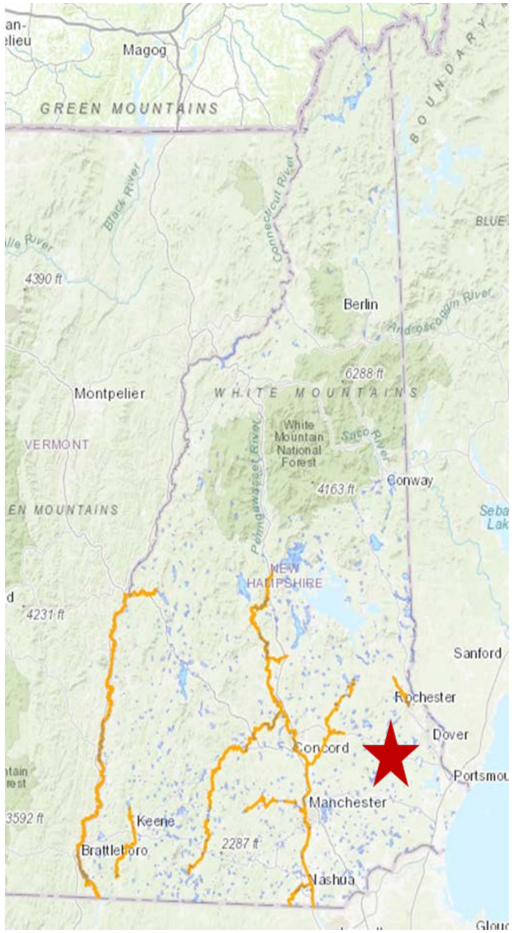
Nippo Lake Case Study—Treating Lakes Once Cyanobacteria Blooms

NH Lakes Congress
June 2, 2023

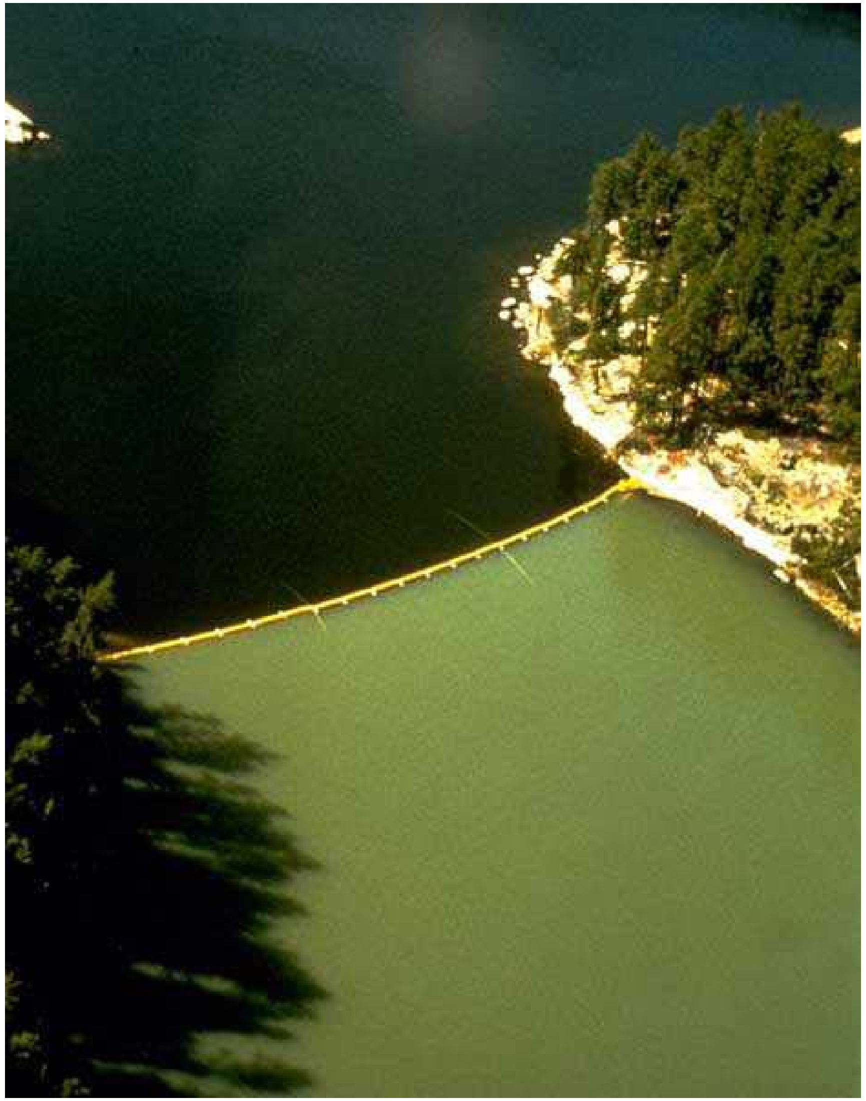


Don Kretchmer CLM, DK Water Resource Consulting LLC
Kevin Fitzgerald Esq, Nippo Lake Association

Partners:

- Nippo Lake Association
- Nippo Lake Golf Course
- NHDES
- UNH LLMP
- DKWRC, Solitude, WRS

1973 experiment by Schindler



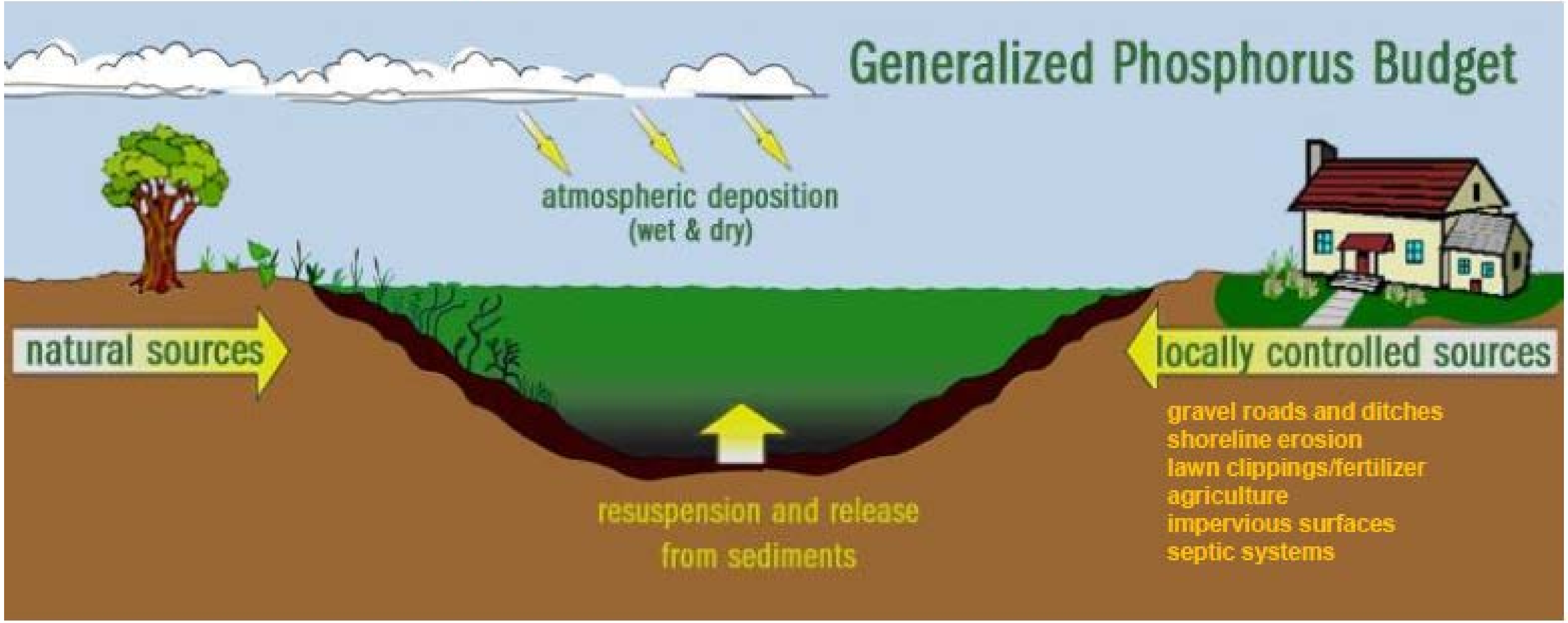
Wentworth
Water

Wentworth
Water With
Phosphorus
Lawn Fertilizer

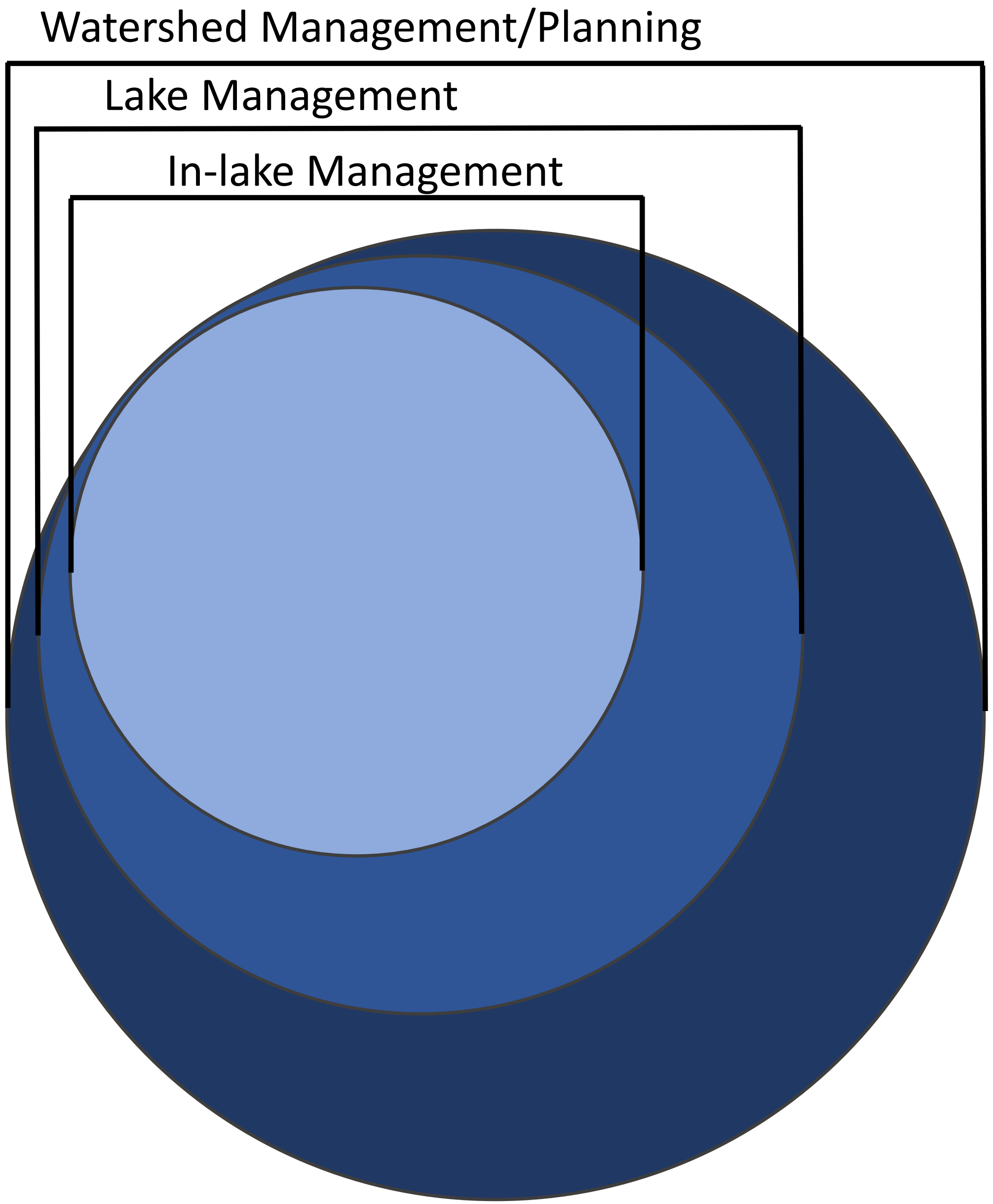
2007 experiment by Kretchmer

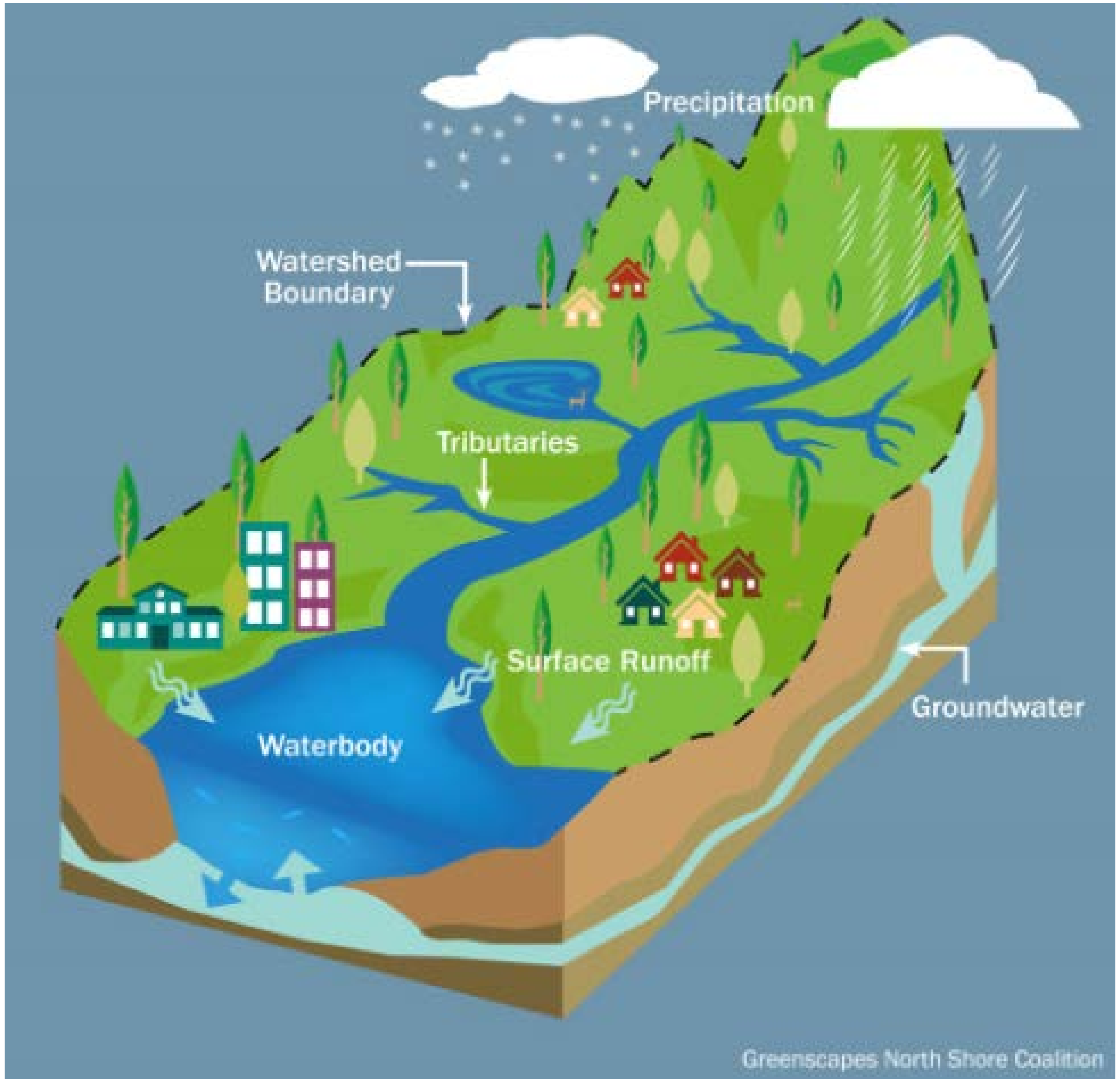

Nippo pre-treatment

Phosphorus Loading



If Watershed Planning is the Universe, then In-lake Management is a Planet

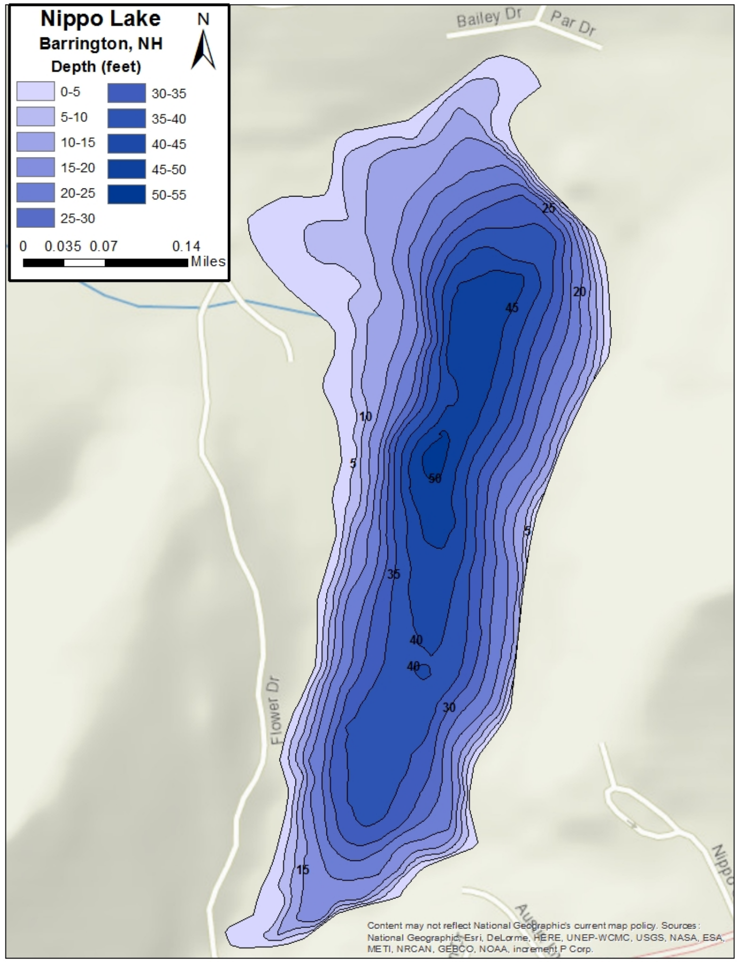




Of the 70+ watershed plans NHDES has funded:

- 18 in direct response to cyanobacteria bloom prevention or remediation
- Only 7 have considered in-lake treatment
- 4 likely require in-lake treatment to control blooms

The evolution of the Nippo Lake restoration



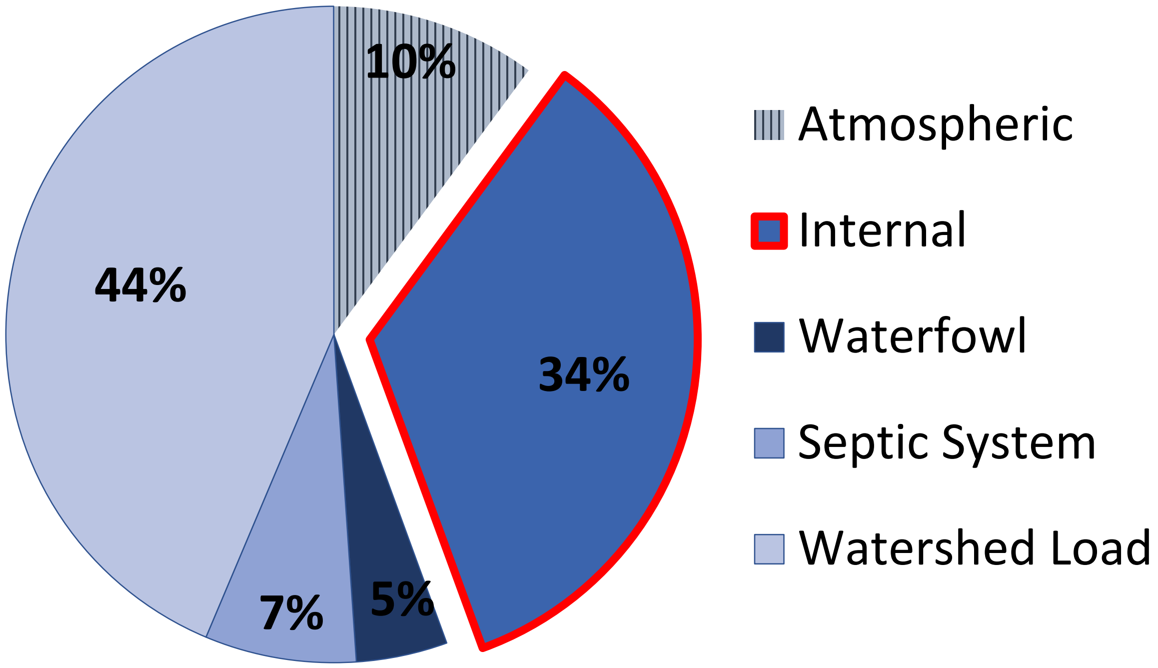
Problem ID: Annual cyanobacteria blooms issued from 2010 – 2020, 85 acres, few inlets, slow flushing (0.4 times/yr), reduced recreation

Technical Lake Investigations: 2015 historic data summary, 2016 stormwater investigation, 2016 in-lake sampling, 2018 lake loading response model, 2019 sediment sampling, 2021 pilot treatment and full treatment, 2021 to today post-treatment monitoring

Watershed plan: Completed in 2019; identified both watershed and "internal loading" as critical. Follow up non-point source pollution activities by NLA w/ NHDES s319 funding.

In-lake management: Phosphorus inactivation recommended to control cyanobacteria blooms and achieve watershed plan goals 2021

How important was internal loading in Nippo Pond?



1/3 of phosphorus comes from bottom sediments

Why?

Phosphorus is released from bottom sediments under low oxygen conditions.

GUIDING PRINCIPLES FOR THIS PROJECT

1) Lake will not recover without addressing both external and internal load

2) External load was addressed through a number of BMPs and individual actions first. Action continues.

3) Internal load could be addressed by several management techniques

4) Inactivation of sediment phosphorus by aluminum was the best option for Nippo due to its small watershed size and likely success of external nutrient control.

Careful Screening of Options

Options potentially applicable	Options deemed not applicable.
Nonpoint source control of phosphorus (watershed-based plan)	Point source control of phosphorus
Pollutant trapping (watershed-based plan)	Dilution and flushing
Circulation and destratification	Drawdown
Hydraulic dredging	Dry excavation of sediment after drawdown
Hypolimnetic oxygenation	Wet excavation of sediment from shore
Algaecides	Light limiting dyes
Phosphorus inactivation	Surface covers
Settling agents	Selective withdrawal of water
Sediment oxidation	Sonication
Mechanical removal/treatment on shore	Selective nutrient addition
Enhanced grazing through food chain interactions	Addition of herbivorous fish
	Bottom feeding fish removal
	Microbial competition
	Addition of pathogens
	Plantings of macrophytes for nutrient utilization
	Plantings of macrophytes for shade

Watershed Management

Phosphorus Inactivation with Aluminum

Balanced Aquatic Community

THREE ACTIONS RECOMMENDED FOR NIPPO LAKE

Steps to get to the in-lake treatment with aluminum

Step 1. Sediment Chemistry Analysis (Jan 2019) – Necessary b/c internal loading was identified as primary phosphorus source.

Step 2. Alternatives analysis (Apr. 2020) – An evaluation potential in-lake options resulted in recommendation of aluminum

Step 3. Request to NHDES for permit (Dec. 2020) – Application submitted by Nippo Lake Association for NHDES review

Step 4. Permit Issuance (May 2021) – NHDES issues State Surface Water Discharge Permit (RSA 485-A, Env-Wq 300).

Step 5. Treatment completed (May - June 2021) – Contractor completes treatments over 3-week period, 9 total days, NHDES provides monitoring and logistics support.

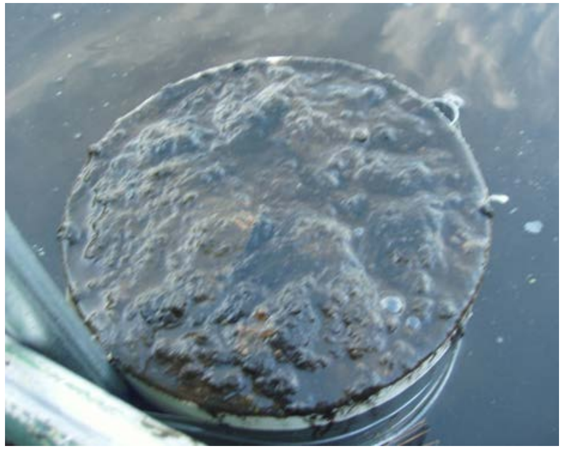
Step 6. Post treatment monitoring (July 2021-present). Determining effectiveness and longevity is critical.

Use of aluminum-based compounds to control sediment phosphorus release

Background:

- Aluminum binds phosphorus in bottom sediment even under low oxygen conditions
- Only successful if external phosphorus loads are minimized
- Typically one-time treatment that can last up to 20 years
- Used since 1950s as in-lake management technique
- Used in many NE lakes that experience internal phosphorus loading
- Last used in NH in 1984 in Kezar Lake, Sutton

Planning factors:
- Hydrology, biologic community, water and sediment chemistry, downstream resources



Risks:

- Aluminum is toxic to aquatic organisms
- Compounds can reduce pH if not applied correctly

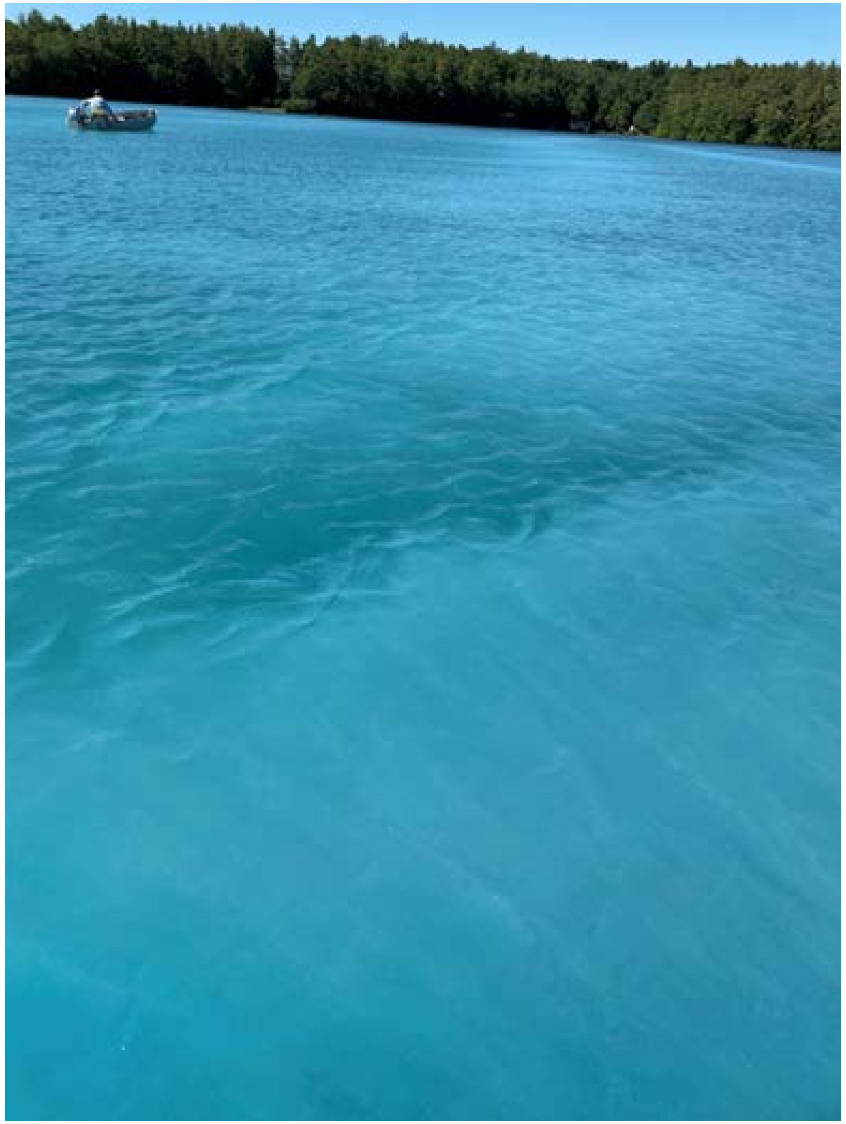
Landing a sediment core to characterize sediments

Daily delivery of Aluminum sulfate and sodium aluminate from plant in Massachusetts

Pump from truck onto tanks on boat. 10-12 loads per day.

Application to lake via hoses and GPS tracking. Each area got ½ dose per treatment.

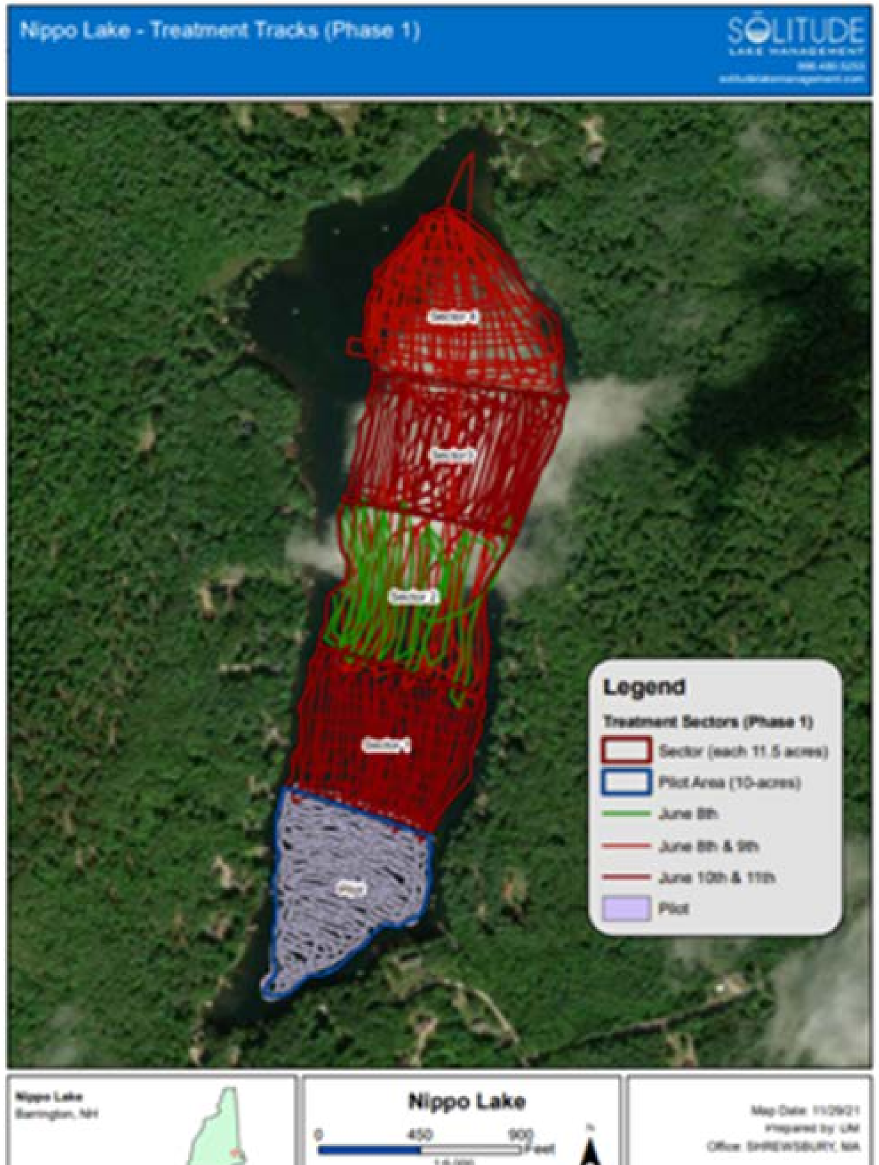
During treatment and end of day treatment in one sector



Flock in water column

Flock on bottom

GPS tracks for each sector (5 days)



Continuous monitoring for pH. Complete water quality before, mid-application and after. Morning observation for fish/invertebrate stress.

Sept. 21, 2021

Water returned to "normal" color in early July.

- Floc is no longer visible, and aluminum is now part of the sediments
- Sediments now have much more capacity to hold phosphorus.
- Reports available from NHDES

R-WD-22-06

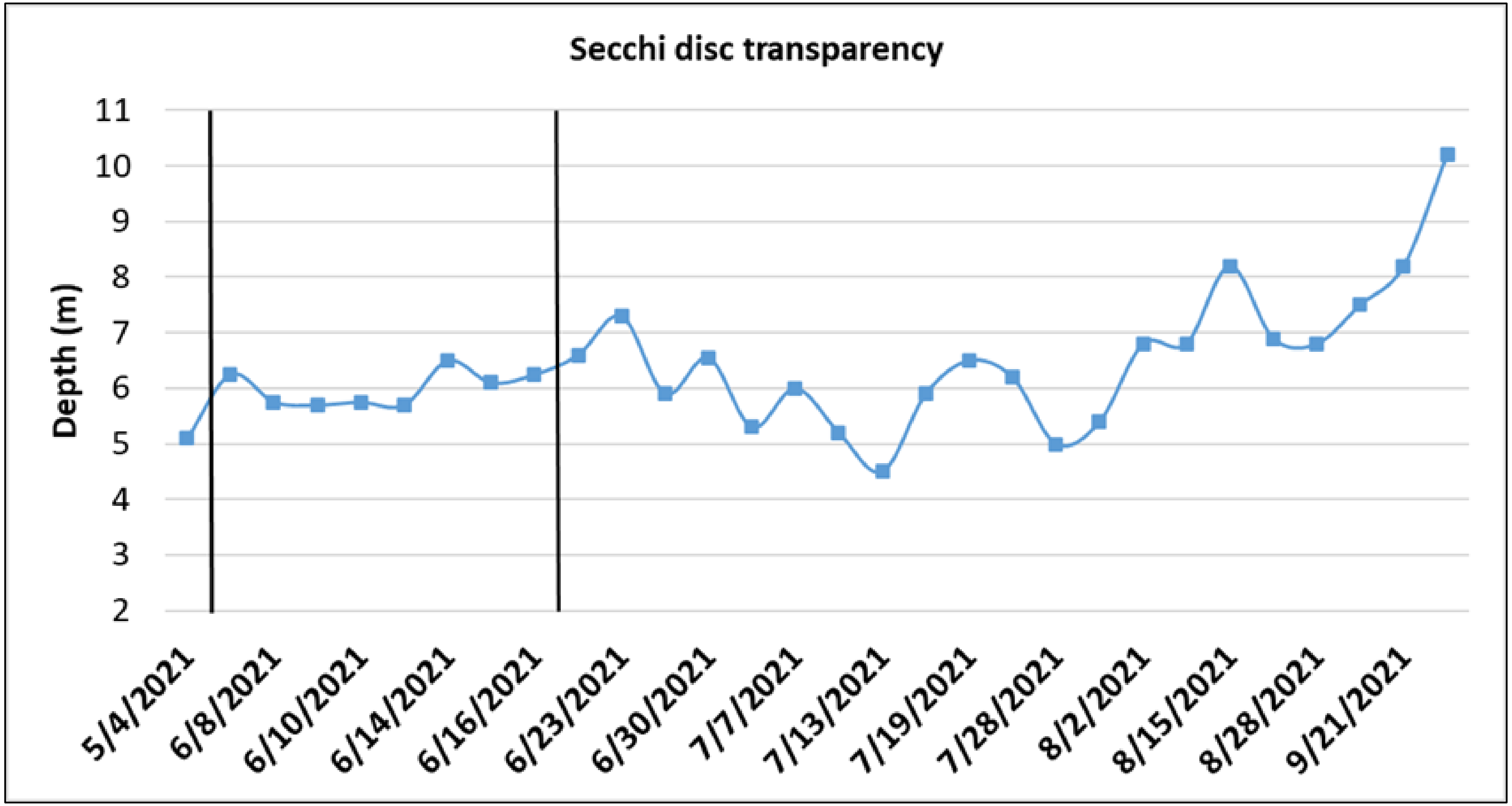
Nippo Lake, Barrington, NH aluminum compound treatment report, 2021

Photo courtesy of Nippo Lake Association

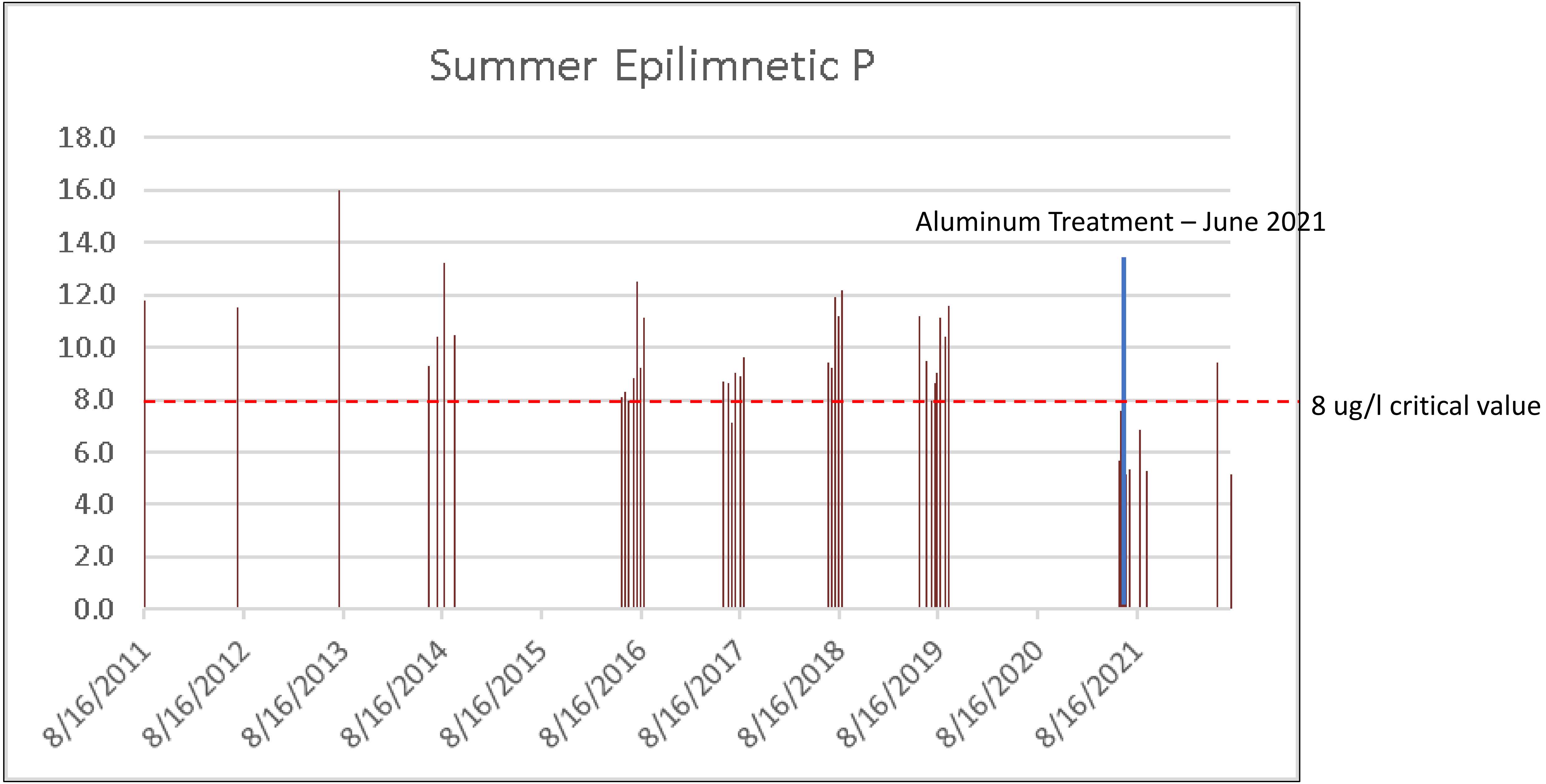
NHDES

June 2022

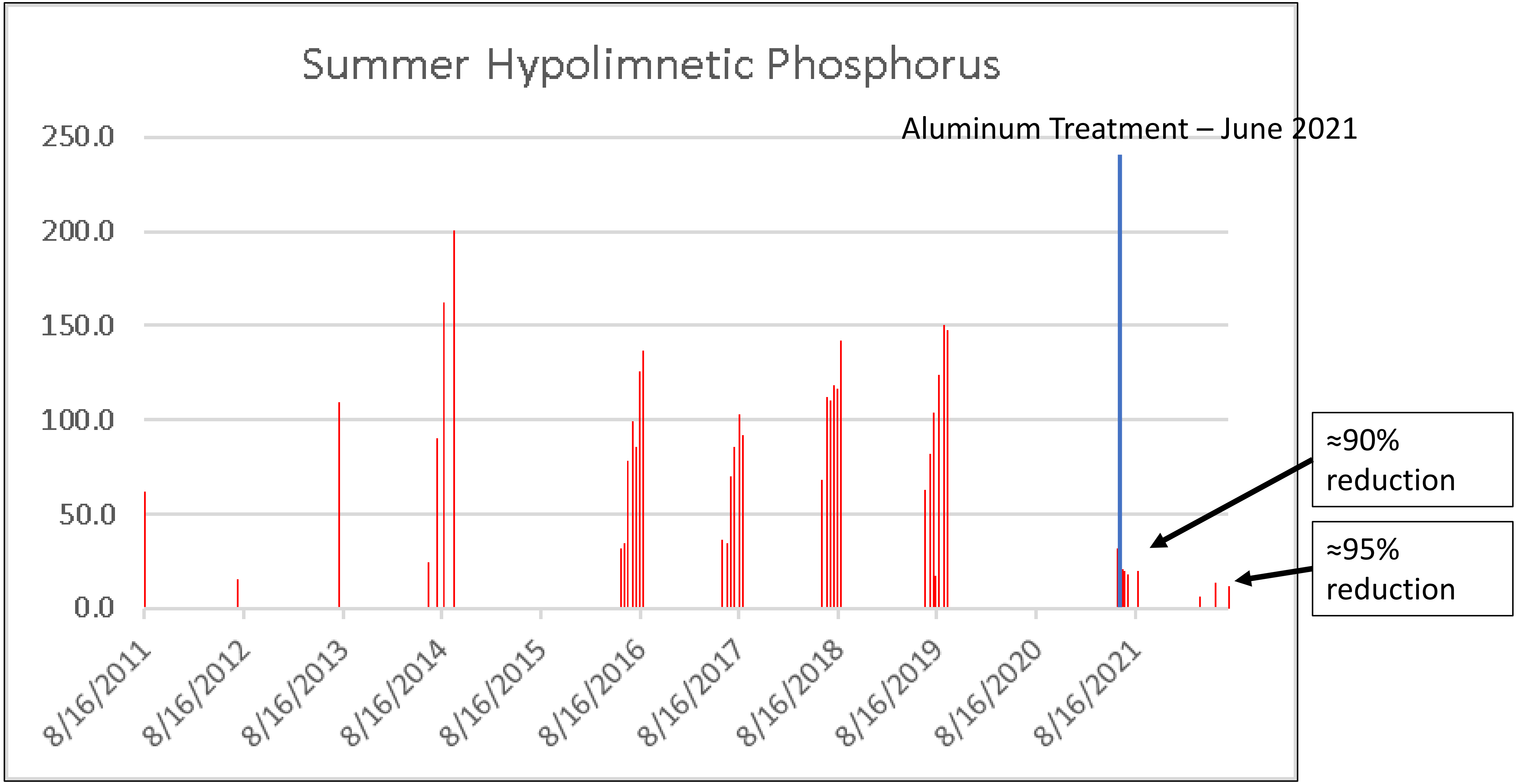
Did it work?



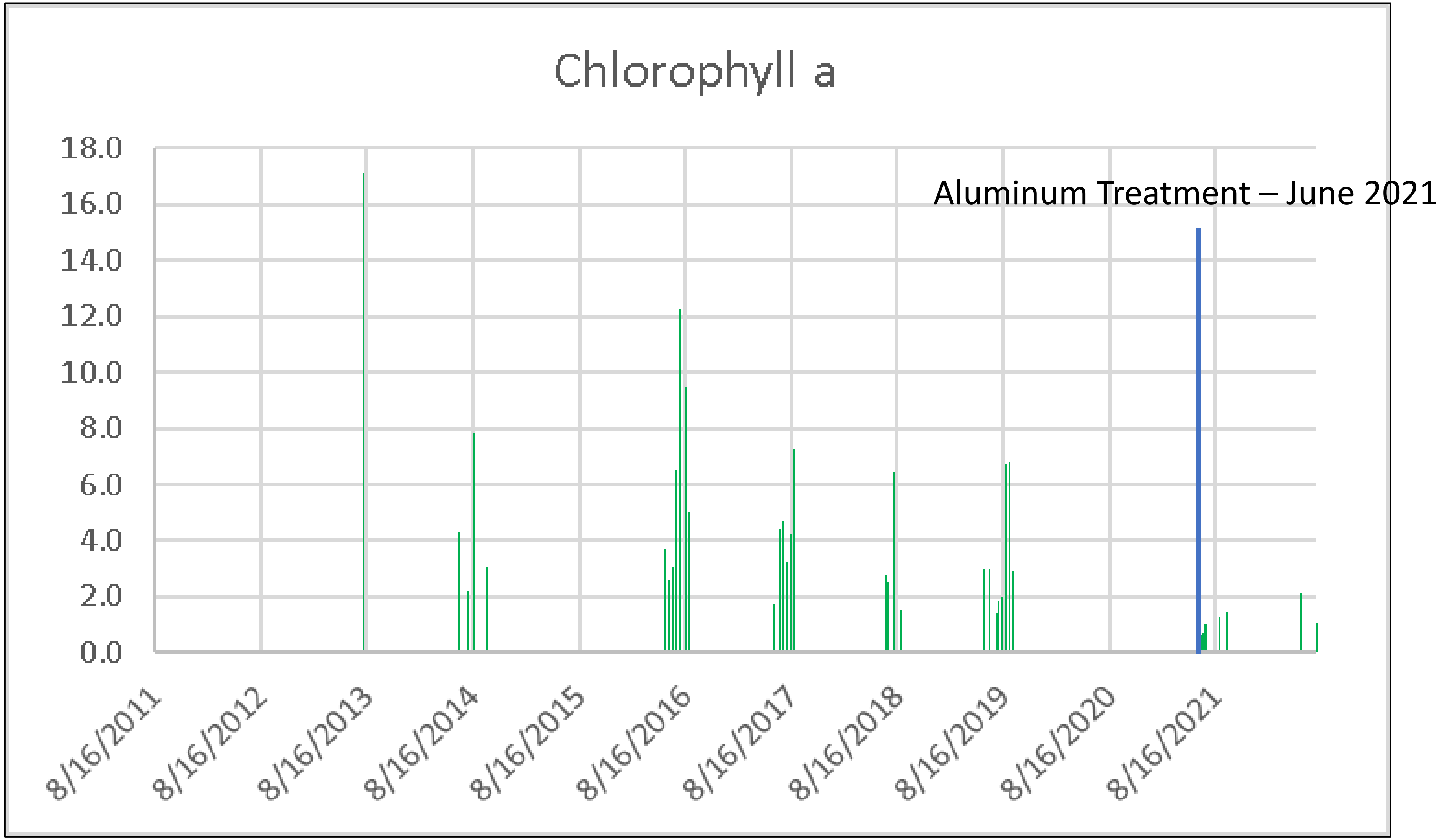
- Transparency increased throughout the summer, unlike other years.



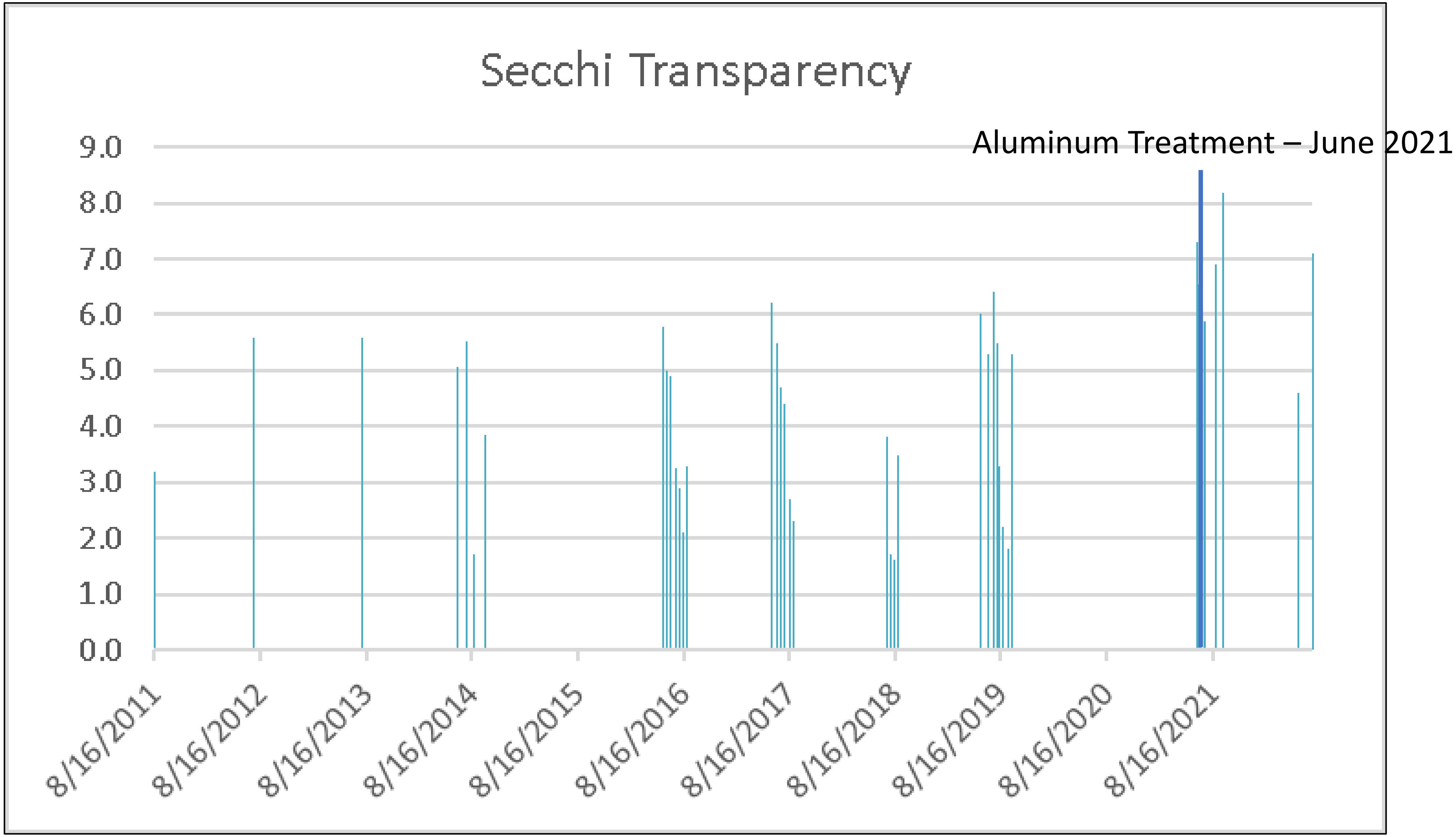
Summer Epilimnetic P
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
8/16/2011
8/16/2012
8/16/2013
8/16/2014
8/16/2015
8/16/2016
8/16/2017
8/16/2018
8/16/2019
8/16/2020
8/16/2021
Aluminum Treatment – June 2021
8 ug/l critical value



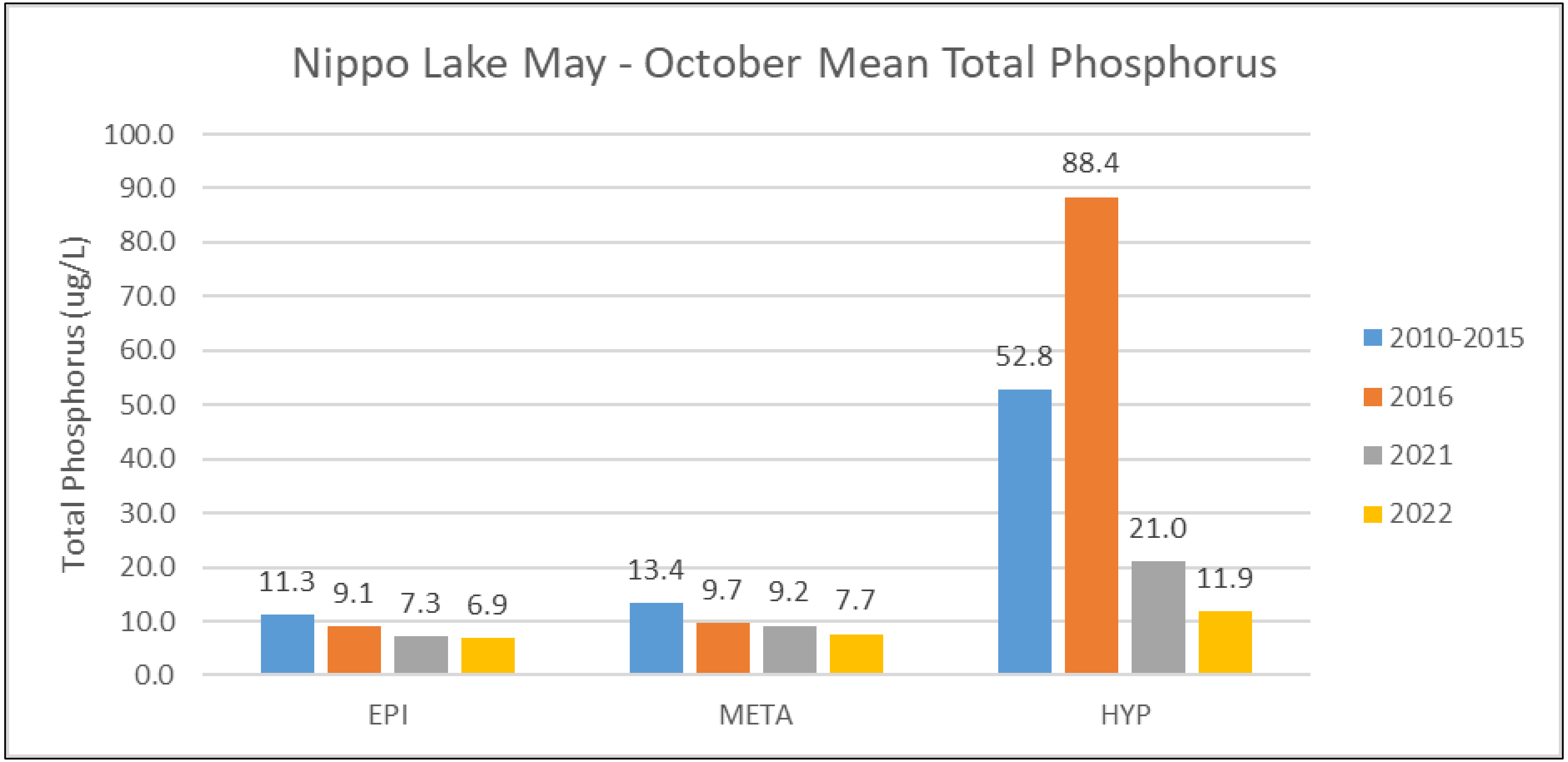
Summer Hypolimnetic Phosphorus
Aluminum Treatment – June 2021
250.0
200.0
150.0
100.0
50.0
0.0
8/16/2011
8/16/2012
8/16/2013
8/16/2014
8/16/2015
8/16/2016
8/16/2017
8/16/2018
8/16/2019
8/16/2020
8/16/2021
≈90% reduction
≈95% reduction



Chlorophyll a
Aluminum Treatment – June 2021
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
8/16/2011
8/16/2012
8/16/2013
8/16/2014
8/16/2015
8/16/2016
8/16/2017
8/16/2018
8/16/2019
8/16/2020
8/16/2021



Secchi Transparency
Aluminum Treatment – June 2021
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
8/16/2011
8/16/2012
8/16/2013
8/16/2014
8/16/2015
8/16/2016
8/16/2017
8/16/2018
8/16/2019
8/16/2020
8/16/2021



- Data collected August through October
- Major drop in phosphorus, particularly in deep portions (90%-95% reduction in hypolimnion)
- Potential for internal loading greatly reduced

Project outcomes

- Hypolimnetic total phosphorus concentrations decreased by 80 – 95%
- Water clarity increased from 4m to 8m; current clarity is >90% lakes in NH
- Chlorophyll a concentrations less than 2 ug/L in epi and metalimnetic layers
- Outstanding partnership among NHDES, NLA, UNH, consulting team

Nippo Lake going forward

- Continuing to monitor
- Continue with watershed BMPs
  - Finding new opportunities to reduce existing sources
  - Making sure existing BMPs are maintained
  - Maintaining septic systems and upgrading where possible
- Permanently protecting critical watershed land to reduce potential for future loading increases
- Enjoying the lake

Challenges based on Nippo Lake "Demonstration Project" Experience

- No dedicated source of funds or staff to support in-lake management project. Nippo Lake cost was 100-200K for in-lake treatment only.

- Permitting process was not ideal; surface water discharge permit meant for "ongoing" municipal or industrial permits.

- Need formalized policy/rules that require external nutrient sources to the be controlled and justification for recommended treatment option(s) over other options.

- NHDES lacks technical expertise to evaluate proposed projects; alum, other chemicals, mechanical mixing.

- Significant pre-, mid-, and post-treatment monitoring required.

- First in-lake treatment since 1984, Kezar Lake

Questions?