The Omega Lake Services Guide to Optimum Pond Dynamics

Written By
Jeff Farmer

OMEGA LAKE SERVICES
447 Desert Lakes Drive
Palm Springs CA 92264

Info@OmegaLakeServices.com

Updated January 2008

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Introduction

We have written this report to provide a quick reference guide into the many factors involved in setting up a balanced program of chemical and biological treatments for weeds and algae in ponds and small lakes. This guide can be uses by pond owners, golf course superintendents, business, municipalities, and others responsible for maintaining lakes and ponds.

It is our hope that by using this paper the reader can work through the confusion and misinformation involved with pond maintenance in the areas of aquatic weed and algae control, water testing and chemical vs. microbial treatments.

This guide will help you make informed choices when deciding on the treatments necessary to keep your pond in optimum condition and will show you the proper progression from chemical treatments to microbial supplementation in a safe, balanced, effective, and economical treatment program.

The Helpful Links Section will give you helpful links to websites from weed identification to barley straw with a lot of useful information in between. The Links Pages is also available on our website at www.OmegaLakeServices.com for quick reference when you need it.

Our goal with this guide is to help you develop a safe, effective and economical treatment program. The most effective treatment program is to address the problems *before* they get out of control. We'll show you how.

Read the *Guide to Optimum Pond Dynamics* and take control of your lake or pond, now!

Ponds and Lakes

Each pond or lake is unique in appearance, chemistry, biology, and physical characteristics. Even within each body, these attributes can vary. For instance, water at the surface of deep lakes may be chemically and biologically different from water at the bottom, because of differences in water temperature and sunlight penetration. In shallow lakes, the differences between top and bottom waters are less.

The basic difference between a pond and a lake is the depth and the size. A pond is a body of water shallow enough to support rooted plants, with light penetration to the bottom, throughout the pond. Plants will often grow all the way across a shallow pond. Water temperature is fairly even from top to bottom and follows the general trend of the surrounding air temperature; however, the changes in water temperature are not as extreme as in the air. There is little wave action and the bottom is usually covered with sediment. Plants grow along the pond edge. The amount of dissolved oxygen may fluctuate greatly during a day. In very cold climates, the entire pond can freeze solid. The dynamics of a pond are often much more intense than in a lake. A pond has no layers or zones and changes in the environment affect the entire body rather than only one area or section.

A lake is bigger than a pond, and is too deep for light to penetrate to the bottom with enough intensity to support photosynthesis by plants except in shallow areas near the shore. Some lakes are big enough for waves, which can provide needed circulation and oxygen transfer.

During spring and early summer, a lake's surface warms up, and its water separates into layers of different temperatures and densities. As the weather cools in the fall, so do the water temperatures and the layers become mixed until the next spring. Water temperatures in lakes during summer months are not uniform from top to bottom. Three distinct layers develop: The top layer stays warm at around 65–75 degrees F (The middle layer drops dramatically, usually to 45–65 degrees F. The bottom layer is the coldest, staying at around 39–45 degrees F. This is a thermocline or temperature gradient. Thermal stratification, or layers of temperature in water, is more likely in deeper ponds and lakes, or ones without adequate circulation. As the sun shines, the pond surface warms and encourages more plant and algae growth. The cooler, denser water settles to the bottom. This becomes more significant as the summer progresses, and finally there is distinctive layering. The line between the layers is the thermocline. The thermocline acts as a barrier to prevent mixing between the top and bottom of the pond. In the fall, as the water cools, the stratification reverses, and the pond “turns over”, the pond “turns over” again as the water warms in the spring. This turning over can create maintenance problems as sediment and nutrients from the lake bottom is carried into the water column and suspended. This causes both increased turbidity (cloudiness) and additional nutrient for algae growth in the water table. In artificial, man-made lakes, proper circulation and aeration will help prevent stratification and the resulting spring and fall “turn-over“.

The layers in a lake are further categorized into zones defined by both water temperature and light penetration as parts of the overall dynamic ecosystem. The distinction between these classifications often becomes blurred because of the varying conditions in the lake.

This is a brief description of these zones. The littoral zone extends from the shore and the water surface to a depth where light is barely sufficient for rooted plants to grow. The pelagic zone (or "limnetic zone") is the surface water layer in offshore areas beyond the influence of the shoreline. The photic (or "euphotic") zone is the lighted and usually well-mixed portion that extends from the lake surface down to where the light level is reduced to 1% of that at the surface. This depends on the degree of water clarity. The aphotic zone is below the littoral and photic zones extending to the bottom of the lake where light levels are too

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low for photosynthesis. This deep, unlit region is also known as the profundal zone. The sublittoral zone, which is the deepest area of plant growth, is a transition between the littoral and profundal zones. Boundaries between these zones vary daily and seasonally with changing sun intensity increase or decrease in water clarity due to algae blooms, sediment inflows, and surface waves. During spring and fall, the lake temperatures are more uniform. Fish and other animals are found throughout the layers of the lake. Even in cold climates, most lakes are large enough so that they don't freeze solid, unlike ponds. Both lakes and ponds undergo a natural aging process known as eutrophication. They gradually fill in, lakes becoming ponds and ponds becoming marshes, filled with sediment. Eutrophication can be controlled or eliminated by adding additional consumers to the system to control these sediments before they build up. The addition of beneficial microbes to the system can control the sediment buildup, stop the eutrophication process and stabilize the ecosystem.

The maintenance requirements of lakes and ponds runs contrary to their size; very small fish ponds need consistent monitoring, while the ponds on golf courses and other sheltered areas require service only once or twice a week. Larger natural lakes often only get seasonal attention if any at all.

Omega Lake Services specializes in maintaining small lakes and ponds, from ½-acre fish ponds on private estates, to golf course and residential areas with ponds up to 10 acres, along with other man made recreational lakes from 10 to 25 acres. As we address water chemistry and treatments options these medium sized ponds and small lakes will be the focus of this discussion. These man-made ponds are becoming more popular in all areas of the US as well as worldwide. As population density increases and natural areas become scarce, we increasingly look for a “beautiful park like setting” to escape to and ponds are a very important part of the tranquility these areas provide.

Our desire is to provide the information you need to keep your pond in the best condition possible. This is accomplished by working to balance the aquatic system and maintain equilibrium in the pond as much as possible. In the next chapters, we will explain the dynamics of pond water chemistry, algae and weed control, and the role of supplemental bacteria in a balanced ecosystem. We have used microbial treatments as the cornerstone of our maintenance program for over 20 years with excellent results.

The Pond Ecosystems;
Water Chemistry, Nutrient Levels and Pond Dynamics.

In this chapter we will discuss the important areas of your pond's ecosystem, how different aspects interact with water chemistry and give you an overview of the many dynamics in a healthy pond.

The Pond Ecosystem

The definition of an ecosystem is 'the physical environment along with the organisms inhabiting that space.' Depending on how biologically productive they are, lakes and ponds run the gamut from clear but nutrient-poor and with little life, to green or murky yet nutrient-rich and full of life, or somewhere in between. How a lake or pond functions and ages is influenced by its size and volume, how much sunlight it receives, the source of it's refill water, the amount and type of outside nutrients entering the lake, and the balance between nutrients entering the system and the amounts consumed in the system. A healthy system will have an abundance of life. All the nutrition needed will be available without becoming excessive, water chemistry will be stable, and outside influences will be minimal.

The freshwater aquatic environment differs from the terrestrial environment in many significant ways. Water acts as a solvent for many of the chemical elements necessary for sustaining life. These include nutrients, minerals, and many gasses (oxygen, nitrogen, and carbon dioxide being the most important to your pond). Aquatic organisms live in an environment that surrounds them with the basic elements of life. All that is needed is an energy source (sunlight), to begin the nutrient cycle in this ecosystem. The absorption of sunlight in a pond depends on water clarity, which in turn is affected by dissolved material like minerals, suspended organic and inorganic material, such as algae and dirt. This suspended material in the water is called turbidity. Other factors to light absorption include artificial inhibitors like shading and dyes.

Understanding the current condition of your pond is another important factor for anticipating what type of maintenance problems you will be facing. Generally, ponds are classified into one of three types: oligotrophic (new), mesotrophic (middle aged) or eutrophic (old).

Oligotrophic (new) ponds are either freshly built or have aged slowly due good design and proper maintenance procedures. Small ponds can be drained and cleaned every few years this restores them to an oligotrophic condition.

Mesotrophic (middle aged) ponds have an intermediate level of nutrients and plants. They experience moderate algae blooms on an intermittent basis.

Eutrophic (old) ponds generally have high nutrient levels, large amounts of sludge, turbid or cloudy water, and large algae and aquatic plant populations.

Remember, these classifications are a measure of the condition of your pond, not the age in years or seasons. Proper maintenance can mitigate or reverse this aging process. A maintenance program using supplemental microbial treatments is an effective way to restore your pond to a balanced and controlled condition.

A healthy ecosystem in a man-made pond begins with good design. Ponds that are fairly deep (10 to 12 feet) have a better chance of dealing with normal nutrient load than very shallow ponds. Circulation is

critical for good pond maintenance. A proper combination of water circulation and aeration is the best tool you have for creating a healthy ecosystem. We will discuss this in more detail in the next chapter.

Water Chemistry

The most important factors influencing water quality are the amount of sunlight, oxygen levels, nutrients levels and pH of the water.

Sunlight is the primary energy source for a pond. It drives photosynthesis in plants and affects water temperature. Shallow bodies of water, less than six feet deep, are generally more difficult to manage than deeper ponds because full light penetration and warmer water can cause more frequent and severe algae blooms. Low levels of sunlight can adversely affect the oxygen levels, as happens during a sustained cloudy period. Algae in the system drop in the production of photosynthetic oxygen and begin to consume oxygen thus depleting oxygen levels.

Dissolved Oxygen or (DO) - **Oxygen is the most important gas in the aquatic environment** and adequate DO levels are critical in maintaining a stable ecosystem. Cold water holds more DO than warm water. In warm water zones the DO levels are lower, which has an adverse effect on most organisms. Low DO levels can lead to reduced microbial growth and minimal aerobic digestion of nutrients. Oxygen enters ponds by several sources such as photosynthesis and wind or wave action. Aquatic plants and algae produce oxygen-using photosynthesis whenever light is present. When there is no light, the plants and algae use oxygen, this is the reason fish kills can occur at night in ponds with heavy planktonic blooms. Wind and wave action allows oxygen to mix with surface waters, and allow oxygen to diffuse into the water. The transfer of oxygen and other gasses into and out of the system is facilitated by bubbles in the water, which provide a medium for gas exchange. Oxygen levels can also be increased mechanically through aeration. This is often the primary method of oxygenation in a pond and is discussed in detail in the section on aeration and water circulation. DO levels below three to four parts per million will cause stress situations in the pond.

The first signs of low oxygen levels are odors and then fish kills. Typically DO is measured in parts per million (ppm) with 0 ppm representing a complete lack of oxygen and 15 ppm representing the saturation point of water. Normal oxygen content in a healthy pond will run between 5 ppm to 10 ppm. Fish and other organisms utilize oxygen to accommodate metabolism, they then excrete carbon dioxide, for use by plants and algae to regenerate oxygen in the pond.

This oxygen cycle, and the oxygen balance are affected by what is known as the biological oxygen demand or BOD in the pond. This involves the decay process of plants and animals and consumes substantial amounts of oxygen in the ecosystem. It is interesting to note that an ecosystem in a good healthy balance will not have wide swings in the oxygen levels but will stabilize according to the many conditions present. It is worth repeating that one method of assuring good dissolved oxygen levels is through mechanical aeration of the water. Many aeration devices are available for this purpose.

Nutrient Levels.

There is a direct correlation between amount of available nutrients and the population of algae and aquatic plants. It is important to determine and understand the source of these nutrients; the most important nutrients in an aquatic system are phosphorus and nitrogen. Phosphorus has been identified as the single biggest contributor to aquatic plant growth. A single gram of phosphorus will produce one hundred grams of algae. Water quality and clarity begin to decline when the level of phosphate reaches 0.05 to 0.1 ppm or the level of nitrates reaches 5-7 ppm.

The most substantial sources of nutrients in medium sized ponds are dead vegetation, landscape debris, runoff from the area surrounding the pond, and waterfowl. As aquatic vegetation grows and dyes, it sinks to the pond bottom, adding to the nutrient level for future aquatic growth. This is called nutrient cycling. Additionally, landscape activity can be a substantial factor in the amount of decaying vegetation. From grass clippings, to trimmings from tree and bushes, to falling leaves, pine needles and pinecones, the landscaping around your lake is a major consideration for your lake maintenance plans and expectations. Lack of control over these factors can be a primary reason your lake slips inexorably into eutrophic condition.

An additional nutrient source from landscaping is from runoff from the area surrounding a pond. Some reports state that up to 4% of the fertilizer applied to the area adjacent to a pond may runoff into the pond. To make the matter worse, it is accepted practice to extend the fertilizer area out into the adjacent pond to assure complete coverage on the terrestrial areas. This is sabotage to your lake maintenance plan. Careful applications of slow release fertilizers are the best method to use when fertilizing around an aquatic system. One solution to this problem is to fertilize the last 15 to 20 feet out from your lake with hand spreaders. Be very careful to not over fertilize, monitor and control run-off into your lakes, try switching to organic fertilizers in the area around your pond; they release more slowly into the water system after rain or irrigation. In some instances, like catfish ponds, fertilizer will be added to ponds to grow Planktonic algae; it's free fish food and blocks sunlight, preventing weed growths. This has nothing to do with your beautiful reflection pond getting loaded with harmful nutrients by negligent landscaping. Fertilizers and landscape materials will not have any beneficial effect on your pond and need to be controlled in every way possible.

An additional source of nutrient is waterfowl. As mentioned above**, it takes only 0.1 ppm of phosphate or 5 -7 ppm of nitrate to reduce your water quality and thus the enjoyment of your pond.** Research shows that it takes 4.2 ducks per surface acre per year to produce this much nitrates and only ½ duck surface acre per year to produce the minimum phosphate. This means that if your one-acre pond has as few as five resident ducks, they could be producing enough nitrates to overload the system, and up to ten times the amount of phosphate needed to foul the pond.

The sediment or sludge at the bottom of the pond can accumulate at a rate of one to five inches per year or more. This rate is higher in warm, nutrient-rich waters. From a practical perspective, **an irrigation pond with one acre of surface area can lose water storage capacity by 80,000 gallons per year** by the loss of volume caused from sediment build up. Naturally-occurring bacteria are present in all ponds, but generally are not present in large enough numbers to combat the sedimentation and extra nutrients available. The use of supplemental microbes will reduce this sedimentation by digesting the organic components which can exceed 90% of the biomass. The remaining inorganic materials, like sand or clay, will remain on the bottom as a component of your healthy ecosystem. This remaining bottom sediment, called the benthic layer, will provide an anaerobic zone, which is important to the denitrification process.

This is discussed in the chapter on The Role of Microbial Supplements in the Aquatic Ecosystem.

Pond Dynamics

Nutrients, like all things in a pond, are continuously recycled. Nitrogen, phosphorus, sulfur and carbon undergo complex cycles as they are converted from one form to another. Phosphorus, nitrogen, and carbon support nuisance algae blooms.

Phosphorus

Only small amounts of phosphorus (as little as .03 ppm total phosphate) is needed to support nuisance algae growth. Once phosphates are present, they are almost impossible to remove, with the best option being to bind up the phosphates or convert them to an inorganic form. Oxygen is required to accomplish this. Phosphates can be bound to positively charged ions present in the water if sufficient oxygen is present. Once bound, phosphorus will precipitated out of the water column and into the bottom sediment. The phosphorus is unavailable for algae growth as long as oxygen levels remain sufficiently high.
As one example of this, there has been great deal of enthusiasm for adding barley straw to a pond as a natural algae control. This is actually a complex method of binding phosphates. The bacteria in the pond break down the barley straw and during this process hydrogen peroxide is produced. The hydrogen peroxide in the water is a natural algaecide and an oxidizing agent and which helps bind up the phosphates in the water.

The various forms and stages of phosphorus in the aquatic system is quite complex. Phosphorus exists in water in either a particulate phase or a dissolved phase. Particulate matter includes living and dead plankton, precipitates of phosphorus, phosphorus adsorbed to particulates, and amorphous phosphorus. The dissolved phase includes inorganic phosphorus and organic phosphorus. Phosphorus in natural waters is usually found in the form of phosphates (PO_4^{-3}). Phosphates can be in inorganic form (including orthophosphates and polyphosphates), or organic form (organically-bound phosphates). Organic phosphate is phosphate that is bound to plant or animal tissue. Organic phosphates are formed primarily by biological processes. **One primary source of phosphates in a pond is found in waterfowl excrement.** Organic phosphates may occur as a result of the breakdown of organic pesticides which contain phosphates. They may exist in solution, as loose fragments, or in the bodies of aquatic organisms. Orthophosphate is sometimes referred to as "reactive phosphorus." **Orthophosphate is the most stable kind of phosphate, and is the form used by plants. Orthophosphate is produced by natural processes of metabolism.**

Polyphosphates (also known as metaphosphates or condensed phosphates) are strong complexing agents for some metal ions. In water, polyphosphates are unstable and will eventually convert to orthophosphate, particularly in lower oxygen environments. Inorganic phosphate is phosphate has been bound up and is not associated with organic material. Types of inorganic phosphate include orthophosphate and polyphosphates.

Ultimately, the pond keeper needs only be concerned about keeping the phosphorus in the system in a form that cannot be utilized by plants for weed and algae growth.

Some pond keepers remove phosphorus from their water through the addition of alum (aluminum sulfate or potassium aluminum sulfate). The alum causes phosphates to form a fluffy precipitate (floc), aluminum phosphate, which has a lower solubility than the aluminum sulfate and will sink to the lake bottom. Within hours of applying the alum, the upper layer of water will become clear and relatively free

of phosphates, but the precipitate or floc can leave a milky appearance in shallow water particularly if the Alum treatment is done on a windy day with strong wave action. .

Alum or aluminum sulfate is one of the most widely used products to treat artificial ponds for clarity and phosphate control. The aluminum ions bond with phosphate molecules in the water. The resulting aluminum phosphate is insoluble in water. This precipitate settles to the bottom of the pond and the phosphate is no longer available as a nutrient

Another important chemical cycle is the Nitrogen/ Ammonia chain. Ammonia is the second most important gas in your pond after Oxygen. Landscape intrusions, excessive feeding of fish, excrement from fish and waterfowl and other decomposing plant and animal material can bring on excessive levels of ammonia. **The presence of ammonia in the pond is normal and ammonia can exist in two forms**: un-ionized ammonia (NH3) and ammonium ion (NH_4^+), while NH3 is extremely toxic to fish, NH_4^+ is nontoxic except at extremely high levels. **Water temperature and pH regulate the levels of each form available in the pond and specific bacteria convert ammonia into other forms of nitrogen.**

Nitrogen

The basic concept to understand here is the nitrogen cycle. The cycle begins when fish eat and then excrete ammonia. The ammonia is toxic to fish and must be removed or changed to a harmless form. Bacteria metabolize the ammonia and excrete nitrite. Nitrite is also toxic to fish and needs to be removed or changed. Another type of bacteria metabolizes nitrite and excretes nitrate. Nitrate is non-toxic to fish in small quantities and is used by plants and other organisms in the pond for food. Nitrate with oxygen are necessary for every living thing in the pond. Finally, to complete the cycle, the fish eat the plants and again excretes ammonia. Excess nitrate is converted, by other bacteria, into nitrogen and carbon dioxide gasses, these gasses are carried to the surface and out of the aquatic system by the formation of bubbles in the water. The role of bacteria in this process is discussed in detail in the next chapter.

Hardness, Alkalinity and pH

Another intricate interrelationship in an aquatic system is that of hardness, alkalinity and pH. These elements act in concert as monitors of the complex reactions between carbon dioxide, bicarbonates, and carbonates and are important measures of the chemical balance in the pond.

pH is the measure of the water's relative acidity, based on a logarithmic scale 0 to 14. On this scale 7 is neutral, less than 7 is acidic, and above 7 is alkaline. This value represents the concentrations of hydrogen ions present in the water. It is important to note that knowing the pH doesn't give a complete picture. A pH test of distilled water can show almost any value since just a tiny amount of residual impurities, either acid or base, can have a major effect on the ratio of the two.

The Alkalinity of the water is related to the actual number of base components and can be thought of as the "intensity" of the pH. If the alkalinity is low, it indicates that even a small amount of acid can cause a large change in pH. Alkalinity is related to the amount of dissolved Calcium, Magnesium, and other compounds in the water and as such, alkalinity tends to be higher in "harder" water and is slowly increased by evaporation which concentrates the source compounds. Alkalinity is naturally decreased over time through bacterial action which produces acidic compounds that combine with and reduce the alkalinity components.

Alkalinity, or hardness, is most often measured in ppm and shown as calcium carbonate ($CaCO_3$) equivalents. Hard waters have the capability to buffer fish from heavy metals that can be toxic, like copper in many common algaecides. This buffering can also reduce the effectiveness of these same algaecides. Waters rich with minerals are termed hard, and will be alkaline, with a pH above 7. Waters without minerals, soft water, will be acidic, with a pH below 7. Most freshwater life including bacteria prefers a pH range between 6.5 and 9.0. Each organism has varying tolerances**. Higher alkalinities are associated with increased productivity along with increased growth of algae and aquatic plants. Many algaecides lose effectiveness in alkaline conditions, making algae control more difficult.**

Another important factor in the pond ecosystem is temperature. Most aquatic organisms are cold-blooded ("poikilothermic") meaning they are unable to internally regulate their core body temperature. Therefore, temperature exerts a major influence on the biological activity and growth of aquatic organisms. **In general, higher water temperatures produce greater biological activity**. Fish, insects, zooplankton, phytoplankton, and other aquatic species all have preferred temperature ranges. As temperatures get too far above or below this preferred range, the number of individuals of the species decreases until finally there are few, or none.

Temperature is also important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen than cool water, so it may be saturated with oxygen but still not contain enough for survival of aquatic life. Some compounds are also more toxic to aquatic life at higher temperatures.

Temperatures in ponds will continuously change, but well circulated ponds will have more stability than poorly circulated ones. The most obvious reason for temperature change in lakes is the change in seasonal air temperature. Daily variation also may occur, especially in the surface layers, which are warm during the day and cool at night. In deeper lakes (typically greater than 15 feet for small lakes and 30 feet for larger ones) during summer, the water separates into layers of distinctly different density caused by differences in temperature. This does not occur in smaller ponds.

Most algae in ponds has a fairly narrow temperature range when compared to other organisms, but the range is broad enough that algae is a problem in many areas from April to October , with a longer season in warmer climates. Algae growth as, well as many other organisms, will become dormant at water temperatures below 50°F and will substantially increase in productivity as water temperatures rise above the 68°F to 72°F . In waters above 75°F algae production reaches optimum levels. However, the ecosystem is always affected by other environmental conditions such as sunlight intensity, basic water chemistry, and available nutrient. Some varieties of algae prefer cooler temperatures and can be a nuisance during the spring and fall when other algae has stopped growing.

The Role of Biological Supplements in Establishing a Healthy Aquatic Ecosystem.

A microbe is any living thing that spends its life at a size visible only with a microscope. It is too tiny to be seen with the naked eye. Microbes are the oldest form of life on Earth. Some types have existed since the earth was first created. They may live as individuals or cluster together in communities. Microbes live in the water you drink, the food you eat, and the air you breathe**. Right now, billions of microbes are swimming in your belly and mouth, and crawling on your skin. Don't worry, over 95% of microbes are good for you and most of the rest are harmless.** Microbes include bacteria, viruses, fungi, algae, and protozoa.

In this chapter, we will discuss how the addition of specifically selected bacteria can stabilize and optimize many of the natural processes in your pond's ecosystem. In converting from ammonia to nitrate there are two bacterial species involved. Nitrosomonas sp. bacteria which oxidize ammonia to nitrite, while Nitrobacter bacteria convert nitrite to nitrate, with both species utilizing the energy released by the reactions. This process involves a complex series of reactions that can be summarized in chemist shorthand as this:

For Nitrosomonas: $55NH_4^+ + 76\ O_2 + 109HCO_3 \rightarrow C_5H_7O_2N + 54NO_2 + 57H_2O + 104H_2CO_3$

For Nitrobacter: $400NO_2 + NH_4+ + 4H_2CO_3 + HCO_3 + 195\ O_2 \rightarrow C_5H_7O_2N + 3H_2O + 400\ NO_3$

What these reactions show is that approximately 4.3 mg of O_2 (oxygen) are consumed for every mg of ammonia-nitrogen oxidized to nitrate-nitrogen and 8.64 mg of alkalinity in the form of HCO_3 are consumed per mg of ammonia-nitrogen oxidized.

This is a substantial amount of alkalinity reduction and will, over a period of time, dramatically change the character of the pond water, affecting both hardness and pH stability. It is also a mild acidifying process, producing a gradual build up of nitric acid**. It should also be noted that the process does not remove any nitrogen from the system it simply changes it from one form to another.** Nitrification uses substantial amounts of oxygen and carbonate, thus reducing water hardness and lowering pH.

So what about the nitrate? Although nitrate does not represent a direct health threat to most fish, high levels are still undesirable. **Nitrate is the one of the basic food sources for aquatic weeds and algae so we can see that increasing the nitrate in the system could create more problems by stimulation growth. There is one final phase of this process necessary to remove excess nitrogen from the ecosystem. Denitrification and dissimilation are parts of another natural process that converts nitrate to atmospheric nitrogen gas**. **THIS PROCESS ONLY OCCURS IN THE ABSENCE OF OXYGEN.** This is why a small amount of bottom sediment is a necessary part of a healthy ecosystem. The sediment in the benthic layer on the pond bottom is a low oxygen environment where these reactions can occur. The first stage is dissimilatory nitrate reduction, which reverses the nitrification process and converts nitrate (NO_3) back to nitrite (NO_2). **The second stage of denitrification converts nitrite to nitric oxide, nitrous oxide and finally nitrogen gas All of these last three products are gases that can be released into the atmosphere**.

The process looks like this; $NO_3{}^-N \Rightarrow O_2{}^-N \Rightarrow O\ N_2 \Rightarrow O \Rightarrow N_2$.

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This process will occur in and near the bottom sediment of the pond called the benthic layer. Oxygen levels are very low in this zone because of the high BOD (biological oxygen demand) within this sediment. Heterotrophic bacteria that derive their energy from oxidation and consumption or absorption of other organisms, when confronted with a low oxygen condition, will switch to this nitrate reduction, thus removing nitrogen from the system as escaping gasses. These same bacteria are responsible for the reduction of the organic sediment on the lake bottom, keeping this build-up from becoming a serious problem. Ponds that are maintained with supplemental microbes will develop a natural layer of sediment consisting of mostly inorganic material that the microbes do not break down. This sediment layer is a necessary part of the bioremediation process. The practices of draining smaller ponds and removing the sediment or vacuuming the sediment out can actually disrupt the established ecosystem.

One word of caution, if your pond has poor circulation and low oxygen content, this process can occur throughout the pond, resulting in excessive nitrite being fed back into the system, causing mysterious fish kills. This is possible during very warm weather when oxygen demand is at its highest, but dissolved oxygen levels at their lowest. During the night when oxygen levels fall to their lowest because of algal respiration, it is possible for oxygen levels to fall below the critical level in a poorly aerated system that is loaded with decomposing organic matter. The situation will be reversed at sun-up when photosynthesis restarts and oxygen is released back into the water, leaving the pond-keeper confused while trying to explain the dead fish he finds each morning. The remedy for this situation is to have adequate circulation or aeration installed in the pond. Circulation is critical to good pond maintenance for a variety of reasons. We will discuss this in the next chapter.

Bioaugmentation is a completely natural and ecologically harmless method of maintaining a proper pond. Typically, small and medium sized ponds have difficulty controlling excess nitrates and ammonia in their confined systems. The buildup of nitrates and ammonia create toxic environments that result in fish kills and eutrophication of the system. These problems can be controlled by the addition of supplemental bacteria.

Most supplemental bacterial formulations use a proprietary blend of naturally **occurring** bacteria plus specific micronutrients to quick-start the microbial growth. **Many work in the entire water column as well as in the bottom sludge to break down and digest organic wastes from a variety of sources. These cultures are completely safe for fish as well as humans, animals, plants, birds and the environment.**

These bacteria generally are derived from natural environments and are not genetically engineered. Useful bacterial strains are grown and blended for application to specific organic problems and commercial uses and typically contain a number of species that have been selected and combined to degrade specific organic compounds or waste products. The strains of bacteria in the blend work together - each producing the enzymes necessary to degrade specific components in the waste and their resulting intermediates until reaching non-harmful compounds such as water and carbon dioxide.
By adding supplemental bacteria to the pond water, a natural cleansing process is established using biologically active bacteria cultures, enzymes, activators and accelerators developed specifically for ponds. The microbes populate the entire system, multiply and produce large quantities of digestive enzymes on an ongoing basis.

Supplemental bacterial cultures will help break down ammonia to form nitrates and nitrites which are then reduced to nitrogen gas. Similarly, other waste materials in the pond, like waterfowl excrement and landscape debris, are broken down in the system into non-hazardous materials. Unless treated with

bacteria, these materials form oxygen-depleting bottom sludge. The break down process gives the bacteria the nutrients they require to grow and reproduce.

The bacteria utilize dissolved oxygen in their digestive processes. However, by removing the undesirable organic materials noted above and reducing BOD in the aquatic system, ultimately, more oxygen will be available in the system. The use of bacteria will not adversely affect a well-aerated pond.

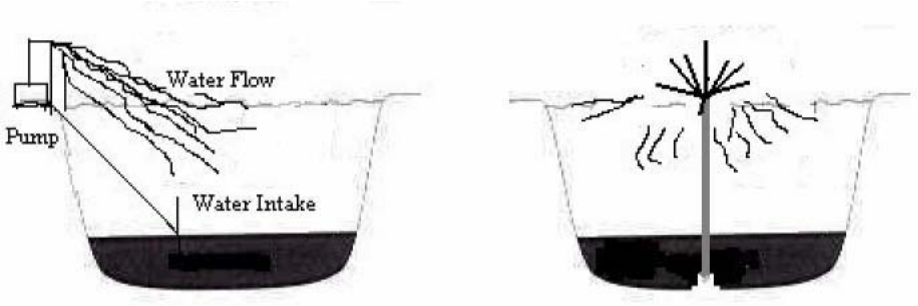
The use of these microbes is not a one-time quick fix for poorly circulated or eutrophic ponds. Rather, a preventative maintenance tool, which requires bacterial additions at regularly, spaced intervals. Using bacteria in your lake on an ongoing basis will assure that your ponds' ecosystem stays healthy. This program helps control nutrient levels, reduce sediment, stabilize pH, alkalinity, and oxygen levels, and bring your pond into optimum condition. Best results are achieved when used in conjunction with other components of a balanced treatment program, including proper circulation and the selective use of algaecides and herbicides needed to control fresh aquatic growths.

Aeration and Water Circulation

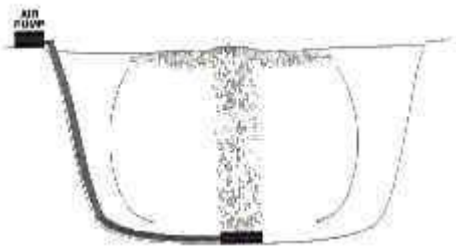
As we've mentioned proper water circulation is critical to an optimized pond ecosystem. So far was have explained how your medium sized pond (½ to 5 acres) has a very different ecosystem from the lake you visited last summer, or from the Koi pond in the back yard. These ponds are unique and are built to add aesthetic appeal to their setting. **Regrettably, they often double as water retention basins for street and landscape run-off. This run-off adds nutrients, dirt and other contaminants that disrupt the ponds ecosystem by increasing the nutrient load. Without proper circulation these beautiful reflections ponds will turn into green, dirty, smelly adversaries.** The residents or patrons that were intended to enjoy the pond are now repelled by it, all the while making vague comments about the health department. **What these lakes need is a consistent treatment program, using microbial treatments, and proper circulation to evenly distribute the water chemistry, water temperature, oxygen and other gasses.**

There are three basic types of circulation available for your pond. The first form of circulation in general use is a floating fountain.

These fountains will move a great deal of water and boast wonderful turn over rates. The drawback, as the diagram above shows, is that these fountains provide a very small area of circulation, leaving the remainder of the lake un-circulated. These fountains *will* add substantial amounts of oxygen and facilitate transfer of gasses, but only near the surface of the lake. Remember that the area that most needs circulation and oxygen is the bottom of the water column near the benthic zone. These fountains can be fairly expensive to install with each unit costing $3000.00 or more. Large ponds may need more than one fountain to even begin to help the circulation in the lake. In the end, these fountains will help with the circulation while adding a new water feature that may or may not add to the aesthetic appeal of the water feature. **They will not provide adequate circulation to completely mix the water in the pond.**



The second type of circulation is set up with a water pump with a water intake near the lake bottom. The pump moves water from the intake and discharges into a waterfall or fountain in the lake. As the above diagrams shows this only provides limited circulation in a channel through the lake with dead areas outside the area of water flow. **With the proper pump size, this arrangement will provide an acceptable water turn over rate but the entire lake is not mixed and there is very little transfer of oxygen or other gasses. This system is designed for aesthetic appeal and not necessarily with the ecosystem in mind.**
If you must rely on either of these systems it would be best to consider using both. By combining the water circulation provided by the pump system and the transfer of oxygen and other gasses provided by the fountains you can achieve a reasonable circulation system.



The third choice in circulation is aeration and is actually the most simple and basic. An air compressor is installed on the lake edge with air lines extending to the lake bottom. Tiny bubbles of air float to the surface transferring needed oxygen into the water throughout the water column. This flow also carries water and creates a permanent circular circulation pattern**. It is also important to note that oxygen transfer actually occurs from air bubbles in the water. This is why the other two types do not transfer as much oxygen; they do not actually create bubbles as much as simple water flow.**

Aeration, on the other hand, is all about bubbles. Bubbles produce the circulation rather than creating bubbles as a side effect of water movement. **In short, aeration is better, more economical and more efficient than the other systems.** The fountains are more easily installed but aeration is worth the extra effort. One more point to consider is the actual diffusers used to create the bubbles. Smaller bubbles carry more water with them and transfer more oxygen. A very large bubble from a central location will not provide as much oxygen transfer but it will create some degree of surface movement by creating ripples around the discharge area. Some people feel this large bubble looks better in the lake because of the added surface action. In the end, smaller, more diffused bubbles actually do more for your pond. **When you purchase an aeration system, check the specks and consider the cost. An aeration system can be very simple and inexpensive and still do an excellent job on circulation.**

It is much less expensive to move air in your pond than to move water. Aeration, will not of course, add any kind of water feature above the surface of the pond, but you can add a fountain or waterfall for their aesthetic appeal while letting the aerators do the real work.

When you look at these choices, you may want to use more than one option. You should consider each choice in assessing the total circulation in your pond. Both water circulation and oxygen transfer are important to your pond. **Very often, a system will be set up with aeration on the pond bottom and either a waterfall or a floating fountain to add a water display above the surface, along with additional water turnover.**
The things you need to consider when installing any system are cost to install, cost to run and maintain, the total area that will be circulated in the lake and the turnover rate. With good aeration and overall circulation, a turnover rate of once every three days will usually be adequate. **Dollar for dollar you can't beat aeration for overall effectiveness.**

If you're building a new pond, it's not difficult to build in a nice circulation system using water circulation and/or aeration diffusers on the lake bottom. All this will be installed as you build the pond, which makes things easy. So, if you are building a pond, do not cut costs now by leaving out a proper circulation system. Your pond needs circulation to establish an ecosystem so you need the circulation equipment installed. **It is much easier to do it right in the beginning than to try to add more later.** However, most of you probably are not building a new pond. You likely have a pond that has been around a while, hasn't had a lot of care and has a few maintenances challenges. That's why you're reading this paper.

Let's look at the setup for each of these choices. Each of these systems will need a power source, breakers and time clock. The floating fountains all come with a pre-built electrical panel including breakers, motor overload, time clock and gfi. Just add power. The water pump or air compressor will need these items installed as part of the set up. **The floating fountains are easy to install. Everything comes in one installation kit.** You just float the unit into the pond with a special submersible power cord attached, set anchor weights or tie lines to hold it in place, set up the electrical panel, attach the power cord to the panel, turn on the power and watch your new water feature go. This is why you see these fountains in so many artificial ponds, they're easy. These fountains are fairly maintenance free. The units come with at least a one year warrantee with some up to three years. You can expect the motor to run at least three years under normal conditions. The cost of these units can be $3,000.00 each or more for a two-horsepower unit. **The problem is that all this water movement is on the lake surface and the bottom of the lake is left un-circulated.**

Installing a circulation system using a water pump has two choices; an above ground pump or a submersible pump. The two diagrams above show these options. You still need the electrical panel, time clock and breakers for each of these but then these choices diverge in the installation process.
The submersible pump is simple to install. There is a broad range of choices on pump type you can use but these fountains are usually set up using a ½ or ¾ hp pump. Larger submersible pumps get very expensive, so most people don't chose to use them in this manner. This doesn't move a lot of water volume so the fountain really is more of a visual effect rather than viable water circulation. The pump sits near the lake bottom where it pumps water up a PVC pipe and discharges in a single stream or through a fountain head. The head can be a threaded PVC cap with ½ "holes drilled in it to create the spray effect shown in the diagram.

Note that these fountain heads can clog up and require cleaning, adding a new maintenance item to the pond-keepers duties. These submersible pumps will often pick up leaves and small fish and shoot them up the pipe to the fountain head where they lodge and require removal. That is why you need a threaded fountain head, don't glue the head or you won't be able to clean it. You'll probably need to dive into the lake to install these pumps. **Don't set the pump right on the lake bottom because it will suck up bottom sediment and could clog up.** The pump should be set inside a container then put on the pond bottom. A 55 gallon drum cut off at about 2 feet works well. Put the pump inside the cut off barrel, include a cinderblock for additional weight and set them on the bottom. Now the water intake is coming from 2 feet off the bottom since the water has to go over the edge of the barrel. Another choice is to build a platform on the lake bottom, with a few cinderblocks for the pump to sit on. **Just as long as the pump is not sitting directly in the bottom sediment, you'll be okay.**

Installing a circulation system using an above-ground pump can be very difficult after the pond is already built and filled with water. It's easy to see why. **You need to install an intake pipe** near the bottom of the lake. Multiple intake pipes in different locations are better to spread the water circulation pattern. **Next, you need to decide where the water will discharge. Do you want a waterfall, or a fountain like we described above, or a small stream, or perhaps just an underwater jet.** Again multiple discharges in different locations will increase the circulation pattern. All this is a lot of plumbing to install underwater in an existing pond. **The highlight of this setup is that the intake and discharge need to be as far from each other as possible to create circulation throughout the pond. Remember the water will flow in a channel between the intake and discharge; the areas outside the channel will still be dead areas.** This system can be set up with as large a pump as is needed to produce adequate water turn over. Two to five horsepower pumps are common on medium sized ponds. These pumps are much less expensive than submersibles of equal horsepower but the cost differential is offset by all the plumbing needed with this system.

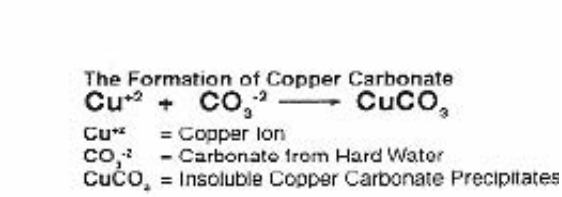
The bottom line is that the water circulation does not always add thorough circulation to the system. The water will move in channels, and the transfer of oxygen and other gasses is limited. Remember that gasses are actually transferred by air bubbles in the water, not simply by water movement. After you understand your treatment options and set up a maintenance program, you must provide the needed circulation to make your program work. **Without proper circulation, even the best treatment choices will have limited success.**

When are Chemical Treatments Needed?

"We just throw some copper sulfate out there when the algae grows. That worked for a while, but the whole thing seems to be getting out of hand now."

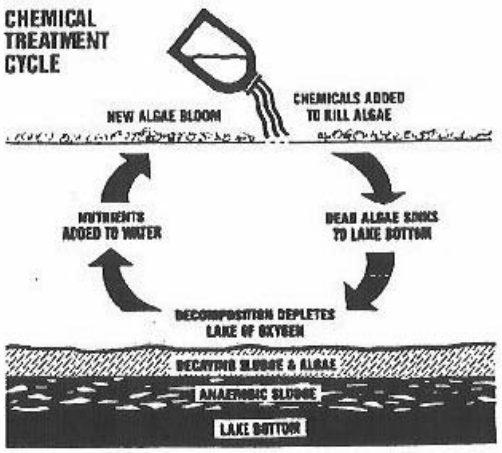
Anonymous CGCS.

In many instances, lake maintenance has not change since the early 1900's when it was discovered that copper sulfate could be used to inhibit algae growth. With all the advancements in made both in chemical and biological treatments, many people still chose to fall back on this old stand-by of throwing some "Bluestone" on the problem and hoping that fixes it. Copper sulfate is widely used as an algaecide and can appear to be economical and effective on some types of algae. **This treatment also has some serious and undesirable side effects as well as definite limitations. Copper sulfate is most effective in slightly acid or neutral pH. Under alkaline conditions, it will form a toxic precipitate, called copper carbonate. Copper carbonate precipitates -drops out of the water column- and will build up in the lake bottom sludge, creating a hazard for fish, waterfowl and other organisms.** Without supplemental bacteria, this sediment will build up quickly. Due to these chemical byproducts building up in the sediment, this material may be considered hazardous waste, making removal or dredging difficult and less feasible as restrictions and regulations become broader and more complex.



Over the years, chemical manufacturers have developed several forms of chelated copper compounds which lock in the copper ion and help prevent the formulation of copper carbonate to a large degree. These products control algae with better success than raw copper sulfate and **copper-based product are the primary treatment tools used by many lake maintenance professionals**. However, these products are still greatly affected by the pH of the water, and copper, as an element, continues to build up in the bottom sediment as treatments continue.

Chemical treatment programs in general are often affected by pH, water temperature, weather conditions, levels of organic materials in the water, and a variety of other conditions that are generally beyond the control of the pond-keeper. These drawbacks and variables, taken as a whole, can make the development of an effective chemical treatment program an extremely difficult, expensive and generally unsuccessful venture. The addition of beneficial microbes to your treatment program will help to control many of these factors and will stabilize the water chemistry both before and after chemicals are applied. **By stabilizing the ecosystem, the microbes can also make chemical treatments more effective when they become necessary to treat specific aquatic growths.**



The diagram above shows the chemical treatment cycle. As chemical treatments are added to the system, each dose kills the existing algae. The dead plant material drops to the bottom, where it begins to decompose. This decomposition frees up nutrients in the water, which are used to feed the next algae bloom. **Throughout this cycle, nutrient levels, plus the levels of residual chemicals, build up** BOD increases, oxygen levels decrease, robbing the lake of its ability to support fish and other aquatic life. In time, anaerobic bacteria take over the decomposition of the dead organic material. Without oxygen these bacteria create methane gas and hydrogen sulfide, giving off foul, 'rotten egg' odors. **Repeated chemical treatments are needed for the recurring algae blooms, while toxic chemicals continue to build up in the lake water and accumulate in the bottom sediment.**

Despite all the time, effort and money invested, the lake gets worse instead of better. The water remains dark and murky and smells bad. The final stage of deterioration has been reached and eutrophication of the lake is completed.

While chemical treatments are only a temporary fix to algae growths, they are sometimes a necessary addition to an effective pond maintenance program. Chemical treatments should be used in conjunction with a ongoing bioaugmentation program to create a stable and balanced ecosystem. One could easily draw an analogy between chemical treatments in a pond and the prescribing of drugs and medications by a medical doctor. The best preventative treatment is to maintain a healthy ecosystem much like a healthy immune system, and chemicals like medical medications are used to correct a condition that grows beyond the systems ability to heal itself.

Where this analogy breaks down is in the results. While medical doctors can often cure disease with proper prescriptions, **chemical treatments made to an aquatic ecosystem will often worsen the condition over all without ever addressing the root cause of the problem. Chemical treatments in a pond produce a predictable cycle of, growth, treatment, die-off, nutrient release and growth, with the overall condition degenerating with each repetition of the cycle.** To compound this problem, oxygen is often severely depleted in the die-off phase, causing fish kills and further eutrophication of the pond environment. **In contrast to this chemical treatment cycle, the addition of beneficial bacteria into the pond environment can help to stabilize the system so growths can not gain dominance in the system.**

The original question in this chapter was, 'when are chemical treatments needed'? The short answer is only when absolutely necessary. Chemicals should be used to address algae and weed growths that are actively growing and still in the in the early stages of growth. As these plants increase they usually need more chemicals for treatment and the treatments get less effective. Repeating

chemical treatments in follow-up applications may be needed for heavy growths. **Many chemicals can be tank-mixed to use as combination treatments for a variety of plants or to increase the effectiveness of the treatment.** You should always follow the label directions regarding treatment amounts and tank mixing. **After weeds and algae are treated with chemicals to kill the plants, you should follow up with applications of beneficial bacteria to reduce excessive nutrient levels and stabilize the ecosystem.** The next section will help you identify the types of weeds in your pond and the correct treatment choices for each.

Algae and Aquatic Weed Control

Aquatic weeds and algae present a constant challenge in pond maintenance. The amount of aquatic vegetation growth is a function of water depth, water clarity, weather patterns, and nutrient loading. In addition to being an eyesore, algae clog filters, pump inlets, and other equipment. Sedimentation is accelerated, oxygen levels reduced, and bad odors result. **The pond's use and state regulations influence the treatments selected.** Aquatic plant management should be a combination of methods that work harmoniously with the environment. There many techniques that help maintain the pond environment. These include pond aeration, filters, controlling runoff, biological methods, and the use of aquatic algaecides and herbicides. **Some plant growth is a viable part of any aquatic ecosystem but excessive plant growth soon becomes an undesirable weed population that requires treatment and control.** Proper identification of plants is critical to the treatment process. Many herbicides are selective and are only effective on specific types or species of plants. On our "links page" we have included several links to weed identification web sites and links to the various algaecide and herbicide labels that are mentioned in this chapter. **This chapter will give you an overview of the various types of weeds and algae, plus a general overview of the best products to use in your chemical treatment program.**

There are five major groups of aquatic plants. They are classified as algae, marginal, submersed, emersed, and floating.

Algae; Fresh water algae is very diverse in shape, color, size and habitat. To describe all species of algae we would need to write a paper that would equal descriptions of all land plants, mosses, ferns, fungi, and seed plants combined. All forms of algae contain the green pigment chlorophyll, but the green color can be masked by other colors including red, brown, blue-green, and black. Algae are often the primary food source for an aquatic environment and are an important producer of oxygen, even under the ice in the winter. Algae can also be the primary problem in a pond and is often difficult to correct. **There are three major groups of algae.**

Planktonic algae or 'pea soup' algae; this group is also called phytoplankton to separate it from the microscopic animal forms called zooplankton. These are microscopic plants that suspend in the upper few feet of the water. These algae can rapidly become a heavy bloom that covers an entire pond with green or brownish scum. Planktonic algae are the most easily controlled with copper compounds but treatments must be applied before this algae reaches the stage of a heavy bloom. Blooms will often use up all available nutrients and die off suddenly causing a serve oxygen drop from decomposition of dead algae. Certain species of Planktonic algae can product toxic substances which are stored in the cells and are released as the cells die. This will poison the water to pets, livestock, wildlife and fish. The addition of supplemental microbial treatments will help control Planktonic algae by depriving it of nutrient, stopping this problem before an algae bloom begins**.**

Filamentous algae, called moss, blanket weed or horsehair clump; Filamentous algae is a chain of identical cells that grow lengthwise at the tips forming free floating filaments. This form usually reproduces by fragmentation. These mats of algae product large amounts of oxygen that gets trapped within the filaments, which causes the mats to rise in the water and float free on the surface causing the algae to spread to other areas of the pond. These free floating clumps also clog pump intakes and foul irrigation lines if the pond water is used in an irrigation system. Applying microbial treatment along pond edges will help stop filamentous algae from developing by reducing nutrient and biomass along the pond edge.

Chara, also called muskgrass; is called attached-erect algae that has a weed-like appearance and is anchored in the pond bottom completely underwater. This type of algae looks like weeds growing on the pond bottom but there are no roots or vascular system since the plant is actually a form of algae. The best way to identify this type of algae from other aquatic weeds is by its musky smell and gritty feel. This is due to calcium deposits on the surface. These calcium deposits make the plant resistant to chemical treatments in the later season and it's best to begin treatments in the early spring. The water tends to be very clear when Chara is present.

Types of aquatic plants: Most species of aquatic plants are found across a wide spectrum of freshwater environments and have wide ranges, often worldwide. Each species of plant plays a role in the ecology of the system. The essential function of aquatic plants includes the following: they produce oxygen to aerate the water (from photosynthesis), provide shelter for fish and freshwater invertebrates, consolidate the pond bed and banks, provide food for aquatic organisms, and a spawning medium for many fish. Marginal plants provide nesting sites and a food source for waterfowl, as well as provide aesthetic appeal to the ponds.

Marginal Weeds– Plants that grow in the saturated soil on the waters edge, like cattails.
Submersed Weeds --True seed plants rooted on the bottom, mostly underwater with a few flowers above the surface like naiads.
Emersed Weeds– Rooted on the bottom with floating leaves and flowers, like arrowhead and waterwillow.
Floating Weeds–Free floating plants or rooted, but leaves rise and fall with water level, like duckweed and waterlilies.

You generally do not have a lot of control over the types of plants that will appear in your pond except for those you purposely plant. Mother Nature has a variety of ways of bringing algae and plants to your pond. Algae are very common organisms that can be found on land as well as in water. They are often the first occupants of your pond; aquatic plants come later. Seeds and fragments are brought in by the wind or on the feet of waterfowl. Plants and algae invited or not, will eventually find their way to your pond.

Before trying to rid your pond or lake of aquatic weeds, consider the benefits they provide to the aquatic environment. Maintaining a healthy balance of aquatic plants is critical to a pond's ecosystem. Aquatic plants provide the basic resources for the rest of the pond community and native aquatic plant communities help prevent the establishment of invasive exotic plants**. It is rarely desirable to remove all the plants from a pond.**

Food and cover are closely related in aquatic habitats, providing cover generally increases fish food production. There are two main types of aquatic cover - aquatic plants and hard cover such as logs, brush or large rocks. **Aquatic plants are a necessary part of the pond environment and when controlled properly can be desirable; many are attractive and improve the aesthetics of a pond or lake**. Their role is important since only plants can convert solar energy into stored chemical energy for use by animals. Most insects used as food by fishes are herbivores - plant eaters - and require coarse organic matter for food. These insects feed directly on aquatic plants or on the microscopic plant and animal communities attached to plant surfaces.

Nearly all fish use aquatic insects as major food items sometime during their life cycle, so it is important to have an adequate supply for good fish growth. Aquatic plants are the habitat for many insects.

Aquatic plants also serve as escape cover for young fish and help prevent over-utilization of forage fish (usually bluegill) by predator fish (usually bass). Aquatic plants ensure that some forage fish can grow up to produce young and thus maintain a sufficient food supply for predator fish.

Ponds without adequate aquatic plant cover often develop a fish population composed of many small, slow-growing bass and a few large adult bluegills. In this situation, the few bluegills just can't produce enough young to satisfy the appetites of all the hungry bass. Many of the young bluegills that are produced are eaten as fry before they grow to a size that would promote growth of adult bass.

Aquatic plants help stabilize pond banks and shorelines, reducing wind and wave erosion. Severe erosion can muddy the water and greatly reduce productivity and fish growth. Emergent plants, like reeds and other shoreline plants provide important foods and nesting areas for waterfowl and shorebirds.
Good aquatic plant management is no accident; it must be planned. A rule of thumb is that about 15 to 20 percent of the surface area of a pond should have aquatic plant cover. The best approach is to have the plants interspersed with open water areas, rather than all in one spot. Using selected spot treatments with aquatic herbicides is the best way to achieve these results.

One point seems obvious but still needs mentioning; never attempt to control aquatic weeds by fertilizing the pond. There have been misconceptions for decades on the practice of pond fertilization. Before the plants become established, fertilization can promote microscopic algae, called plankton. As the planktonic algae grow, they color the water green. At this stage they will help limit the depth of sunlight penetration and may limit the establishment of higher multicellular aquatic plants. This is not an acceptable method of weed control and will only serve to throw your pond in a eutrophic condition.

You have to decide the amount of aquatic plants you want in your pond or lake and the location where they will not affect the use of the pond, like interfering with golf ball removal or fishing in the pond. **Not every aquatic plant becomes invasive where it will "take over" your pond.** Some grow slowly and never become a problem. Because bass and bluegill prefer structure or cover, they will stay around the edges of your plants searching for food or seeking relief from direct sunlight in the shade the plants provide.

The first and most important step in controlling weeds and algae is proper identification. We have included several links to weed identification sites to help you with this task. See the Links section at the end of this paper or on our web site at www.OmegaLakeServices.com . **The control method, products you chose, treatment method, application rates, expected results, and side affects to the ecosystem all depend on the type of plant present in your pond.** Don't overlook this step.

In general, there are four ways to control or remove aquatic plants. We will address the first three for reference but **the focus of this discussion is on the chemical control method.** SePRO Corp. the makers of SONAR, K-Tea and Komeen among other products, have a great, seven page PDF called, Options for Aquatic Plant Management , which does a good job of explaining pros and cons of alternative weed control options.

Manual/Mechanical: includes hand-pulling and raking or mechanically harvesting plants. Some States regulate these operations and a permit may be required.

Physical: includes bottom plant barriers and water drawdown. These methods are used only in special circumstances because they involve a placing structure on the bed of a lake and/or effect lake

water level. Barriers are difficult to add to an existing lake and are generally reserved to new constructions.

Biological: includes herbivores and bacteria. Currently the most common biological controls are the stocking of grass carp, which will eat some varieties of aquatic weeds and the Galerucella beetle, which is used to control the exotic invasive plant Purple Loosestrife.
Adding the bacteria microbial treatments will help reduce the bottom sediments in ponds and can reduce the growing area available to some aquatic plants.

Chemical: includes algaecides, herbicides, and dyes. Chemical treatments can be the most difficult, costly and unpredictable part of a pond maintenance program. Chemical treatments to ponds usually require an applicators license in most states. The purpose of the license requirements is to make certain the applicator is properly trained and understands the legal and safety factors involved in using the products. **We feel this understanding of the products and other factors is critical to the applicator. You should read the product labels carefully when deciding which treatments to make.** It is also important for one individual to be responsible for the treatments to your pond. **You need to become aware of the results of each treatment, positive or negative.** Each pond is a unique ecosystem with unique water chemistry and aquatic life. **This experience with the pond becomes an important tool to the pond-keeper in making ongoing treatment decisions to a dynamic environment.**

When you choose chemical herbicides, there are two different types of action: contact and systemic. Contact herbicides achieve fast results, but may require multiple treatments during algae bloom season. Additionally, exposure of every part of the target plant is necessary. Systemic herbicides are slower to kill, however they often provide seasonal control, and there is less oxygen depletion due to rapid decomposition of vegetation. Only those chemicals registered with the U.S. EPA may be used. When controlling aquatic plants with chemicals, **proper identification of the plants and the appropriate chemical for treatment is important** to be certain that treatment occurs at the proper timing and dosage. In order to apply chemicals in most states, the applicator must be licensed with the State. **If you are a pond owner, it is probably best to contact a licensed applicator for these treatments.**

Aquatic herbicides are chemicals specifically formulated for use in water to kill or control aquatic plants. Herbicides approved for aquatic use by the United States Environmental Protection Agency (EPA) have been reviewed and are considered compatible with the aquatic environment when used according to label directions. Many individual states also impose additional constraints on their use.

Aquatic herbicides can be sprayed directly onto floating or emergent aquatic plants or are applied to the water in a liquid or pellet form. **Systemic herbicides are capable of killing the entire plant. Contact herbicides cause the parts of the plant in contact with the herbicide to die back. Non-selective, broad-spectrum herbicides will generally affect all plants that they come in contact with. Selective herbicides will affect only some plants** (often dicots - broad leafed plants like Eurasian water milfoil, will be affected by selective herbicides whereas monocots like Brazilian elodea (Egeria densa) may not be affected). Most aquatic plants are monocots. **This is the reason why proper weed identification and the appropriate chemical are so important. When we make general spot treatments to clean out an area of a pond we often use contact herbicides that will kill all the plants in the application area.** By treating only a portion of the pond with each application, you can avoid the problems of oxygen depletion and excessive nutrient release. **Applying bacteria after these weed treatments will help remove the dead organic material in the system and control nutrient and sediment build up.**

. **This is a list and description of the most common herbicides and algaecides currently in use, some general information on each, and the types of plants each will control.**

Aquatic Herbicides;

Komeen Aquatic Herbicide (8% copper ethylene diamine complexes) -a copper-based aquatic herbicide, usually has no restrictions such as buffer or setback zones, re-entry intervals or holding periods. Immediate access to water for drinking or recreational purposes is permitted after an application, so there's virtually no down time. Komeen's formulation gives fast uptake of any copper herbicide, effectiveness in hard water, a long shelf life, and the flexibility to use treated water on turf and ornamentals. Komeen can be used in golf, ornamental, fish, irrigation and fire ponds as well as fresh water lakes, fish hatcheries, potable water reservoirs, crop and non-crop irrigation systems.
This is a fairly broad spectrum herbicide; check the label for specific plants. Rates: Varies with depth of water. Example: In one foot of water, use 5 to 10 oz. per 1,000 sq. ft.

Glyphosate - (Trade names for aquatic products with glyphosate as the active ingredient include: Rodeo, AquaMaster, and AquaPro). This systemic broad spectrum herbicide is used to control floating-leaved plants like water lilies and shoreline plants like purple loosestrife. It is generally applied as a liquid to the leaves. Glyphosate does not work on underwater plants such as Eurasian watermilfoil. Although glyphosate is a broad spectrum, non-selective herbicide, a good applicator can somewhat selectively remove targeted plants by focusing the spray only on the plants to be removed. Plants can take several weeks to die and a repeat application is often necessary to remove plants that were missed during the first application.

Fluridone – (Trade names for fluridone products include: Sonar and Avast!).
Fluridone is a slow-acting systemic herbicide used to control Eurasian watermilfoil and other underwater plants. It may be applied as a pellet or as a liquid. Fluridone can show good control of submersed plants where there is little water movement and an extended time for the treatment. Its use is most applicable to whole-lake or isolated bay treatments where dilution can be minimized. It is not effective for spot treatments of areas less than
five acres. It is slow-acting and may take six to twelve weeks before the dying plants fall to the sediment and decompose. 2,4-D – There are two formulations of 2,4-D approved for aquatic use. The granular formulation contains the low-volatile butoxy-ethyl-ester formulation of 2,4-D (Trade names include: AquaKleen and Navigate). The liquid formulation contains the dimethylamine salt of 2,4-D (Trade name - DMA*4IVM). 2,4-D is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian watermilfoil and other broad-leaved species. Both the granular and liquid formulations can be effective for spot treatment of Eurasian watermilfoil. 2,4-D has been shown to be selective to Eurasian watermilfoil when used at the labeled rate, leaving native aquatic species relatively unaffected.

Aquathol - Endothall - Dipotassium Salt - Endothall is a fast-acting non-selective contact herbicide which destroys the vegetative part of the plant but generally does not kill the roots. Endothall may be applied in a granular or liquid form. Typically endothall compounds are used primarily for short term (one season) control of a variety of aquatic plants. However, there has been some recent research that indicates that when used in low concentrations, endothall can be used to selectively remove exotic weeds; leaving some native species unaffected. Because it is fast acting, endothall can be used to treat smaller areas effectively.

REWARD- The active ingredient in REWARD, diquat dibromide, has been used successfully without environmental concern for more than 25 years. When used according to label directions, REWARD poses virtually no environmental risks. Unlike some grounds maintenance herbicides, REWARD will not contaminate ground water. When applied, REWARD adsorbs quickly onto soil sediments, vegetation and organic matter, rendering it biologically unavailable. Because of its low application rates, REWARD is low in toxicity to fish and wildlife**. Diquat is a fast-acting non-selective contact herbicide which destroys the vegetative part of the plant but does not kill the roots.** It is applied as a liquid. Typically diquat is used primarily for short term (one season) control of a variety of submersed aquatic plants and algae**. It is very fast-acting and is suitable for spot treatment and for shoreline algae growths.** However, turbid water or dense algae blooms can interfere with its effectiveness.

Renovate3 -Triclopyr - There are two formulations of triclopyr. The TEA formation of triclopyr is registered for use in aquatic or riparian environments. Triclopyr, applied as a liquid, is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian watermilfoil and other broad-leaved species such as purple loosestrife. Triclopyr can be effective for spot treatment of Eurasian watermilfoil and is relatively selective to Eurasian watermilfoil when used at the labeled rate. Many native aquatic species are unaffected by triclopyr. Triclopyr is very useful for purple loosestrife control since native grasses and sedges are unaffected by this herbicide.

Habitat -Imazapyr -This systemic broad spectrum, slow-acting herbicide, applied as a liquid, is used to control emergent plants like spartina, reed canarygrass and phragmites and floating-leaved plants like water lilies. Imazapyr does not work on underwater plants such as Eurasian watermilfoil. Although imazapyr is a broad spectrum, non-selective herbicide, a good applicator can somewhat selectively remove targeted plants by focusing the spray only on the plants to be removed.

Algaecides;

Copper Compounds - Copper is an element used as an aquatic herbicide in several different formulations. All products have been used to control algae and other aquatic vegetation in slow-moving or quiescent bodies of water, including golf courses, ornamental fish and irrigation ponds, lakes and rivers.
Copper is naturally occurring and is found in soil and water often in the form of complexes, both organic and inorganic. Removal of elemental copper from an aqueous system occurs through binding to sediments and dissolved organic compounds. Many products containing copper are registered for use in most states, but some states have begun to restrict copper products because of the residual build up involved. **Some algae may become resistant to copper with repeated applications.**

Products containing copper sulfate include a variety of manufactures and product names (most of which contain 99% copper sulfate pentahydrate) and Earthtec (containing 20% copper sulfate pentahydrate). Other products contain copper complexes differing in the percent of copper as the active ingredient. These include Cutrine-Plus (9% copper ethanolamine complexes), Cutrine-Plus Granular (3.7% copper ethanolamine complexes), Lescocide-Plus Granular (3.7% copper ethanolamine complexes), K-TEA algaecide (8% copper triethanolamine complexes) and Komeen Aquatic Herbicide (8% copper ethylene diamine complexes).

These are product descriptions for some of these products; Copper Sulfate is a copper compound used for years as an algaecide. This product is used all forms of algae including: filamentous, planktonic, and

branched algae. The crystal form is most effective on bottom mats while the fine crystal is broadcast over the treatment area or dissolved in water. Copper sulfate is less effective in hard water than chelated copper products. This product is corrosive to metal equipment and toxic to fish in soft water. Normal application rate is 2.7 pounds per acre foot of water treated. Effective for control of swimmers itch with special application methods. **We feel Copper Sulfate is the least desirable choice of the copper based treatment products because of the draw backs that have been mentioned earlier.**

If you find a copper algaecide that is working well in your pond, keep using it. You will begin know what to expect and when, where and how to apply. If you use a different product each time you treat, it is difficult to get any track record of the results for each treatment.

K-TEA Algaecide- (8% copper triethanolamine complexes) provides effective control of various filamentous, planktonic and branched algae which occur in quiescent bodies of water including golf courses, fresh water lakes, ponds and fish hatcheries. K-TEA is most effective when applied at the first signs of an algal bloom. K-TEA treated water can be used to irrigate crops, turf, fairways, putting greens and ornamental plants immediately after treatment. Application methods include aerial or ground spraying, spraying from a boat as a direct surface spray or direct subsurface application through weighted hoses.

Cutrine Plus -A 9% chelated copper algaecide for use in lakes, potable water reservoirs, farm ponds, fish and industrial ponds, fish hatcheries and raceways, crop and non-crop irrigation conveyance systems, ditches, canals, and laterals. Cutrine Plus under field conditions, is effective in controlling a broad range of algae including Chara, Spirogyra, Cladophora, Vaucheria, Ulothrix, Microcystis, and Oscillatoria. Effective in hard water. Treated water may be used for swimming, fishing, drinking, livestock watering, or irrigation immediately after treatment. Application rates range from 0.6 to 1.2 gallons per acre foot of water treated.

Cutrine Plus (Granular)- A 3.7% granular chelated copper algaecide ideally suited for treatment of bottom growing algae including Chara and Nitella and spot treatments along docks, beaches, boat launches, and fishing areas. This formulation helps control growth before it reaches the surface. Cutrine Plus Granular is registered for use in lakes, potable water reservoirs, farm and fish ponds, fish hatcheries, and golf course water hazards. Treated water may be used for swimming, fishing, drinking, livestock watering, or irrigation immediately after treatment. Spread as evenly as possible over treatment area at a rate of 60 pounds per surface acre.

Cutrine Ultra - This formulation has the same active chelated copper content as Cutrine Plus with the addition of a non-ionic surfactant. Cutrine Plus Ultra is more effective against hard to control algae. The action of these products is very similar but the effectiveness of each product can vary with the water chemistry and the species of algae in each pond.

Other Types of Algaecides

GreenClean is a granular peroxide based product. This product is new to the industry for the 2004 season and is not yet available in some states. The mode of action is oxidation, which provides immediate control of algae, and it releases oxygen as it works. GreenClean is one of the few non-copper based algaecides currently on the market. GreenClean can be applied by broadcasting, as a dissolved liquid, or as a subsurface application. Application rates range from 3-170 pounds per acre-foot depending on the amount of algae growth. Because of the method involved, this product is nonselective and will have an effect on all types of algae. Dead matter floats to the surface for removal. Once GreenClean kills algae, bacteria goes to work cleaning up organic material. GreenClean does not harm bacteria populations when used as directed.

Hydrothol 191 -**Endothall - Amine Salt – Hydrothol 191 is a rapidly acting non-selective contact herbicide or algaecide.** Several treatments each season may be needed to control algae. **Hydrothol 191® has a high acute toxicity to fish and must be used with extreme care.** Unlike copper compounds that are also used for algae control, Hydrothol 191 does not accumulate in sediments and breaks down rapidly. There are water-use restrictions associated with the use of Hydrothol 191. Grass Carp may be killed by this product. **Be very careful in it's use.** Check the label for application rates.

We recommend that you work with as few of these products as is feasible in your situation. Most of these products have a broad spectrum of use and the affected plants overlap between products. As we've mentioned, the first thing you need to do is identify the aquatic plants you are trying to control. Next, check the product labels for these plants and algae, then select an algaecide or herbicide to address the problem**. Using more than one chemical to treat the same problem is not always necessary or even a good idea.** Many algaecides and herbicides can be tank-mixed and applied together as a chemical cocktail. The product labels give you directions on mixing rates, but don't use more chemicals that are necessary.

It is sometimes a better idea to try one treatment alone first. If you are treating for algae, select an algaecide that is labeled for that problem. Adding other chemicals makes it difficult to determine the effectiveness of the individual chemical. **When you find an algaecide that is working well, stay with that product. The copper based products each have a different formulation and concentration so getting to know one product is better than using a different formulation each time you make a treatment.** Many of the weed treatments cover the same plants, so try one to see what the results are before you add additional chemicals to the environment.

Dyes- Many brands of dye are available for lakes. **In addition to adding a pleasant blue color these dyes can help to sun light inhibit photosynthesis and thus control some forms of weeds and algae**. Most of these dyes are not registered with the EPA and do not require a chemical applicators permit. Aquashade is one dye that is both patented and registered by the E.P.A. for control of aquatic plant growth. Aquashade is a unique blend of blue and yellow dyes specifically designed to screen or shade portions of the sunlight spectrum required by underwater plant and algae growth. This shading inhibits photosynthesis in young, bottom growth suppressing growth and development of nuisance conditions. **Dyes can be used in place of, or as a companion to, registered aquatic herbicides and algaecides in managing aquatic nuisance growth.**

It is best to apply dyes before the growing season starts, or when growth is on the bottom. Application rates and the shade of color vary from product to product. **This is one type of product where experimentation is a good idea.** Each brand will be a different shade of blue and the look of the pond will vary by the brand you chose the results from dye can be seen right away so if you don't like the shade of one dye, try another brand next time you need to add color**. We usually prefer to use dyes with a "true blue" color rather than dyes that add yellows or greens. While the addition of other color spectrums can be effective at inhibiting photosynthesis the actual look of the dye in the water is arguably not at nice as a simple blue color.**

You should note that you probably won't need to add more dye more often than every 4 to 6 weeks and that using the full application rate suggested by many manufactures will give your pond a dark blue color. We recommend that you add only 1/3 the suggested rate per application until you reach the color intensity that looks best in your situation. Wait at least 2 days before adding more dye. You can always add more dye if you chose but you cannot remove it when you inadvertently use too much so start low and add more with discretion.

Muddy or cloudy water will change the appearance of the dye into a more brown or green look rather than the pleasant blue appearance you wanted when applying the dye. If your lake is turbid, wait on the dye until you can clear the lake up. **Remember that your goal is to achieve a pleasant esthetic look to your pond and that too much dye might not help.**

Here's some final notes on weed treatments**. Aquatic herbicide application can be less expensive and more effective than manual or mechanical removal especially when used in controlling wide-spread infestations.** Aquatic herbicides are easily applied around pump intakes and underwater obstructions. Some herbicides have swimming, drinking, fishing, irrigation, and water use restrictions (check the label). Non-targeted plants as well as the nuisance plants may be controlled or killed by some herbicides. **Be very careful of back-spray onto terrestrial plants. Many aquatic herbicides will also kill plants and grass along the lake edge if not applied properly.** Depending on the herbicide used, it may take several days to weeks, or several treatments during a growing season, before control is achieved. Rapid-acting herbicides like some copper formulations, endothall and diquat may cause low oxygen conditions to develop as plants decompose. Low oxygen can cause fish kills so make these applications on smaller areas with each treatment to avoid a major die-off at one time. To be most effective, generally herbicides need to be applied to rapidly growing plants, usually in the early part of the growing season. **Some expertise in using herbicides is necessary in order to be successful and to avoid unwanted impacts. Chemical treatments should be done with planning and a degree of precision, more is not necessarily better for your ponds ecosystem.**

Follow up any chemical treatments with applications of microbial treatment to stabilize the ecosystem and help mitigate some of the adverse affects of chemical use. It is usually advisable to wait one week after these treatments before applying bacteria.

Sources of Nutrient Loading in Ponds

Nutrients can enter ponds through several sources runoff, over fertilization, waterfowl and landscape debris are all sources of nutrient from outside the pond ecosystem.

Have you ever wondered where leaves blown into drainage ditches, storm drains or ponds end up? Landscaping activities run off, draining pools and street cleaning can contribute a great deal to the nutrient levels in your pond. Many ponds, either intentionally or through poor design, can act as retention basins for the street and landscape areas near them. Virtually anything that touches the ground can make its way into storm drains and landscape drainage systems and flow directly into ponds. Leaves, grass clippings and fertilizers can be carried into ponds increase the load of decomposing organic matter in the environment. The accumulation of debris results in an increased BOD (Biological Oxygen Demand), decreasing in the level of oxygen available to aquatic organisms, and moving the pond toward eutrophication. Other pollution like cleaning chemicals, paint, oil and dirt can also enter the pond in this manner.

Watershed Analysis is a helpful tool for identifying nutrient loading concerns but this field of study can get very complex. Excess nutrients speed the aging process of ponds and lakes and add to weed and algae problems. **This analysis does not need to be overly complicated to be helpful** in identifying most of the major problem areas where nutrients are entering the pond. Often, simple changes in design or management can significantly improve water quality.

Watershed analysis is defined as ecosystem analysis at the watershed scale. A watershed analysis is performed to determine the ecological stability of a watershed. **Every watershed is different, so every watershed analysis should have a different focus.** Many watershed analysis reports contain carefully written narratives, comprehensive tables, and electronically-generated maps, all on familiar subjects: soil, vegetation/landscaping, wildlife, fish habitat, roads, sediment, and so on. The subjects may be grouped under different headings, such as "issues" or "conditions," but they remain the same basic concerns found with any small pond.

A complete watershed analysis can be very time consuming and expensive and might not be necessary. Simply checking the pond for obvious problems can identify most of the sources of extra nutrients entering your pond. This is a composite list of some of the things you might find with an observant eye.

Landscape debris can be a major problem in small ponds. This comes from many sources; mowers , blowers and weedeaters throwing the debris into the pond can be a major contributor. Branches and leaves falling or being trimmed along the pond edge are another source, Fertilizer can enter the pond either while being applied or through runoff. Be very careful when fertilizing around the lake edge and try to control runoff after fertilizer is applied to the adjacent areas.

Street drains can carry a wide variety of material into the pond. If you have streets draining into your lakes, they should be kept free of trash and debris and every effort should be made to keep foreign material off the streets and out of the drains. We have seen an endless number of possibilities of what people have put down street drains; oil, paint, carpet cleaning tanks, cleaning supplies, swimming pools and spa cleaning chemicals, and endless amounts of dirt and mud from street cleaning and hosing off the street near construction sites and other work areas.

Once you find any of these intrusions you should do as much as possible to correct the problem. Even small changes can do a lot for your water quality.

It is becoming more common for golf courses and other pond owners to use recycled water for filling ponds and irrigating turf. In many instances the local regulations make it mandatory that these large water users make effluent water a part of their water program. This recycled or effluent water is less expensive and recycling helps conserve a precious resource, fresh water. While the recycling of water is important and beneficial to all of us, incoming water from treatment plants is also very high in nutrients and salts. Excess nitrogen and phosphorus are commonly found in effluent water. This water is also often treated with chlorine at the source. Chlorine has no part in a natural pond maintenance program. You should consider that while the chlorine will dissipate from the pond water fairly quickly it also will leave a variety of salts that would not have been present without the effluent water. Awareness that effluent water is nutrient-enriched water will help in determining the proper management approach. It is very helpful to mix the effluent water and fresh water at the source. If your fill water only contains 50% effluent you will be much better off than with 100% effluent. Effluent ponds can be managed with the same approach as fresh ponds, the effluent water just intensifies some of the concerns and your maintenance decisions and treatment amounts will need to be adjusted accordingly**. A microbial approach is the best way to address the excess nutrients, although your treatment amounts may go up to compensate for the extra nutrients.. Good circulation and aeration becomes even more important.**

When a pond is filled and fed completely with recycled water it is possible for the pH and alkalinity to get too high for bacteria to survive. When this happens you lose your last possibility of making this pond into a pleasant balanced aquatic environment. What you have left is a retention pond for smelly, nutrient rich, turbid, recycled water. The best choice is to avoid using recycled water in your ponds or to dilute the effluent with fresh water at the source to keep the impact to a minimum.

Another major source of nutrient loading is from waterfowl excrement. Waterfowl, including ducks, are the most common visitors to urban waterways. Ducks all appear much the same, but there is an underlying struggle taking place between wild duck species and more domestic waterfowl. The Mallard is the most widespread duck species throughout the Northern Hemisphere. There are thirty or more duck types derived from the Mallard that have the ability to interbreed and produce fertile offspring, further exerting a negative impact on the wild population. The Mallard is very adaptable and is found near large marshes, small rivers and bays, city and golf course ponds. Most of its natural diet is vegetable matter. It will feed in shallow water, on dry ground and will graze. **While other species of ducks will migrate through and will forage in the pond, the mallard is very easily domesticated, often taking up permanent residence on ponds.**

Coots are another species that can become a real problem. American Coots are noted for many qualities, some considerably less redeeming than others. Conspicuous, noisy, and aggressively territorial, they have a repertoire of about fourteen displays or actions to communicate among themselves. Coots are opportunistic feeders. In addition to hunting for themselves, they will also take leftovers from other species such as Mallards. They pirate plants, brought to the surface by diving ducks, such as Canvasbacks. Young coots are opportunistic as well. Groups of up to five juveniles may pirate aquatic vegetation from the bills of ducks and geese. **Coots are among the least graceful of marsh birds. Commonly called "splatterers", they scramble across the surface of the water with wings flapping not only to confront intruders but also to become airborne.** Coots bob their heads while walking. While foraging on insects, they bob quickly; while eating greens, they bob slowly. **Appearing somewhat like aquatic pigeons, coots also bob their heads while swimming.**

Both Mallards and coots will feed on landscape vegetation as well as turf and they can do a great deal of damage. **Waterfowl excrement contains heavy amounts of both nitrogen and phosphorous.** We have mentioned before that your pond can be effected by as low as .05 ppm of phosphates and 5 ppm of nitrates. The duck population needed to achieve this is amazingly small. About four ducks per surface acre will add the needed nitrates, and less than 1 duck per surface acre can add more phosphates than your pond can handle. The amounts of nutrient entering your pond will vary with several factors, including where the birds are feeding and the food source.

Bird populations are often artificially supported by augmented feeding, commonly seen when parents bring their children along to feed the ducks and enjoy a wildlife experience. The result is a quickly established high-density bird population**. Avian diseases can also spread rapidly in this situation,** and are ruthless once unleashed within the waterfowl population, causing ducks to die in large numbers, which can distress the visitors who consider these birds their pets. Salmonella and viral infections that originate in **the local duck population are also an often underestimated risk to people trying to enjoy the park or golf course where these fowl live. Waterfowl is one of the primary carriers of the Avian Flu that is becoming a serious worldwide health issue.**

There is a standardized set of tests used to evaluate these risks in public waterways called the Water Quality Index. **The Water Quality Index is used to evaluate aquatic systems and includes collection of 9 tests developed in 1970 by the National Sanitation Foundation.** The index encompasses comparisons of different rivers and lakes, at different locations, over extended periods of time. The WQI is determined by obtaining data related to nine different water quality indicators:

1. Dissolved Oxygen
2. Fecal coliform
3. pH
4. 5 day Biochemical Oxygen Demand
5. Temperature
6. Total phosphates
7. Total nitrates
8. Turbidity
9. Total solids

Despite the problems waterfowl may cause, they are a valuable natural resource; they are a source of recreation for hunters and bird lovers alike. It is important to remember that ducks, geese, as well as other migratory birds, are protected by the Migratory Bird Treaty Act of 1918. Destroying waterfowl is not an acceptable solution to the problem. The answer lies in managing waterfowl populations in order to prevent damage. You should do your best to keep waterfowl populations to a minimum and strongly discourage artificial feeding. Even with strenuous effort to control waterfowl, they will often reach excessive levels on golf courses and public ponds. **If you do not want to, or cannot rid your pond of waterfowl, then the extra nutrient load should be considered when deciding on a treatment approach.**

Bioaugmentation is the most practical way to address a situation of heavy nutrient loading. The microbes will help keep nutrient levels in line, even with a consistent load being added from outside sources.

Consistent addition of beneficial bacteria, coupled with good aeration of the water, will help prevent harmful bacteria from developing in the pond that can be dangerous to waterfowl, wild and domestic animals and humans coming in contact with the water.

Closing Comments

Each pond or lake is unique in appearance, chemistry, biology, and physical characteristics. Water chemistry and condition will vary between ponds as well as different areas of the same pond. Conditions like landscape debris, waterfowl density and runoff will affect the entire pond as well as create unique areas in the pond.

In writing this guide, we hope we have given you all the basic information you need to make informed decisions on how to address your pond maintenance needs. **A good maintenance program and a properly maintained pond will require less effort than a neglected or sporadically maintained pond.**

Your pond has a few basic needs for a healthy life. The most essential element in a healthy ecosystem is oxygen. Maintaining good oxygen levels and aerobic conditions throughout the pond does not need to be difficult. **While you have several options, adding aeration is the easiest, most effective and most efficient.** A basic aeration system is very easy to install and maintain, with an air compressor being the only working part. While the minute bubbles coming from an aeration line do not produce the most intense visual effect, a continually running aerator will provide circulation, water turn over and oxygen transfer.

Once you have the aeration system doing the primary job, you may want to add other circulation for additional water turn-over and visual appeal. There are a variety of options for water circulation including waterfalls, and fountains. Water movement is an important part of the look of your pond. Do you want an active pond that has large water displays? Do you like waterfalls and streams? Do you prefer a tranquil placid pond that just looks nice? What about the expense of installing, running and maintaining these systems? These are the questions you have to answer when you begin to assess your circulation needs.

It is important to remember that 'all water circulation is not the same' as far as benefit to you pond goes. Water will move in channels through the pond. This provides movement to some areas, leaving other areas without movement. Sediment deposits will be heaver in the dead areas. Water channels tend to remain near the surface, which will help keep the lake surface free of debris and scum. Heavy water movement can help prevent certain algae's from forming in the circulated areas. Debris tends to move toward the intake lines of you circulation system, so they should be located where debris can easily be removed. Skimmer baskets can be included to catch debris. This condensing of the surface debris, or collecting it in skimmers, can be a great time saver when you are skimming and cleaning the lake surface. Pond maintenance is a dynamic undertaking with conditions that are constantly changing. The best management of a pond is to make adjustments to the ecosystem to keep an ecological balance. Clean and clear ponds can be a beautiful, aesthetic asset, as well as a necessary component for healthy turfgrass irrigation. Water features add a luster to the environment that can transform any landscape into an inviting oasis.

Too often, we see ponds or lakes that have become management nightmares, diminishing their aesthetic, as well as functional value. Many times, these problems could have been avoided. Knowledge of the dynamics that affect water quality make it possible for pond keepers to effect solutions which will make water features less problematic and easier to manage.

A thorough understanding of the factors which impact water quality will aid in the design and management of your ponds. Aquatic weeds, algae, sludge build-up, odors and poor clarity are the most common problems. Not surprisingly, these problems are often inter-related.

Nature has supplied us with an effective water clean-up tool, aerobic digestion. Aerobic bacteria will metabolize organic nutrients in the water, making them unavailable for vegetation. When a pond is in balance, there are sufficient levels of oxygen in the water to allow the bacteria to respire and digest these nutrients. When nutrient influx outstrips the bacteria's metabolic rate, the lake is thrown out of balance. The bacteria cannot keep pace with nutrient loading, and nutrient levels explode. We commonly see algae bloom as the result.

By taking a proactive approach to water quality management, you can help ensure that your ponds and lakes have cleaner waters and the aesthetic appeal you desire.

All water features have a life cycle; as they gradually fill in with sludge and nutrients and the aging process accelerates. By remembering the factors which impact water quality (nutrients, temperature, light, depth, and outside influences) you can make proper management decisions and chose tools to create lakes and ponds which are functional, beautiful and have a long life. **Integrated lake management, or combining several practices, can help ensure your lakes never reach crisis levels.**

Microbes, used in conjunction with other lake treatment products, will give you the pristine healthy and balanced pond you want. Your treatment program does not need to be complicated to be effective. The more balanced your system is, the less work it will become. A well-managed pond can be a pleasure to both the pond-keeper and those trying to enjoy the aquatic environment.

To begin a basic treatment program using supplemental bacteria, you need to start with assessing your pond's current condition and address the existing problems one at a time. Do you have proper circulation and aeration? Are there outside nutrient sources that need to be addressed? Do you have current algae and weed problems? Is there heavy turbidity?

Once you have good water movement and the waterfowl and runoff issues are addressed, you should **decide which chemicals are needed** to most effectively address the existing problems. Generally, one of the basic copper algaecides, coupled with a contact herbicide if you have weeds, is a good way to begin. **You should always read the product labels carefully.** These labels are the overriding "legal" document regarding the use of the product. If you follow the label, you will generally be in compliance with regulations, provided the product is legal for use in your state. Many states have their own restrictions on which chemicals they will allow and chemicals may be restricted for a variety of reasons. It is interesting to note that even with the overwhelming acceptance of copper based algaecides; some states have now banned their use because of their hazard to the environment. Other states are more concerned about the actual application of the products and the hazards to the applicator and public more than the environmental considerations.

We usually prefer to address weeds and algae on a spot treatment basis. Treatments can be made to one area of the lake at a time and the risk of oxygen depletion or serious problems with water chemistry can be minimized. Copper based algaecides and herbicides can be effective on both weeds and algae, especially in the early season. SePRO Corporation makes two copper formulations, K-Tea Algaecide and Komeen Herbicide that we have used with good success. Cutrine Granular Algaecide made by Applied Biochemists is very helpful with filamentous algae and Chara. REWARD, made by Syngenta Professional Products is both an algaecide and an herbicide and works very well as a general treatment to

bring a lake into stable condition quickly. Results can be seen in as little as twenty-four hours and additional treatments can be made promptly if necessary. Reward does not work well in turbid water.

GreenClean Algaecide, manufactured by BioSafe Systems, is another helpful algaecide in some situations. It will oxidize algae on contact and leave a clean lake edge in its path; can also decreases turbidity by oxidizing particulate matter out of the water column. Unlike other oxidizers, green clean is safe for the aquatic environment, leaves no harmful byproducts and actually adds oxygen to the system. It should not harm microbial populations when used as directed. Read the product labels for spot treatment application rates and procedures.

Once you have made initial chemical treatments to address the established problems in the pond, you can begin treatments of the supplemental bacteria. Wait one week after chemical treatments before the fist bacteria application. Generally, we like to make treatments to the ponds on a weekly cycle. Since every pond is different it isn't possible to write a precise treatment schedule, and the experience of the pond-keeper is an important factor on making these decisions, these guidelines that might be helpful.

Bacteria can be applied successfully in waters down to 50° F. You should apply bacteria every two weeks while the surface zone temperatures are above 50° F. **Ponds are usually very nutrient-rich in the spring because there has been very little biological activity over the winter to use up these nutrients.** When water temperatures reach the 60° F, weeds and algae will begin to come out of winter dormancy and begin to grow. You will want to apply algaecides or herbicides to begin to control the new growths before they advance very far. Once you have made initial chemical treatments, wait one week before making the next microbial treatment. These bacteria break down dead organic material so, it is important to let the chemical treatments do their work before making the follow-up microbial treatments. We recommend applying bacteria every two weeks throughout the growing season. Make any needed chemical treatments on the alternate weeks. This quickly becomes a standard treatment schedule. First make any spot treatments needed to control any current growths, follow this up one week later with bacteria to breakdown the free organic nutrient and biomass, wait one week to decide if additional chemical treatments are needed. You should only use chemicals on actively growing aquatic plants and algae, dead algae will be consumed by the consistent microbial treatments.

Remember, your goal is not the total removal of all vegetation from the pond, but to reach a stable equilibrium where the available nutrient is consumed by either the microbial population or the aquatic plants which produce oxygen and sustain the aerobic microbes. Your pond should have 15 to 20 percent coverage with light to moderately heavy aquatic plants. Moderate growths of filamentous algae or Chara can help keep the water clear while reducing planktonic algae, which is the least appealing variety of algae. This ecological balance is in constant flux; when you kill aquatic weeds, algae may grow, when you kill filamentous algae or Chara, planktonic algae may grow. When planktonic algae grow, it reduces sunlight for aquatic weeds, the weeds die, releasing heavy nutrient into the system. Without the weeds, oxygen can drop causing fish kills, and changes in the microbial population**. Aeration and well timed chemical treatments can overcome these ecosystem crashes, giving the aerobic bacteria a chance to reduce nutrient levels and stabilize the ecosystem.**

If the pond ecology is balanced, these changes and swings in the ecosystem are readily manageable. If you are aware of what organisms are currently developing in the system, you can be prepared with the appropriate treatment to bring the system back to equilibrium, rather than completely annihilating each specific organism. You should always familiarize yourself with the types of plants growing in your pond. Check the various herbicides to determine the proper control tool make spot treatments as a part of the

biweekly treatment cycle and watch the results. If one species or section of the pond is getting out of control, you can make well timed, selective chemical treatments to address that specific problem without disrupting the ecosystem by "nuking it" with heavy additions of chemicals.

The basic treatment schedule is consistent and easy to work with … Make any needed chemical treatments … Wait one week for the chemicals to work, then apply the bacteria … Wait one week to apply additional chemicals … Wait one week to apply additional bacteria.

The bacteria will do much of the work for you. They will stabilize water chemistry, pH, alkalinity, oxygen levels and nutrient levels**.** The bacteria will also breakdown and remove bottom sediment maintaining a minimal benthic zone. All this is done with a simple application of microbial supplements, every two weeks on a regular schedule, while water temperatures remain above 50° F.

Well-circulated ponds will have consistent water temperatures throughout the system. **Monitoring these water temperatures can provide some predictable insight into the aquatic growths that will be developing.**

At 50° F the system wakes up from winter dormancy; some signs on new growth develops. Odors may begin to be noticeable. You should begin microbial treatments. Consider adding lake dye if the water is currently clear. Circulation can run as little as 8 hours per day.

At about 60 ° F, aquatic plants and algae are ready to begin active growth. This is affected by nutrient levels, sunlight and weather conditions, turbidity, and level of dye in the lake. You may want to begin light spot treatments of chemicals to keep growths to a minimum, allowing bacteria populations to begin to dominate the system. Circulation should run at least 10 hours per day.

At 70 ° to 74° F, algae and aquatic weeds are actively growing. These growths are still dependant on sunlight and are affected by weather conditions and other factors. As the water temperatures rise, oxygen levels can be reduced, so circulation should be run 10 to 12 hours per day and the aeration system should be run four hours into the night to compensate for oxygen drops at night. **Summer water temperatures can maintain a consistent 75° F in moderate climates to as high as 90° in some desert areas**. Summer is when heavy growths of weeds or algae can develop and you want to make chemical treatments promptly if aquatic growths begin to develop rapidly. You can effectively treat these plants within the schedule laid out above, if you are ready with the correct treatment, on schedule, when and where it is needed.

Preparation and research are important during the summer, so you know where, when and how to apply chemicals to nudge the ecosystem the direction you want it to go. **When daytime water temperatures are near 80° or above, your system is very vulnerable to oxygen-related problems.** Your circulation should be running 12 to 14 hors per day with the aeration system running continuously. This will prevent a variety of adverse conditions from developing in the system and keep the aerobic bacteria, and thus the entire ecosystem, stable and happy.

To find out more about Omega Lake Services visit our web site at www.OmegaLakeServices.com . Check out the links page in this paper or on our website for other useful information on a variety of maintenance related subjects. We hope this paper has been helpful to you and we wish you great success in maintaining the pristine balanced ponds that we all desire.

Helpful Links

This section is an eclectic mix of helpful websites all related to lake and pond maintenance. We have added categories to help you find various types of information. These links are provided as a service to you, the reader. We have no control over, and make no warranty regarding, the actual content of these web sites.

Weed and Algae Identification and Management -Various sites for aquatic weed and algae identification. - Note the photos on many of these sites may take some time to load.

University of Florida Center for Aquatic and Invasive Plants - If you want to know about aquatic weeds, Florida has them all. This site is a comprehensive weed identification site with photos, line drawings and descriptions. Click on the link to Particulars and Photographs for drawings and photos. The photos take some time to load.

Virginia Tech Weed Identification Guide - Has photo and descriptions of most common weeds listed by common name and scientific name.

The Texas cooperative Extension -Has an interactive site called AQUAPLANT that will walk you through identifying which type of plant or algae you have and how to treat it.

Helpful Publications and PDF's

SRAC- Southern Regional Aquaculture Center Publication on Aquatic Weed Management - Seven page PDF - Tells you about several common herbicides, including brands, formulations, application rates, restrictions, effectiveness on many common plants, treatment timing, treatment methods. This is very succinct and helpful.

Options for Aquatic Plant Management- A seven page PDF from SePRO- Helpful In deciding between the various control methods for aquatic weed.

TRAINING MANUAL FOR AQUATIC HERBICIDE APPLICATORS IN THE SOUTHEASTERN UNITED STATES, K. A. Langeland, Editor, University of Florida. HTML format, this is a very good and very intensive report with tons of information on the subject. Eleven chapters.

Algaecides

www.syngentaprofessionalproducts.com -Makers of REWARD landscape and aquatic herbicide- No-Wait No Worry Aquatic Weed Control With REWARD herbicide, you never have to wait for aquatic weed control. A non-selective, highly active contact material, REWARD spreads quickly through the water and makes fast contact with aquatic weeds and algae.

Applied Biochemists' Products for Aquatic Weeds and Algae-For over 30 years, Applied Biochemists has maintained its position as a leading manufacturer of specialty algaecides and aquatic herbicides.

Cutrine Granular Algaecide -One of the Applied Biochemists products, CUTRINEPLUS GRANULAR is an algaecide especially formulated for the control of Chara, Nitella, and other bottom growing algae in potable water reservoirs, fire ponds, farm and fish ponds, golf course water hazards, lakes, and fish hatcheries.

K-Tea Algaecide-K-Tea algaecide is a good choice for eliminating standing or slow-moving water of unsightly and troublesome planktonic and filamentous algae. Enjoy the performance and application flexibility K-Tea offers as well as the minimum restrictions for its use on a broad spectrum of algae, including Cyanophyceae (bluegreen), Chlorophyceae (green), Diatomaceae (diatoms), and Protozoa (flagellates).

Hydrothol 191 -Hydrothol 191 is the only registered broad spectrum organic algaecide on the market It is an excellent alternative to copper products, providing equal performance in controlling algae with environmental advantages. When used as labeled, Hydrothol® 191 dissipates quickly in the environment, leaving no residue, and does not bioaccumulate in fish or hydrosoil and Hydrothol 191 will not have adverse effects on the environment, fish, birds or other forms of aquatic life.

Herbicides

Komeen Herbicide-Aquatic weeds such as Hydrilla, Egeria and Southern Naiad can render waterbodies on golf courses, parks and private property unsightly and unusable. Komeen provides consistent and reliable control of these nuisance weeds and more in a wide variety of application situations. Komeen carries no restrictions on how it may be applied or how soon the water may be used after treatment. Water treated with Komeen can be used immediately after treatment for drinking, watering livestock, fishing, swimming and recreation.

Syngenta Professional Products -Makers of REWARD landscape and aquatic herbicide- No-Wait No Worry Aquatic Weed Control With REWARD herbicide, you never have to wait for aquatic weed control. A non-selective, highly active contact material, REWARD spreads quickly through the water and makes fast contact with aquatic weeds.

Aquathol K -Aquathol K is a quick-acting contact herbicide that controls major aquatic weeds including hydrilla, milfoil and curly-leaf pondweed. When used as labeled, it will not harm the environment, fish, birds or other aquatic life. Endothall is the active ingredient in this product.

Sonar -Sonar aquatic herbicide offers both selective and broad-spectrum control capabilities. Since each lake is different in shape and size, water flow pattern, aquatic plant species and type of use, the development of an effective aquatic vegetation management program requires an aquatic herbicide formulation that is flexible enough to adapt to a wide range of applications. Sonar selectively manages problem weeds for a year or longer, with minimal risk to the environment.

Water Clarifiers and Flocculants

Flocculants or water clarifiers are generally polymers that attract organic and inorganic particles in the water table and form precipitates that will sink to the pond bottom. These products are not as readily available to buy as algaecides and herbicides and usually need to be ordered from the manufacturer.

TRAMFLOC has many products and they can work with you in your specific situation. Check these pages -More Than You Really Want To Know About Polymers, Polymers for Coagulation, Environmentally Friendly, Oil-Free Polymers

Aluminum Sulfate- Here are a couple good 2 page PDF's about using Alum in your pond. Lake and Pond Treatment by Nutrient Inactivation Author: Christopher Lind, formally with General Chemical Corporation, Parsippany, New Jersey, Alum treatments to control phosphorus in lakes, Wisconsin Dept. of Natural Resources.

PhosClear - A buffered Aluminum Sulfate treatment for phosphate control and water clarity. ½" pellet that sinks to the bottom of a pond, disintegrates after five minutes and binds with phosphate where it mainly resides – at the bottom pond sediment An environmentally friendly and proprietary blend of Alum (Aluminum Sulfate) and other minerals.

Aeration and Circulation Systems

Aquatic Eco-Systems Inc.- One Stop Shopping for all your equipment need. These folks can help you with your circulation needs with one call. Check out the aeration section on the web site.

Vertex manufactures lake aeration systems and floating fountains for ponds and lakes to improve the water quality and aesthetics of your pond, lake or practically any water body.

Miscellaneous

Algae Control in Ponds with Barley Bales: On-site Results - The name says it all.

Aquatic Plant Management, Barley straw for algae control, Carole A. Lembi, Professor of Botany Botany and Plant Pathology, Purdue University – 8 Page PDF that gives you a complete picture of how and why to use barley straw for algae control.