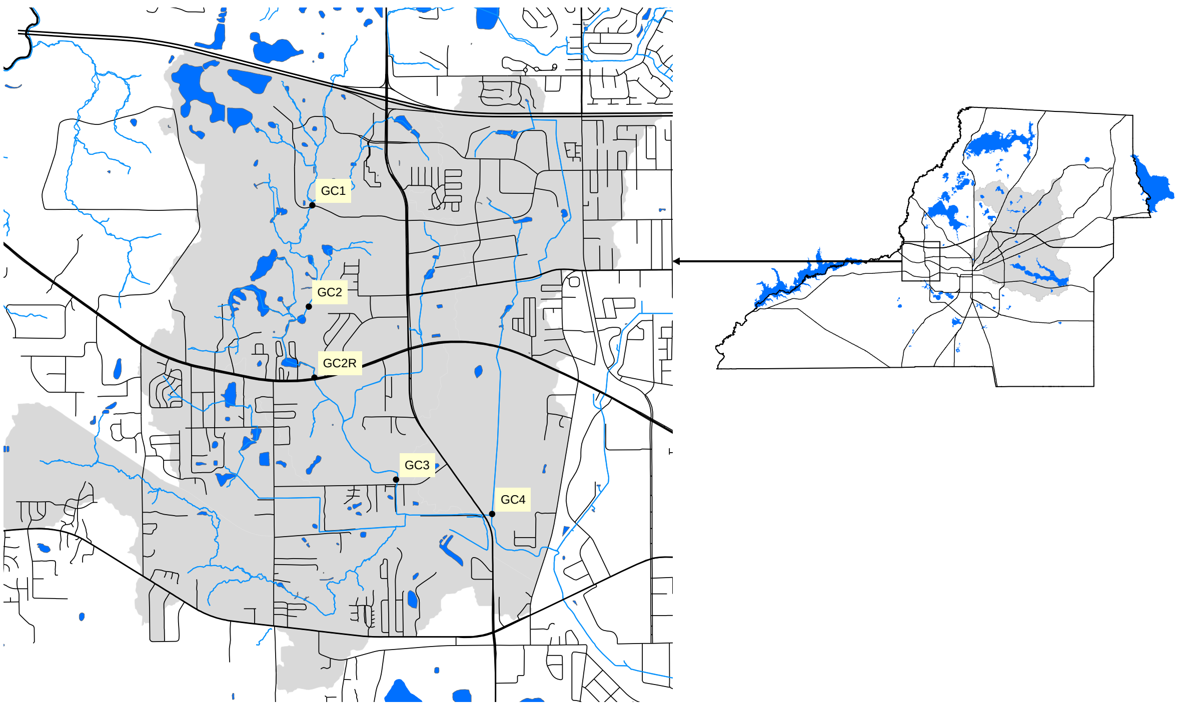


FIG. 8.7-14. Overview Map of the Gum Creek watershed.

As shown in **Figure 8.7-15**, approximately 46% of land use in the Gum Creek watershed is residential, commercial, industrial, or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

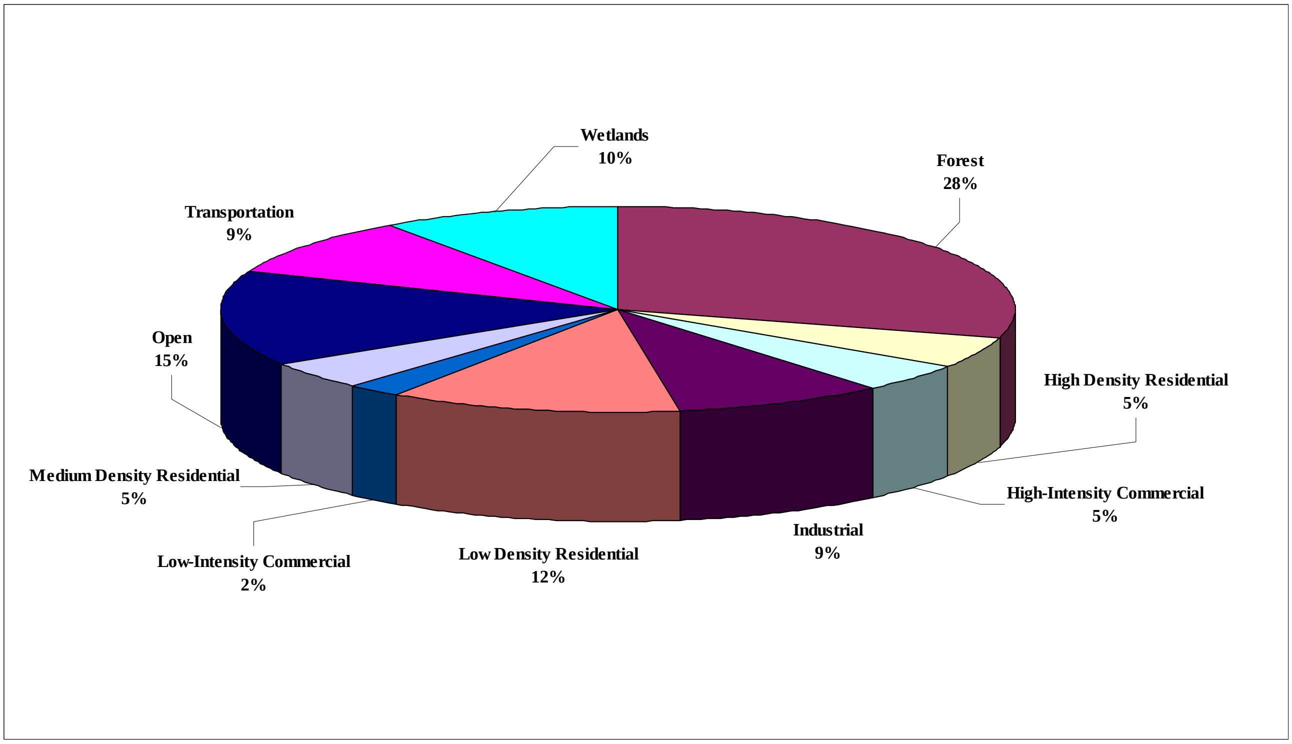


FIG. 8.7-15. Land use in the Gum Creek watershed (5,407 acres).

Due to access issues, the GC2 station was dropped in 2009 and was replaced with GC2T.

Due to the past drought, stations were sometimes dry during the sampling period. When viewing figures, seasons lacking bars mean samples were not collected due to lack of flowing water in the creek.

In September 2008, FDEP issued a report that presented the TMDL for fecal coliforms, for portions of Munson Slough, including Gum Creek (considered part of the Slough). The TMDL establishes the allowable loadings to Gum Creek that would restore the slough so that it meets applicable water quality thresholds (Wieckowicz, et al, 2008). Fecal coliform levels exceeded the TMDL criteria at all stations throughout the period of record **(Figure 8.7-16)**. This could possibly be the result of septic tank failures, sanitary sewer overflows, or wildlife activity.

Sampling stations did not always meet Class III water quality standards for DO **(Figure 8.7-17)**. Lead exceeded Class III water quality standards for the February (2.7 µg/L), sampling event. Current sources of lead include automobile batteries; however lead does not degrade, so former uses of lead including lead paint, leaded gas, solder, and cable sheathing can cause elevated lead levels. Elevated BOD levels during some sampling events showed that elevated microbiological activity may be contributing to low DO **(Figure 8.7-18)**. Generally, nutrients have decreased or stabilized **(Figures 8.7-19 - 8.7-22)**. This may be due to the area's return to a more normal rainfall pattern. Station GC4 orthophosphate levels during the September 2009 sampling event (0.11 mg/L) and station GC2T nitrite (NO_2) + nitrate (NO_3) levels (0.14 mg/L) are two exceptions.

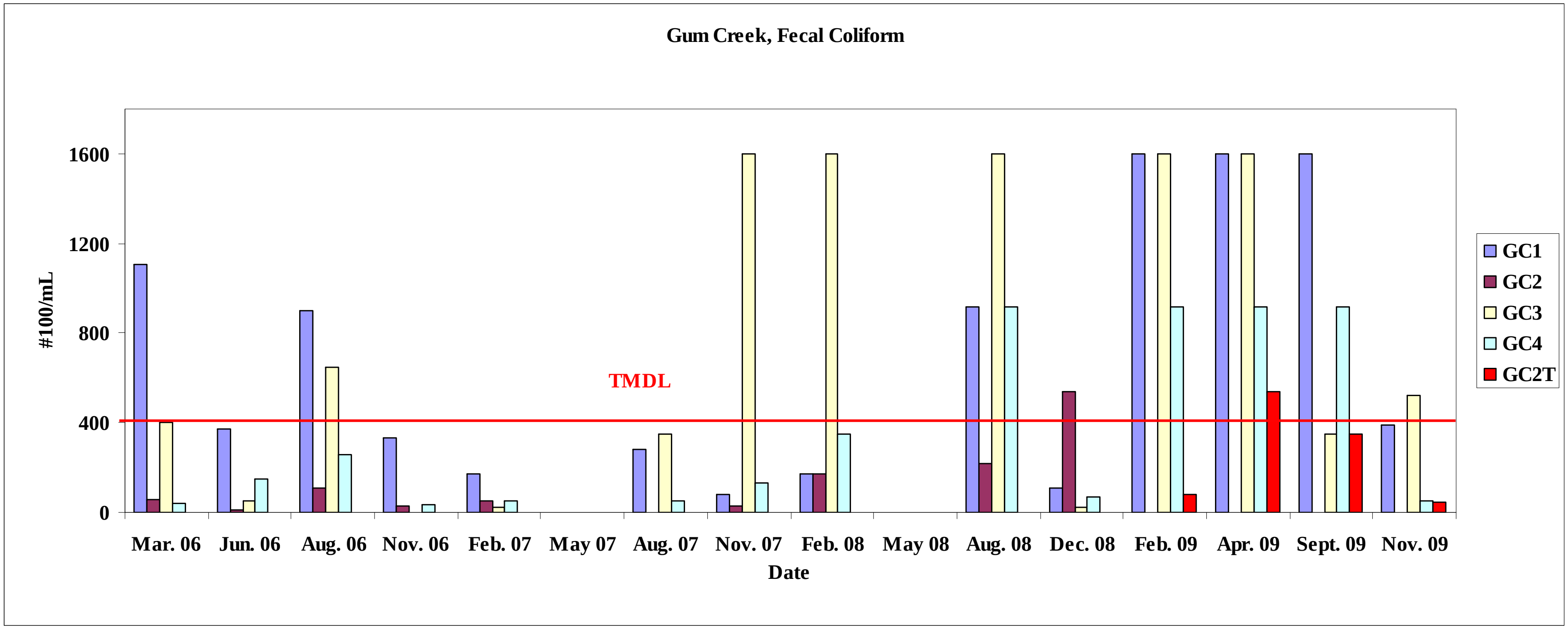


Fig. 8.7-16. Parameter of concern.

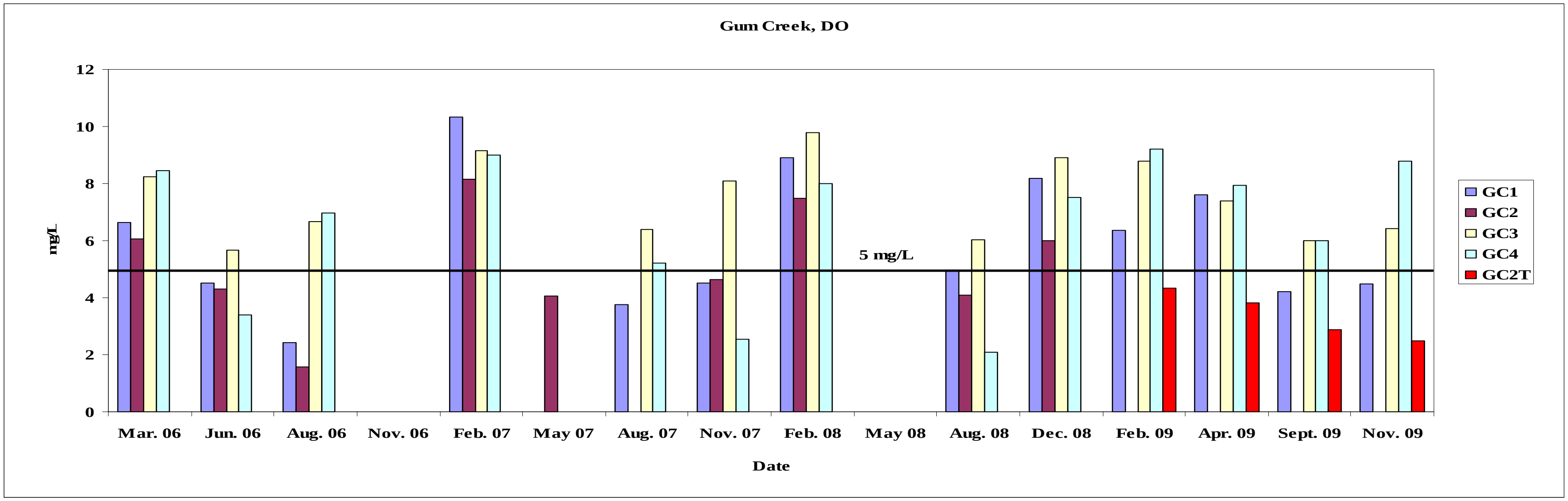


Fig. 8.7-17. Parameter of concern.

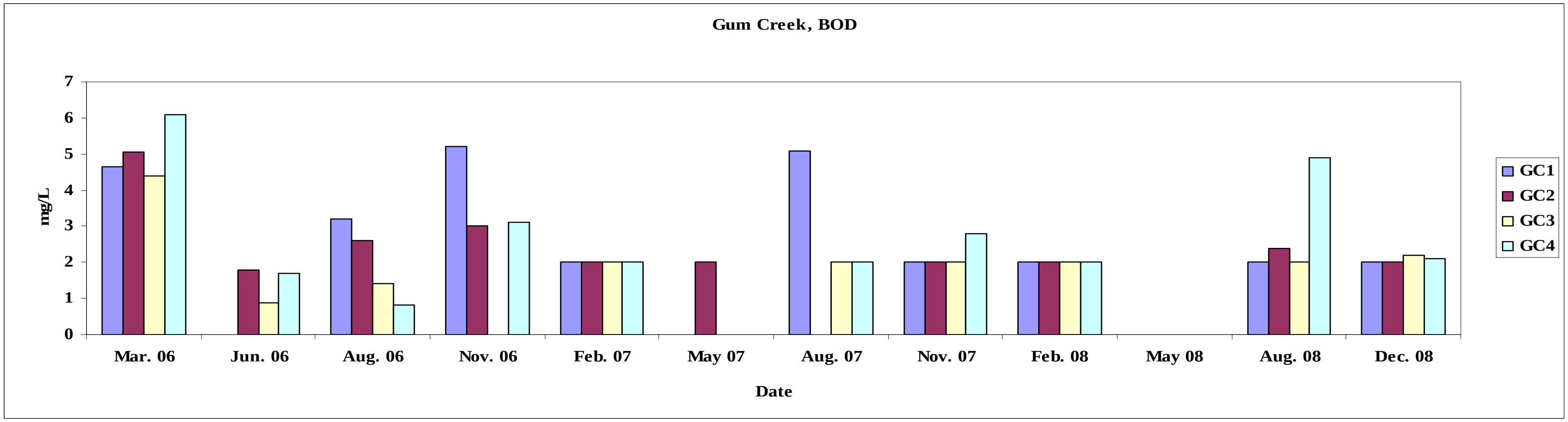


Fig. 8.7-18. Parameter of concern. The detection limit of the BOD analysis is 2.0 mg/L.

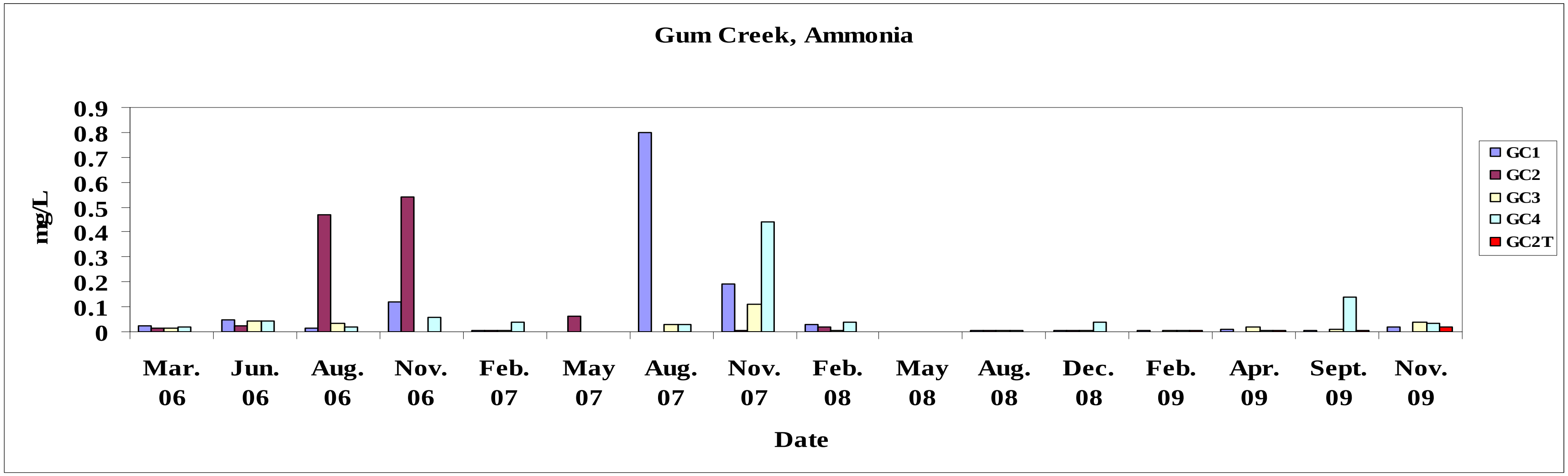


Fig. 8.7-19. **Ammonia.**

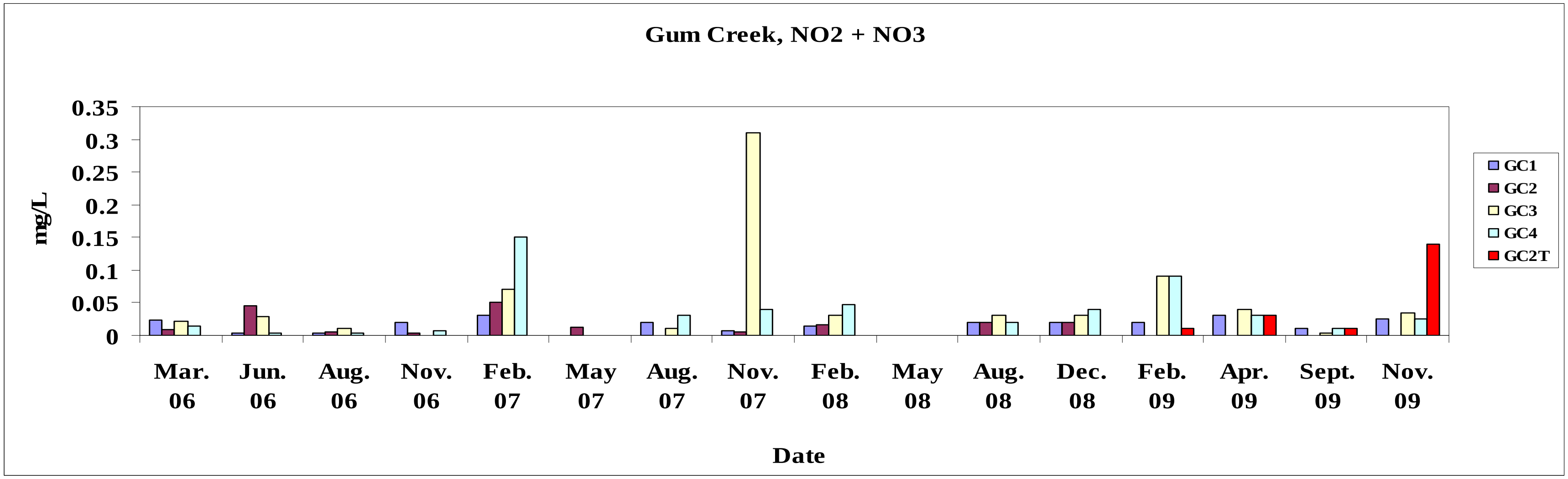


Fig. 8.7-20. **Nitrite and nitrate levels.**

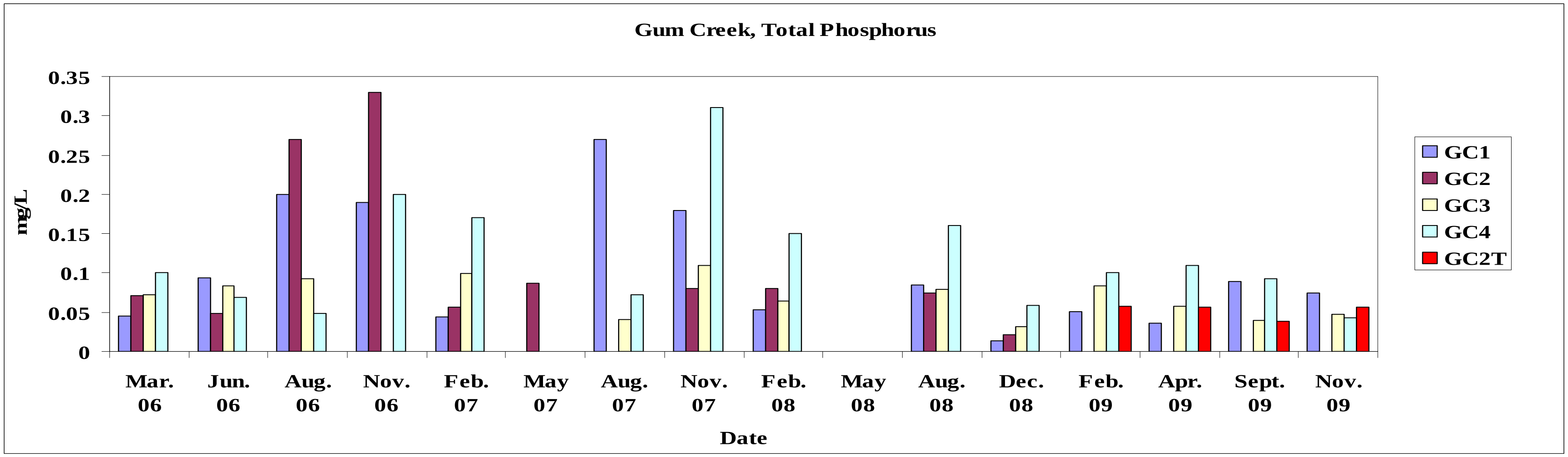


FIG. 8.7-21. **Total phosphorus.**

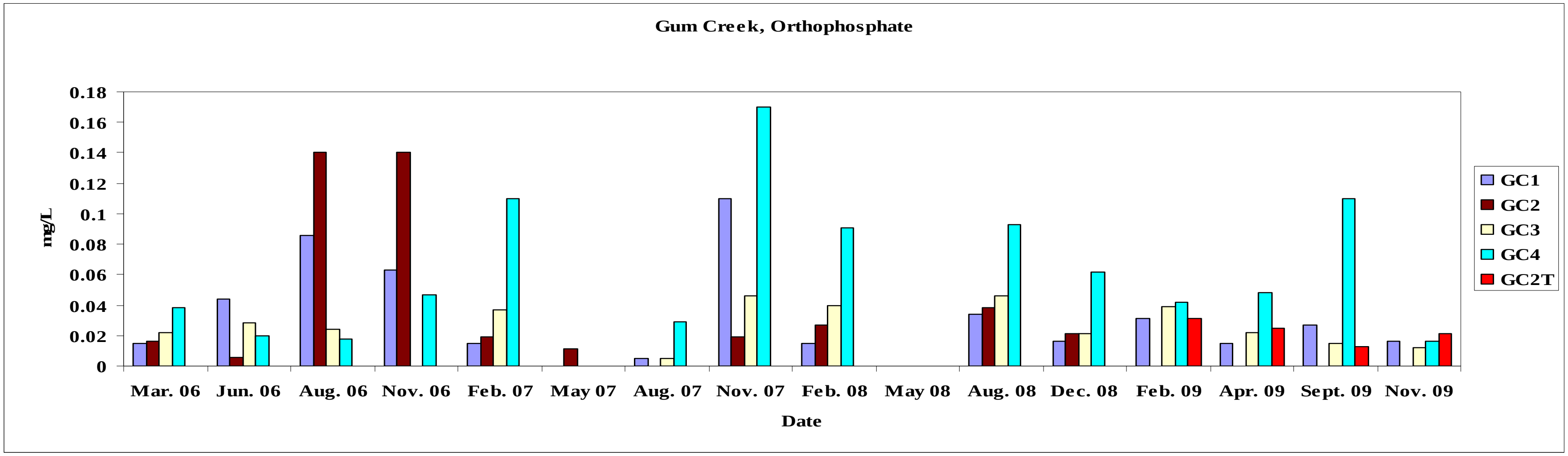


FIG. 8.7-22. **Orthophosphate.**

Since the Gum Creek watershed is heavily urbanized, and Gum Creek itself has been significantly altered over the years, there are several reasons why there are elevated nutrients in this system. Urban runoff tends to have high nutrient loads due to fertilizers, lawn clippings, sediments, animal droppings, sewer overflows, etc. While the County and the City of Tallahassee have made great strides in reducing non-point source pollution (various stormwater facilities in the City and County, etc.), work will need to continue to further improve water quality in this system.

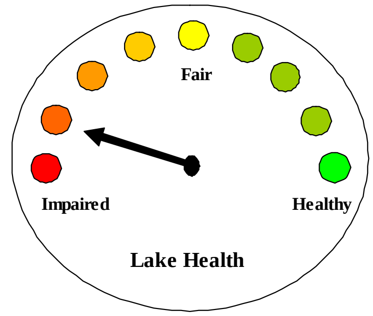
1. Stream Condition Index

Relatively normal rainfall patterns undoubtedly contributed to three of the four Gum Creek stations receiving a "healthy" SCI score **(Table 8.7-1)**. Station GC2, with a "marginal" habitat score of 62 was the only station that received a score of "impaired". In the case of GC4 the "poor" habitat score of 41 does not suggest a healthy aquatic invertebrate community. Habitat smothering, low water, artificial channelization, poor bank stability, and lack of productive habitat should have contributed to inadequate conditions for a healthy population of macroinvertebrates. It is thought that the recent rainfall prior to the SCI sampling event may have washed the macroinvertebrates from the adjoining wetland into the sampled reach where they were collected. It will be interesting to see if this pattern continues in 2010.

TABLE 8.7-1. SCI and Habitat Assessment scores and interpretation

Gum Creek	GC1 Dup 1	GC1 Dup 2	GC2 Dup 1	GC2 Dup 2	GC3 Dup 1	GC3 Dup 2	GC4 Dup 1	GC4 Dup 2
SCI Metric								
Total Taxa	36	37	36	42	36	38	35	42
Ephemeroptera Taxa	2	1	1	1	1	1	3	2
Trichoptera Taxa	1	1	0	1	0	1	2	2
% Filterer	41.95	36.65	1.7	2.2	21.8	20.2	41.25	33.65
Long-lived Taxa	1	1	1	0	0	1	0	1
Clinger Taxa	3	3	0	0	2	3	3	2
% Dominance	22	15.3	31.1	28.6	14.8	11.4	23.3	14.5
% Tanytarsini	25.3	23.3	2.7	4.4	34.7	27.6	41.9	35.8
Sensitive Taxa	2	2	1	1	2	3	1	0
% Very Tolerant Taxa	17.4	18	16.6	13.2	22.3	25	10.1	12.5
Total SCI Score	**48.11**	**47.14**	**22.24**	**26.53**	**38.44**	**44.64**	**49.47**	**51.32**
Average of two aliquots	**48**		**24**		**42**		**50**	
Score Interpretation	**Healthy**		**Impaired**		**Healthy**		**Healthy**	
Habitat Assessment Score	**96**		**62**		**83**		**41**	
Score Interpretation	**Sub Optimal**		**Marginal**		**Sub Optimal**		**Poor**	

E. Lake Munson



Lake Munson is an approximately 255 acre cypress-rimmed, nitrogen-limited, lake located south of the City of Tallahassee **(Figure 8.7-23)**. The lake is believed to have originally been a cypress swamp but has since been impounded and now functions as a shallow man-made lake (Bartel and Ard, 1992). Lake Munson receives the majority of its water from the heavily altered Munson Slough and its tributaries. Lake outflow continues southward via Munson Slough and finally drains into Ames Sink. Dye trace studies have confirmed a direct connection between Ames Sink and Wakulla Springs.

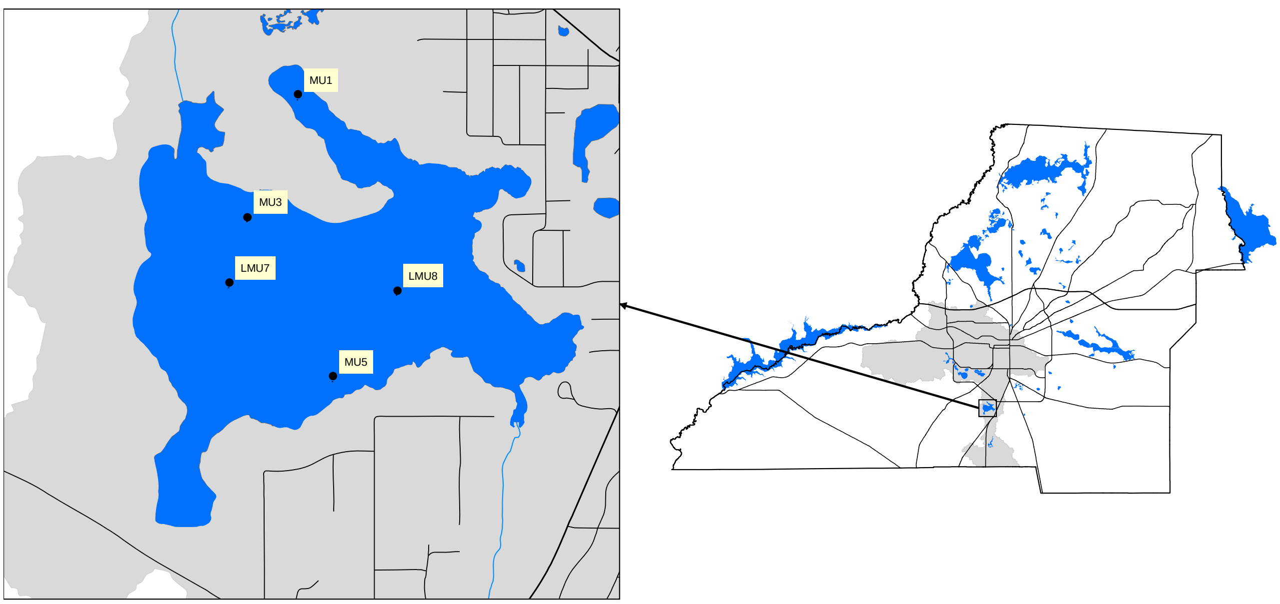


FIG. 8.7-23. Lake Munson Basin with locations of Lake Munson water quality sampling stations shown.

The lake has a history of severe water quality and ecologic problems including fish kills, algal blooms, floating aquatic vegetation, high nutrient and bacterial levels, low game fish productivity, sediment contamination, and depressed oxygen levels (Maristany and Bartel, 1989). More recently, an exotic apple snail (*Pomacea insularum*) has invaded the Lake Munson Basin, annihilating the aquatic plant population in the lake. There is also a fish consumption advisory due to PCB and mercury contamination on certain fish in the lake.

As shown in **Figure 8.7-24**, approximately 45% of land use in the Lake Munson Basin is residential, agricultural, commercial, or transportation. Increases in stormwater runoff and waterbody nutrient loads can often be attributed to these types of land uses.

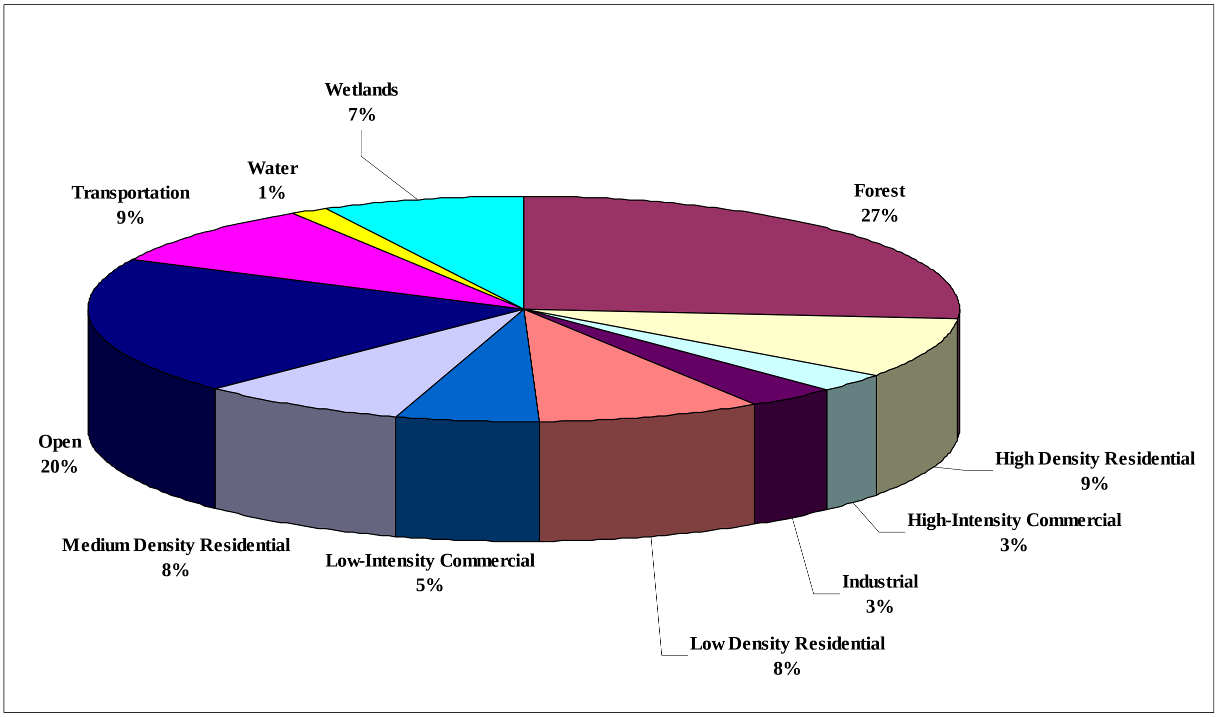


FIG. 8.7-24. Land use in the Lake Munson watershed (42,526 acres).

In March 2010, the Florida Department of Environmental Protection submitted a report to the U.S. Environmental Protection Agency that presented the Total Maximum Daily Load (TMDL) for nutrients (Trophic State Index), DO (linked to nutrients and BOD), and turbidity for Lake Munson. The TMDL establishes the allowable loadings to Lake Munson that would restore the lake so that it meets applicable water quality thresholds for nutrients and DO (Gilbert, et al, 2009). When appropriate, the following graphs denote the TMDL for the applicable parameter.

Figures 8.7-25 and **8.7-26** represents Lake Munson's trophic state utilizing the FDEP Trophic State Index. Yearly averages show that Lake Munson exceeded the 60 threshold in 2007 and 2008, as well as exceeding the TMDL limit from 2005-2008 and would be considered impaired according to FDEP standards. Seasonal values showed similar exceedances.

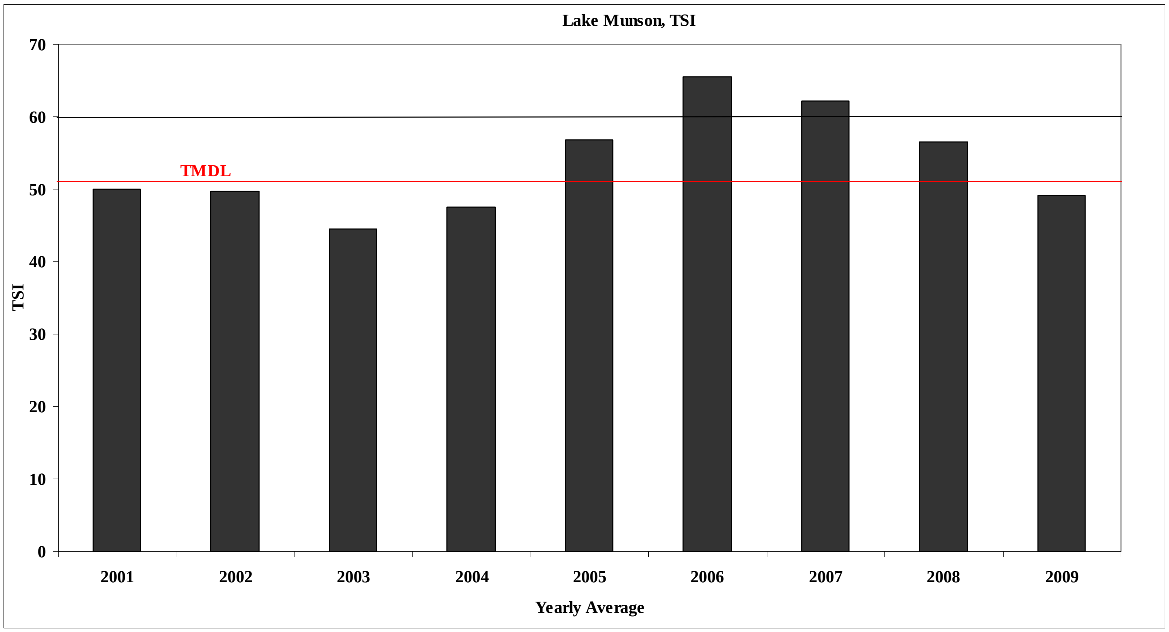


FIG. 8.7-25. Lake Munson trophic state index (yearly average).

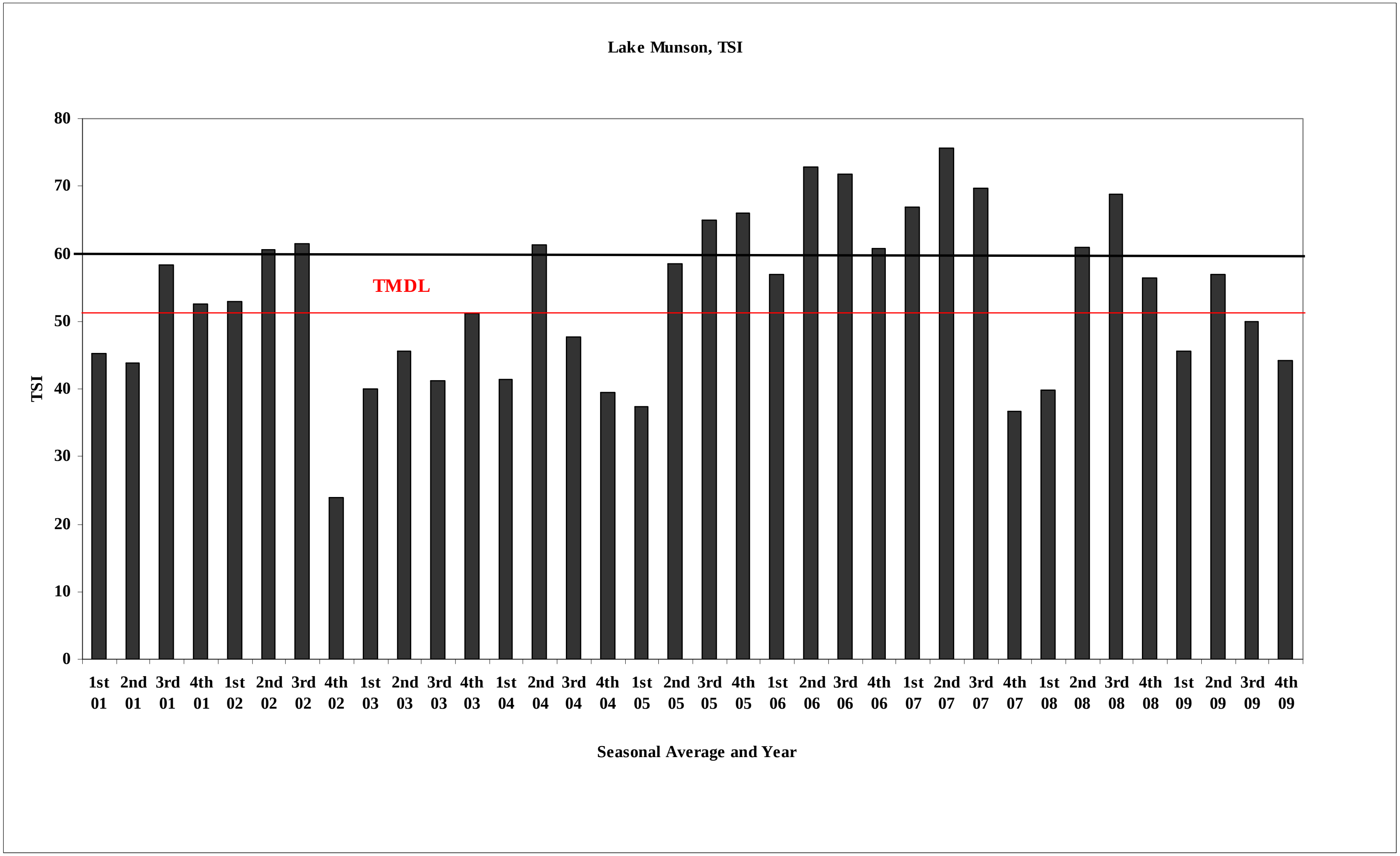


FIG. 8.7-26. Lake Munson trophic state index (seasonal average).

The seasonal average chlorophyll *a* value during the 2001-2009 sampling period was 22.32 µg/L placing Lake Munson in the eutrophic range. However, recent chlorophyll levels (averaging 12.51µg/L in 2009 versus 27.90µg/L in 2008) were considerably lower. While yearly chlorophyll levels were lower in 2009, individual and seasonal chlorophyll levels were still elevated, measuring 65.9µg/L at LMU8 in the second quarter of June 2009 with an average of 33.45µg/L for the same quarter **(Figure 8.7-27)**.

Phosphorus also followed similar trends, gradually increasing throughout the 3rd quarter of 2009 allowing Lake Munson to reach a hypereutrophic status, then dropping sharply off **(Figures 8.7-28)**. Nitrogen levels were slighter higher in 2009 than in 2008 **(Figure 8.7-29)**. Organic nitrogen continues to be the predominant form of nitrogen. This indicates that most of the nitrogen in the water column was derived from the blue-green algal bloom that dominated the lake for several months. As the algae died and decomposed, nitrogen was rapidly transformed and was utilized by other algae, continuing the cycle. During the colder months, nitrogen (and phosphorus) levels were not as high, further indicating that both nitrogen and phosphorus being measured were a direct measure of nutrients tied up in algae.

In 2006 and 2007 the exotic apple snail *Pomacea insularum,* consumed the majority of vegetation in Lake Munson allowing the lake to transition from a lake dominated by macrophytic vegetation to a lake dominated by algae. The algae proliferated rapidly, taking up nutrients and space that were originally being used by the macrophytic vegetation, and therefore showed elevated nutrient levels in the water column. Even though the main source of water for Lake Munson (Munson Slough) had high nutrients, the relatively recent increases in nutrients in Lake Munson did not always correlate with increases in upstream nutrients. In some instances Munson Slough had lower levels of nutrients than Lake Munson, indicating that nutrient recycling and probable assimilation of nutrients from the organic rich sediment in Lake Munson was occurring. In addition, the 2006-2007 droughts accelerated nutrient recycling from the organic rich bottom sediments when the shallow water was retained longer in the lake during the drought. The lack of macrophytic plants to utilize the nutrients created the optimum condition for the extensive algal blooms witnessed in Lake Munson. These blooms are more evident during the summer when temperatures and sunlight drive metabolic activities. During the winter months, the bloom subsides, and the lake will show lower levels of nutrients and chlorophyll *a* in the water column. The lower nutrient levels in 2008-2009 may show that the lake is stabilizing to degree due to the fact that some nutrients have “flushed” out of the system and to the return of a relatively normal rainfall pattern. It is unknown if this pattern will persist.

Despite lower nutrient levels, algal blooms have multiple effects. As shown in **Figure 8.7-30**, unionized ammonia concentrations exceeded Class III water quality limits several times. High levels of unionized ammonia are caused by elevated temperature, ammonia and pH. During daylight hours, algae take carbon dioxide from the water for their metabolic processes. This increases water pH values, allowing unionized ammonia levels to reach potentially toxic levels.

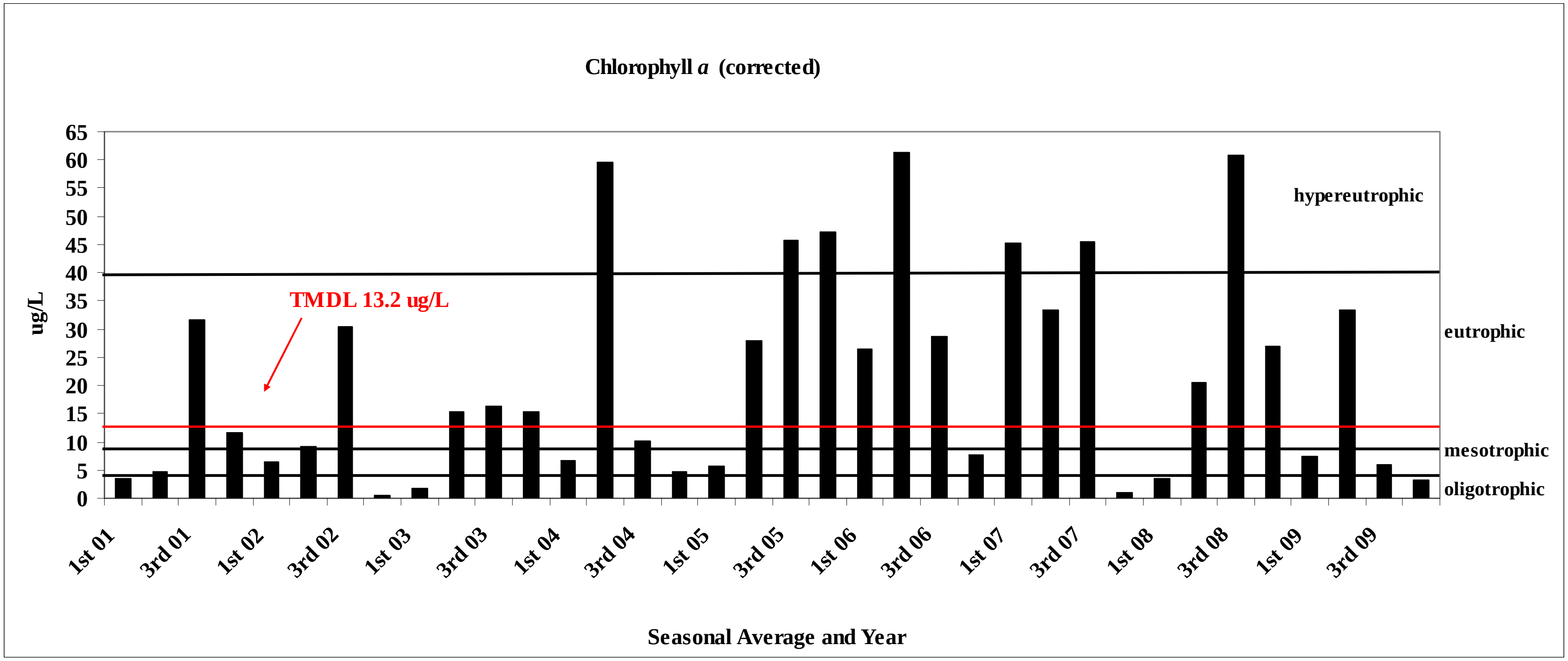


FIG. 8.7-27. Parameter of concern. Red line denotes the proposed TMDL.

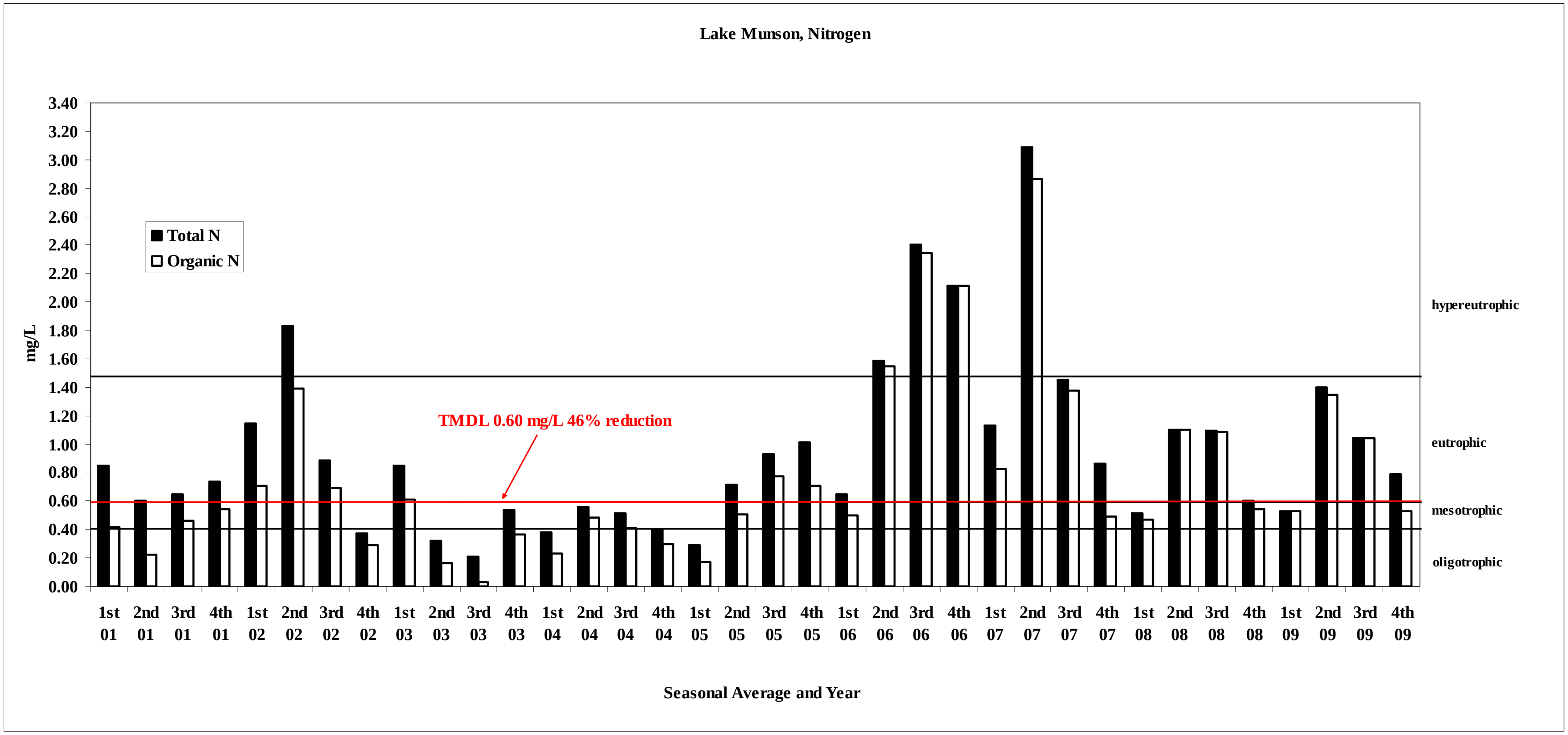


FIG. 8.7-28. Parameter of concern. Red line denotes the proposed TMDL.

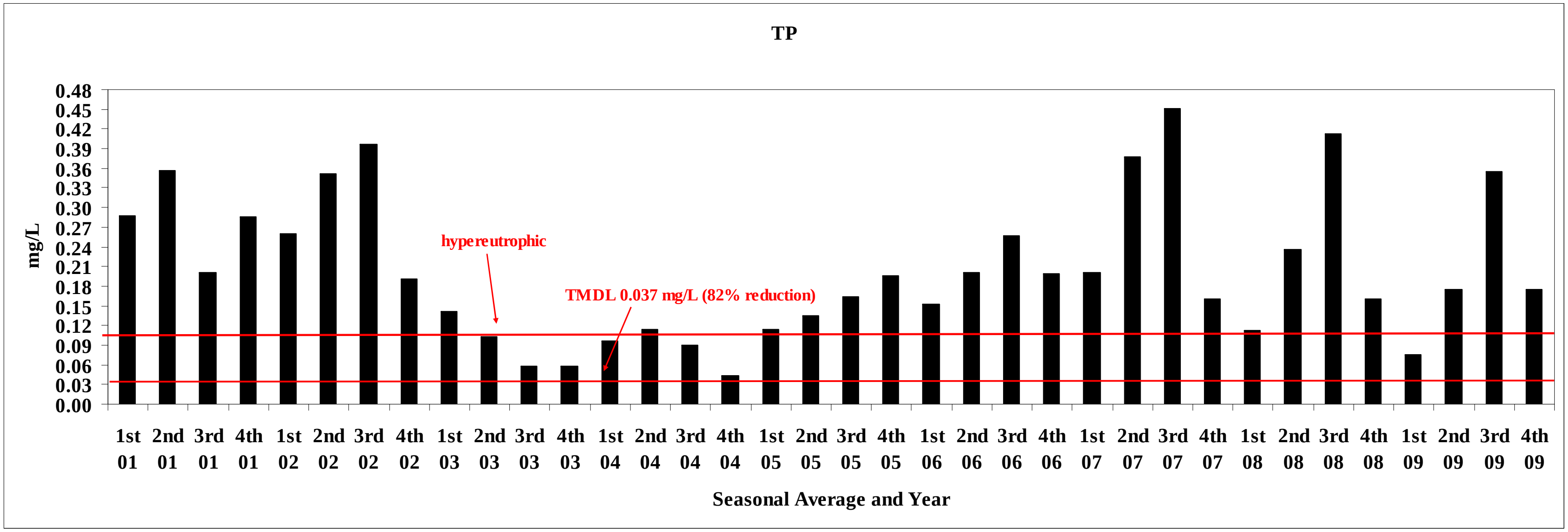


FIG. 8.7-29. Parameter of concern. The lower line line denotes the proposed TMDL.

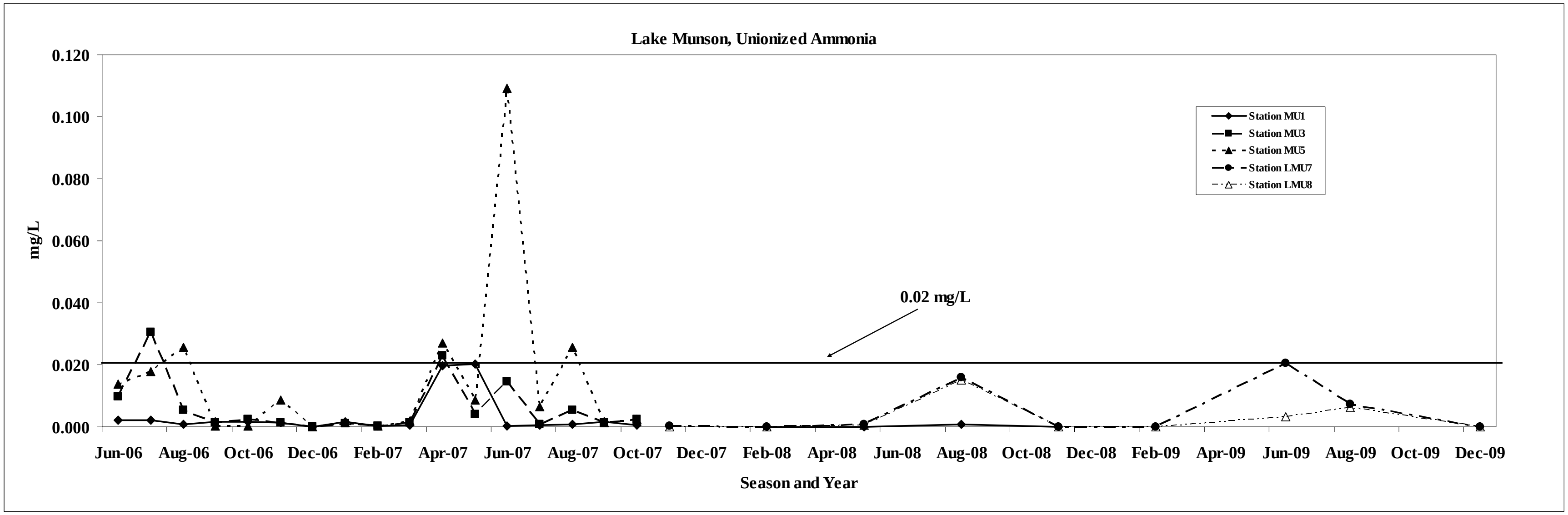


FIG. 8.7-30. Parameter of concern. Stations MU1, MU3, MU5 were replaced by stations LMU7 and LMU8 in November 2007. MU1 was sampled periodically in late 2008.

FDEP verified Lake Munson as impaired by turbidity and set a proposed TMDL of 31.0 NTU. As shown in **Figure 8.7-31**, turbidity values fluctuated in 2006 and the early part of 2007. In 2008, turbidity averaged 13 NTU, but the August 2008 values exceeded the TMDL value.

FDEP also verified Lake Munson as impaired by elevated levels of BOD and set a proposed TMDL of 2.0 mg/L. As shown in **Figure 8.7-32**, BOD levels were extremely elevated in 2006 and 2007, and remain elevated throughout most of 2008 and 2009.

At times, dissolved oxygen levels did not meet acceptable criteria for Class III waterbodies; during other instances, dissolved oxygen percent saturation reached supersaturated levels in the water column **(Figures 8.7-33 and 8.7-34)**. During sunny days, the algae produced abundant levels of oxygen raising percent saturation. At night, when algal respire; they utilize oxygen, depleting levels to a potentially dangerous level for fish and invertebrates.

Fecal coliforms also exceeded Class III criteria several times over the sampling period **(Figure 8.7-35)**. This could possibly be the result of septic tank failures, sanitary sewer overflows, or wildlife activity.

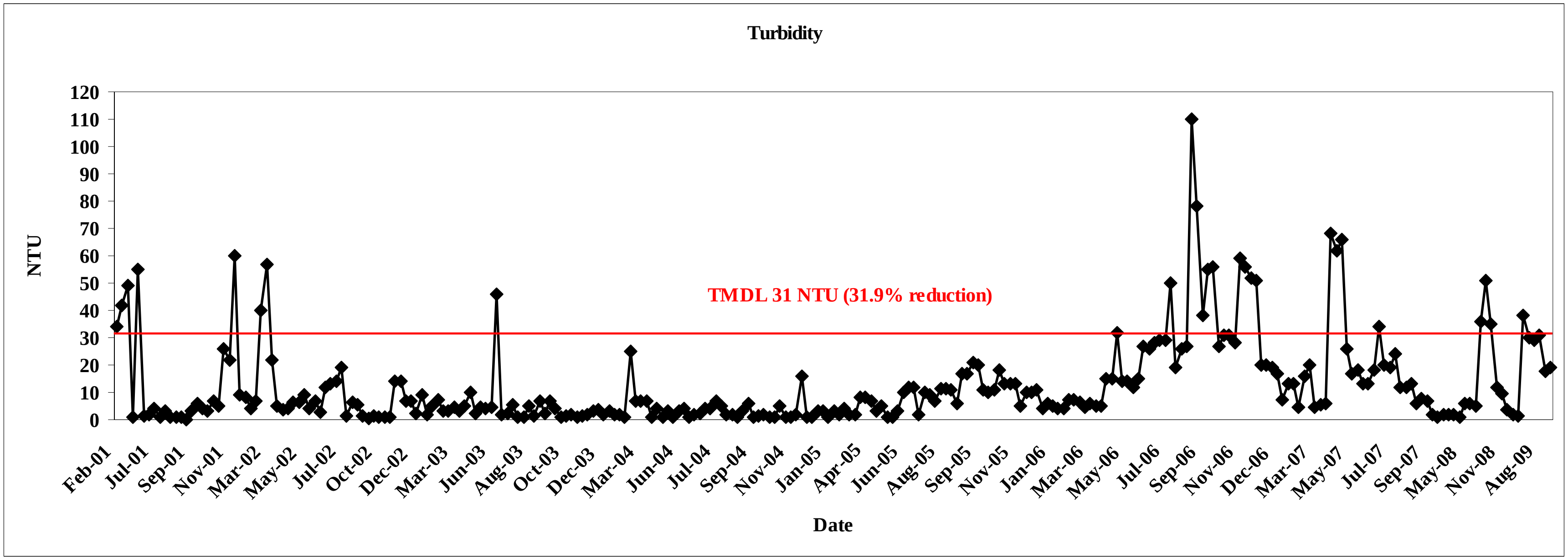


FIG. 8.7-31. Parameter of concern. Red line denotes the TMDL.

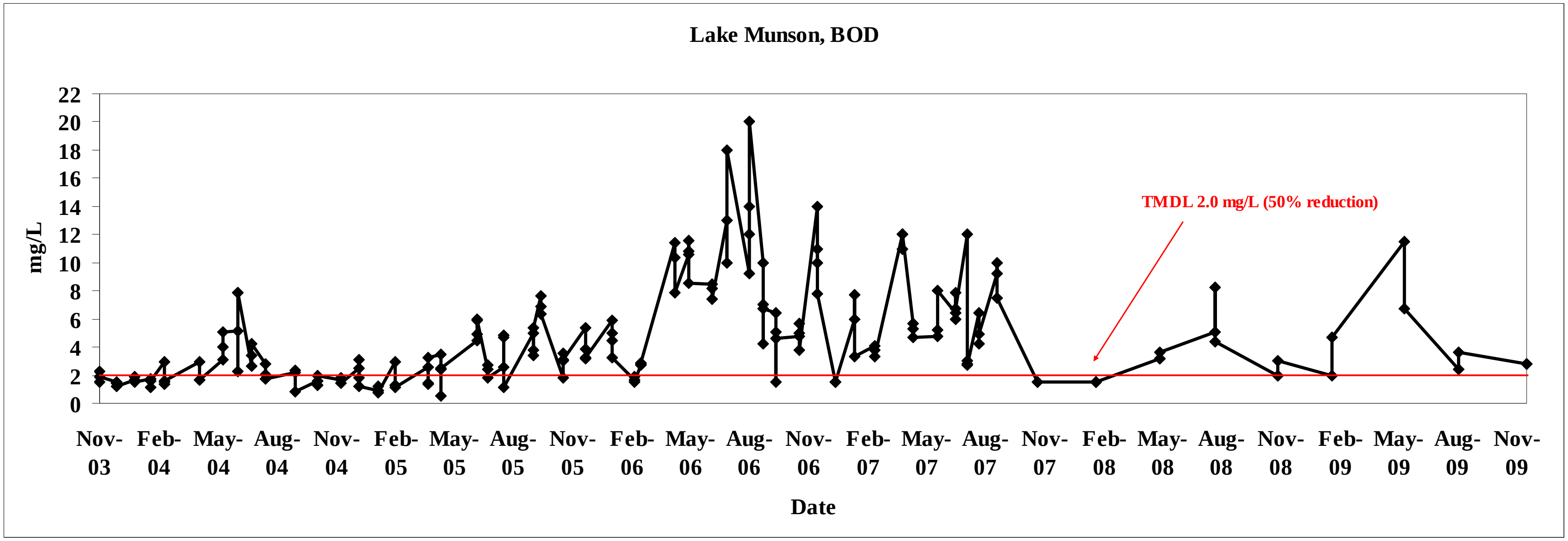


FIG. 8.7-32. Parameter of concern. Red line denotes the TMDL.

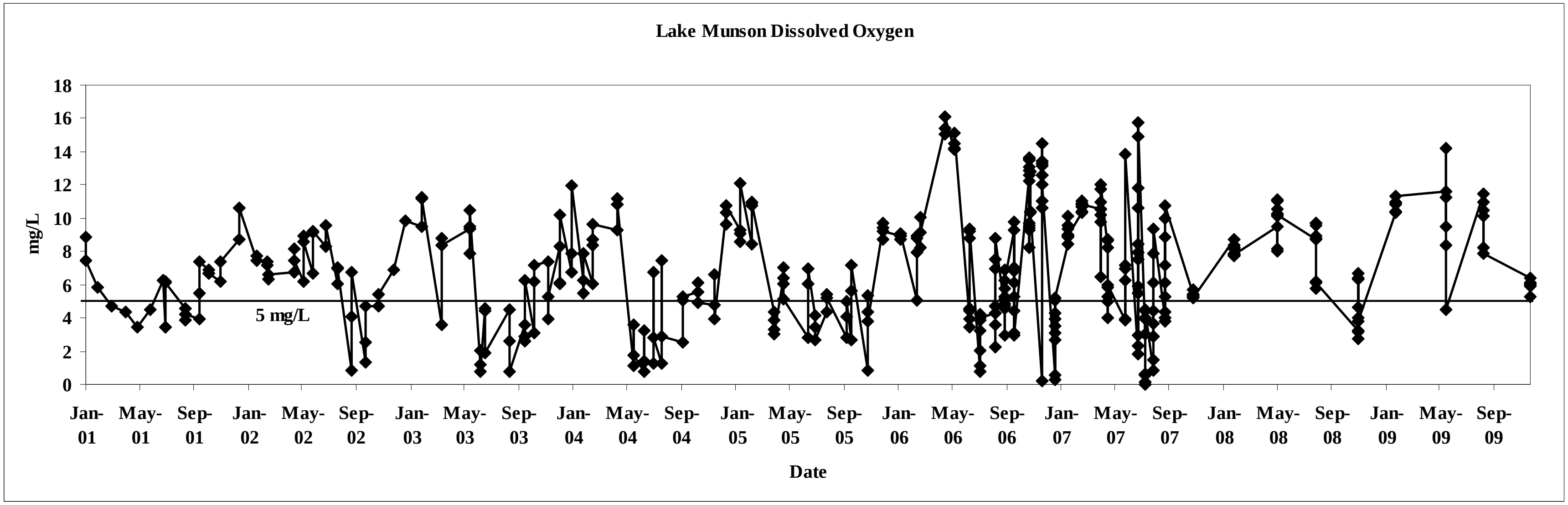


FIG. 8.7-33. Lake Munson DO levels. Markers represent individual measurements. Starting in June 2006, top, mid-depth, and bottom DO measurements were taken where appropriate.

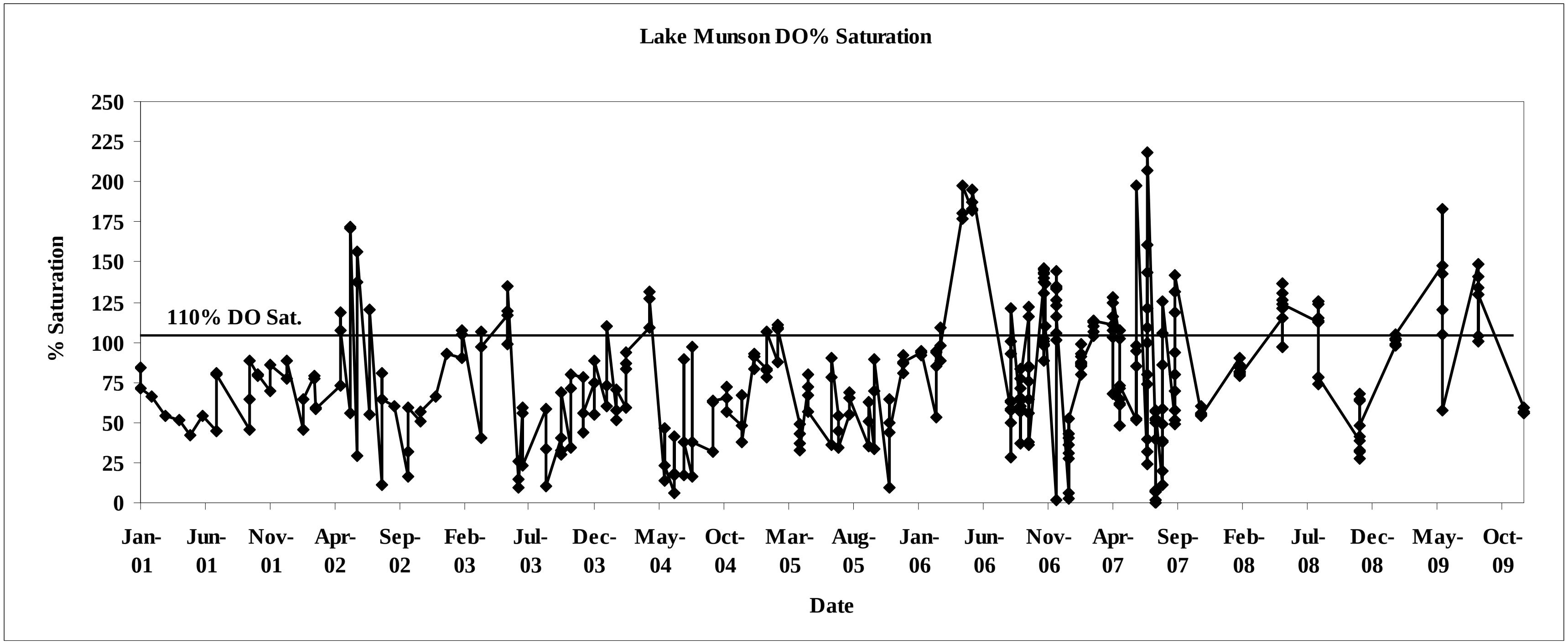


Figure 8.7-34. Lake Munson DO % saturation levels. Markers represent individual measurements. Starting in June 2006, top, mid-depth, and bottom DO % saturation measurements were taken where appropriate.

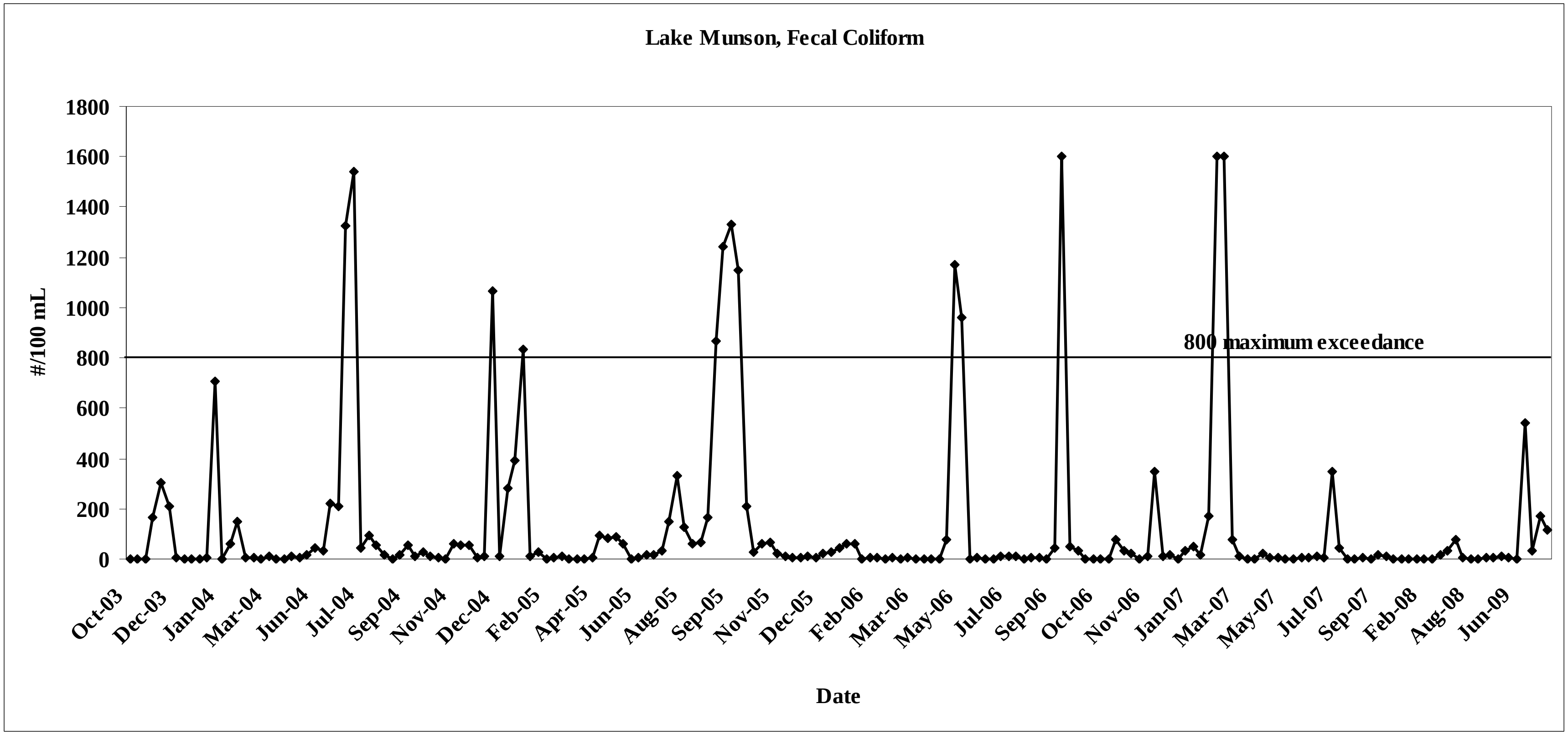


FIG. 8.7-35. Lake Munson fecal coliform levels. Markers represent individual measurements.

1. Lake Vegetation Index

Surprisingly, the LVI score for Lake Munson was 61, placing the lake in the "Healthy" category.

Given the amount of detrimental impacts that the lake has faced, the littoral plant community has done surprisingly well. The native species, pond cypress (*Taxodium ascendens*) dominated the shoreline area of Lake Munson and was the most dominant species in the lake. Other native shoreline vegetation includes; red maple (*Acer rubrum*), buttonbush (*Cephalanthus occidentalis*), flat sedge (*Cyperus odoratus*), Water pennywort (*Hydrocotyle umbellata*), sweetbells (*Leucothoe racemosa*), dotted smartweed (*Polygonum punctatum*), and netted chain fern (*Woodwardia areolata*).

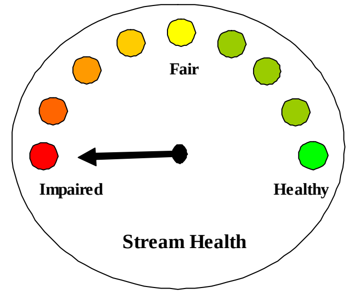
Not surprisingly, there were a number of invasive exotic plant species present. Wild taro (*Colocasia esculenta*), Chinese privet (*Ligustrum sinense*), and Chinese tallow (*Sapium sebiferum*), were found in Lake Munson's littoral zone and are listed as Category I Invasive Exotics by the Florida Exotic Pest Control Council. Alligator weed (*Alternanthera philoxeroides*), and rattlebox (*Sesbania punicea*), both considered Category II Invasive Exotics were also present in Lake Munson.

Ironically, Lake Munson's relatively high LVI score for such an impacted lake was influenced by the invasive exotic apple snail, *Pomacea insularum*. Historically, Lake Munson was dominated by exotic vegetation (**Figure 8.7-36**). Over time, the snails consumed all vegetation in the water column including water hyacinth (*Eichnoria crassipes*), water lettuce (*Pistia stratiotes*) and hydrilla (*Hydrilla verticillata*) all listed as Category I Invasive Exotics by the Florida Exotic Pest Control Council (**Figure 8.7-37**). The presence of these species would have contributed to a lower LVI score. The snail also consumed native plants including the American lotus (*Nelumbo lutea*), but the overwhelming abundance of exotic plants in the water column would probably have negated any positive effects the native vegetation would have had on the LVI.

FIG. 8.7-36. Lake Munson in October 2003. The water surface is dominated by water hyacinth (*Eichnoria crassipes)* a Category I Invasive Exotic.

FIG. 8.7-37. Lake Munson in August 2009. The water surface is completely devoid of aquatic plants.

F. Munson Slough



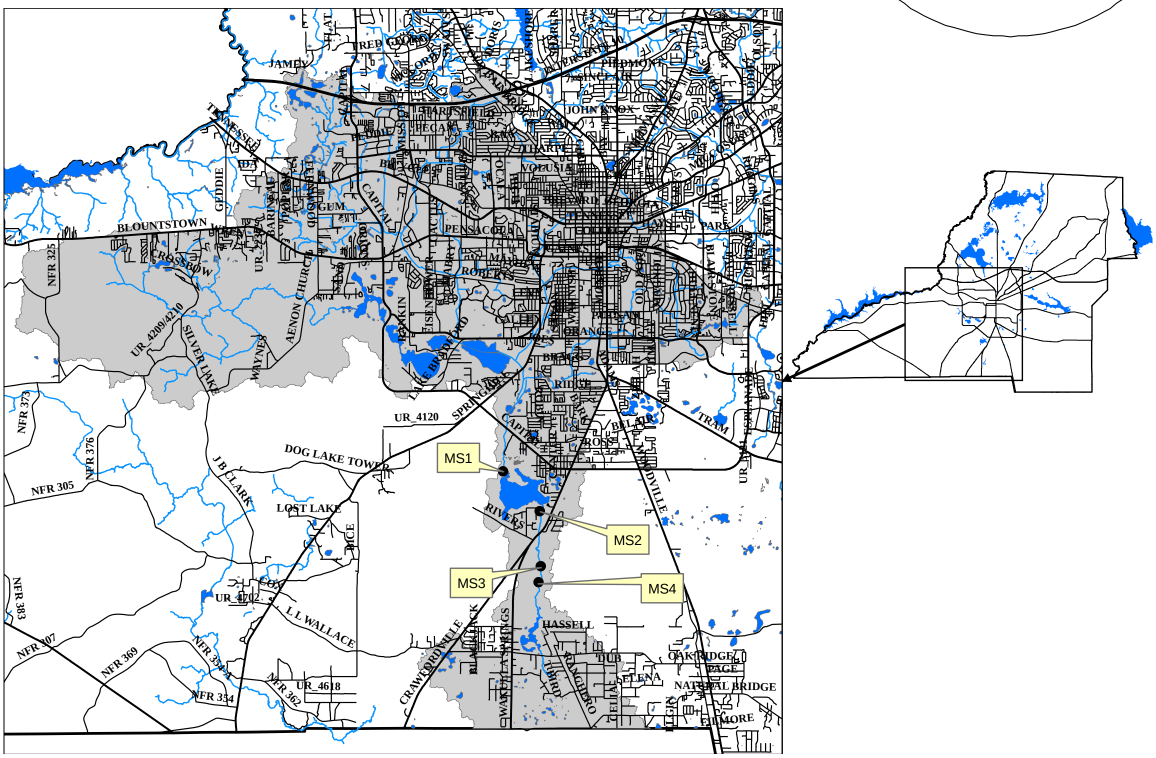


FIG. 8.7-38. Overview Map of the Munson Slough watershed.

The heavily urbanized Munson Slough and its tributaries are located in central Leon County **(Figure 8.7-38)** and drain a portion of the City of Tallahassee. The Slough flows south into and out of Lake Munson, then continues south into Eight Mile Pond. After exiting Eight Mile Pond and flowing under Oak Ridge Road, the Slough enters Ames Sink, which is a known contributor of water to Wakulla Springs.

As shown in **Figure 8.7-39**, approximately 45% of land use in the Munson Slough watershed is residential, commercial, industrial, or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

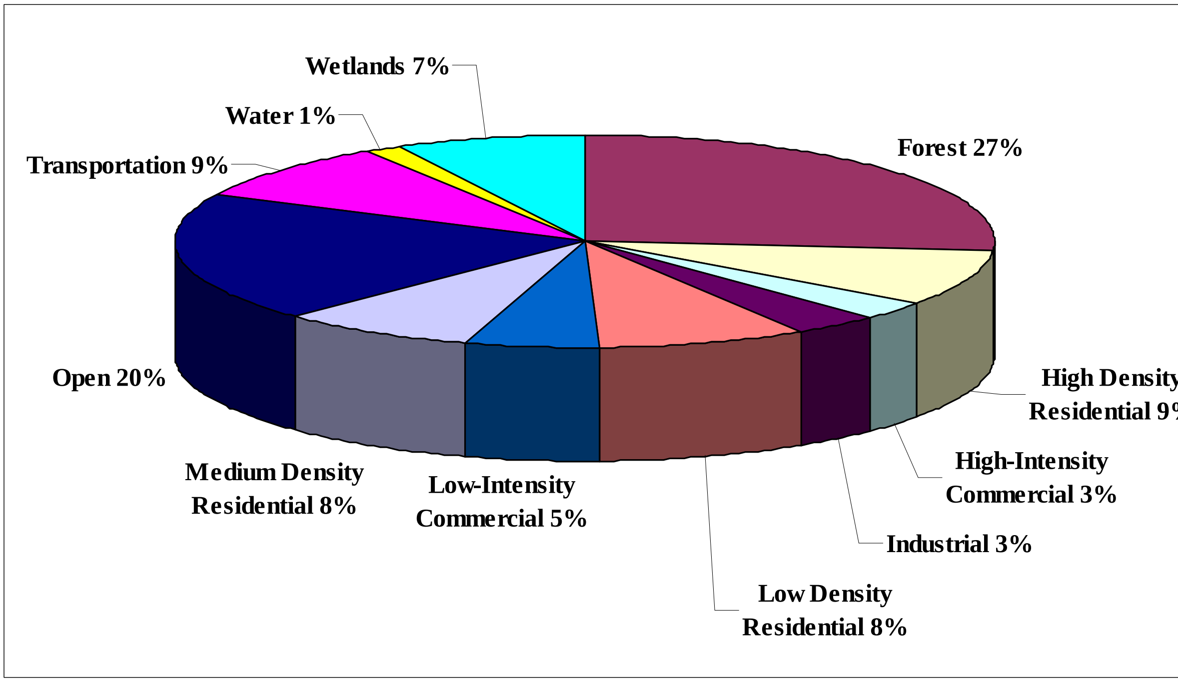


FIG. 8.7-39. Land use in the Munson Slough watershed (42,526 acres).

In September 2008 and March 2010, FDEP issued two reports that presented the TMDL for fecal coliforms, BOD, TN, TP, and NH_3N for portions of the Slough. The TMDL establishes the allowable loadings to Munson Slough that would restore the slough so that it meets applicable water quality thresholds (Gilbert, et al, 2010). When appropriate, the following graphs denote the TMDL for the applicable parameter. When viewing figures, seasons lacking bars mean samples were not collected due to lack of flowing water in the Slough.

At times, fecal coliform levels were elevated above the TMDL limit (>400 in 10% of the samples) at stations MS1, MS2 and MS4 **(Figure 8.7-40)**. This could possibly be the result of septic tank failures, sanitary sewer overflows, or wildlife activity.

At times, sampling stations did not meet Class III water quality standards for DO **(Figure 8.7-41)**. Elevated BOD levels during some sampling events showed that elevated microbiological activity may be contributing to low DO **(Figure 8.7-42)**. The microbial activity appears to have been stimulated by the elevated levels of ammonia and nitrite + nitrate in this predominantly nitrogen limited system **(Figures 8.7-43 and 8.7-44)**. In the case of ammonia, levels at sampling stations MS3 and MS4 during the 2006, season 2 sampling event exceeded levels found in 95% of all streams in Florida. It should be noted that these levels occur after the Slough exits Lake Munson, suggesting that nutrient recycling is occurring in Lake Munson. Nitrite + nitrate levels during the 2007 season 1 sampling event at all stations exceeded levels found in 80% of Florida streams. Stations MS2 (0.2 mg/L), MS3 (0.03 mg/L), and MS4 (0.03 mg/L) exceeded the 0.02 mg/L Class III limit for unionized ammonia during the May 2006 sampling event.

Total nitrogen values (average over the entire sampling period was 1.22 mg/L) exceeded the TMDL limit (0.72 mg/L) 43 of the 71 sampling events or 61% of the time **(Figure 8.7-45)**.

Elevated total phosphorus **(Figure 8.7-46)** and orthophosphate **(Figure 8.7-47)** were also detected at all stations (total phosphorus levels at station MS2 during the 2007, season 2 sampling event exceeded levels found in 80% of streams in Florida). Total phosphorus values (average over the entire sampling period was 0.22 mg/L) met or exceeded the TMDL limit (0.15 mg/L) 41 of the 59 sampling events or 69% of the time.

Elevated nutrients also contributed to high concentrations of algae/cynaobacteria as evidenced by the high chlorophyll levels at Stations MS1 (July 2009) and MS2 (April 2007 and July 2009) **(Figure 8.7-48)**. MS2 levels during the 2007 2^{nd} and the 2009 3^{rd} quarter sampling event exceeded levels found in 95% of Florida Streams, as well as exceeding FDEP's annual mean chlorophyll concentration of 20 µg/L (62.303.351(2) F.A.C., 2007). High concentrations of algae often contribute to fish and invertebrate kills in waterbodies due to depleted dissolved oxygen concentrations in water caused by algal proliferation, death, decay, or night respiration.

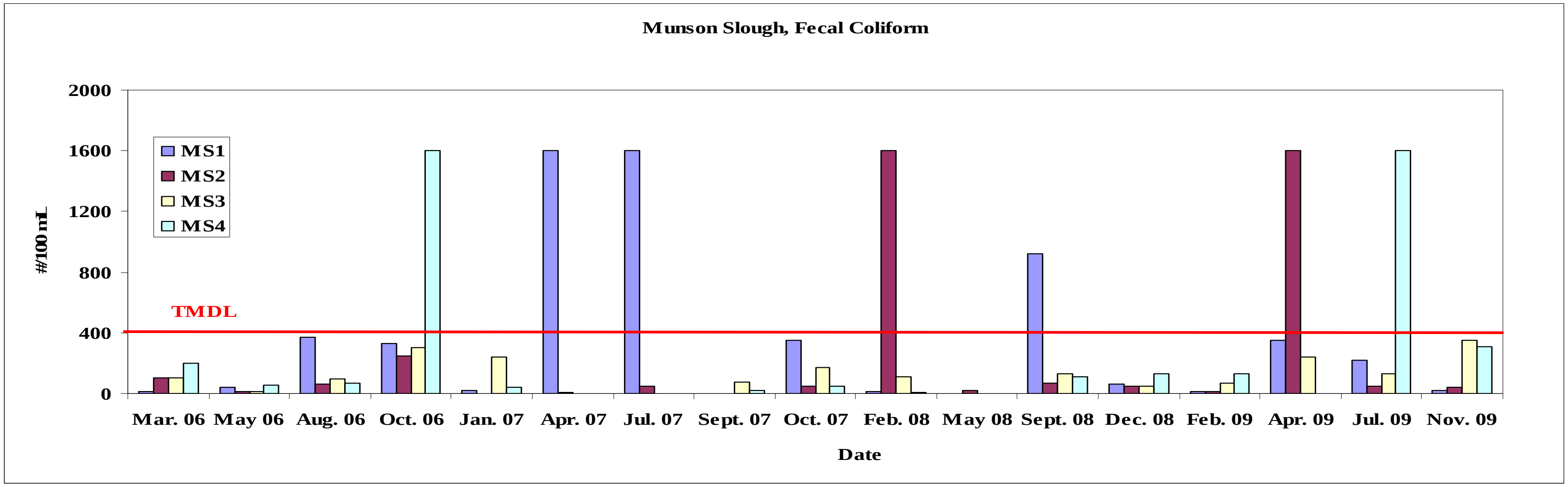


FIG. 8.7-40. Parameter of concern. Red line denotes the proposed TMDL for Munson Slough above Lake Munson (MS1).

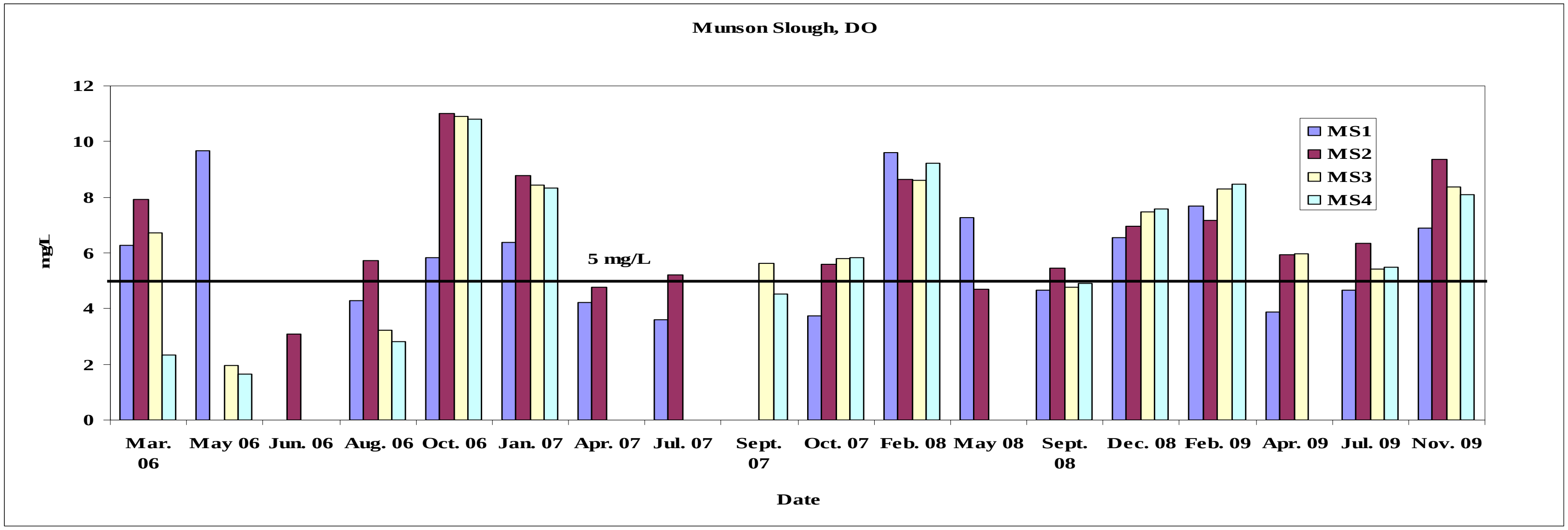


FIG. 8.7-41. Parameter of concern.

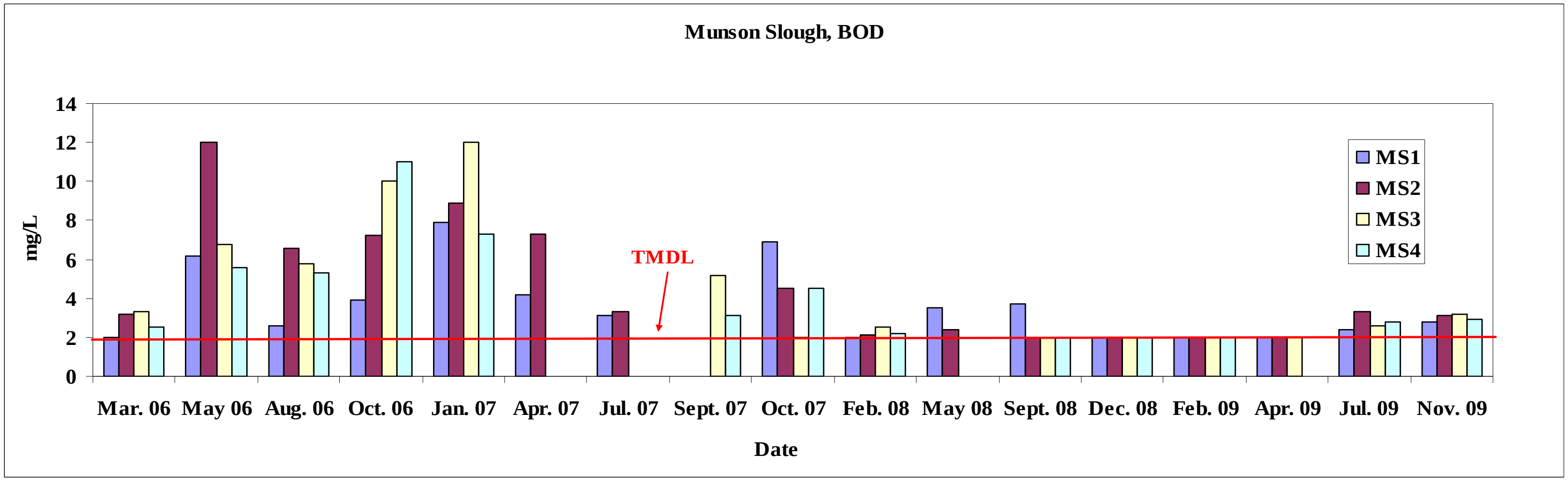


FIG. 8.7-42. Parameter of concern. Red line denotes the TMDL for Munson Slough.

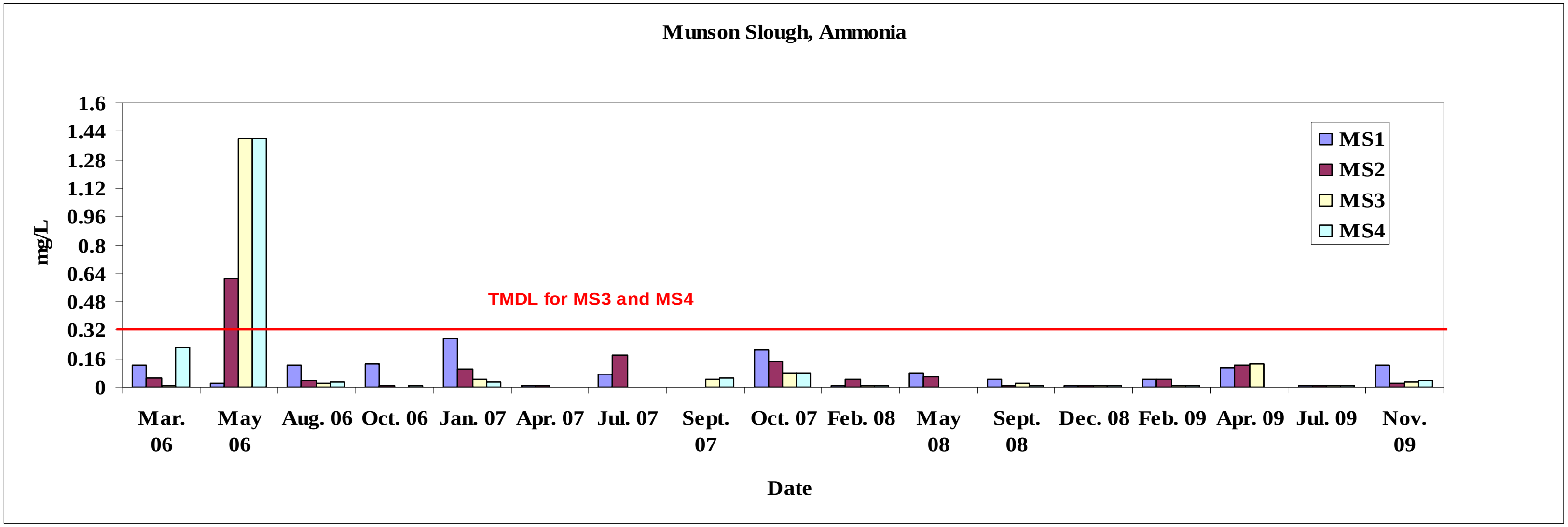


FIG. 8.7-43. Parameter of concern. Red line denotes the TMDL for Munson Slough below Lake Munson (MS3 and MS4).

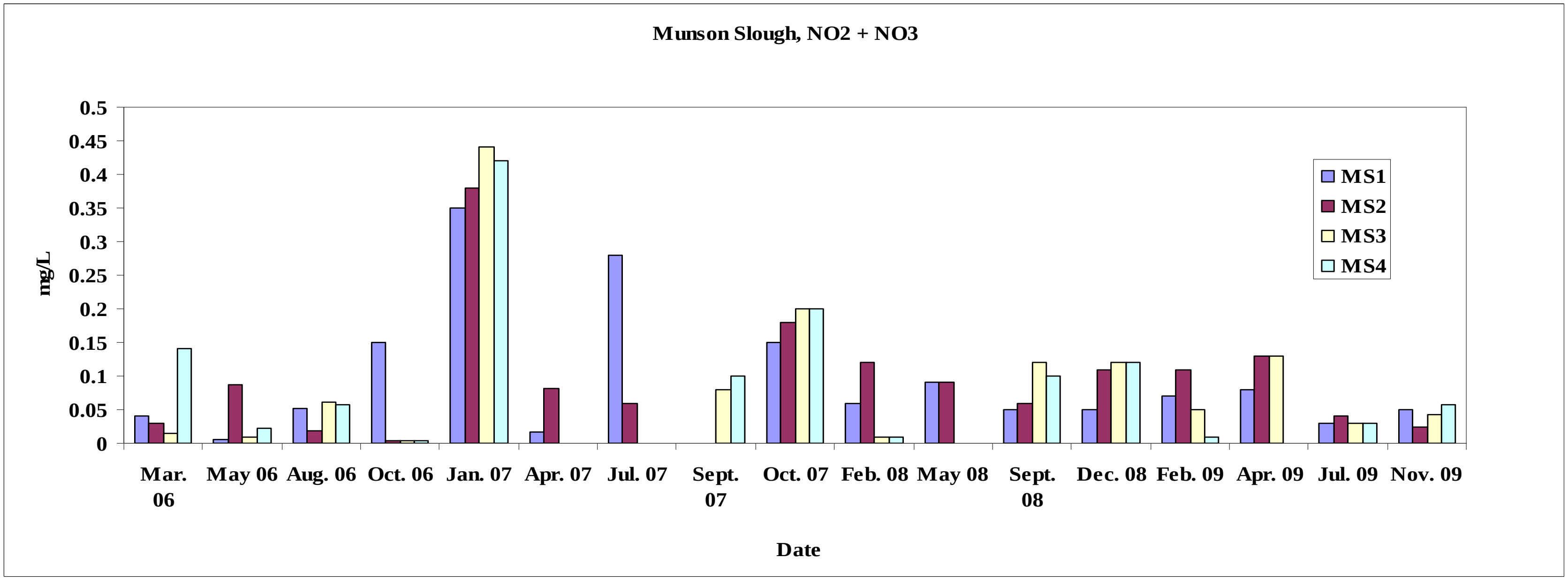


FIG. 8.7-44. Parameter of concern.

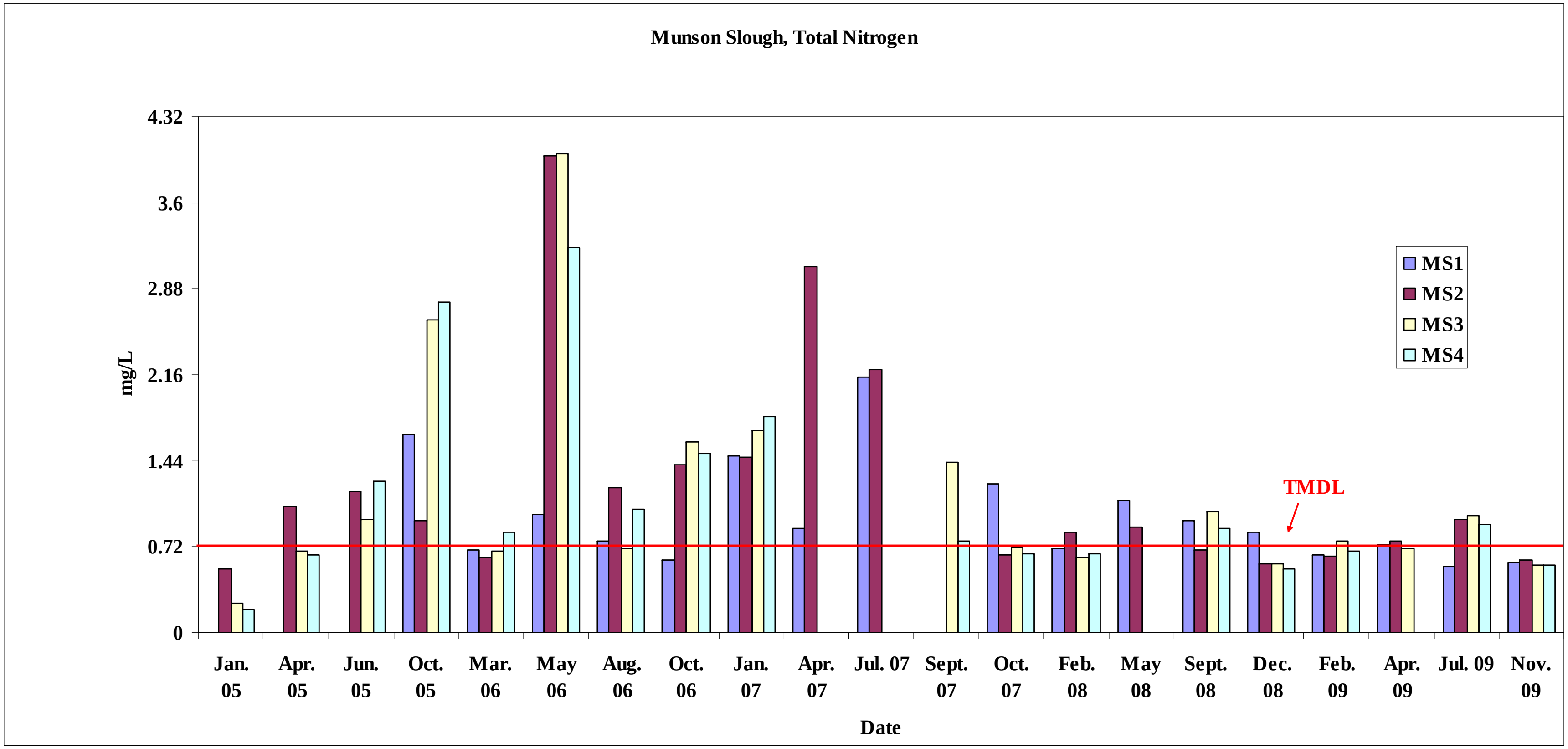


FIG. 8.7-45. Parameter of concern. Red line denotes the proposed TMDL for Munson Slough above Lake Munson (MS1).

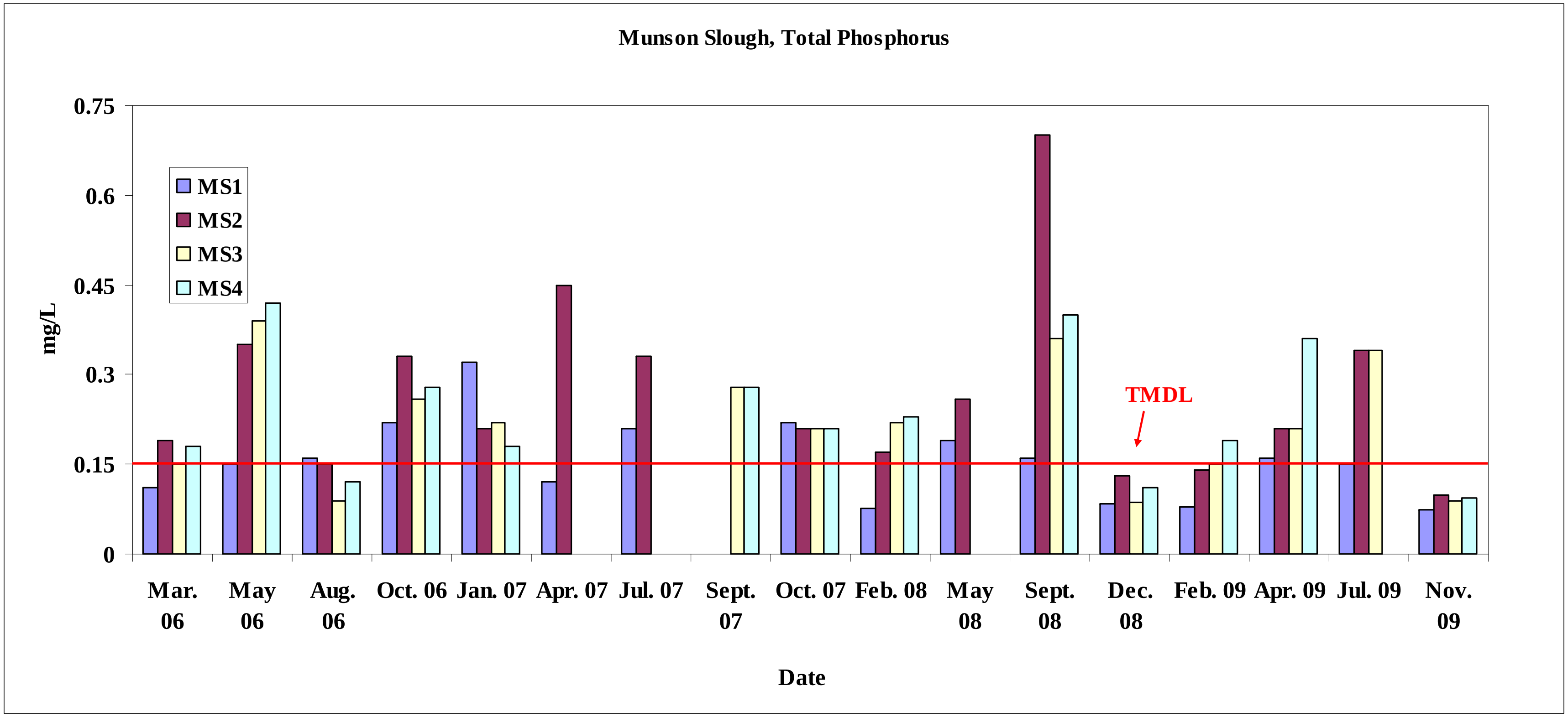


FIG. 8.7-46. Parameter of concern. Red line denotes the proposed TMDL for Munson Slough above Lake Munson (MS1) .

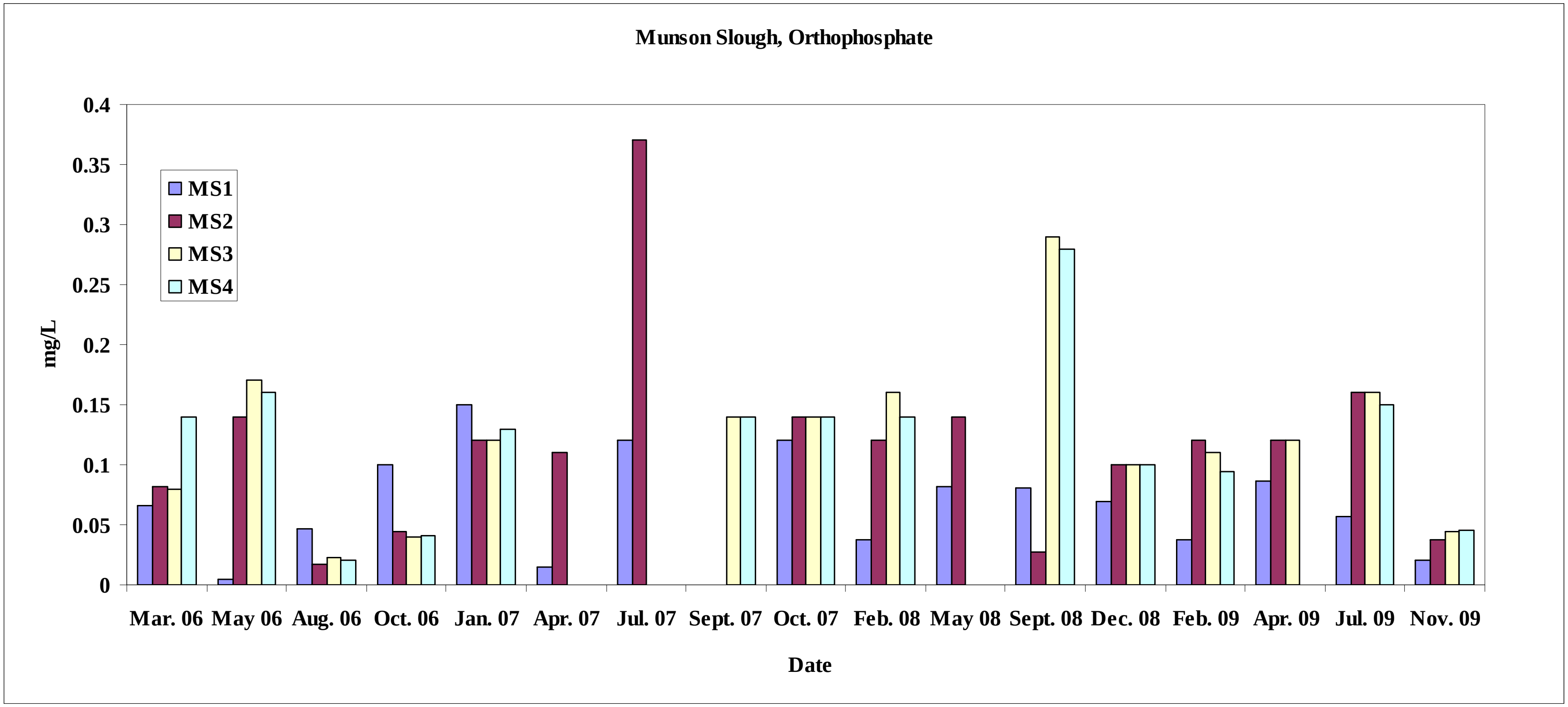


FIG. 8.7-47. Parameter of concern.

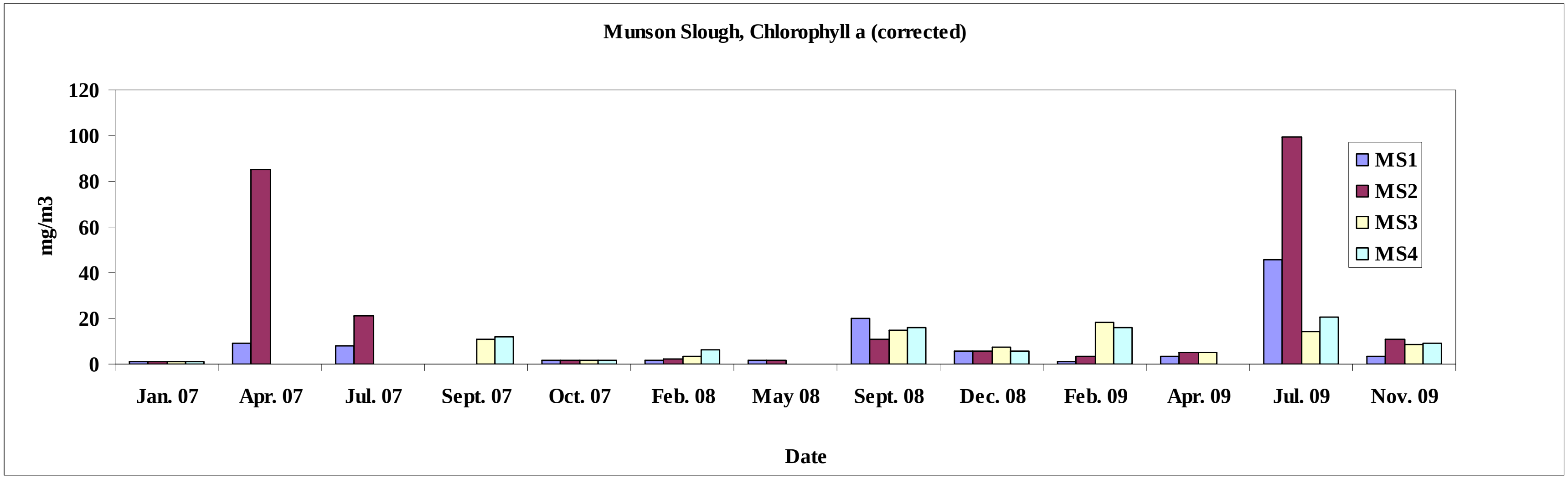


FIG. 8.7-48. Parameter of concern. Chlorophyll *a* samples were only collected at all stations starting in 2007.

Since Munson Slough drains a significant portion of Tallahassee, has been significantly altered over the years, and drains the nutrient-laden Lake Munson, there are obvious reasons why there are elevated nutrients in this system. Urban runoff tends to have high nutrient loads due to fertilizers, lawn clippings, sediments, animal droppings, sewer overflows, etc. While the County and the City of Tallahassee have made great strides in reducing non-point source pollution (various stormwater facilities in the City and County, Munson Slough restoration, etc.), work will need to continue to further improve water quality in this system.

1. Stream Condition Index

The habitat assessment scores for Stations MS1 (78) and MS2 (86) were in the marginal category, while MS4's score (95) was in the suboptimal category. SCI scores for MS1 (9), MS2 (18) and MS4 (30) places all stations in the impaired range **(Table 8.7-2)**.

The Munson Slough Stations have few productive habitats available for macroinvertebrate colonization or refugia, and habitat smothering was a major parameter of concern. Low water velocity, artificial channelization, poor riparian vegetation quality and low buffer width also contributed to low habitat assessment scores that directly affected the SCI scores for both stations. Like Black and Gum Creeks, increased base flow will possibly improve the station habitat scores by increasing DO levels for macroinvertebrates that require more oxygen in the water column. Unfortunately, Munson Slough is a "flashy" system, so there is frequent scouring of habitats and macroinvertebrates due to extreme water velocities (> 1 meter/second). In addition, regular maintenance provided by the County removes possible sources of habitat (i.e. snags that fall into the water) and disturbs the stream bed, adding to the instability of the habitat.

Table 8.7-2. SCI and Habitat Assessment scores and interpretation.

Munson Slough	**MS 1 Dup 1**	**MS 1 Dup 2**	**MS 2 Dup 1**	**MS 2 Dup 2**	**MS 4 Dup 1**	**MS 4 Dup 2**
SCI Metric						
Total Taxa	23	28	11	16	15	18
Ephemeroptera Taxa	0	2	0	0	0	0
Trichoptera Taxa	0	0	2	2	2	1
% Filterer	0	0.35	14.7	11.65	69.7	69.2
Long-lived Taxa	0	0	1	0	0	0
Clinger Taxa	0	1	3	3	3	3
% Dominance	61.4	52.3	54	63.3	68.3	64.8
% Tanytarsini	0	0	12.7	10	68.3	64.8
Sensitive Taxa	1	0	0	0	0	0
% Very Tolerant Taxa	11.3	10.7	59.3	68	13.8	17.6
Total SCI Score	**6.31**	**11.99**	**19.82**	**16.10**	**30.34**	**28.73**
Average of two aliquots	**9**		**18**		**30**	
Score Interpretation	**Impaired**		**Impaired**		**Impaired**	
Habitat Assessment Score	**78**		**86**		**95**	
Score Interpretation	**Marginal**		**Sub Optimal**		**Sub Optimal**	

2. Habitat Smothering

A stream's equilibrium and stability are controlled by sediment load and hydrology. Since stream channels are dynamic systems, they are constantly adjusting in an attempt to maintain equilibrium with their flow regime and surroundings. Urbanization of a watershed can contribute large volumes of sediment to stream channels during storm events and can exceed the stream's finite capacity to transport the excess sediment. When the transport capacity is exceeded, sediment begins to accumulate in the channel, filling pools and covering up existing habitat. In response to the increased load of sediment, the stream channel will become straighter, and the banks will become more incised. Urbanization also contributes to the volume of runoff during storm events due to the increase of impervious surfaces. The additional sediment to the system increases the erosion of the stream bed and banks and further degrades the habitat for the local biotic population. In Munson Slough, habitat smothering due to high sediment loads has significantly degraded the habitat. In order to improve the biological integrity of the system, storm event runoff must be controlled so that peak flows are significantly reduced (volume control), and proper BMP practices should be utilized during construction to prevent the initial sediment loads from entering the streams.

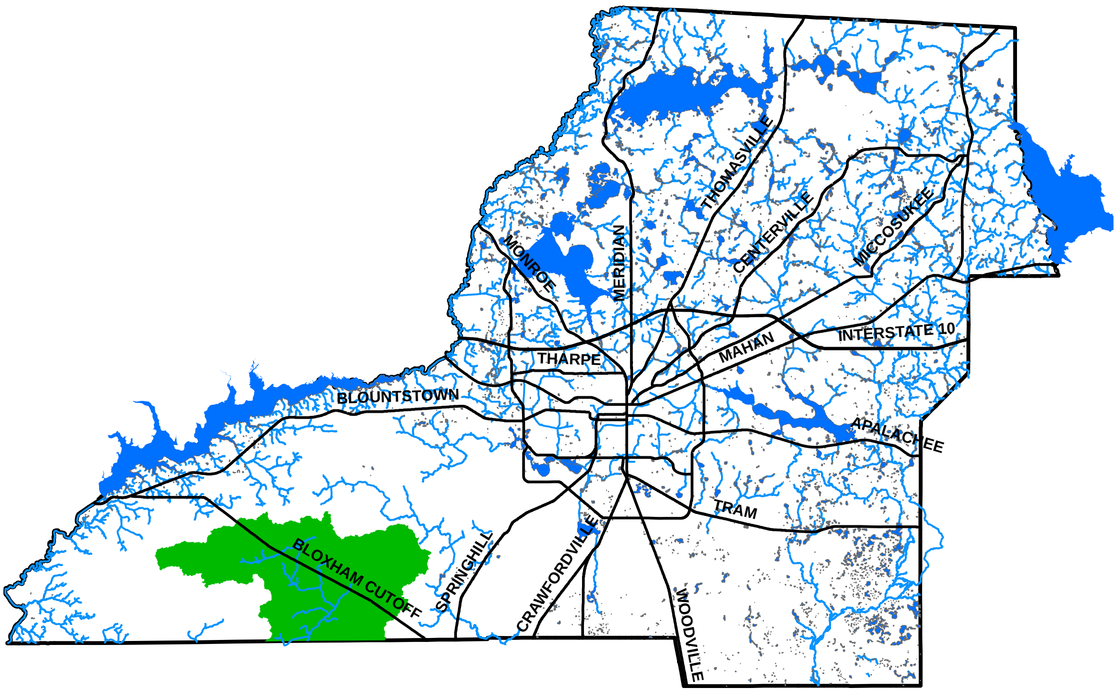
3. Low Flow

Munson Slough, and other Leon County streams, have been seriously affected by the residual effects of drought. The low water levels could have also been exacerbated by urbanization. Impervious surfaces diminish groundwater recharge, so water is flushed away downstream instead of resupplying the groundwater table. This flushing of water increases the severity of flood events while decreasing the base flow of urban streams by "starving" the stream of its groundwater recharge. This has serious implications for habitat quality.

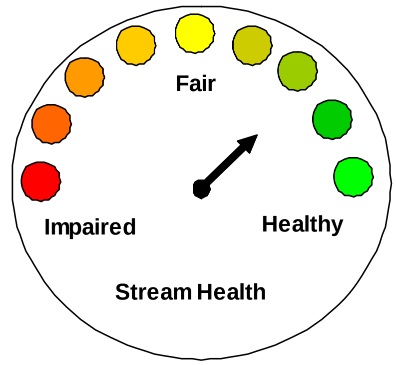
4. Habitat Quality

Historically, stormwater managers feel that any impediment to stream flow in an urban stream is considered detrimental to the stream's supposed function, which is to move water from one point to another. While this practice undoubtedly arose from public concerns about flooding, the practice can lead to the complete removal of biotic habitat from the stream, as well as contributing to the further destabilization of the stream's bank and stream bed. A compromise can be reached to allow habitat substrate to accumulate in certain areas of a stream or purposely create areas of habitat in a specific area of the stream, thus promoting increased biota richness and allowing the stream to function more naturally.

8.8. Lost Creek Basin



1. Lost Creek



Lost Creek is a tannic, acidic, phosphorus-limited stream located in southwest Leon County **(Figure 8.8-1)**.

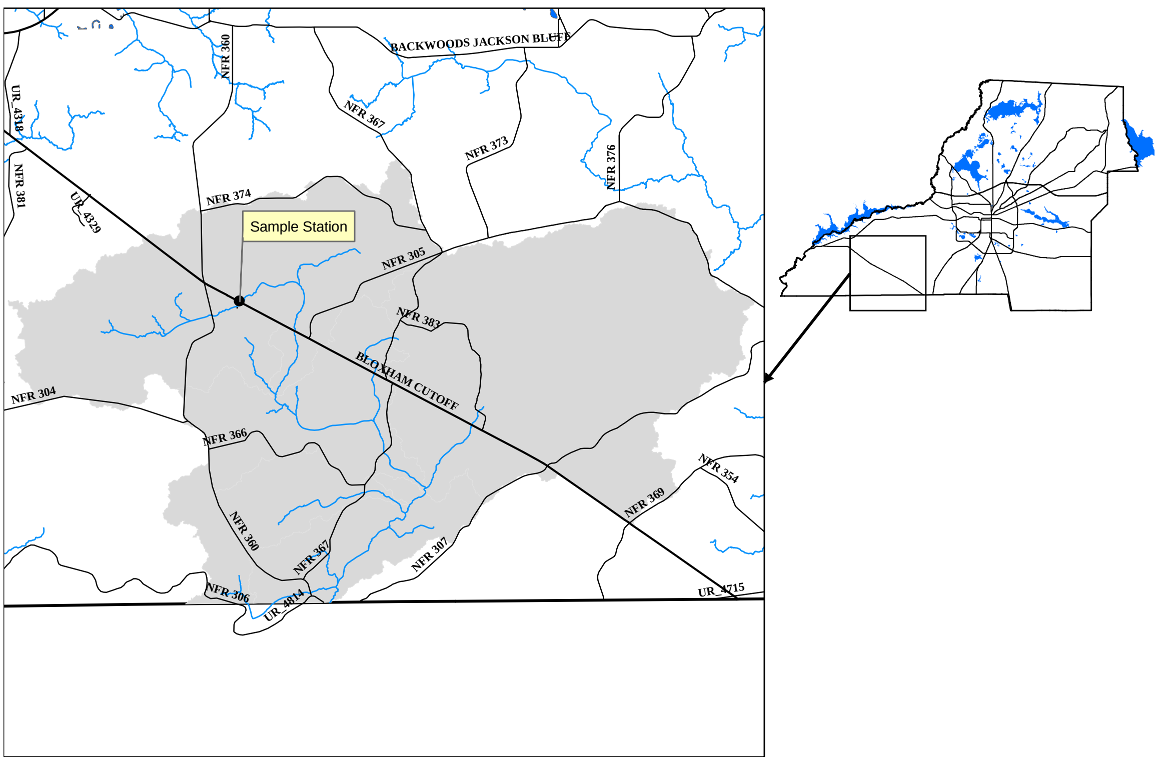


FIG. 8.8-1. Overview Map of Lost Creek watershed (33,682 acres).

Figure 8.8-2 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Transportation uses make up approximately 1% of the watershed.

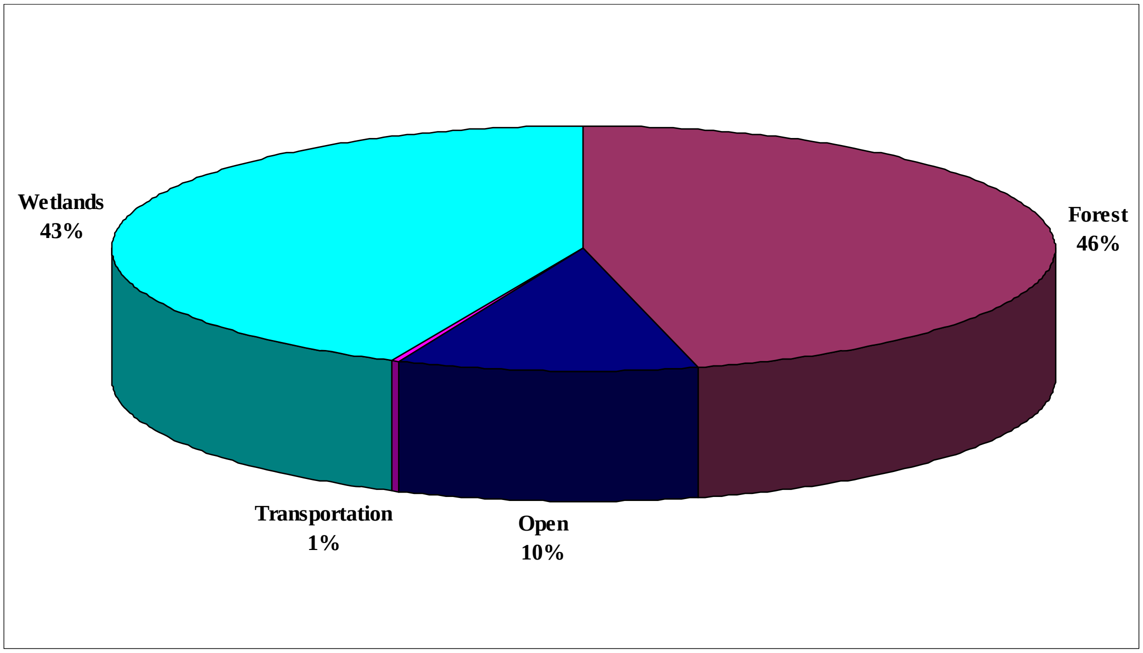


FIG. 8.8-2. Land use in the Lost Creek watershed.

Total phosphorus, TKN and nitrite + nitrate, BOD and fecal coliform values in 2009 were relatively low compared to other Florida streams. Dissolved oxygen values were below the 5 mg/L Class III water quality standard during several sampling dates **(Figure 8.8-3)**. Low gradient, darkwater, wetland-fed streams such as Lost Creek typically have low DO levels, so this is probably a natural occurrence.

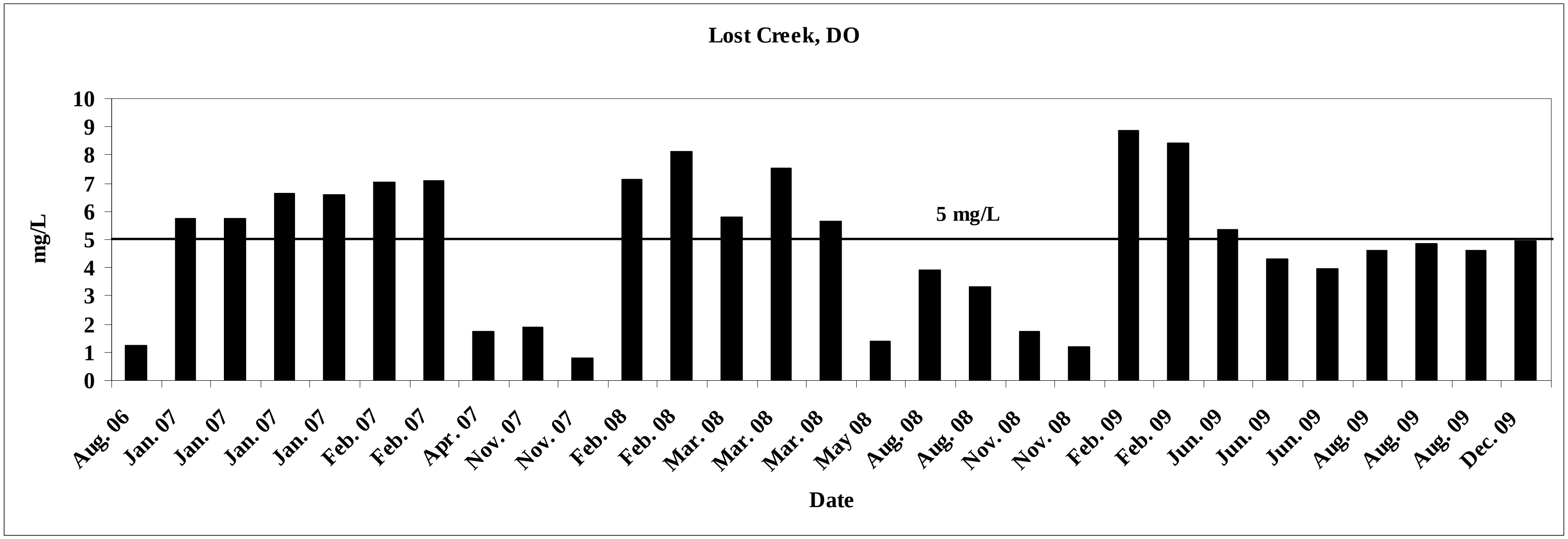
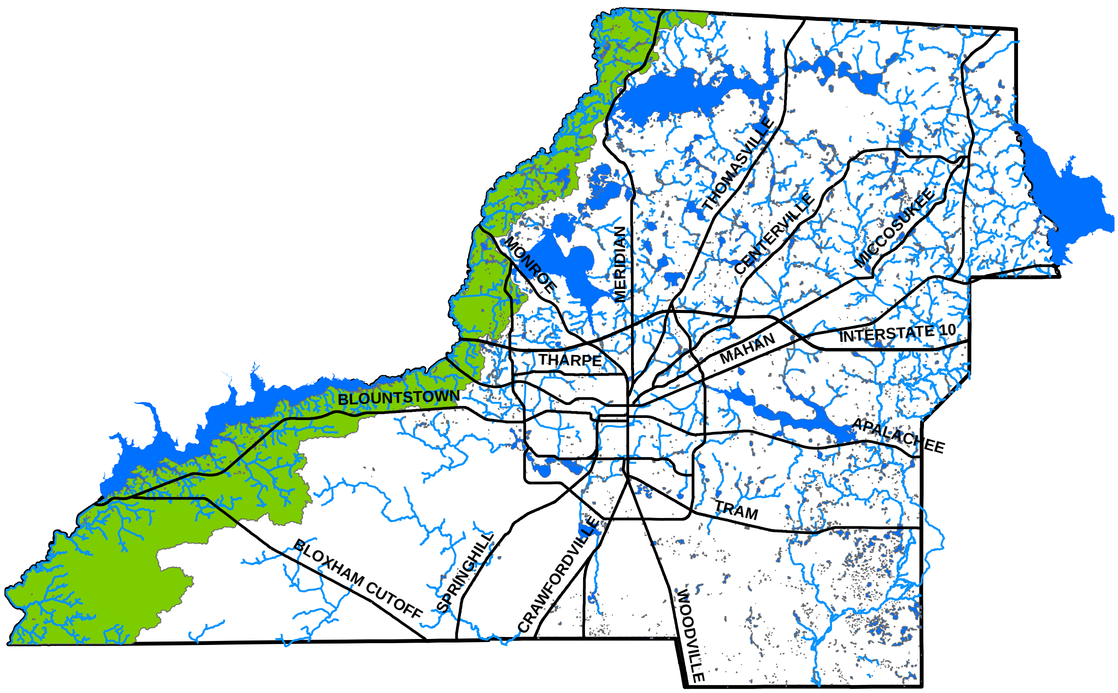
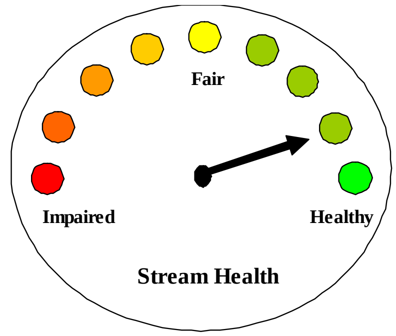


FIG. 8.8-3. Parameter of concern.

8.9. Ochlockonee River Basin



A. Freeman Creek



Freeman Creek is a minimally disturbed, phosphorus-limited stream located in southwest Leon County in the Ft. Braden community **(Figure 8.9-1)**. The stream flows south to north eventually flowing into Lake Talquin.

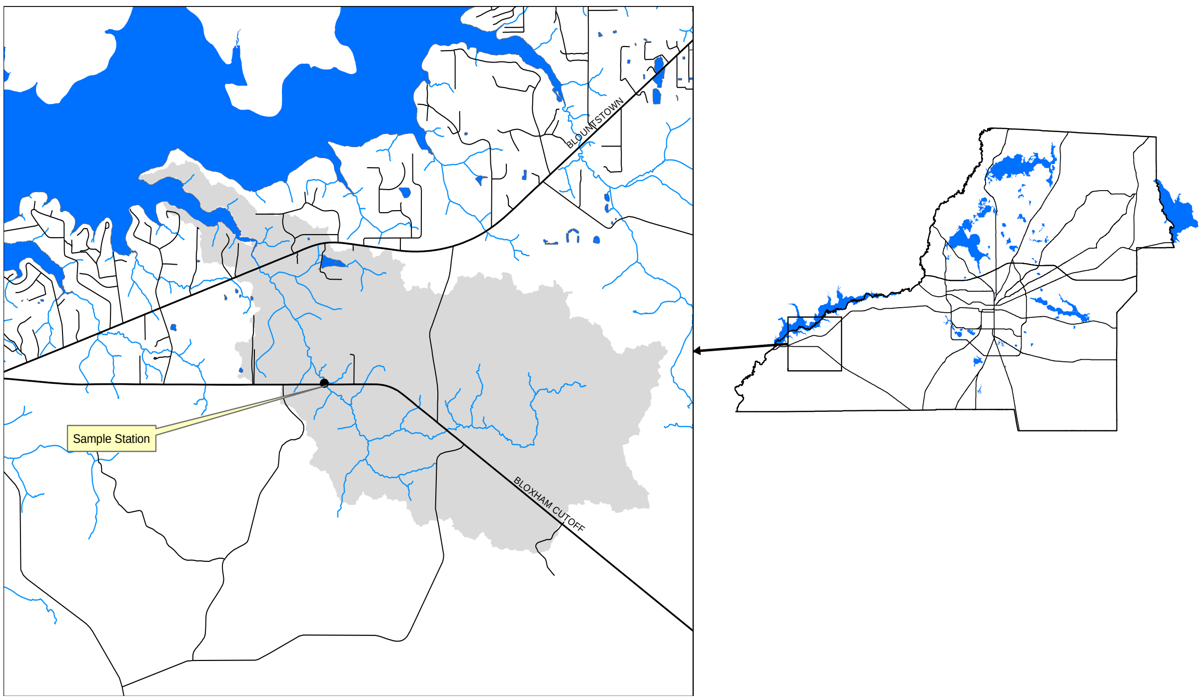


FIG. 8.9-1. Overview Map of Freeman Creek Watershed (574 acres).

As shown in **Figure 8.9-2**, approximately 16% of land use in the Freeman Creek watershed is residential, agriculture or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

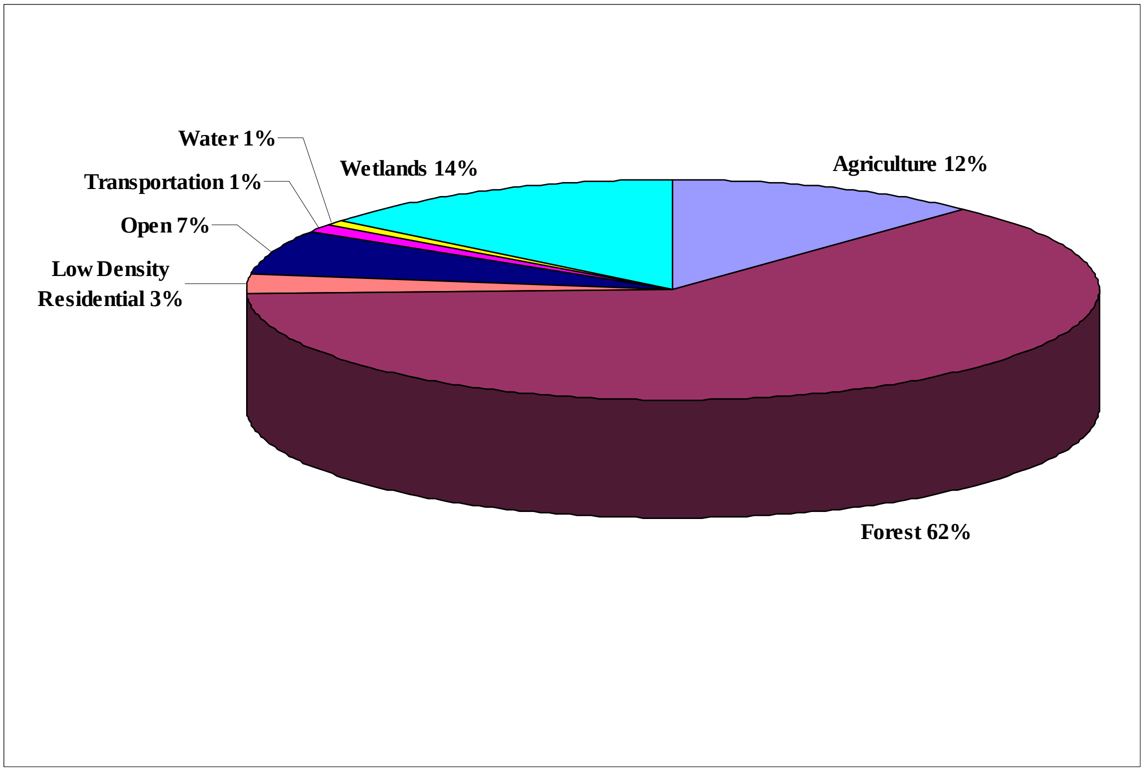


FIG. 8.9-2. Land use in the Freeman Creek watershed.

Total phosphorus and nitrite + nitrate levels were close to or below detection limits while TKN levels for Freeman Creek were also consistently low over the sampling period when compared to other Florida streams. However fecal coliform levels were high, at times surpassing the Class III water quality standard daily limit **(Figure 8.9-3)**. Since the watershed is relatively undeveloped, the high fecal levels could be the result of wildlife in the area. Further testing is recommended to determine possible sources of fecal contamination. TKN and color were elevated during the August 2008 sampling event, undoubtedly due to surface runoff attributed to Tropical Storm Fay **(Figures 8.9-4 – 8.9-5)**. Increased color in 2009 was attributed to increased tannin laden surface runoff into the stream caused by the return of relatively normal rainfall patterns. The habitat assessment score total for Freeman Creek (133) was in the optimal category; while the SCI score (45) was in the healthy range **(Table 8.9-1)**. Overall, Freeman Creek is a healthy system.

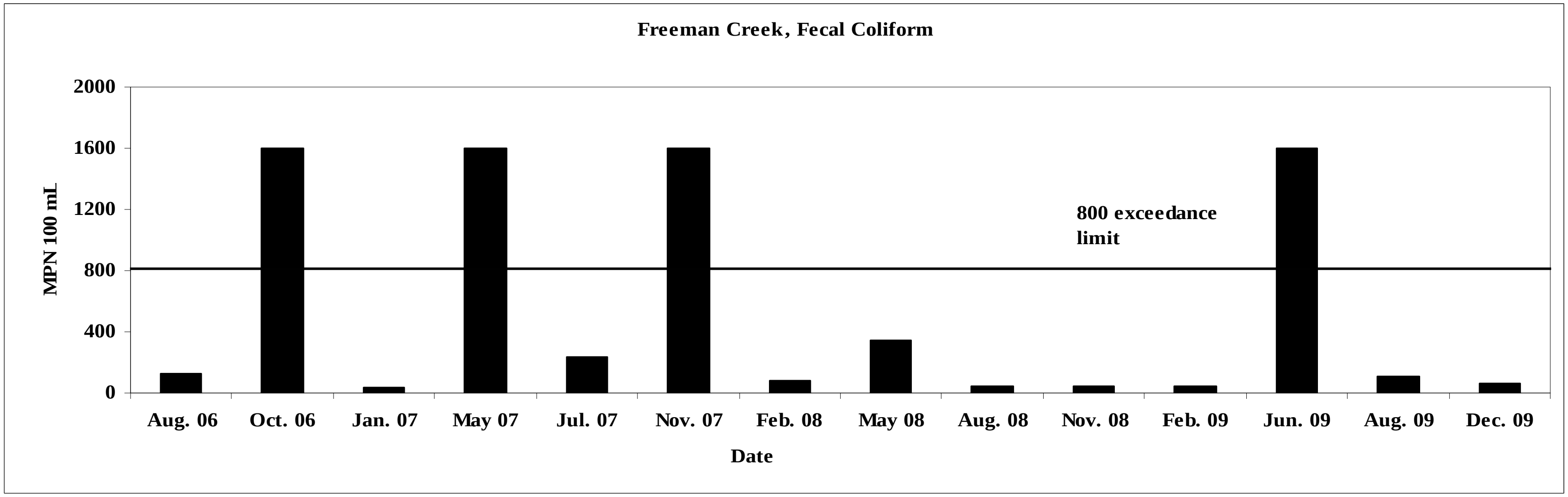


FIG. 8.9-3. Parameter of concern.

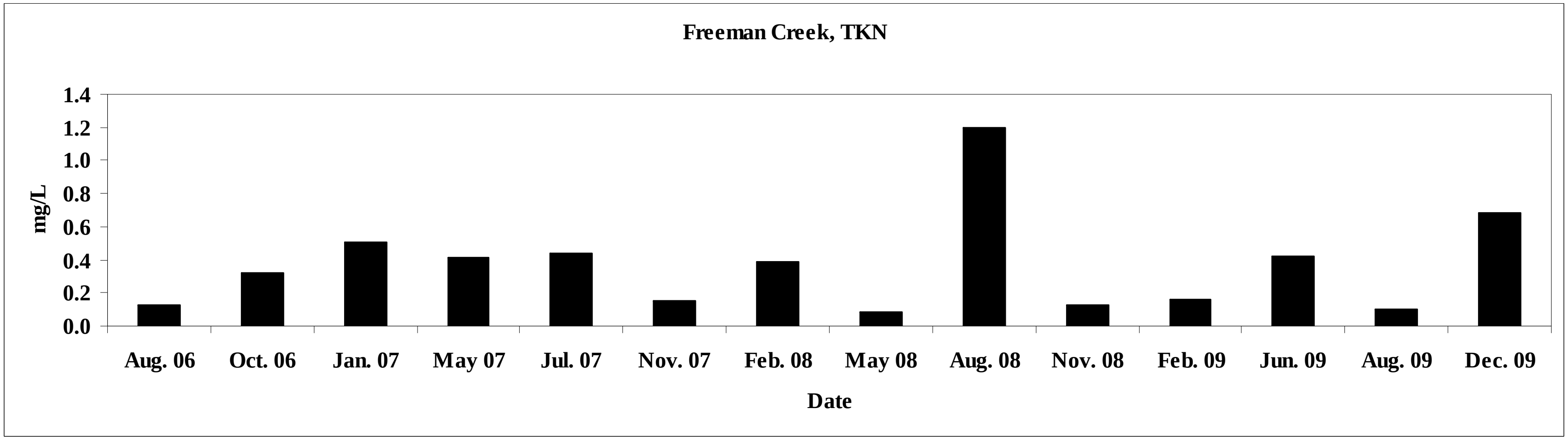


FIG. 8.9-4. Parameter of interest.

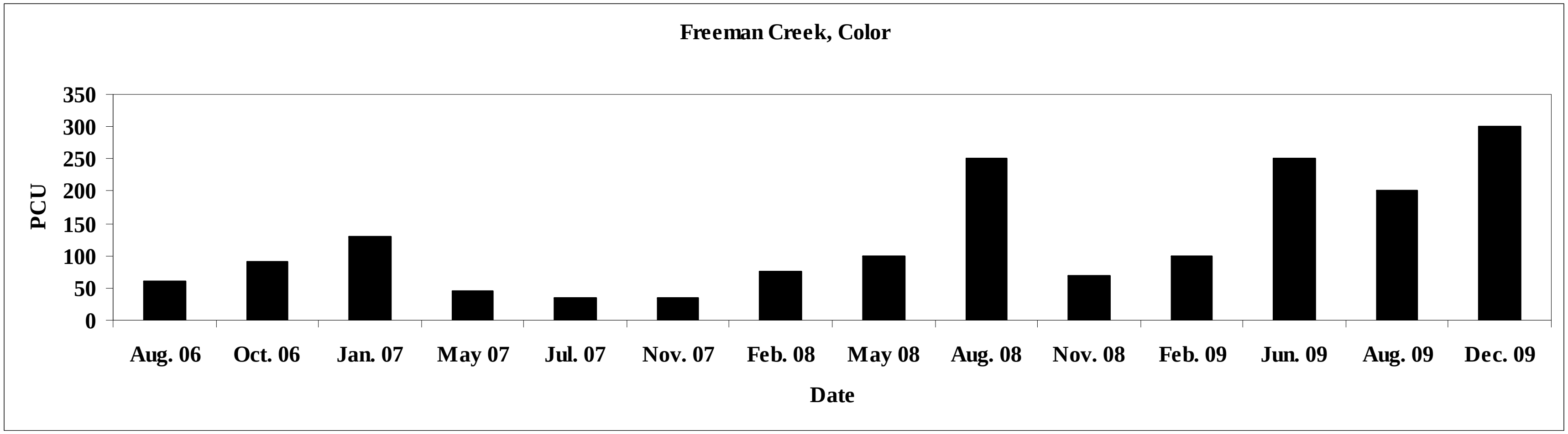
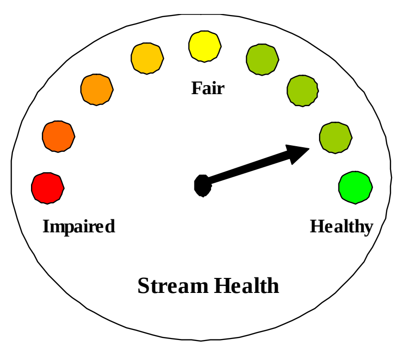


FIG. 8.9-5. Parameter of interest.

TABLE 8.9-1. SCI and Habitat Assessment score and interpretation.

Freeman Creek @ 267	**Dup 1 2009**	**Dup 2 2009**
SCI Metric		
Total Taxa	33	33
Ephemeroptera Taxa	1	1
Trichoptera Taxa	3	1
% Filterer	2.85	3.4
Long-lived Taxa	2	5
Clinger Taxa	5	4
% Dominance	19.4	18
% Tanytarsini	2.5	5.4
Sensitive Taxa	8	8
% Very Tolerant Taxa	7.6	5.4
Total SCI Score	**42**	**48**
Average of two aliquots	**45**	
Score Interpretation	**Healthy**	
Habitat Assessment Score	**133**	
Score Interpretation	**Optimal**	

B. Harvey Creek



Harvey Creek is a tannic, slightly acidic, phosphorus-limited stream that flows into Lake Talquin and is located off of Hwy 20 in western Leon County **(Figure 8.9-6)**.

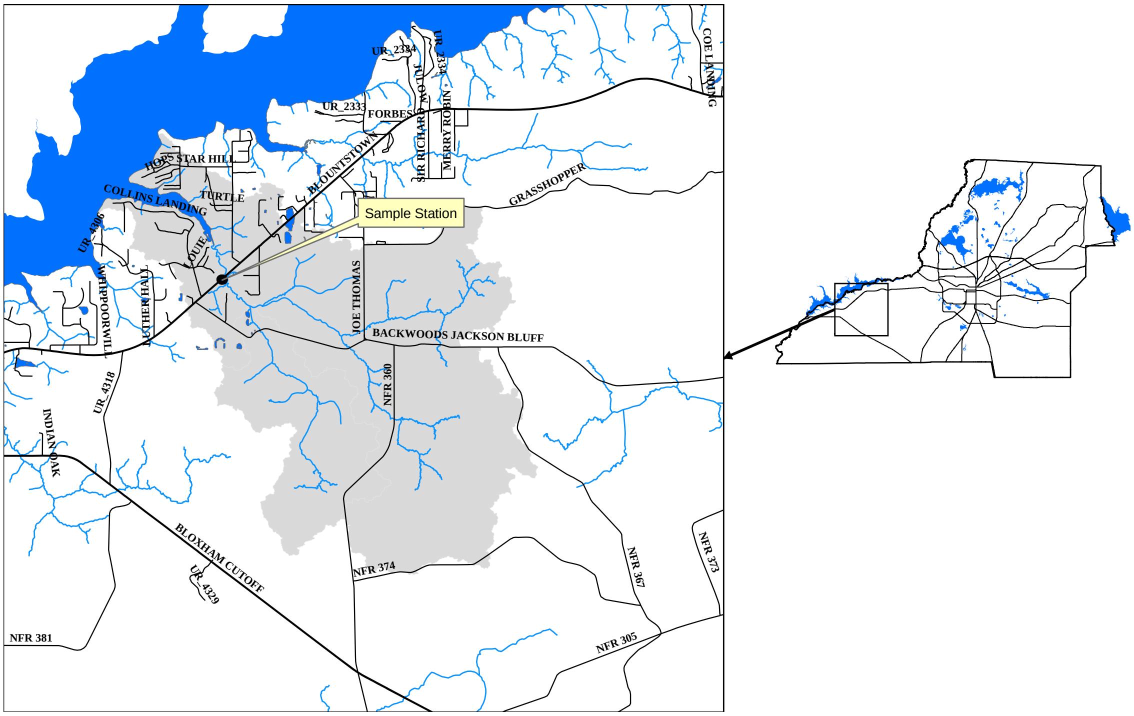


FIG. 8.9-6. Overview Map of Harvey Creek watershed.

Figure 8.9-7 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Residential, agricultural, and transportation uses make up approximately 12% of the watershed.

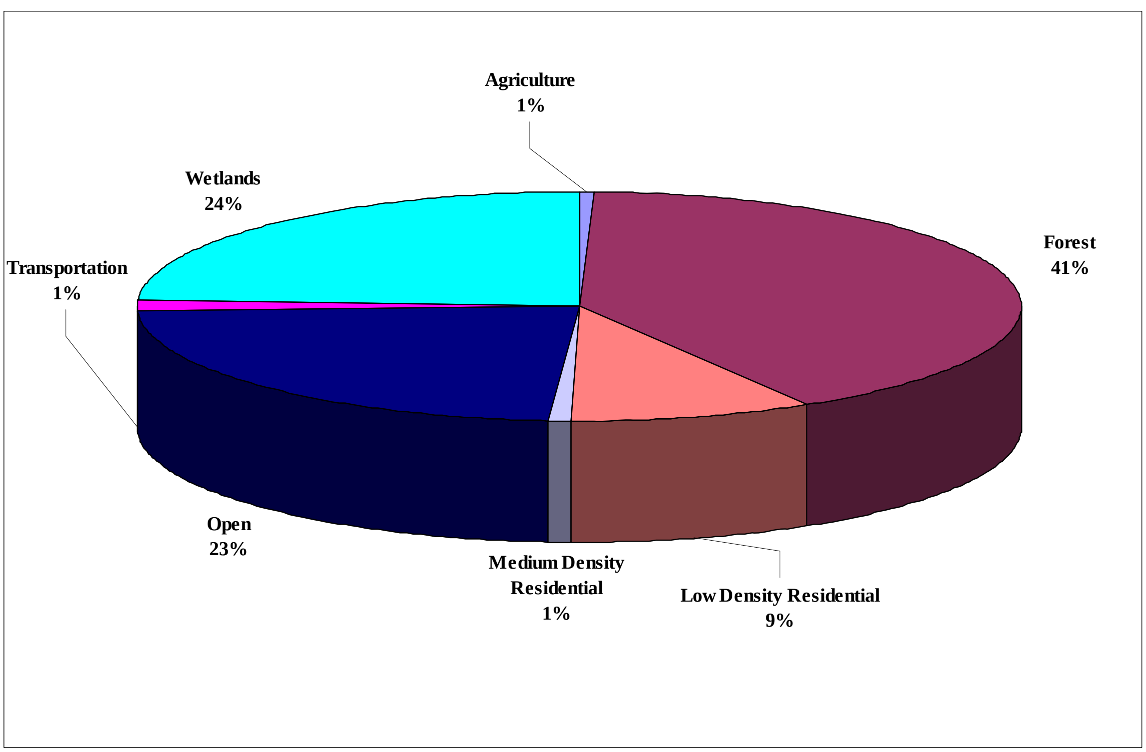


FIG. 8.9-7. Land use in the Harvey Creek watershed (5,679 acres).

Nutrients were very low in Harvey Creek. Total phosphorus concentrations were undetectable (<5 µg/L) or not quantifiable over the course of the sampling program. TKN and nitrite + nitrate values were relatively low compared to other Florida streams (at or below the 30^{th} percentile concentrations). Dissolved oxygen values were above the 5 mg/L Class III water quality standard during all sampling dates.

While still elevated, fecal coliform bacteria values in 2009 did not exceed the FDEP Class III maximum daily value of 800 MPN **(Figure 8.9-8)**. It is still unknown why past values were elevated. Since the watershed is relatively undeveloped, past elevated fecal levels could be the result of wildlife in the area. Further testing is recommended to determine possible sources of fecal contamination.

The habitat assessment score total for Harvey Creek (126) was in the optimal category and the SCI score (61) was in the healthy range **(Table 8.9-2)**.

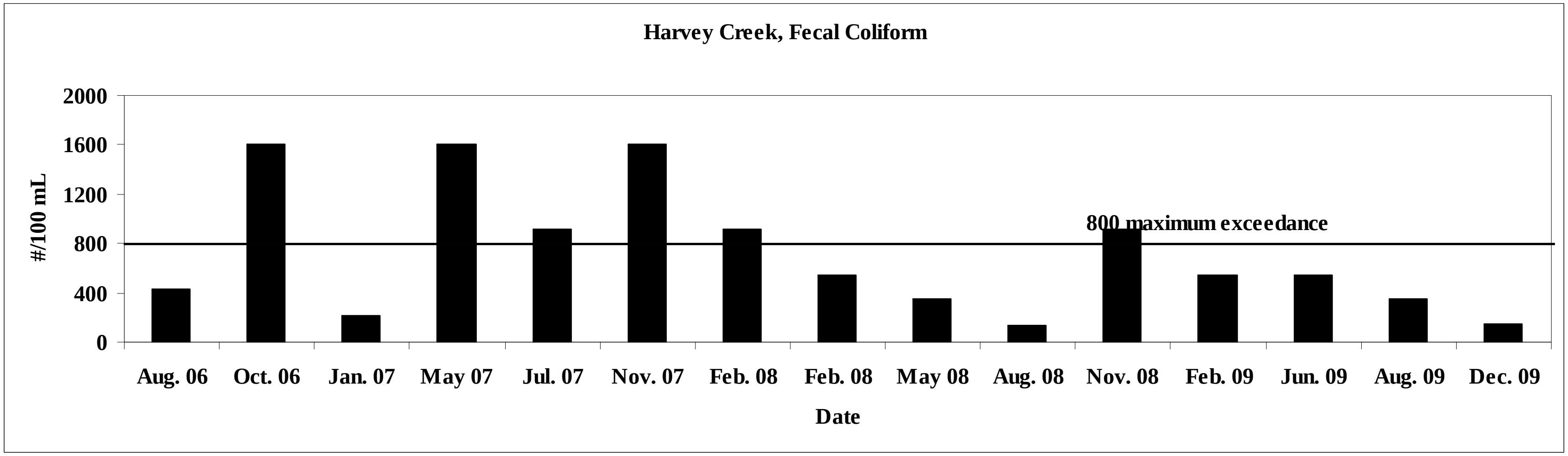
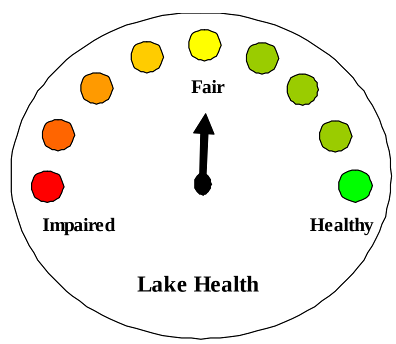


FIG. 8.9-8. Parameter of concern.

TABLE 8.9-2. SCI and Habitat Assessment scores and interpretation.

Harvey Creek @ 20	**Dup 1 2009**	**Dup 2 2009**
SCI Metric		
Total Taxa	44	50
Ephemeroptera Taxa	0	0
Trichoptera Taxa	4	4
% Filterer	15.8	10.35
Long-lived Taxa	1	4
Clinger Taxa	7	7
% Dominance	16.3	12.7
% Tanytarsini	23.9	14.7
Sensitive Taxa	9	12
% Very Tolerant Taxa	4.9	6.7
Total SCI Score	**57.43**	**65.03**
Average of two aliquots	**61**	
Score Interpretation	**Healthy**	
Habitat Assessment Score	**126**	
Score Interpretation	**Optimal**	

C. Lake Talquin



The 6,963 acre Lake Talquin **(Figure 8.9-9)** is considered an Outstanding Florida Water by FDEP and is located in western Leon County with part of its basin extending into surrounding Florida counties as well as southern Georgia. Lake Talquin State Park is along the southern shoreline of the lake and was acquired as a donation to the state from Florida Power Corporation.

The lake was formed in 1929 when the Jackson Bluff Dam was constructed on the Ochlockonee River to produce hydroelectric power. The dam, built and managed by the West Florida Power Company (later to become Florida Power Corporation) operated the facility until 1970, when it was abandoned as a power plant and turned over to the Florida

Department of Natural Resources (later to become Florida Department of Environmental Protection) who managed the dam, without producing power until 1981. The City of Tallahassee then took over the dam, refurbishing the dam and power plant and reinstalled generators. In August 1985, the plant became operational as the C. H. Corn Hydroelectric Power Generating Plant (City of Tallahassee, 2008).

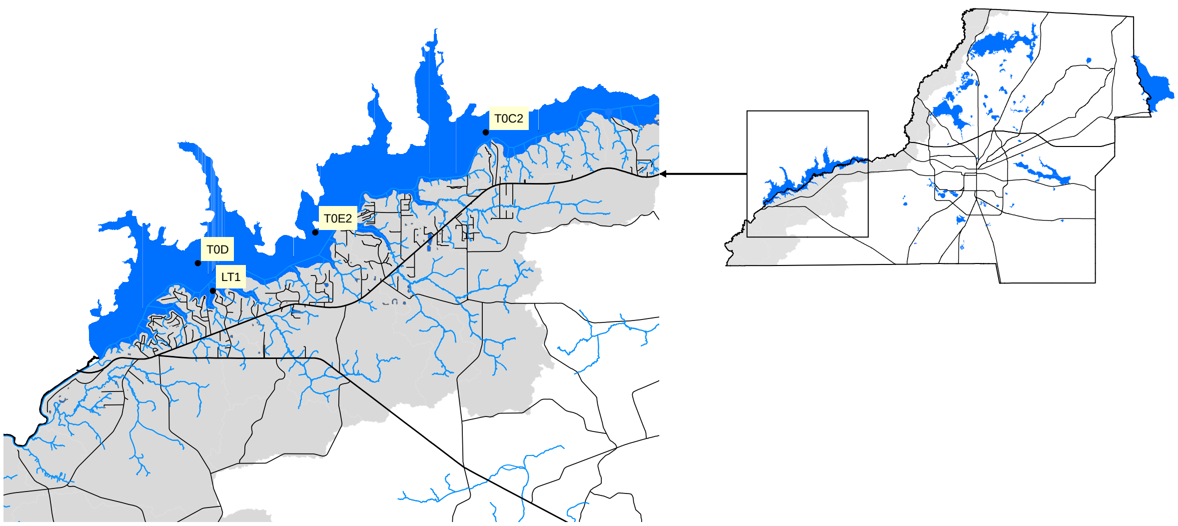


FIG. 8.9-9. Overview map of Lake Talquin basin and current (2009) water quality sampling stations.

Figures **8.9-10** and **8.9-11** represents Lake Talquin's trophic state utilizing the FDEP Trophic State Index (TSI). The annual TSI value was calculated averaging all stations and their seasonal TSI. Yearly averages show that Lake Talquin did not exceed the threshold at which FDEP considers a waterbody impaired (60 TSI), while seasonal averages show three exceedances slightly above the 60 TSI threshold.

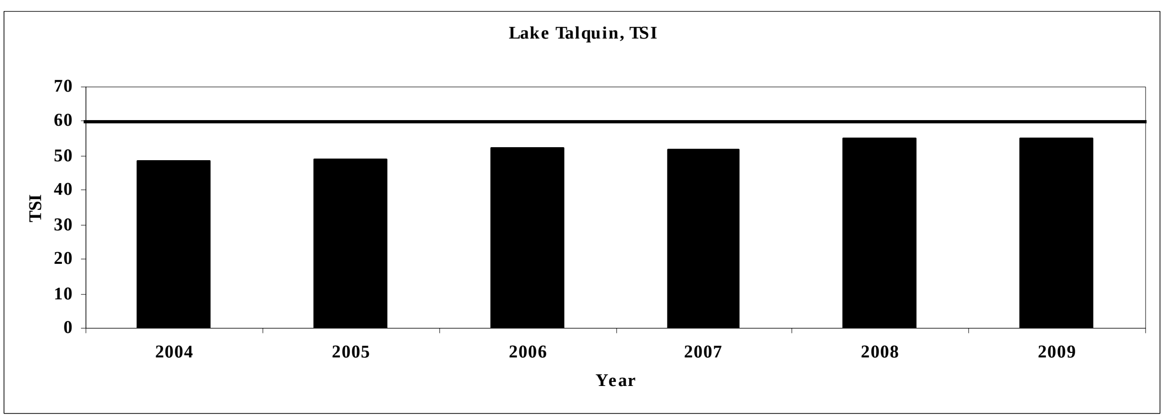


FIG. 8.9-10. Lake Talquin trophic state index (yearly average). Bars exceeding a TSI of 60 would indicate impairment.

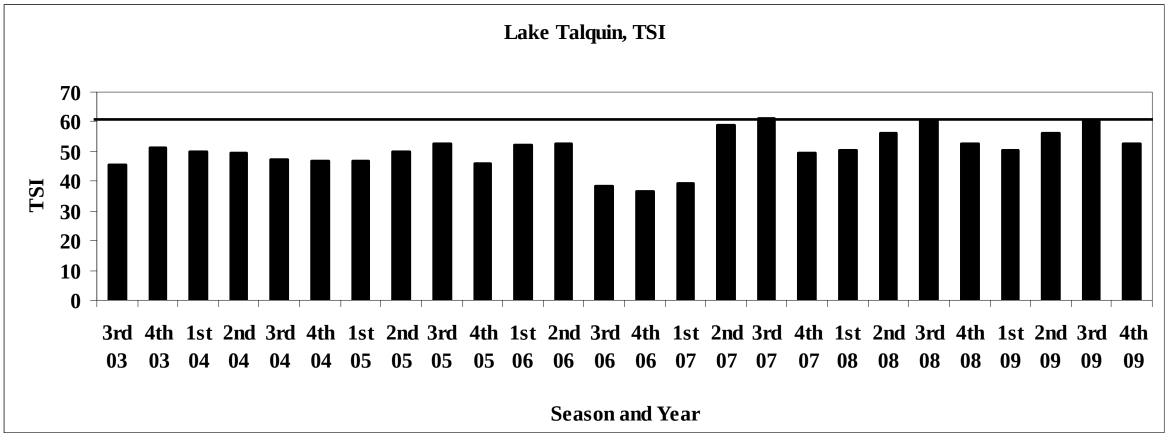


FIG. 8.9-11. Lake Talquin trophic state index (seasonal average). Bars exceeding a TSI of 60 indicate impairment.

Mean (based on seasonal values) total nitrogen (0.69 mg/L), total phosphorus (0.08 mg/L) and total corrected chlorophyll *a* (11.76 µg/L) suggest Lake Talquin is a eutrophic lake. There does appear to be an increase in the amounts of total nitrogen detected in Lake Talquin in the latter part of 2004 through the 4th quarter of 2009 **(Figure 8.9-12)**. Total phosphorus decreased through the 2nd quarter of 2003 and has remained generally steady through the end of 2009 **(Figure 8.9-13)**. Chlorophyll *a* levels were extremely elevated during the 3rd quarter of 2008, but do not show any definite trends **(Figure 8.9-14)**.

Dissolved oxygen levels failed in several instances to meet Class III water quality standards **(Figure 8.9-15)**. Several values were not used from the early 2002 period, due to unreasonable values, probably the result of transcription errors. Fecal coliforms at one sampling station exceeded the Class III water quality standard daily limit for the February and August 2009 sampling event.

Elevated algal levels in a lake (as evidenced by elevated chlorophyll *a* levels) can contribute to violations of the DO standard by bacterial decay of algal cells that settle to the lake bottom and by algal respiration exceeding algal photosynthetic oxygen production below the photic zone. These conditions are exacerbated during warm, stagnant conditions when the lake can become thermally stratified thereby reducing oxygenation of bottom waters through mixing with surface waters (Gallagher, 2007). This appears to be occurring in Lake Talquin.

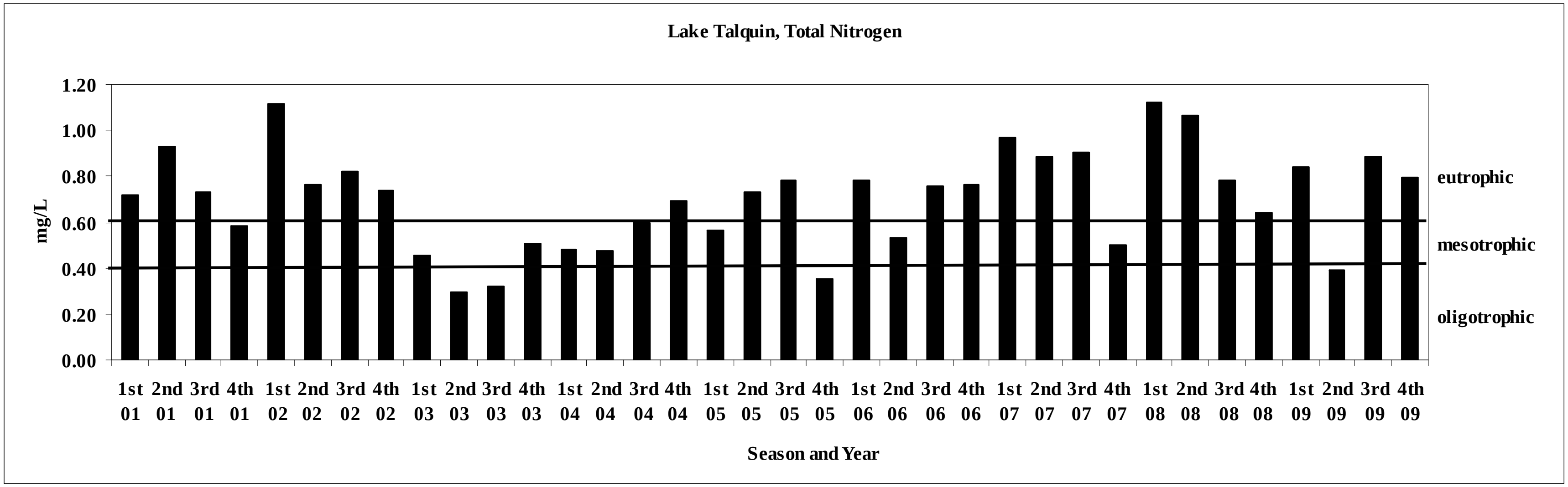


FIG. 8.9-12. Parameter of concern.

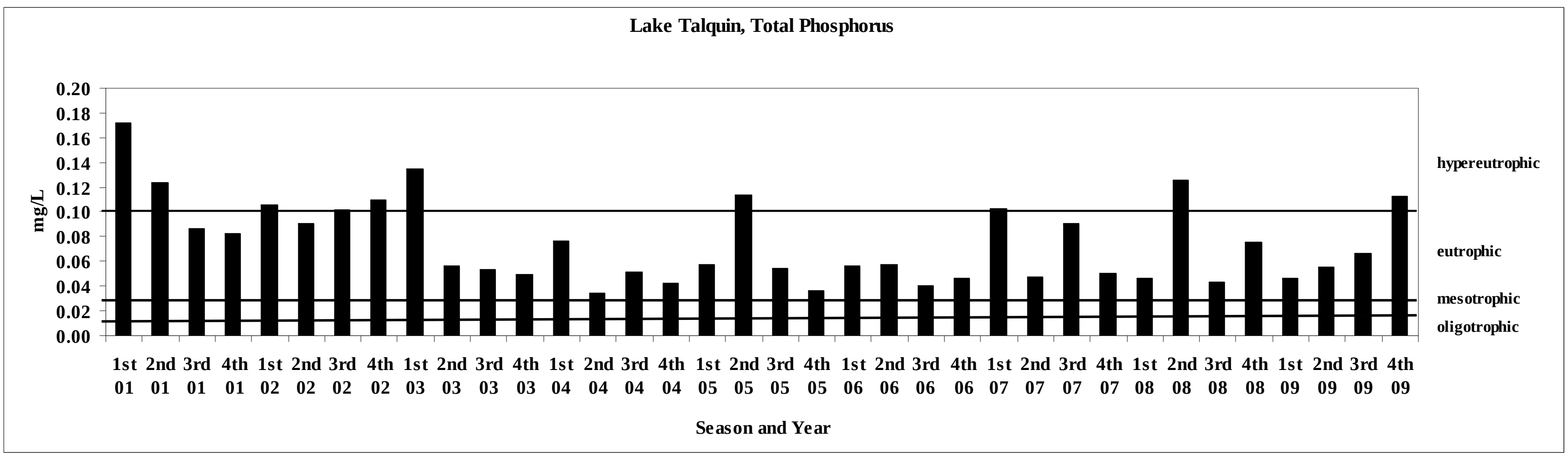


FIG. 8.9-13. Parameter of concern.

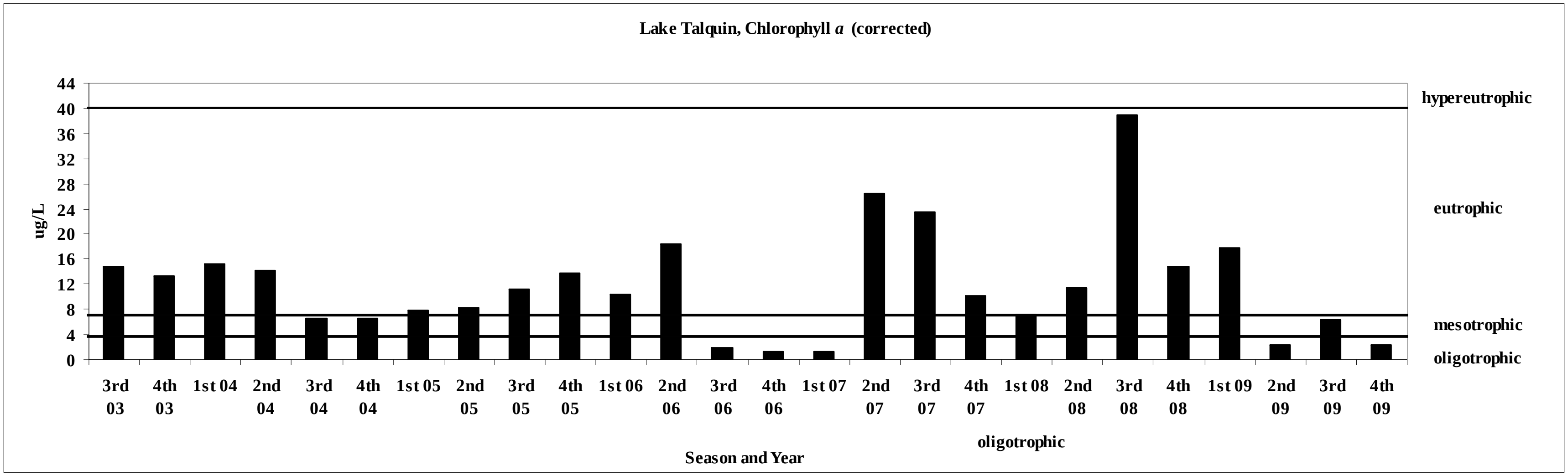


FIG. 8.9-14. Parameter of concern. Each bar represents the seasonal average.

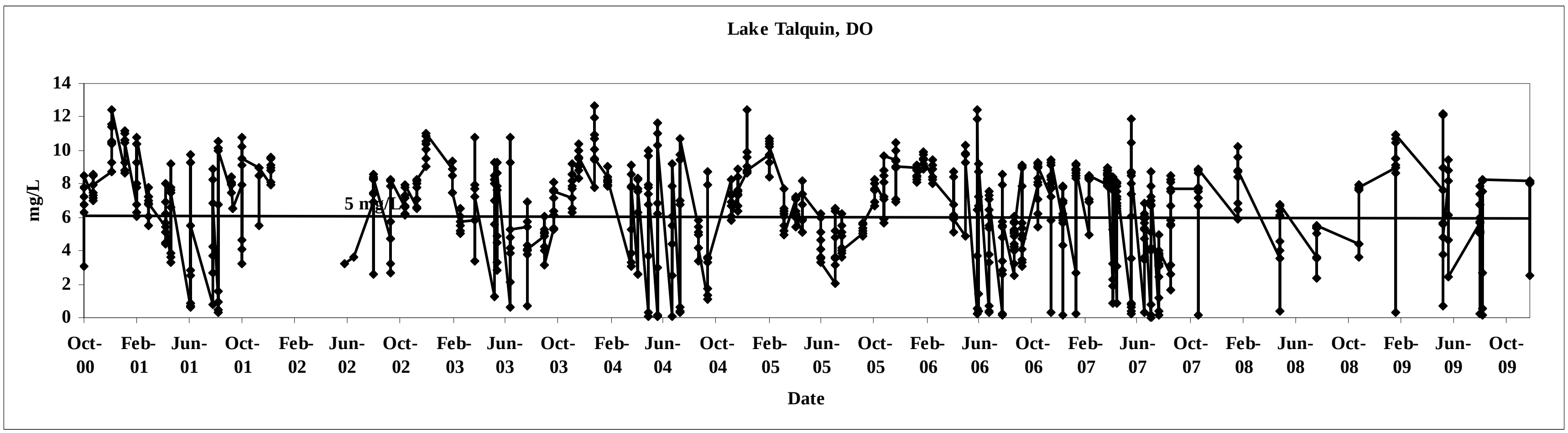
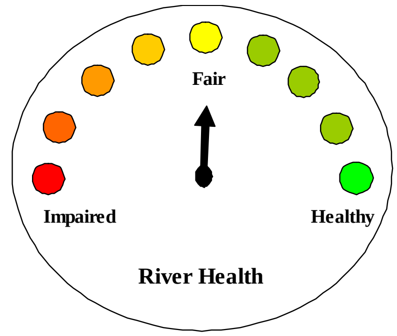


FIG. 8.9-15. Parameter of concern. Markers represent individual measurements. Starting in June 2006, top, mid-depth, and bottom DO measurements were taken where appropriate

D. Ochlockonee River



The Ochlockonee River originates in south-central Georgia and flows about 206 miles south to Ochlockonee Bay, draining about 2,400 square miles and all or part of eleven counties in both states (NWFWMD, 2006) **(Figure 8.9-16)**. The river is impounded by the Jackson Bluff Dam forming Lake Talquin.

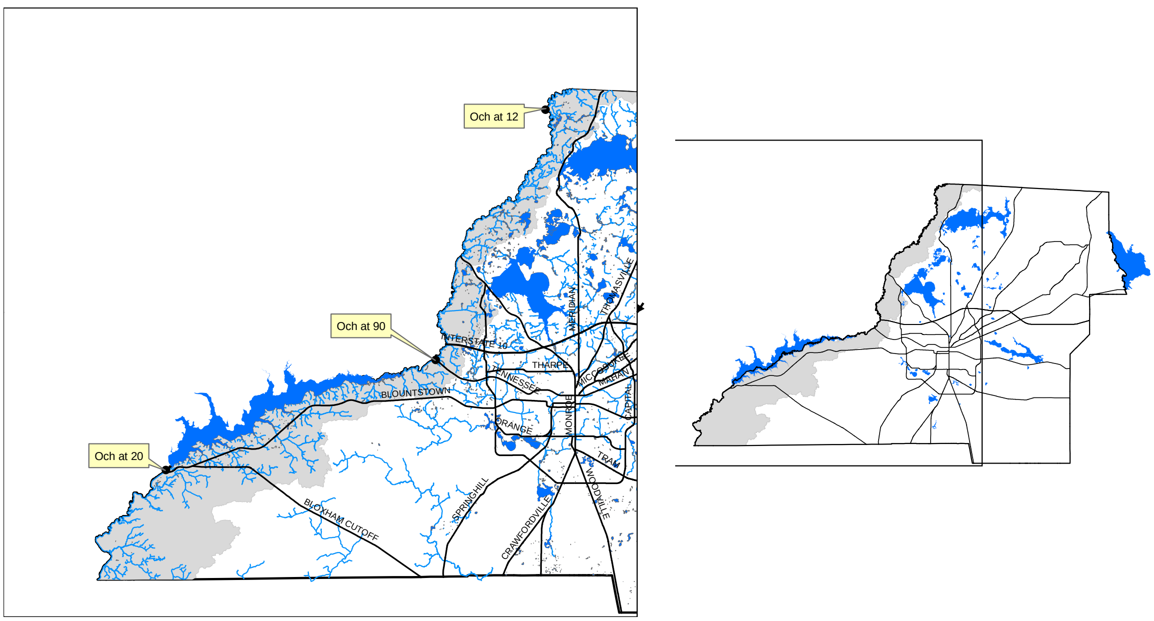


FIG. 8.9-16. Overview Map of the Ochlockonee River Basin and sampling stations.

The river has been declared an Outstanding Florida Water by FDEP, has been identified as an Integrated Wildlife Habitat (formerly known as a Strategic Habitat Conservation Area) by the Florida Fish and Wildlife Conservation Commission, and parts of the Ochlockonee have been designated critical habitat for mussels by the U. S. Fish and Wildlife Service (F.A.C. 62-302, 2006, and Federal Register, 2007). Unfortunately, past agricultural and silvicultural practices, as well as point source problems, have led to increased turbidity, higher nutrient concentrations, bacterial problems and increased sedimentation to the river. While relatively recent water quality data suggest that the river's water quality appears to be improving, in the latter part of 2006 and throughout the first part of 2008, total nitrogen and phosphorus levels increased over 2003- mid 2006 levels **(Figures 8.9-17 and 8.9-18)**. This is most readily apparent at the northernmost station, located on S.R. 12. This is potentially the result of decreased amounts of water flowing down the river during that period vs. a relative constant level of nutrients. In the case of phosphorus, levels during the 3rd quarter of 2007 rose to levels that were higher than 80% of the streams/rivers in Florida **(Figure 8.9-18)**. In the case of nitrite + nitrate, average levels at the northernmost station at S.R. 12 during the 2006-2008 years were higher than 90% of sampled streams/rivers in Florida **(Figure 8.9-19)**. Nutrients appear to be slightly decreasing in 2009, possibly due to the return of relatively normal rainfall patterns to the region.

As shown by **Figures 8.9-17** and **8.9-18**, nutrient levels are highest at the northernmost station and tend to decrease as the water heads south. This is the result of assimilation of the nutrients by biological and possible denitrification processes as the water flows downstream. Elevated chlorophyll *a* levels **(Figure 8.9-20)** at the sampling station south of the Jackson Bluff Dam also show that nutrients are being utilized by algae that were recently flushed out of Lake Talquin. Chlorophyll *a* levels at the aforementioned station were elevated for a riverine system (higher than 80% of measured streams in Florida). Since the station is relatively close to the dam, it is assumed that the majority of the algal population (that chlorophyll *a* indirectly measures) is being flushed out of Lake Talquin and levels would not normally be so elevated in the river.

Dissolved oxygen levels occasionally did not meet Class III water quality standards at all stations **(Figures 8.9-21 - 8.9-23)**, while the Fairbanks Ferry station fecal coliform levels (920/100 mL) exceeded Class III water quality standards during the August 2009 sampling event.

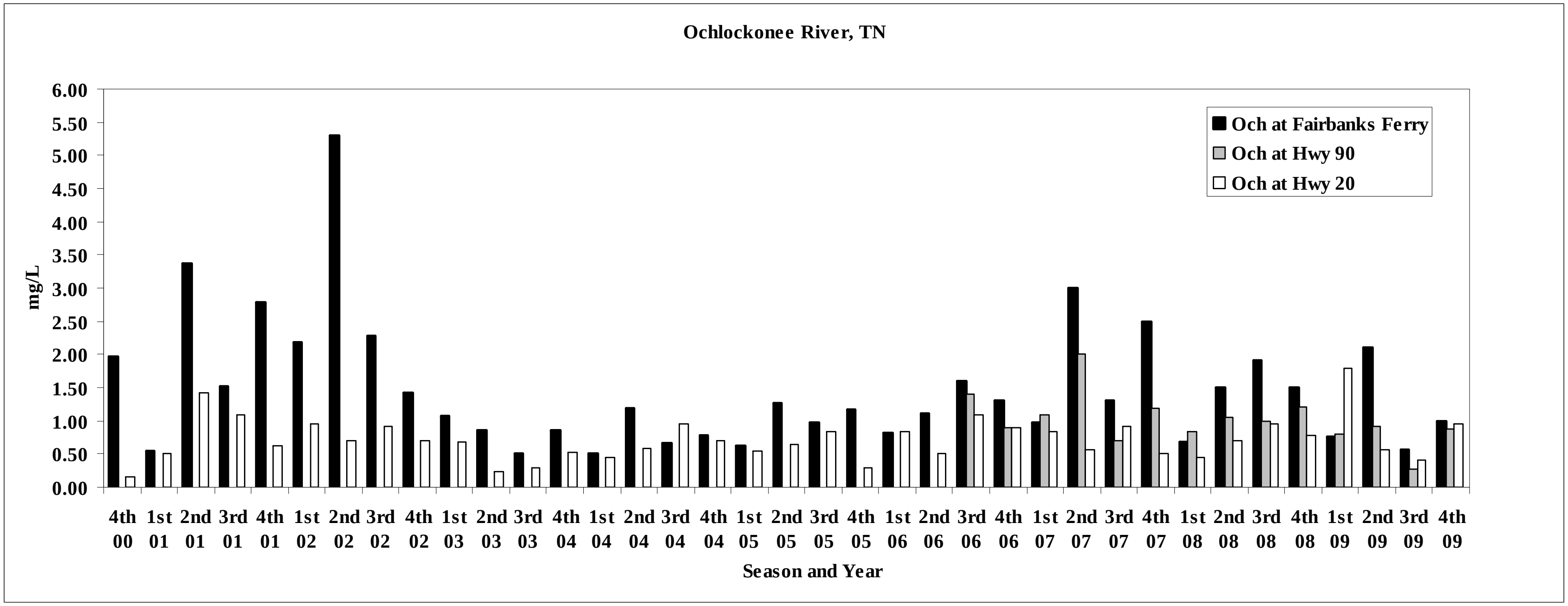


FIG. 8.9-17. Parameter of concern. Bars represent the seasonal average. The "Och at Hwy 90" station was added in the 3rd quarter of 2006.

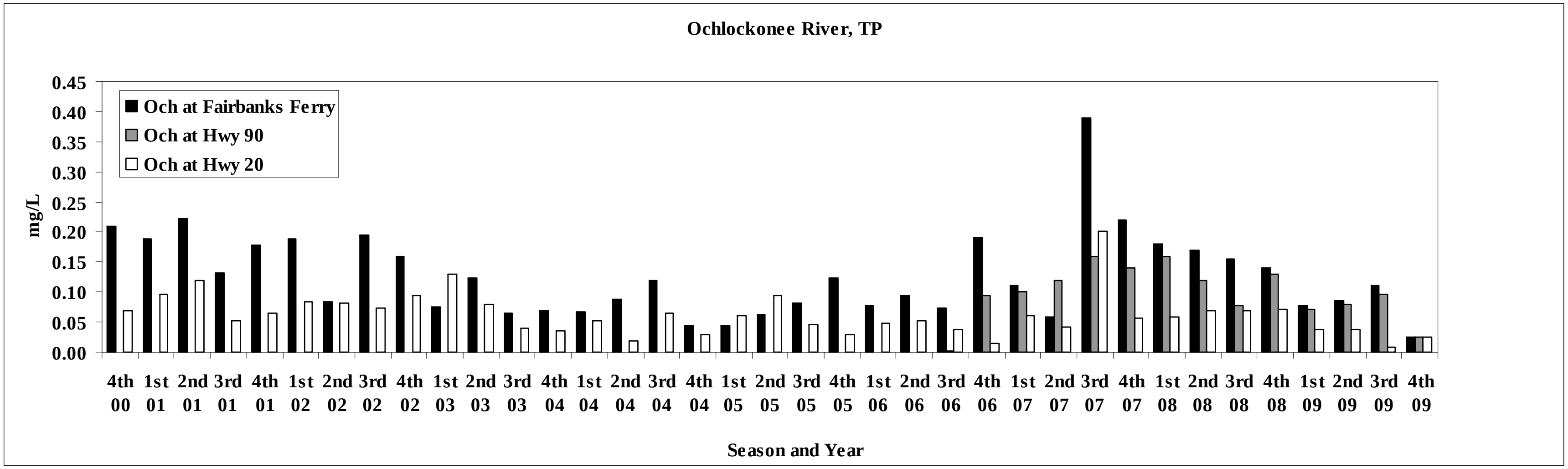


FIG. 8.9-18. Parameter of concern. Bars represent the seasonal average. The "Och at Hwy 90" station was added in the 3rd quarter of 2006.

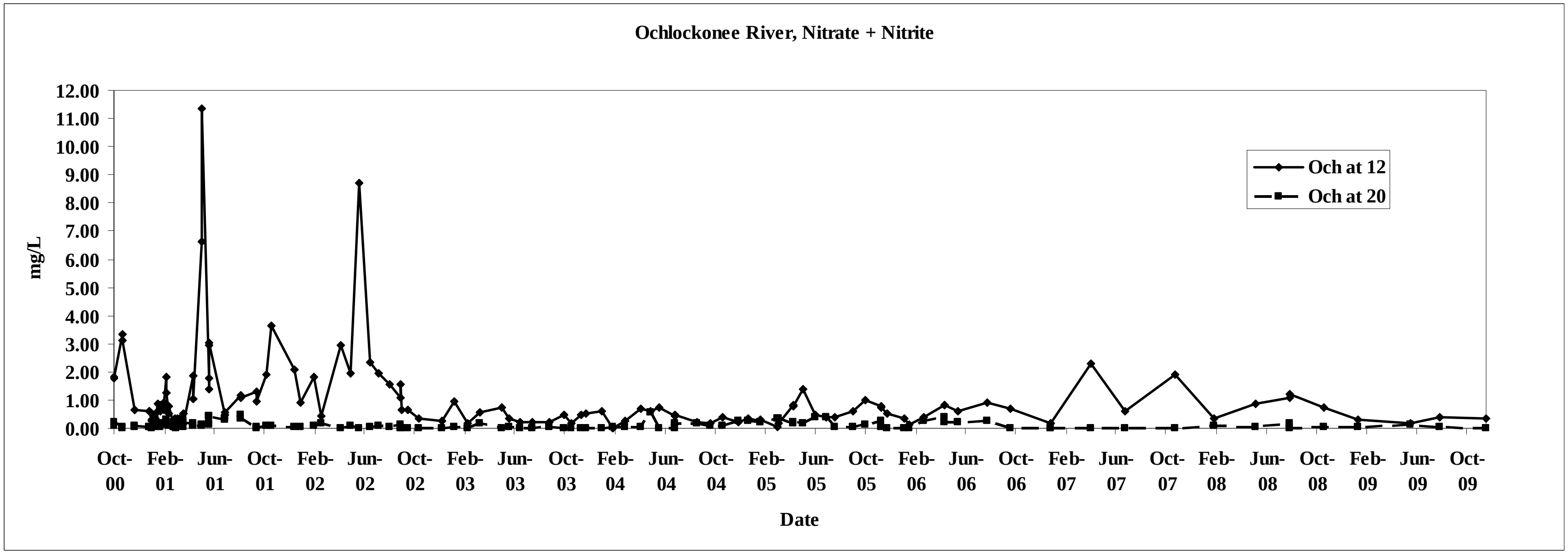


FIG. 8.9-19. Parameter of concern.

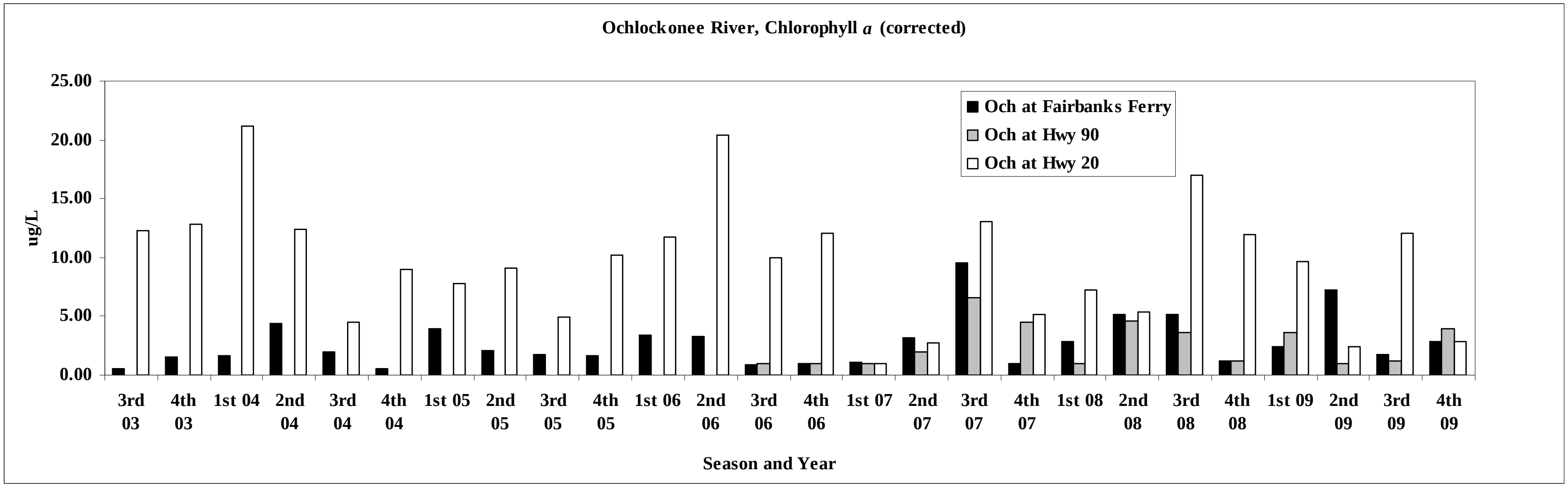


FIG. 8.9-20. Ochlockonee River chlorophyll *a*. The "Och at Hwy 90" station was added in the 3rd quarter of 2006.

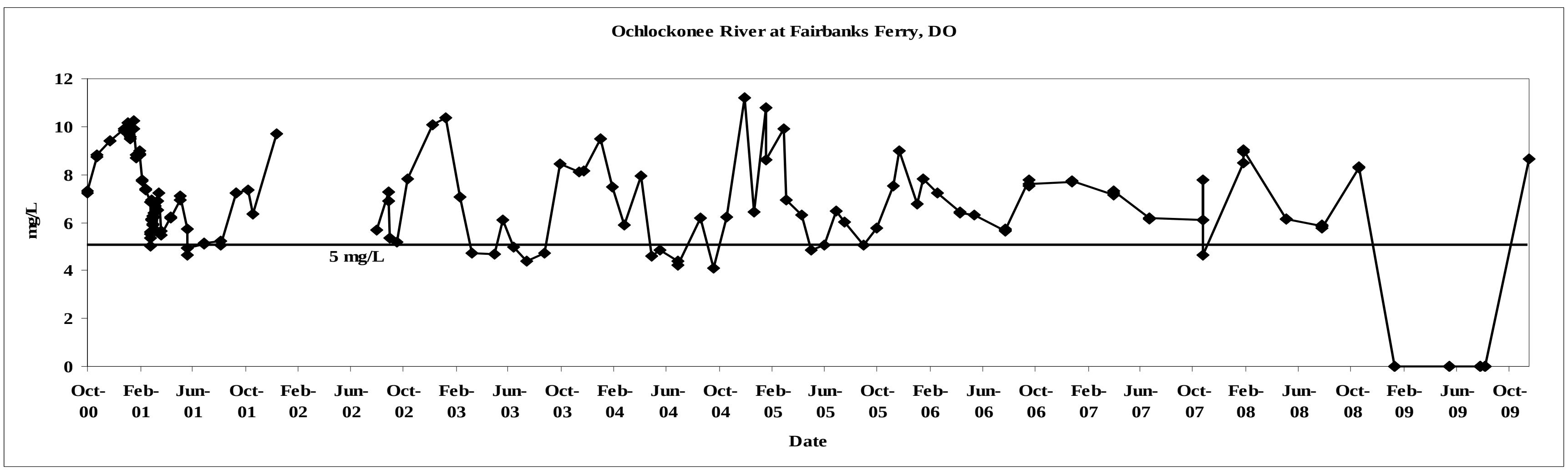


FIG. 8.9-21. Ochlockonee River DO at SR 12. Markers represent individual measurements.

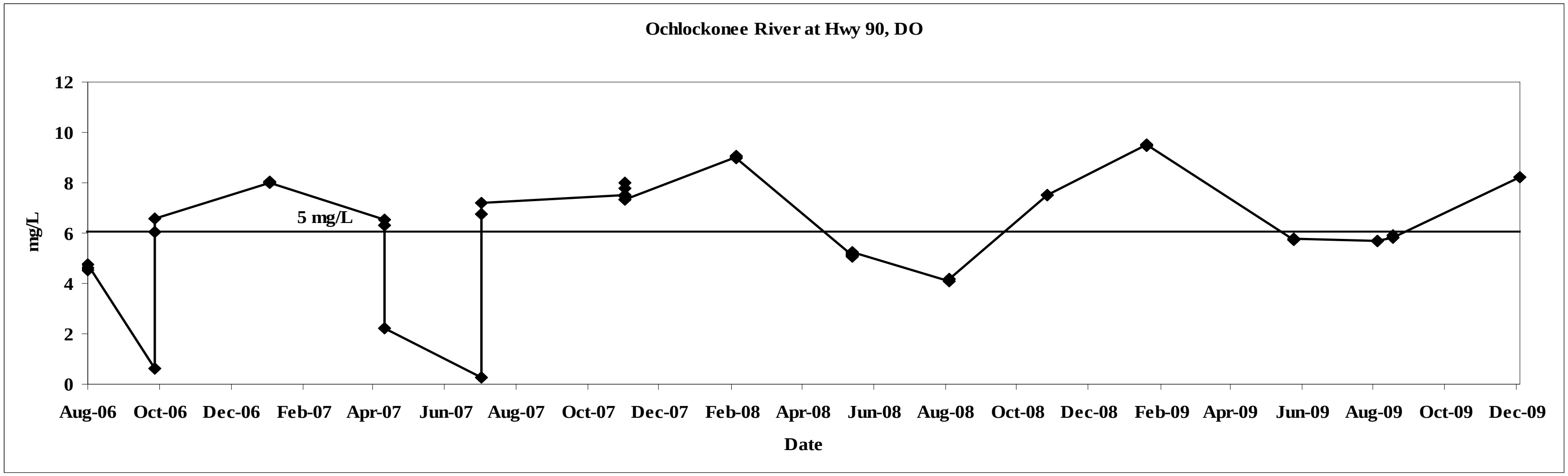


FIG. 8.9-22. Ochlockonee River DO at Hwy 90. Markers represent individual measurements.

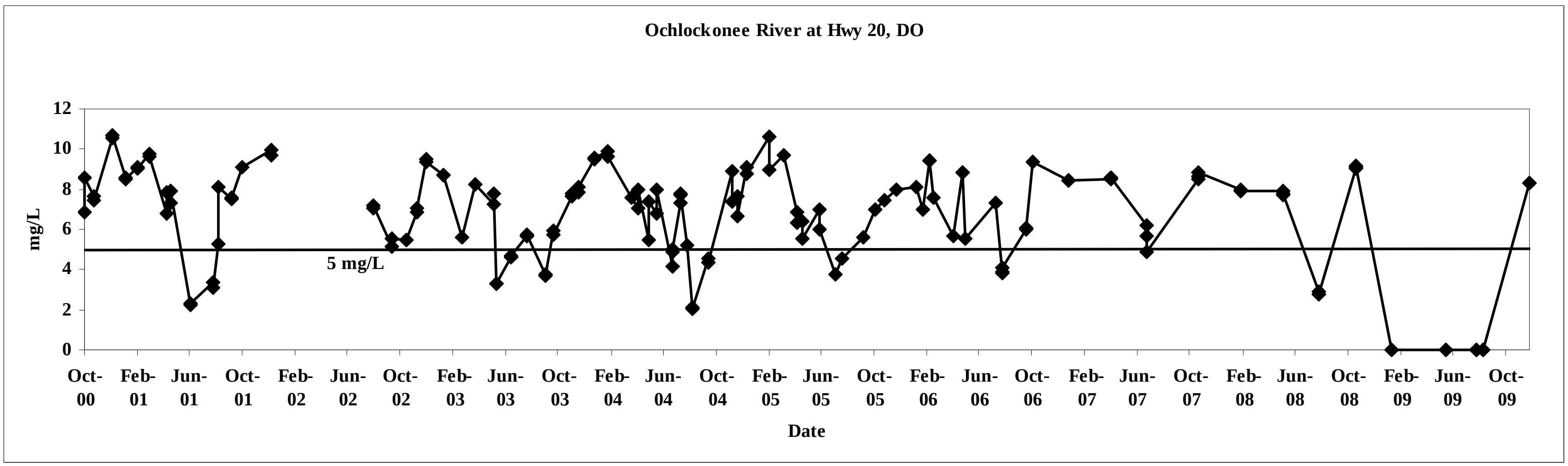
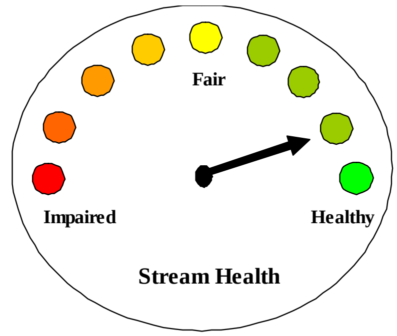


FIG. 8.9-23. Ochlockonee River at SR 20. Markers represent individual measurements.

E. Polk Creek



Polk Creek is a minimally disturbed, slightly tannic stream located in western Leon County **(Figure 8.9-24)**. The stream flows west eventually reaching Lake Talquin.

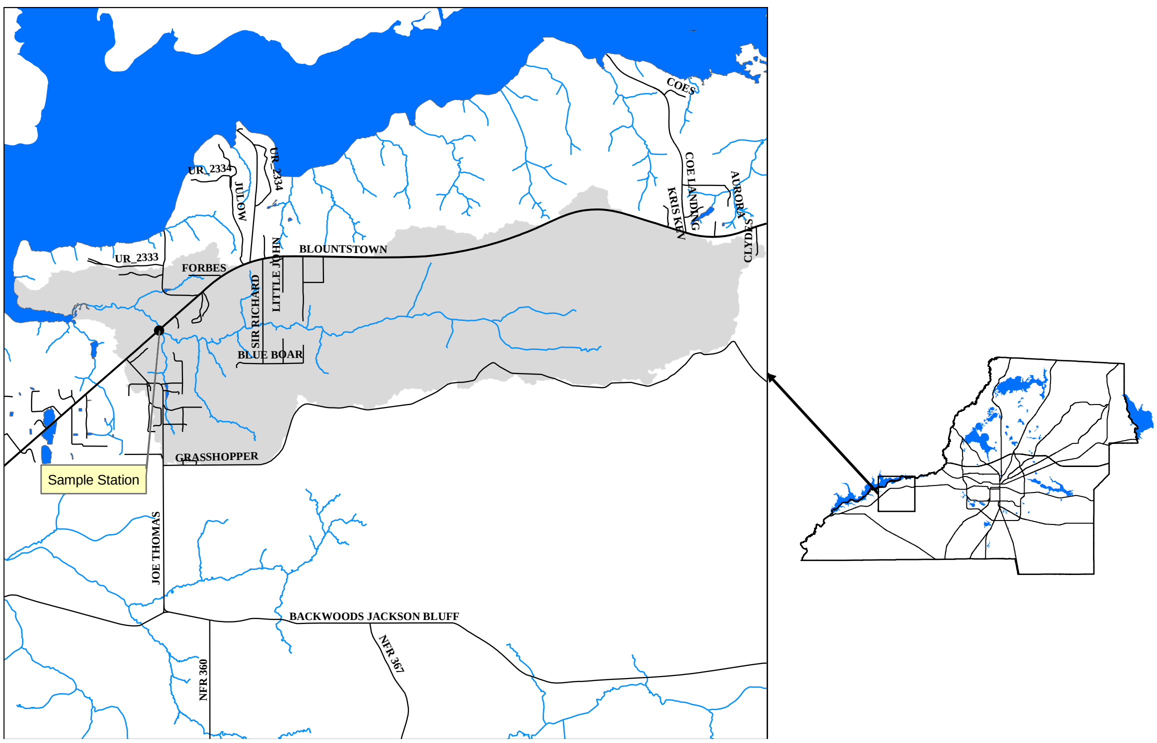


FIG. 8.9-24. Overview Map of the Polk Creek watershed.

As shown in **Figure 8.9-25**, approximately 15% of land use in the Polk Creek watershed is residential or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

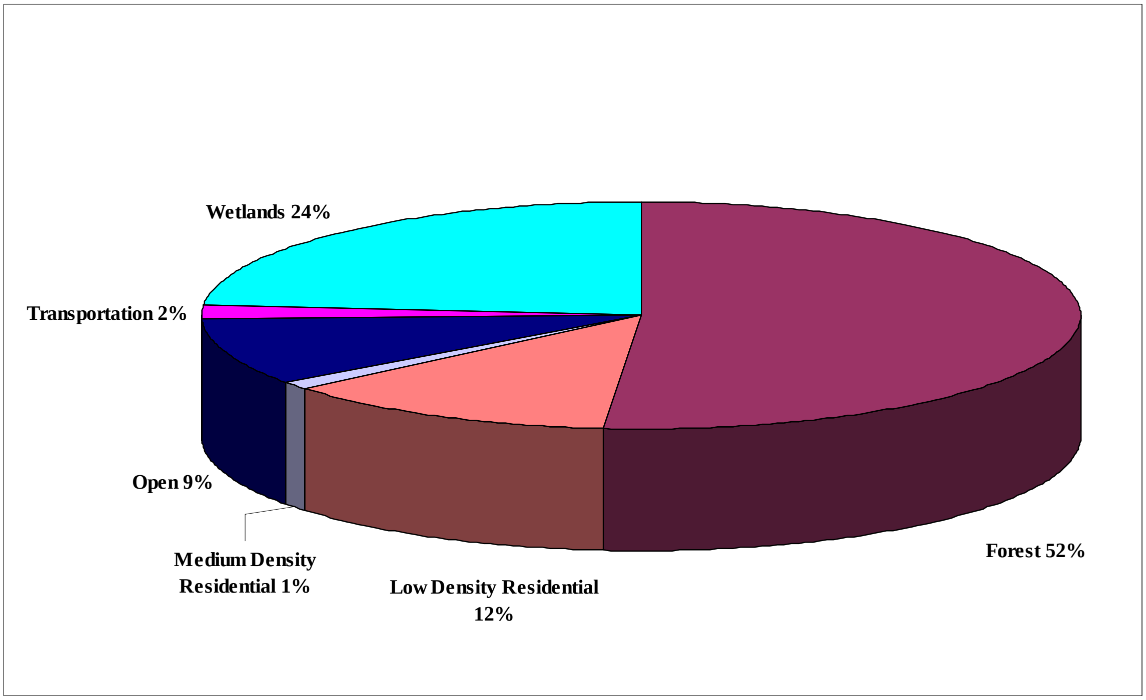


FIG. 8.9-25. Land use in the Polk Creek watershed (2,599 acres).

Nutrient levels for Polk Creek were consistently low when compared to other Florida streams. Fecal coliform levels were high, at times exceeding the Class III water quality standard for daily maximum exceedance **(Figure 8.9-26)**. Since the watershed is relatively undeveloped, the high fecal levels could possibly be the result of wildlife in the area. The habitat assessment score total for Polk Creek (118) was in the sub-optimal category; while the SCI score (45) was in the healthy range **(Table 8.9-3)**.

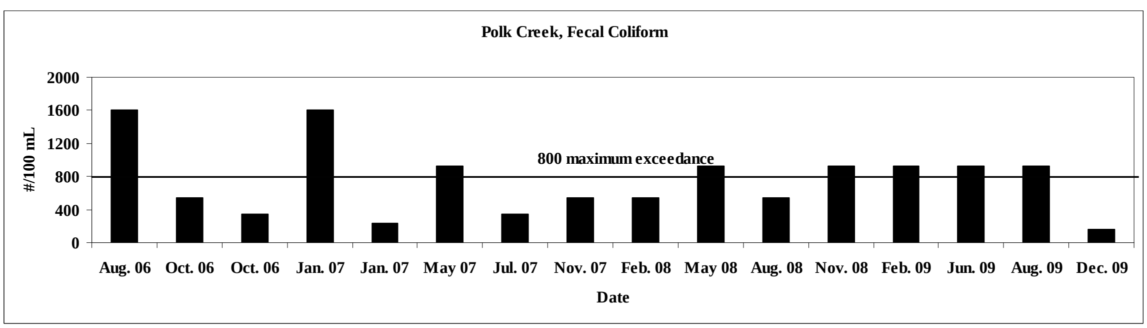
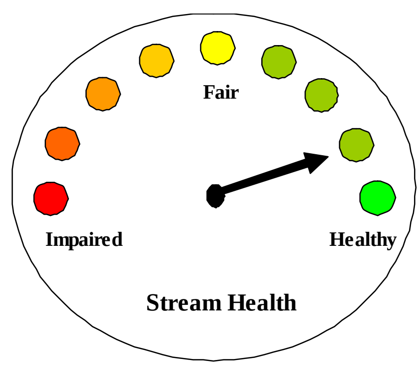


FIG. 8.9-26. Parameter of concern.

TABLE 8.9-3. SCI and Habitat Assessment scores and interpretation.

Polk Creek @ 20	Dup 1 2009	Dup 2 2009
SCI Metric		
Total Taxa	38	35
Ephemeroptera Taxa	2	1
Trichoptera Taxa	1	3
% Filterer	4.8	7.85
Long-lived Taxa	2	2
Clinger Taxa	5	6
% Dominance	13	17.1
% Tanytarsini	6.6	2.9
Sensitive Taxa	7	9
% Very Tolerant Taxa	15.4	17.8
Total SCI Score	**45.19**	**44.12**
Average of two aliquots	**45**	
Score Interpretation	**Healthy**	
Habitat Assessment Score	**118**	
Score Interpretation	**Sub Optimal**	

F. Soapstone Creek



Soapstone Creek is a minimally disturbed phosphorus limited stream located in southwest Leon County **(Figure 8.9-26)**. The stream flows west eventually reaching the Ochlockonee River downstream of Lake Talquin.

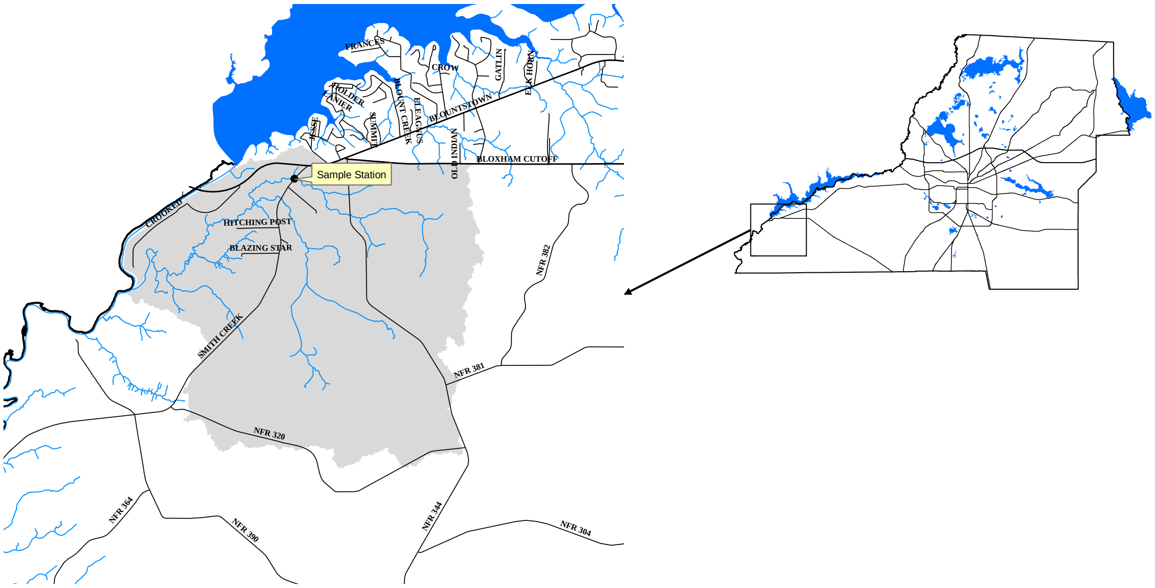


FIG. 8.9-26. Overview map of Soapstone Creek and water quality sampling stations.

Figue 8.9-27 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Residential and transportation uses make up less than 6% of the watershed.

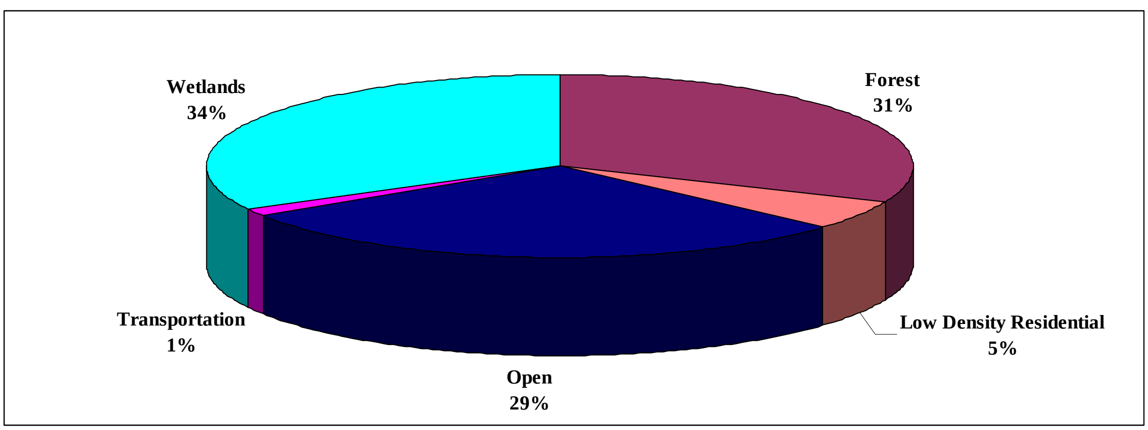
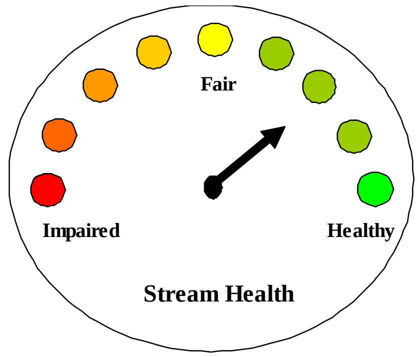


FIG. 8.9-27. Land use in the Soapstone Creek watershed.

Nutrient levels were very low when compared to other streams in Florida. No Class III water quality parameters were exceeded.

G. West Black Creek



West Black Creek is a minimally disturbed, phosphorus limited stream located in southwest Leon County **(Figure 8.9-28)**. The stream flows west eventually reaching the Ochlockonee River.

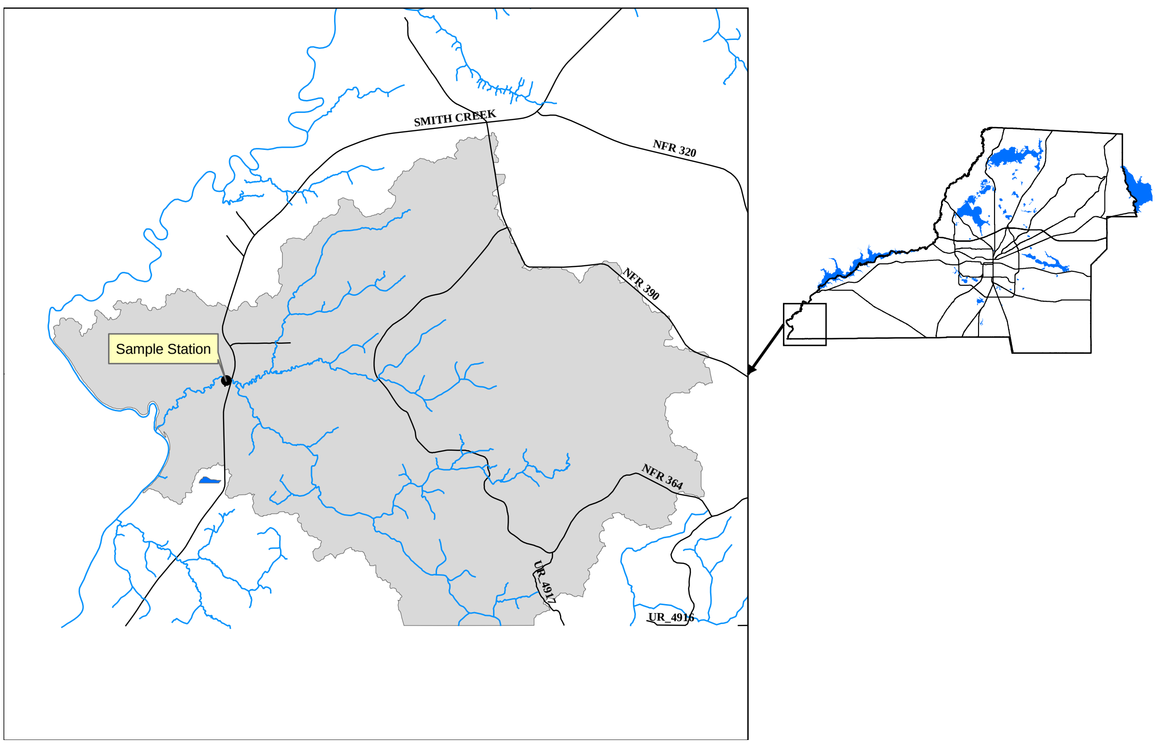


FIG. 8.9-28. Overview Map of the West Black Creek watershed.

Figure 8.9-29 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Residential uses make up less than 2% of the watershed.

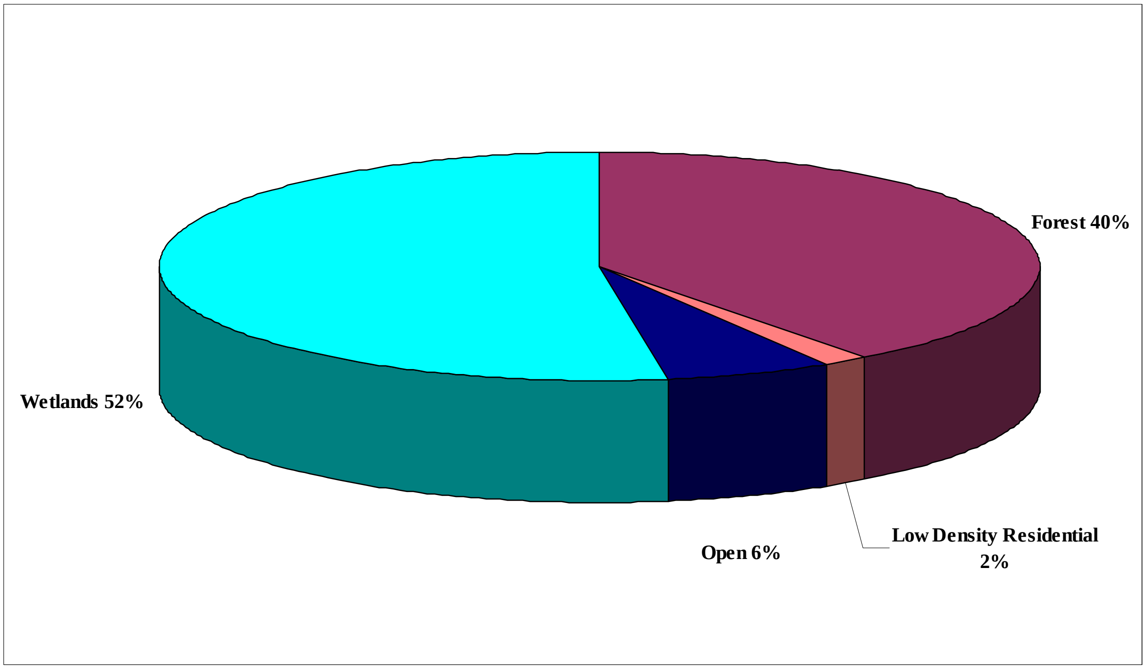


FIG. 8.9-29. Land use in the West Black Creek watershed (5,595 acres).

In September 2008, FDEP issued a report that presented the TMDL for fecal coliforms for West Black Creek. The TMDL establishes the allowable loadings to the creek that would restore the creek to applicable water quality thresholds (Wieckowicz, et al, 2008).

Fecal coliform levels were elevated above the 400 in 32% of the samples for Class III waters **(Figure 8.9-30)**. Since the watershed is relatively undeveloped, the high fecal levels could be the result of wildlife in the area.

With the exception of the TKN results, nutrient levels for West Black Creek were consistently low when compared to other Florida streams **(Figure 8.9-31)**. Sources of TKN include the decay of organic material such as plant material and could have been washed into the creek due to runoff. Rainfall that occurred in the area prior to the August 2008, June and December 2009 sampling events supports this theory. The elevated TKN values in November 2007 can not be explained.

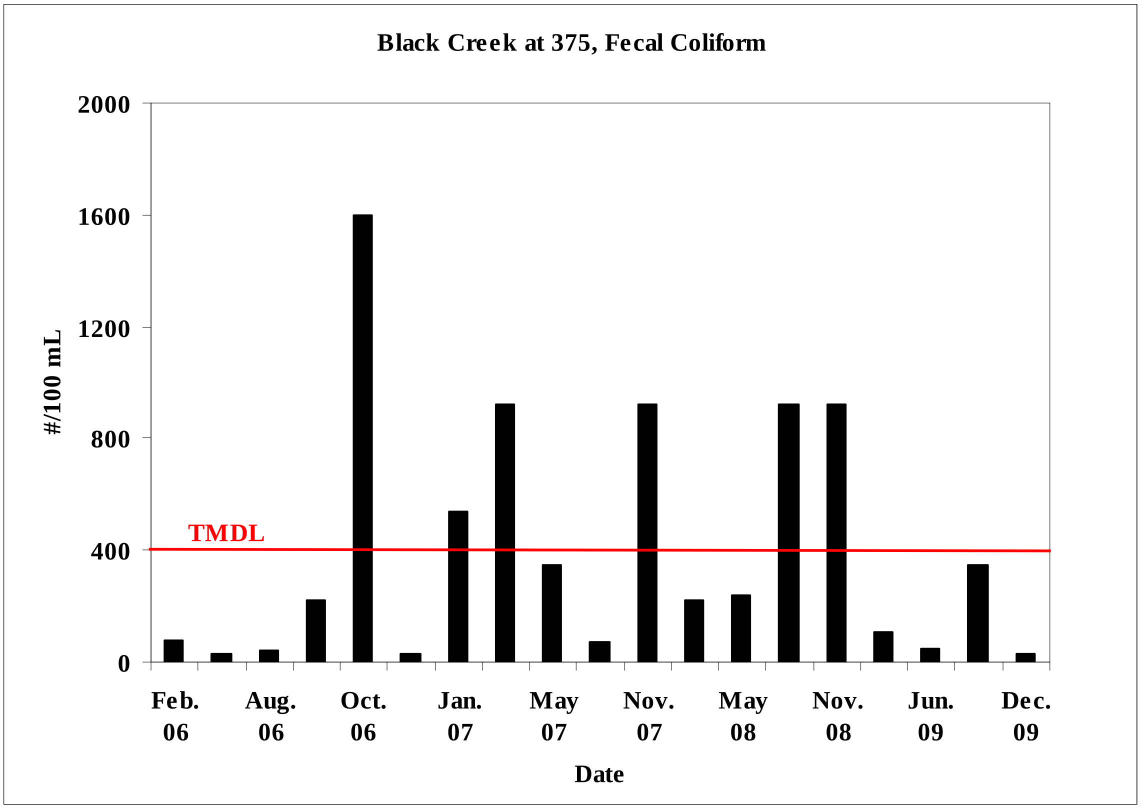


FIG. 8.9-30. **Parameter of concern.**

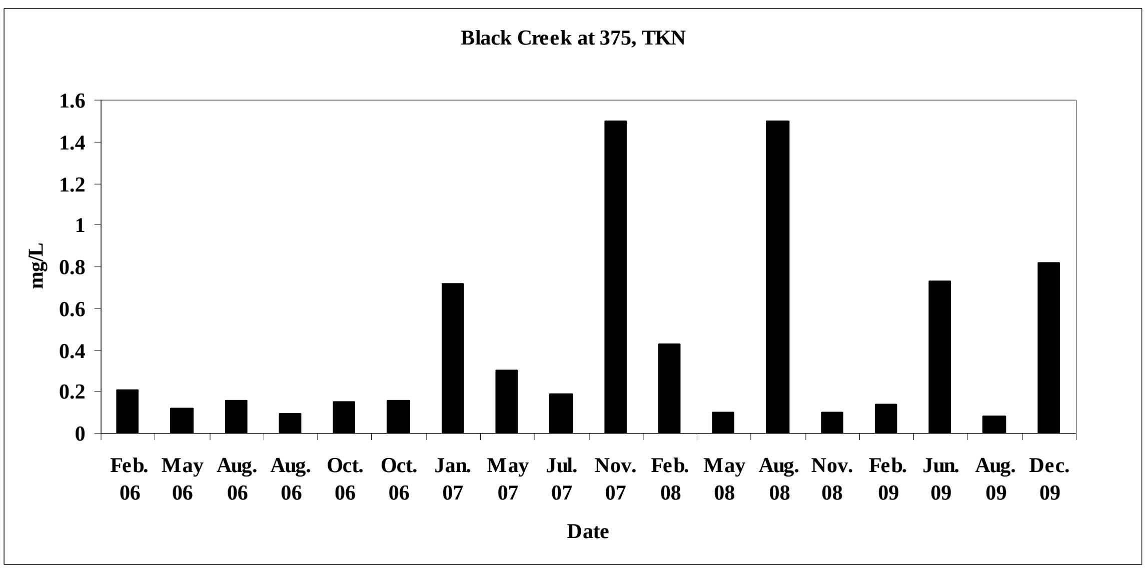
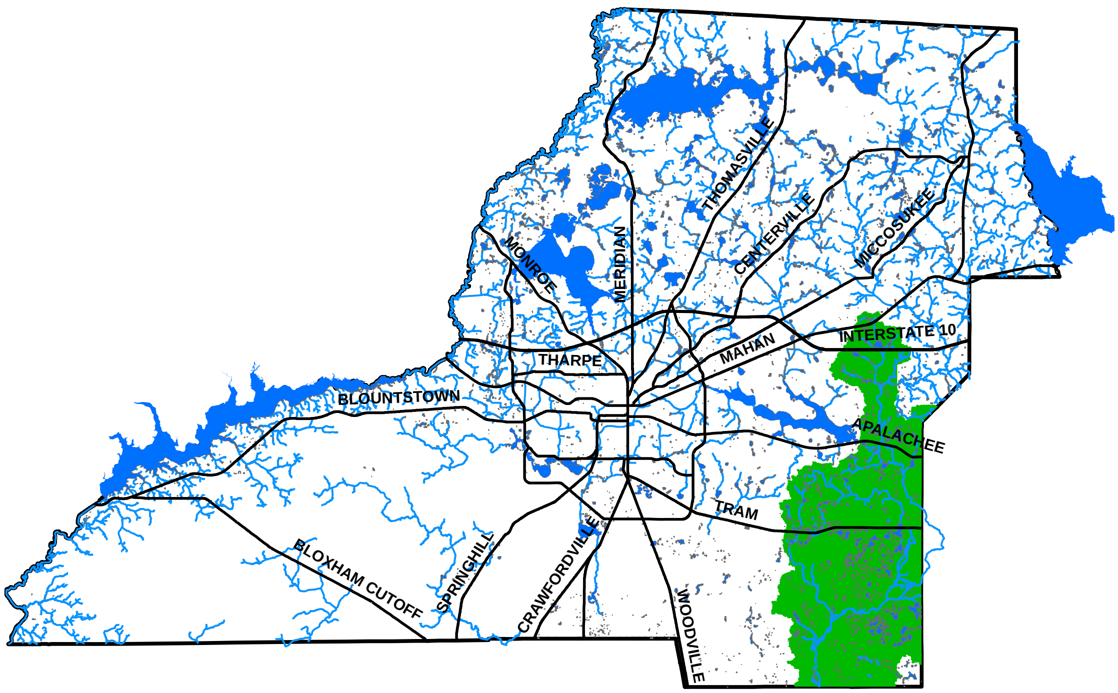
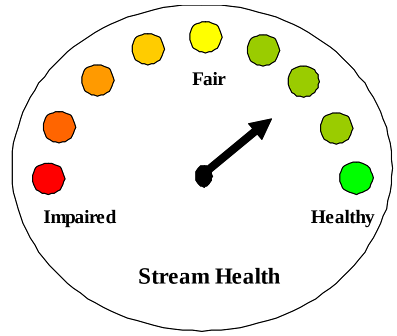


FIG. 8.9-31. **Parameter of concern.**

8.10. St. Marks River Basin



A. Chicken Branch



Chicken Branch is located in southeast Leon County **(Figure 8.10-1)**. The stream is partially fed by Chicken Branch Spring and flows southeast, eventually entering into the St. Marks River.

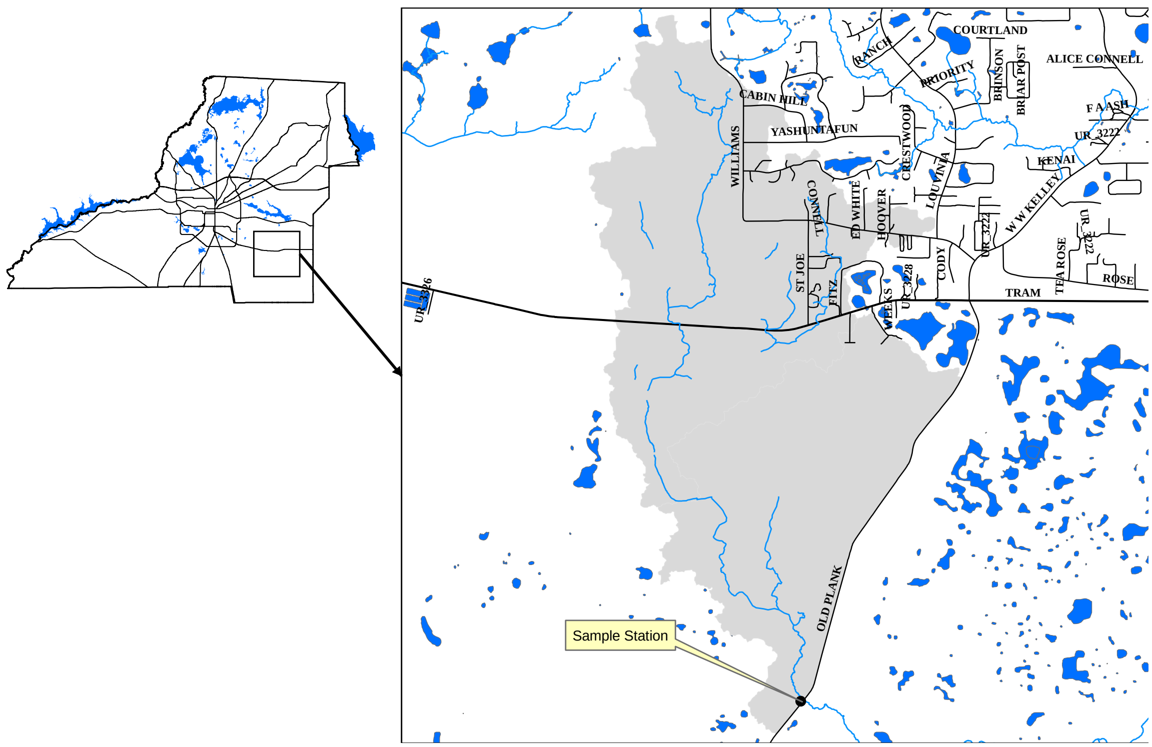


Figure 8.10-1. Overview Map of Chicken Branch Watershed.

Figure 8.10-2 shows land use in the watershed. Increases in stormwater runoff, waterbody nutrient loads, etc. can often be attributed to increased development of a watershed. Residential, commercial, agricultural and transportation uses make up approximately 15% of the watershed.

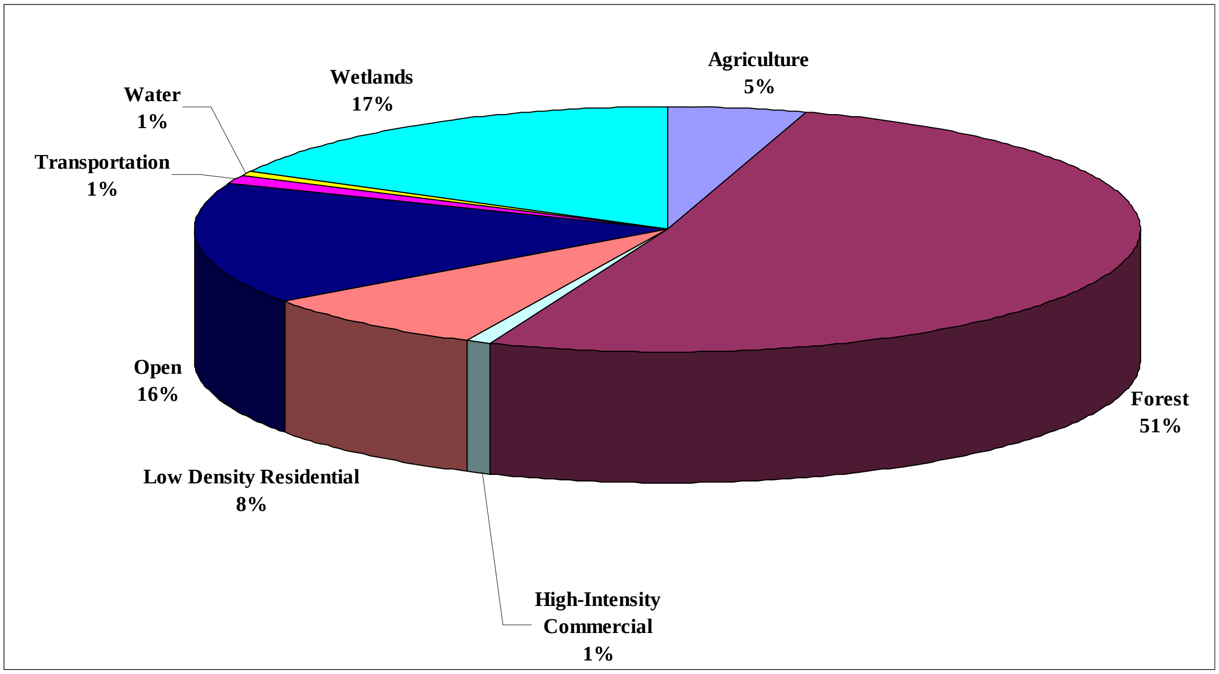


FIG. 8.10-2. Land use in the Chicken Branch watershed (5,054 acres).

The March and August 2008 TKN value exceeded the 80th percentile of streams in Florida and coincided with elevated color values **(Figures 8.10-3 and 8.10-4).** Elevated color values in December 2009 also coincided with the slightly elevated TKN values. Both sets of values were possibly the result of rainfall generated runoff from the relatively undeveloped watershed. Dissolved oxygen did not meet Class III water quality standards several times during the sampling period **(Figure 8.10-5)**. Low DO levels as well as high conductivity values **(Figures 8.10-5 and 8.10-6)** are typical of Florida spring-run streams. The habitat assessment score total for Chicken Branch (136) was in the optimal category; while the SCI score (34) was in the impaired range **(Table 8.10-1)**. The naturally high conductivity levels of Chicken Branch inhibited the macroinvertebrate community that would normally be found in areas with such optimal habitat conditions.

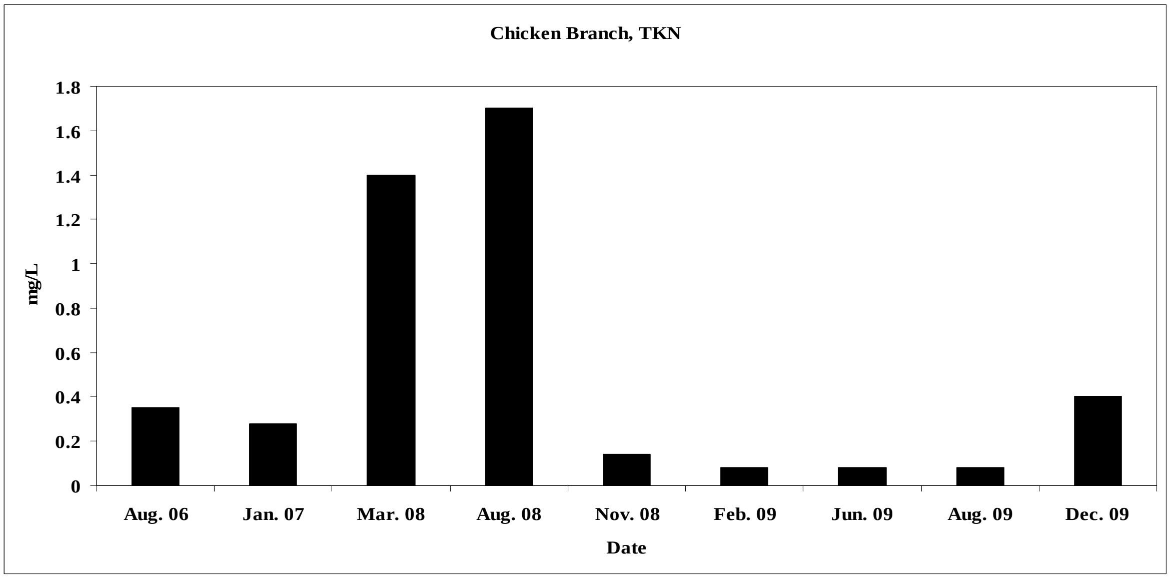


Figure 8.10-3. Parameter of concern

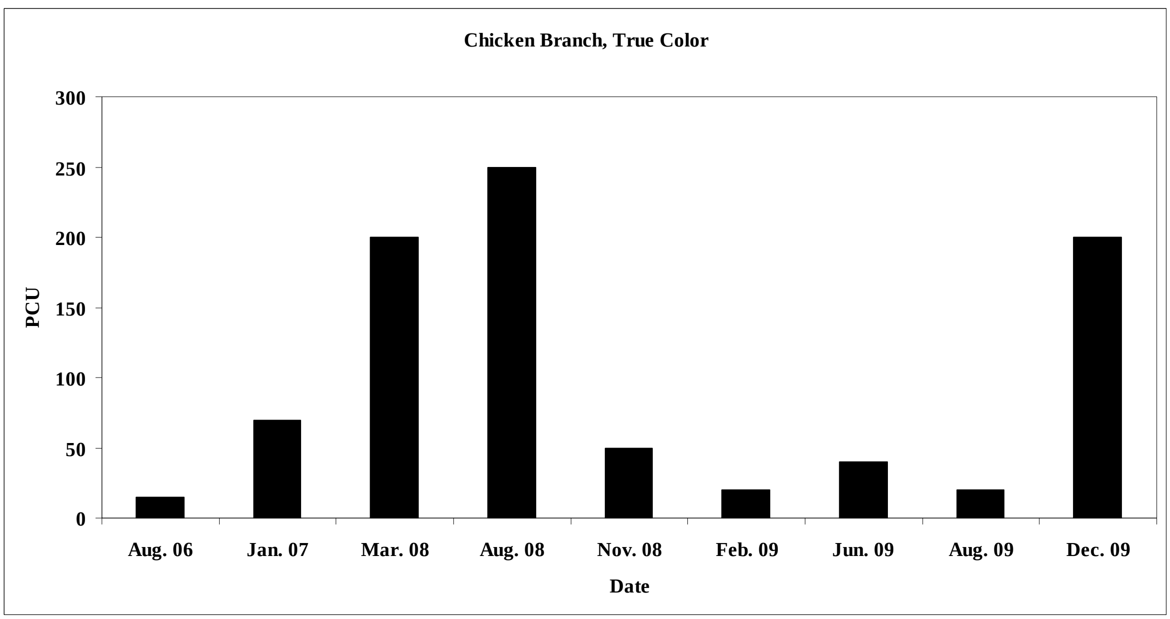


Figure 8.10-4. Parameter of interest

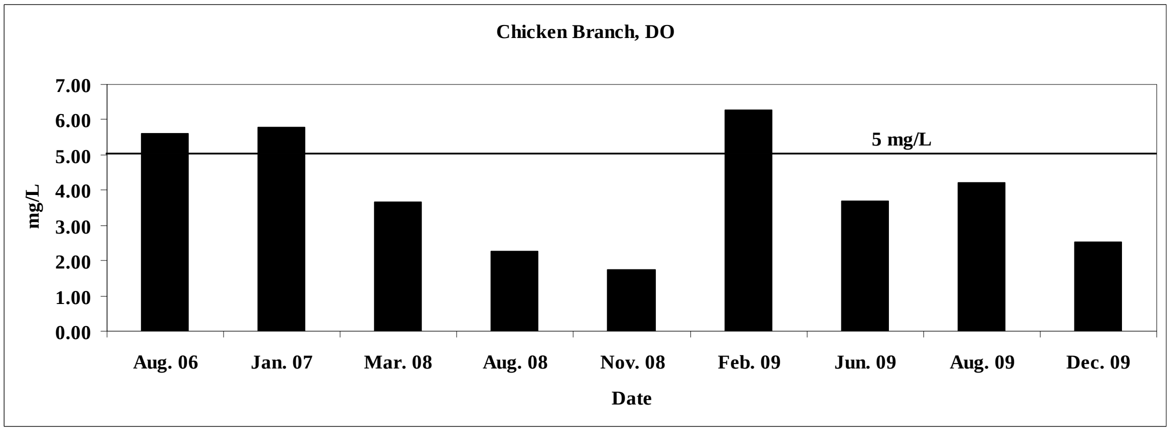


Figure 8.10-5. Parameter of concern

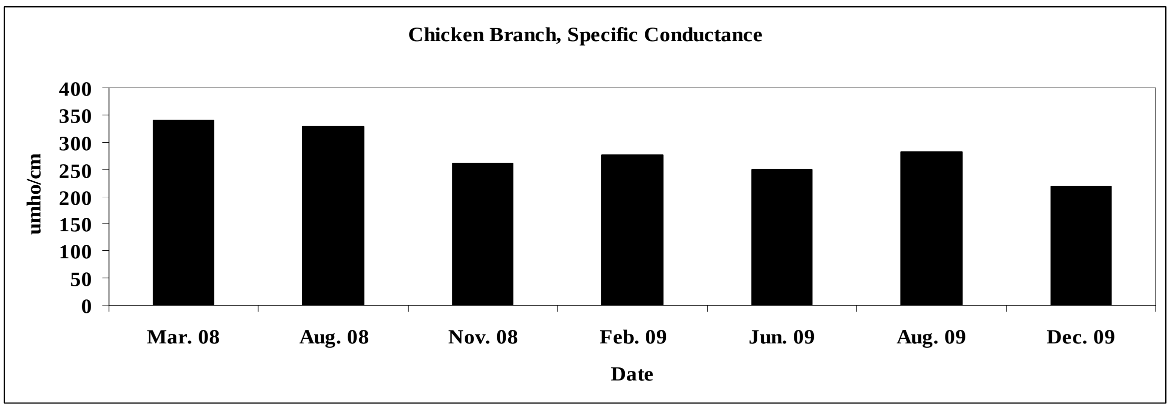
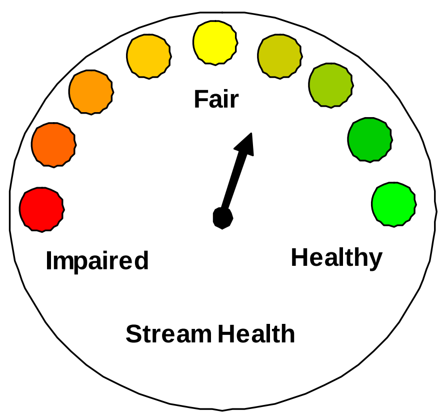


Figure 8.10-6. Parameter of interest

TABLE 8.10-1. SCI and Habitat Assessment score and interpretation.

Chicken Branch at Old Plank	**Dup 1**	**Dup 2**
Aliquot	A1	A2
# Taxa	24	18
Ephemeroptera Taxa	1	1
Trichoptera Taxa	1	1
%Filterer	40.1	50
Long-lived Taxa	0	0
Clinger Taxa	3	2
%Dominance	37.1	48
%Tanytarsini	37.8	49.3
Sensitive Taxa	3	2
% Very Tol. Taxa	29.8	20.1
Scores per Aliquot	34.77	33.98
Average Score	**34**	
Interpretation	**Impaired**	
Habitat Assessment Score	**136**	
Interpretation	**Optimal**	

B. Lake Weeks



Lake Weeks is a small, 10 acre, tannic lake located in the southeast portion of Leon County **(Figure 8.10-7)**.

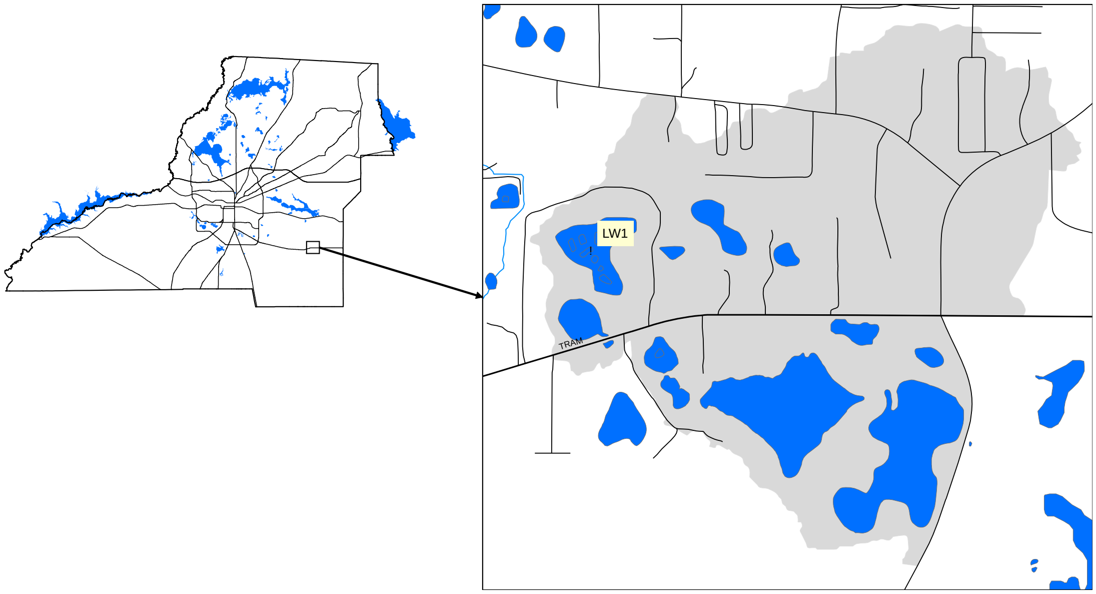


FIG. 8.10-7. Overview map of Lake Weeks watershed and water quality sampling station.

As shown in **Figure 8.10-8**, approximately 49% of land use in the Lake Weeks watershed is residential, or transportation. Increases in stormwater runoff, and waterbody nutrient loads can often be attributed to these types of land uses.

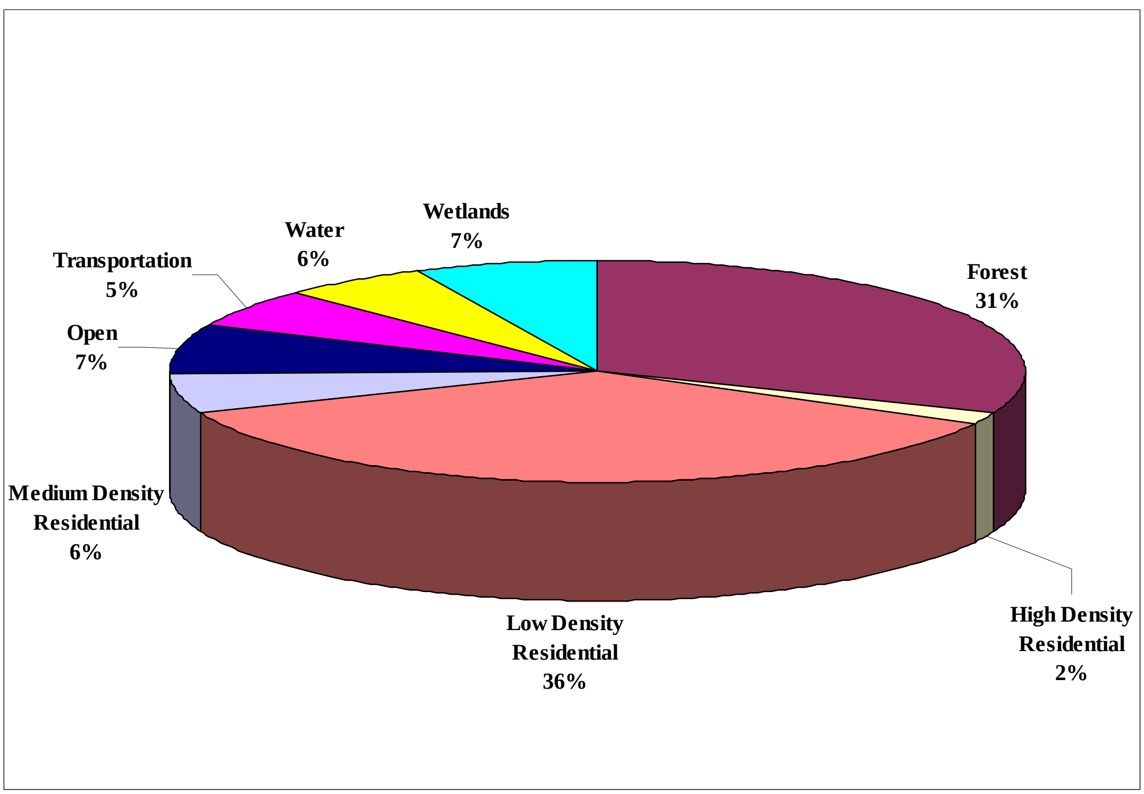


FIG. 8.10-8. Land use in the Lake Weeks watershed (614 acres).

Figures 8.10-9 and **8.10-10** represents Lake Weeks's trophic state utilizing the FDEP Trophic State Index. Yearly and seasonal averages show that Lake Weeks TSI values substantially decreased in 2009 and did not exceed the 60 TSI threshold and would not be considered impaired according to FDEP standards.

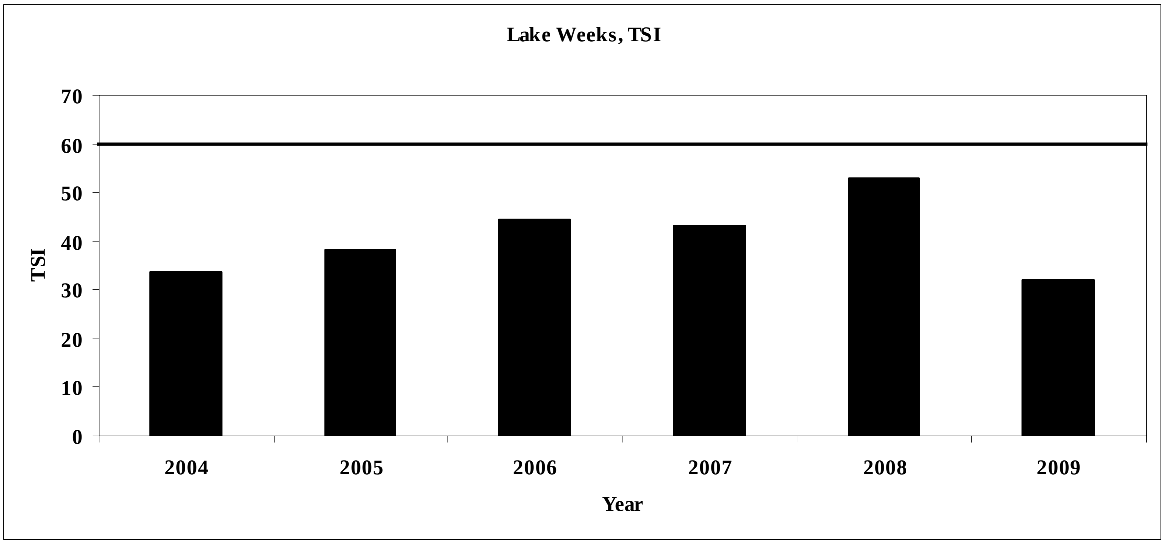


FIG. 8.10-9. Lake Weeks trophic state index (yearly average). Bars exceeding a TSI of 60 would indicate impairment.

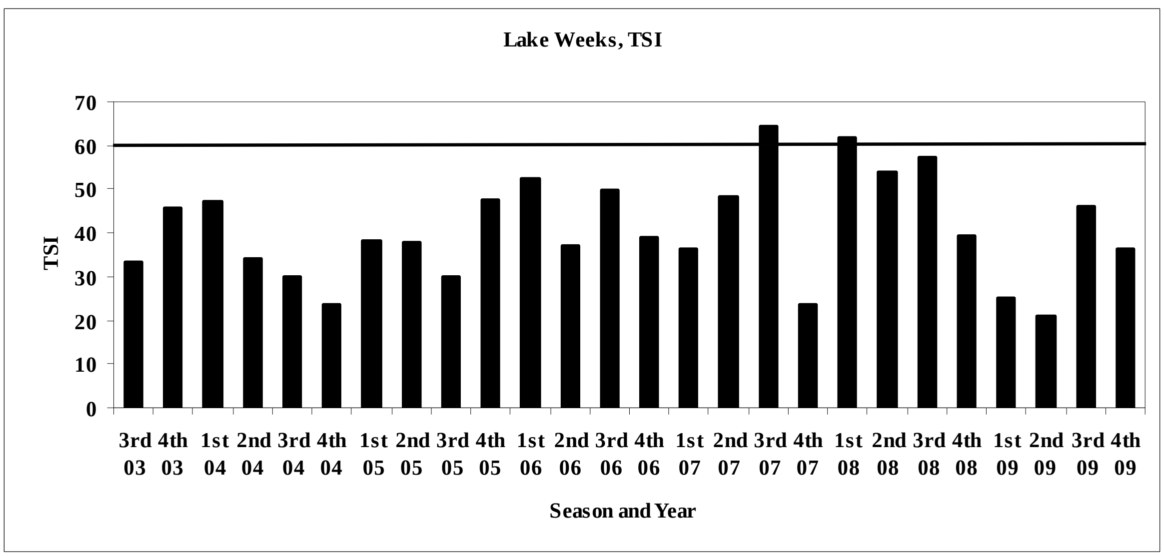


FIG. 8.10-10. Lake Weeks trophic state index (seasonal average). Bars exceeding a TSI of 60 indicate impairment.

At times, DO levels did not meet Class III water quality standards **(Figure 8.10-11).**

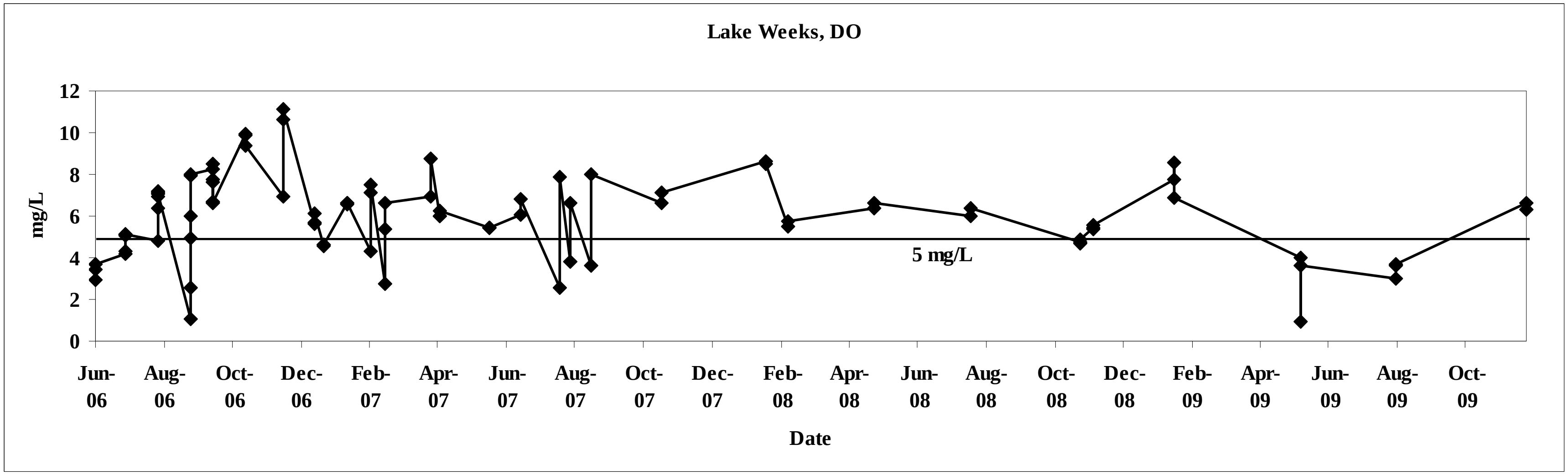
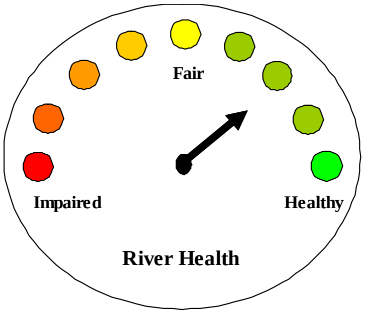


Fig. 8.10-11. Parameter of concern.

C. St. Marks River



The predominantly nitrogen-limited St. Marks River, declared an Outstanding Florida Water by FDEP, originates in the hardwood and cypress swamps of the Red Hills area and flows approximately 35 miles south before emptying into Apalachee Bay. At Natural Bridge, the river disappears underground and reappears approximately a mile downstream. The location of the river and sampling stations are shown in **Figure 8.10-12**. It should be noted that there are interactions between the St. Marks River and Lake Lafayette during elevated water conditions and during extremely elevated water conditions (ie Tropical Storm Fay) there are additionally interactions that include: Bird Sink, Patty Sink, and Lloyd Creek (Jefferson County).

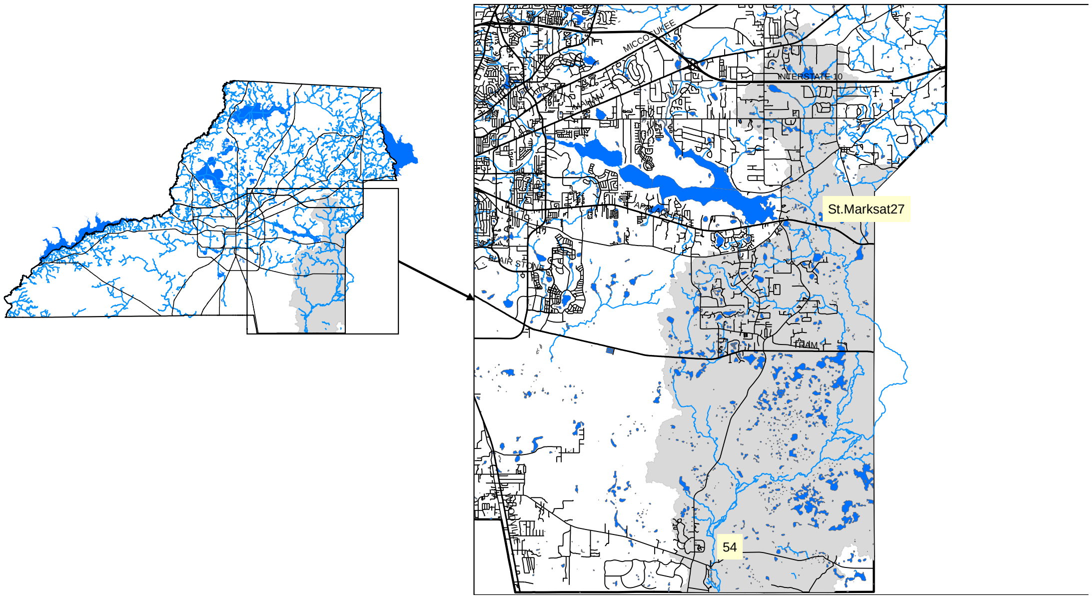


FIG. 8.10-12. St. Marks River Basin in Leon County with locations of water quality sampling stations shown.

St Marks at 27

Due to low water, only one water quality sample was collected in 2009 at the St. Marks at 27 station **(Table 8.10-2)**. From what little can be inferred from one sample, nutrients appear to be lower than typical streams in Florida, while BOD and fecal coliforms were elevated.

Table 8.10-2. Water Quality Data for St. Marks at 27.

Water Quality Data (12/15/2009)	Result	Units	Qualifier
Alkalinity, Total	5	mg/l	U
BOD, Biochemical oxygen demand	3.8	mg/l	
Carbon, Total Organic (TOC)	17.6	mg/l	
Chlorophyll *a*, corrected for pheophytin	1.4	mg/m3	
Dissolved Oxygen (DO)	5.49	mg/l	
Dissolved oxygen saturation	55.8	%	
Fecal Coliform	210	#/100ml	
Nitrogen, ammonia as N	0.069	mg/l	
Nitrogen, Kjeldahl	0.63	mg/l	
Nitrogen, Nitrate (NO3) as N	0.025	mg/l	U
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	0.025	mg/l	U
Nitrogen, Nitrite (NO2) as N	0.025	mg/l	U
Nitrogen, Organic	0.56	mg/l	
Nitrogen, Total	0.63	mg/l	
pH	6.86		
Phosphorus as P	0.034	mg/l	V
Phosphorus, orthophosphate as P	0.011	mg/l	
Solids, Dissolved	56	mg/l	
Solids, Total Suspended (TSS)	5	mg/l	U
Specific conductance	33	umho/cm	
Temperature, water	16.03	deg C	
Total Coliform	740	#/100ml	
Total Nitrogen/Total Phosphorus Ratio (TN:TP)	18		
True Color	125	units	
Turbidity	1.8	NTU	

V – Indicates that the analyte was detected at or above the method detection limit in both the sample and the associated method blank
U – Not detected in the sample

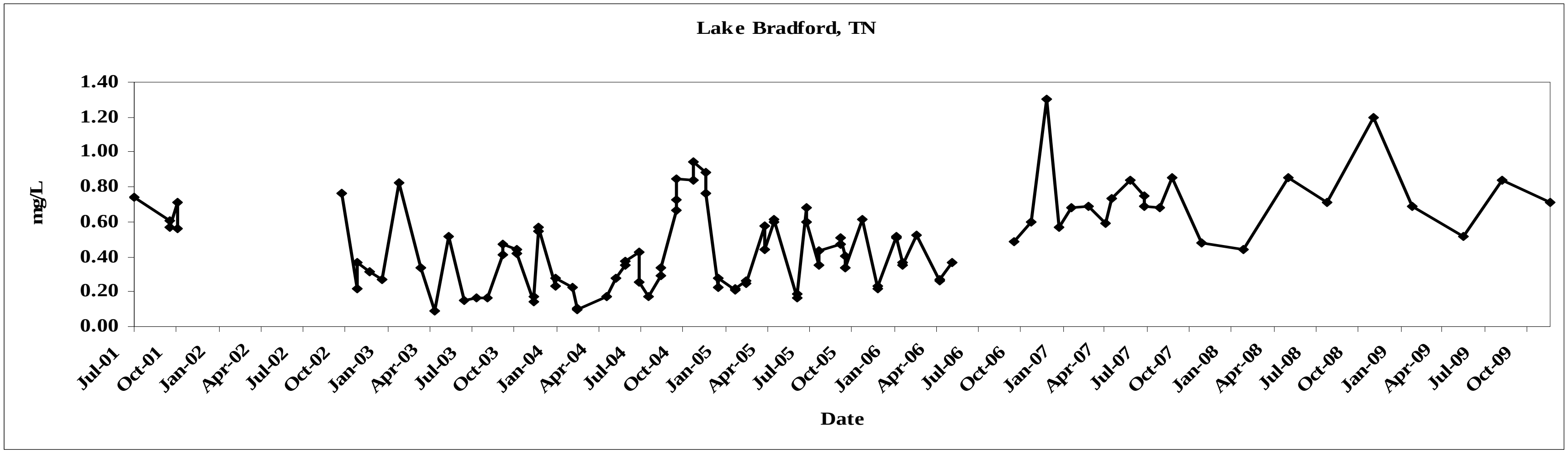
D. St Marks at Natural Bridge Road

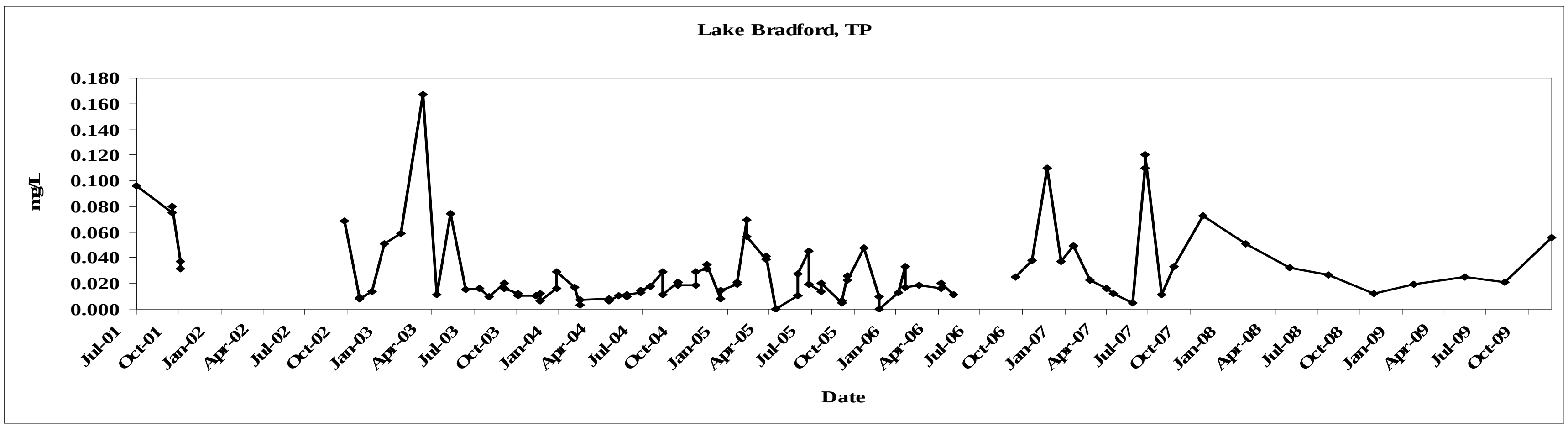
Fecal coliform, turbidity and DO levels met Class III water quality standards in 2009. Nutrients values fell into the lower 30th percentile of Florida streams.

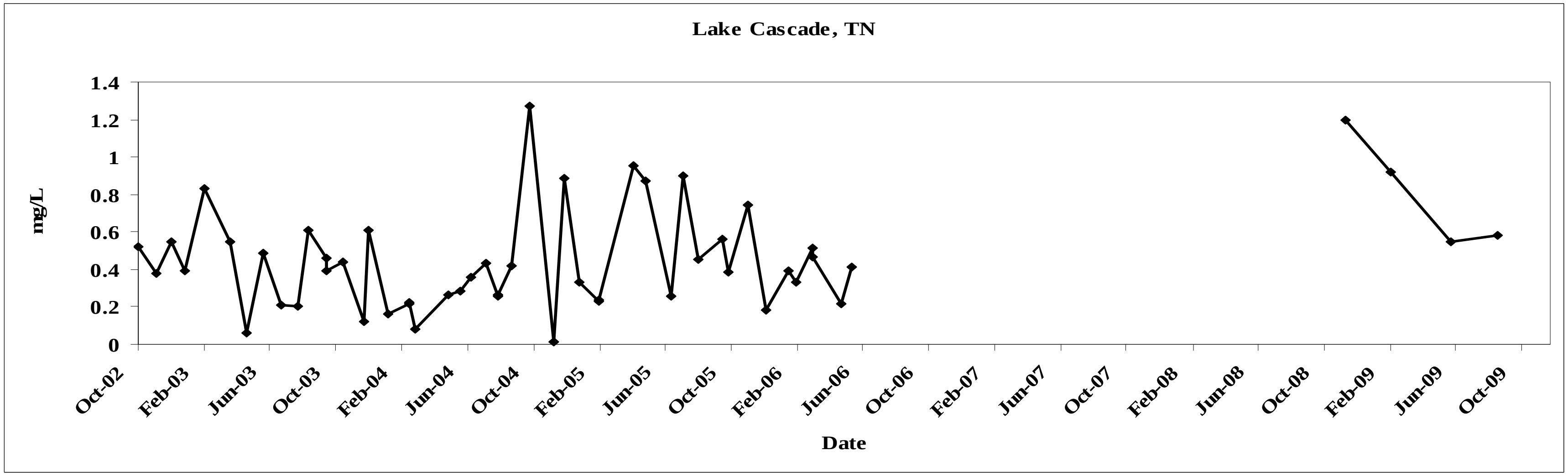
Appendix

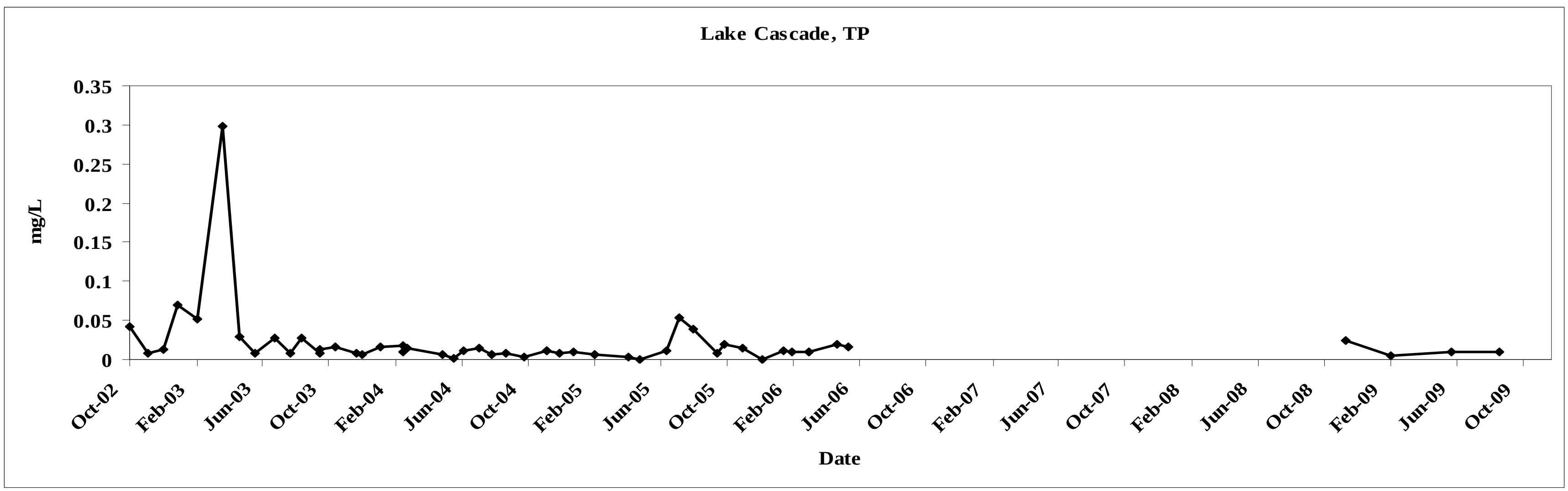
The following graphs represent long term nutrient levels of Leon County lakes sampled over the course of the Water Quality Monitoring Program. Data is taken from the County's long term sampling program and is used as reported by Leon County or their contractors.

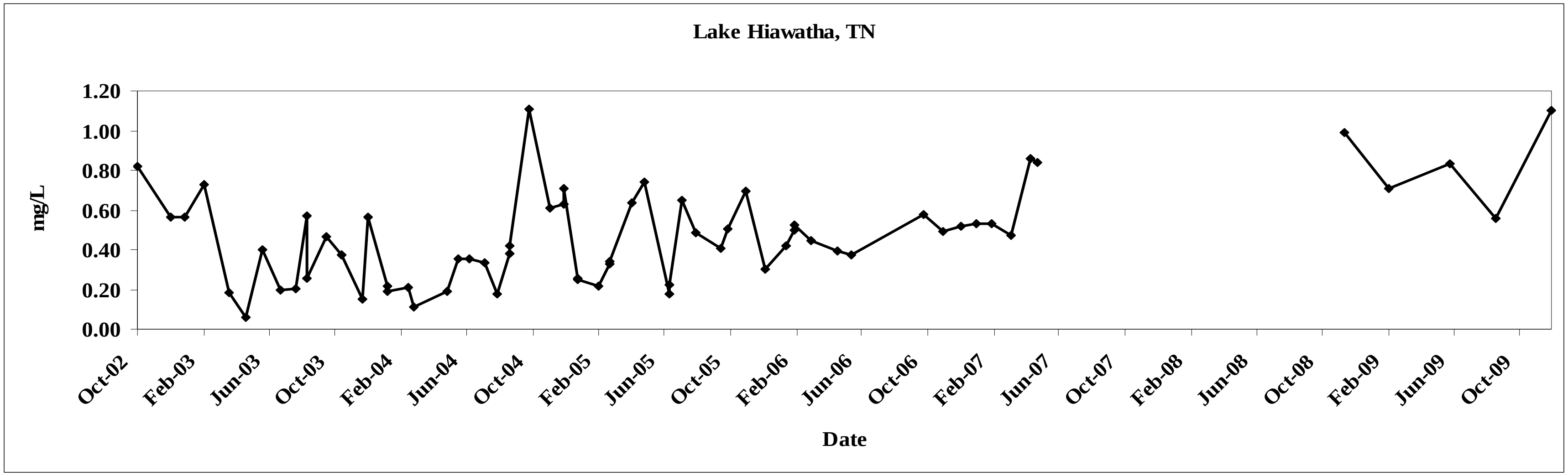
Bradford Chain of Lakes (Lake Bradford, Cascade and Hiawatha)

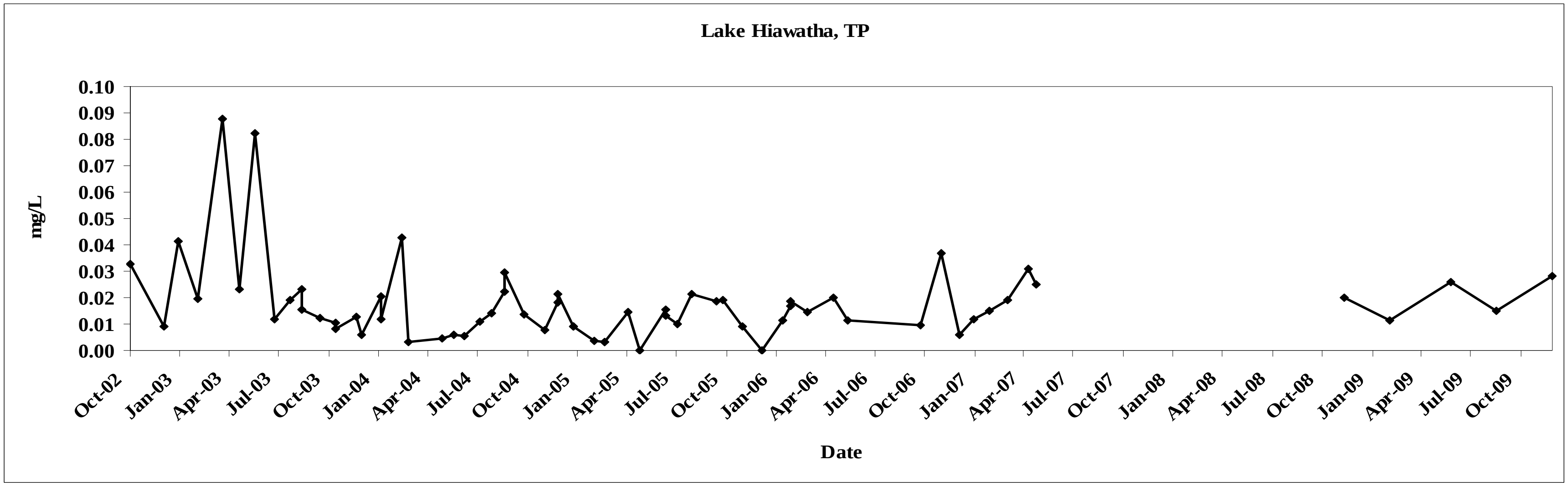




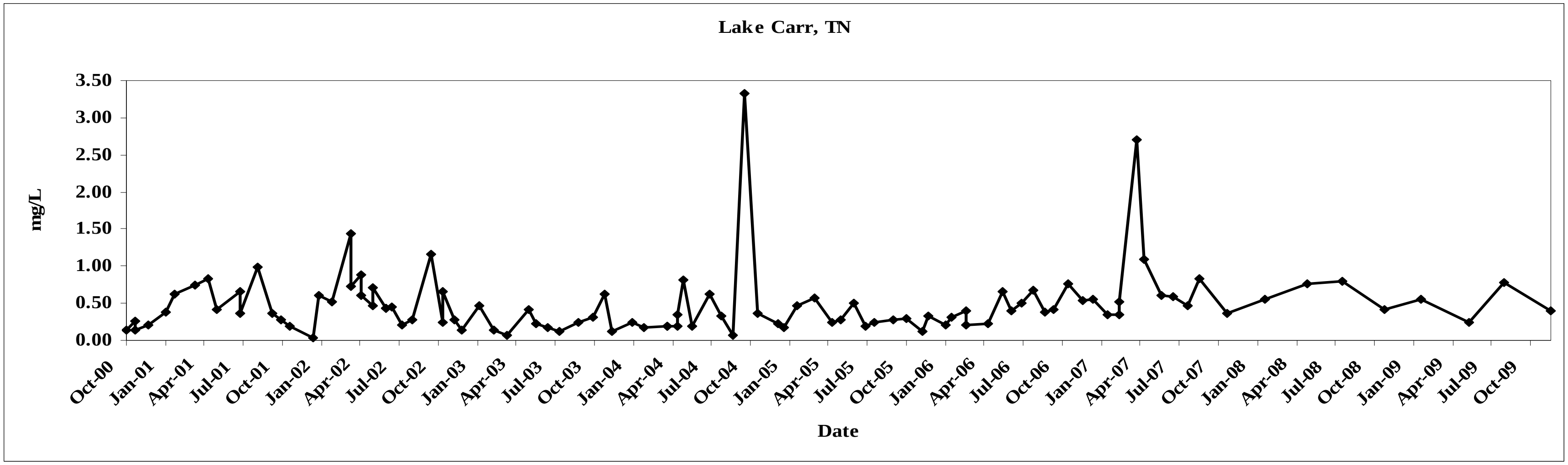

Lake Cascade, TN
mg/L
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Oct-02
Feb-03
Jun-03
Oct-03
Feb-04
Jun-04
Oct-04
Feb-05
Jun-05
Oct-05
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Date


Lake Cascade, TP
mg/L
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Oct-02
Feb-03
Jun-03
Oct-03
Feb-04
Jun-04
Oct-04
Feb-05
Jun-05
Oct-05
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Date

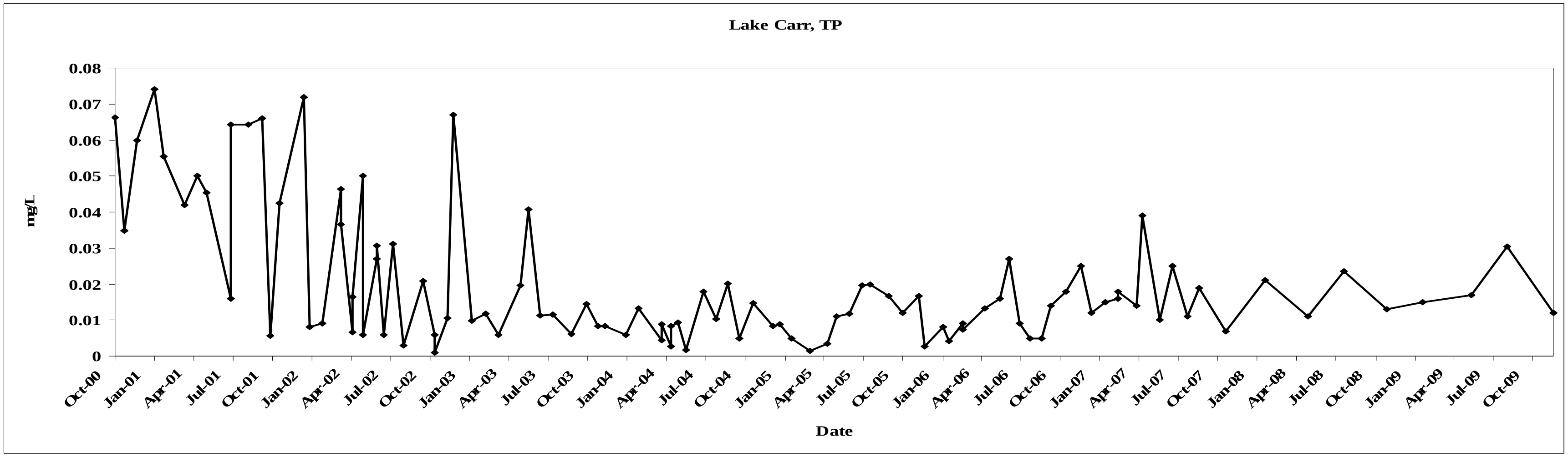

Lake Hiawatha, TN
mg/L
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Oct-02
Feb-03
Jun-03
Oct-03
Feb-04
Jun-04
Oct-04
Feb-05
Jun-05
Oct-05
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Date


Lake Hiawatha, TP
mg/L
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Oct-02
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07
Apr-07
Jul-07
Oct-07
Jan-08
Apr-08
Jul-08
Oct-08
Jan-09
Apr-09
Jul-09
Oct-09
Date

Lake Carr

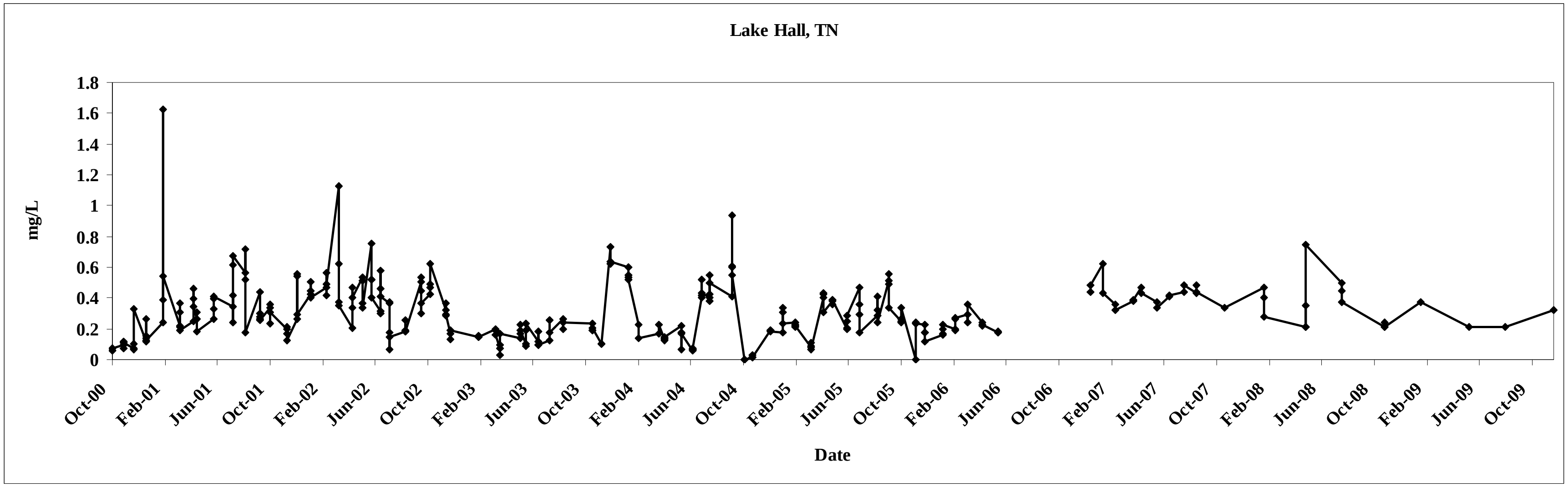


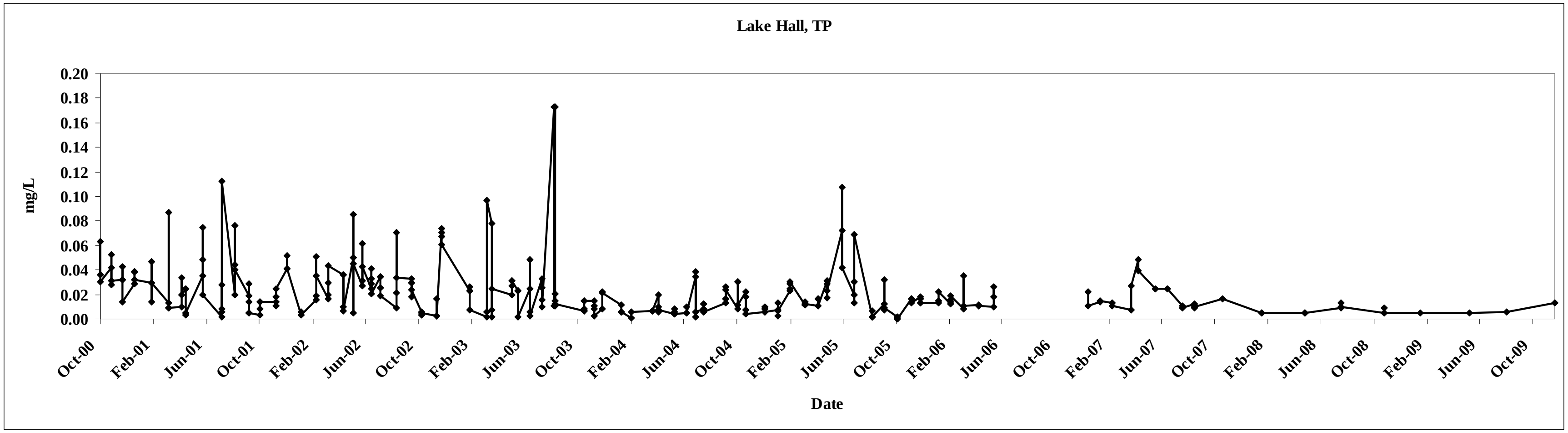
Lake Carr, TN
mg/L
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Oct-00
Jan-01
Apr-01
Jul-01
Oct-01
Jan-02
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07
Apr-07
Jul-07
Oct-07
Jan-08
Apr-08
Jul-08
Oct-08
Jan-09
Apr-09
Jul-09
Oct-09
Date



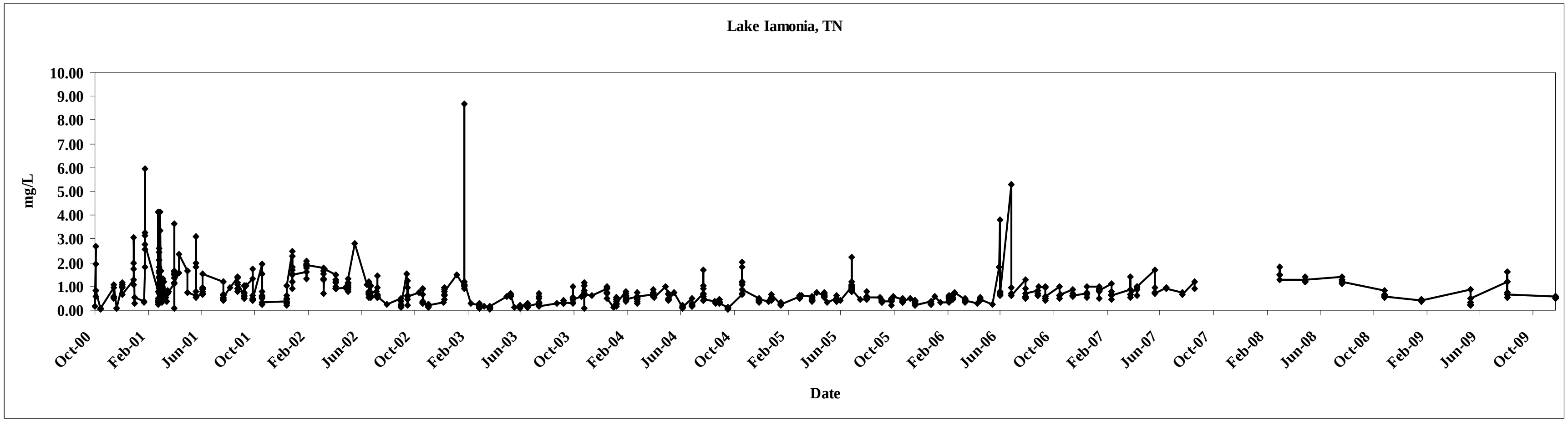
Lake Carr, TP
mg/L
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Oct-00
Jan-01
Apr-01
Jul-01
Oct-01
Jan-02
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07
Apr-07
Jul-07
Oct-07
Jan-08
Apr-08
Jul-08
Oct-08
Jan-09
Apr-09
Jul-09
Oct-09
Date

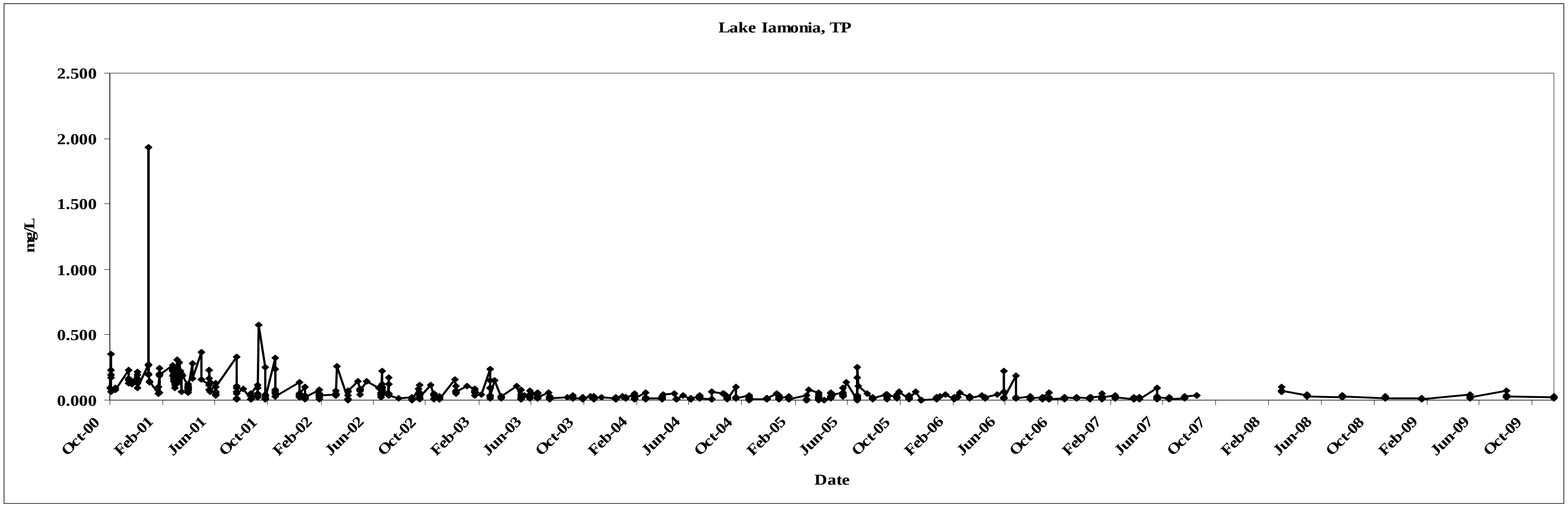
Lake Hall


Lake Hall, TN
mg/L
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Oct-00
Feb-01
Jun-01
Oct-01
Feb-02
Jun-02
Oct-02
Feb-03
Jun-03
Oct-03
Feb-04
Jun-04
Oct-04
Feb-05
Jun-05
Oct-05
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Date

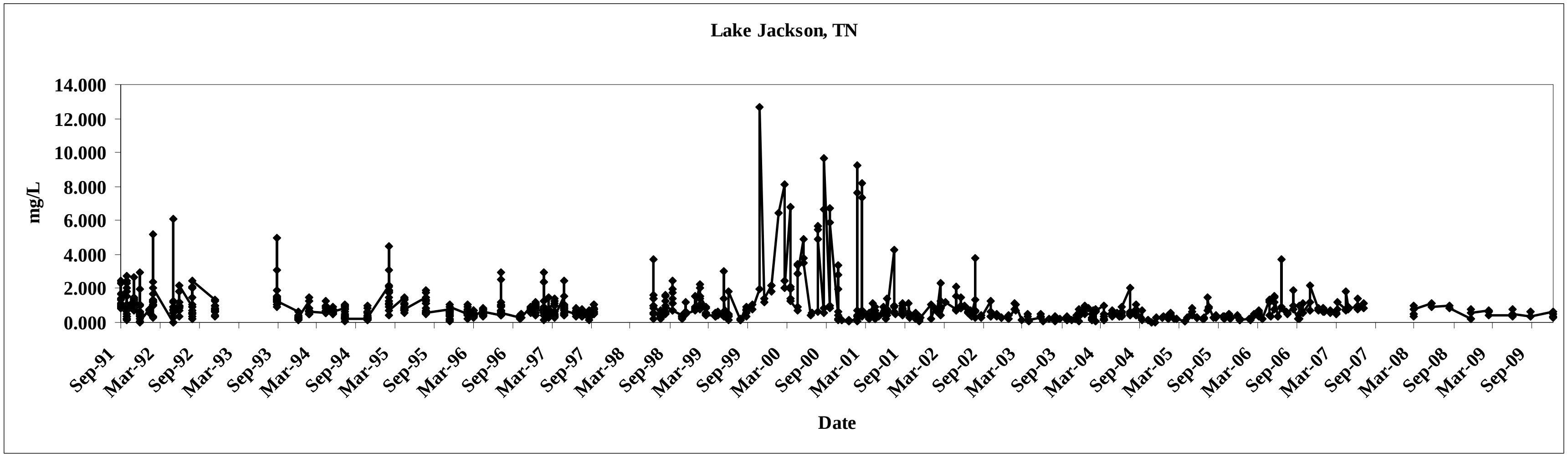

Lake Hall, TP
mg/L
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Oct-00
Feb-01
Jun-01
Oct-01
Feb-02
Jun-02
Oct-02
Feb-03
Jun-03
Oct-03
Feb-04
Jun-04
Oct-04
Feb-05
Jun-05
Oct-05
Feb-06
Jun-06
Oct-06
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Date

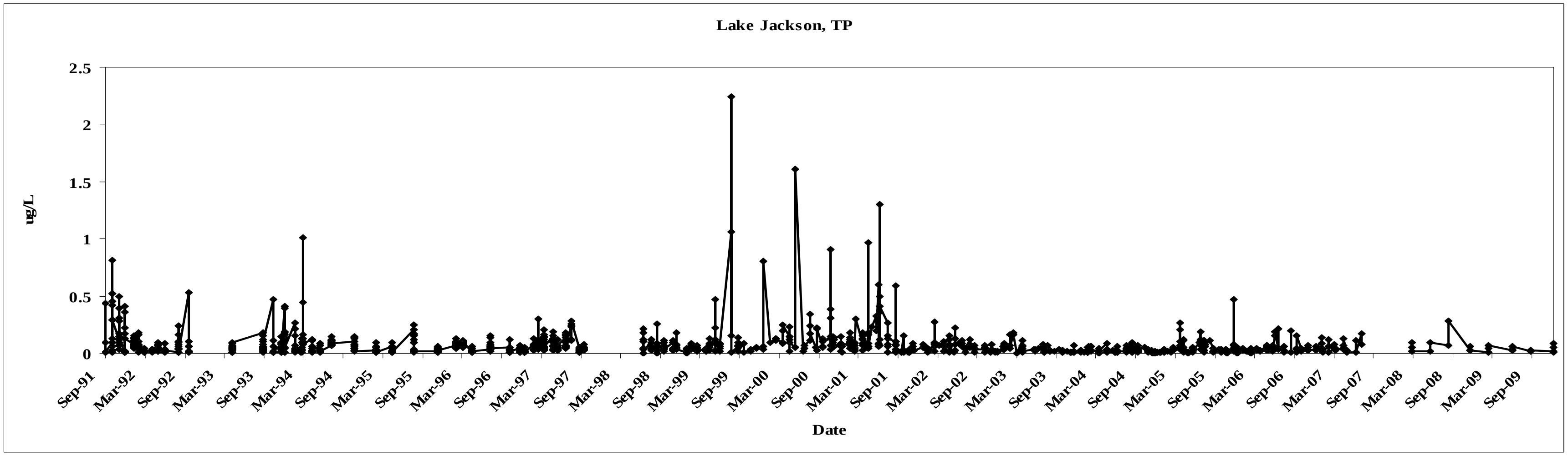
Lake Iamonia





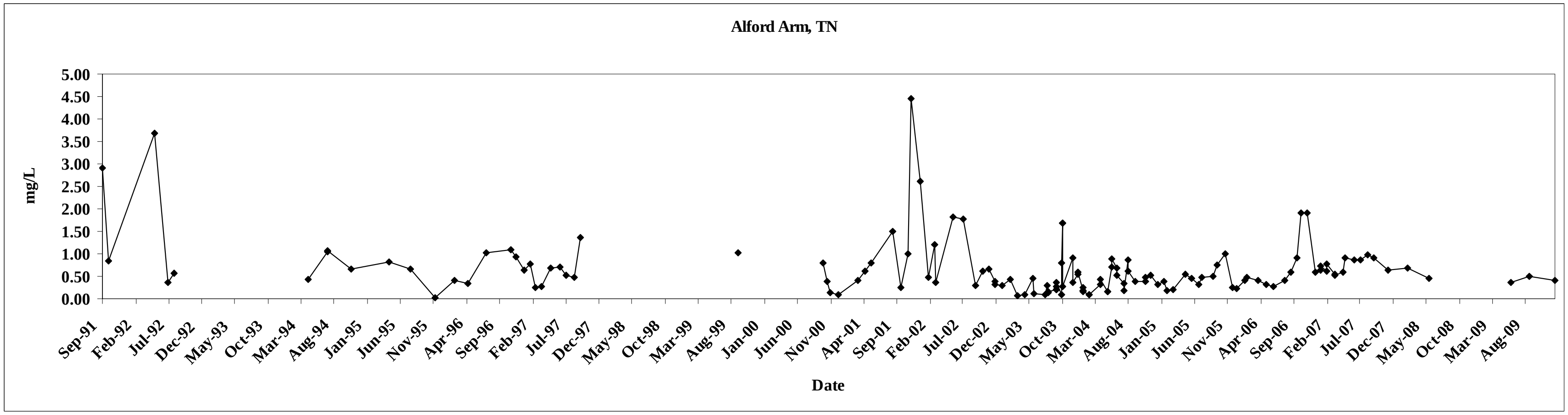
Lake Jackson

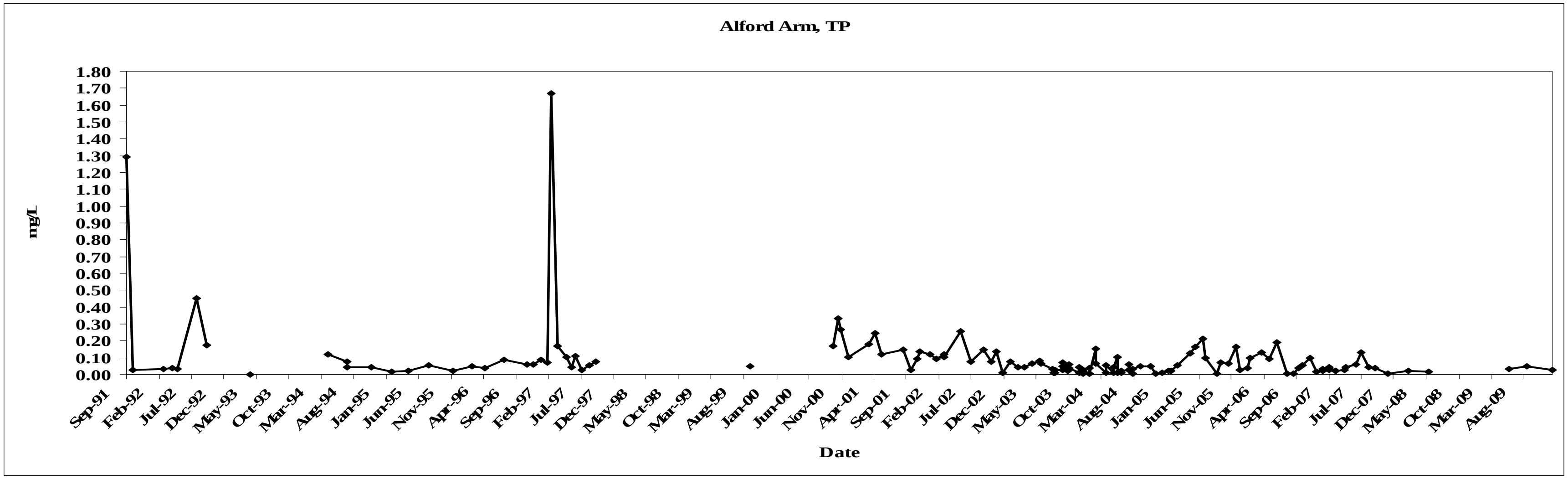




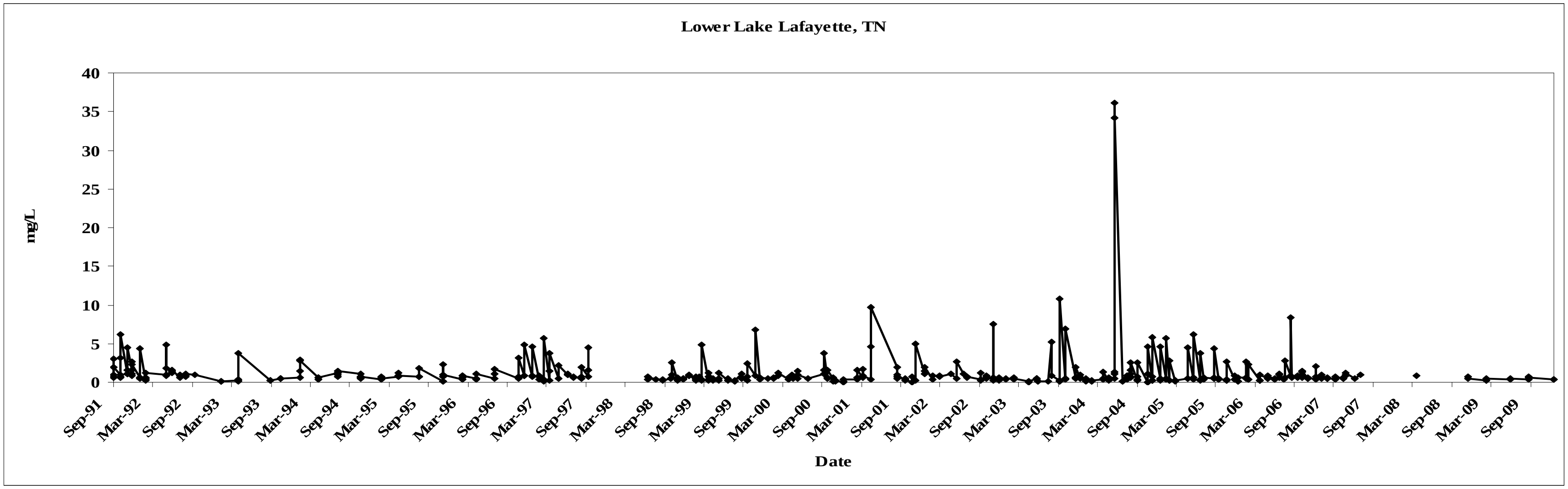
Lake Lafayette

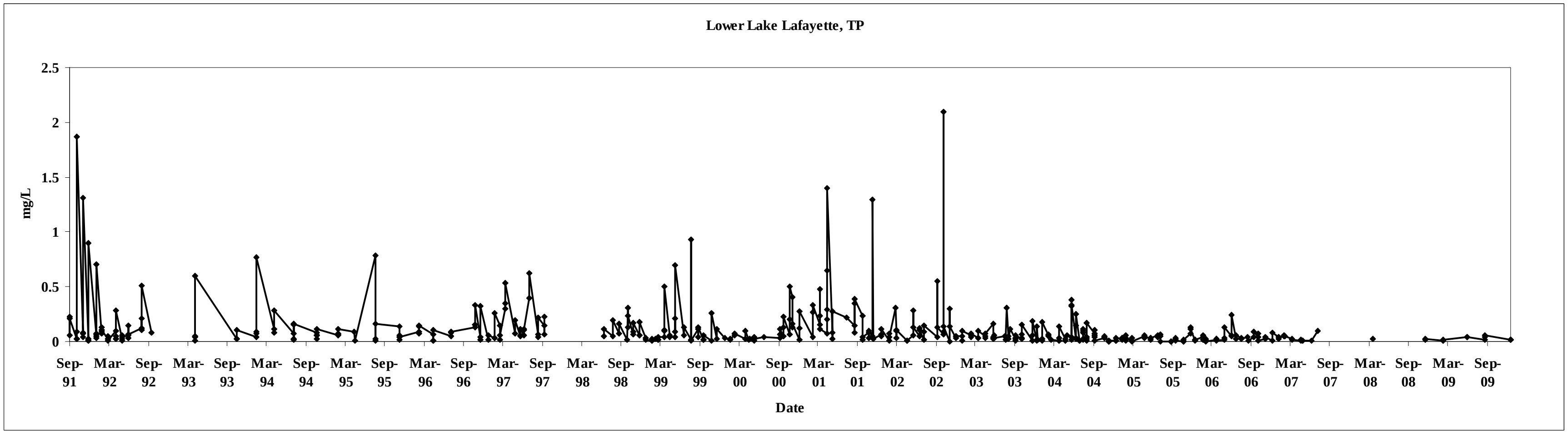
Alford Arm



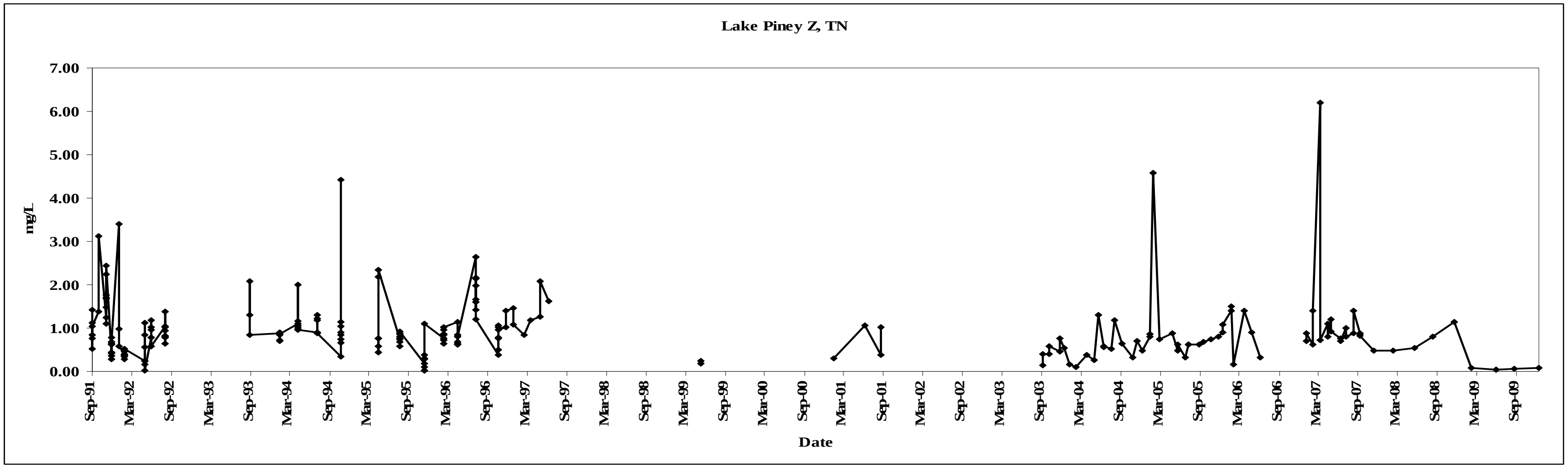


Lower Lake Lafayette

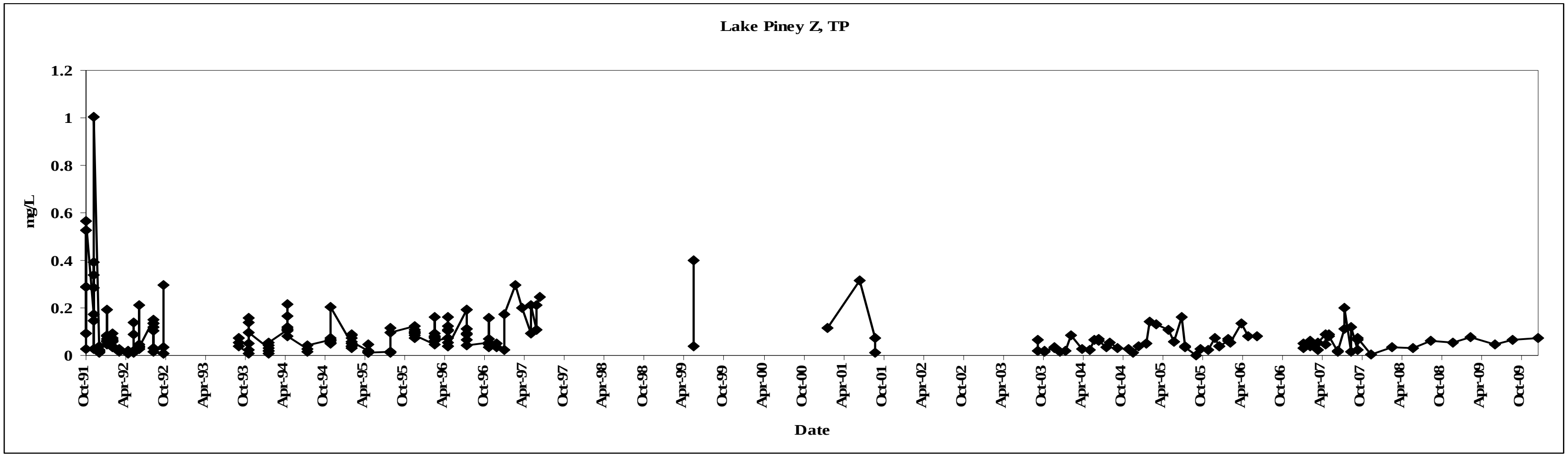




Lake Piney Z

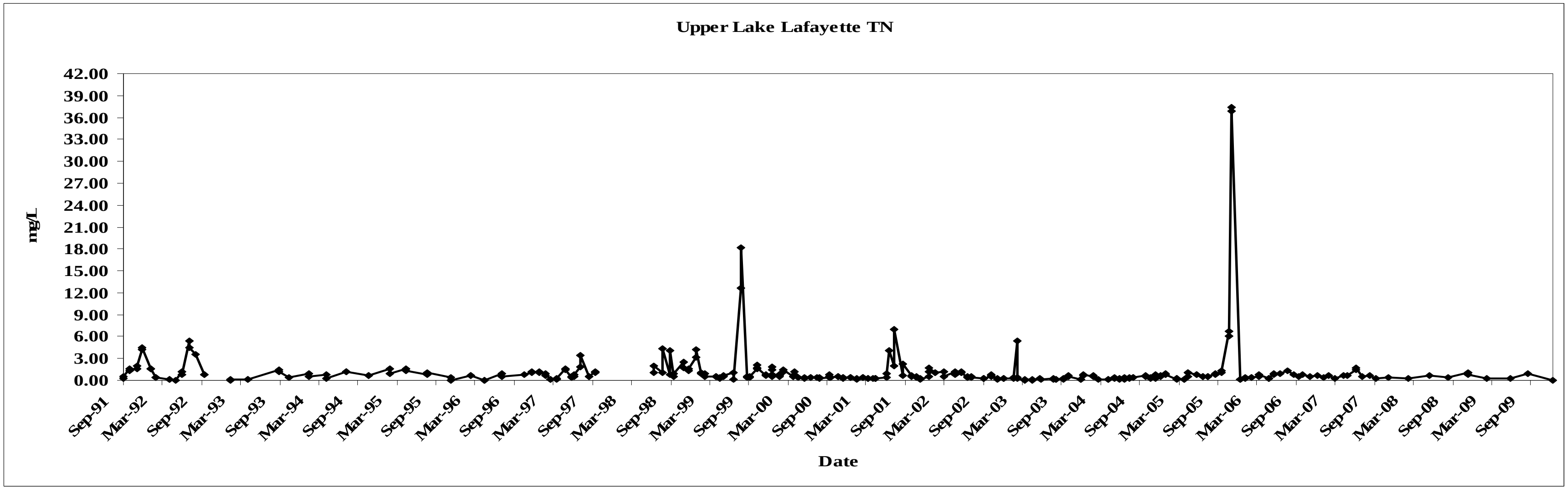


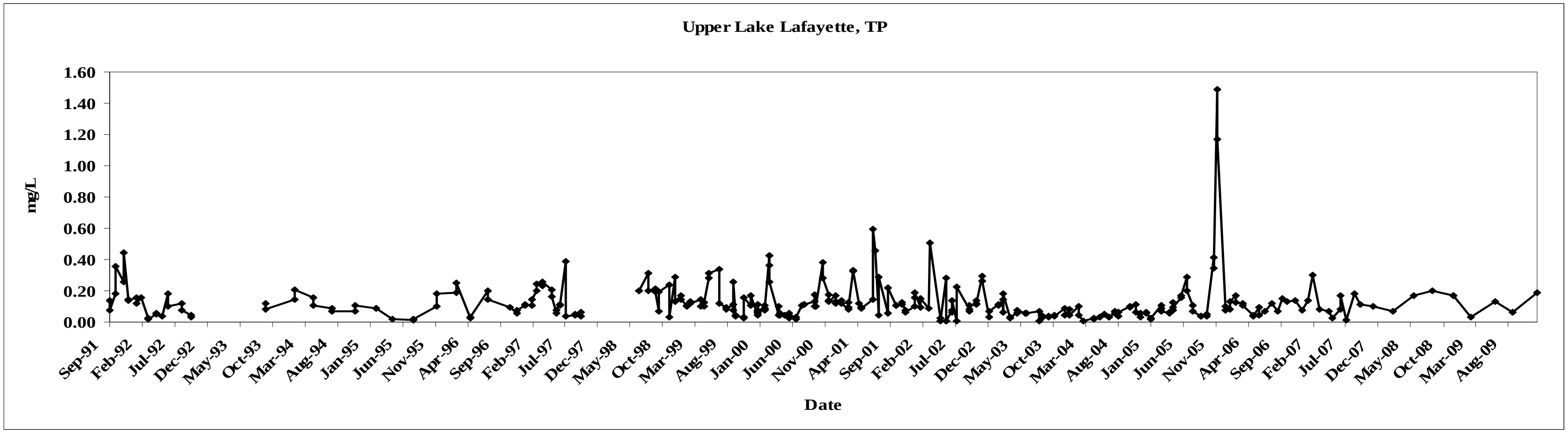
Lake Piney Z, TN
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
mg/L
Sep-91
Mar-92
Sep-92
Mar-93
Sep-93
Mar-94
Sep-94
Mar-95
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Sep-05
Mar-06
Sep-06
Mar-07
Sep-07
Mar-08
Sep-08
Mar-09
Sep-09
Date



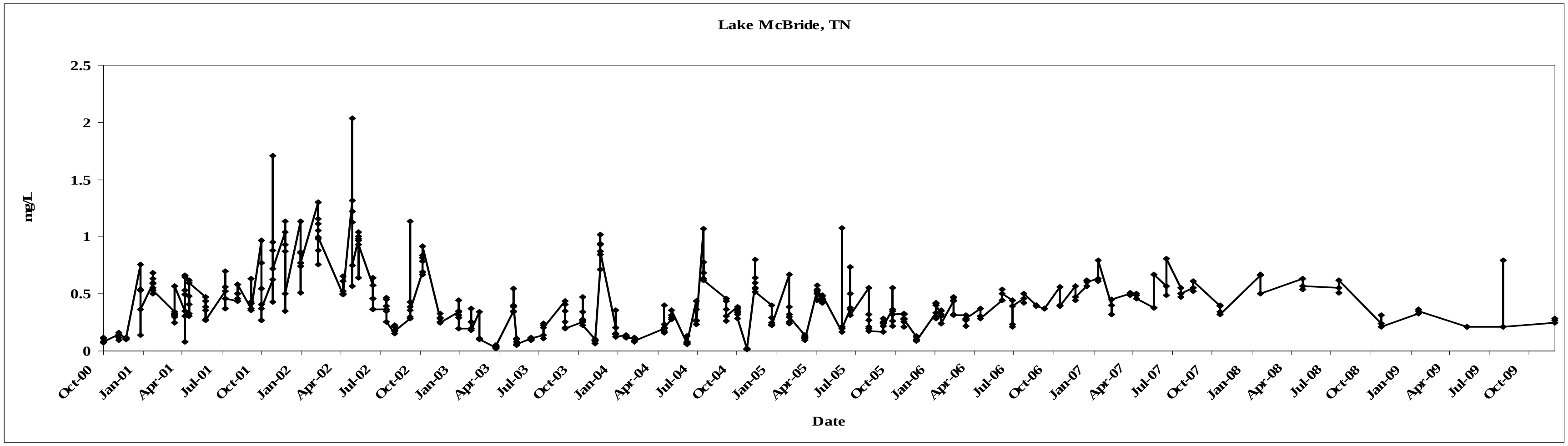
Lake Piney Z, TP
1.2
1
0.8
0.6
0.4
0.2
0
mg/L
Oct-91
Apr-92
Oct-92
Apr-93
Oct-93
Apr-94
Oct-94
Apr-95
Oct-95
Apr-96
Oct-96
Apr-97
Oct-97
Apr-98
Oct-98
Apr-99
Oct-99
Apr-00
Oct-00
Apr-01
Oct-01
Apr-02
Oct-02
Apr-03
Oct-03
Apr-04
Oct-04
Apr-05
Oct-05
Apr-06
Oct-06
Apr-07
Oct-07
Apr-08
Oct-08
Apr-09
Oct-09
Date

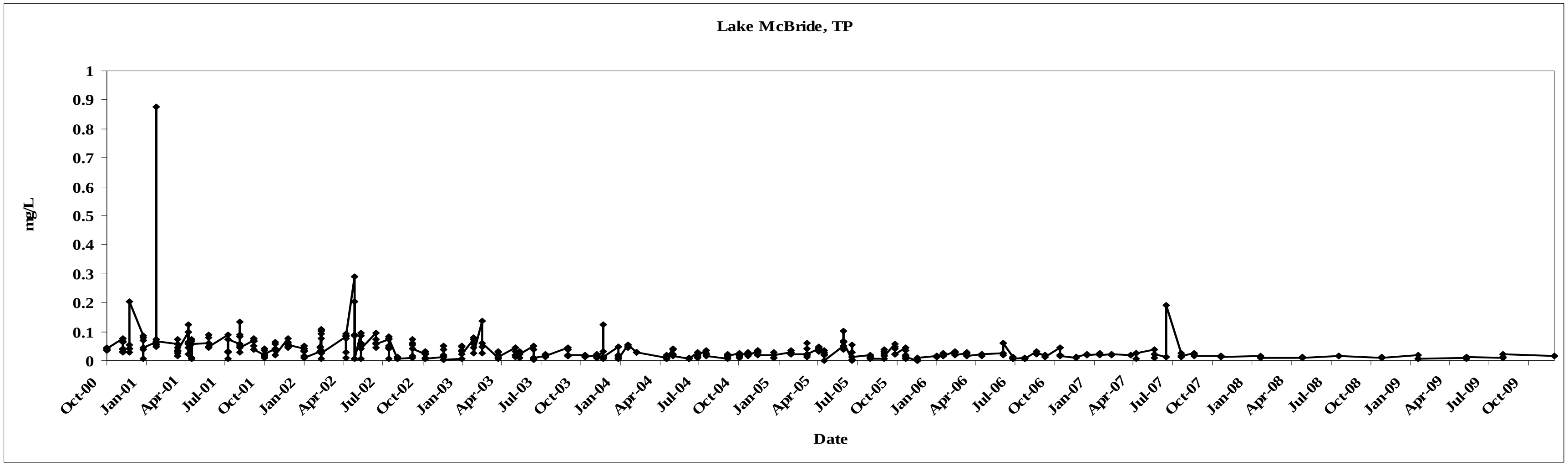
Upper Lake Lafayette



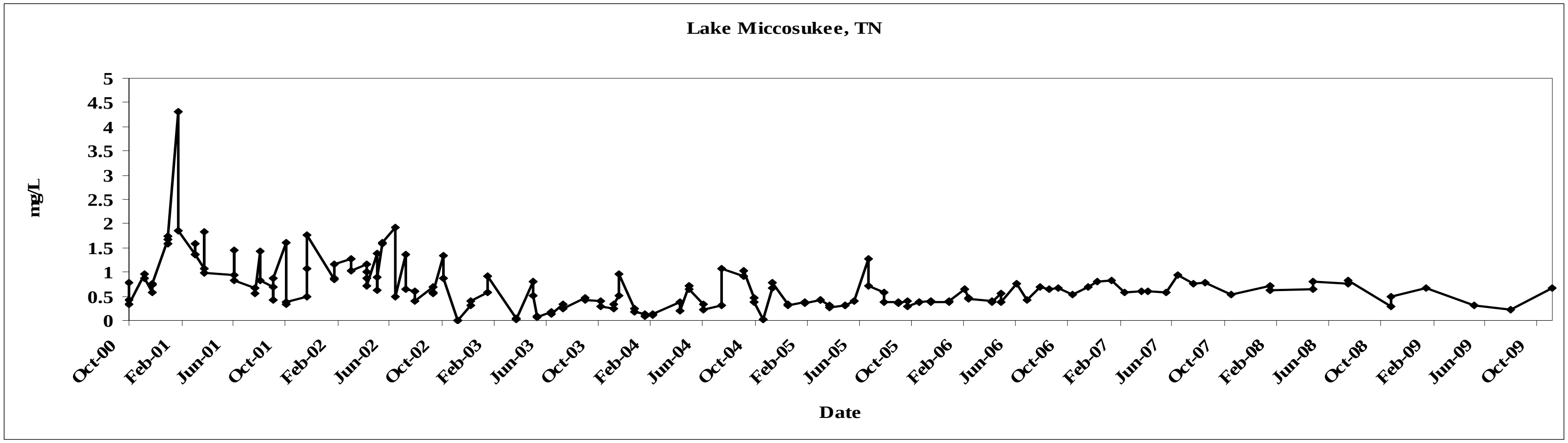


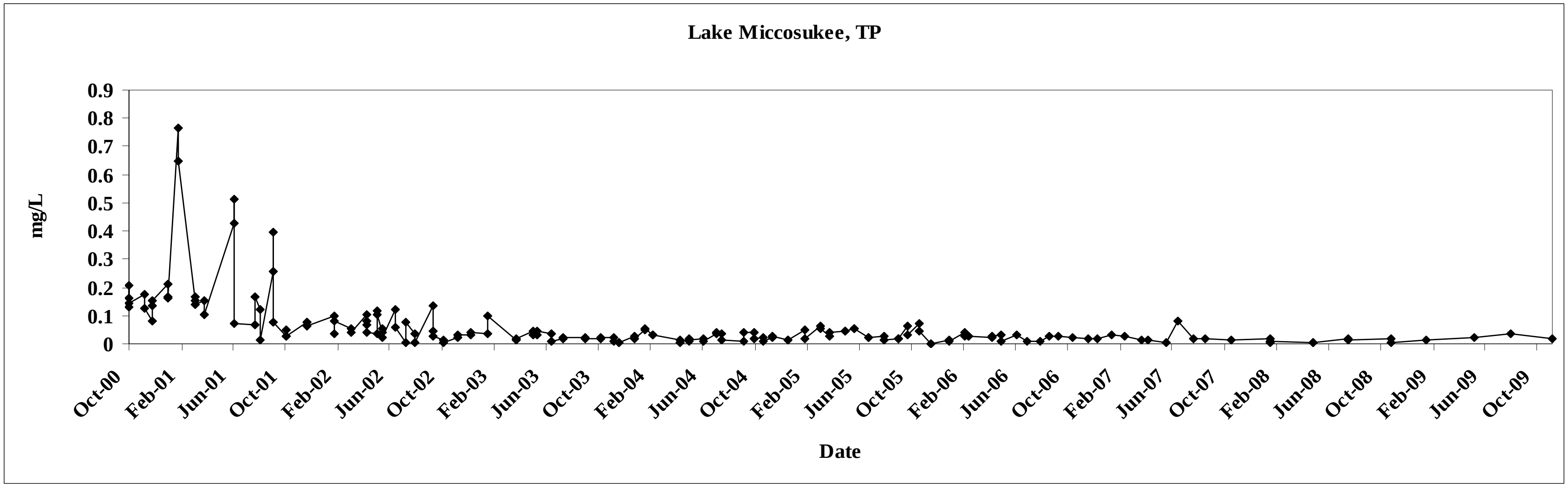
Lake McBride



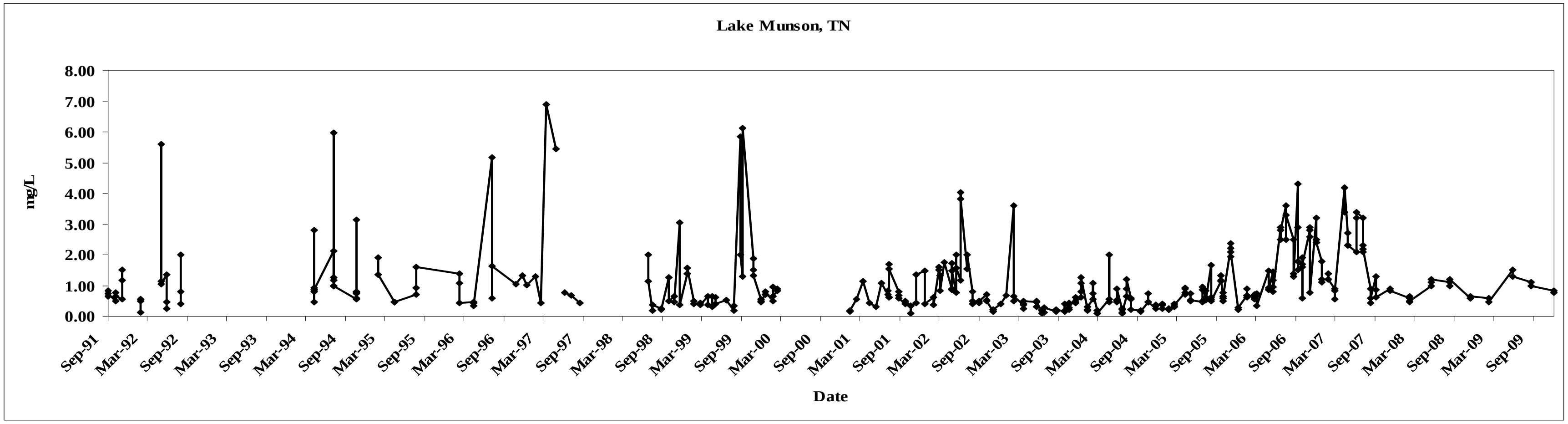


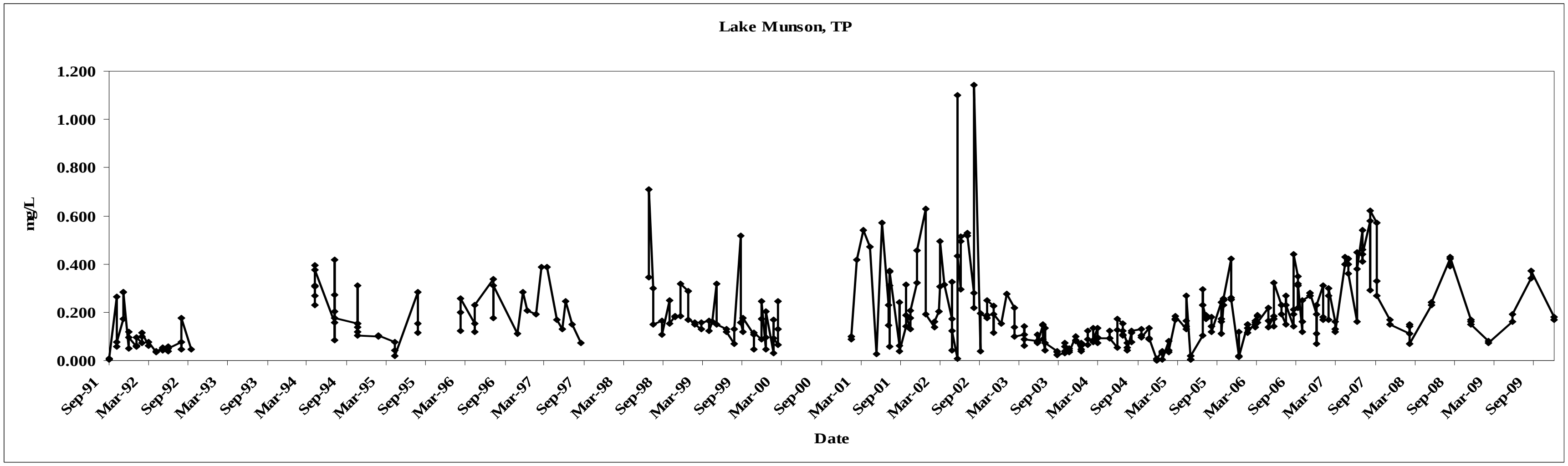
Lake Miccosukee



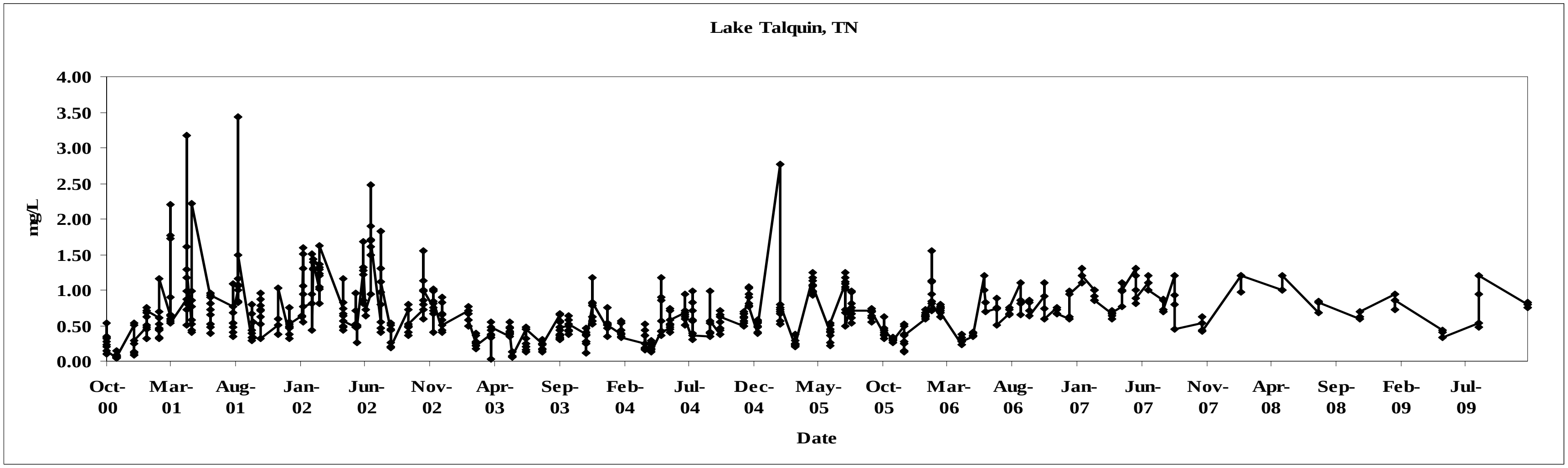


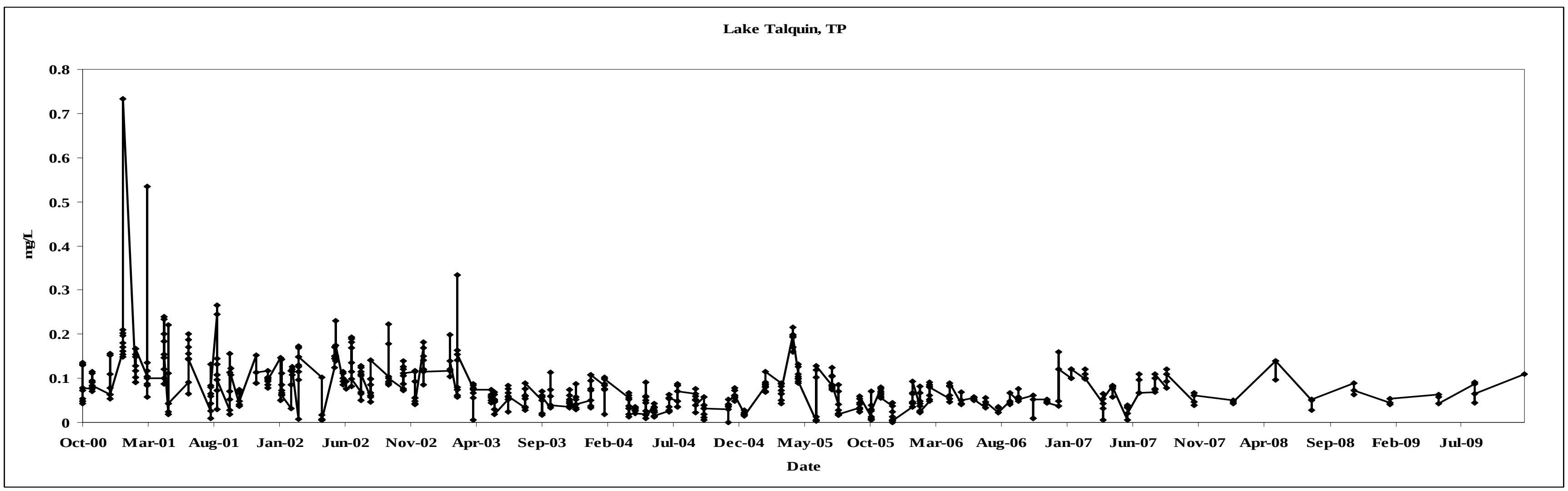
Lake Munson


Lake Munson, TN
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
mg/L
Sep-91
Mar-92
Sep-92
Mar-93
Sep-93
Mar-94
Sep-94
Mar-95
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Sep-05
Mar-06
Sep-06
Mar-07
Sep-07
Mar-08
Sep-08
Mar-09
Sep-09
Date

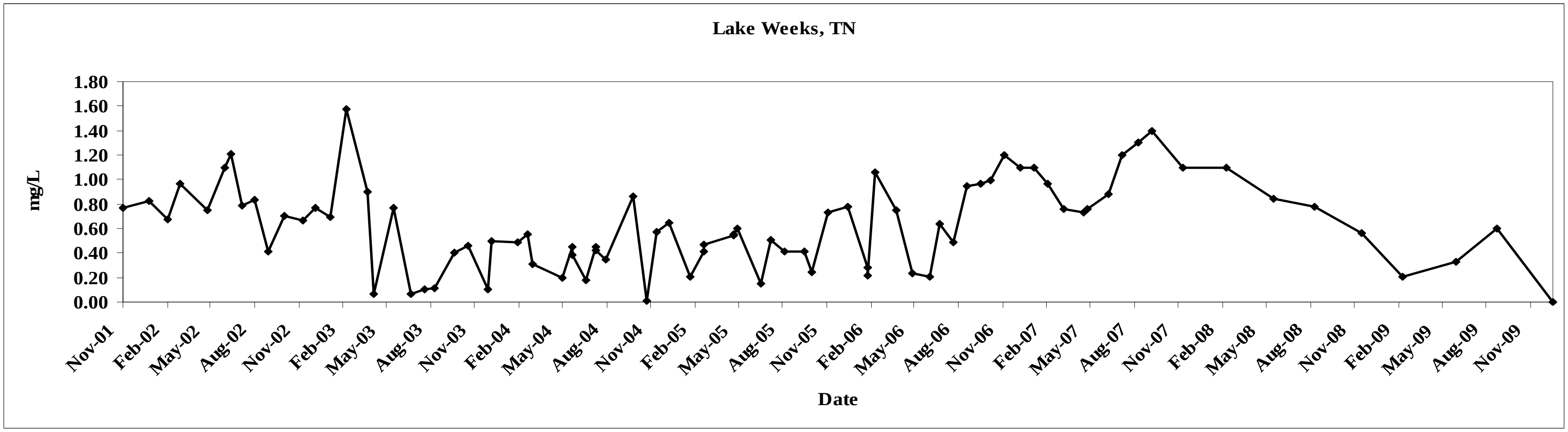

Lake Munson, TP
1.200
1.000
0.800
0.600
0.400
0.200
0.000
mg/L
Sep-91
Mar-92
Sep-92
Mar-93
Sep-93
Mar-94
Sep-94
Mar-95
Sep-95
Mar-96
Sep-96
Mar-97
Sep-97
Mar-98
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Sep-05
Mar-06
Sep-06
Mar-07
Sep-07
Mar-08
Sep-08
Mar-09
Sep-09
Date

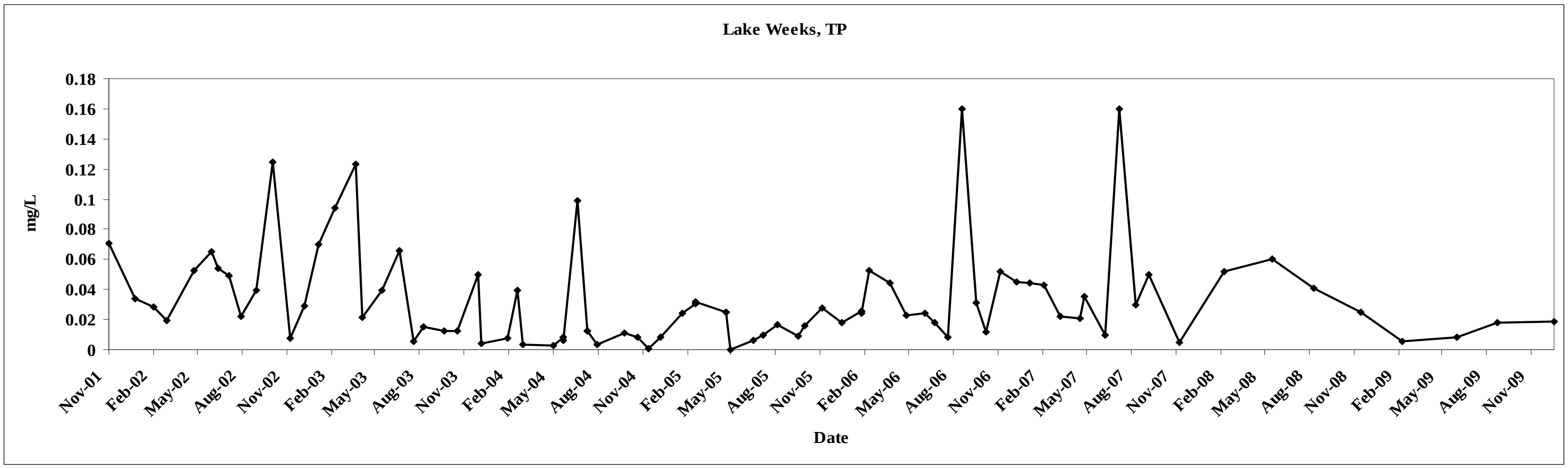
Lake Talquin





Lake Weeks


Lake Weeks, TN
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
mg/L
Nov-01 Feb-02 May-02 Aug-02 Nov-02 Feb-03 May-03 Aug-03 Nov-03 Feb-04 May-04 Aug-04 Nov-04 Feb-05 May-05 Aug-05 Nov-05 Feb-06 May-06 Aug-06 Nov-06 Feb-07 May-07 Aug-07 Nov-07 Feb-08 May-08 Aug-08 Nov-08 Feb-09 May-09 Aug-09 Nov-09
Date


Lake Weeks, TP
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
mg/L
Nov-01 Feb-02 May-02 Aug-02 Nov-02 Feb-03 May-03 Aug-03 Nov-03 Feb-04 May-04 Aug-04 Nov-04 Feb-05 May-05 Aug-05 Nov-05 Feb-06 May-06 Aug-06 Nov-06 Feb-07 May-07 Aug-07 Nov-07 Feb-08 May-08 Aug-08 Nov-08 Feb-09 May-09 Aug-09 Nov-09
Date

REFERENCES:

Allen, J., David. 2004. Landscapes and Riverscapes: The Influence of Land Use on Stream Ecosystems. In: Annu. Rev. Ecol. Evol. Syst. 35:257-84. Annual Reviews.

Anderson, N. H., and Cummins, K. W. 1979. The influence of diet on the life histories of aquatic insects. J. Fish. Res. Bd. Can. 36:335-342.

Camp, B., and Lake Iamonia Task Force. 1991. Lake Iamonia Management Plan. Leon County.

Carpenter, S., Caraco, N. F., Correll, D. L., Howarth, R. W., Sharpley, A.N., Smith, V. H. 1998. Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen. In: Issues of Ecology, Number 3. Washington, DC 20036.

Chen, Z.Q, Donoghue, J. F., Hess, D.W., Ragland, P.C., Milla, K. 1994. Geochemical history of Lake Miccosukee, Florida. Geological Society of America, Abstracts with Programs ; Vol/Issue: 26:4; 43. annual meeting of the Southeastern Section of the Geological Society of America; 7-8 Apr 1994; Blacksburg, VA (United States).

City of Tallahassee. 2008. Recycling an Old Power Plant. www.talgov.com.

Davies-Colley R.J., Vant W. N., Smith D. G. 2003. Colour and Clarity of Natural Waters: Science and Management of. Blackburn Press, Caldwell, NJ.

Davies, S. P. Jackson, S. K. 2006. The biological condition gradient: a descriptive model for interpreting change in aquatic ecosystems. Found in; Ecological Applications, 16(4), pp. 1251-1266.

Environmental Protection Agency. 1997. Volunteer Stream Monitoring: A Methods Manual. EPA 841-B-97-003.

Falconer, I. R. 2004. Cyanobacterial Toxins of Drinking Water Supplies. CRC Press, Boca Raton, FL.

Federal Register. 2007. Part II, Department of Interior, Fish and Wildlife Service. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Five Endangered and Two Threatened Mussels in Four Northeast Gulf of Mexico Drainages; Final Rule. Vol. 72, No. 220, Thursday, November 15, 2007, Rules and Regulations.

Florida Administrative Code (F.A.C.). 2007. Chapter 62-302 Surface Water Quality Standards.

Florida Administrative Code (F.A.C.). 2007. Chapter 62-303 Identification of Impaired Surface Waters.

Florida Department of Environmental Protection Webpage. Biological Assessment http://www.dep.state.fl.us/labs/biology/baintro.htm

Florida Department of Environmental Protection. ftp://ftp.dep.state.fl.us/pub/labs/assessment/library/docs/ecoassess.pdf

Florida Department of Environmental Protection; TMDL Program Overview. http://www.dep.state.fl.us/water/tmdl/docs/TMDL_Program_Overview.pdf.

Florida Department of Health. 2007. Your Guide to Eating Fish Caught in Florida. http://www.doh.state.fl.us/environment/community/fishconsumptionadvisories/2007eng_final_fish_eating_guide.pdf.

Florida LAKEWATCH 1999. A Beginner's Guide to Water Management – The ABCs. Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences, University of Florida/Institute of Food and Agricultural Sciences. University of Florida, Gainesville.

Florida LAKEWATCH 2000B. Information Circular #101. A Beginner's Guide to Water Management-Nutrients. Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences, University of Florida/Institute of Food and Agricultural Sciences. University of Florida, Gainesville.

Forsberg, C., Ryding, SO. 1980. Eutrophication parameters and trophic state indices in 30 Swedish waste-receiving lakes. Arch Hydrobiol 89:189-207.
Gallagher, T. 2007. Lake Talquin Water Quality Assessment Technical Report. Draft.

Gardner, T. 1991. Lake Jackson Aquatic Preserve Management Plan. Bureau of Submerged Lands and Preserves Division of State Lands. http://www.dep.state.fl.us/coastal/downloads/management_plans/aquatic/LakeJackson.pdf.

Gilbert, D. Wieckowicz, R., Kang, Woo-Jun, Wilcox, E. G., Ralys, B. Nutrient, Dissolved Oxygen, Turbidity, and Un-ionized Ammonia TMDLs for Munson Slough/Lake Munson Watershed WBIDs 807, 807C, and 807D. 2009 http://www.dep.state.fl.us/water/tmdl/draft_tmdl.htm.

Gordan, N., McMahon, T., Finlayson, B., Gippel, C., Nathan, R. 2004. Stream Hydrology, an Introduction for Ecologists. John Wiley and Sons Ltd. The Atrium, Southern Gate, Chichester, West Sussex, England.

Manahan, S. E. 1991. Environmental Chemistry, 5th Edition. Lewis Publishers, Inc., Chelsea Michigan.

Maristany, A. E., Bartel, R. L. 1989. Wetland and Stormwater Management: A case study of Lake Munson Part I: Long-term treatment efficiencies. Wetlands: Concerns and Successes, American Water Resources Association.

Northwest Florida Water Management District. 2006. Surface Water Improvement and Management Program; Priority List for the Northwest Florida Water Management District. Northwest Water Management District, 81 Water Management Drive, Havana, FL 32333. www.state.fl.us/nwfwmd/.

Phlips, E. J., Cichra, M., Aldridge, F. J., Jembeck, J. 2000. Light availability and variations in phytoplankton standing crops in a nutrient-rich blackwater river. Limnology Oceanography, 45(4), 916-929. American Society of Limnology and Oceanography, Inc.

Resh, Vincent H., Myers, Marilyn, J., Hannaford, Morgan, J. 1996. In: Methods of Stream Ecology. Editors; Hauer, Richard., Lamberti, Gary, A. Academic Press, Orlando, FL.

Riley, Ann L. 1998. Restoring Streams in Cities; A guide for Planners, Policymakers, and Citizens. Island Press, Washington, D.C., Covelo, California.

Rosenberg, David, M., Resh, Vincent, H. 1996. In: An Introduction to the Aquatic Insects of North America. Editors; Merritt, R. W., Cummins, K., W. Kendall/Hunt Publishing Company, Dubuque, IA.

St. Johns River Water Management District. 2005. Blue-green algae in Florida Waters. http://www.sjrwmd.com/publications/pdfs/fs_algae.pdf.

Stormwater Center http://www.stormwatercenter.net

United States Environmental Protection Agency; Intro to TMDLs www.epa.gov/owow/tmdl/intro.htm.

Walsh, C. J., Roy, A. H., Feminella, J. W., Cottingham, P. D., Groffman, P. M., Morgan II, R. P. 2005. The urban stream syndrome: current knowledge and the search for a cure. Journal of the North American Benthological Society 24(3): 706-723.

Wetzel, R. 2001. In: Limnology; Lake and River Ecosystems, Third Edition. Academic Press, San Diego, CA.

Wieckowicz, R., Wilcox, E. G., Ralys, B. TMDL Report. Fecal Coliform TMDL for Black Creek Watershed WBID 1024. 2008. http://www.dep.state.fl.us/water/tmdl/final_tmdl.htm.

Wieckowicz, R., Wilcox, E. G., Ralys, B. TMDL Report. Fecal Coliform TMDL for Munson Slough Watershed, WBID 807D. http://www.dep.state.fl.us/water/tmdl/final_tmdl.htm.

World Resources Institute, United Nationas Environment Programme, United Nations Development Programme, and the World Bank. 1998. From: World Resources 1998-99:

Environmental change and human health. http://www.wri.org/publication/world-resources-1998-99-environmental-change-and-human-health#.

GLOSSARY OF TERMS

303(d) list	List of Florida's water bodies that do not meet or are not expected to meet applicable water quality standards with technology based controls alone.
305(b) report	Section 305(b) of the Clean Water Act requires states to report biennially to the USEPA on the quality of the water in the state.
Algal Blooms	Rapid increase in the algae population in an aquatic ecosystem that can adversely affect water quality.
Alkalinity	Measure of the buffering capacity of water, or the capacity of bases to neutralize acids.
Aquatic Macrophyte	Aquatic plants that are large enough to be apparent to the naked eye.
Basin	Whole geographic area having a common outlet (such as river, stream, or lake) for its surface runoff.
Biochemical oxygen demand (BOD)	Measure of the quantity of oxygen consumed by microorganisms during the decomposition of organic matter.
Biological Productivity	Measure of growth in living systems.
Biota	All living organisms found in a given area.
Chlorophyll a	Is the primary photosynthetic pigment of all oxygen-evolving photosynthetic organisms and is present in all algae and cyanobacteria.
Clean Water Act (CWA)	Establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Under the CWA, USEPA has implemented pollution control programs such as setting wastewater standards for industry, and setting water quality standards for contaminants in surface waters.
Color	The appearance of objects (or light sources) described in terms of a person's perception of their hue and lightness (or brightness) and saturation. Color in water usually results from the decay of organic matter, including cypress needles, etc (blackwater). or as the result of minerals dissolved or suspended in the water.
Dissolved Oxygen % Saturation	The percentage of dissolved O_2 concentration relative to that when completely saturated at the temperature of the measurement depth.
Dissolved Oxygen (DO)	The amount of oxygen present in the water.

Eutrophication	The process in which a body of water becomes rich in nutrients resulting in excessive plant growth and oxygen depletion. This can occur through natural or man-made processes.
Fecal Coliforms	Type of bacteria that originate from the feces of warm blooded animals. Usually a strong indicator of pollution or possible pathogenic bacterial contamination.
Habitat Assessment	A method used to evaluate eight attributes that are known to have potential effects on stream biota. Attributes include; substrate diversity, substrate availability, water velocity, habitat smothering, artificial channelization, bank stability, riparian buffer zone width, and riparian zone vegetation quality.
Invertebrate	An animal without a backbone.
Limiting Nutrient	A nutrient that determines plant growth but is available in quantities smaller than needed for algae and aquatic plants to increase their abundance.
Macroinvertebrate	An animal without a backbone large enough to be seen without a microscope.
National Pollutant Discharge Elimination System (NPDES)	A program established under the Clean Water Act to control the discharge of pollutants to surface waters from point sources.
Nitrogen, Total	A measure of all the inorganic and organic forms in water.
Non-Point Source	Diffuse runoff without a single point of origin that flows over the surface of the ground by stormwater and is introduced to surface or groundwaters.
Polychlorinated biphenyl (PCB)	PCBs were used as coolants and insulating fluids in transformers and capacitors, and were banned in the 1970s due to their high toxicity. They are very persistent in the environment and bioaccumulate in animals.
pH	The measure of the acidity or alkalinity of a solution. The measurement ranges from 0 (acidic) to 14 (alkaline) with neutral being 7.
Phosphorus, Total	The measure of the inorganic and organic forms of phosphorus in a water sample.
Point Source	An identifiable and confined discharge point for one or more water pollutants, such as pipe, channel, vessel, or ditch.
Pollutant	Substance introduced into the environment that adversely affects the usefulness of a resource or

the health of animals, plants, and/or ecosystems

Pollution	An undesirable change in the natural environment caused by the contamination of harmful substances that can adversely affect the health or activities of humans or other living organisms.
Specific Conductance	Measure of how well water can conduct an electrical current.
Stream Condition Index (SCI)	A composite macroinvertebrate index made up of several of the measurements including; taxa richness, ephemeroptera taxa, trichoptera taxa, % filterer, long-lived taxa, clinger taxa, % dominance, % tanytarsini, sensitive taxa.
TN/TP ratio	The ratio of total nitrogen (TN) to total phosphorus (TP).
Total Dissolved Solids (TDS)	Are solids that pass through a 0.45 micrometer filter.
Total Maximum Daily Load (TMDL)	A tool for implementing state water quality standards and are based on the relationship between pollutants and in-stream water quality conditions.
Total Suspended Solids (TSS)	Are solids in water than can be trapped by a filter (usually with a pore size of 0.45 micrometers).
Trophic Levels	Energy levels or steps in a food chain or food web, i.e., primary producer, primary consumer, secondary consumer, tertiary consumer and so forth.
Trophic State Index (TSI)	Measures the potential for biological productivity, usually algal growth, and is used to indicate the water quality of lakes. Its components include total nitrogen, total phosphorus, and chlorophyll *a*.
Turbidity	The amount of particulate matter such as clay, silt, finely divided organic matter, or plankton that is suspended in water.
Water Quality Standards	State-adopted and EPA-approved ambient standards for water bodies. The standards prescribe the use of the water body (such as drinking, fishing and swimming, and shellfish harvesting) and establish the water quality criteria that must be met to protect designated uses.
Watershed	Subset of basin. The land area that drains into a single stream.