

An Evaluation of the Effectiveness of an Alum Treatment to Address the Internal Phosphorus Load at Lake Hopatcong, New Jersey's Largest Waterbody

New York State Federation of Lake Associations
May 2026

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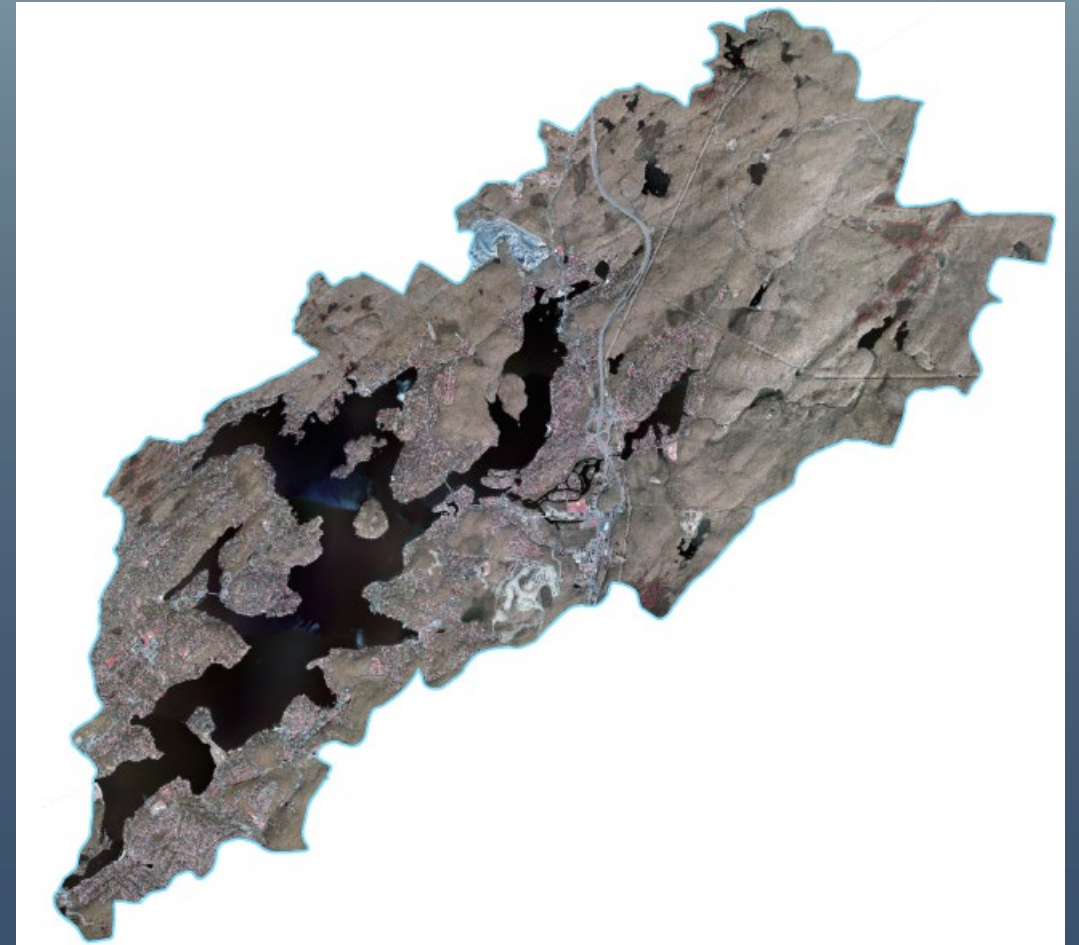
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Lake Hopatcong, New Jersey

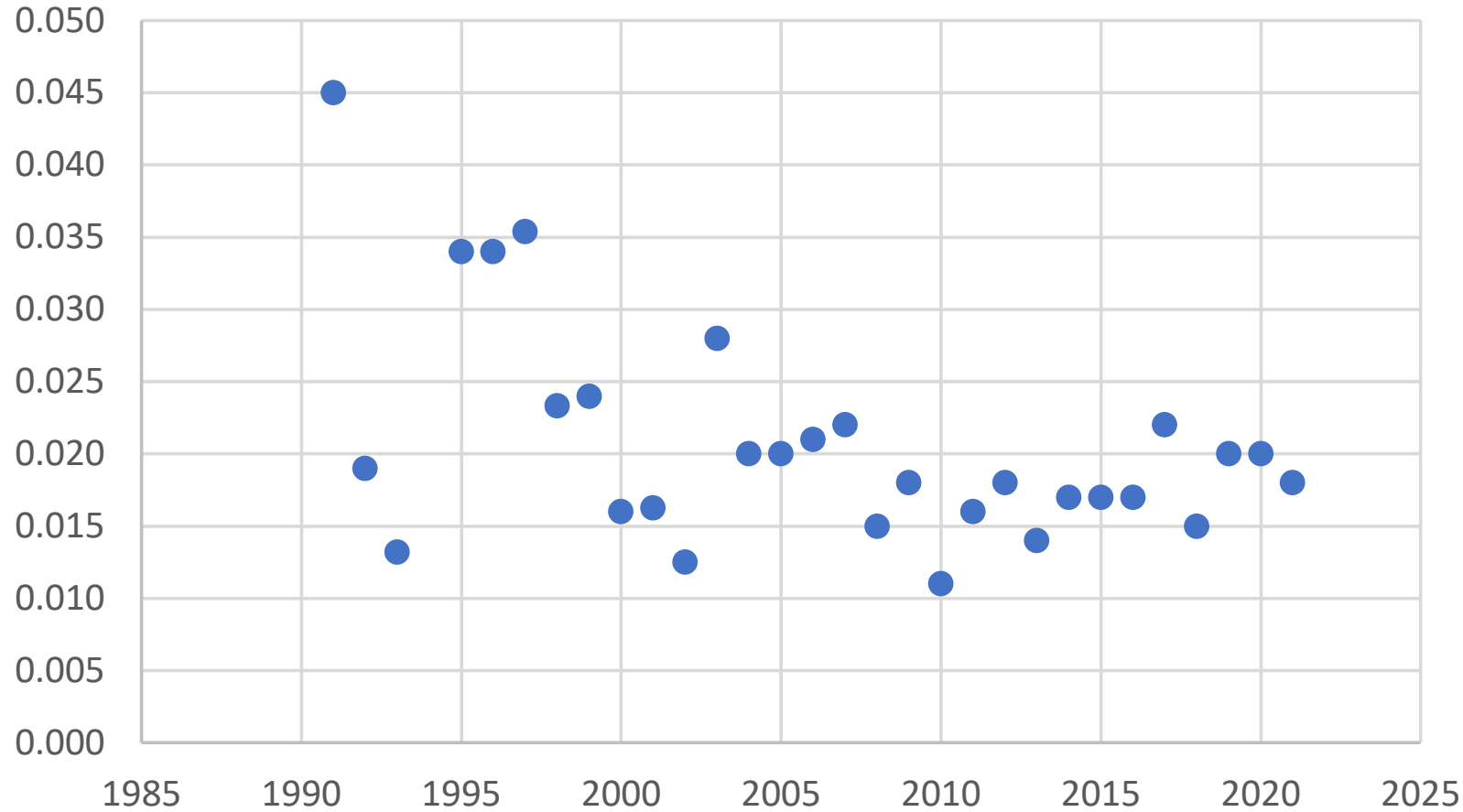
- ✓ Largest lake in NJ (2,686 acres; 1,087 ha).
- ✓ Five municipalities in the watershed (13,548 acres; 5,483 ha).
- ✓ More than 500,000 people visit the lake or live in the watershed.
- ✓ Issues with SAVs and HABs.



Annual TP Budget for Lake Hopatcong

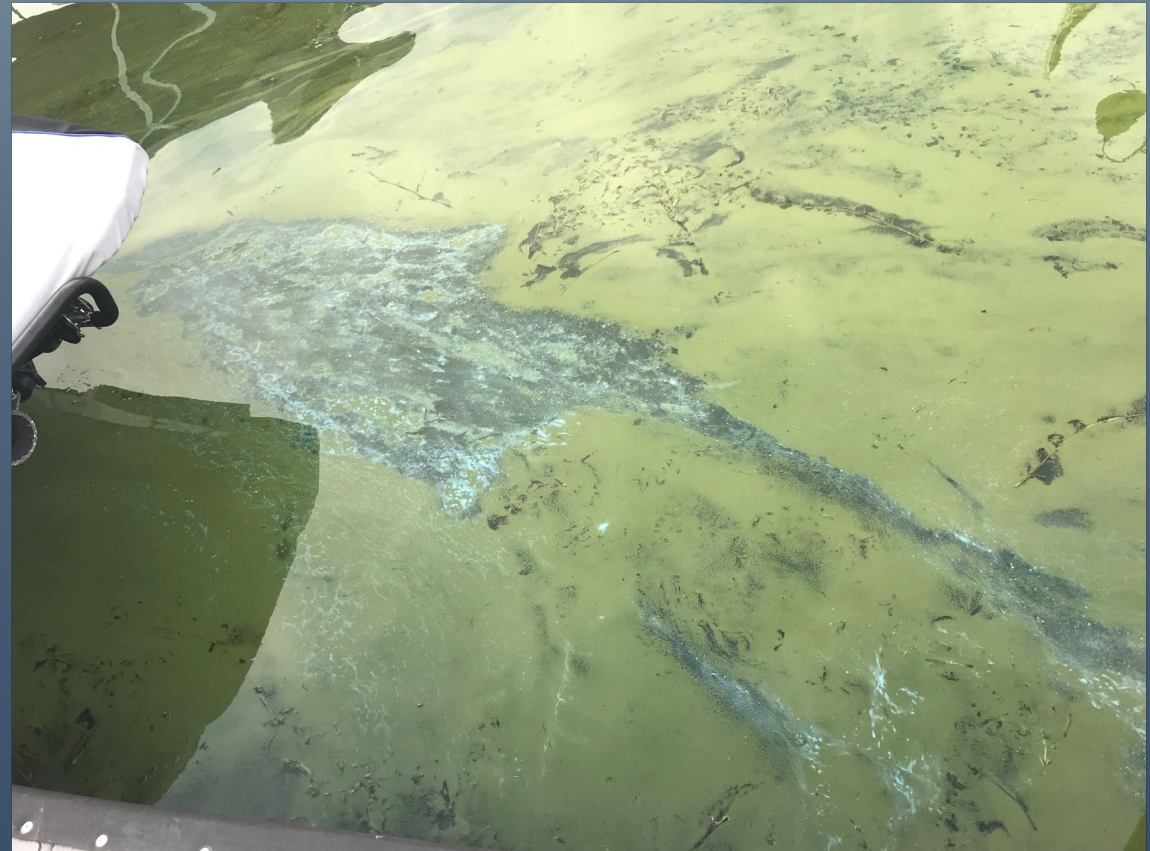
Source	Kg of TP / year	Percent
Surface Runoff	2,466	31
Sparta Township	138	2
Septic Systems	4,223	52
Atmospheric	68	1
Internal Loading	595	7
Outlet of Lake Shawnee	607	7
Total	8,097	100

Annual Event Mean Surface TP (mg/L)



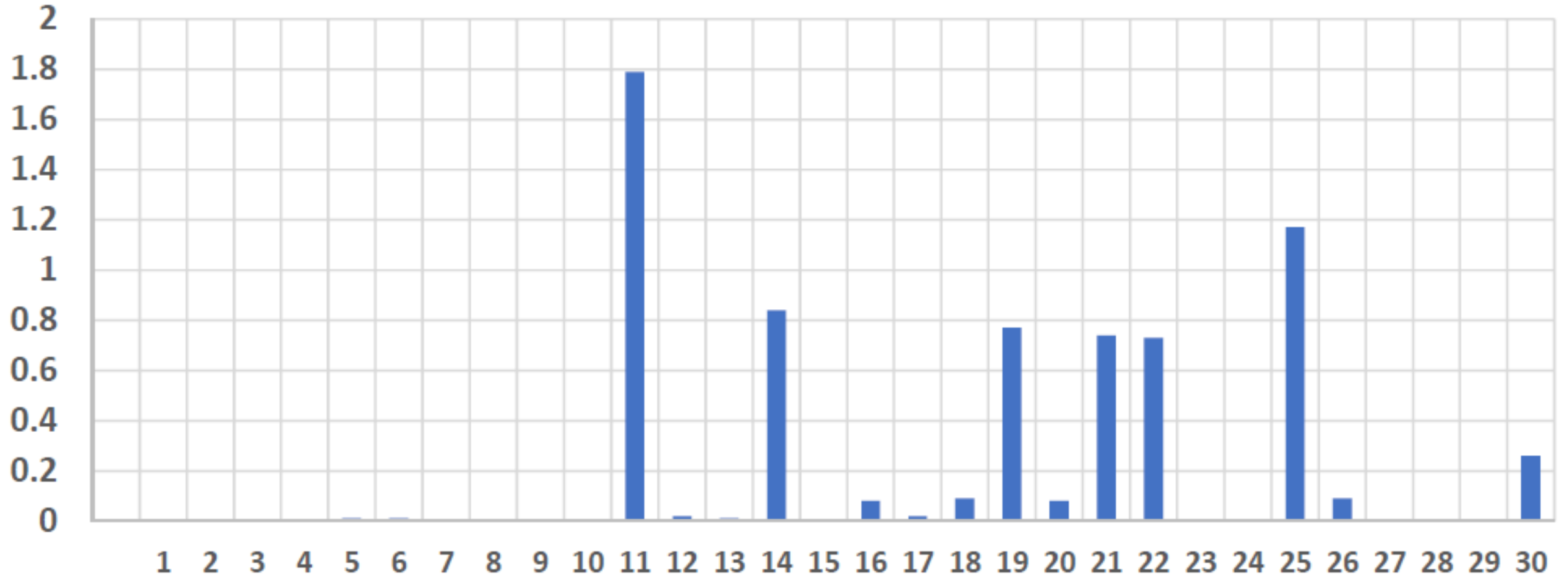
Year	TP (mg/L)
2022	0.014
2023	0.020
2024	0.028
2025	0.022

Blooms at Lake Hopatcong, New Jersey persisted over the 2019 growing season.

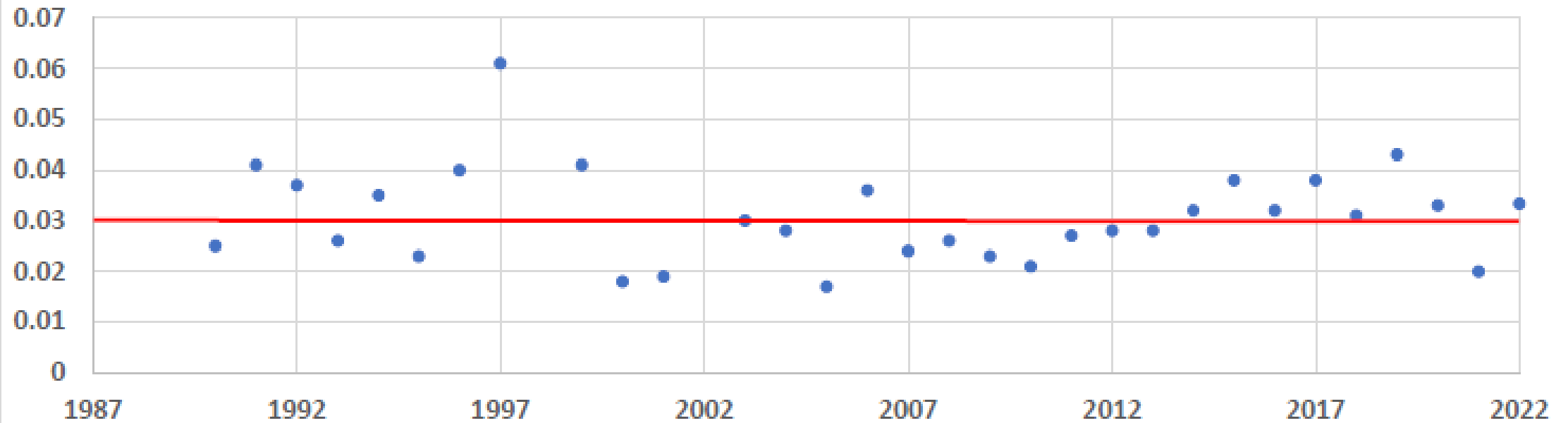


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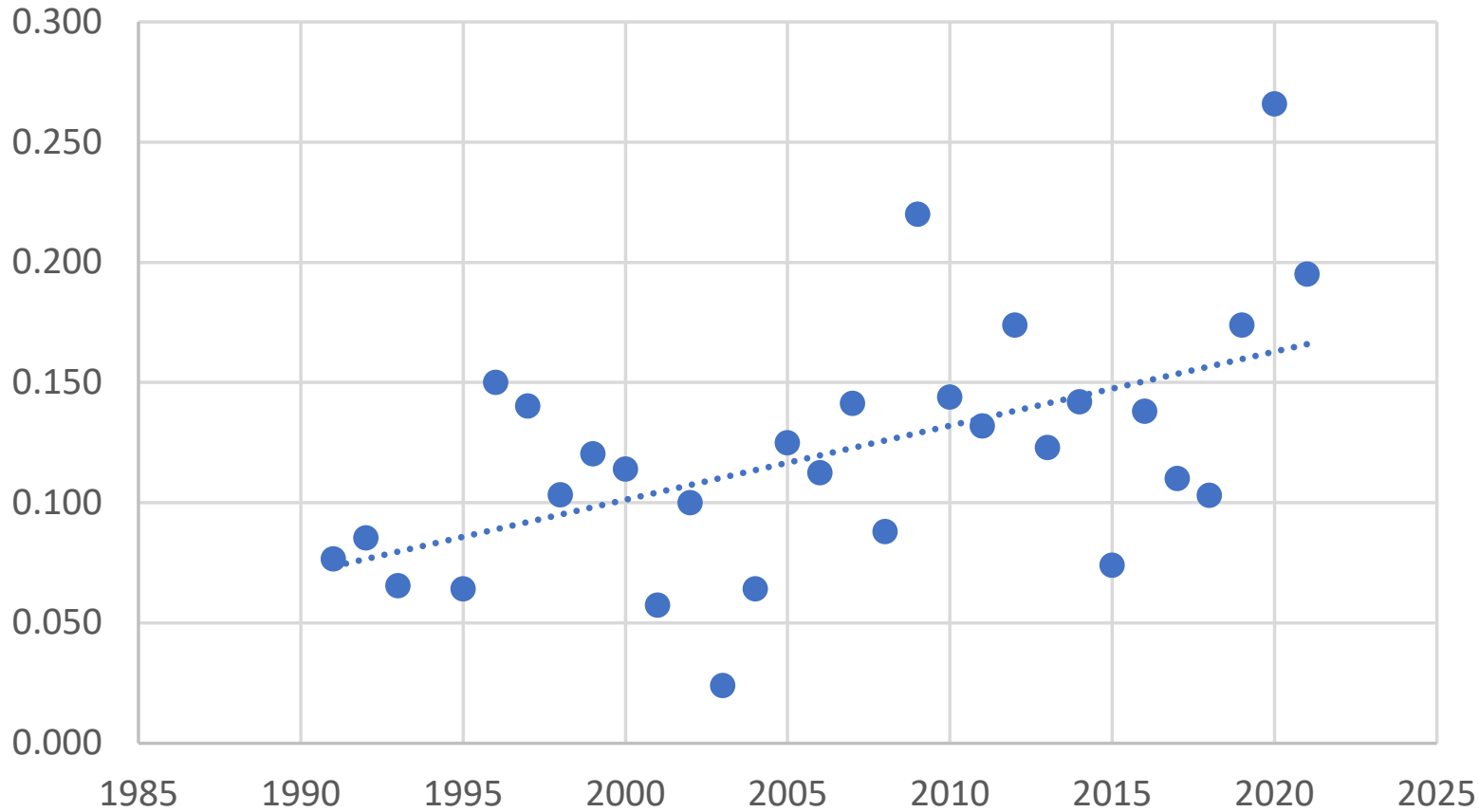
Rainfall in June 2019 - Morris County - Boonton 1 SE Station



Mean June Total Phosphorus Concentrations (mg/L) in Lake Hopatcong, Sussex and Morris Counties, NJ



Annual Event Mean Deep TP (mg/L)

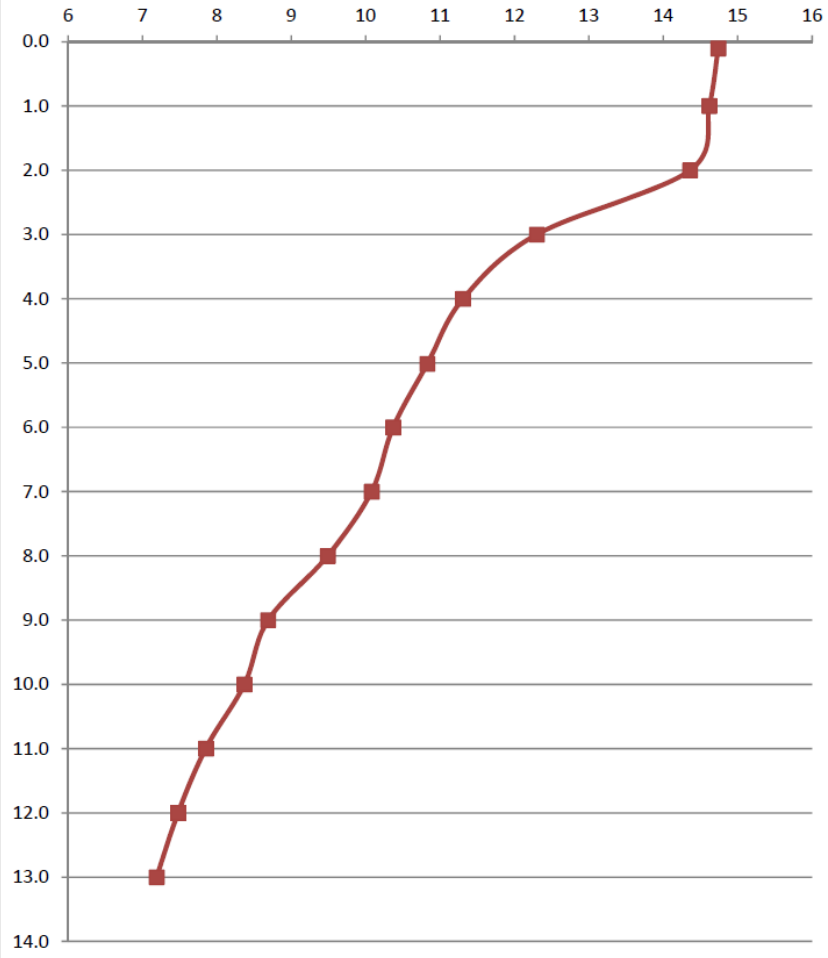


Year	TP (mg/L)
2022	0.13 (0.20)
2023	0.18 (0.42)
2024	0.13 (0.21)
2025	0.12 (0.17)

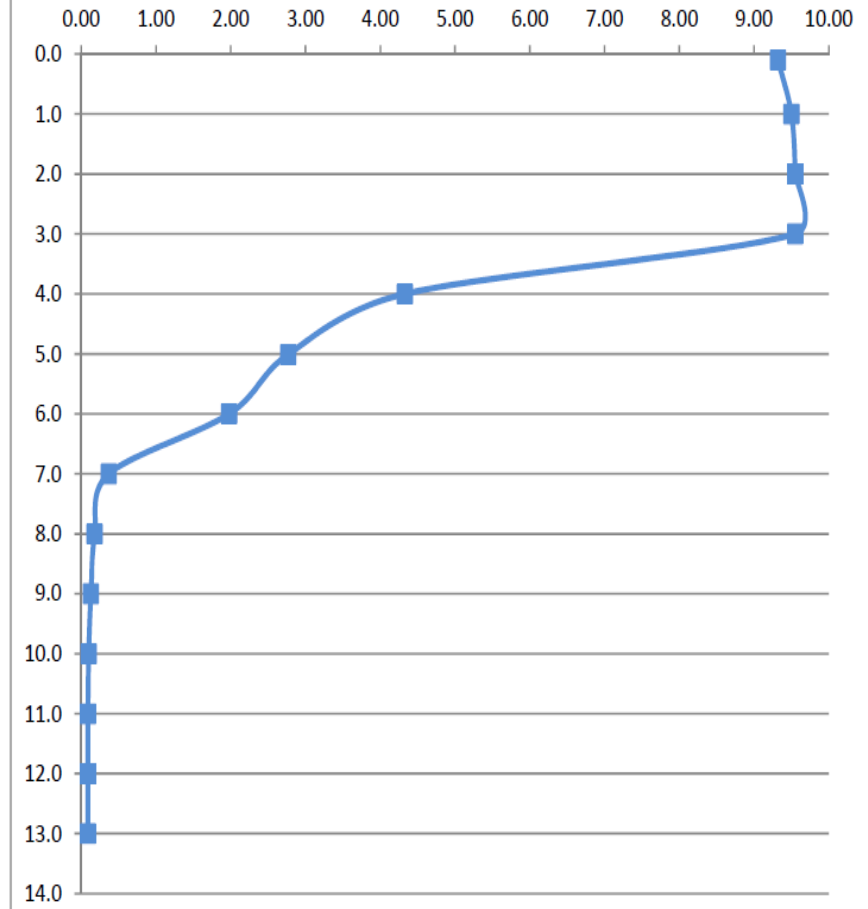
Internal Loading

- ✓ The “classic” view of internal loading is the release of phosphorus from deep water sediments.
- ✓ Under oxygenated conditions ($\text{DO} > 1 \text{ mg/L}$) phosphate is bound to iron (ferric iron) and remains in sediments.
- ✓ However, once the DO falls below 1 mg/L (anoxic), the bond between phosphate and iron (ferrous iron) is broken and both are soluble.
- ✓ The phosphate can accumulate in the deeper, anoxic waters.

Temperature profiles (°C)
Lake Hopatcong (10 July 2019)

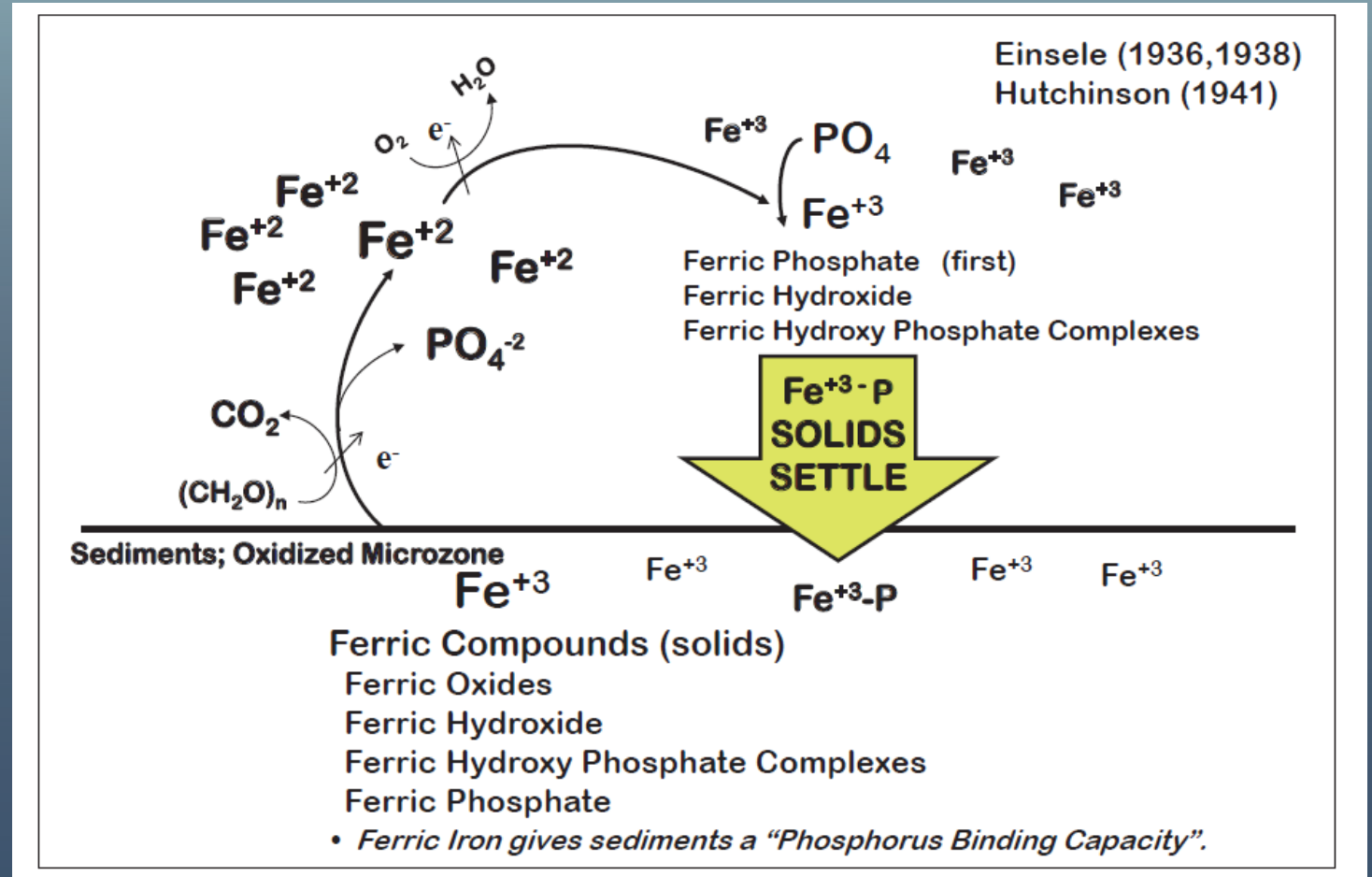


Dissolve Oxygen profiles (mg/L)
Lake Hopatcong (10 July 2019)



Internal Loading

- In the presence of DO ($> 1 \text{ mg/L}$) the phosphate binds with iron, making it unavailable for algal growth.
- When DO falls below 1 mg/L this phosphorus is available for algal growth.



Kortmann, 2020

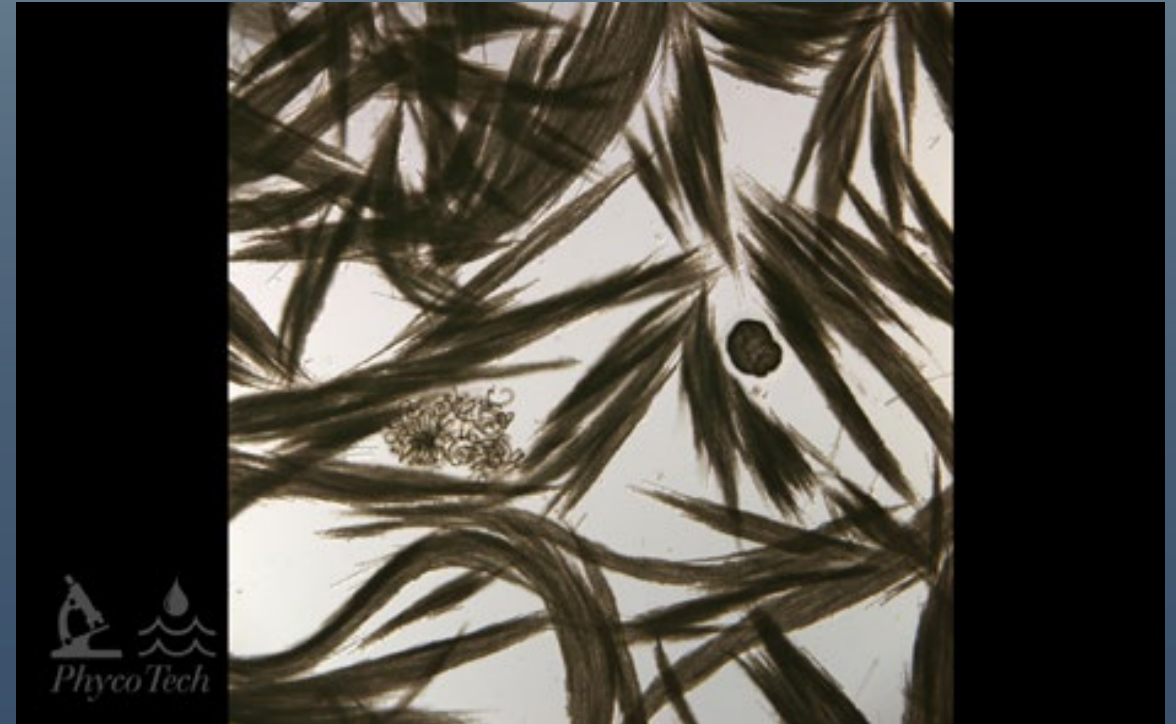
Gas Vacuoles and Gas Vesicles

- Gas vacuoles (also called aerotopes) are membrane-bound organelles in the cyanobacterial cell that fills with gas.
- Gas vacuoles are clusters of gas vesicles.
- Essentially provide a means for planktonic cyanobacteria to control / regulate their position in the water column through buoyancy.



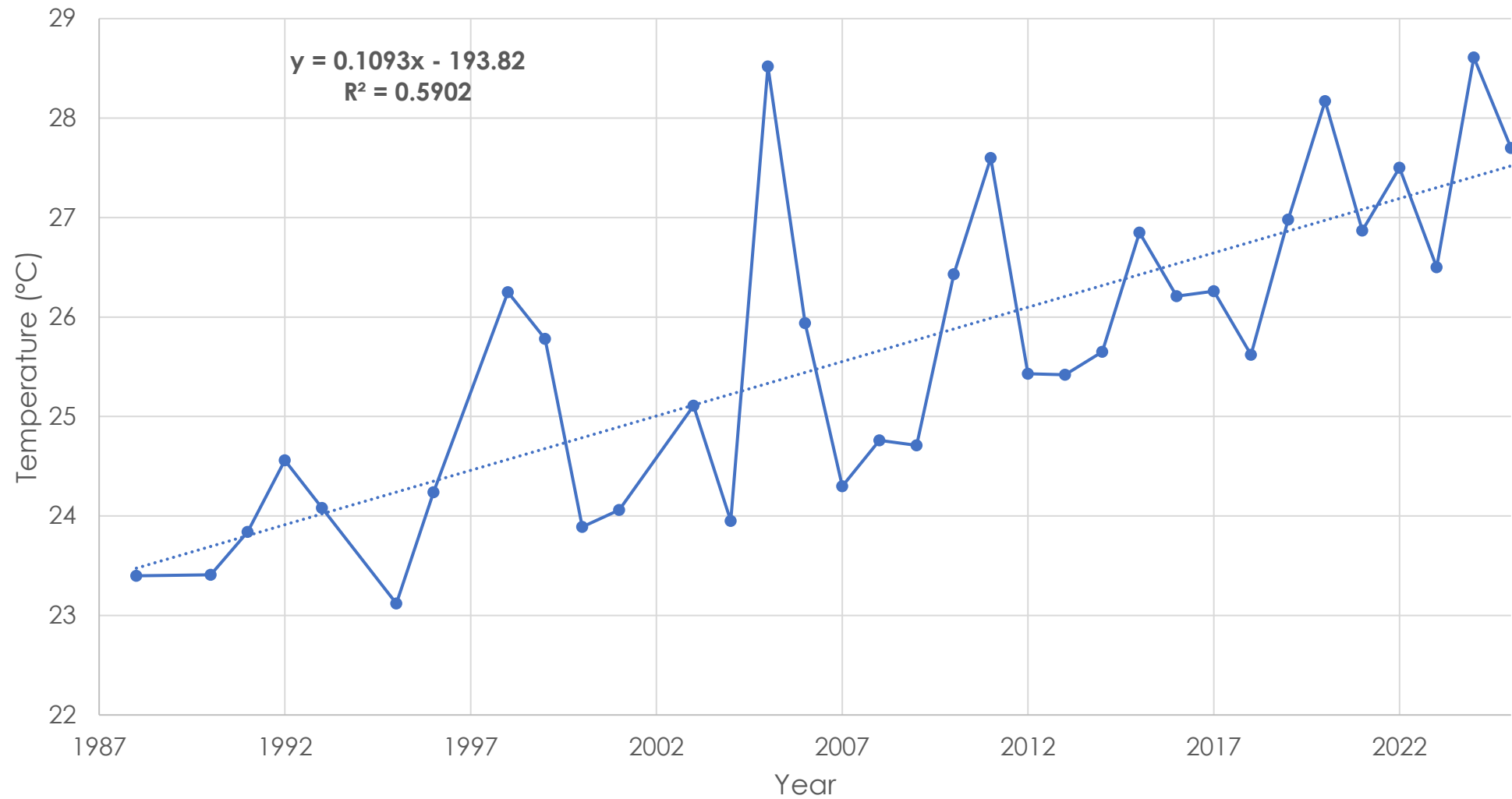
Lake Hopatcong Cyanobacteria

- Some of the dominant cyanobacteria in Lake Hopatcong over the last few years.
- *Dolichospermum* (left) and *Aphanizomenon* (right)

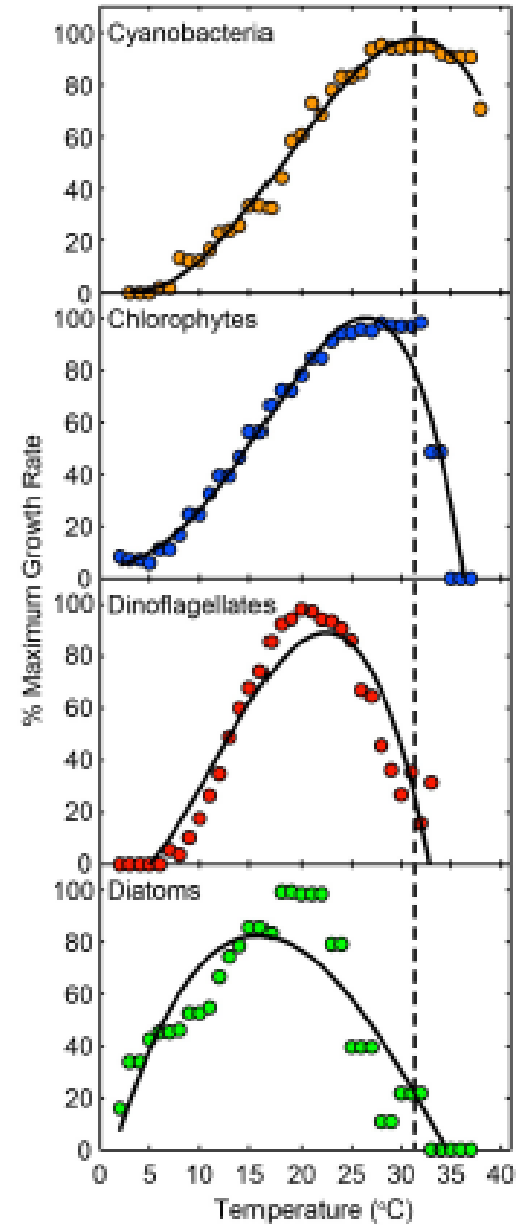


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Lake Hopatcong July Surface Temperature, Station 2

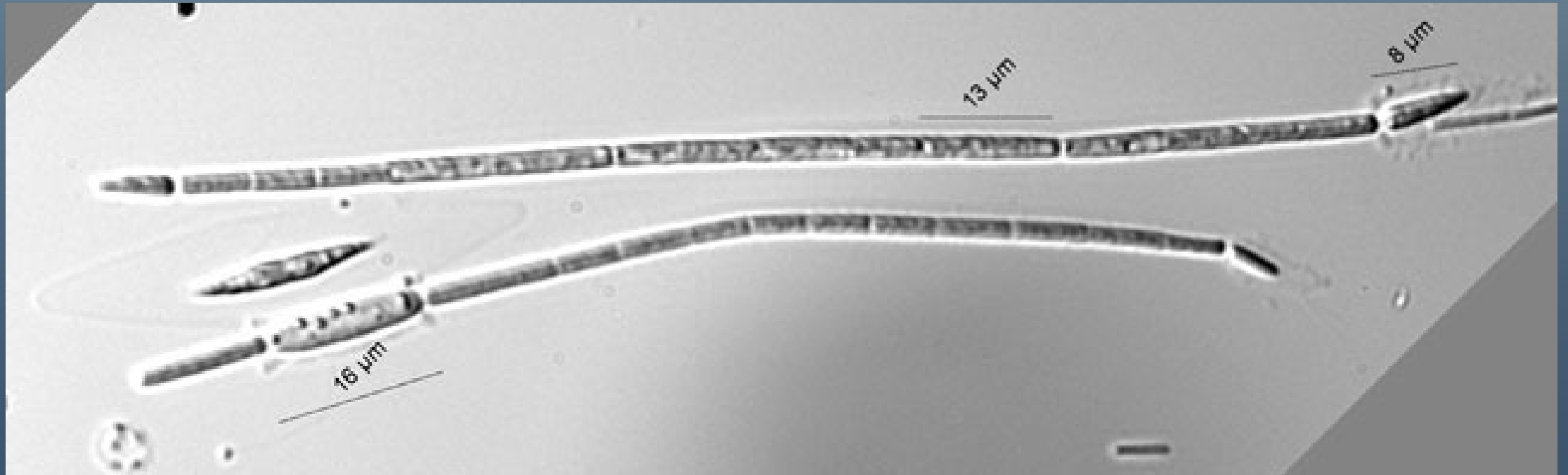


Maximum Growth Rates (Paerl, et.al., 20216)



Raphidiopsis (formally Cylindrospermopsis)

- Thought of as a sub-tropical species that has been appearing in more temperate systems over the last 10 years.
- An invasive cyanobacteria



2019 and beyond – “one, two punch”

- **Watershed sources** (stormwater and septic leachate) in June triggered the HABs.
- However, **internal sources of phosphorus** (from the deep-water sediments when they go anoxic) allowed the HABs to remain through the entire growing season.



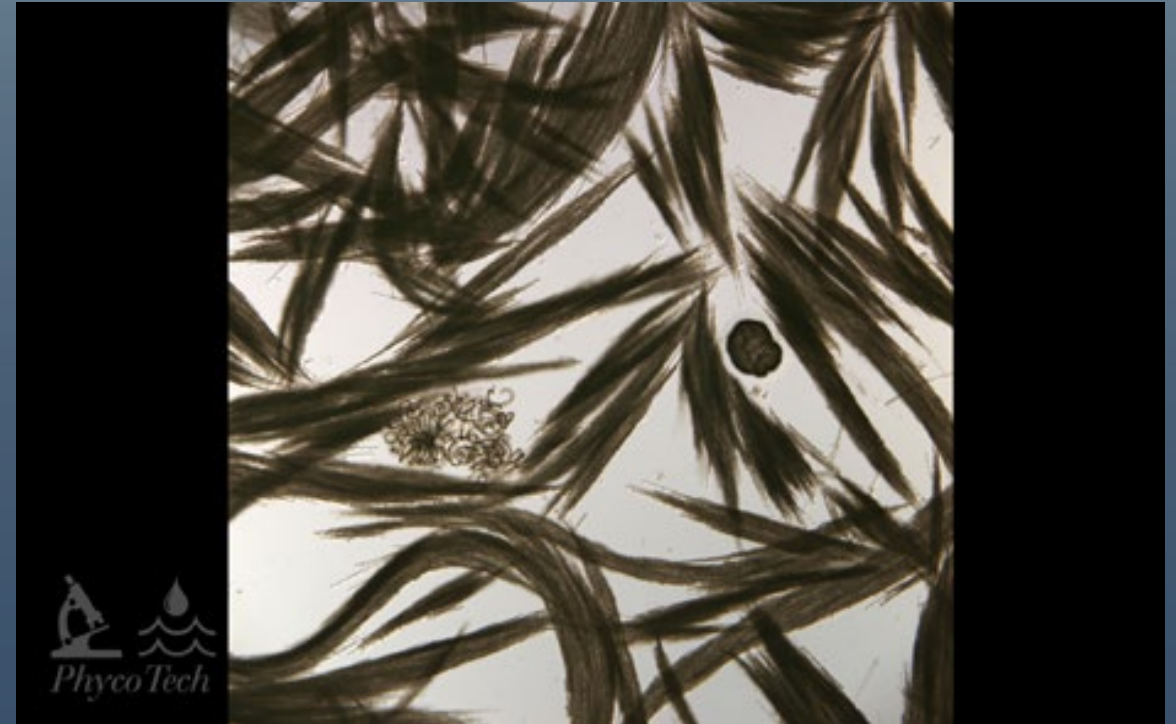
The Relative Contribution of the Internal Phosphorus Load

- ✓ On an annual basis, the lake's internal phosphorus load is less than 10% of the lake's total phosphorus load.
- ✓ However, by late June the internal load can account for around 50% of the total phosphorus load.
- ✓ From July through early September (particularly during drier summers) the internal load accounts for between 60 and 70% of the total load.
- ✓ Thus, over the summer season, when cyanobacteria do their best, the internal P load can be the largest pool of this nutrient.



Lake Hopatcong Cyanobacteria

- Some of the dominant cyanobacteria in Lake Hopatcong over the last few years.
- *Dolichospermum* (left) and *Aphanizomenon* (right)



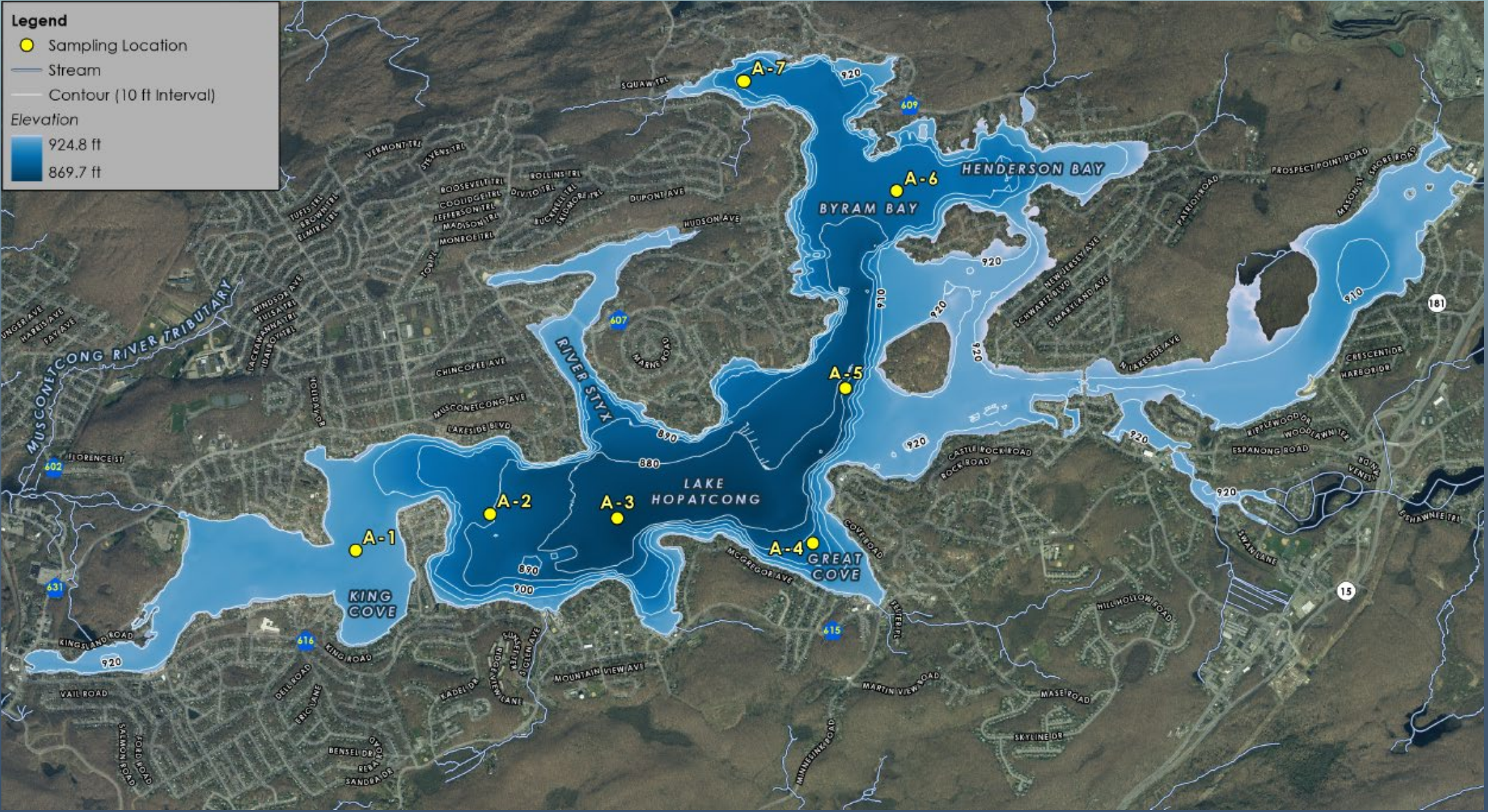
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Impacts of Climate Change on Internal Nutrient Loading

- ✓ Increased temperatures in surface waters and in near-shore areas.
- ✓ Closer proximity of algae to nutrient-rich sediments.
- ✓ Increased duration of anoxic conditions. At Lake Hopatcong the stratification period is approximately 30 days longer.
- ✓ Increased hypolimnetic phosphorus concentrations.
- ✓ Increase in the surface area and volume of anoxic conditions.
- ✓ Reduce the annual and seasonal flushing rates.

Nutrient Inactivation – Alum (aluminum sulfate)

- ✓ Updated the bathymetry of the lake.
- ✓ Conducted a feasibility study – a series of alum bench tests.
- ✓ Permitting – 2024, the first year of the NJDEP HAB Management Permit.
- ✓ NJDEP approved QAPP for monitoring
- ✓ Pre-treatment monitoring
- ✓ Treatment of alum
- ✓ Post-treatment monitoring and data analysis



Bench Test Analyses

- ✓ Bench test analyses were done on nine (9) stations throughout the targeted treatment zone.
- ✓ The samples were titrated with aluminum sulfate and the pH was measured at identified dosage rates.
- ✓ This is a standard method for the assessment of alum for nutrient inactivation (Cooke, et. al.).
- ✓ Compare the safe (maximum) dosage rate to the targeted dosage rate to ensure the pH remains above 6.2.

Lake Hopatcong Alum Bench Tests: pH

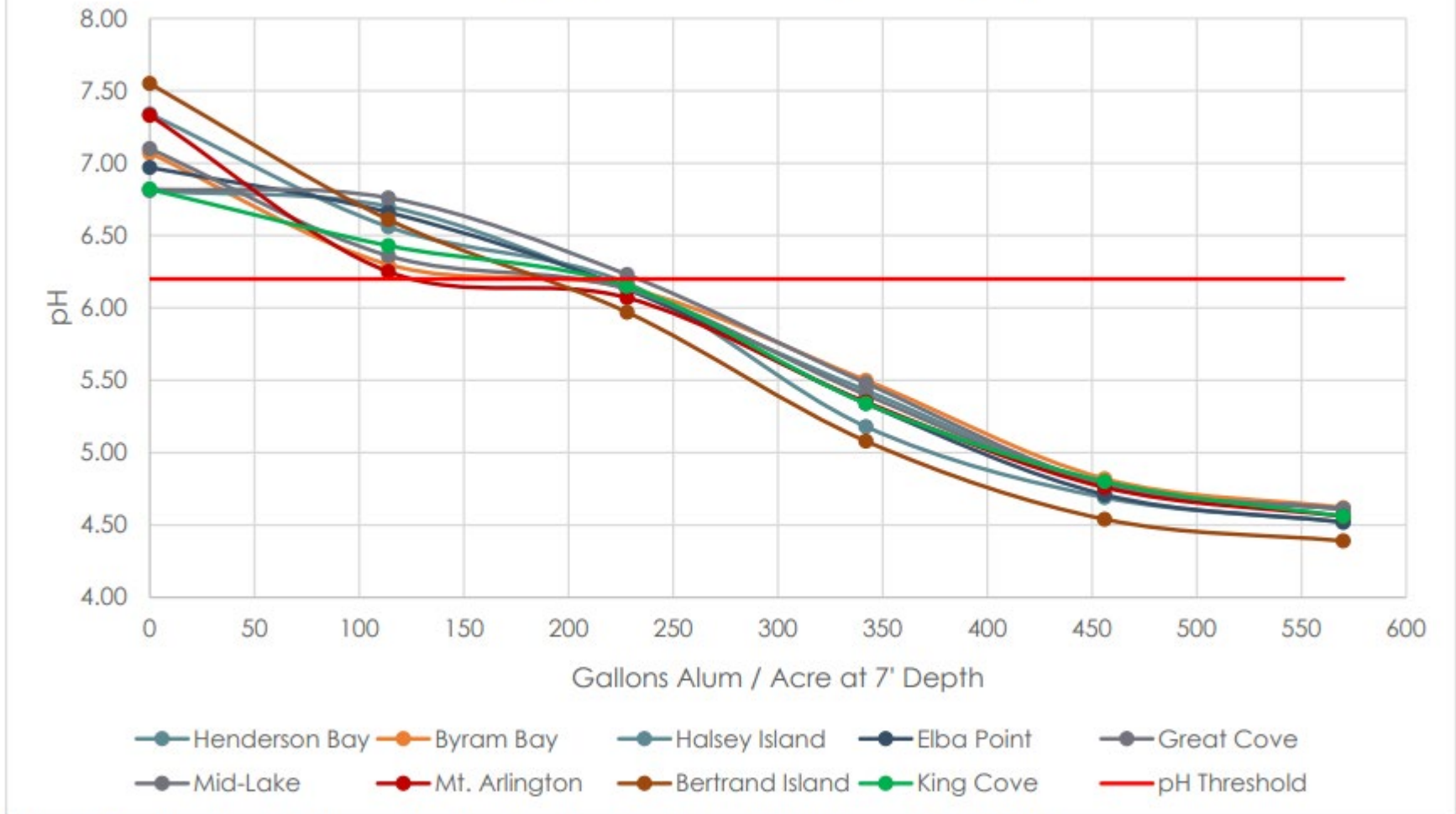


Figure 3.1: pH values at increasing dose rates of gallons of alum/acre at 7' depth

Dosage Rate

- ✓ A dosage rate of 100 gallons per acre would be safe.
- ✓ The highest safe dosage rate is 125 gallons per acre.
- ✓ To inactivate the targeted TP load over five years, the alum dosage rate is 86.5 gallons per acre.
- ✓ Thus, we originally recommended 100 gallons per acre (submission on State grant application).
- ✓ However, had enough funds to increase the dosage rate to 115 gallons per acre.
- ✓ Thus, a total of 112,240 gallons of alum were required.



Lake Hopatcong, New Jersey

- Alum treatment
- Late October 2024



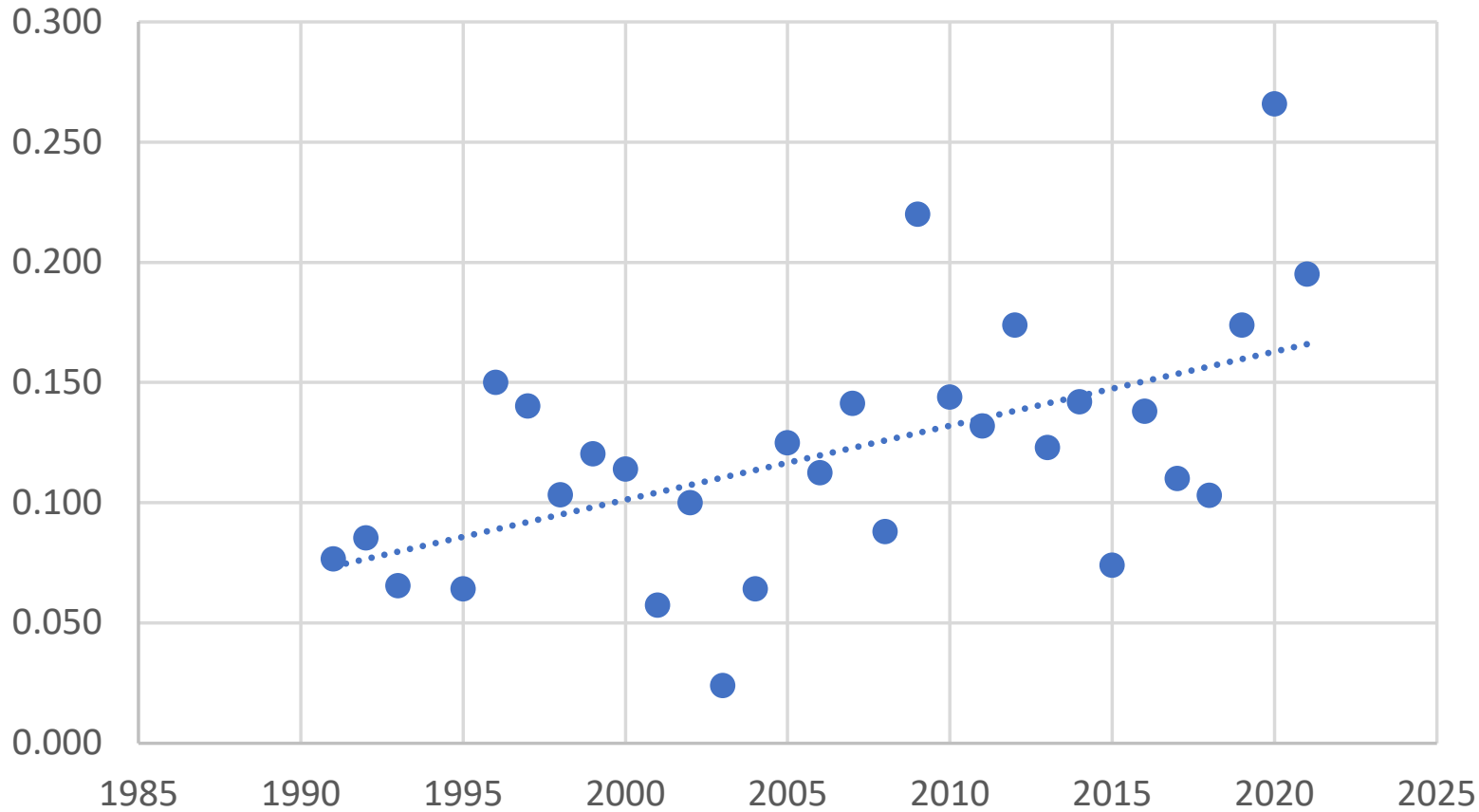
Lake Hopatcong, New Jersey

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Station 2 (3) – Impacts of the Alum Treatment

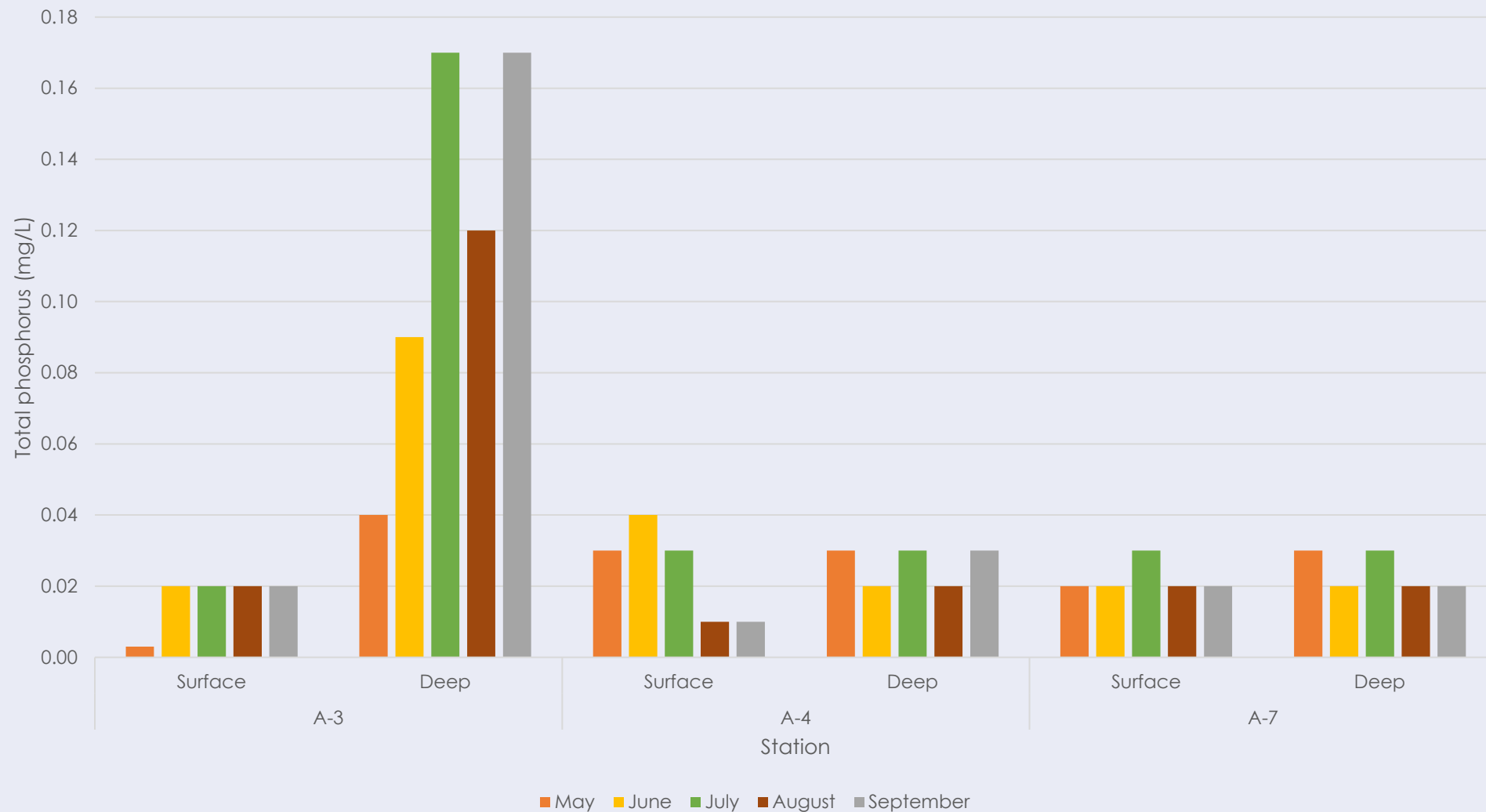
- ✓ In 2025 (post-alum) the highest bottom water TP concentration was 0.17 mg/L.
- ✓ In 2024, 2023, 2022 and 2021, the highest bottom water TP concentrations were 0.21, 0.42, 0.20 and 0.59 mg/L, respectively.
- ✓ In 2024 bottom water SRP concentrations varied between 0.002 to 0.085 mg/L with a mean of 0.044 mg/L.
- ✓ In 2025 bottom water SRP concentrations varied between <0.001 and 0.021 mg/L with a mean of 0.008 mg/L.
- ✓ From 2024 to 2025 there was an 82% reduction in bottom water SRP concentrations due to the alum treatment.

Annual Event Mean Deep TP (mg/L)

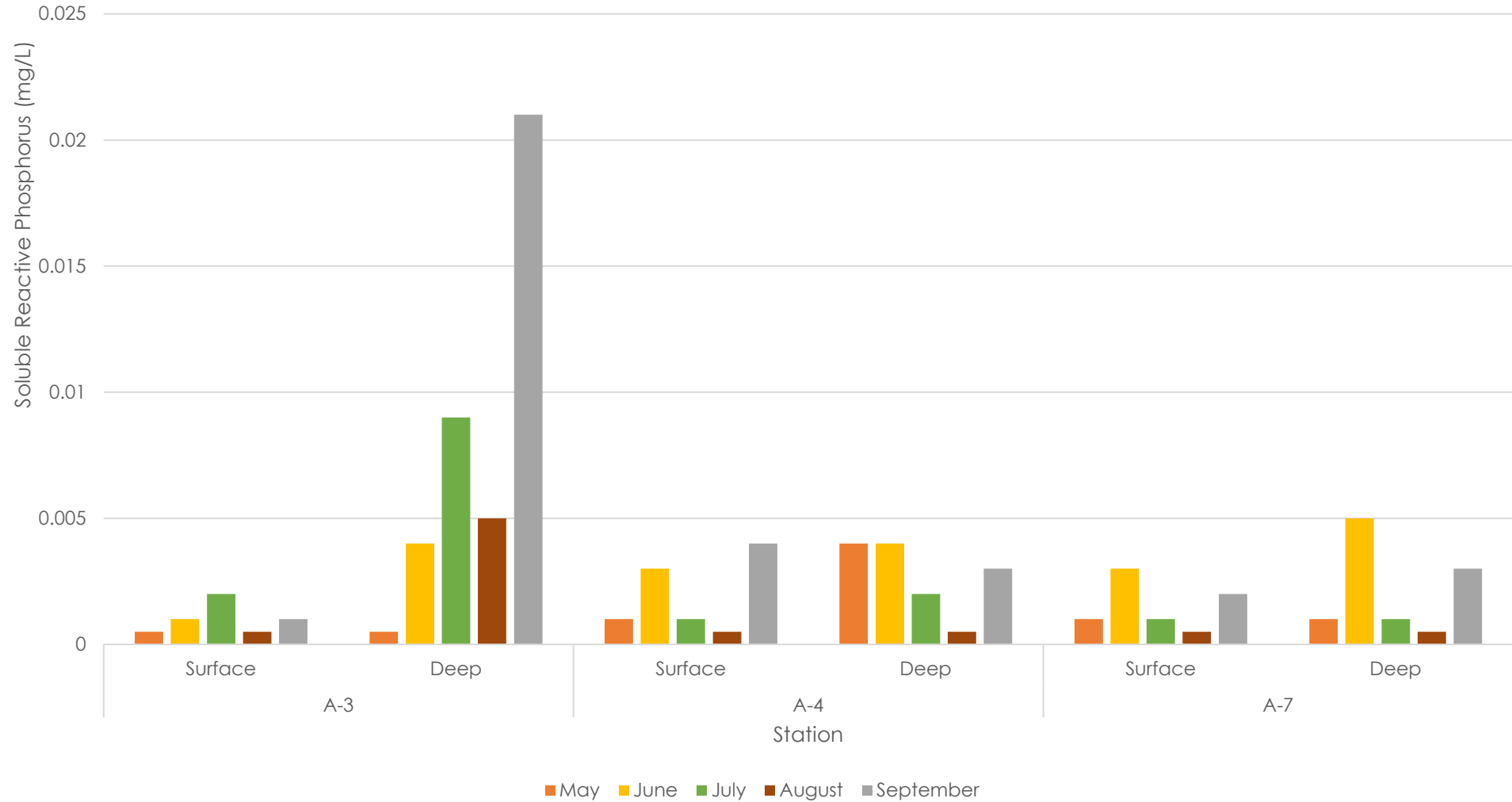


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Lake Hopatcong Alum: Longer-Term TP



Lake Hopatcong Alum: Longer-Term SRP



Station 2 (3) – Pre (2024) and Post (2025)

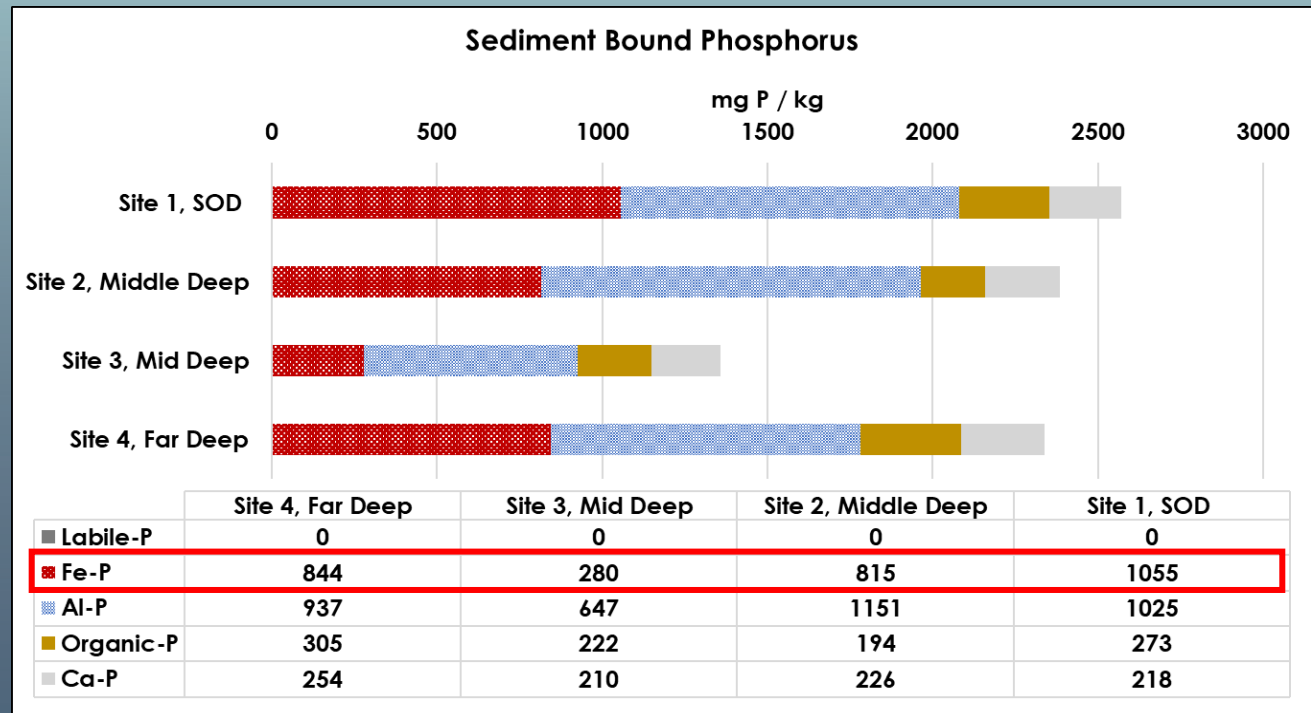
Surface		
Parameter	Aug-24	Aug-25
chl-a (mg/m ³)	16	11
SRP (mg/L)	0.002	0.001
TDP (mg/L)	N.S.	0.01
TP (mg/L)	0.03	0.02
Secchi (meters)	0.9	1.1

Deep		
Parameter	Aug-24	Aug-25
chl-a (mg/m ³)	N.S.	N.S.
SRP (mg/L)	0.049	0.004
TDP (mg/L)	N.S.	0.01
TP (mg/L)	0.13	0.14
Max. seasonal TP (mg/L)	0.21	0.17

Station 2 (3) – Impacts of the Alum Treatment

- ✓ Cyanobacteria cell counts in the surface waters in 2024 (pre-alum) varied between 22,472 and 317,293 cells / mLs, with a mean value of 114,082 cells / mLs.
- ✓ Cyanobacteria cell counts in the surface waters in 2025 (post-alum) varied between 38,392 and 91,893 cells / mLs, with a mean value of 55,073 cells / mLs.
- ✓ A 52% reduction in cell counts from 2024 to 2025.

Sediment Phosphorus Speciation



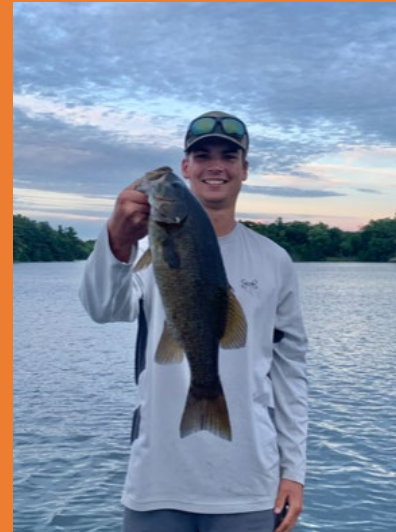
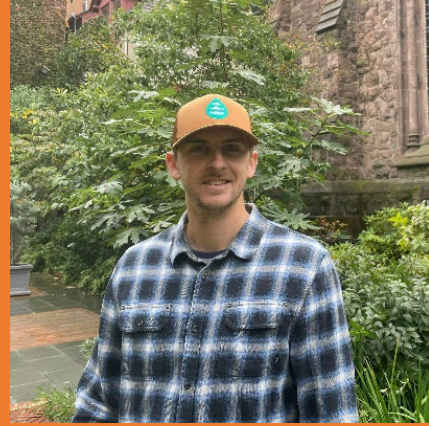
Location	Iron (Fe) (mg/kg)	Total P (mg/kg)	Fe:P
Site 1, SOD (>50 ft)	57,100	2,572	22
Site 2, Middle Deep (>50 ft)	53,700	2,385	23
Site 3, Mid Deep (~40 ft)	33,200	1,358	24
Site 4, Far Deep (>50 ft)	51,600	2,340	22

Conclusions

- ✓ Observed reductions in phosphorus concentrations, particularly the deep-water SRP concentrations.
- ✓ Moderate improvements in water quality (Secchi depth and chlorophyll-a).
- ✓ The deepest section of the lake is still
- ✓ Will continue to monitor and evaluate the impact of the treatment.
- ✓ Consider a secondary treatment in 2-4 years that covers a substantially smaller section of the lake, over the deepest part.

The Components of Lake Management

- ✓ Watershed management strategies.
- ✓ In-Lake management / restoration techniques (internal load control).
- ✓ Management of the near-shore, shallow (littoral) sections of a large, deep dimictic lake or a shallow polymictic lake.
- ✓ Stakeholder management (will not be covered but very important).



QUESTIONS?



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*THANK
YOU!*

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