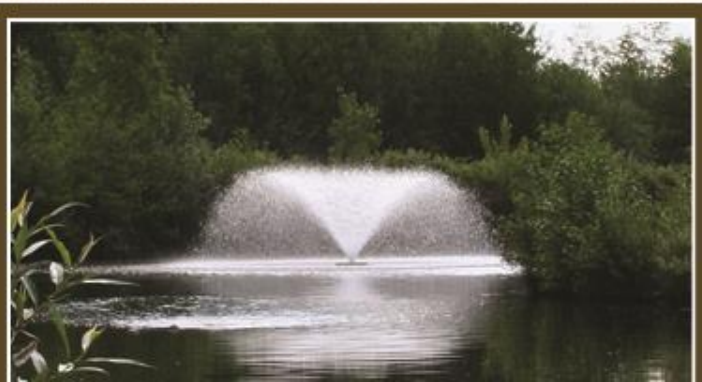
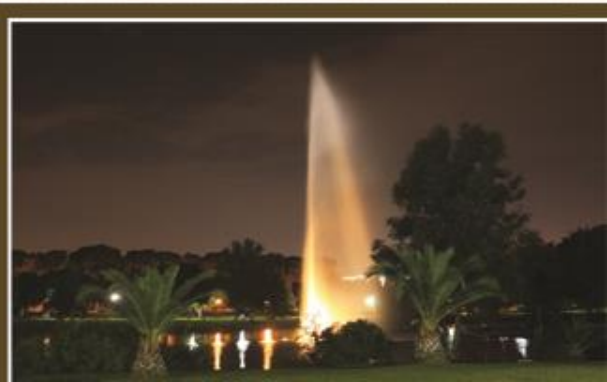
INTEGRATED POND & LAKE MANAGEMENT

Otterbine Aerators, Water Aeration Systems Industry Leader

"We Treat Your Water Right"





INTRODUCTION

- Aging Process of Lakes
- Causes of Water Quality Problems
- Water Chemistry
- Effects of Poor Water Quality
- Costs of Not Acting
- Preventive Practices
- Aeration
- Summary

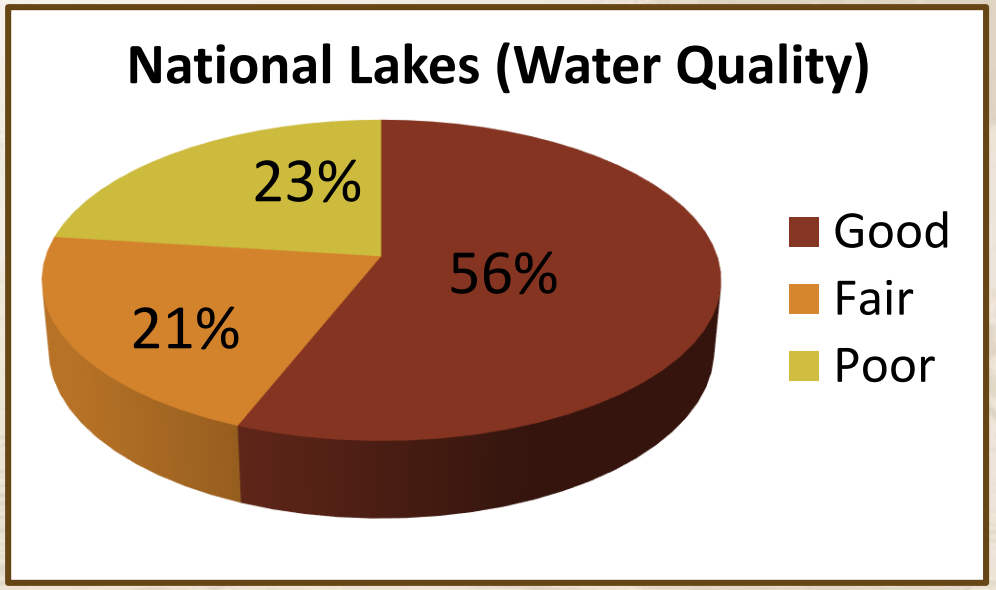
WATER QUALITY MANAGEMENT

- Water quality is a critical factor in the successful management of any property.

WATER QUALITY VARIES

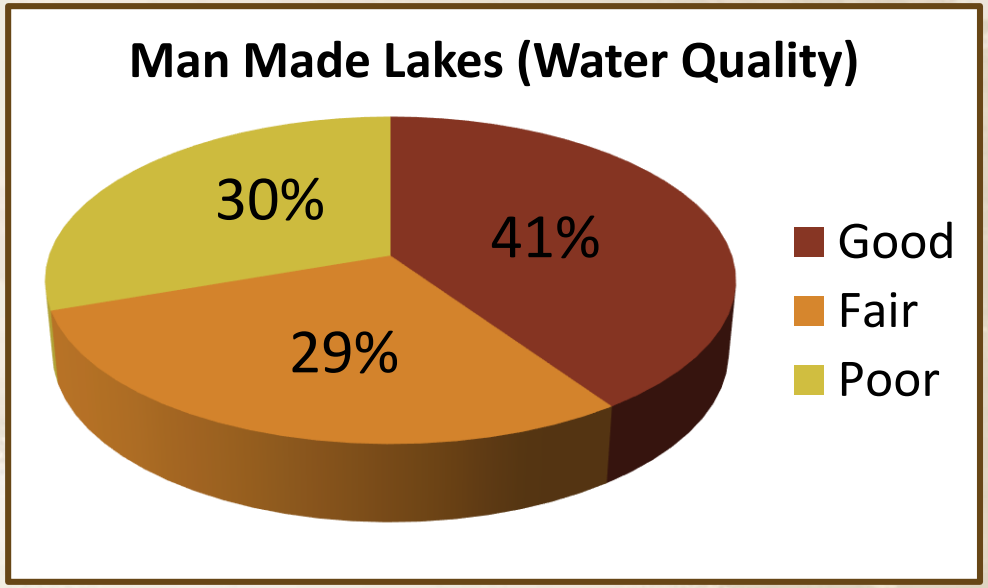
- Water quality varies at each location
- Recent studies from the US EPA indicates consistent measures in first world countries.

44% of all lakes rank fair or poor in water quality



MAN MADE LAKES FARED WORSE

Almost 60% of man made lakes are rated poor or fair



- Target man made lakes when developing water quality management plans

IDENTIFY THE CAUSES

- Every lake is a unique ecosystem
- If you can identify the causes, you can implement a solution
- Focus on environmental balance

OLIGOTROPHIC LAKES

- Oligotrophic lakes are biologically “new” lakes
- These lakes have very low levels of nutrients, usually less than .001mg\l of phosphorus
- These lakes have little or no algae and macrophyte growth.

MESOTROPHIC LAKES

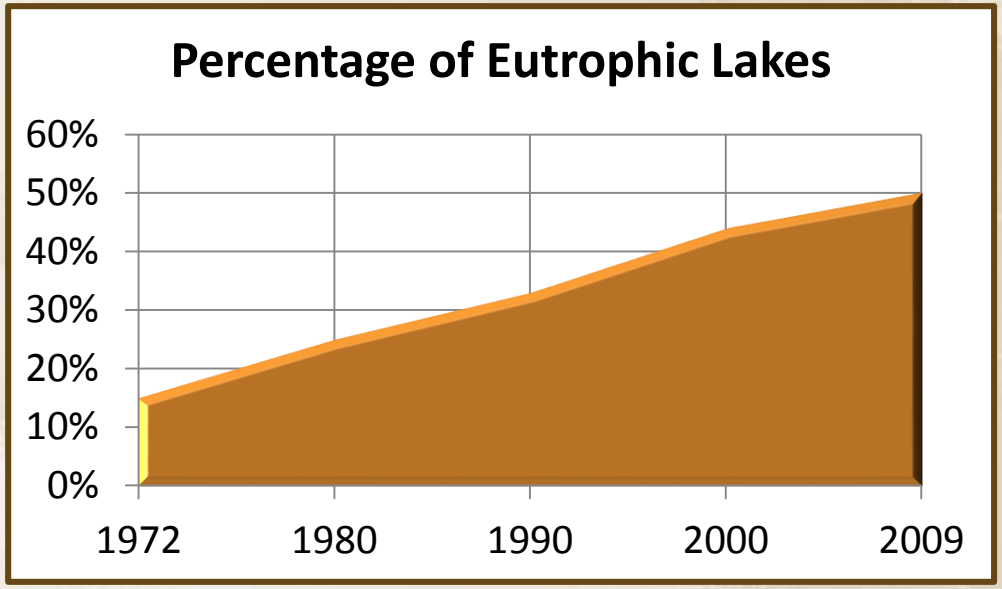
- Mesotrophic lakes tend to have intermediate levels of nutrients, phosphorus in the range of 0.1mg/l range and could be considered middle age lakes.
- These lakes have higher levels of phosphorus and experience some algae and weed problems.

EUTROPHIC LAKES

- Eutrophic lakes are older lakes characterized by high turbidity, nutrient levels, algae and macrophyte populations.
- Phosphorus levels can be in the range of 1mg/l. One gram of phosphorus supports 100 grams of algae. Nutrient levels determine the biological age of the lake.

NATIONAL LAKES ASSESSMENT

The percentage of Eutrophic lakes has tripled since 1972



- Eutrophic lakes need aeration as a matter of fact

CAUSES OF POOR WATER QUALITY

1. Light and Temperature
2. Nutrients
3. Oxygen

LIGHT, TEMPERATURE, & DEPTH

Shallow lakes (less than 6 ft./ or 2m) receive light at the lake bottom

- The entire water column will be productive from a rooted weed and algae standpoint.
- These lakes tend to be very warm.
- This is a favorable condition for algae and aquatic weed growth.

Shallow Lakes Are a Water Quality Management Challenge!

STRATIFIED WATERS

- Sources of oxygen are surface interchange, photosynthesis, and rain
- Bottom waters are removed from sources of oxygen.
  - Aquatic clean-up organisms move or die
  - Pollution tolerant anaerobic bacteria develop
  - Chemical reactions occur
    - Insoluble phosphorus & iron become soluble
    - Sulfide becomes Hydrogen Sulfide
    - Organic decomposition slows

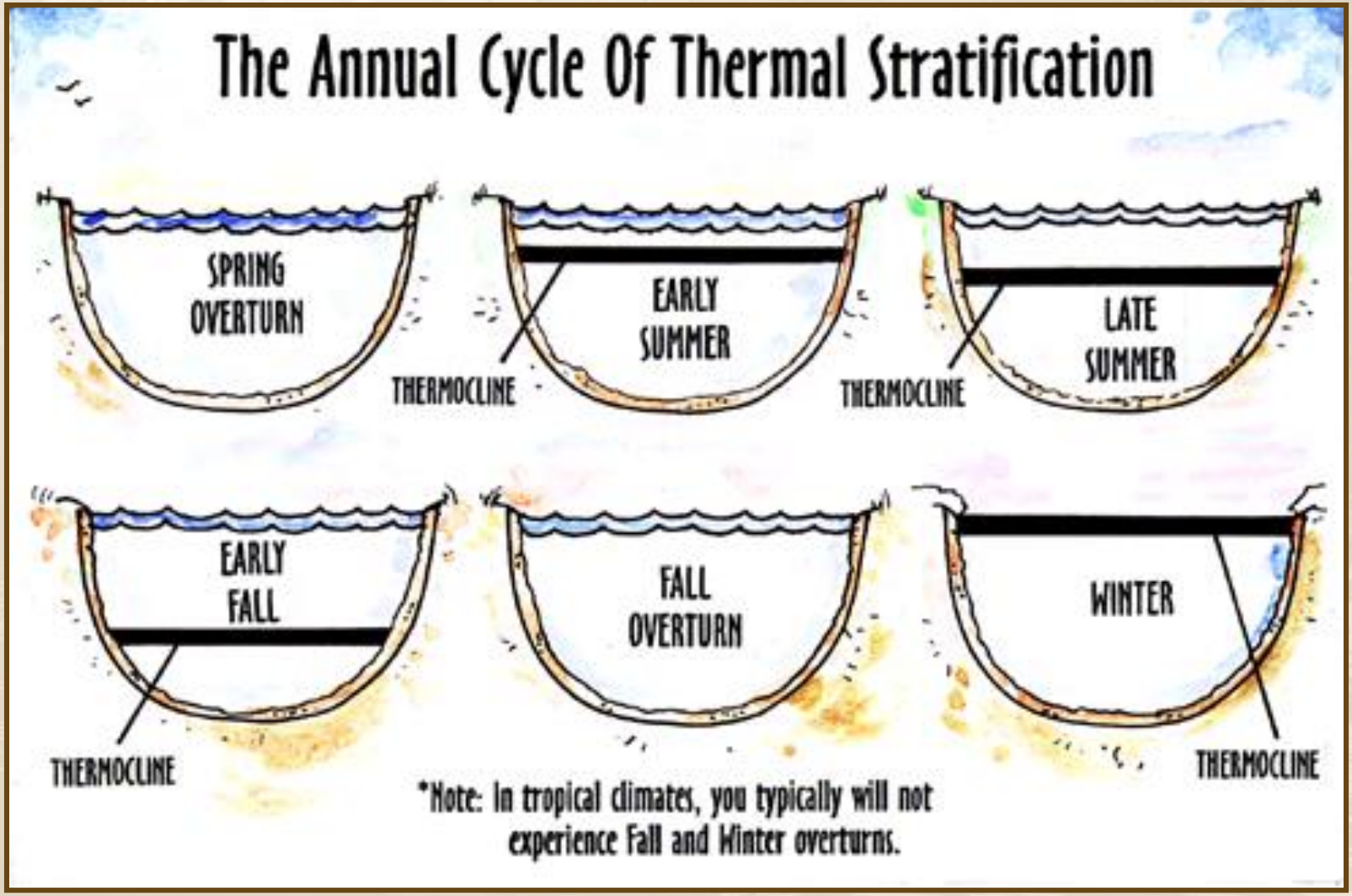
THERMAL STRATIFICATION
Effects on Dissolved Oxygen

Degrees Celsius	Degrees Fahrenheit	Oxygen Saturation
11	52	11 mg\l
17	62	10 mg\l
22	72	9 mg\l
27	80	8 mg\l

Warm water has a diminished capacity to hold oxygen.

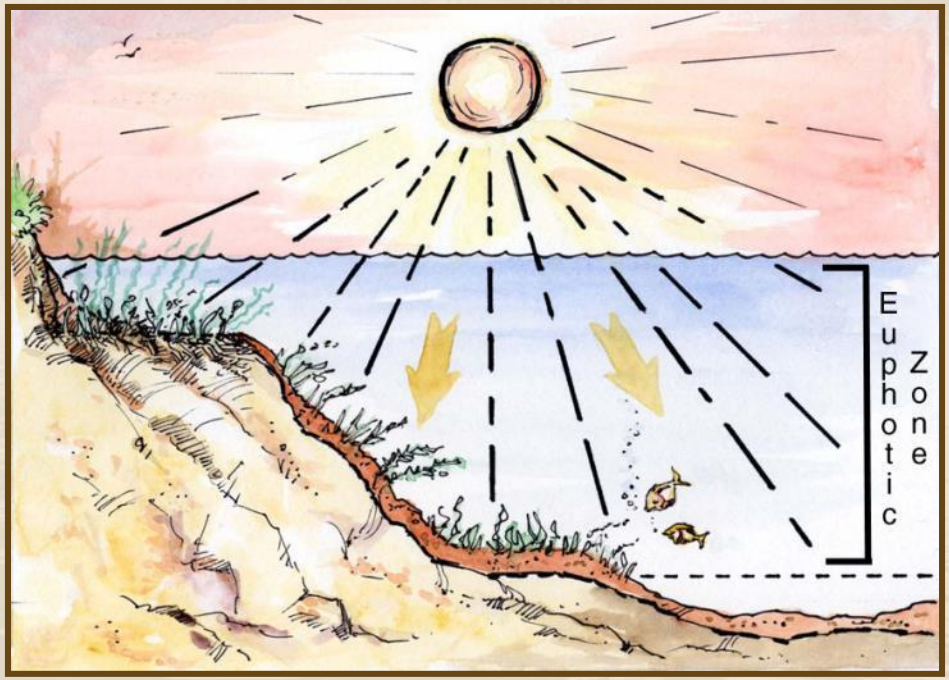
In fact, cool waters can hold over 40% more oxygen than warm waters.

THERMAL STRATIFICATION
SEASONAL EFFECTS



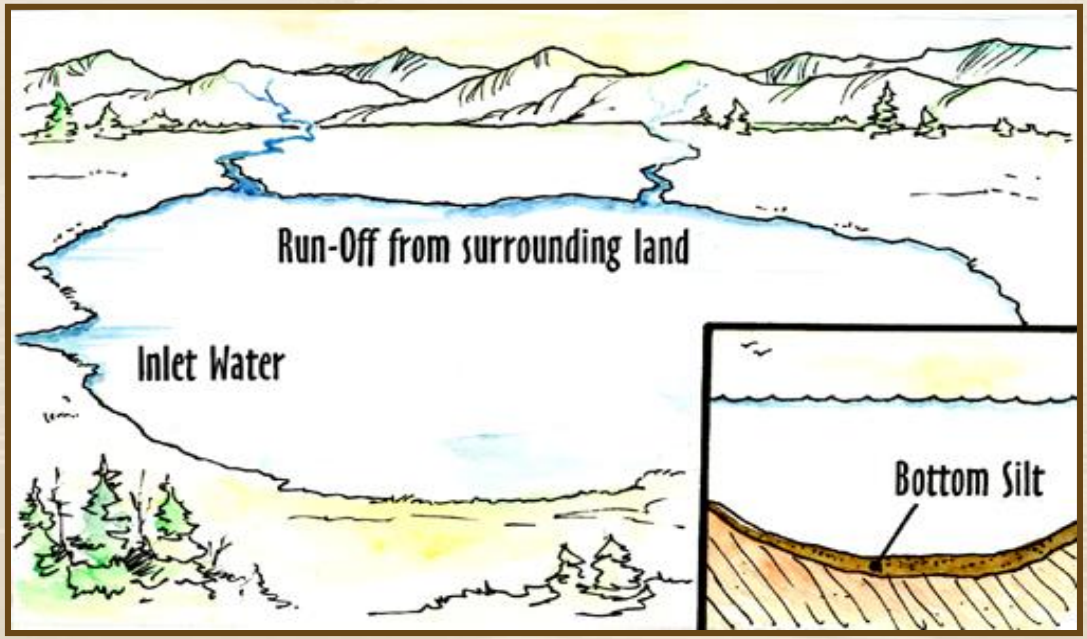
EUPHOTIC ZONE OR PHOTOZONE

- The section of the water column where enough sunlight penetrates to promote the growth of green plants.



AQUATIC NUTRIENT SOURCES

- Three most common sources are:
  1. Sediment and Vegetation in the Lake
  2. Run-off Water from Surrounding Turf Areas
  3. Incoming Water



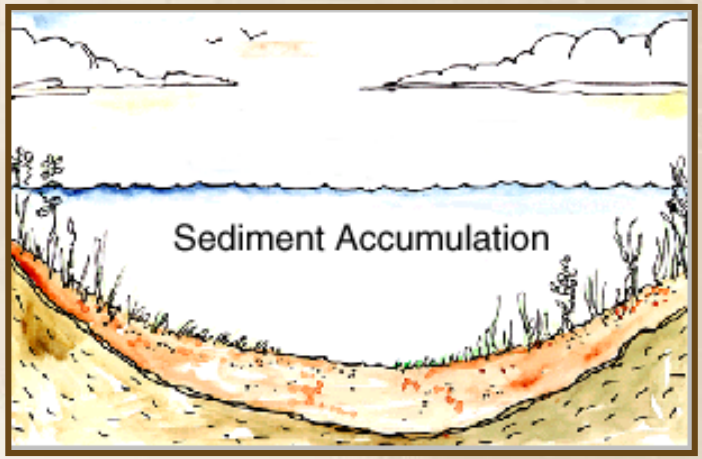
NUTRIENT CYCLING

- Simple algae reproduces as often as every 20 minutes and has a two week life cycle
- Dead algae sinks to the bottom of the lake adding to Biomass *(biological matter in the lake)*

Sediment can accumulate on the lake bottom at the rate of 1-5 in. or 2.5 - 12 cm Per Year!

WATER STORAGE CAPACITY

- At a mid-range sediment accumulation rate of 3in or 8cm per year
  - A one surface acre or 4000 m^2 lake would lose 80,000 U.S. gallons or 300m^3 of capacity per year



RUN-OFF FROM SURROUNDING TURF AREAS

- USGA reports that studies by Dr. Beard estimate that up to 4% of fertilizers run-off or leach into lakes

- If 16 metric tons are applied per season up to 1/2 ton or 500 kilograms of phosphorus can run-off into a lake.
  - One gram of phosphorus equals 100 grams of algae
- Leaves, grass clippings and other nutrients add to the problem.

NUTRIENT AND INLET WATERS

- Effluent from sewage, waste water treatment plants and leeching from septic systems
- Well water contains little or no Dissolved Oxygen
- Foaming is an indication of excess phosphorus

OXYGEN'S ROLE IN POND/LAKE

Oxygen Producers

- Aquatic Plants: Photosynthesis (Light Side)
- Wave & Wind Action
- Surface Diffusion
- Rain

Oxygen Consumers

- Bacteria
- Fish & Wildlife
- Aquatic Plants: Photosynthesis (**Dark Side**)

OXYGEN'S ROLE IN POND/LAKE

Oxygen's Role in Pond:

- Support Animal & Plant Life
- Support Aerobic Bacteria in the Consumption of Excess Nutrients

Healthy Ecosystem

- O_2 Producers Keep Pace with O_2 Consumers

  Natural Clean-Up Process Keeps Nutrients at Low Levels

Unbalanced Ecosystem

- Nutrients Outpace Digestion
- Oxygen Consumption Outpaces Supply

ORGANIC DIGESTION
Aerobic vs. Anaerobic Bacteria

AEROBIC (good)

- Requires Oxygen
- Fast
- Efficient
- Complete digestion
- Breaks down wastes into water, carbon dioxide and polysaccharides

ANAEROBIC (bad)

- Anoxic
- 5 to 6 times slower
- Inefficient
- Incomplete digestion
- Terrible odors
- Poisonous by-products
  - methane
  - hydrogen sulfide
  - ammonia

Bacteria's metabolic rate increases in warm temperature

WATER QUALITY TESTS
Appropriate US EPA Levels

Dissolved Oxygen	⇨	>4 mg\l Check before sunrise
BOD	⇨	<5 mg\l
pH	⇨	6 to 9 (7 - 8 are neutral)
Alkalinity	⇨	>50 mg\l is well buffered
Chlorophyll	⇨	<2 mg\l
Suspended Solids	⇨	<5 mg\l
Fecal Coliform	⇨	<200 colony forming units per 100ml *No human contact if >400
Total Nitrogen	⇨	<5 mg\l
Total Phosphorus	⇨	>.05 mg\l is considered high >.1 mg\l will experience algae blooms

POOR WATER QUALITY
Effects or Symptoms

- Algae
- Weeds
- Odors
- Fish Kills

Once a lake has lost its ecological balance and goes into crisis, the costs of restoring the lake increases dramatically.

PLANKTONIC ALGAE

- Planktonic Algae are single celled plants found in the Epilimnion
  - This algae has the appearance of pea soup.
- Oxygen stress occurs at night when these populations are high.

BENTHIC OR FILAMENTOUS ALGAE

- Benthic is a very difficult algae to control.
- Algae grows from the bottom of the lake, breaks loose and floats to the surface.
- Only grows in waters where sunlight reaches the lake bottom

VASCULAR PLANTS (Bottom Rooted)

- Plants contain small air sacks which float the weed and keep it suspended.
- Sunlight must penetrate to the bottom for these plants to grow.

COST OF NOT ACTING

- Impact is on the property, both functionally and aesthetically
  - Clogged Irrigation System
    - Pumps, Valves, & Sprinklers
  - Sludge Build Up in the Lake
    - Loss of storage capacity
    - Black zone
  - Odors, Fish Kills, Insect Breeding
  - Loss of Aesthetic Appeal

CLOGGED PUMPS

- Impossible to irrigate
- Commercial diver must be brought to the site
- 4 to 8 hours to clear the pump
- Damage to the turf in the interim period

Minimum costs:
$500 to $1000 USD

CLOGGED VALVES & SPRINKLERS

- Damage to turf before the problem is I.D.
- Turf is either burnt or saturated with excess water
- 2 to 4 hours to dig up and repair
- Ground is now “under repair”

Minimum costs:
$250 USD and up

BLACK ROOT ZONE

- Sediment passes through irrigation system onto turf grass. Sediment contains:
  - Heavy Metals
  - Anaerobic Bacteria
  - Partially Decomposed Organic Nutrient

BLACK LAYER

- When sediment is applied to turf grass it creates a “black layer” or “black root zone”
- This effectively seals the turf and it cannot get necessary oxygen and nutrients

COST OF NOT ACTING | Black Layer

- When turf is effected by sediment it may be necessary to install new USGA mix in the turf or rebuild the greens

Costs:

- Re-core with USGA mix $10,000 -$15,000\green
- Rebuild and shape Green $35,000 - $45,000

Total Possible Cost $850,000

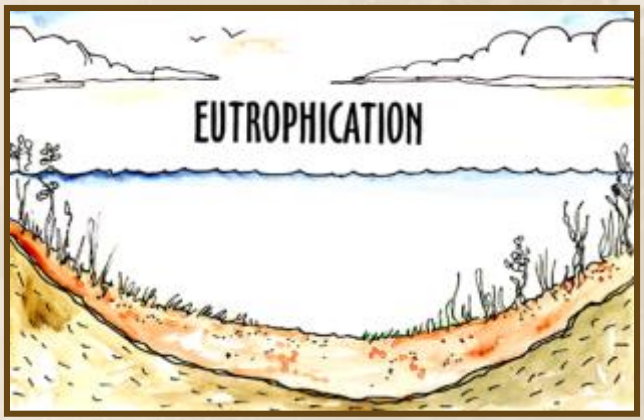
"This is a lot bigger problem than people realize. It's destroyed a lot of greens…because of lousy water quality,"

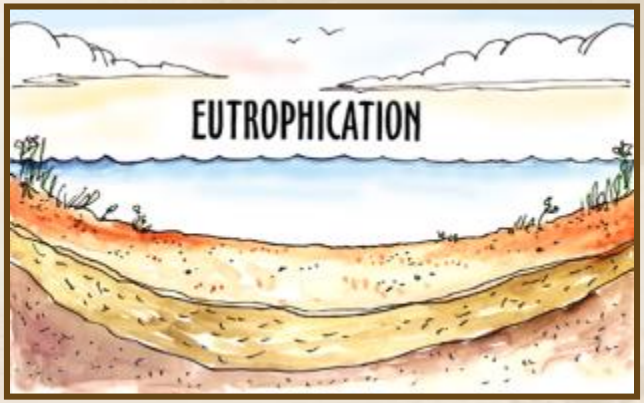
Mr. Jim Moore, USGA Director of Education

LOSS OF STORAGE CAPACITY

Sediment-sludge accumulates at 1in to 5in, or 2cm to 12cm per year

- At mid range rate of 3” or 8cm. per year a surface acre (4000m^2) lake loses 80,000 U.S. gallons or 300 m^3 of storage capacity.





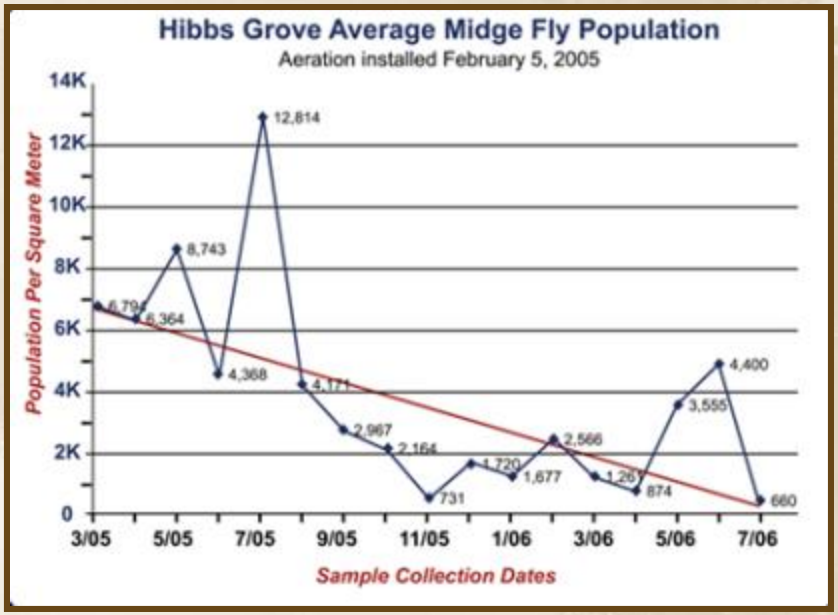
Imagine the effects after 20, 50 or 100 years.

COST OF NOT ACTING
Oxygen Depletion

- **Fish Kills:** Fish require 4-5 mg\l of Dissolved Oxygen
- **Foul Odors:** Most odors occur in anoxic conditions
- **Insect Infestation**

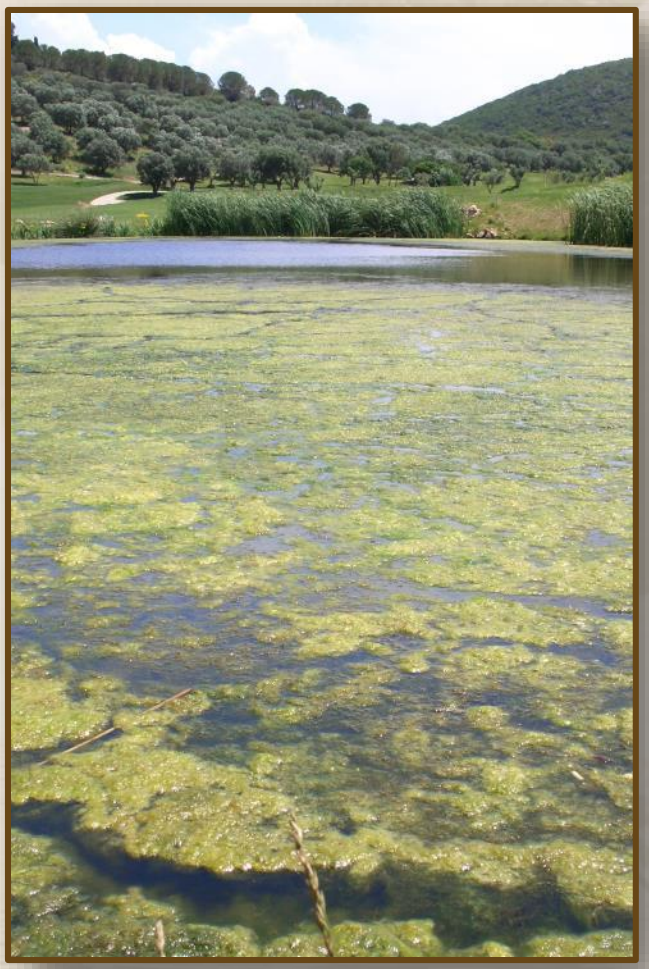
INSECT CONTROL

- Insects breed in waters that are:
  - Rich in organics
  - Low in oxygen
  - Calm or still
- Recent case study
  - Insect larvae population at 6,794 per square meter (6X's the nuisance level)
  - Aeration system installed and run for 14+ months
  - Larvae population drops to 660 per square meter



REACTIVE PRACTICES

- Reactive means waiting until the lake is out of balance before acting, and is often crisis driven
- Reactive practices tend to be less environmentally friendly and more costly



REACTIVE PRACTICES

Lake Harvesters

- Harvester removes floating weeds, algae and debris by skimming it off the surface
- Process is expensive and results are short lived

REACTIVE PRACTICES

Dredging:

- Severe eutrophication will require dredging
  - 40 hours to remove 4,000 cubic meters/yards

Cost: $35,000 USD or more

Dredging Pond

Sludge Removal

Dredging Machine

Pump Sediment to Shore

HERBICIDES AND ALGAECIDES

Most algaecides are copper based

- Granular forms
  - Used for rooted weeds
- Liquid forms
  - Used for floating weeds

HERBICIDES AND ALGAECIDES

- Dosages depend on alkalinity of the lake
- The higher the alkalinity the greater the chemical application
- Water testing must be done before application
- Use with caution as chemicals add heavy metals to the water

HERBICIDES AND ALGAECIDES

- Broad range chemicals can kill on contact
- Beneficial plants are often killed
- Plants sink to the bottom and create greater oxygen demand on the lake

GRASS CARP

- Help keep weed growth under control
- Eat 2-3x their body weight per day
- Can Grow to 45 lb. (20k)
- 12 fish per acre or 4000 m2
- They can eliminate <u>all</u> plant growth leading to low oxygen and water quality problems

PROPER PREVENTIVE PRACTICE

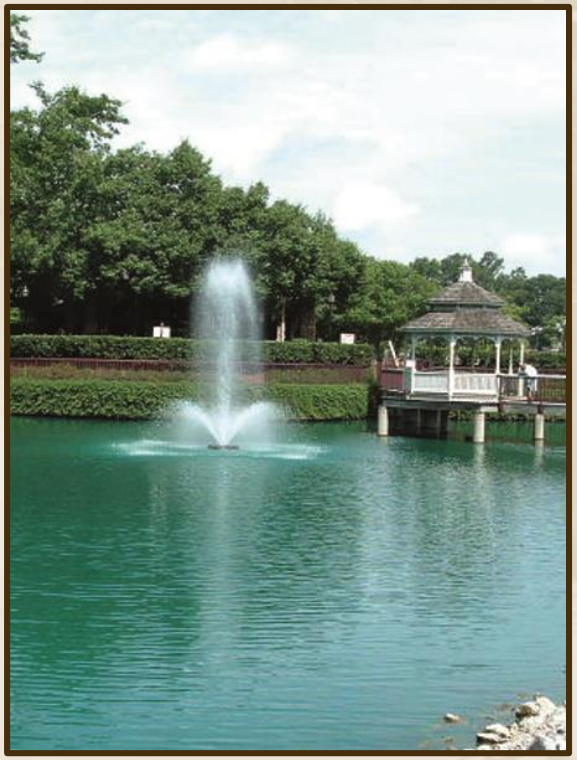
- Identify the causes
- Focus on the three key factors of water quality management
  - Light/Temperature
  - Nutrients
  - Oxygen
- Design a solution utilizing the “Best Management Practices” geared toward the causes

BLOCKING UV RAYS

- Lake Dyes are an important proactive management provision for shallow ponds and lakes (less than 8 feet or 2.5 meters).
- These products help offset the lack of depth by reducing UV energy absorbed by the lake.

LAKE DYES

- Lake Dyes come in powders or liquids
- Choose a dye that has government or EPA approval
- Use only in lakes with no outlets
- Dyes last an average of 6-8 weeks
- Will not stain
- Will not harm fish or wildlife



NUTRIENT ORIENTED SOLUTIONS

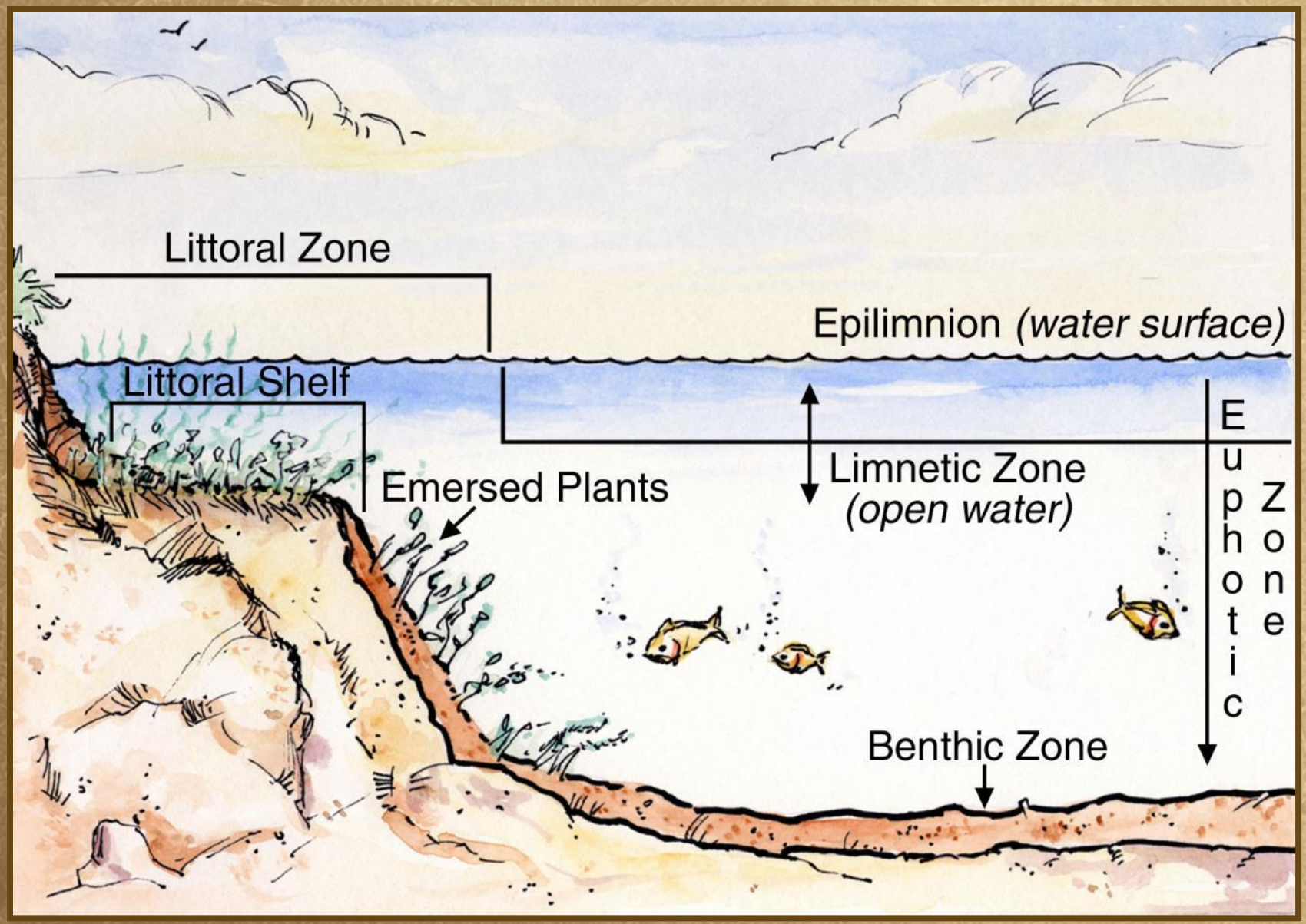
Greatest degree of control is to prevent run-off into the lake.

- Create a 30ft or 10m “No Fertilizer Zone” around the lake
- Use slow release fertilizers
- Let the turfgrass grow longer around the lake
- Design a Berm or Swale around the lake perimeter to trap nutrients

AQUASCAPING SOLUTIONS

- Use vascular weeds and plants as buffers in the Littoral Zone to absorb nutrients
- Technique was pioneered by Dr. Bob Blackburn who calls it the Lake Manager's "first line of defense"

LAKE REGIONS



AERATOR VS. FOUNTAIN

- Aerators move large volumes of water and adds oxygen to the water.
- Fountains use a nozzle under pressure to create a decorative spray pattern.

Aerator

Fountain

AERATION DEFINED

- Aeration is the addition of dissolved oxygen to the water
- The second component of aeration is mixing and de-stratification

WHAT DOES AERATION DO?

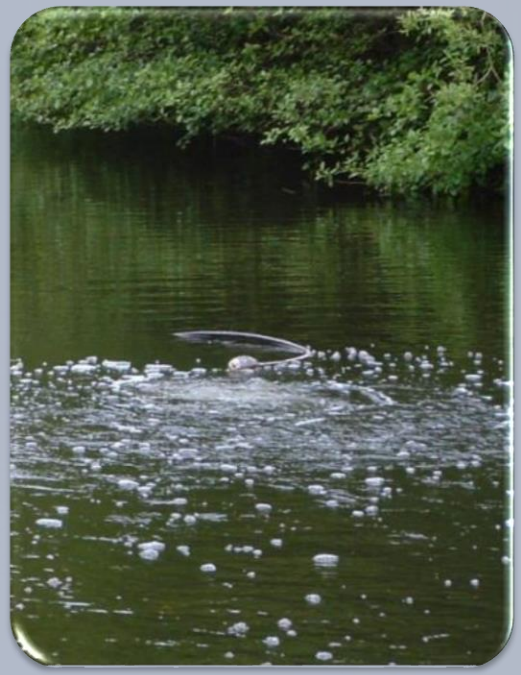
- Aeration improves water quality by impacting the 3 factors:
  1. **Oxygen:** Aeration encourages aerobic digestion of nutrients by adding oxygen
  2. **Nutrients:** These are kept in balance through digestion and oxidation
  3. **Temperature:** Mixing breaks down stratification adding O2 to lower levels

POSITIVE EFFECTS OF AERATION

- Introduction of oxygen prevents anaerobic digestion and foul odors
- Oxygen introduced at lake bottom inhibits phosphorus release from sediment
- Oxygen in water converts Phosphorus to an insoluble form

TYPES OF AERATION

Surface Aeration

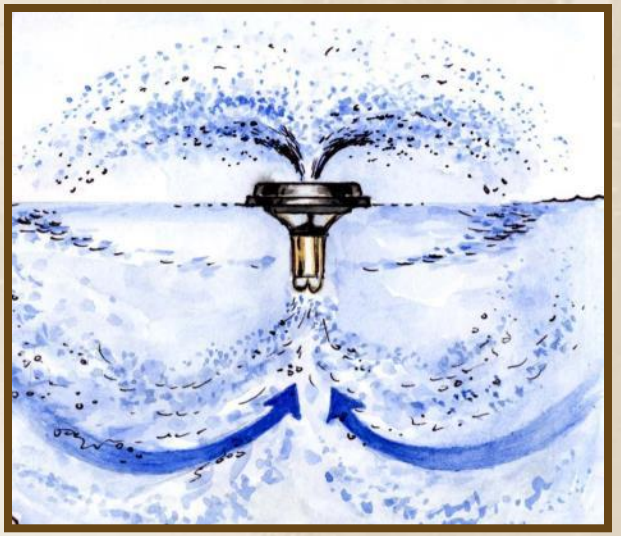


Horizontal Mixers & Aspirators

Air Diffusion

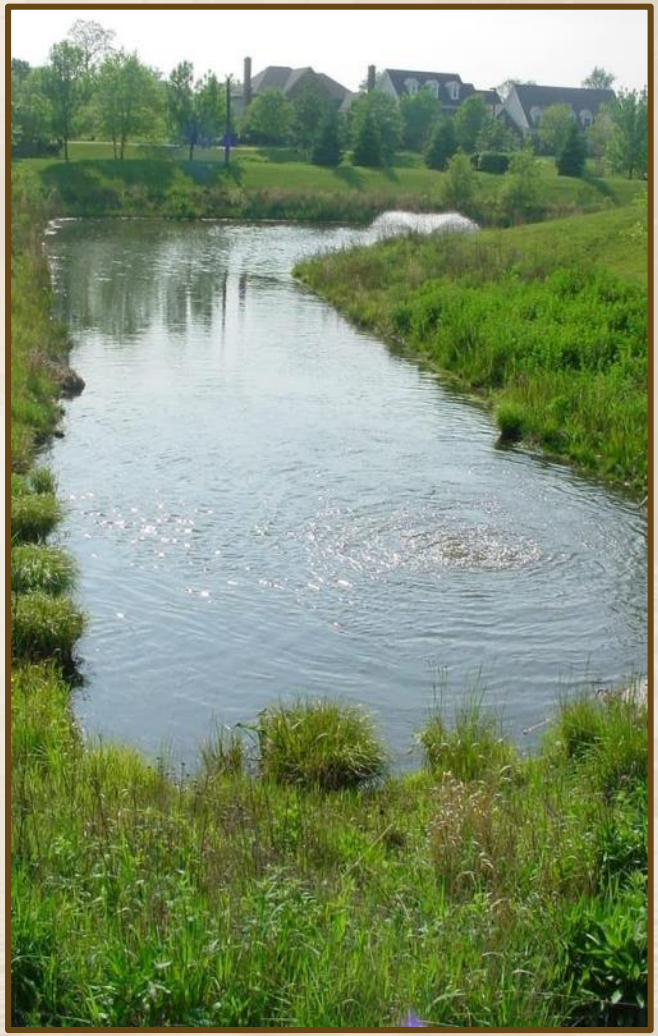
SURFACE SPRAY AERATION

- Provides the best aeration and circulation in lakes less than 15ft or 5m deep
- Mixes surface and bottom waters, aerating and creating convection patterns
- Independent research shows that surface aeration adds 2 mg\L of dissolved oxygen at 10ft or 3m
- Wave pattern is excellent for breaking up algae mats



HORIZONTAL MIXERS & ASPIRATORS

- These aeration systems are best suited for 3-12ft. or 1-4m
- Units are used to create circulation in long narrow channels or lakes
- Good choice when a spray pattern is not desired



AIR DIFFUSION SYSTEMS

- Effective in 15ft or 5m or deeper
- Depth must be sufficient to allow for rising air bubbles to expand towards the water surface
- Most unobtrusive off all systems
- No electricity running water
- Shore mounted compressor forces air to diffusers installed at the bottom of the pond

CRITERIA FOR AN AERATOR

- Aerator must pump a minimum of 400GPM or 90m^3/hr
- True aerators are rated by their oxygen transfer rate.
  - Look for a system that has independent oxygen transfer testing!!
- Good Spray or Aspirating Aeration System will develop 2-3 lb. or 1-1.3 kilos of oxygen per hour.
- Look for safety testing: CE, CSA, ETL or UL.

AERATOR PLACEMENT

- Placement is dependent on size & shape
  - Place aerators or diffusers to insure maximum circulation
  - Use multiple units for best results
- Streams and canals are best suited for horizontal aspirating aeration systems

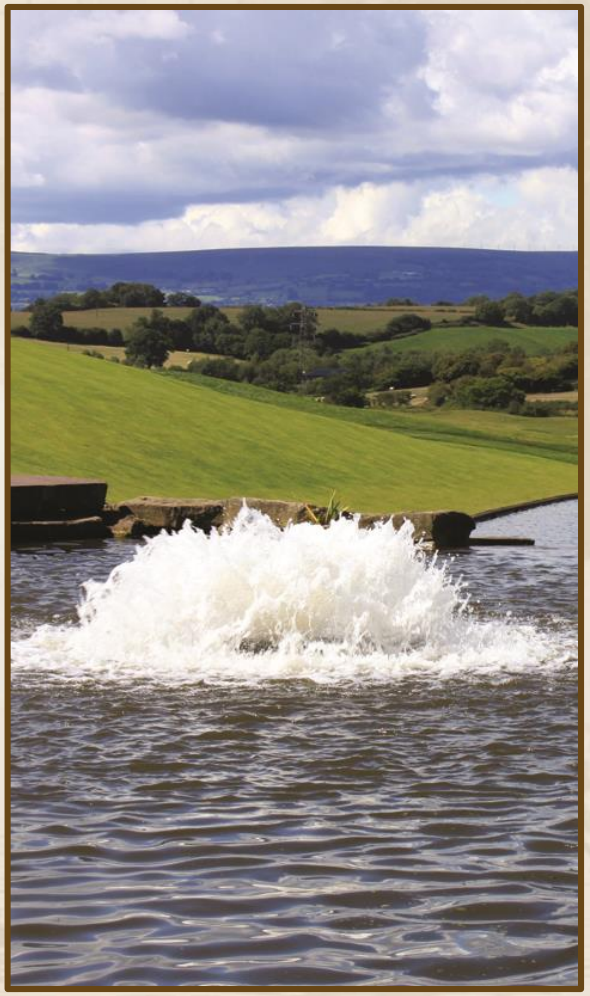
SUMMARY

Water Quality Management is a Science

- Identify the causes of your problems:
  - Light
  - Temperature
  - Nutrients
  - Oxygen

INTEGRATE BEST MANAGEMENT PRACTICES | Align to the Causes

- Minimize Light & Heat
- Minimize Nutrient
- Accelerate Digestion
- Use Proactive Tools as the Basis for Your Program
- Use Reactive Tools in Crisis



REVIEW

- Aging Process of Lakes
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- Costs of Not Acting
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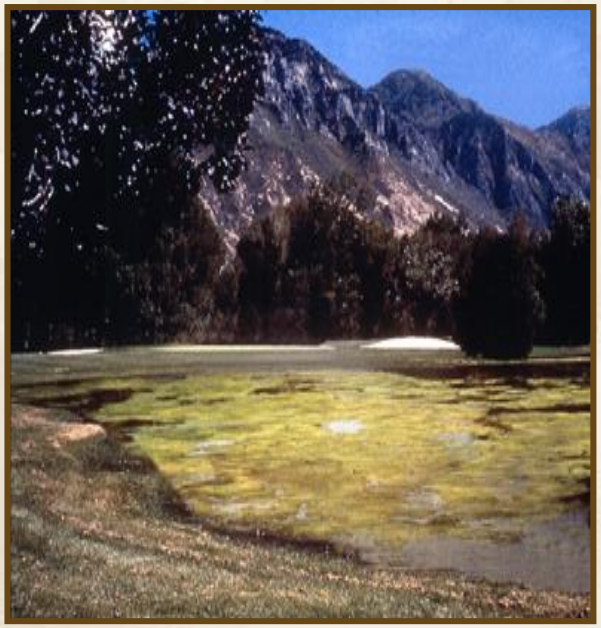
INTEGRATED SOLUTIONS

BEFORE



No Lake Management Program

6 WEEKS LATER

Aeration & Lake Dye

THANK YOU FOR YOUR TIME!

Please visit Otterbine at **www.otterbine.com**
or call 1-800-237-8837 (610-965-6018)