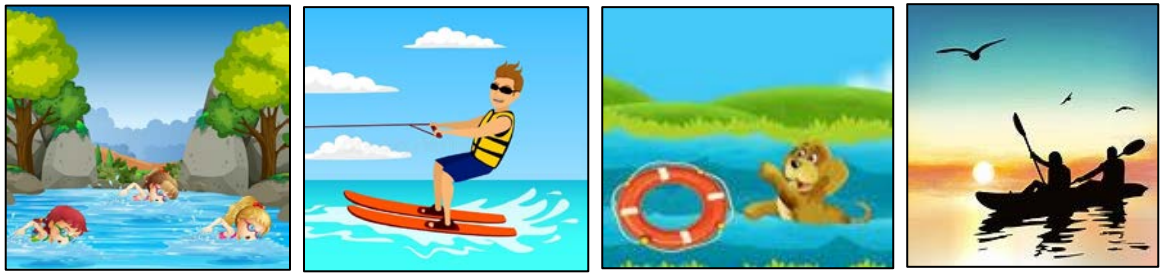
This information was presented to the Board of Directors in a Special Executive Session held April 16, 2025, by the **Facilities & Lake Operations Committee.**

Assuring Safety While Recreating



Background Information on the Proposed LMOA Lake Health Project

Our Lake is a Precious Community Resource

Protecting Residents, Wildlife and Property Values

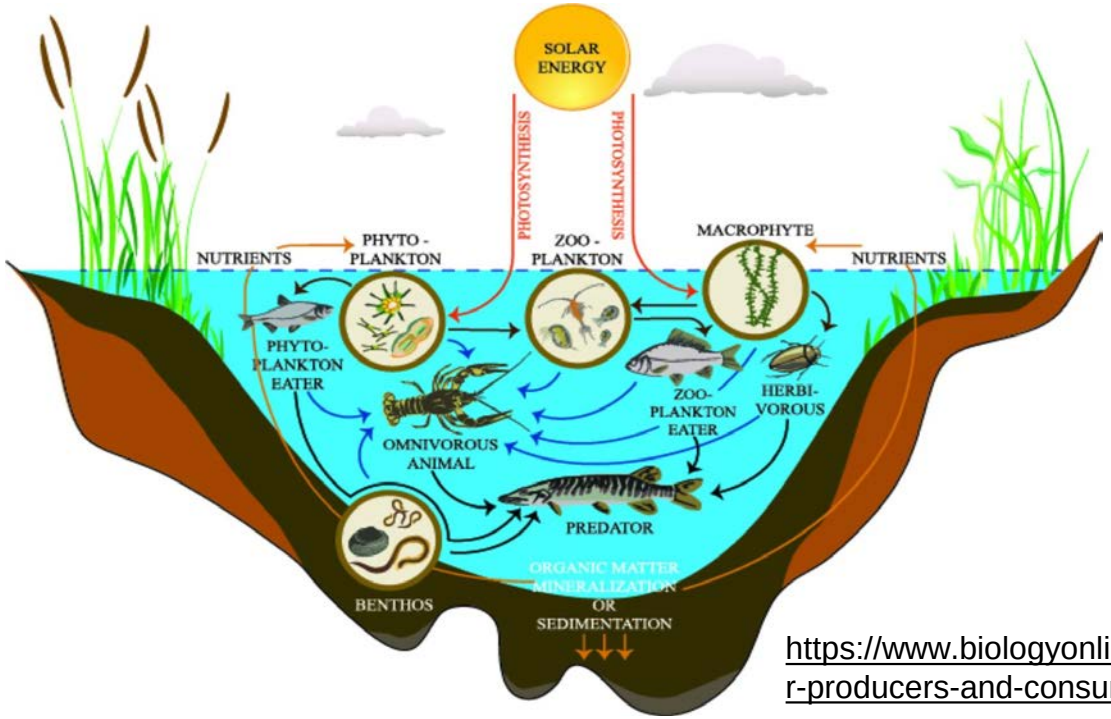
Discussions

- Some Terminology and Lake Health Background
- Lake Monticello Lake Health
- Solution for Preserving Lake Health
- Recommendations

Lake Water Aquatic Food Web

Sustainability = An Ecosystem in Balance

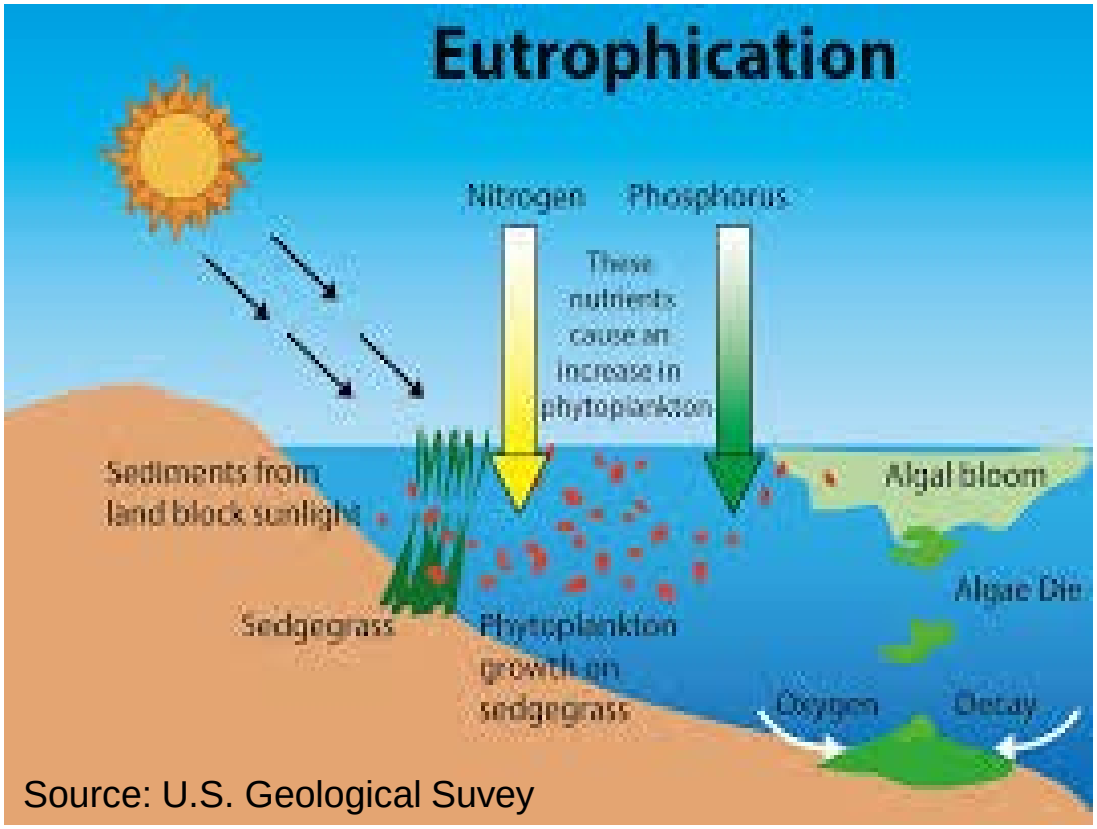
Food chains are part of a larger system of cycles, checks and balances to maintain a stable ecosystem.



https://www.biologyonline.com/tutorials/freshwater-producers-and-consumers

Our lake, like many in the US (and globally) is out of balance as evidenced by the measurements we have collected over time.

Eutrophication



Source: U.S. Geological Suvey

- Lake transitions from a nutrient clearing to a nutrient recycling ecosystem.
- Lake becomes **enriched with nutrients** (e.g., phosphorous) where cyanobacteria dominates over algae.
- Oxygen gets depleted at deeper depths.
- Harmful blooms, fish kills and other ecological problems occur.

Summer temperatures/warm surface water, more intense rainfall and increased nutrients from the watershed all feed this process, increasing the risk of HABs.

Harmful Algae Blooms (HABs)

- Algal Blooms are characterized by sudden rapid increase in the density of algae.
- You can't tell by looking if it is harmful or not, the only way is by sending a sample to a lab. NEVERTHELESS, it shuts down the lake.

Source: https://www.dailymaverick.co.za/article/2025-03-21-how-cyanobacteria-and-government-inaction-are-threatening-thecountrys-water-supply

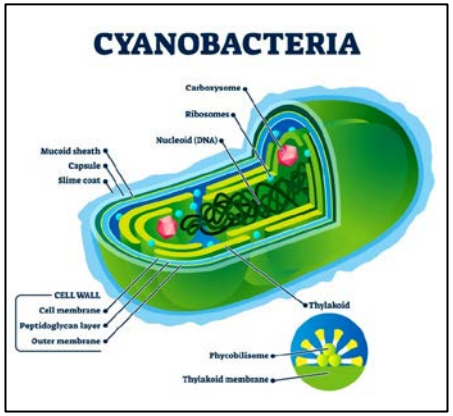
HABs:

- Occur when cyanobacteria dominate over single cell algae and grow out of control, **producing toxins** and causing other harmful effects.
- Triggered when nitrogen and phosphorus concentrations increase, with the right combination of temperature, sunlight, and low flow.
- Even if not toxic, algal blooms thrive on nutrients, particularly phosphorus, and deplete oxygen levels in the water, harming aquatic life.

Harmful Algae Blooms (HABs)

Impact on Our Community

- Toxins from HABS can remain in the water for days or weeks after a bloom has disappeared.
- People can be exposed by contacting, swallowing water, or eating contaminated fish causing liver damage.
- Symptoms: Rash, hives, skin blisters, stomach pain, nausea, vomiting, diarrhea, severe headaches, fever.



Source: https://www.dailymaverick.co.za/article/2025-03-21-how-cyanobacteria-and-government-inaction-are-threatening-thecountrys-water-supply

- **Children are more at risk**
  - they are more likely to accidentally swallow water
  - often spend more time in the water than adults
- **HABs are newsworthy**, as experienced at Tufton Pond
  - A main lake shutdown would be a bigger story.
  - Health concerns, community reputation and recurrences
  - Potential impact on property values.

Harmful Algae Blooms (HABs) in the United States and Virginia

- Harmful algal blooms (HABs) are on the rise in the United States, and **Virginia is no exception.**
- **83 percent of the rivers, lakes and waterways in Virginia are impaired** (exceed Clean Water Act limits for pollutants),
  - Including several sections of the Rivanna River which is upstream of Lake Monticello.
- More than 75 percent of Virginia's estuaries and tidal rivers, 86 percent of Virginia's lakes, and 16,184 miles of rivers and streams have been affected by algal blooms
- HABs have already occurred in nearby Smith Mountain Lake, Lake Anna and in our own Tufton Pond in the past few years.
- Lousia has experienced over 40 HABs and Spotsylvania County has experience over 30 HABs since 2017.

Lake Anna has experienced HABs since 2018, most recently in June/July 2023 and 2024 in the Upper and Middle North Anna branch and the Upper and Middle Pamunkey branch of the lake.

HABs experienced have been linked to elevated phosphorus levels.

Source: www.vdh.virginia.gov (Lake Anna HAB Status Report -Advisory Update for North Anna Branch Pamunkey Branch;; Terry's Run Branch; 6/9/2024

Dissolved Oxygen (DO)

- DO concentrations widely considered the **single most important metric of lake and reservoir water quality**
- Fish, invertebrates, and other underwater animals use their gills to get oxygen from the water. They need a **5 mg/liter** DO.
- Lakes with high concentrations of organic matter in sediments become **hypoxic (low oxygen)** or even **anoxic (<0.2 mg/l = no oxygen)**.
- When DO is low, ammonia and hydrogen sulfide are difficult to decompose which will affect water quality and biological health.
- However, sufficient oxygen in the water inhibits the development of toxic substances.

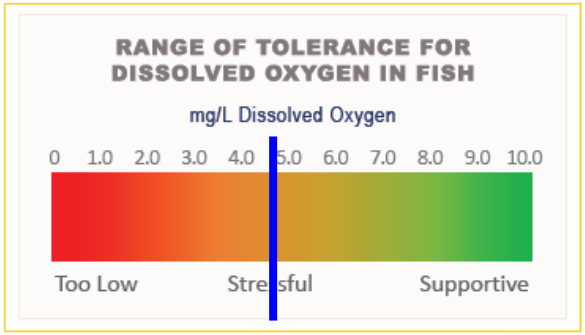
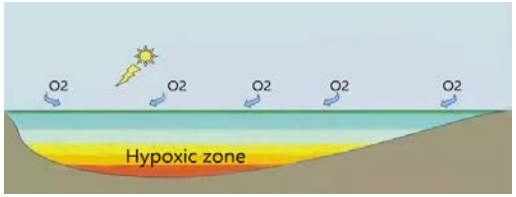
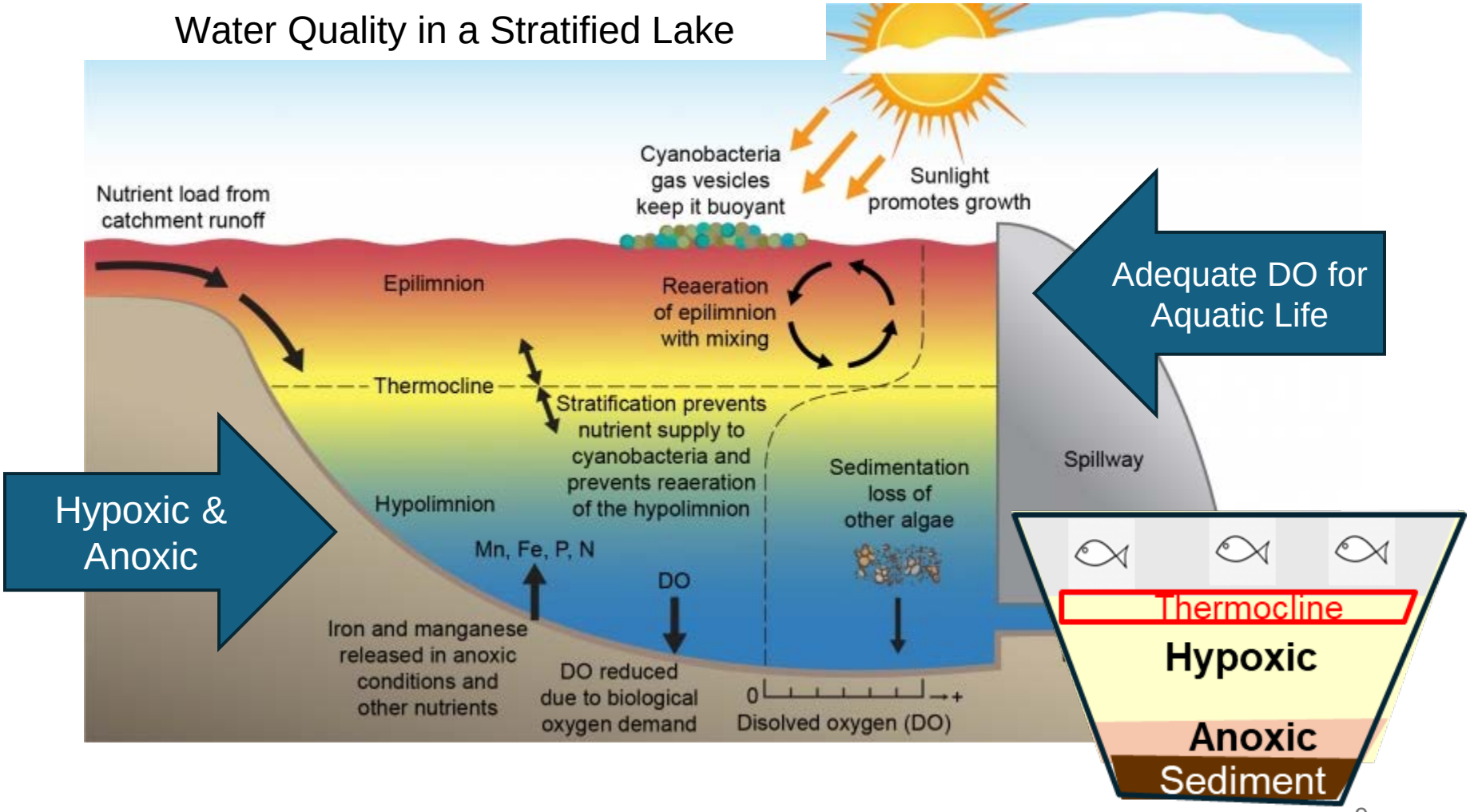


Figure 1. General freshwater fish tolerance for dissolved oxygen concentrations – tolerances vary by species.



Source: epa.gov/awma/factsheets-water-quality-parameters

Lake Stratification

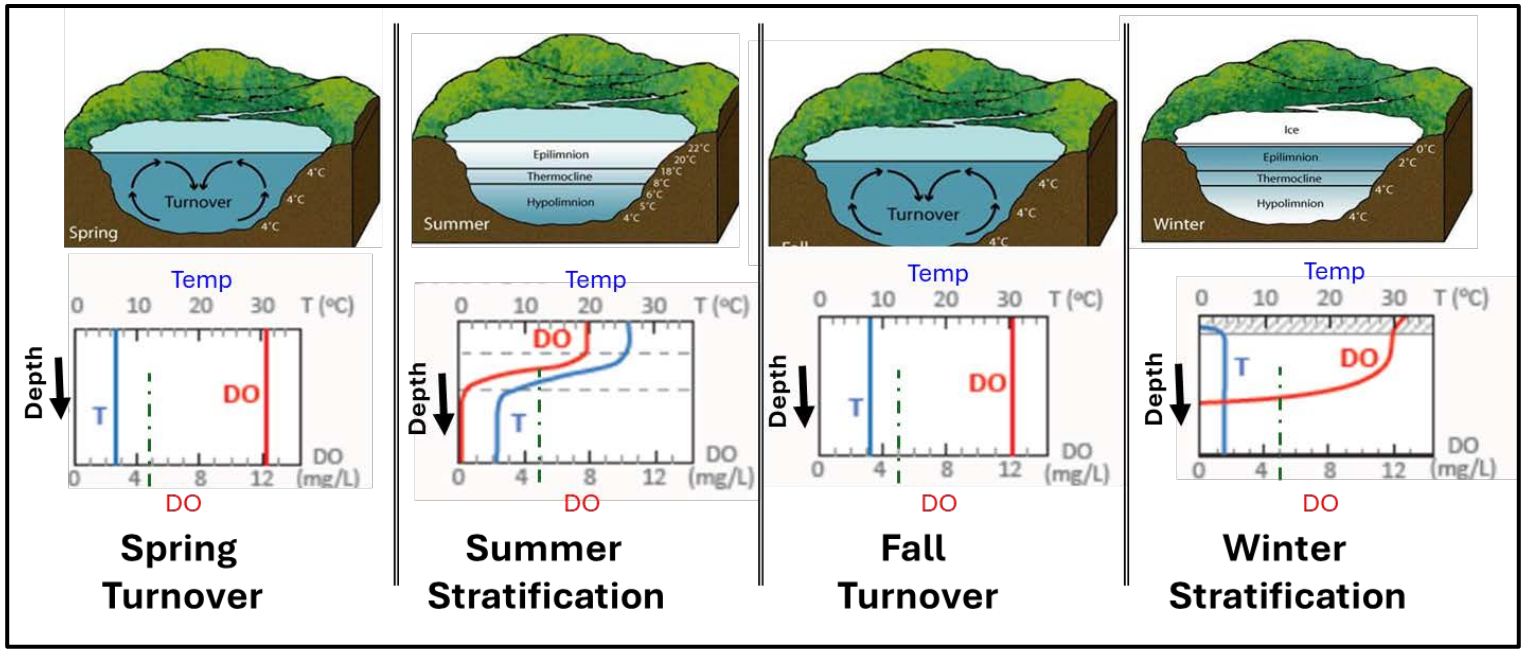


Source: Cold Water Pollution: A Review; UNSW Sydney (www.unsw.edu.au)

Lake Turnover

The natural process a lake water column seasonally “mixes”, effecting ecosystem imbalance, impacting:

- **Dissolved Oxygen**
- **Algae/Cyanobacteria**
- **Phosphorus**



Temperature variations can impact the degree to which turnover is achieved.

Source: https://www.Cleanlakesalliance.org/lake-turnover

Source: epa.gov/awma/factsheets-water-quality-parameters

Insufficient Turnover

(or sustained stratification)

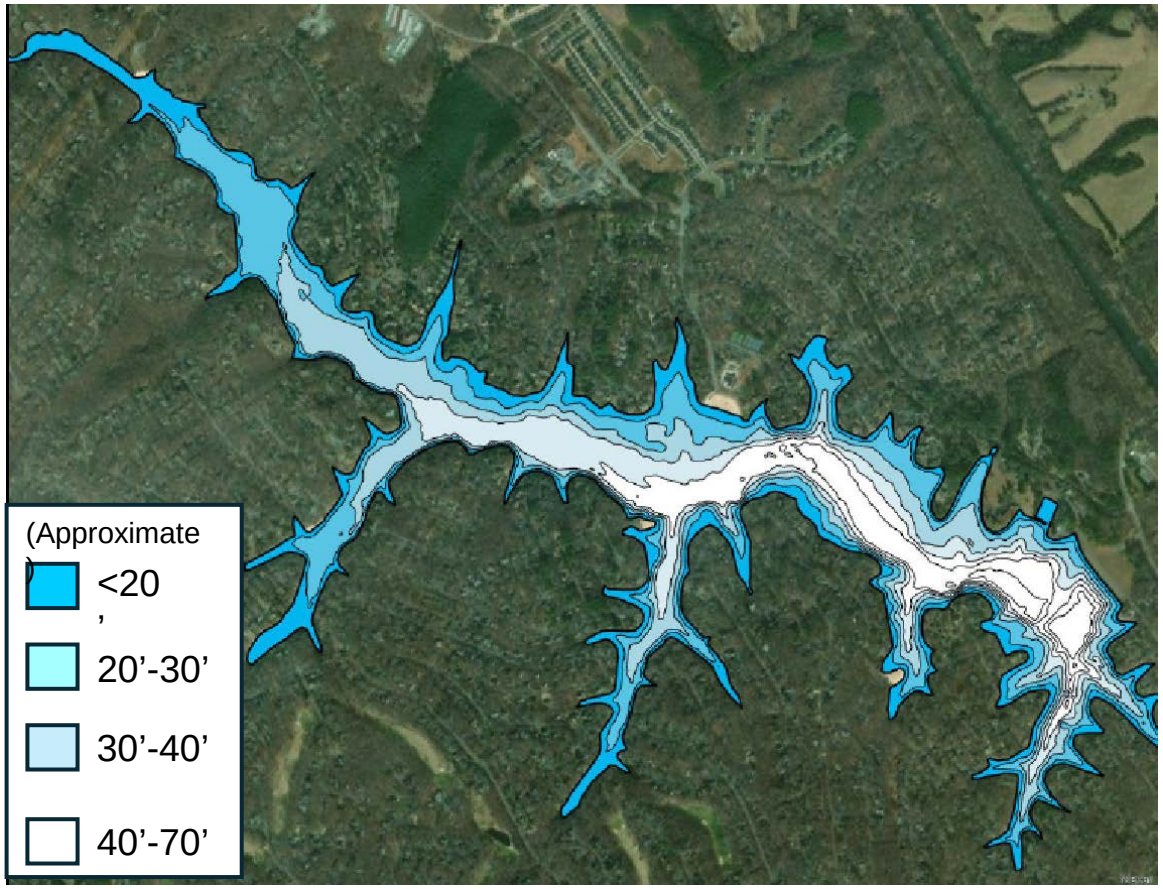
Effects

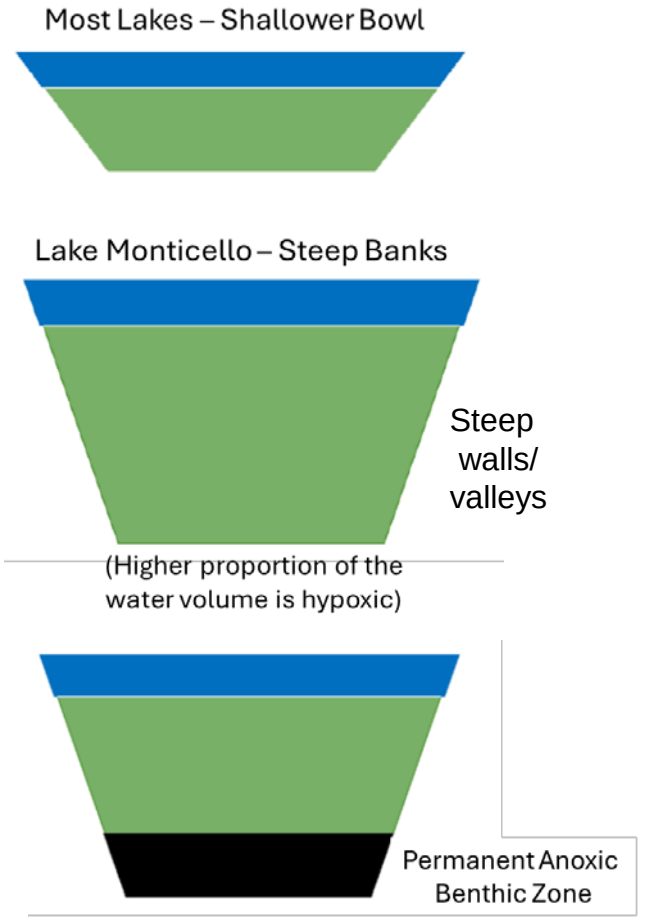
- **Oxygen Depletion** occurs in deeper water, creating "dead zones" where aquatic life cannot survive.
- **Habitat Degradation:** The lack of oxygen, nutrient accumulation and decaying organic matter can degrade the lake's habitat for fish and other aquatic organisms.
- **Algal Blooms:** Leads to nutrient buildup near the bottom (hypolimnion), which is then be released into the epilimnion during mixing, potentially triggering algal blooms.

Consequences

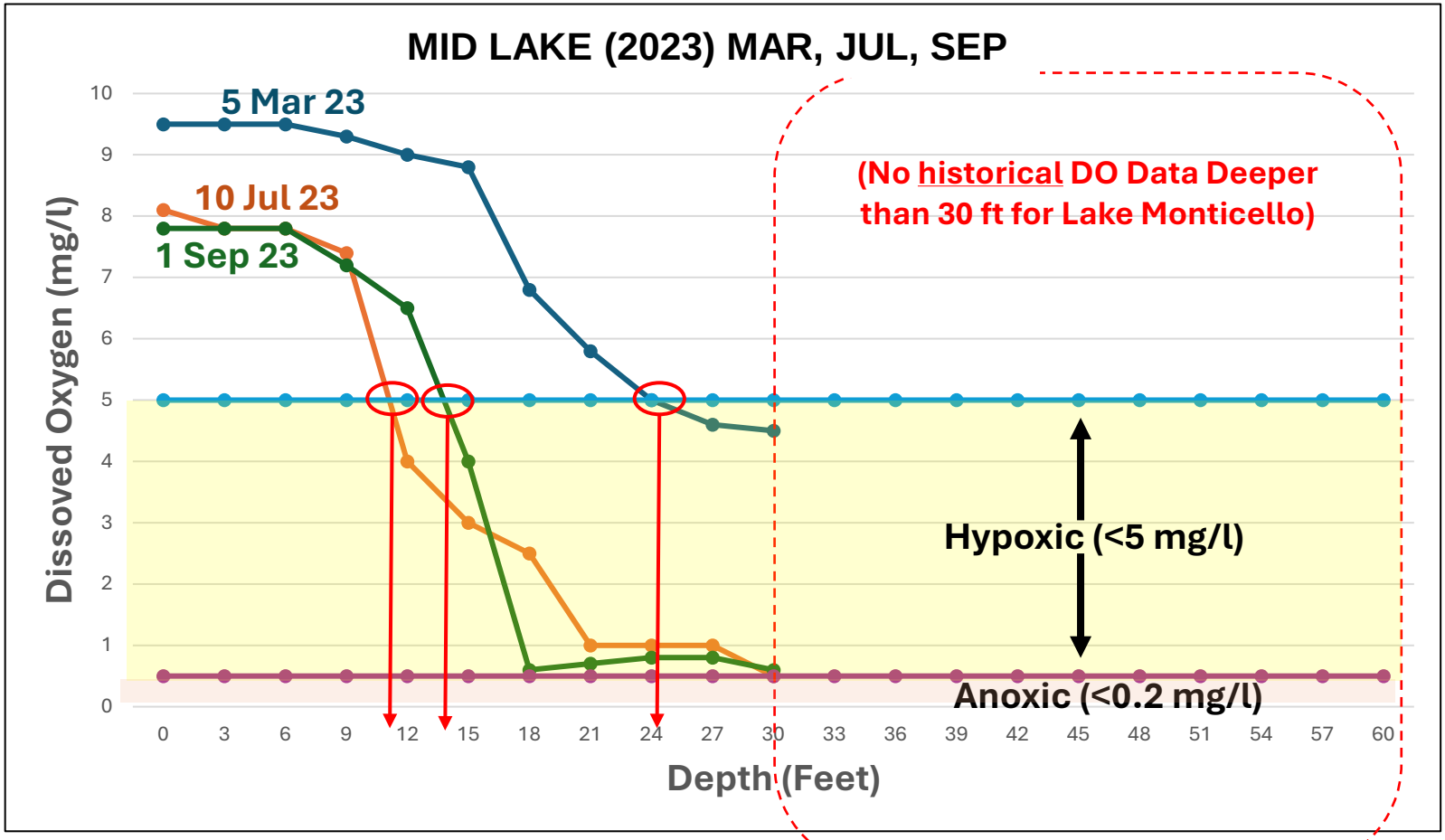
- **Fish Kills:** Severe oxygen depletion can lead to fish kills, especially in cold-water fish species.
- **Reduced Aquatic Life:** In general, incomplete turnover can lead to a decline in the diversity and abundance of aquatic organisms.
- **Water Quality Degradation:** The accumulation of nutrients and decaying organic matter lead to poor water quality, including algal blooms and unpleasant odors.

Lake Monticello





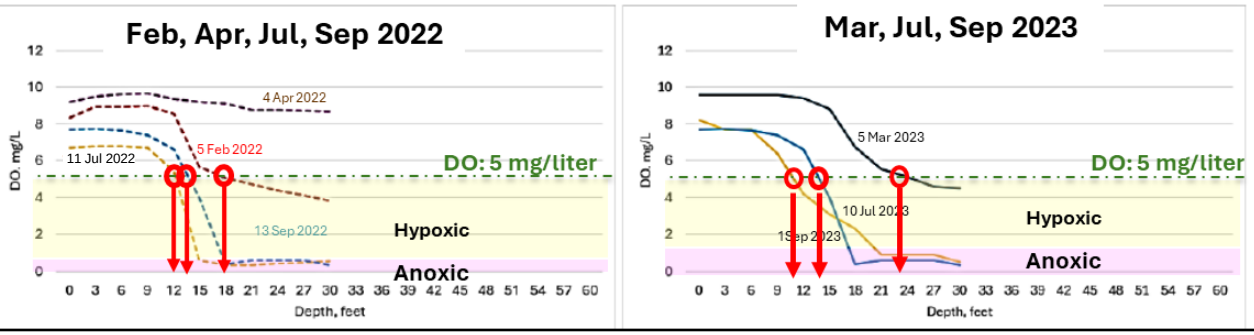
Lake Monticello
Dissolved Oxygen vs Depth

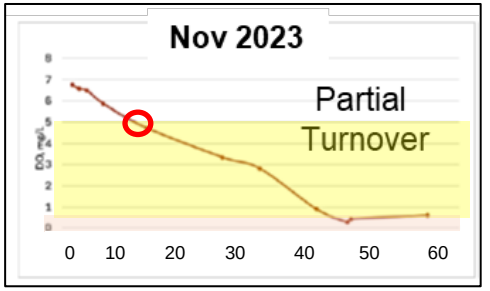


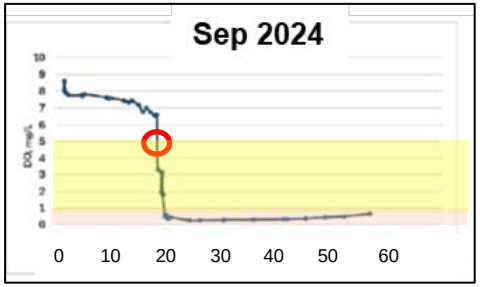
(Source: extracted from LMOA.ORG Lake Health Archives)

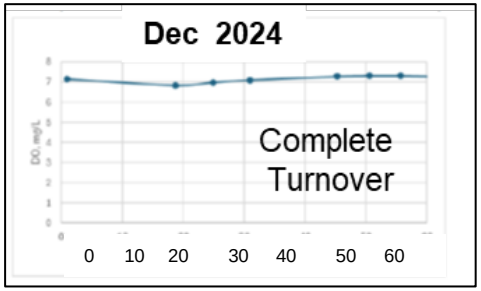
Lake Monticello – Current Health Status
Stratification/Dissolved Oxygen

MID-LAKE (2022 and 2023)

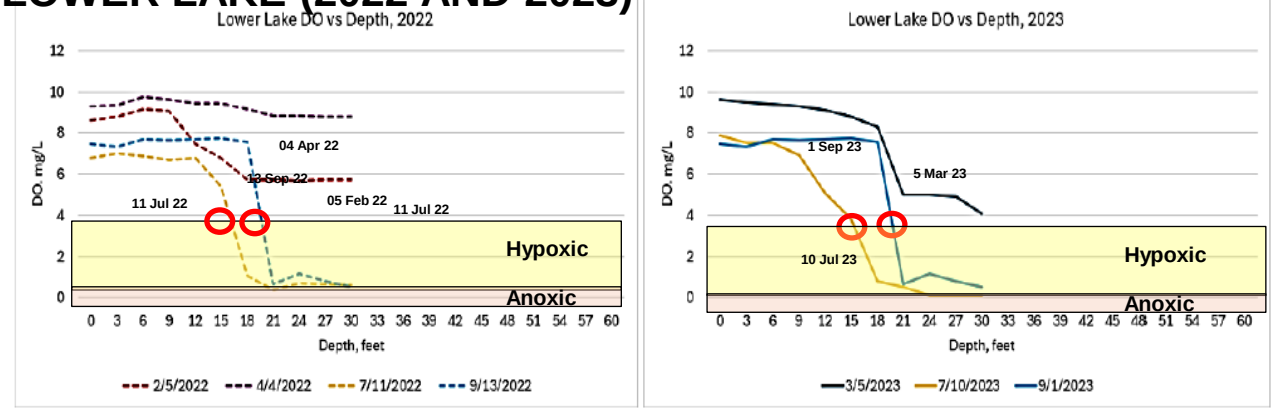








LOWER LAKE (2022 AND 2023)



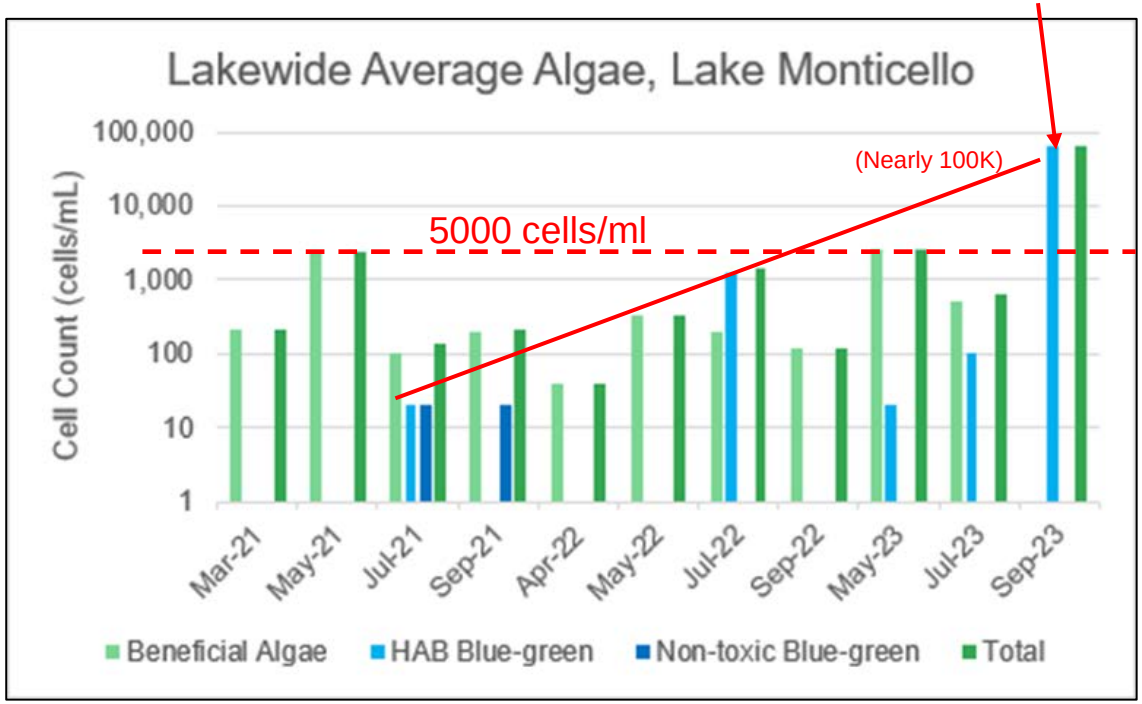
(Source: extracted from LMOA.ORG Lake Health Archives)

Lake Monticello - Current Health Status
Algae and Cyanobacteria Levels (2021-2023)

We've had 4 HABs at Tufton Pond and several elevated e-Coli events on the main lake in the past few years.

Cyanobacteria is becoming more dominant

Phosphorus levels elevated

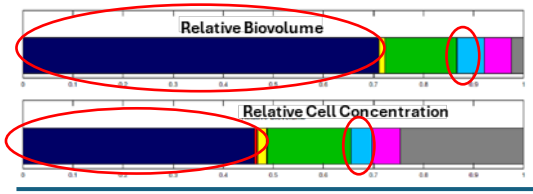
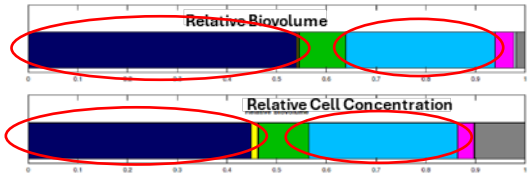
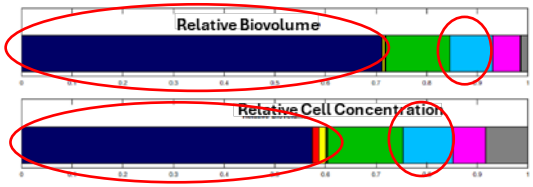
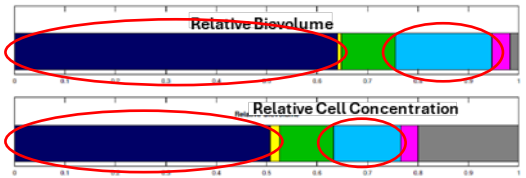
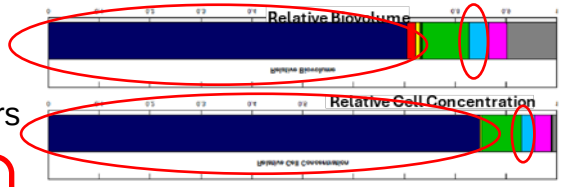
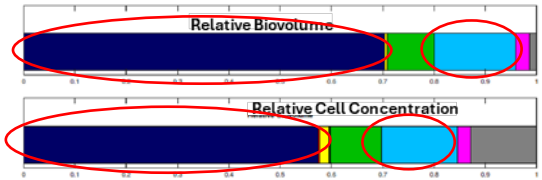
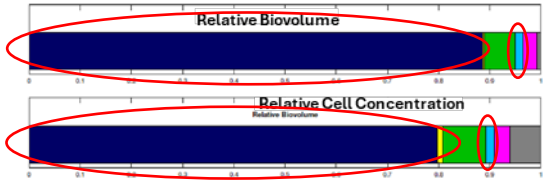
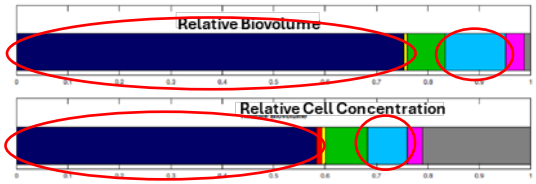


Our main lake is at increased risk of HABs

(Source: extracted from LMOA.ORG Lake Health Archives)

Lake Monticello – Current Health Status

Algae Content in August and September 2024

		Aug 2024		Sep 9th 2024
BG	Non-harmful cyanobacteria		Q1 Main Lake	
CER	Ceratium			
CP	Chryptopytes & Dinoflagellates		Q2 Main Lake	
DY	Chrysopytes, Haptophytes & Diatoms			
E	Euglenophytes		Q3 Main Lake	
G	Chlorophytes			
TO	Taste & Odor Producers			
HAB	Harmful Cyanobacteria		Jackson Cove	
M	Miscellaneous			
U	Unknown			

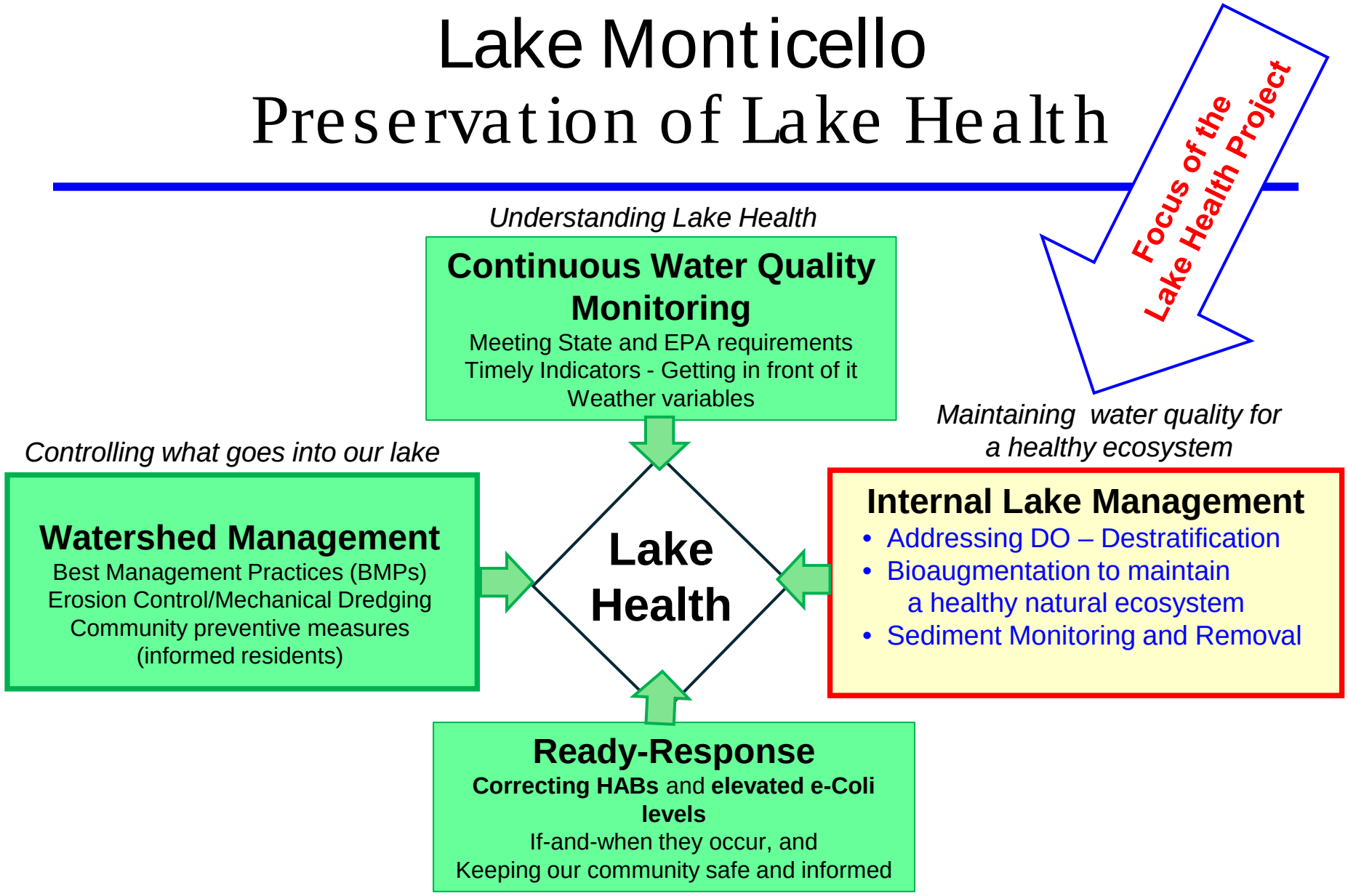
(Source: extracted from LMOA.ORG Lake Health Archives)

Lake Monticello – Current Health Status

"Hyper-stratified with hypoxia and sediment nutrient sequestration driving ecological imbalance"

- Lake Monticello remains safe for recreation virtually year-round **as long as HABs and e.Coli are not present**
- **Stratification** of our lake leads to **hypoxic levels below the thermocline** and **anoxic DO levels on the bottom**.
  - Suppresses nutrient levels in the upper water column
  - Limits nutrient cycling.
  - Causes a persistent level of hypoxic water in a large volume of our lake.
  - Promotes increasing levels of cyanobacteria among declining levels good phytoplankton and zooplankton
- DO measurements confirmed our stratification issues and laboratory results confirmed our algae imbalances.

Lake Monticello
Preservation of Lake Health



Solutions for Restoring Lake Health

Material Solutions Examined

Our Committee:

- Researched all options / Conferred with national and regional experts at EPA
- **Recommends a PROACTIVE approach to address stratification and restore ecological balance of our lake.**

Biological Methods

- Bio-manipulation (Introduction of Aquatic animals and micro-organisms)
- **Bio-dredging/Bio-augmentation**

Chemical Methods

- Algacides and Algae Inhibitors
  - CuSO4, H2O2, Diuron (DCMU) (Herbicides)
  - Aluminum Sulfate (Chemical precipitation
- Nanoparticles (NPs)
  - AgNPs,, CuNPs, TiO2 NPs, ZnO NPs, and iron oxide NPs

Physical Methods

- **Mechanical Aeration/Oxygenation**
- Cationic Flocculants
  - (positively charged polymers)
- Ultrasonic and UV Radiation
- Membrane Filtration
- Dredging