Aeration:
A key tool in aquatic system restoration and management

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Research Biologist

Vertex Water Features
Lake Aeration Systems & Floating Fountains

http://www.vertexwaterfeatures.com

Topic Overview

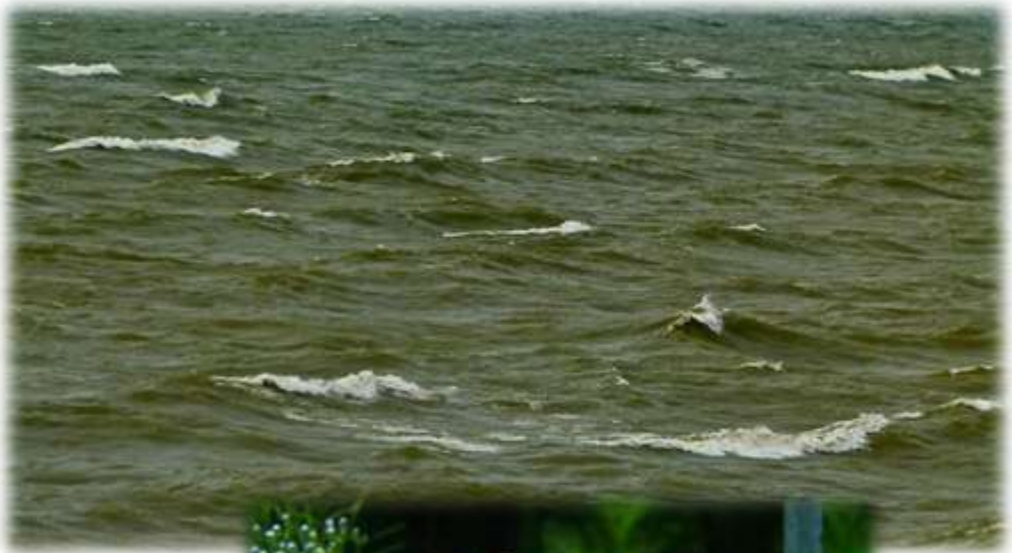
- Types of Aeration systems
  - Pros and Cons
- Aerations effect on lake ecology
  - Physical
  - Chemical
  - Biological
- Designing Aeration Systems

Aeration

- Aeration –the process by which air is circulated through, mixed with or dissolved in water to increase the oxygen saturation of the water.
  - Natural
  - Artificial

Natural aeration

- Wind action

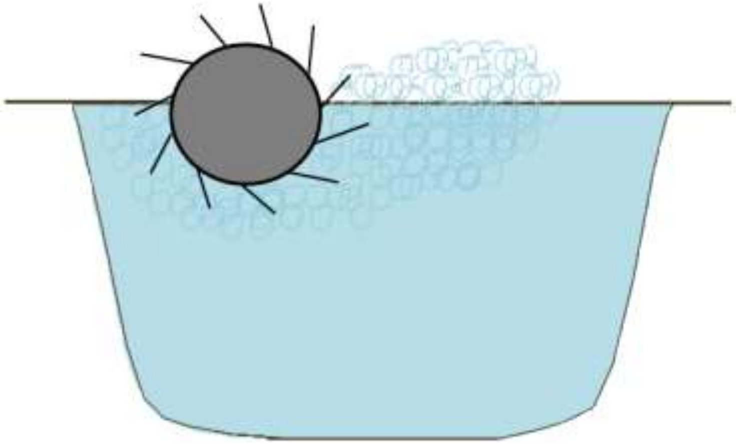


- Photosynthesis

Artificial aeration

- Water circulated using a device
- Types of aeration systems:
  - Surface
    - Paddle wheel surface aerators
    - Fountain aerators
    - Aspirator pumps
  - Subsurface
    - Diffusers
    - Hypolimnetic Injectors

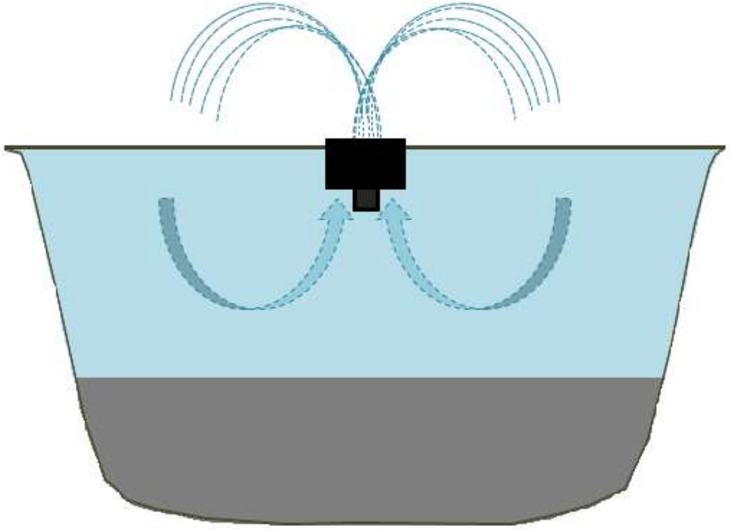
Paddle wheel surface aerators



Highly effective in O2 exchange
Good for fish farm ponds

Best in shallow lakes
Not aesthetically attractive
Noisy
Physical obstruction
Energy intensive

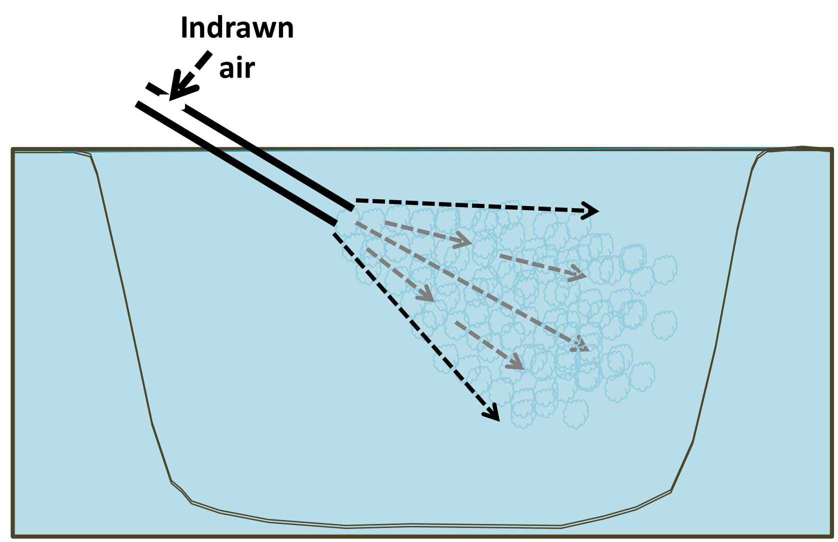
Fountains aerator



Aesthetically attractive
Can scale to size of lake
Quiet operation

Not highly efficient system
Best in shallow lakes
Not energy efficient
Physical obstruction
Relatively expensive

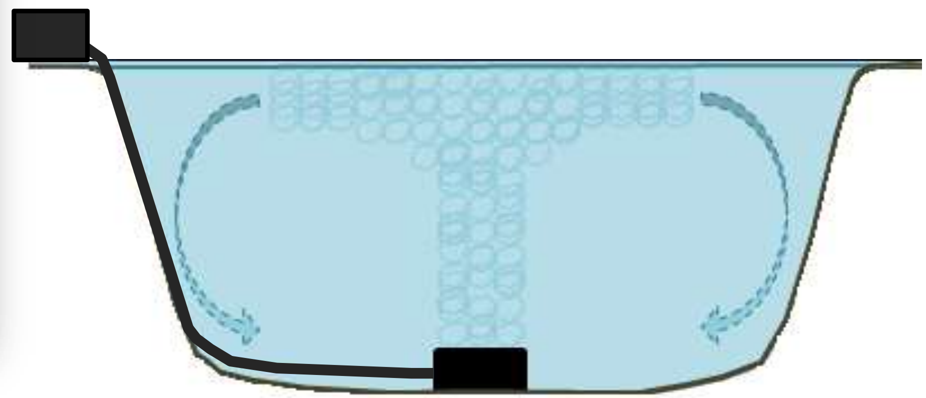
Aspirator pump



Highly efficient system
Good for creating flow
Quiet

Not aesthetically attractive
Can disturb biota and sediment
Physical obstruction
Concern of N2 supersaturation

Sub-Surface: Diffusers



Highly efficient system
Can scale to size of lake
Energy efficient
No electricity in water
No physical obstruction
Destratifies

Not suited for very shallow lakes
Compressor cabinet reduces noise

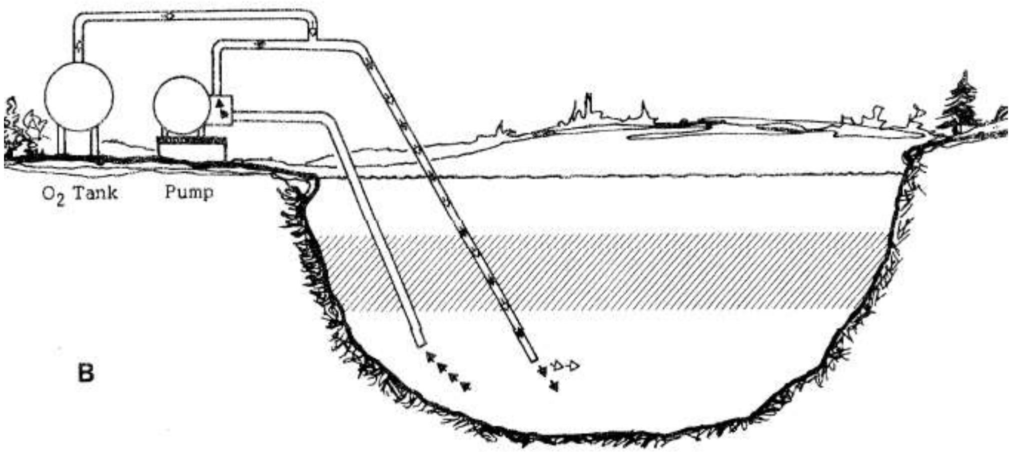
Sub-surface diffusers

Fine Bubbles **Vs.** **Coarse Bubbles**

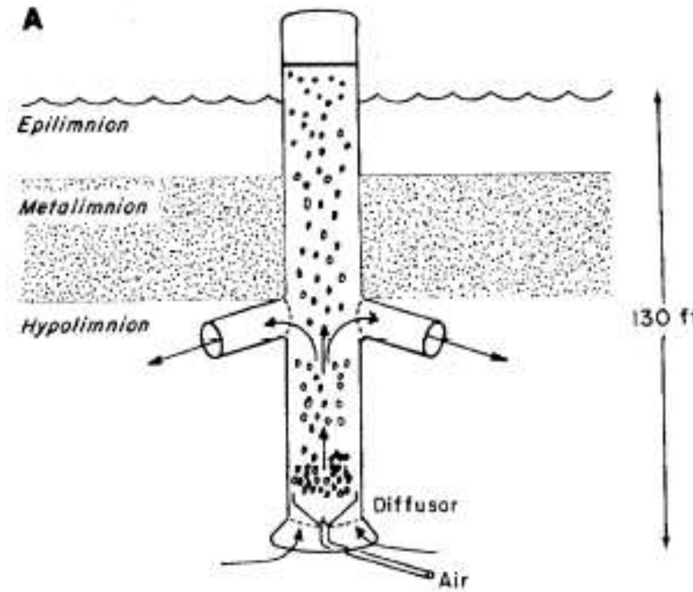
- Less than 2mm in diameter

- More than 2mm in diameter

Hypolimnetic Injectors



Lorenzen, 1976

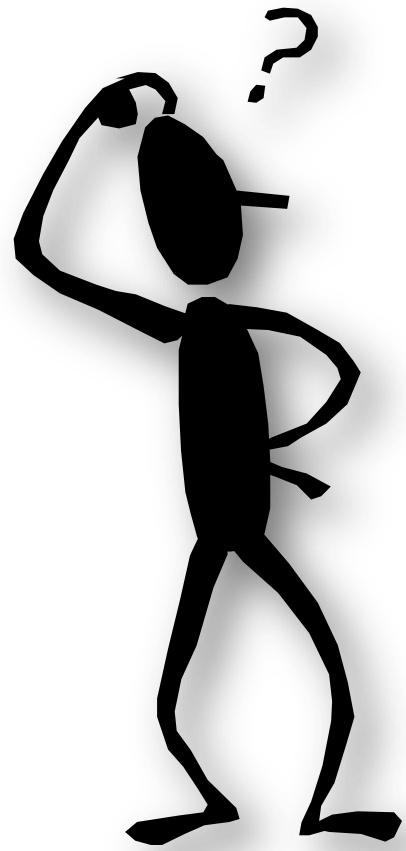


Smith et al., 1975

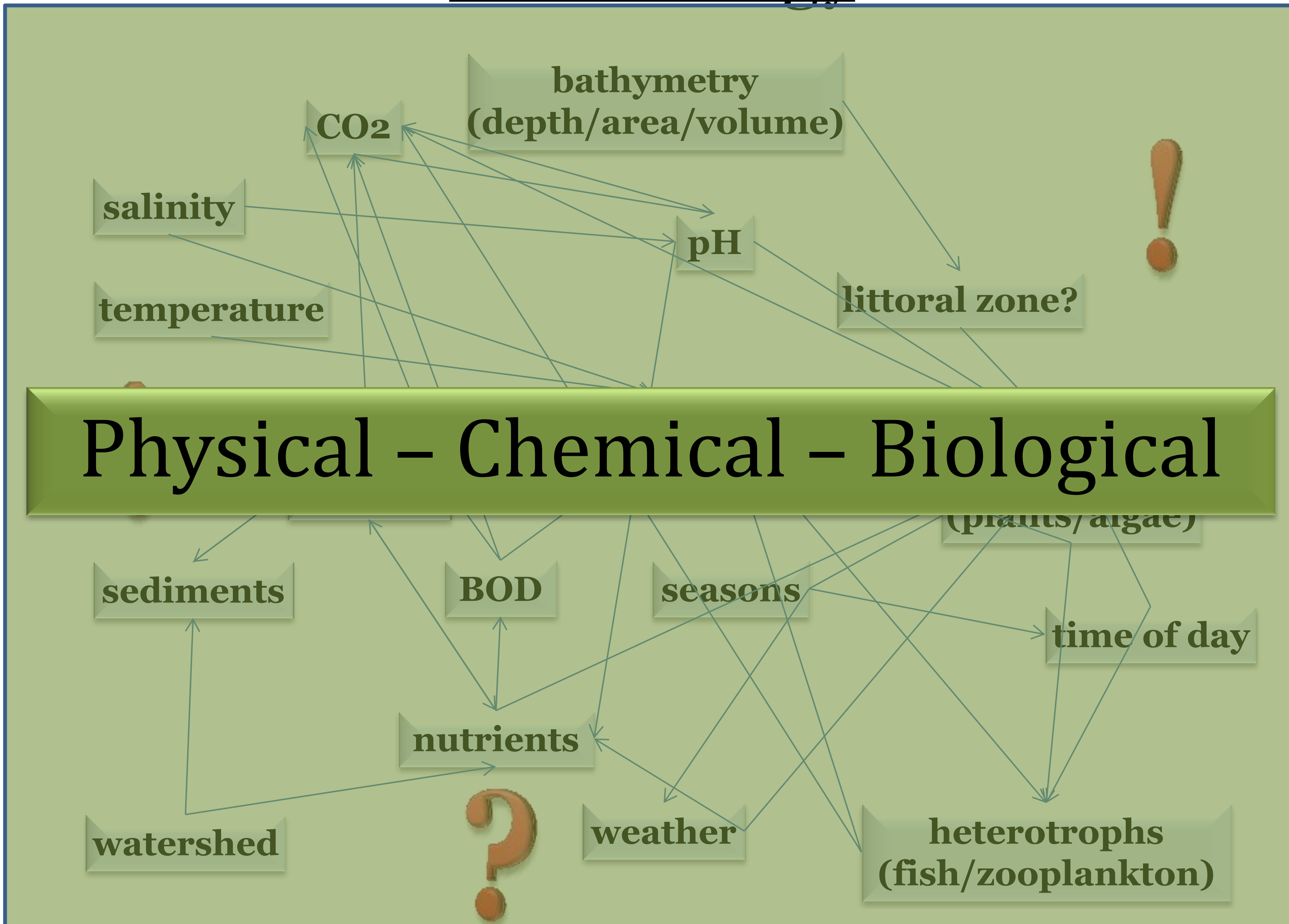
Good for cold water fisheries

Expensive

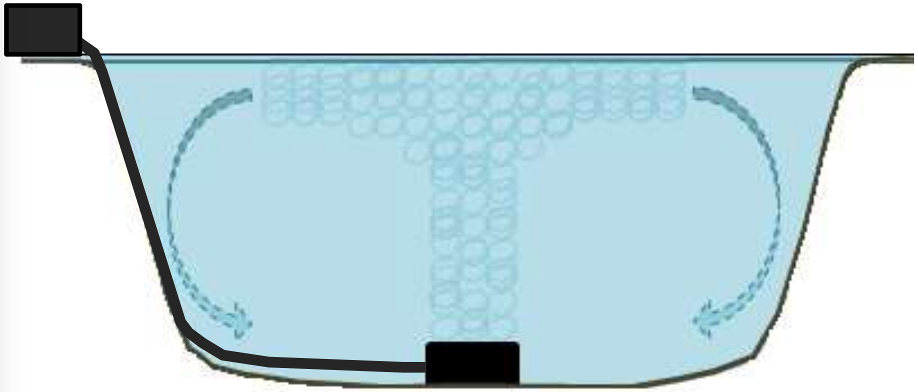
How does aeration improve your lake?



Lake Ecology



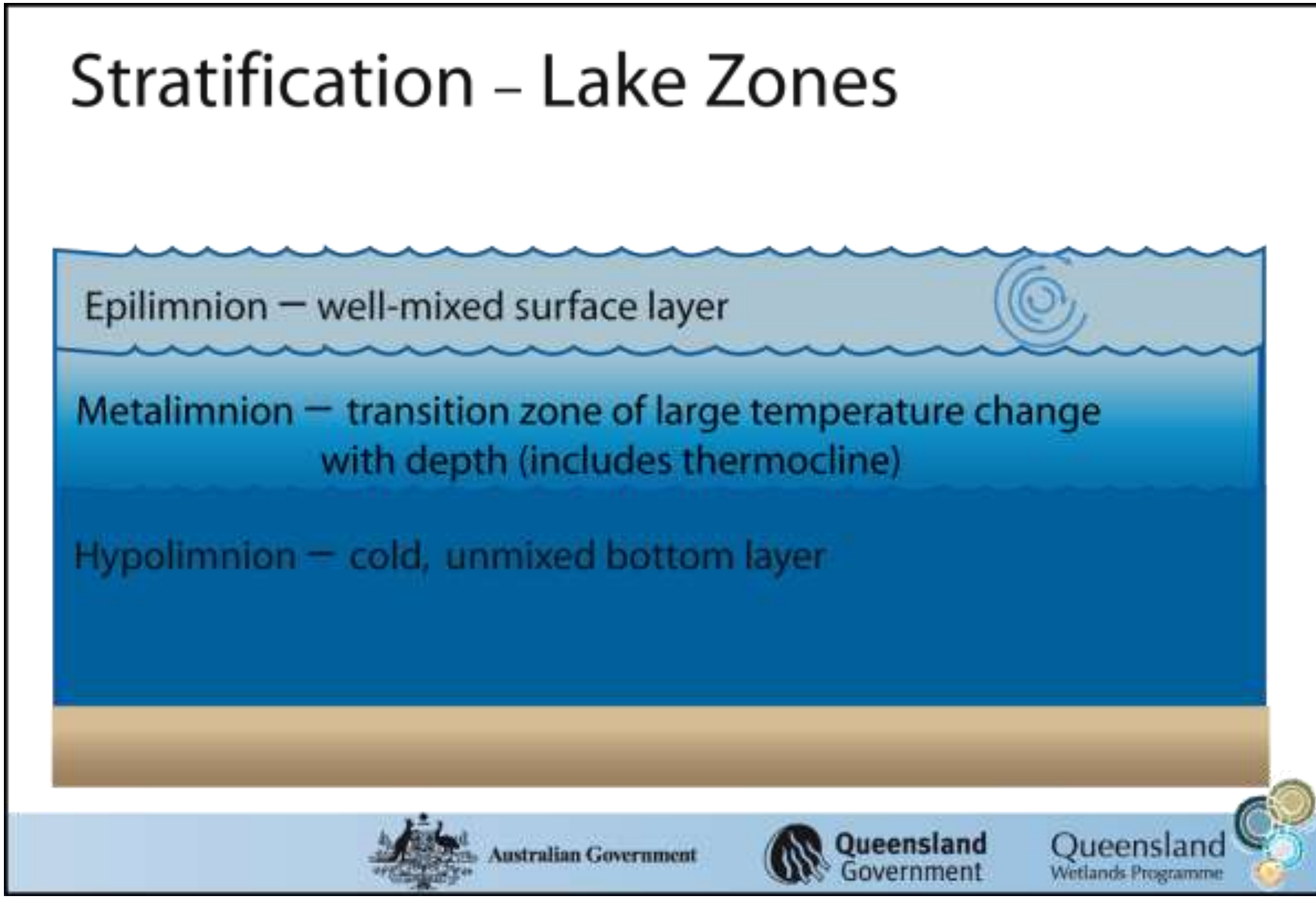
Sub-Surface: Diffusers



Main lake/pond issues - Physical

- Stratification
  - Temperature
- Turbidity: water clarity
  - Total suspended solids (TSS)
- Muck Accumulation/Water depth
  - Decomposition/sedimentation rates
  - Odor

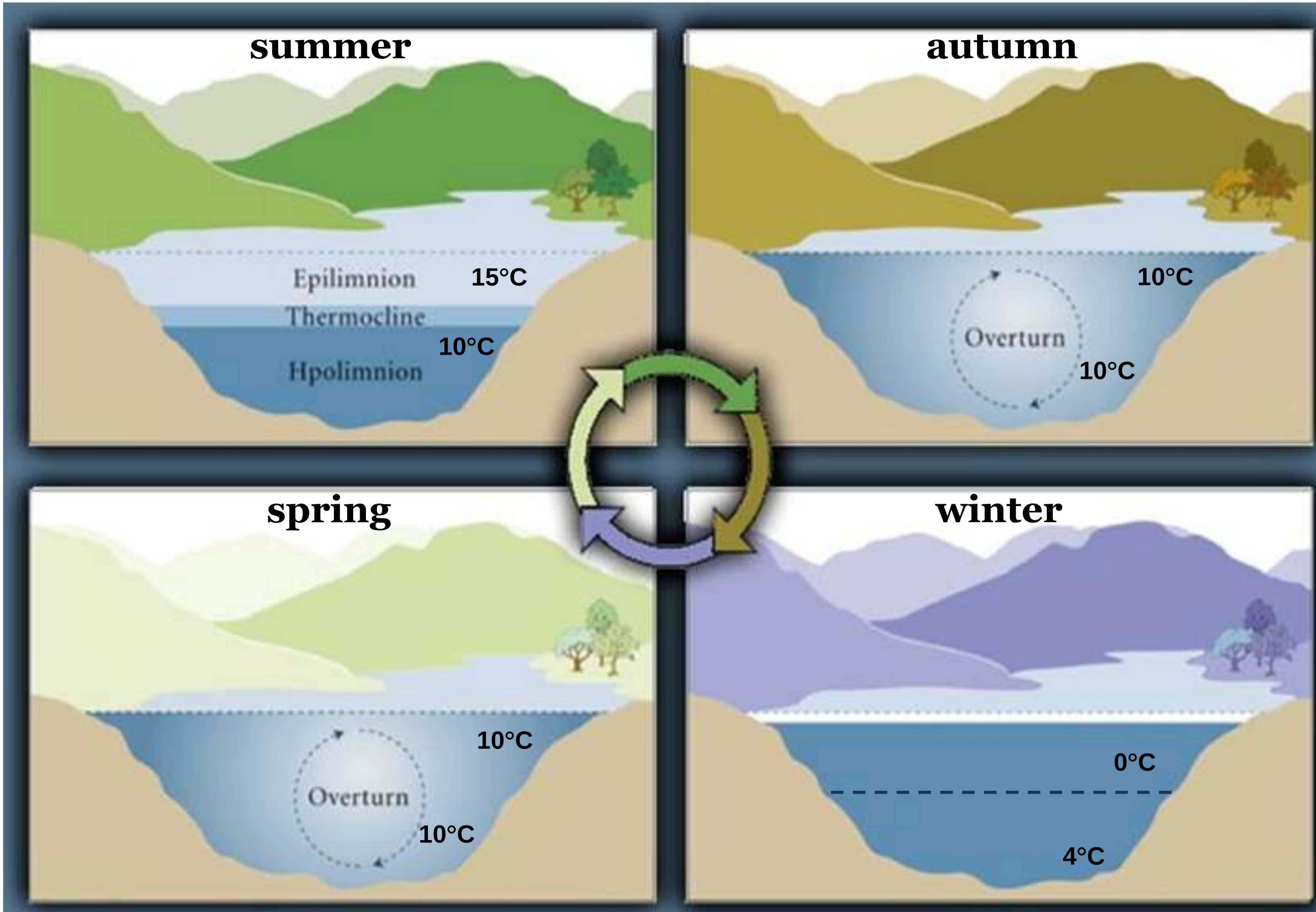
Stratification and Temperature

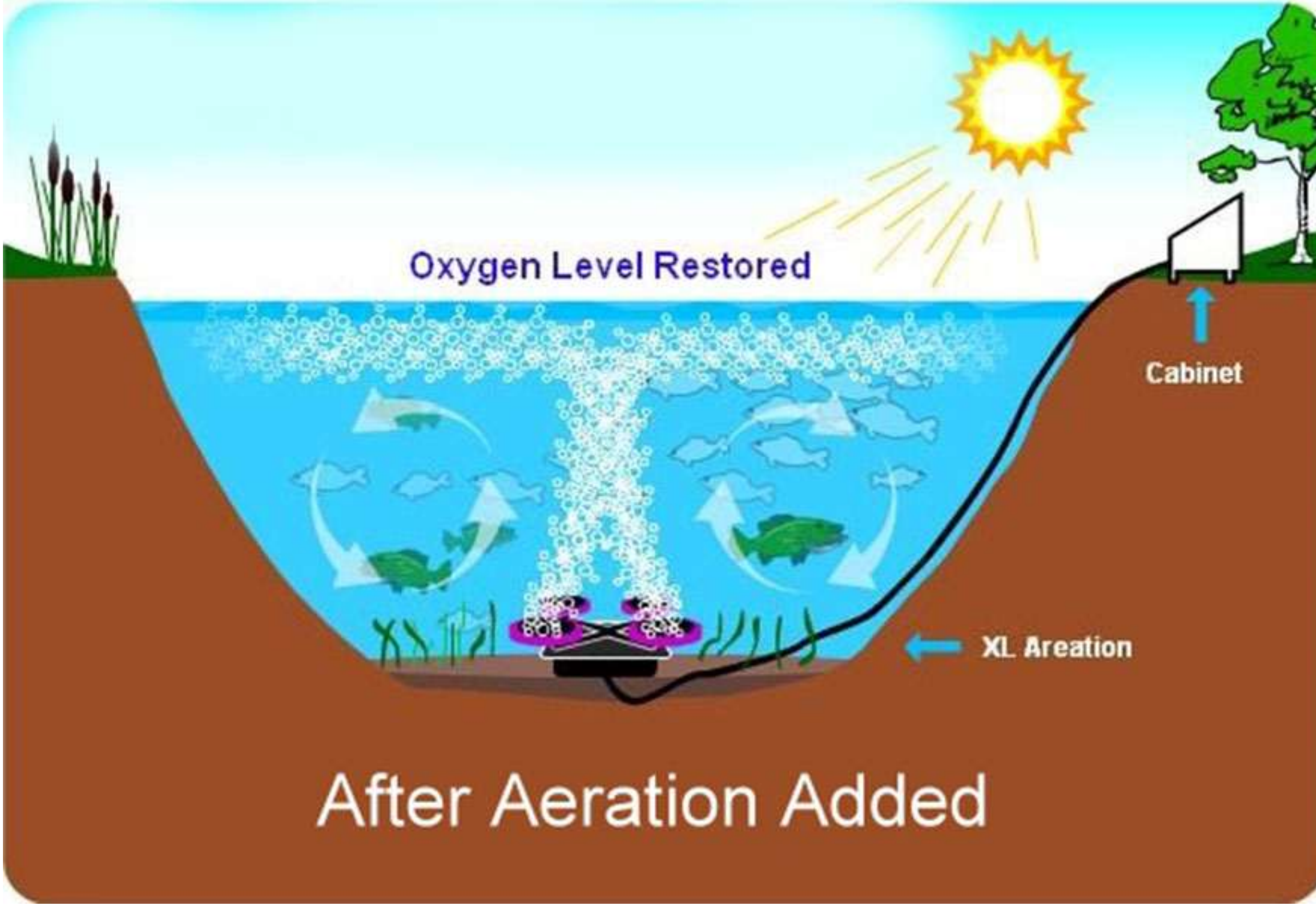


Varies depending on:

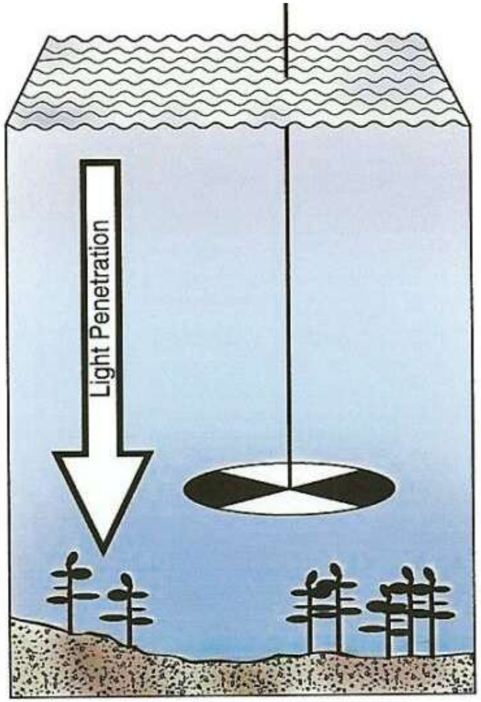
- Lake depth (>8-12ft)
- Time of year

Stratification and Temperature




Oxygen Level Restored
Cabinet
XL Areation
After Aeration Added

Turbidity



- Total Suspended Solids
  - Suspended sediments
  - Particulate Organic Matter
  - Phytoplankton

Muck build up and Water depth

- Muck Accumulation
- Sedimentation mostly occurs when a lakes stratified.
- Organic matter reduces the binding capacity of phosphorous and promotes nutrient re-cycling
  - (Borggaard et al., 1990).

Muck build up and Water depth

- Anaerobic decomposition is much slower than that of aerobic decomposition (Reed, 1979; Barnes & others' 1985).
- When oxygen concentrations fall below 1.5-2 mg/L, the rate of aerobic oxidation is reduced significantly (Chin, 2006).

<u>Odor</u>

- Hydrogen sulfide gas (H_2S) is generated under **<u>anaerobic</u>** conditions
- Aeration reduces H_2S by:
  - Circulating water and increasing diffusion of H_2S out of water
  - Increasing oxygen, which encourages aerobic respiration

Main lake/pond issues – Chemical

Low dissolved oxygen levels

Low Redox or ORP

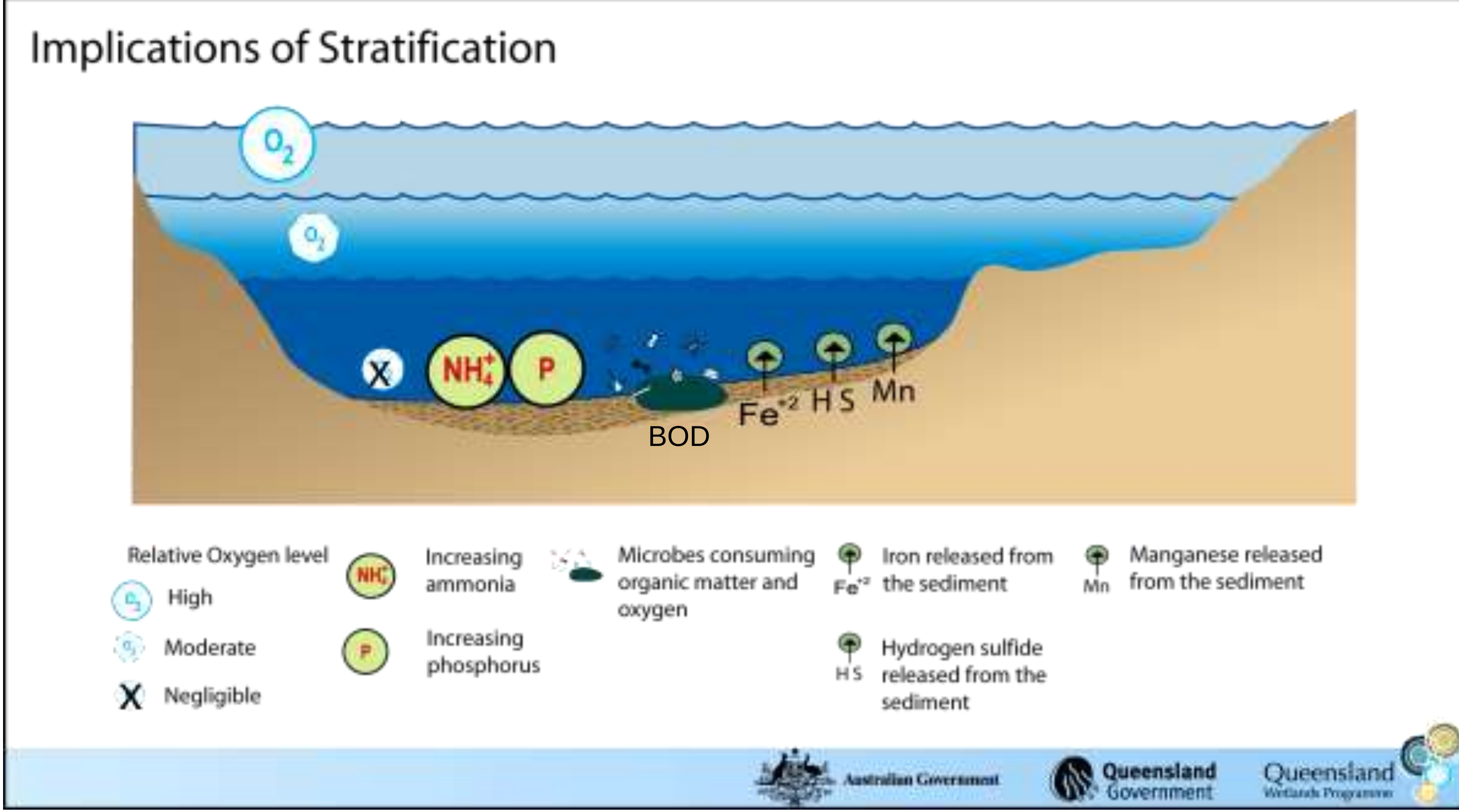
High Biological oxygen demand

Phosphorus

Nitrogen

Classifying different levels of dissolved oxygen:

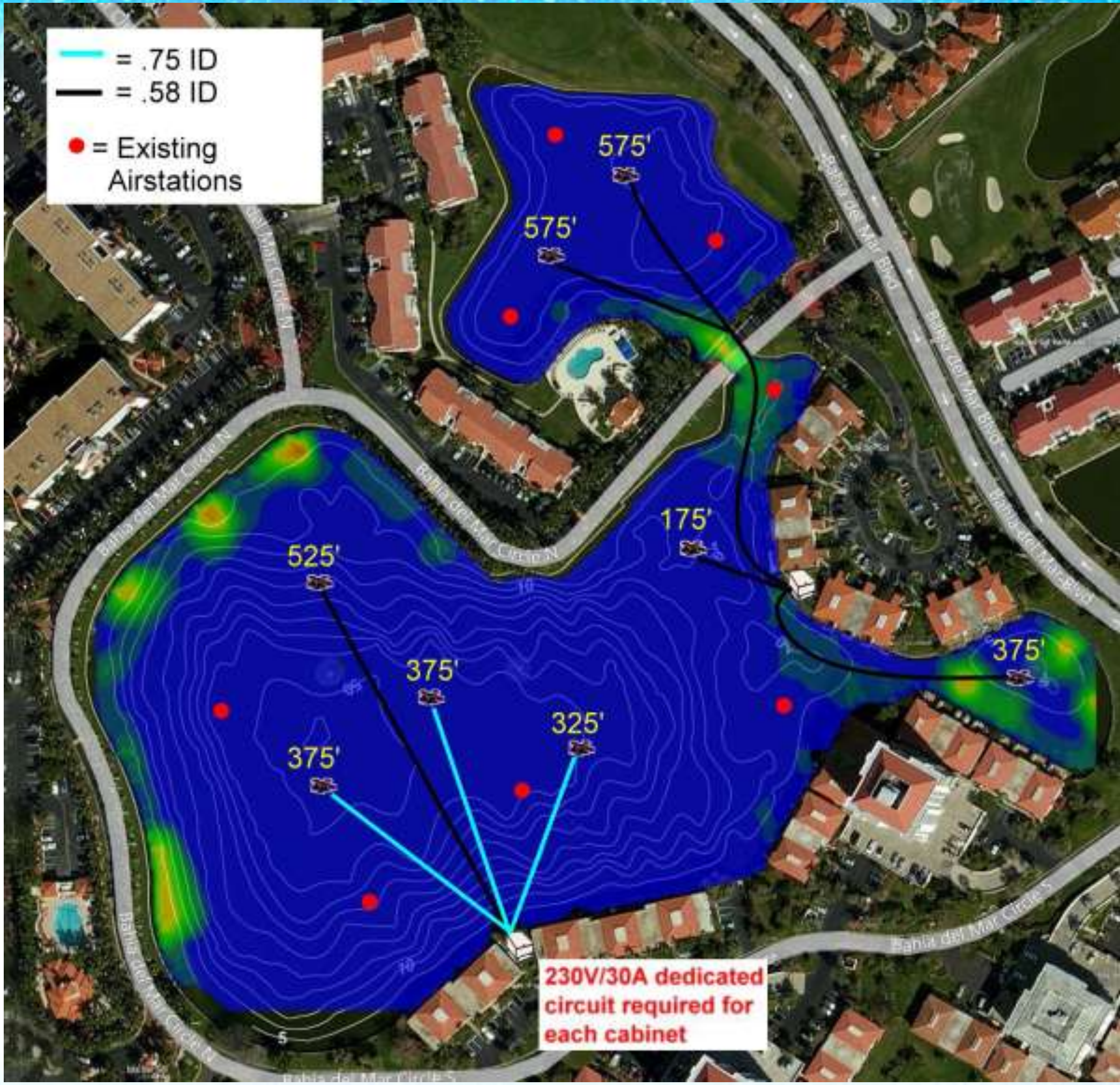
1. **oxic conditions**: measurable oxygen present (>0.06 mg/L to about 16 mg/L)
2. **low O2 conditions**: <4 mg/L
3. **hypoxic conditions**: <2 mg/L stressful for all aerobic organisms
4. **anoxic conditions**: 0 mg /L only anaerobic bacteria or archaea can survive

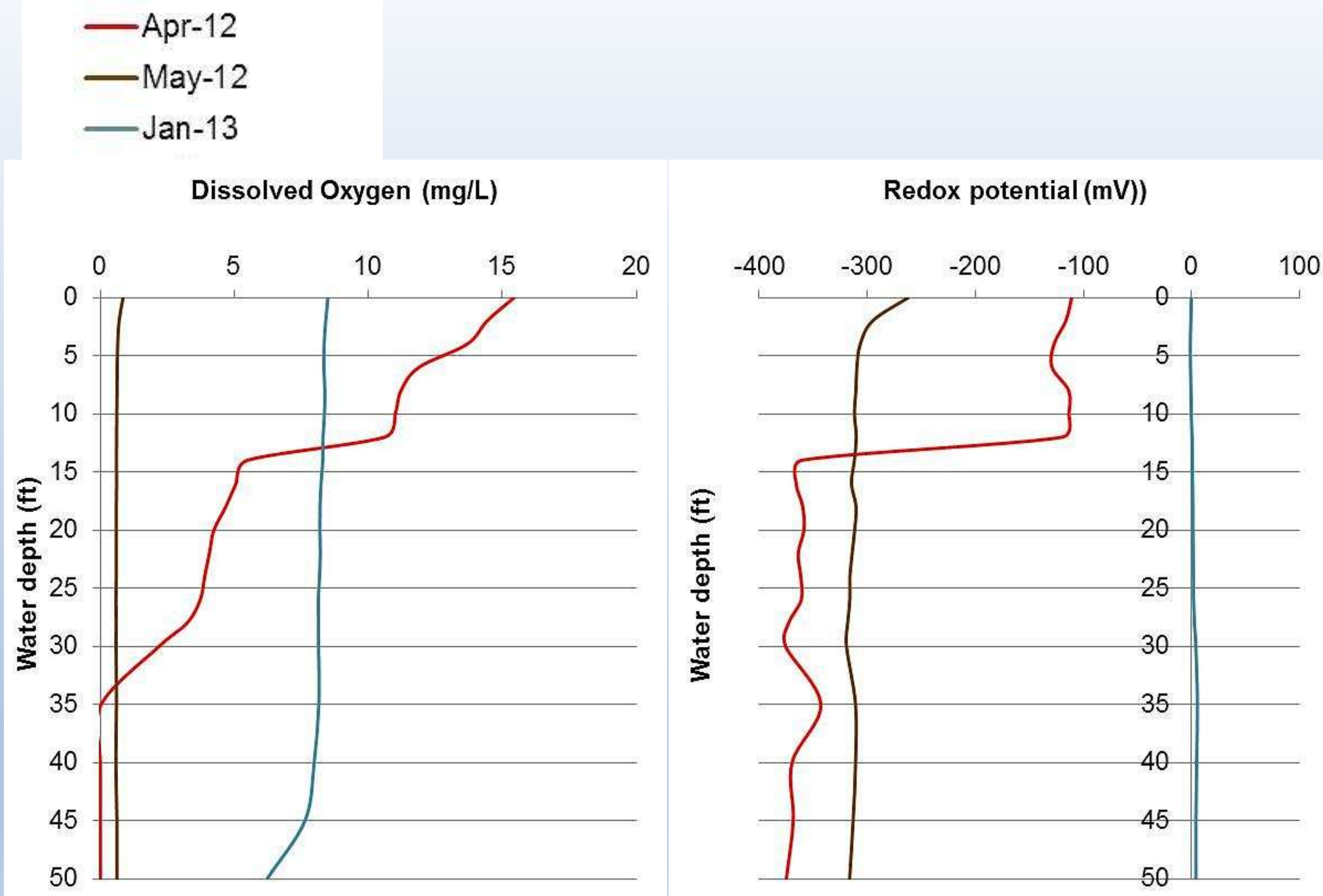


- Low DO, High CO_2
- High BOD
- Low redox/ORP

Bahia del Mar

- St. Petersburg, FL
- Brackish water lake
- Area: 14 Acres
- Depth 18 - 51ft





Apr-12
May-12
Jan-13
Dissolved Oxygen (mg/L)
0
5
10
15
20
Water depth (ft)
0
5
10
15
20
25
30
35
40
45
50
Redox potential (mV))
-400
-300
-200
-100
0
100
Water depth (ft)
0
5
10
15
20
25
30
35
40
45
50

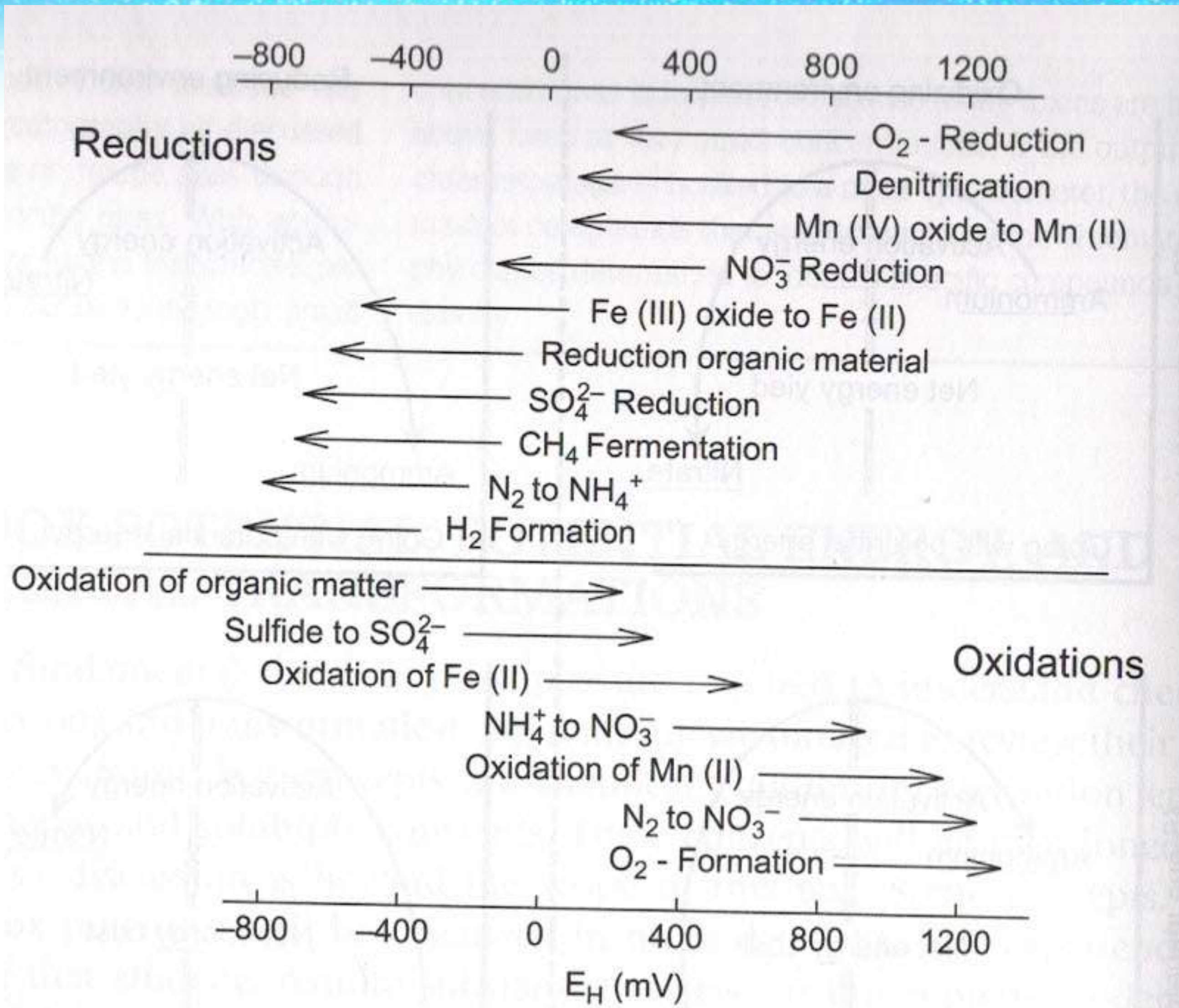
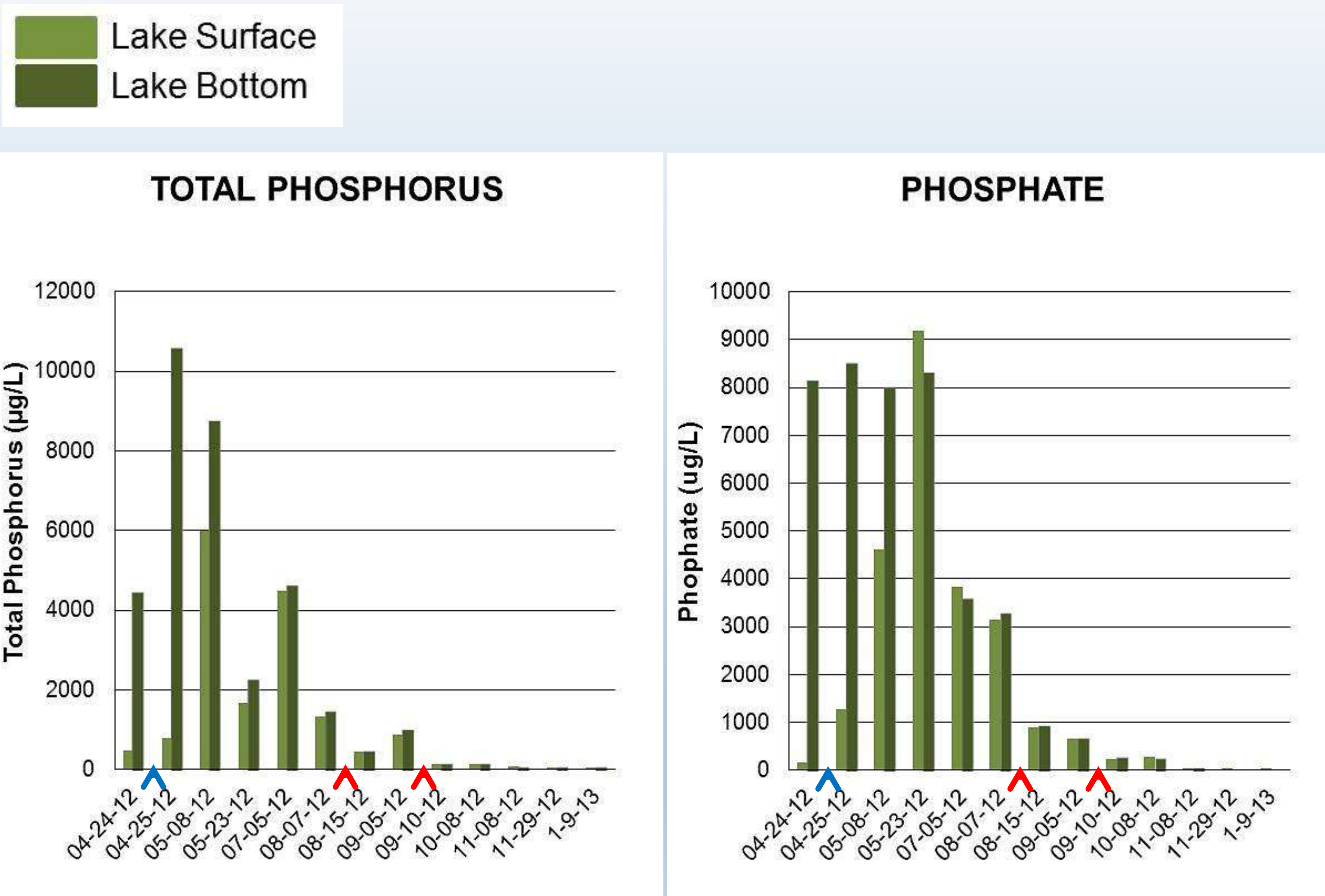
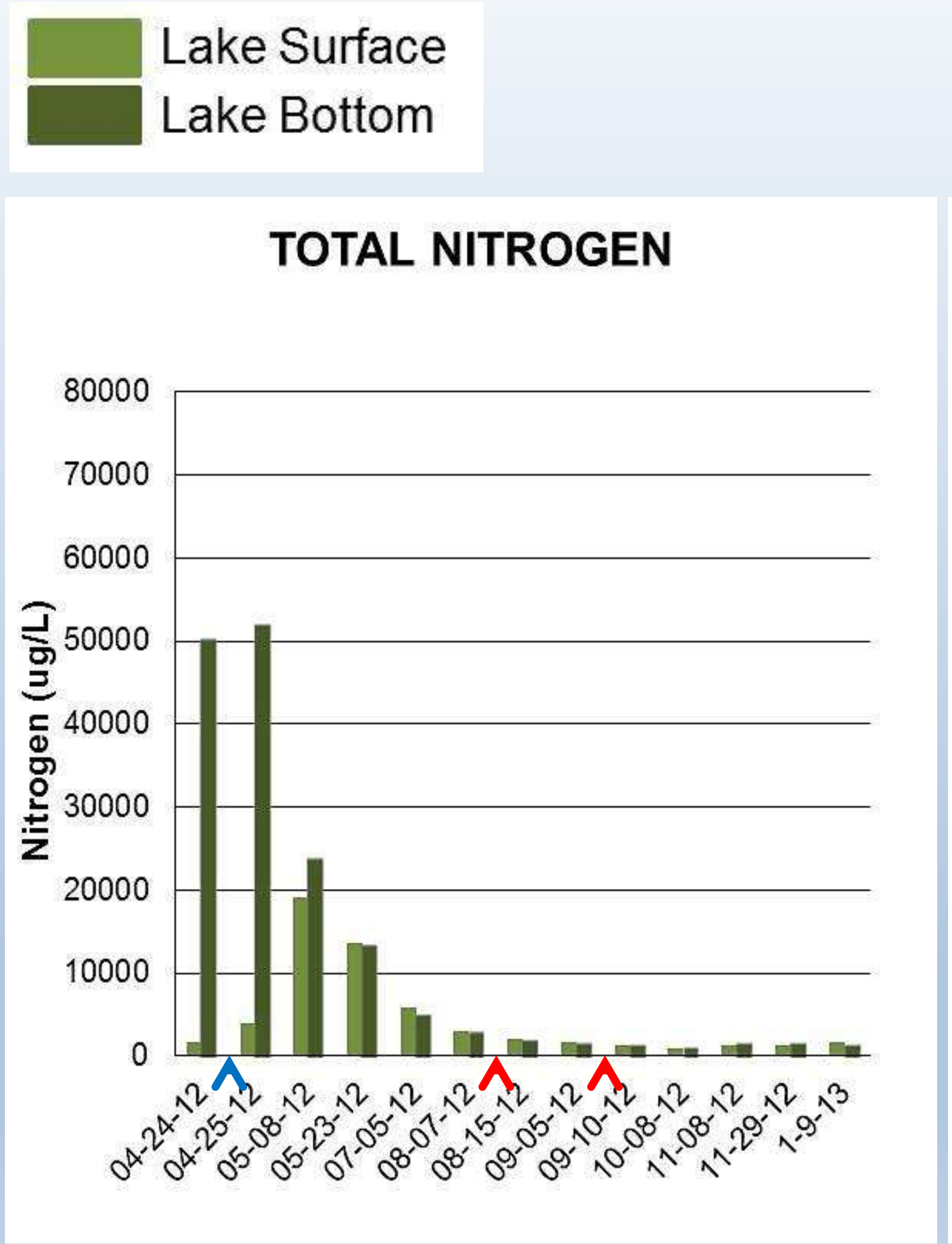
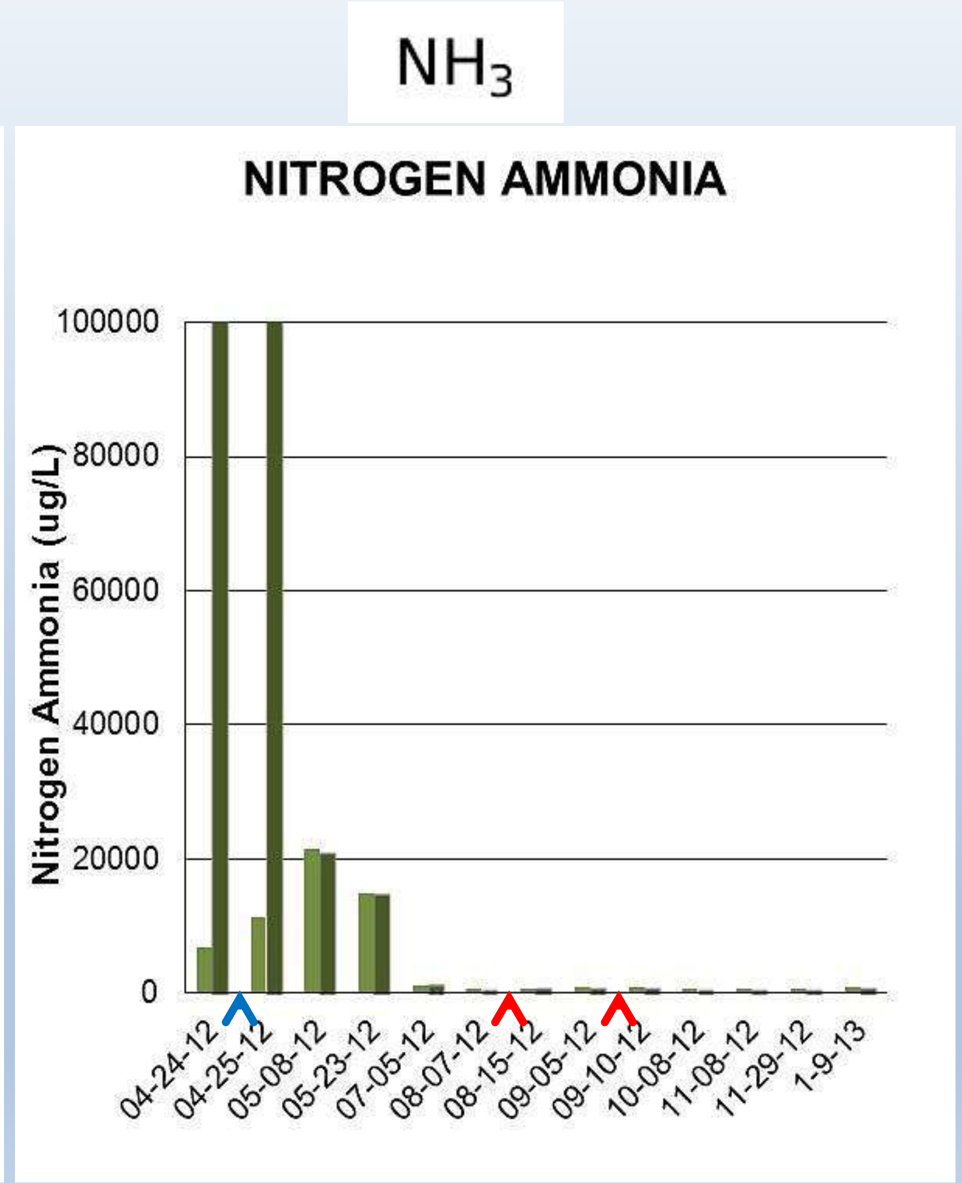


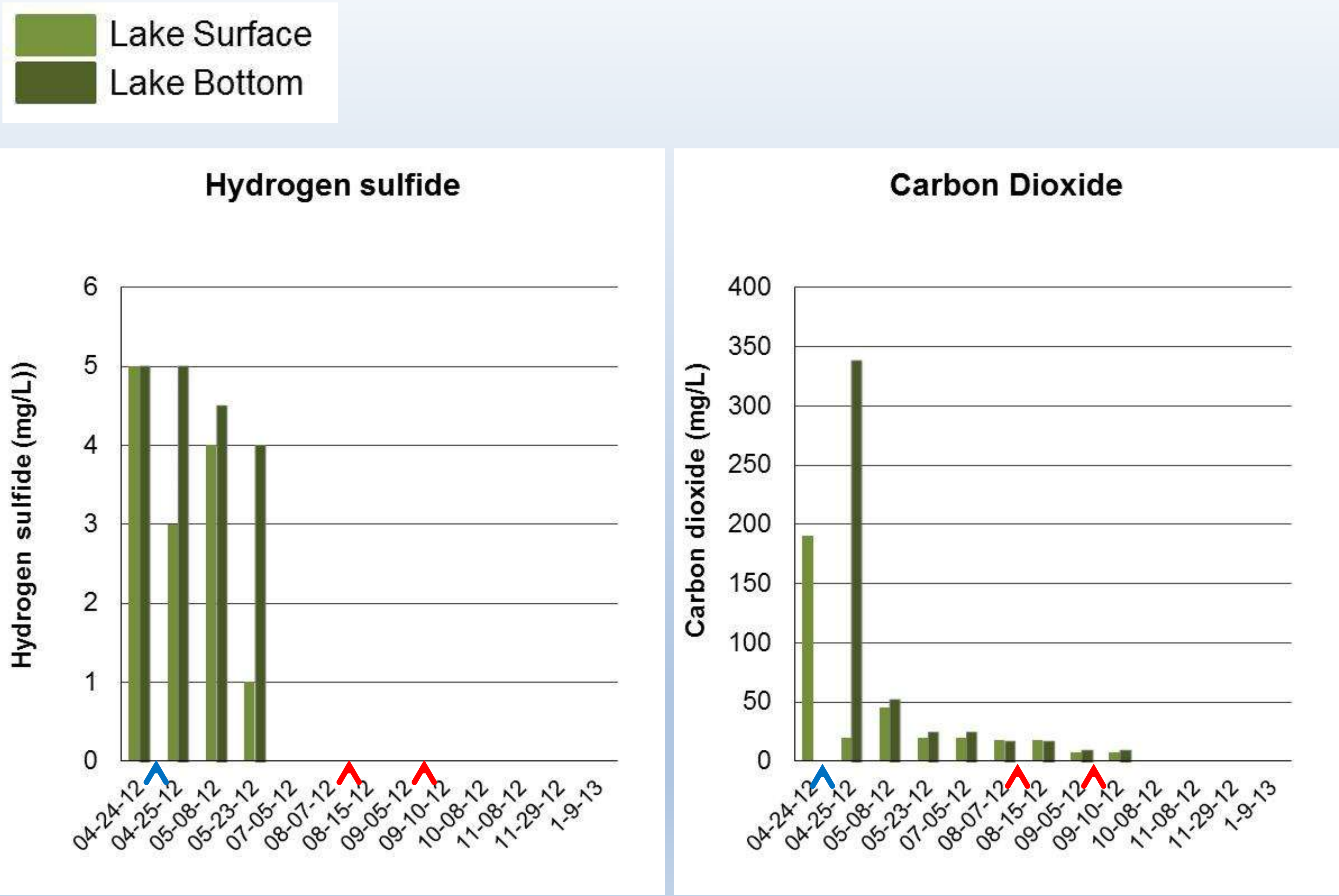
Figure taken from Dodds, 2002

Microbe-mediated chemical transformations using Redox (mV)

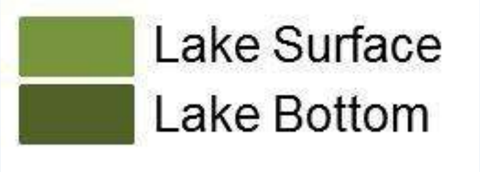

Lake Surface
Lake Bottom
TOTAL PHOSPHORUS
Total Phosphorus (μg/L)
12000
10000
8000
6000
4000
2000
0
04-24-12
04-25-12
05-08-12
05-23-12
07-05-12
08-07-12
08-15-12
09-05-12
09-10-12
10-08-12
11-08-12
11-29-12
1-9-13
PHOSPHATE
Phophate (ug/L)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
04-24-12
04-25-12
05-08-12
05-23-12
07-05-12
08-07-12
08-15-12
09-05-12
09-10-12
10-08-12
11-08-12
11-29-12
1-9-13

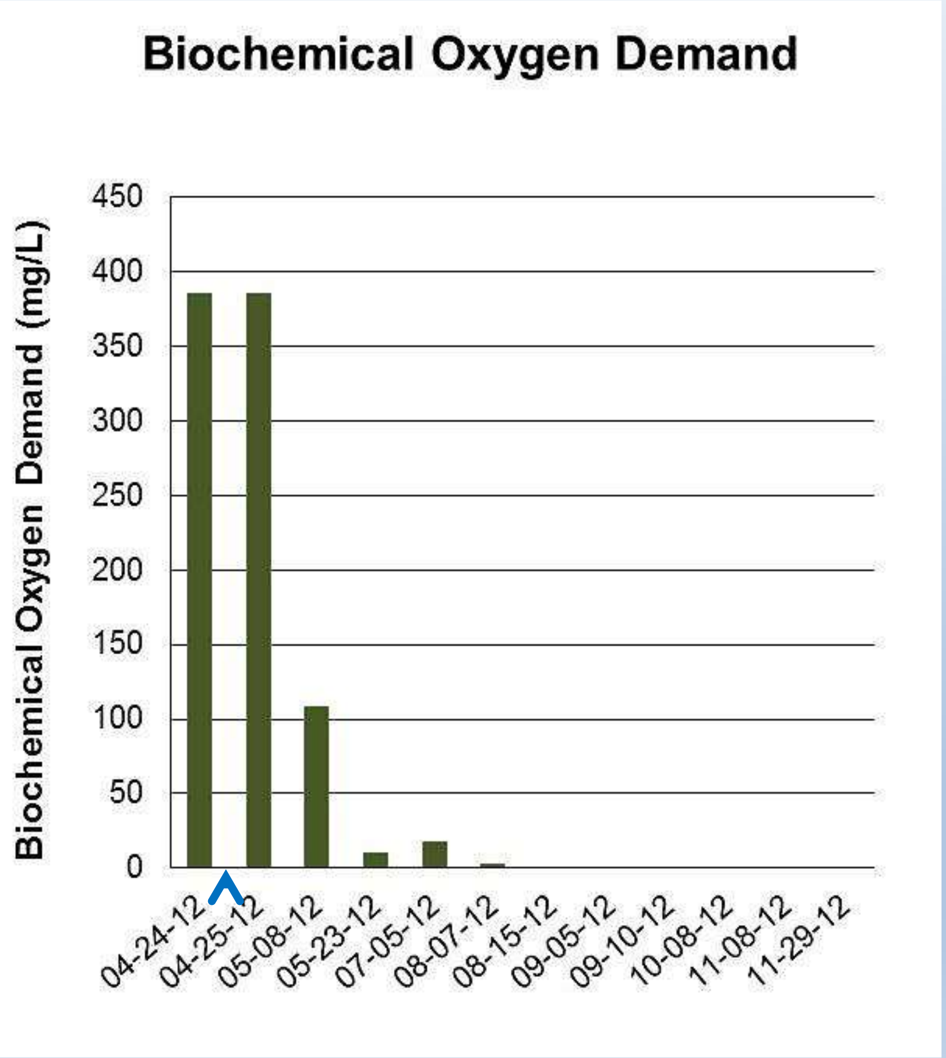

Lake Surface
Lake Bottom
TOTAL NITROGEN
Nitrogen (ug/L)
80000
70000
60000
50000
40000
30000
20000
10000
0
04-24-12
04-25-12
05-08-12
05-23-12
07-05-12
08-07-12
08-15-12
09-05-12
09-10-12
10-08-12
11-08-12
11-29-12
1-9-13


NH3
NITROGEN AMMONIA
Nitrogen Ammonia (ug/L)
100000
80000
60000
40000
20000
0
04-24-12
04-25-12
05-08-12
05-23-12
07-05-12
08-07-12
08-15-12
09-05-12
09-10-12
10-08-12
11-08-12
11-29-12
1-9-13



Lake Surface
Lake Bottom
Hydrogen sulfide
Hydrogen sulfide (mg/L))
6
5
4
3
2
1
0
04-24-12
04-25-12
05-08-12
05-23-12
07-05-12
08-07-12
08-15-12
09-05-12
09-10-12
10-08-12
11-08-12
11-29-12
1-9-13
Carbon Dioxide
Carbon dioxide (mg/L)
400
350
300
250
200
150
100
50
0
04-24-12
04-25-12
05-08-12
05-23-12
07-05-12
08-07-12
08-15-12
09-05-12
09-10-12
10-08-12
11-08-12
11-29-12
1-9-13


Lake Surface
Lake Bottom

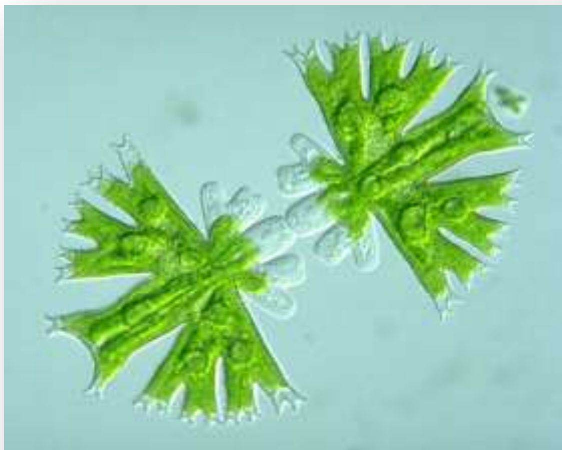

Biochemical Oxygen Demand
Biochemical Oxygen Demand (mg/L)
450
400
350
300
250
200
150
100
50
0
04-24-12
04-25-12
05-08-12
05-23-12
07-05-12
08-07-12
08-15-12
09-05-12
09-10-12
10-08-12
11-08-12
11-29-12

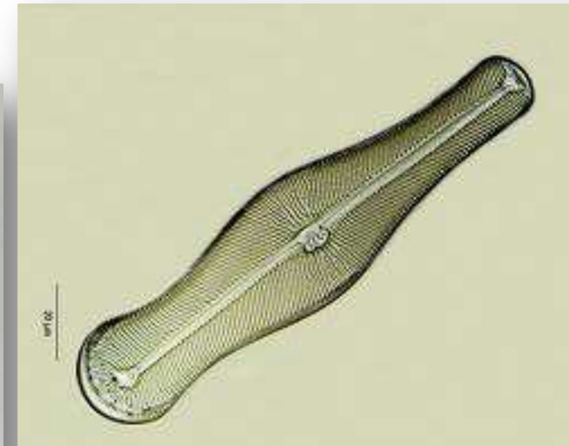
Main lake/pond issues - Biota

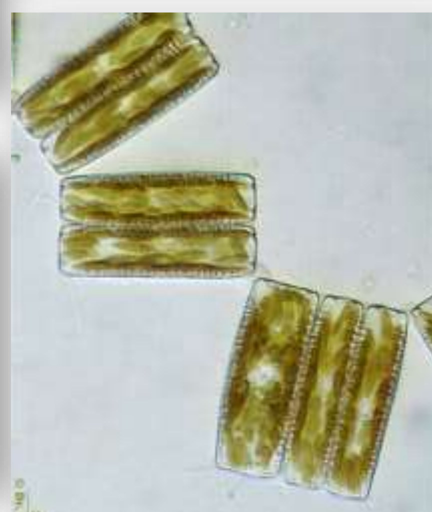
- Algae
- Fish kills
- Mosquitoes
- Midge Flies
- Macrophyte overgrowth

Algae and bacteria

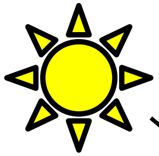
- Algae and bacteria are natural components of freshwater systems:





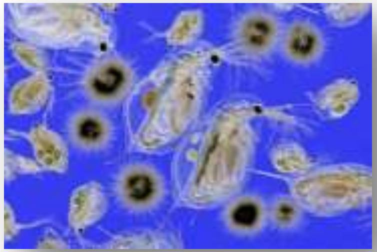


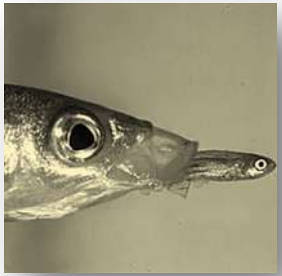
Basic Aquatic Food Web:



Nutrients → Primary Producers → Primary Consumers → Secondary Consumers → Tertiary Consumer

Trophic level:	1	2	3	4
	Algae/Plants	zooplankton	Planktivorous Fish	Piscivorous Fish





Nutrient enrichment or Eutrophication

- Disrupts the food web and encourages:
  - Periphyton mats
  - Phytoplankton blooms
  - Toxic algae
  - Pathogenic bacteria

Algae and bacteria

Aeration can reduce algae overgrowth by:

- Circulating water
- Increasing Oxygen→ Changes the water Chemistry

Circulating the Water

1. Algal cells will be mixed to deeper, darker lake areas, decreasing the cells time in the sunlight and there by reducing their growth rate.
2. Some algae species that tend to sink quickly and need mixing currents to remain suspended (e.g., diatoms) may be favored over more buoyant species such as the more noxious blue-greens.
3. mixing of algae-eating zooplankton into deeper, darker waters reduces their chances of being eaten by sight-feeding fish; hence, if more zooplankton survive, their consumption of algae cells also may increase.

Increasing oxygen → Changes the Biota

1. Helps control internal nutrients cycling =less algal growth
2. Changes in the lake's water chemistry (pH, carbon dioxide, alkalinity) brought about by higher DO levels can lead to shifts from blue-green to less noxious green algae or diatoms

<u>Fish kills</u>

- Fish kills occur due mainly to <u>low oxygen levels</u>, <u>high ammonia levels</u> and or <u>high suspended solids levels</u>
- Aeration is insurance against fish kills!

BUT…

- Must have a start up schedule

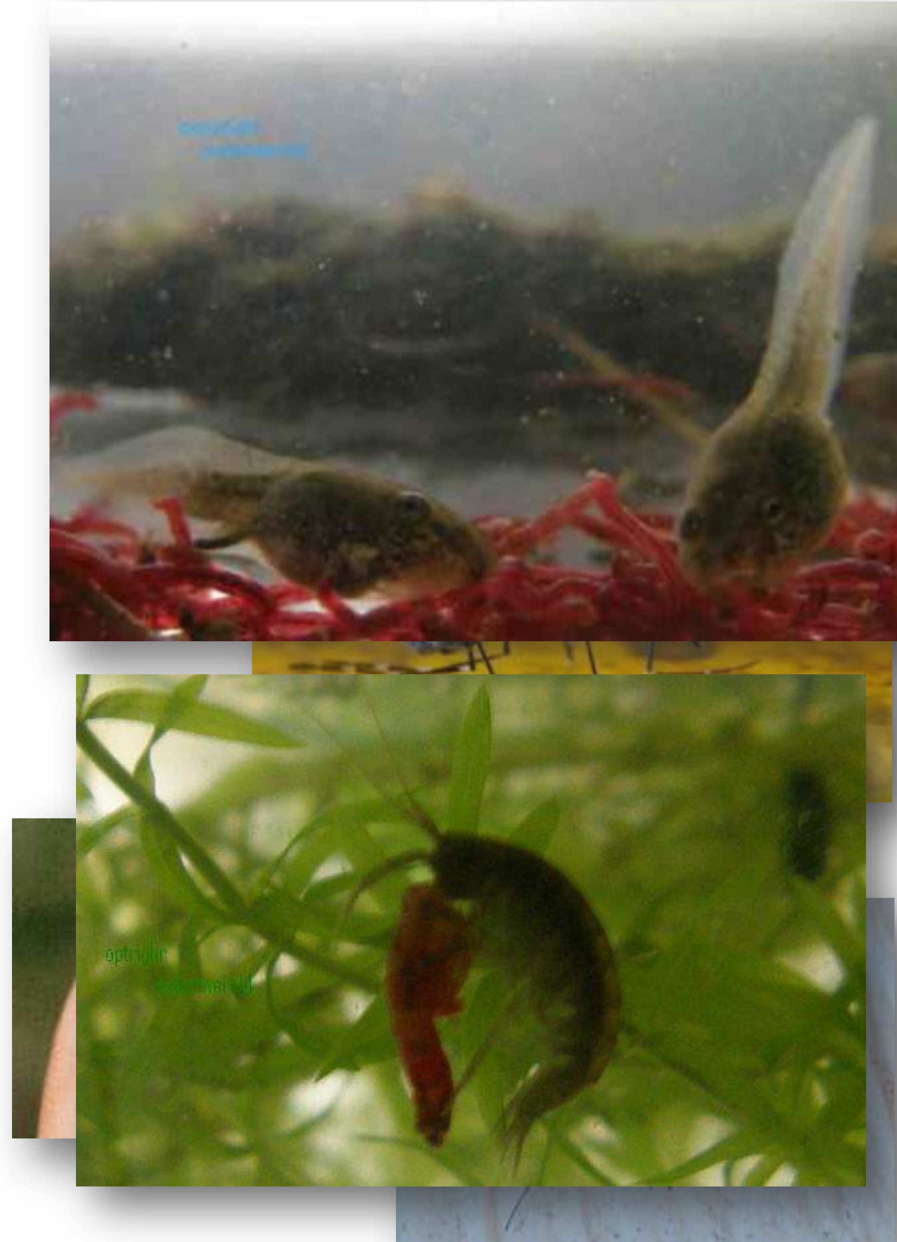
Aeration and Fishiereis

1. Increases the loading capacity
   – Expanding habitat range

2. Encourages healthy benthic macro-invetabrates

Mosquitoes and Midge Flies

- Stagnant water allows the establishment of:
  - Mosquitoes
  - Midge Flies
- Aeration reduces insect pests:
  - Circulates water
  - Increases oxygen
  - Encourages insects and fish that consume pests

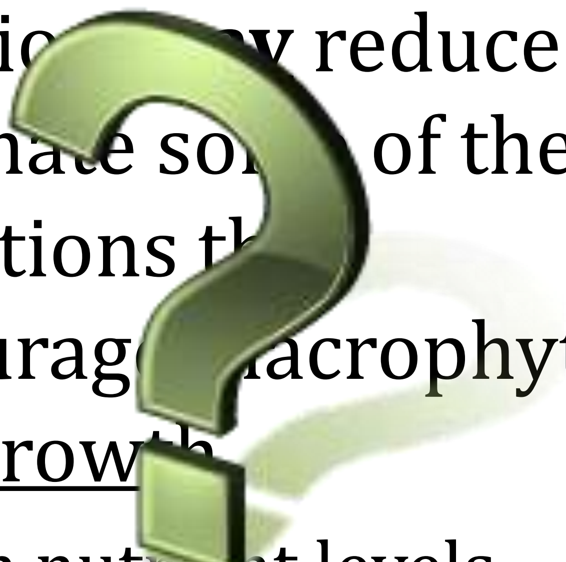


Macrophytes

- Macrophyte <u>overgrowth</u>
- Circulation is <u>**NOT**</u> weed control!

  BUT…

- Aeratio **y** reduce or eliminate so of the conditions th encourag acrophyte <u>overgrowth</u>
  - high nutri nt levels



Aeration Summary

INCREASES:

- Circulation
- Dissolved oxygen levels
- Water clarity

DECREASES:

- Stratification
- TSS
- Carbon dioxide levels
- Biological oxygen demand
- Toxic gases and chemicals (e.g. hydrogen sulfide and ammonia)
- Odor
- Phosphorus and Nitrogen levels
- Muck build up
- Algal over growth
- Fish kills
- Mosquitoes and midge flies

Sizing & Designing Aeration Systems

- Sizing Standards
- Size
- Shape
- Depth
- Water quality
- Owner’s goals

Sizing Standards – Minimum 1 turnover/day

Surface Acres: 17.00
Perimeter Feet: 5,676
Slope Ratio Relative to 1 3.0
Average Center Depth: 15.0
Average Depth 12.4
Circulation Constraint Percentage 0.0
Total Acre Feet 211.0
Lake Volume (Gallons) 68,760,990
Monthly Influent Volume (Gallons) 0
Total Volume Requiring Aeration (Gallons) 68,760,990
GPM / XL5 AirStation 6,644
Gallons Pumped / Day 76,533,466
System Working Pressure (PSI) 16.9
Air Delivery Per AirStation at Depth(CFM) 2.5
Number of XL5 AirStations Specified: 8
Complete Turnovers / Day 1.11

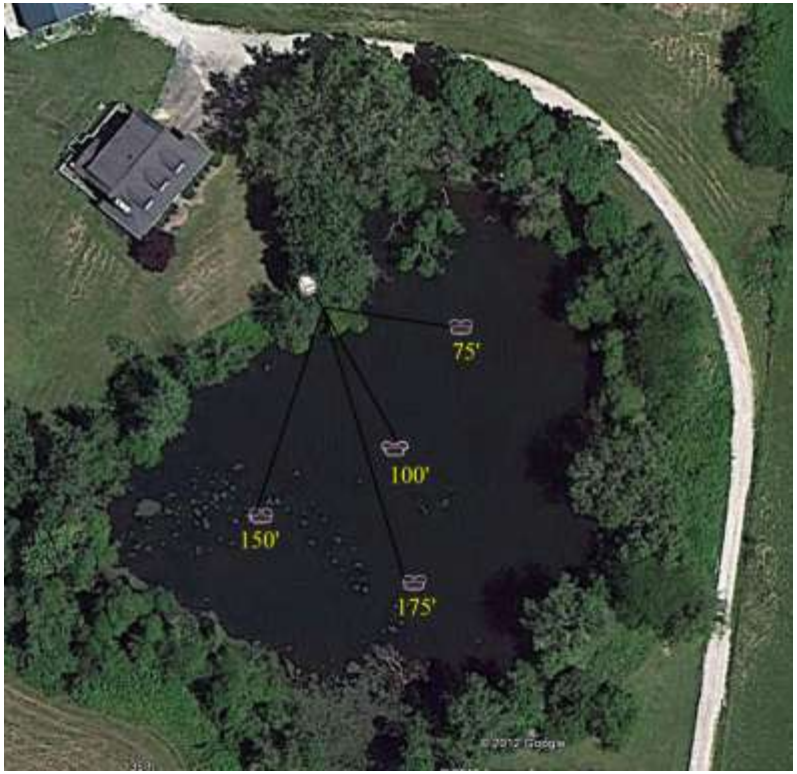
Surface Acres: 63.00
Perimeter Feet: 15,720
Slope Ratio Relative to 1 3.0
Average Center Depth: 9.0
Average Depth 8.3
Circulation Constraint Percentage 0.0
Total Acre Feet 523.1
Lake Volume (Gallons) 170,468,920
Monthly Influent Volume (Gallons) 0
Total Volume Requiring Aeration (Gallons) 170,468,920
GPM / XL5 AirStation 5,250
Gallons Pumped / Day 181,455,552
System Working Pressure (PSI) 15.9
Air Delivery Per AirStation at Depth(CFM) 2.6
Number of XL5 AirStations Specified: 24
Complete Turnovers / Day 1.06

Shape of a Pond

Ben Brenman Park: 6.3 Acres

Goddard Space Flight Center: 6.5 Acres

Depth of Pond

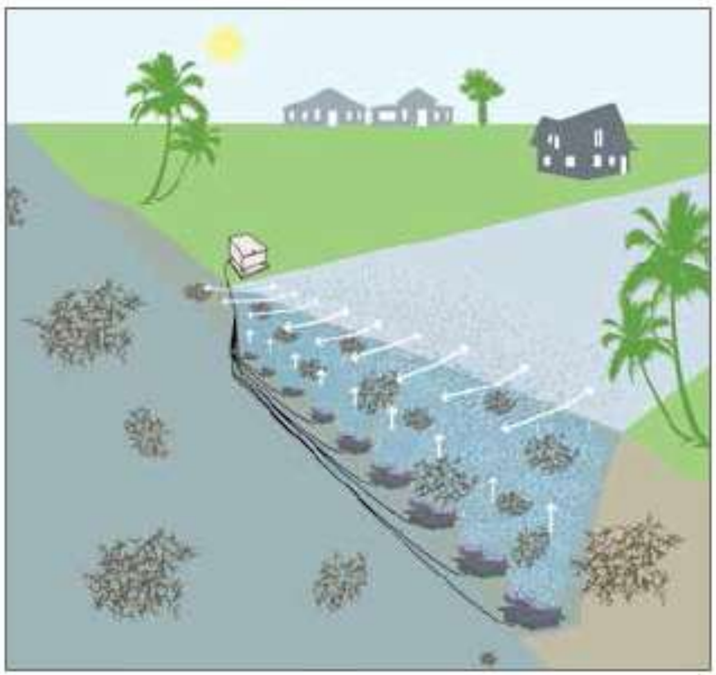


2 acres, 4’ deep

2 acres, 20’ deep

Water Quality Considerations

Pond Owner's Goals



Building World Record

By JAMES HALL

Can Dr. Gary Schwarz grow a 23-pound bass? Research, current shock data and his track record indicates that he can

Adding A Lot Of Air

Private lakes can be plagued with a number of issues that will kill bass. Turnover, thermal stratification and a plankton crash all can kill small fisheries. To protect against this at La Perla Lake, Dr. Gary Schwarz commissioned the biggest private aeration system in the world dedicated to maintaining a bass fishery.

"A normal aeration system has a 1-horsepower compressor and a handful of oxygen stations to help keep a stable environment in a fishery. To protect La Perla and the incredible investment of time and resources Gary has put into the lake, we designed a system unlike any other I've ever heard of," says John Jones, owner of Lochow Ranch Lake Management.

The La Perla system starts with a 20-hp compressor that pumps air through more than 4 miles of hose to 52 air stations around the lake.

The side benefit of this sprawling system is that it eliminates unproductive water, vastly increasing the lake's carrying capacity for fish.

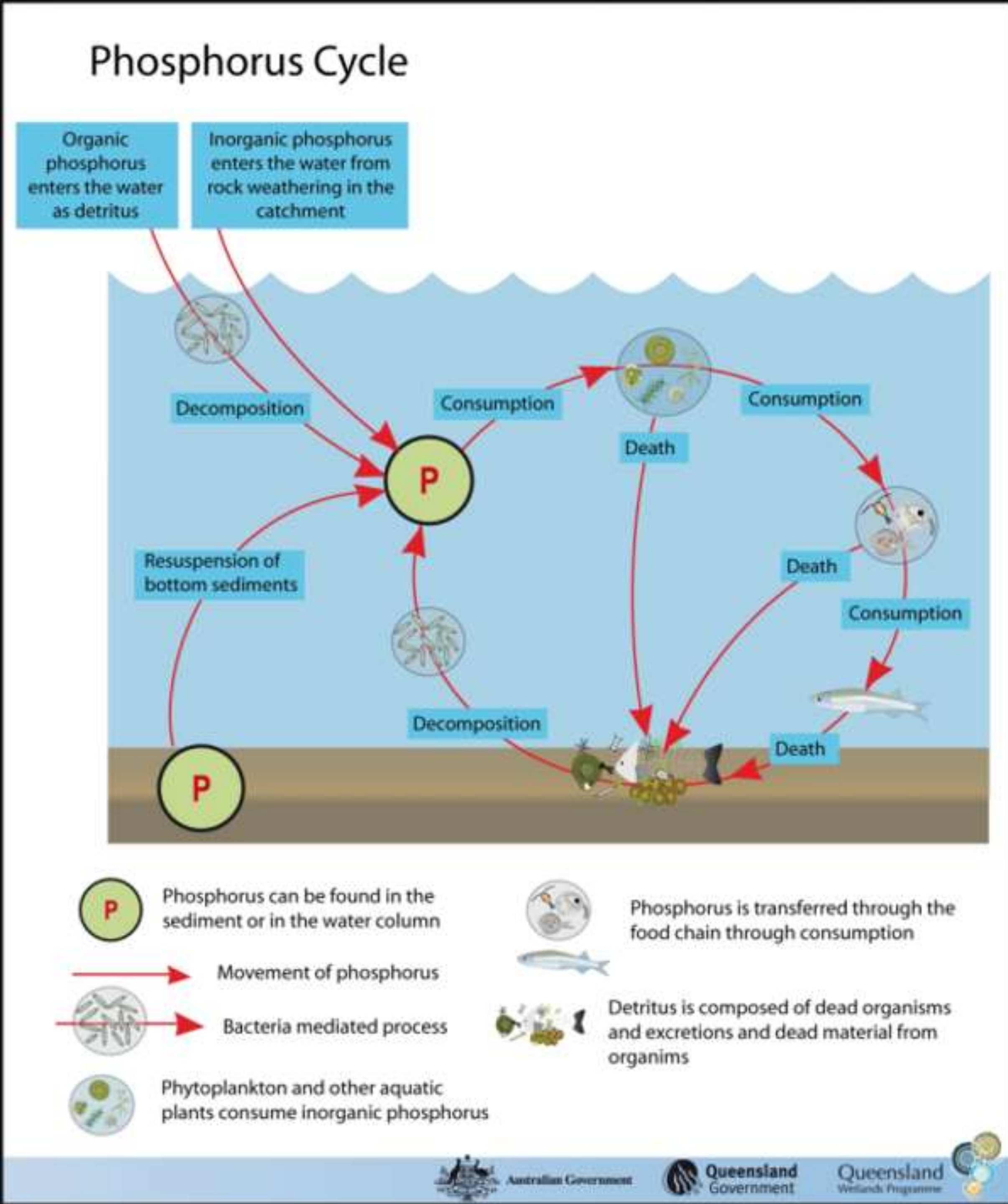
Thank you!

Questions?

Vertex Water Features
Lake Aeration Systems & Floating Fountains

Email: Patrick.Goodwin@aquaticsystems.com

Phone: 1-800-432-4302



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Nitrogen Cycle