Welcome to the Florida Lakes and Ponds Guide

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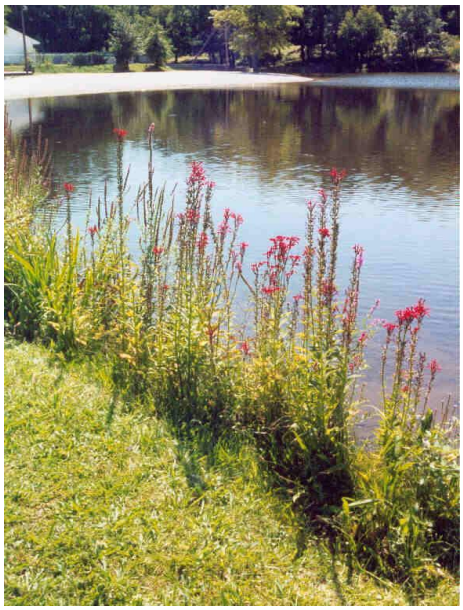
Florida has thousands of lakes and ponds that provide opportunities for recreation and valuable habitat for a wide diversity of plants and animals. However, over the years, many citizens of Florida have observed a decline in the health of their lakes and ponds. By choosing to read this guide you are taking the first step towards protecting your lake or pond. This manual is a starting point for concerned citizens who wish to learn about *lake ecology* and ways they can protect the future of their lake or pond.



The first two chapters will help you understand the basic concepts of watersheds and the *ecology* of lakes and ponds. It covers the importance of a watershed approach to lake and pond protection and the ecology and cycles within a lake system. The following chapters address the main causes of reduced water quality and outline ways that you, as a concerned citizen, can adopt a proactive role in preventing further degradation to our waterbodies. The last section provides guidance for people who wish to go one step further and begin or join a lake association, apply for grant or obtain additional education publications. Words in italics are defined in the glossary in the back of the book.

Act now and protect your lake's future!

The water of our planet is stored in many areas.

94% fills our oceans,

2% remains trapped in glaciers and snowcaps, 4% lies under ground,

and only 0.1% of all the water on the Earth is fresh surface water.

It is crucial for citizens to work toward the protection of this precious and vulnerable resource.

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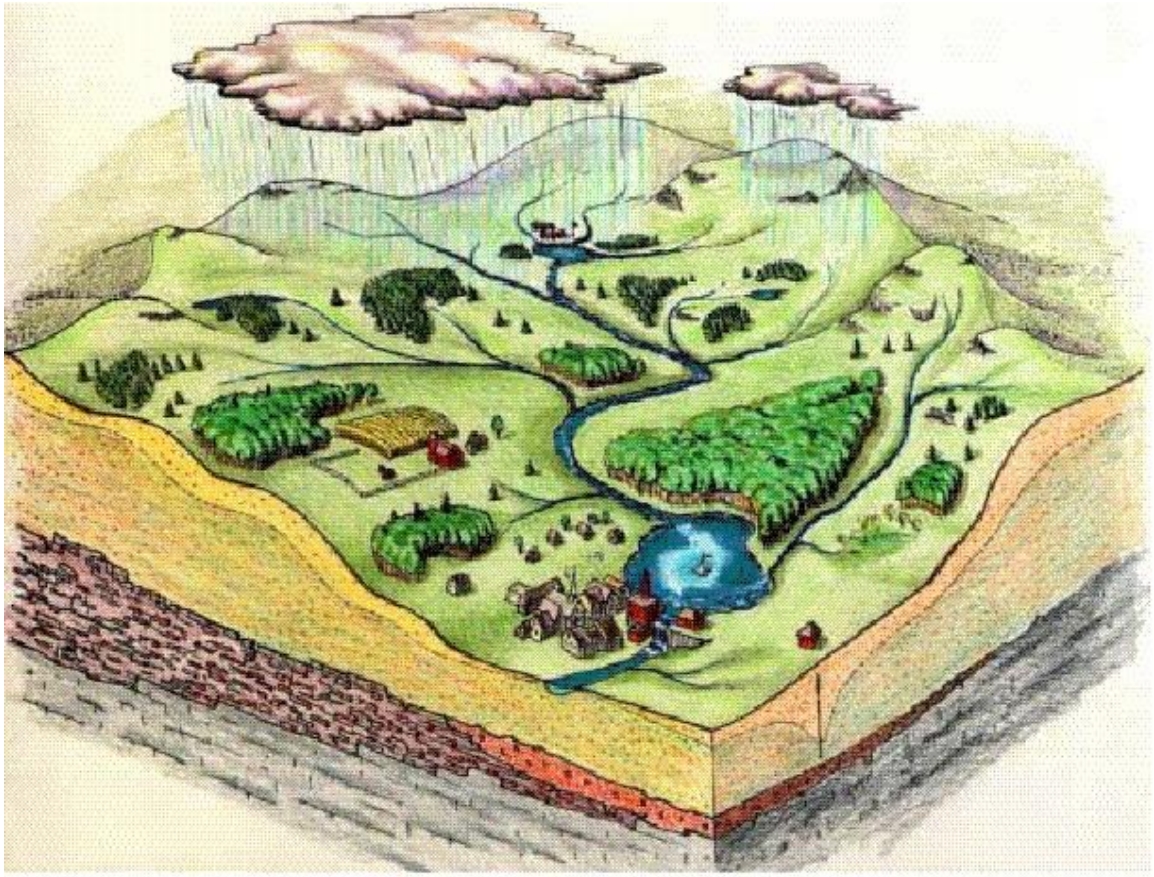
In the 1800's, Henry David Thoreau, inspired by Walden Pond, wrote, "*A lake is the landscape's most beautiful and expressive feature. It is earth's eye; looking into which the beholder measures the depth of his own nature*."

More than one hundred years later, residents and visitors continue to be inspired by the scenic lakes of Florida. There are thousands of lakes and ponds in Florida that provide drinking water, flood control, irrigation, aesthetic value, recreation and habitat for fish and wildlife. The lake environment creates a diverse habitat for wildlife and provides a home for hundreds of animals, including threatened species. Today, the future of many of Florida's lakes is at stake. Aquatic nuisance species, pollution, shoreline and watershed development and stormwater issues threaten the health of our lakes. In many lakes, the rate of *succession* has accelerated and is causing them to become "old" before their time. It is critical that citizens become involved and take an active role in improving the health of their lakes and protecting these valuable resources for future generations. This guide was created to provide information and guidance for concerned citizens who wish to secure a safe future for their lakes.

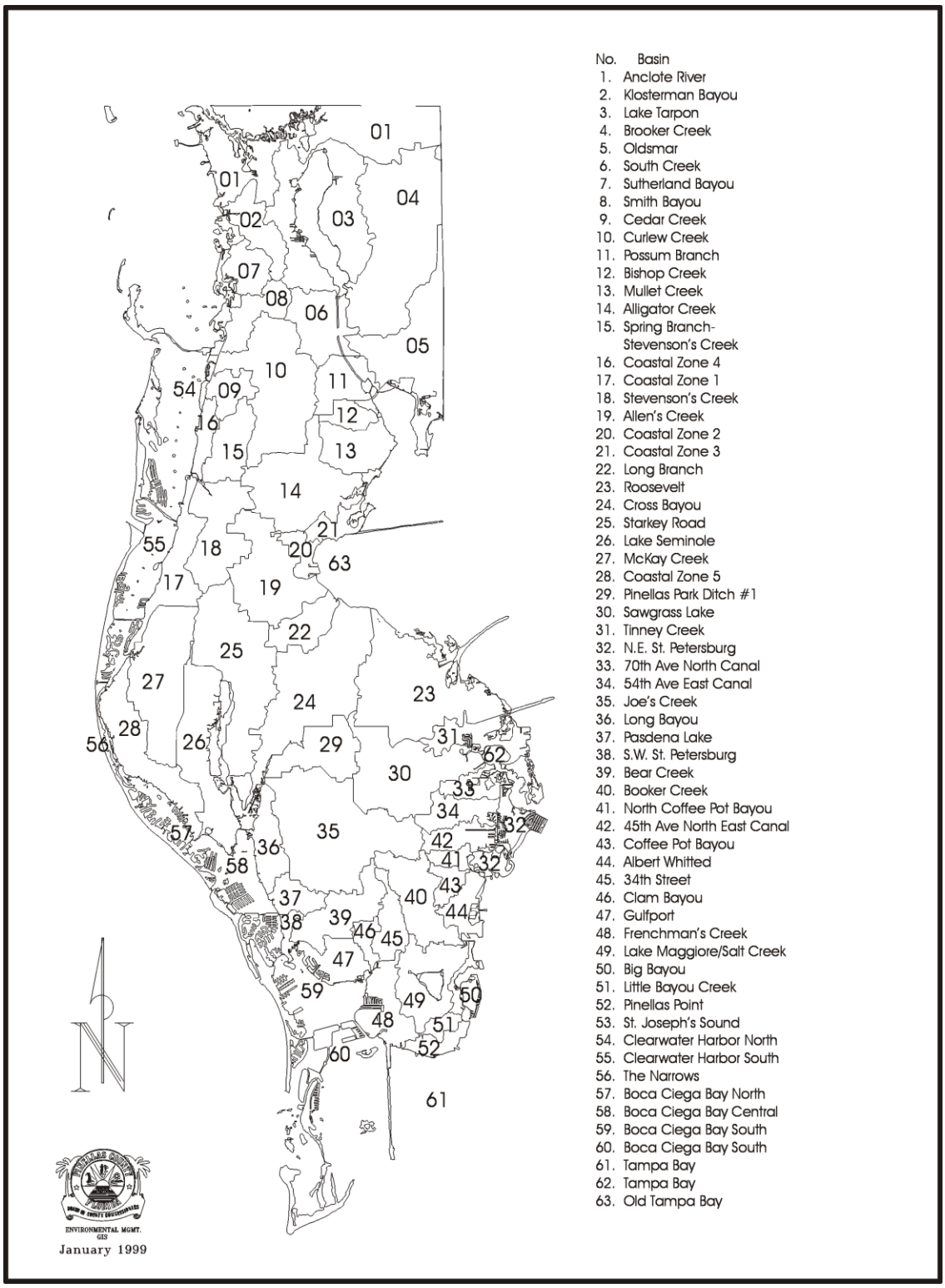
Understanding Watersheds



Chapter 1
What is a Watershed?

A watershed is an area of land from which water drains into a particular river or other surface waterbody. The boundaries of a watershed are determined by higher areas of land, which separate it from adjacent watersheds. There are 30 watersheds in Florida and within each of the major watersheds are the smaller watersheds of each lake or pond. Within each lake or pond's watershed all the water in that area flows to the lowest point and enters the lake or pond.
In Florida, under natural conditions, approximately 50% of rainfall evaporates, the rest either infiltrates back into the ground or runs off over land. The precipitation that seeps down into the earth replenishes the *groundwater* supply. Any pollutants or toxins that are not filtered out can contaminate the groundwater. About 96% of all the drinkable water on the planet is stored in groundwater and over half of all Americans rely on groundwater for their drinking supply. Groundwater is primarily stored in aquifers and moves very slowly. Any toxins that enter the groundwater move beneath the earth as a toxic plume waiting to discharge into a lake, stream or well.
In other areas, where soils are less porous or where the land has been paved, less water soaks into the ground and water travels primarily over the surface as *run-off*. Since all the land in a watershed drains water into a lake or stream, every activity in that watershed ultimately has an effect on the lake or stream. Picture a drop of water falling near the summit of a mountain. As the droplet begins to travel down the mountainside it may pick up sediment and oil residue as it trickles over a road. The droplet continues to wind its way downward through a garden collecting pesticide residues, fertilizer and waste from a pet, and eventually enters a lake, stream or pond. This type of pollution is called *non-point source pollution* because the pollution did not enter the lake from a single identifiable location, such as a pipe, instead, the pollution came from multiple locations. When trying to maintain a healthy lake it is important to monitor all the activities within the watershed and to prevent nutrients, such as phosphorus, sediments and other forms of pollution from draining into a lake. This topic is covered in greater detail in Chapter Three.

What is Your Watershed Address?



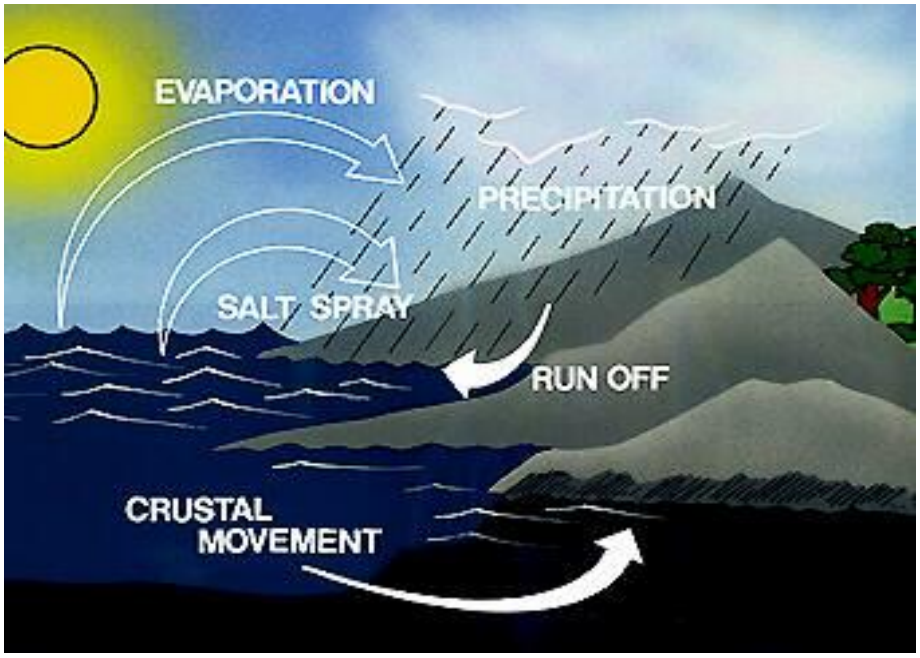
Chapter 2

Lake and Pond Basics

- **Hydrological Cycle**
- **Solar Radiation**
- **Oxygen & Nutrients**
- **Understanding pH**
- **Living Components**
- **Eutrophication/Enrichment**

Hydrological Cycle

Water enters lakes and ponds in a variety of ways, but precipitation is the largest factor determining most lake levels in Florida. A large portion of precipitation re-enters the atmosphere through evaporation and transpiration of plants. Some rainfall flows overland as stormwater run-off through one of the 30 watersheds in Florida to enter streams and lakes. A portion of precipitation soaks into the ground and travels beneath the surface as groundwater. Changes on the earth's surface, including paving and construction, alter the amount of rainfall that can filter down in the soil to refill the water table, thus affecting the hydrology of the area. Although dams can help maintain water levels, fluctuations in the lake levels are normal. The underlying geology of a lake is another important factor in determining the source of water to lakes. The properties of the underlying bedrock determine whether water will seep down into the water table or be retained in the lake.



Solar Radiation

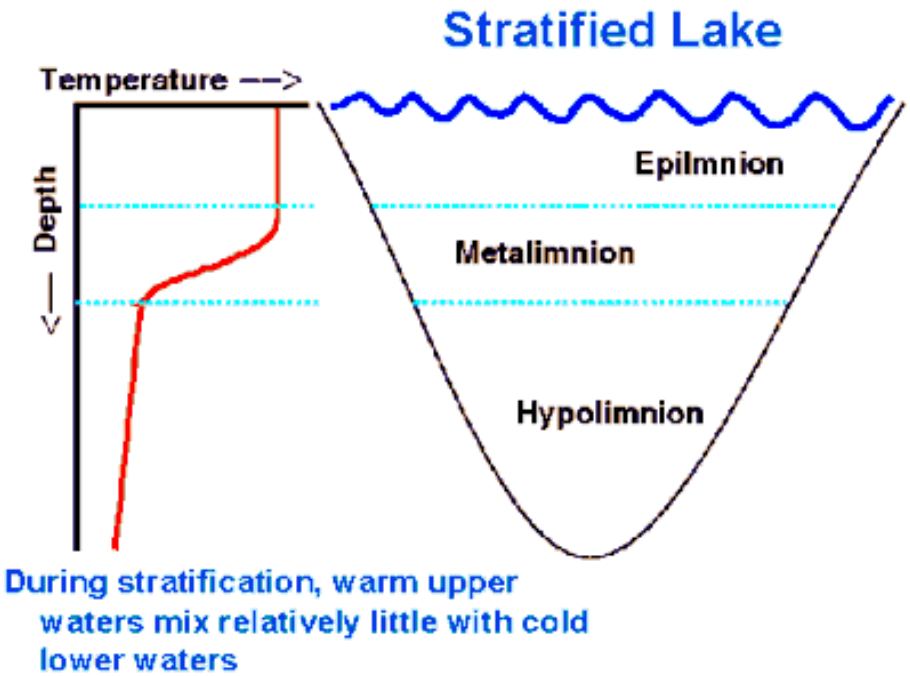
Solar radiation affects a lake in many ways: warming water to create thermal stratification and seasonal “circulation”, creating the wind patterns that mix lake waters and providing energy for photosynthesis.

Thermal Stratification

During certain seasons deeper lakes have thermal layers within them due to temperature variations in the water. Stratification is a reflection of the variations in water density. The density of water changes with temperature; usually, cooler denser water sinks, warmer water rises. During the spring, lakes thaw and the surface water is warmed. Eventually this warmer water mixes with deeper waters and creates a turnover *or circulation period*. The stratification becomes more defined as summer progresses and three distinct layers develop in ponds with adequate depth (See diagram). The top layer, or epilimnion, is the layer of greatest productivity due to warmer temperatures and abundant light. The middle layer, called the metalimnion, has a rapid temperature change that helps to form a physical barrier, called the thermocline, between the top and bottom layers. Although the barrier is not visible, the difference in the water densities is strong enough to prevent mixing of water, chemicals and gases (including dissolved oxygen) between the upper and lower layer. The waters in the deepest layer, the hypolimnion, are relatively cool, usually with lower dissolved oxygen and little light. When you dive down into a thermally stratified lake or pond you may feel the changes in temperature as you pass through the three thermal layers. During the fall, the layers dissipate as the surface water cools and eventually the layers mix together.

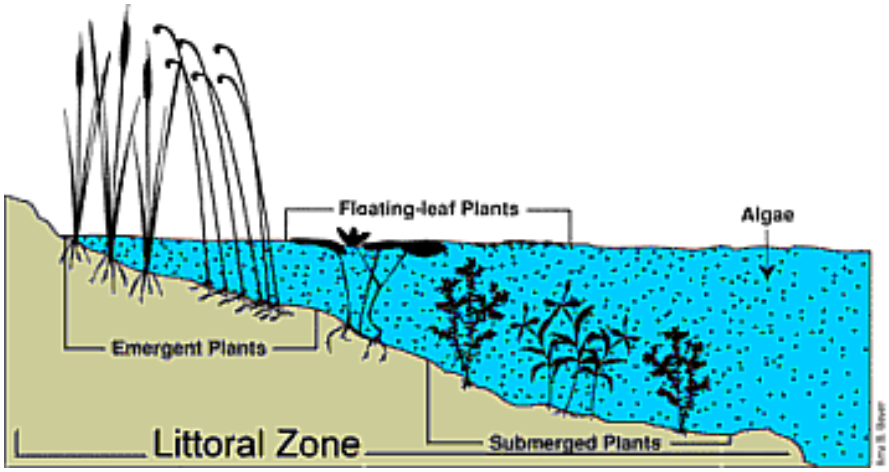
Thermal Stratification Diagram

Epilimnion: warmer well-mixed, well lit waters, with adequate dissolved oxygen.
Metalimnion/Thermocline: Area of rapid temperature change that forms a barrier to prevent the upper and lower waters from mixing.
Hypolimnion: Bottom layer of cooler, heavier and darker waters. This layer may have little dissolved oxygen during the summer. Due to lack of light, plants do not grow and thus release oxygen in this layer.



Light Zonation

Light is critical for *photosynthesis* in plants. Photosynthesis is the process by which plants convert carbon dioxide and light to energy and release oxygen. Photosynthesis can only occur where there is light, so plant growth is limited to the *littoral zone* of the lake (see diagram). The well-lit *photic zone* of the lake includes waters down to the point where light dims to 1% of the light at the surface. In the *aphotic zone* light levels are too low for photosynthesis to occur, however, *respiration* continues at all depths, so the aphotic zone still consumes oxygen but does not produce any.



Oxygen

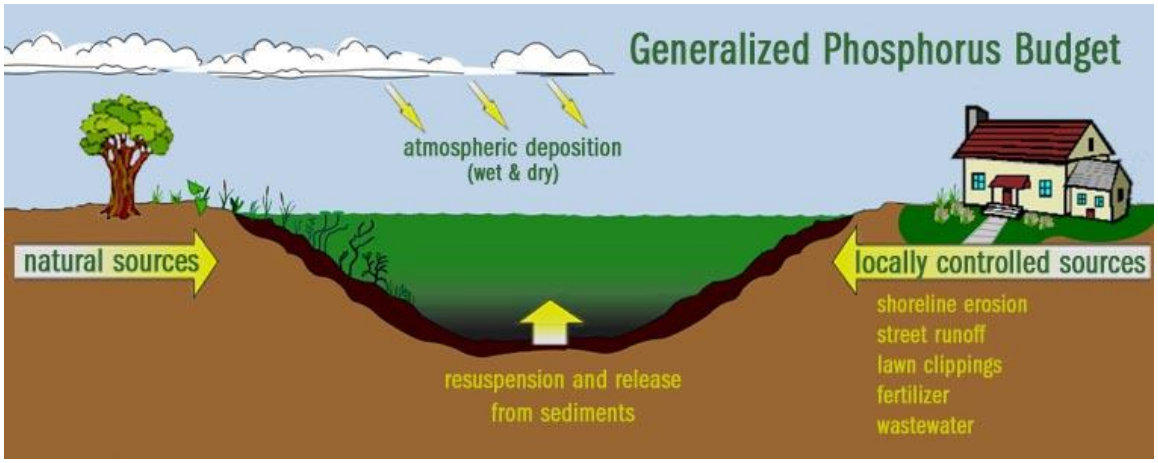
Most aquatic organisms require oxygen to live and the amount of *dissolved oxygen* in the water often determines where organisms can be found. In *temperate lakes*, during the summer months, very little oxygen is present in the hypolimnion, the deepest layer, because the decomposition of plant and animal material may use up the available oxygen. When water has less than 0.5ml/l dissolved oxygen (DO) it is called *anoxic* and fish cannot survive this condition.

Nutrients in a Lake

The two key nutrients that determine the algae and vegetative growth in a lake are nitrogen and phosphorus.

Phosphorus

Phosphorus is generally not available in the environment because there is a relative lack of phosphorus-containing materials. Phosphorus has no atmospheric gaseous phase and it is tightly bound by many organic sediments, and is therefore unavailable for uptake by organisms. When one nutrient is not as readily available as other nutrients it is called the *limiting nutrient* because its availability determines plant growth. Although phosphorus is relatively rare, human sources such as fertilizer, sewage and soil *erosion* can overload lakes with available phosphorus. Excess phosphorus introduced to a lake provides food for plants and algae and can increase the vegetation growth within a lake. Large concentrations of phosphorus may create *algal blooms*, which turn the waters murky, kill fish and diminish the lake's recreational and aesthetic appeal. The decaying algae and plants eventually die and sink to the lake bottom where oxygen is utilized as they decompose. As the already low oxygen levels in the hypolimnion decline, the phosphorus once trapped in the sediment is released, increasing the availability of phosphorus to the lake system.



Nitrogen

Nitrogen is the fourth most common cellular element necessary for plant growth. Nitrogen is readily available to plants from several sources. First, the atmosphere consists of approximately 72% gaseous nitrogen (N_2) and blue-green algae can convert N_2 to a form that is useable for other plants. In addition, nitrogen moves rapidly through soils and is quickly converted from one form to another by nitrifying bacteria. Human sources of nitrogen include fertilizers, acid rain, human waste and changes in the surrounding vegetation due to fires, floods or clearing.

Other Nutrients

Other nutrients including iron, sulfur, and magnesium are essential cellular constituents that are needed in low concentrations. Sodium and potassium are required in small amounts, and calcium plays a critical role in determining the hardness and pH of the lake's water. The composition of the soils and bedrock in the surrounding watershed determine the amount of calcium that enters the lake via storm water run-off. Aquifers rich in limestone minerals can also supply lakes with calcium.

Understanding pH

pH is an expression of the amount of hydrogen ions (H+) in the water. A pH 7 (ex. distilled water) has equal amounts of hydrogen (H+) and hydronium (OH-) ions. As the amount of hydrogen ions increases, the pH reading is lower and the water is considered more acidic. Conversely, when the quantity of hydrogen ions decreases, the pH reading is higher and the water is more alkaline. (see illustration below) A change in 1 on the pH scale represents a tenfold difference in the amount of hydrogen ions in the water. For instance, a lake with a pH 6 is *ten times* more acidic that a lake with a neutral pH 7.

acidic 1 2 3 4 5 6 7 8 9 10 11 12 13 14 alkaline

One way acid rain is formed is when moisture and carbon dioxide mix in the atmosphere. On average, acid rain has a pH of 5.6, which is lethal to many aquatic organisms and can inhibit spawning in some fish species. In addition, as water becomes more acidic, the level of several toxic chemicals, including mercury, increases. Mercury does not necessarily kill fish, instead it bioaccumulates and remains stored in the tissue and over time becomes increasingly concentrated. Humans and animals that consume mercury-laden fish may face serious health risks. The increase of mercury in acidic lakes has been cited as one of the causes for the decline in osprey and eagles. Lakes vary in their ability to buffer acid rain. The calcium carbonate system in a lake determines its ability to neutralize acid. The presence of calcium carbonate ($CaCO_{3-}$) and calcium bicarbonate ($H2CO_{3-}$) raise the hardness and pH of the water, thus reducing the harmful effects of acid rain. As mentioned before, the level of calcium in a lake is dependent on the surrounding watershed and from the other sources of water (such as aquifers or streams) that feed the lake.

Living Components

Phytoplankters

Phytoplankters are free-floating microscopic algae that are a source of food for other organisms, produce oxygen as a byproduct of photosynthesis and their presence can affect the taste, color and odor of the water.

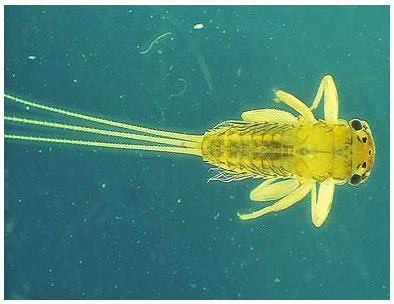
Zooplankton

The second group of organisms, the zooplankton (from the Greek word “wanderer”), are free-floating or weakly swimming microscopic animals at the mercy of the wind and waves. Zooplankton are important because they are a bridge between the base of the food chain and the higher trophic levels. Zooplankton are the primary consumers and graze heavily on the phytoplankton. In turn, the zooplankton population is controlled by fish and other animal predation.

Plants

The rooted plants that thrive along the edges and in the littoral zone are called *macrophytes*. These plants are divided into three main groups: submerged, floating-leaved, and emergent. Native aquatic plants are important in the ecological balance of lakes because they provide oxygen, food, habitat, shelter, and contribute to the diversity of the aquatic environment. In addition, their roots help stabilize the shore and slow the flow of sediments and pollutants into the lake.

Macroinvertebrates



The macroinvertebrates are another source of food and they process energy in the ecosystem. Many of these animals are found in the benthic zone, or bottom layer, of the lake, and their tunneling activity helps to release nutrients from the sediments. This group includes immature dragonflies, mayflies, beetles, snails, leeches, crayfish and bivalves.

Bacteria

Bacteria are single-celled organisms that break down and decompose matter within a lake's ecosystem. Although most bacteria are beneficial, a few, such as *Giardia*, can be harmful to humans.

Fish

Fish are cold-blooded animals and comprise 40% of all the vertebrate species on earth. The variety of fish enhance the biodiversity of the aquatic system and they play a major role in the food chain. Fish are often categorized based on their water temperature requirements. Cold water species, such as trout and salmon, prefer more pristine water conditions with cool temperatures and high dissolved oxygen. As the trophic state of lakes shift (see next section), warm water fish, including bass and carp, are supported. These species are more tolerant of decreased clarity and lower levels of dissolved oxygen and can withstand warmer temperatures.

Reptiles and Amphibians

Other wildlife found in and near lakes and ponds include many species of amphibians and reptiles. Amphibians and reptiles are also cold-blooded animals. Amphibians, such as frogs and toads, are dependent on water for at least one stage of their life cycle. In the spring they reproduce and lay eggs in the water. The eggs hatch into a larval stage (tadpoles), which develop adaptations for living on land as they mature. Reptiles are independent of water for reproduction and lack a larval stage. However, many reptiles including turtles and snakes, make their homes in and around lakes and ponds.

Birds

Most birds have developed adaptations for flight and species, such as ducks, egrets, cormorants and herons have adjusted to a mainly aquatic life. Florida has a variety of waterfowl that thrive in the aquatic environment.

Mammals

Many mammals including otters live in lakes and ponds. These mammals hunt for fish and freshwater bivalves, retreat to the water for safety and create homes out of branches and mud.

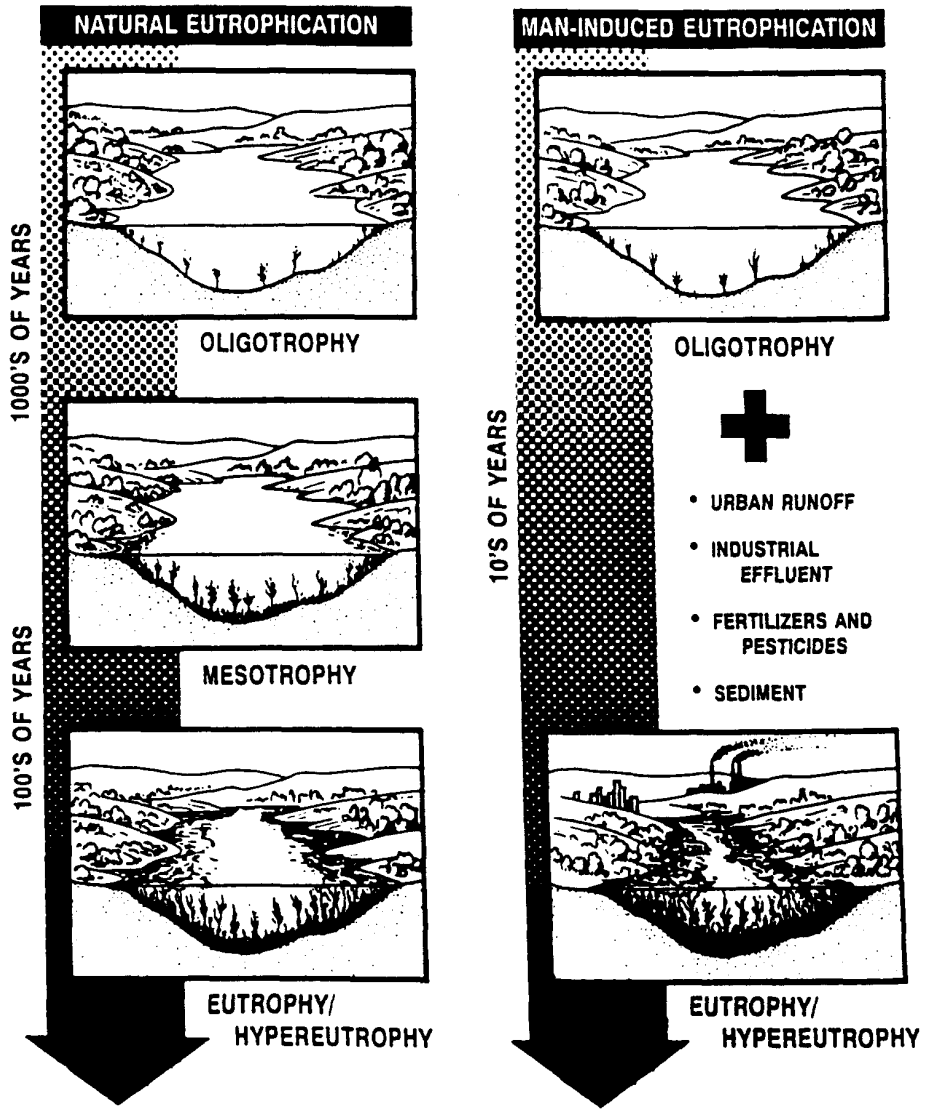
Eutrophication & Enrichment

Natural Enrichment

"Lakes are destined to die" is a phrase commonly used by *limnologists* to describe the process of *succession*. Lakes are constantly changing as sediments and decomposing organisms slowly fill in the basin and changes occur in the succession of plant and animals. Lakes usually start out in an oligotrophic (nutrient poor) state and progress towards a eutrophic (nutrient rich) state. (see diagram next page). An oligotrophic lake tends to have clear water, barren basins and little aquatic plant growth. As time progresses, silt from rivers and decaying organisms begin to fill in and enrich the lake. Plants start to take root, organisms that feed on algae and plants increase in number, and the lake becomes more biologically complex. Gradually, the succession of plant and animal communities shift as the once clear lake moves toward a more nutrient enriched, mesotrophic state. Most lakes in Florida are considered to be mesotrophic or eutrophic. As nutrient levels continue to increase, the lake enters a hypereutrophic marsh-like state. Lake depth, nutrient levels in the surrounding watershed, and erosion rates are all contribute to the successional process of a lake.

Cultural Eutrophication

A lake's succession usually takes thousands of years, but human activity often accelerates the process. The process by which a lake receives unnaturally higher amounts of nutrients is called cultural eutrophication, and human activities are the usual causes of this. Phosphorus from fertilizers, sediments from run-off, urban development, land clearing, recreation and septic waste all expedite the level of eutrophication. Chapter Three describes some of the issues that affect the level of eutrophication and how concerned citizens can adopt a proactive stance towards protecting their lakes.



Chapter 3
Lake Issues and Management

- **Stormwater**
- **Invasive Species**
- **Algal Blooms**
- **Bacteria**
- **Common Lake Issues**
- **Watershed Controls**
- **In-lake Restoration Techniques**
- **Aquatic Plant Control Techniques**


Know where it all goes
Where sewage goes
SCREENS
GRIT TANK
SETTLING TANK
SLUDGE DIGESTERS
SECONDARY TREATMENT
TERTIARY TREATMENT
SEWER MAIN

Stormwater

One of the greatest threats to the quality of water in our lakes and ponds and the health of the aquatic environment is stormwater pollution. According to the U.S. Environmental Protection Agency (EPA), non-point source pollution is the Nation's leading cause of water quality degradation. When it rains or snows, the water rushes over highways, parking lots, streets and lawns and collects nutrients, oils, toxins, sediments and other pollutants. This untreated water flows into storm drains and frequently empties into our lakes or ponds. Stormwater poses a greater threat to water quality in urban and agricultural areas than in undeveloped lands. In forested areas, the earth absorbs most of the stormwater and the soil and vegetation filters out pollutants. In developed areas there is a larger percentage of *impervious surfaces*, including pavement, roofs, and asphalt, which prevent water from soaking into the ground. As a watershed becomes increasingly developed, the percent of land that is covered by impervious surfaces increases and more stormwater runs off into receiving waterbodies. Stormwater is an example of *non-point source pollution* because the pollution comes from a very broad area rather than a single identifiable source such as a pipe. Non-point source pollution is harder to control because it results from many activities that occur in our watersheds, including development, fertilizing, and other human activities. In addition, rain absorbs pollutants from the atmosphere and deposits them on the ground or in waterbodies.

Point Source Vs. Non-Point Source Pollution

Contaminants in Stormwater

Stormwater can carry a variety of contaminants that may degrade the receiving waterbody including: *nutrients*, sediments, bacteria, metals, toxic substances, trash, and warmer water with low dissolved oxygen.

Nutrients

Excess levels of phosphorus and nitrogen are introduced to waterbodies from a variety of sources including failing septic systems, sewer overflow, urban stormwater run-off (carrying detergents, fertilizers, organic debris) and atmospheric deposition from industry and automobiles. Phosphorus is relatively rare in lakes and ponds and therefore, the level of available phosphorus controls the amount of plant growth. When additional large amounts of phosphorus are introduced to a waterbody, algal blooms may result. The decomposition of algae utilizes the available oxygen and fish often perish as the oxygen level drops. In addition, many toxins and pollutants are released from the sediments and become more water soluble under low oxygen (anoxic) conditions. Excess nutrients also accelerate the rate of eutrophication.

Sediments

Sediments from a variety of sources are carried via stormwater run-off into waterbodies. Although most sediment comes from construction and agriculture, there are also many urban activities including winter road sanding, landscaping, loss of vegetation (which leads to erosion) and the development of new

drainage pathways, which can be a source of sediments. Increasing the load of sediments into a lake or ponds has many harmful effects. The sediments slowly fill in the lake basin, causing the lake to become increasingly shallow and less capable of retaining and storing floodwaters. Sediments and shallow water can trap solar radiation, which increases water temperature while simultaneously decreasing the water clarity, and the breakdown of organic particles in the sediments can also deplete the available oxygen in a lake. This negatively impacts cold-water fish that are dependent on cool, clear, oxygenated waters. Suspended sediment particles reduce light transmission, which may negatively impact the plant growth that bass and other fish require for shelter.

Bacteria and Pathogens

Many disease causing organisms can be carried via stormwater run-off into lakes and ponds or when they are accidentally released from failing septic systems, agriculture waste, animal waste from pets or wildlife, and wastewater treatment plants. Although most bacteria are beneficial, some strains of bacteria can cause disease, alter the color, taste and odor of the water or force swim beach closures.

Metals

Metals pose a serious risk to our lakes in ponds, as they can be highly toxic to humans and aquatic animals. Metals from industry and commercial waste materials, atmospheric deposition, mining and automobile emissions all contribute metals to waterbodies. Some metals found in stormwater include copper, zinc, lead, chromium, and cadmium. Metals can accumulate in animal tissue and increase in concentration over time (bioaccumulation) leading to impaired reproduction, growth and development or even death. Humans who consume fish with accumulated level of mercury or other toxic metals are also at risk.

Oils and Grease

Oils and grease from vehicles build up over time on the surface of the roads. During a rainstorm, water washes these toxins off the road and carries them to nearby stormdrains where they are transported to nearby waterbodies.

Pesticides/Organic Compounds/Salts

Oil leaks, pesticides, road salts and other toxic compounds are often spilled or incorrectly disposed of, and then are carried via stormwater run-off to lakes and ponds. These compounds can reduce oxygen levels in a lake and are often lethal to juvenile fish or sensitive organisms. Many of these contaminants affect groundwater and other drinking water supplies.

Litter

Plastics, organic litter, and other toxic debris often degrade lakes and ponds when they are carried by stormwater into the waterbody. Not only does the aesthetic appeal of the lake decline as trash accumulates, but animals can become entangled in the debris and the breakdown of certain products release toxins into the water column.

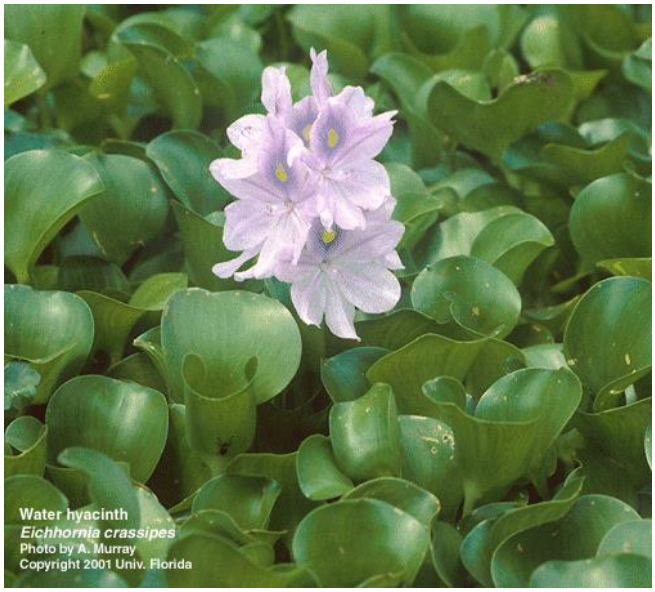
Warm Water/ Low Dissolved Oxygen

Stormwater is often heated as it flows over surfaces that have been warmed by the sun, and consequently may increase the water temperature of the receiving lakes and ponds. Warmer water holds less oxygen and often accelerate the breakdown of toxic substances and the release of contaminants from the soil.

Invasive Species

What is an Invasive Species?

Many plants that are found in Florida were originally brought here from other places around the world, and these plants are called non-native or *exotic*. Although many non-native species such as water hyacinth (see photograph) are beautiful, they can be extremely destructive to the environment because they disrupt the delicate balance of the ecosystem. Some exotic species are harmless, but others can have a very detrimental impact on the environment by out-competing native species and taking over the waterbody. Once a species, native or non-native, dominates or disrupts the biological community, it is considered *invasive*.



How did exotic species arrive here?

Exotic, or non-native species have been introduced to Florida in a variety of ways including accidental release through the aquarium or water garden trade. Some were deliberately imported and planted as colorful additions to gardens and ponds**.**

Why are they harmful?

Since exotic species originated in other regions, most have not evolved natural predators in this region to keep their populations in control. In recent years, exotic invasive species have been spreading throughout Florida's lakes at an alarming rate. Invasive species out-compete other species for space, light and nutrients. Since exotic invasive plants often do not provide ideal sources of food and *habitat*,

as native plants die, many of the animals that were dependent on native plants must attempt to relocate or they may perish. In essence, invasive species often create single species stands, thus reducing biodiversity. Once established in a lake they are almost impossible to eradicate, and managing them is very costly. Invasive species can impede recreational activities and in cases when dense mats have formed, boat navigation is no longer possible.

In addition, infestations of invasive species can lower property values, decrease aesthetic value, restrict movement of vertebrates, stunt fish growth, displace wildlife, and in some cases, damage docks, dive gear and boat motors.

What is being done to control invasive species?

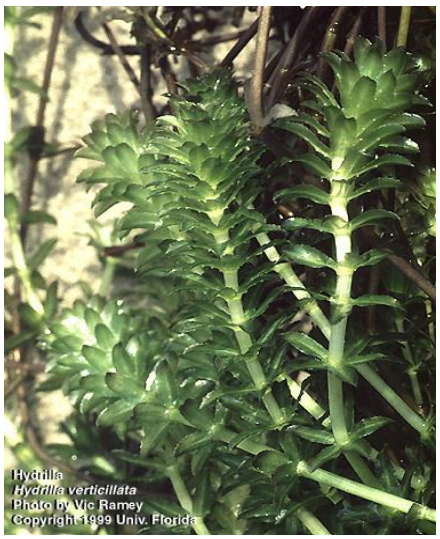
The best method for controlling exotic invasive plants is to prevent them from becoming established in a waterbody. The Florida Department of Environmental Protection (FDEP) has developed a **Weed Alert Program** for early detection. The program also includes handing out informative brochures and placing educational signs at boat ramps.

Bureau of Invasive Plant Management
Preserving the Real Florida
Florida Department of Environmental Protection

STOP AQUATIC HITCHHIKERS!™
Prevent the transport of nuisance species.
Clean all recreational equipment.
www.ProtectYourWaters.net

Torpedo Grass *(Panicum repens)*

Giant salvinia (*Salvinia molesta)*



Hydrilla (*Hydrilla verticillata*)

Wild taro (*Colocasia esculenta)*

Potential Threats

It is important to learn to recognize these species and always remember to inspect your boat motor, trailer, bait buckets and gear to prevent their spread to Florida waterbodies. If you have concerns about an invasive species please call the

Florida Department of
Environmental Protection
Bureau of Invasive Plant Management
South Gulf Office
8302 Laurel Fair Circle, Suite 140, Tampa, FL 33610
TEL 813-744-6163 FAX 813-744-6165
Contact: john.rodgers@dep.state.fl.us

Stop the Spread of Aquatic Invasive Species!

Boaters:

- Remove all plant parts from your boat motor, trailer, anchors, fishing gear and dive gear.
- Dispose of plant matter on dry land away from shore or in a trash can.
- Dispose of live well, bait and cooling water away from the shore after each use.
- If you are leaving a waterbody known to be infested, wash your boat with hot water and allow it to completely dry before entering another body of water.
- Never release a species, either plant or animal, into a body of water unless it came out of that body of water.

Everyone:

- Help spread the word and inform others about exotic invasive plants.
- Request a free “Stop the Spread of Invasive Weeds” sign for your boat ramp.

- Familiarize yourself with the invasive species by requesting free color guides. (http://www.dep.state.fl.us/lands/invaspec/index.htm).

You Can Make a Difference! For more information go to www.protectyourwaters.net

Algal Blooms

Algae are microscopic plants that grow naturally in lakes and ponds but are able to adapt to a wide range of conditions including oceans, rivers, ponds, deserts and hot springs. Algae are photosynthetic, yet lack vascular tissue such as roots and leaves and are considered to be evolutionarily less advanced than higher plants, such as macrophytes. Algae are the primary producers in the aquatic environment and provide food and energy for other animals. In addition, during photosynthesis, algae release oxygen into the waterbody.

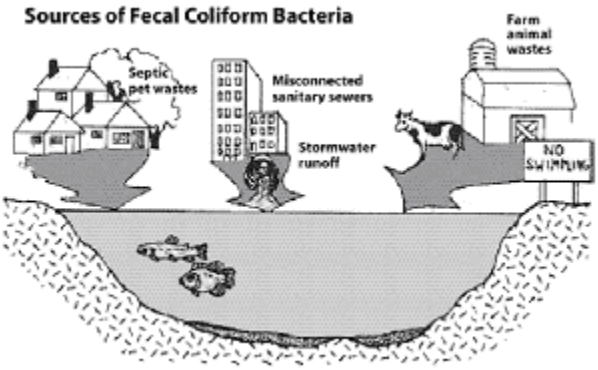
• Although algae are an important part of the lake ecosystem, their rapid growth can create a condition called an *algal bloom*. Algal blooms can form scum or dense mats on the water's surface and may also affect water color, odor and taste. During an algal bloom, the excess algae die, and the decomposition process consumes oxygen and may result in *anoxic* conditions, which is harmful or fatal to some aquatic animals.

The most common algal blooms are caused by diatoms and blue-green algae. Diatoms affect the water color, turning it bright green or brown, but rarely create an offensive odor or scum, and may even occur unnoticed. On the other hand, blue-green algal blooms are rarely undetected. The wind concentrates blue-green algae into dense, unsightly surface mats, or surface scum, which may wash up on shore and produce a noxious odor as it decays.

What causes algal blooms?

Although there are a variety of reasons for algal blooms to occur, the primary reason is the introduction of excess nutrients, such as phosphorus from fertilizers and detergents, into a waterbody. Storm water run-off, loaded with nutrients, generated from a variety of human activities, flows over the land or through a storm drain system into a waterbody. Excess nutrients entering the aquatic system allow algae populations to explode. If your lake experiences algal blooms, it is important to complete a watershed assessment to evaluate land use, soil types, erosion, point sources (such as leaking septic systems), and other possible causes of nutrient loading. The lake's nutrient chemistry, fish population, dissolved oxygen and flow all should be examined as these various factors can also affect the algal population in your lake. Although an introduction of excess nutrients to the waterbody is usually the culprit, it is not the sole cause of algal blooms. The size of the algal population is also controlled by microscopic herbivores, called zooplankton, which graze heavily on algae and keep the algal population under control. However, zooplankton are in turn eaten by small fish. If the population of small fish in the lake increases, then less zooplankton are available to consume algae and an algal bloom can result. There are many management options for controlling algae, but there is no "quick fix" solution. Reducing the level of nutrients in the watershed is usually the best course of action.

Bacteria



Bacteria are single-cell organisms that live in our environment. Although many are harmless, others are capable of causing serious health problems for humans. The majority of beach closings in Florida are a result of high levels of the type of microorganisms that are found in sewage. The Florida Department of Health (FDOH) routinely monitors public swimming areas as part of the Healthy Beaches Program. If the test fails, then the swim beach is closed until further testing can be completed and the water quality passes. There are different types of bacteria that contribute to the total fecal coliform count, however, testing water samples for each and every type of disease-causing bacteria is very costly. Samples are only tested for the presence of *E. coli,* a generally harmless type of bacteria that lives in the intestines of all warm-blooded animals including humans, beaver, geese and dogs. Since *E. coli* occurs in high numbers in human sewage it is used as an indicator organism. Large amounts of *E. coli* indicate a *possible* source of contamination from sewage, thus indicating that other disease-causing bacteria could potentially be in the water. There are many possible sources of fecal coliform, including failing septic systems, farm animal waste, polluted stormwater run-off and wildlife (see illustration). Septic systems near waterbodies can fail and release raw sewage into the lake or pond. Run-off from agriculture can also contribute bacteria to the lake. Storm drains may be overloaded after heavy rainfall and overflow, discharging polluted stormwater into nearby lakes and ponds. If a lake continuously has high *E. coli* counts, other tests are available that examine the genetic material (RNA) of the bacteria to determine exactly which species of animal is responsible for adding the bacteria to the water. By knowing whether to focus on inspecting septic systems, improving storm drains, reducing waterfowl, or addressing urban run-off, lake managers are better able to control the bacteria loading to a lake.

Common Lake Issues

Murky Colored Water

During the summer, lake water may turn murky and have an unpleasant odor. The scum looks like blue-green paint and often drifts to the windward shore. This may be an algal bloom. Algae are microscopic plants that are natural components of lakes. Algal blooms are often the result of excess phosphorus (often from lawn fertilizers or other sources) entering a waterbody.

Yellow Green Dust

During the early summer months a yellow dusting may appear on your lake or pond. This dust is likely pollen from nearby pine trees. Over time the pollen will become water logged and sink to the lake bottom.

Dark Oily Cloud

The dark oily cloud may be insect cases left behind from a hatch of aquatic insects. The wind can concentrate the cases along the shore, and as they decompose, an oily sheen forms.

Dead Fish

An occasional dead fish is not cause for alarm. Sometimes anglers release an injured fish or the midsummer stress due to warm water and disease may be the culprit. If you notice numerous dead fish, especially of more than one species, please contact the your local government or the Florida Fish and Wildlife Conservation Commission (*FWCC*).

Foam (suds) on the shore

Foam on the shore is often natural and occurs when the surface tension of water is reduced and air mixes with the water, creating bubbles. This natural foam will have an earthy or fishy aroma. Many natural organic compounds are capable of reducing the surface tension of water.

Watershed Controls

What are BMPs (Best Management Practices)?

There are many actions that towns can take that will help reduce the harmful effects of polluted stormwater. BMPs, or *Best Management Practices*, have been developed for town planners and lake planners to enable them to make wise choices for the lake's future. BMPs are either non-structural, (education, build-out assessments), or structural (installing new systems, creating wet ponds). A few have been listed below but for a complete list contact FDEP or the Florida Lake Management Society (FLMS).

Non-Structural Best Management Practices

Zoning and Land Use Planning

By studying a town's current demographics, economics, existing natural resources, current land uses and forecasted growth, planners are able to create educated zoning plans and land use controls that will ensure protection of water resources and critical areas. These projects, called build-out assessments, include simple steps such as determining minimum lot sizes, creating development plans with the least fragmentation, and determining best land use. These plans will help to insure a healthy future for the lake, town and other fragile resources.

Education

Education is a critical component in any watershed management or town plan, and can be geared towards both municipalities and citizens. Training programs help to introduce stormwater management issues and new design technologies. Development of interactive community programs, including: storm drain stenciling, rain gardens, hazardous waste recycling days, responsible pet clean-up, water conservation education, holding lake-friendly home design workshops and promoting phosphorus-free fertilizer rebates help to encourage citizen involvement and convey the message about the value of our water resources.

Routine Storm Drain Maintenance/Mapping

Routine street sweeping and catch basin cleaning prevents an overflow of sediments and other contaminants into waterbodies. It is also important to have current mapping and ground-truthing of storm drain locations for each town.

Source Reduction

There are many bylaws that towns can adopt to reduce the source of stormwater contaminants including; banning fertilizers and detergents that are high in phosphorus, encouraging recycling of hazardous materials and reducing litter.

Maintain Riparian Areas and Buffer Strips

Riparian areas and *buffer* strips are complex ecosystems established along drainage areas that function to slow/reduce stormwater velocity, trap suspended sediments, filter out contaminants, absorb nutrients and reduce *shoreline erosion*.

Site Planning

Unlike watershed planning, site planning is a small-scale approach. The soils, potential land uses, location in the watershed, topography and impacts of the proposed activities are all evaluated as part of the planning or subdivision process. There are several BMPs that can be followed when designing a home, and during construction, that can reduce the negative impacts of stormwater. These may include minimizing the driveway surface area, increasing lawn area and using pervious pavement.

Preventative Construction Techniques

Protecting exposed soils with tarps and hay bales, careful storage and removal of chemicals or other waste, installing washing areas, protecting storm drains and utilizing secure sanitary facilities will help to prevent stormwater contamination during construction.

Structural Best Management Practices

Structural BMPs include pre-treating the stormwater with a variety of new technologies, filtering, storing and moving stormwater, preventing erosion and upgrading existing systems.

Pre-treatment of Stormwater

There are many new designs that can be implemented to improve the quality of stormwater before it reaches its destination. Some of these may include paving streets with porous pavement, which allows a greater percentage of water to infiltrate into the soil, thus reducing the volume of run-off and recharging groundwater. Implementing new storm drain designs, including porous french drains and infiltration basins, allow water to slowly filter out into surrounding soils. Dry wells collect run-off primarily from rooftops and direct it into infiltration pipes where it can seep into the surrounding soils rather than rush into storm drains.

Filtration of Stormwater

Sand filters, which allow stormwater to pass through layers of sand that filter out metals, bacteria, sediments and other contaminants, can be added to most storm drain systems to improve the quality of the stormwater.

Transport of Stormwater

Vegetated swales can be constructed along roadsides and in residential neighborhoods to collect and filter street run-off.

Settling of Stormwater

Wet ponds are capable of retaining stormwater and later releasing it at a controlled rate, while constructed wetlands detain and treat stormwater before it is released. Both of these reduce the velocity of stormwater, allow it to be filtered and then release it slowly.

Erosion Control

Vegetated natural *buffers* provide natural protection to sensitive areas by slowing approaching run-off and filtering contaminants. By slowing the velocity of run-off, erosion is decreased and infiltration increased.

Installing New Technological Systems

Many companies have created systems to treat stormwater by filtering out grease, sediments and other contaminants. Some of the many available systems include: StormTreat®, AquaShield®, StormFilter®, and Vortechs®.

In-Lake Restoration Techniques

Here is some general guidance on solving some common lake problems and some advantages and disadvantages of each. Because each lake or pond is unique, before implementing any method an initial study should be performed to identify the cause of the problems noted. Suggested methods may require permits and/or need to be implemented by a professional. Please contact your local government or the Southwest Florida Water Management District (SWFWMD) for more information.

Aluminate sulfate (alum treatment)

Alum lowers phosphorus levels and blocks the release of phosphorus from sediments. Alum also provides temporary improvement in water clarity (*transparency*). This may lead to an increase in plant growth.

Artificial Circulation

Aeration systems may prevent or disrupt stratification. Aeration does increase the levels of oxygen in the water and extends aerobic zone. Aeration may increase *turbidity* but will not affect plant/algae growth.

Dilution

Adding water to the lake or pond removes algae on the surface and lowers the levels of nutrients. However, it will require a large amount of water to flush the lake. Dilution will not reduce the inputs of phosphorus to the waterbody and may have downstream impacts.

Dredging

Dredging deepens the lake by removing accumulated sediments and increasing the water volume, which can improves water clarity. Dredging also removes aquatic plant matter, temporarily disturbs the habitat and may increases turbidity. If pesticides or other chemicals are present in the sediment, dredging may release toxins from sediment into the water column.

Hypolimnetic Aeration

Hypolimnetic aeration adds oxygen to deep waters, which limits the release of phosphorus from sediments. Deep aeration may cause destratification, will not control macrophytes and may cause algae blooms.

Water Drawdown

Lake level fluctuation is an effective control technique for macrophytes. It allows for dock repair/maintenance and may improve the shoreline habitat. Lake drawdown may have a negative impact on fish and other organisms and may cause problems downstream due to reduced water flow.

Aquatic Plant Control Techniques

Manual Methods (hand pulling, cutting)

Manual removal is inexpensive and non-toxic and affects only the target plant species. This removal method does not harm beneficial plants however it is labor intensive and can stir up the sediment. Manual removal is not practical for very large areas and it may require divers for deeper waters.

Benthic Barriers (bottom covers)

Pond liners restrict upward plant growth, limit light penetration to the lake bottom and are harmful to *benthic communities*. Liners are good for small areas near docks and are non-toxic, but you will need to inspect them often. Bottom covers can be damaged by anchors. Due to the build up of hydrogen sulfide in un-oxygenated sediments, liners must be anchored securely as gases may cause the barrier to float up.

Mechanical Cutting (clipping plants below the water)

Mechanical removal is fairly inexpensive, the results are immediate, it targets one area of the waterbody and is fairly species specific. Non-toxic. Roots may re-grow. Must do several cuts each season. May cause plant fragments, which can re-grow. Not species specific.

Mechanical Harvesting

Mechanical harvesting removes all plants from the area however; it can be labor intensive and expensive. Mechanical harvesting does not target specific plants and because machinery can only cut up to 5' below surface, plant fragments may re-grow.

Hydro-raking

Hydro-raking removes the entire plant including the plant roots. This process disturbs sediments which negatively impacts bottom dwellers, increases turbidity, and may release nutrients and toxins from sediments. In addition, any fragments that break off may re-grow.

Biocontrols (weevils)

Biocontrols are species specific and non-toxic. They also have potential for providing long-term control. Weevils will not remove all the plants, can be expensive and have a slow response.

Herbicides

Herbicides, when used properly, are very effective and ideal for large areas. Herbicides may be used to spot treat specific plants. When incorporating herbicides into an aquatic plant management program it is important to harvest the dead plant material before it sinks to the bottom. If left, decomposing plant matter will release nutrients, decrease oxygen levels in the water and increase the muck layer on the bottom of the lake. When using herbicides, beneficial plants may be killed and recreational activities and lawn irrigation may be temporarily restricted.

Drawdowns

Lake level drawdown is a non-toxic method of vegetation control that works on most plants. This process may inconvenience dock owners. Drawdown is not species specific and may affect other organisms. Weather conditions may alter effectiveness/feasibility of lake lowering activities. Lake drawdown may affect out-flowing streams, wells and irrigation systems.

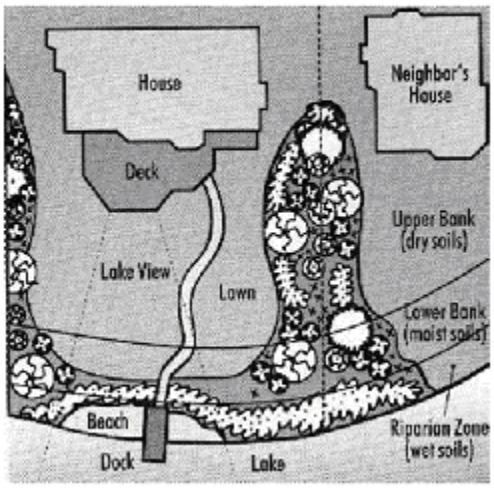
Chapter 4

Actions you can take to Protect your Lake

- **Thoughtful Landscaping**
- **How to Start a Lake Group**
- **Laws That Protect Your Lake**

Thoughtful Landscaping

If you reside on lakefront property, use environmentally-friendly landscaping techniques to prevent sedimentation and pollution.



- If possible, build homes where the land has the gentlest slope.
- Leave as much vegetation on slopes as possible to reduce the velocity of run-off and to filter out sediments.
- Create the greatest possible buffer along the shoreline (a minimum of 30' is recommended) by leaving existing vegetation and rocks or by planting small shrubs. This buffer will reduce the effects of stormwater run-off and erosion from waves, while still providing a view of the lake.
- Develop a winding dirt path to your shore or dock. The reduced slope of a winding dirt path generates less erosion and run-off than a steep paved path.
- Do not add sand to your shoreline area; introduced sand is a major source of sedimentation and phosphorus.
- If you plan to do construction in an area where the soil will be left unprotected, use hay bales and fabric fences to hold the soil in place. Mulch disturbed areas just prior to the final grading.
- Improve your driveway so that stormwater is diverted through u-shaped gravel or vegetated ditches that are designed to filter sediments and nutrients.
- Work with your town to improve drainage from town roads and parking lots.
- Direct run-off towards wooded areas so sediments, toxins and nutrients can be filtered out. Work towards a goal of zero run-off from your property.

Reduce Phosphorus

Maintain Your Septic Tank

- Conserve water and reduce the burden on your septic system by fixing leaking faucets. Choose commercial drain cleaners carefully as many may be harmful to the groundwater and to your leach field.
- Monitor the levels of sludge in the septic system and have the tank cleaned when it reaches half full. When septic systems are not pumped routinely, the leach field may become clogged.
- Bleach, drain cleaners, chemicals, and paints harm beneficial microorganisms in the septic system.
- Paper towels, cigarettes and garbage disposal debris should never be flushed as these products can overload the septic system.

Reduce the level of phosphorus that is released into the watershed and/or lake.

- Carefully read the levels of phosphorus in cleaning products and make wise choices. If the code on the packaging begins with ”O” then there is less than 0.5% phosphorus, however, if the code begins with a ”P” the phosphorus content is higher. (All®, Bold®, Arm and Hammer®, Cheer®, Dash®, Surf®, Whisk®, Shop n’ Save® have less than 0.5%.)
- Perform a soil test in the spring to determine if fertilizer is needed, before applying. Your local extension service has additional information regarding soil testing.
- Do not fertilize or use herbicides prior to or just after any precipitation because stormwater run-off may carry the phosphorus and toxins to the lake.
- Select plants that require little fertilization and spot treat with liquid fertilizer only as needed. To determine the phosphorus content in the fertilizer, read the middle number in the formula on the package. For example: 16- 4 –8; four is the phosphorus content.

Reduce Hazardous Materials

Consumer products such as paints, paint thinners, solvents, batteries, and household cleaning products are hazardous materials and need to be disposed of properly. Many of these products cause cancer and once released into the environment, will remain there for many years.

- Seek alternatives to hazardous cleaning products and reduce the use of heavy metals.
- Store hazardous materials in approved containers, in a safe location, and check for leaks.
- Never dispose of oil or gasoline on your driveway or street. Many gas stations recycle batteries and oil. Contact your local government for a list of companies that offer free disposal of automotive fluids.
- Dispose of solvents and paint thinners responsibly because these products are toxic to the environment and are not biodegradable. Watch for a "Hazardous Waste Disposal Day" or encourage your town to hold one.

Do not purchase mercury thermometers. Mercury is very toxic and exposure can cause hearing, memory or vision loss, paralysis, psychological effects, kidney problems and at high doses, death. Mercury can cause congenital malformations, and pregnant women can pass mercury along to their child after eating contaminated fish. If you own a mercury thermometer, learn about disposal and trade-in options.

Reduce the Use of Pesticides

- Pesticides can be harmful to the environment so always follow safety precautions.
- Refrain from using pesticides during or after a storm and do not discard left over pesticides down drains or on the ground; always dispose of properly.
- Rake as little as possible because leaf litter will help to soak up toxins.

Alternatives to Pesticides

- Marigolds help repel asparagus beetles.
- Pour beer or vinegar in a shallow pan to attract and trap snails and slugs.
- Bacterial spray can be used to kill gypsy moths during their larval stage.
- Aphids can be treated with a mixture of Murphy's oil soap, vegetable oil and water.
- Cockroaches can be removed with a 1:1 powdered sugar and boric acid mix sprinkled along baseboards and in corners. Make sure that no water is available for the cockroaches to drink.
- If you do need to use pesticides, read labels carefully.
- Contact your local extension service for additional alternatives to pesticides.

Select Native Plants

Native plants are ideal for landscaping lakeshore homes, and are often more disease resistant and hardier than their exotic counterparts and thus require less pesticide and fertilizer. Many native plants are a good source of food for wildlife and will enhance bird watching and other activities. For a brochure on Landscaping with Native Plants contact your local extension office.

How to Start a Lake Group

If you live on or near a lake, starting a lake group is a good first step towards protecting your lake's future and resolving problems that are currently threatening your lake's health. Although one person working alone can make a difference, a group of people with similar concerns and interests have a much larger voice and can have a greater impact. Members of a lake association meet to discuss lake issues and determine courses of action to protect their lake. You and your neighbors can:

- Attend town meetings to be a voice for your lake,
- Apply for grants to protect or improve your lake,
- Monitor your lake or pond for invasive species and to check water quality through the Florida LakeWatch Program,
- Work with the towns to address watershed issues including increased cleaning of storm drains, implementing new stormwater control techniques,
- Work with planning boards to reduce the impact of increasing development,
- Attend workshops to gain more knowledge about lake ecology, hydrology etc., and
- Hold training workshops to educate the community about lake and watershed issues.

Laws that Protect Your Lake

Determining what rules and regulations protect your lake or pond can be a difficult task. At the local level, if your lake or pond is part of the stormwater system, it may be protected by the National Pollutant Discharge Elimination System (NPDES) permit required by all cities and counties in Florida. Contact your municipality or county government for more information regarding local laws or ordinances.
Additional protection may be provided by the FDEP or the Southwest Florida Water Management District (SWFWMD) if your lake is greater than 10 acres. Contact your regional FDEP or SWFWMD office for additional information.

FDEP Southwest District
3804 Coconut Palm Drive
Tampa, Florida 33619-8318
(813) 744-6100
Fax (813) 744-6084
or
170 Century Boulevard
Bartow, FL 33830
(863) 534-1448

Southwest Florida Water Management District
2379 Broad Street
Brooksville, FL 34604-6899
(352) 796-7211
(800) 423-1476 (FL only)

Chapter 5

Resources

Guidance Materials

A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans*:* Washington State Department of Ecology: Water Quality Program, http://www.ecy.wa.gov.

Citizen Monitoring*:* Florida LakeWatch Program,
http://lakewatch.ifas.ufl.edu
University of Florida
Department of Fisheries and Aquatic Sciences
7922 NW 71st Street Gainesville, FL 32653
Citizen Hotline: 1-800-LAKEWATCH (525-3928)
Phone: 352-392-4817
Fax: 352-392-4902

A Guide to Environmentally Friendly Landscaping*:* Florida Yards and Neighborhoods Handbook.
http://www.ifas.ufl.edu/extension/ces.htm

Handling Conflicts on Your Lake*:*
Write Ecovision Associates 76 E. Sherwood Road, Williamstown, MI 48895-9435.

Living at the Lake - A Handbook for Florida Lakefront Property Owners*:* University of Florida, Institute of Food and Agricultural Sciences (IFAS) and the Florida Cooperative Extension Service.
http://ifas.ufl.edu or 1-800-226-1764.

Stormwater Ponds: A Citizen's Guide to Their Purpose and Management*,* Southwest Florida Water Management District
1-800-423-1476.

Your Lake and You, Lake Line and Managing Lakes and Reservoirs
NALMS PO Box 5443 Madison, WI 53705 5443
email:nalms@nalms.org
or visit the web at www.nalms.org

Glossary

A-E

Algae: Algae are small, non-vascular (lacking roots and leaves) plants that grow in the water.
Anoxic water: Waters that contain less than 0.5 ml/l of dissolved oxygen. Most aquatic animals cannot survive with so little available oxygen.
Blue-green Algae: Although not actually algae, they are often indicators of high phosphorus concentrations in the water.
Algal Bloom: An algal bloom is the burst of algae growth that can result in scum on the water surface, odor, color or taste changes and decreased oxygen in the water.
Aphotic Zone: Zone where there is insufficient light for photosynthesis, so plants cannot survive.
Benthic Communities: The diverse group of animals (including snails, leeches, and some stages of insects) that live in the lake bottom and have a major role in the decomposition of organic material.
Best Management Practices: BMPs are practices that minimize the impact from non-point source pollution including logging, stormwater run-off, construction and agriculture.
Buffer: Trees, shrubs, grass and other plants that lie between a body of water and an area of development. The vegetation helps to absorb nutrients, slow stormwater run-off and reduce sedimentation.
Circulation: The seasonal mixing of layers of water in a lakes or ponds of adequate depth. Often referred to as spring turnover or fall turnover.
Dissolved Oxygen: (DO) Refers to the amount of free oxygen dissolved in the water. Low levels of DO can be harmful to fish and other animals.
Ecosystem: This is a spatial unit including the relationship between living things, and their physical environment including one another.
Erosion: The gradual removal of rock or soil particles through the actions of weather (wind, water, and ice) or human activities.

Erosion controls: Methods developed to reduce erosion during human activities. Hay bales, silt fencing, and mulching buffers are all physical barriers that help prevent erosion.
Exotic Species: An exotic species is a species that has been introduced to a new region. Since the species did not originate in the area, it often does not have natural control agents (ex. disease) and may spread rapidly and disrupt the ecosystem.
FWCC: The Florida Fish and Wildlife Conservation Commission.

G-O

Groundwater: Water that travels or is stored beneath the surface of the earth, yet occasionally discharges into lakes, streams or the ocean.
Habitat: An area where animals can find suitable shelter, food and are able to reproduce and live.
Impervious Surface: A surface, such as pavement or rooftops that limit or prevent water from entering and being filtered by the soil. These surfaces disrupt normal groundwater recharge, increase the amount and velocity of run-off, heat the run-off and alter natural hydrological flows.
Invasive Species: A species, native or non-native, that is able to spread rapidly and alter or dominate an ecosystem.
Lake Ecology: The study of the relationship between living things and the lake environment.
Limiting Nutrient: A nutrient, such as phosphorus, required by plants to grow, that is relatively rare in the environment. Therefore, its availability determines the amount of plant growth.
Limnologist: A person who studies fresh water ecology. Limnologists work on lake management, restoration, pollution control and other issues.
Littoral Zone: The area extending from the shore to the maximum depth of plant growth.
Macrophytes: Vegetation with vascular tissue; considered evolutionarily “higher” than algae.
Non-point Source Pollution: Pollution that enters a waterbody from a variety of sources, including stormwater, wildlife influences and recreational activities. Non-point source pollution does not come from a specific identifiable source, such a pipe or drain.

Nutrients: Nutrients are substances, including nitrogen (N), phosphorus (P) and carbon (C), that are required for the survival of plants and animals.
Oligotrophic: A term that describes a lake that is not very productive, low in algae and nutrients, usually has clear waters and, if stratified, has adequate oxygen in the lower layer.

P – T

Pelagic Zone: describes "open waters" that do not have contact with the shore or lake bottom.
pH: pH describes the acidity of water on an exponential scale of 1-14. A range of 0-7 is acid, 7-14 is alkaline. A pH of exactly 7.0 is neutral. Derived from a French word meaning "strength of the hydrogen"
Phosphorus: This is a nutrient that is required by all living organisms. Phosphorus is found naturally in the environment and also in fertilizers and sewage.
Photic Zone: The sunlit upper waters that extend from the surface to the point where light dims to 1% of that at the surface.
Photosynthesis: The process by which plants and some other organisms convert carbon dioxide to sugars and oxygen, using the sun's energy and chlorophyll.
Point Source: Pollution that can be traced to a specific source such as a pipe.
Respiration: The process that utilizes oxygen to convert food molecules, such as glucose, into energy, water and carbon dioxide.
Run-off: Run-off is the water from rain or melting snow melts that runs downward over the earth's surface. Stormwater run-off is often considered a key source of non-point pollution.
Secchi Disk: The Secchi disk is a simple tool used to measure water transparency. The black and white disk is lowered into the water to the point where it is just visible and the depth is recorded.
Sediment: Particles of minerals and organic soil that are carried from one place to another by wind, glaciers and flowing water.
Shoreline Erosion: The loss of soils along a shoreline into the lake. This is often accelerated by the removal of vegetation near the shore that held soils in place.
Succession: the natural process of a lake from nutrient poor to increasingly productive and nutrient rich. Under natural conditions, this process can take thousands of years to occur.

Temperate (lake): Lakes that are located in a climate where the summers are warm and the winters relatively cool. This zone extends between the Tropic of Cancer to the Arctic Circle.
Thermocline: The zone of rapid temperature change that creates a physical barrier to mixing. It creates the seasonal upper and lower layers of water in lakes with adequate depth.
Transparency: Describes the clarity of water. When many soils or organic particles are clouding the water, turbidity is increased.
Turbidity: Describes that clarity of water. The presence of suspended matter in the water reduces transparency.

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Page 11 Lake Stratification Graphic from http://www.lakeaccess.org

Page 12 Littoral Zone Graphic from http://www.dnr.state.mn.us

Page 13 Generalized Phosphorus Budget from http://www.lakeaccess.org

Page 20 Eutrophication Graphic from Pinellas County Public Works Department (2001, September). *Lake Seminole Watershed Management Plan.*

Page 22 Stormwater Graphic from http://www.epa.nsw.gov.au

Page 28 Bureau of Invasive Plant Management Graphic from http://www.dep.state.fl.us
Stop Aquatic Hitchhikers Graphic from http://www.protectyourwaters.net

Page 33 Sources of Fecal Coliform Bacteria Graphic from http://www.epa.gov

Page 44 Landscaping Graphic from http://www.lakeaccess.org

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Page 4 Great Blue Heron: Kelli Hammer Levy, Pinellas County

Page 16 Phytoplankton and Zooplankton from http://www.cedareden.com
Lake Plants from A. Murray, University of Florida

Page 17 Macroinvertebrates from http://www.bugsurvey.nsw.gov.au
Bacteria from http://www.cedareden.com
Fish from http://www.co.leon.fl.us

Page 18 Softshell turtle from http://www.animalpicturesarchive.com
Little Blue Heron: Randy Roth
Otter from http://www.nae.usace.army.mil/recreati/bhd/bhotter.htm

Page 19 Natural Enrichment: picture 1- University of Florida,
picture 2- Kelli Hammer Levy, Pinellas County

Page 23 Stormwater Issues: picture 1 from
http://epics.ecn.purdue.edu/ed/image29.htm, picture 2- Melanie
Poirier, Pinellas County

Page 24 Woman Fertilizing from http://www.swfwmd.state.fl.us
Sediments: Melanie Poirier, Pinellas County

Page 27 Water Hyacinth: A. Murray, University of Florida

Page 28 Water Hyacinth: University of Florida

Page 29 Torpedo Grass: University of Florida
Giant Salvinia: University of Florida
Hydrilla: University of Florida
Wild Taro: University of Florida

Page 31 Algae Bloom from http://www.dnr.metrokc.gov

Page 36 Riparian Buffer from http://www.sustland.umn.edu

Page 38 Swale from http://www.swfwmd.state.fl.us