Possible Cyano Treatment Options for PL

PL is impaired, eutrophic with increasing phosphorous levels - very shallow lake with multiple watershed input that flushes only once/year.
Primary phosphorous load is runoff to the lake, and then re-suspension of sediments, followed by input from septic systems.
No significant turnover or thermocline due to being shallow.
PL past treatment .. Copper sulfate that was used in PL 1965-1967 for blooms, as well as artificial water mixing into 1970s. Neither resulted in any significant change.

Cyanobacteria is in ALL fresh waters in the world. It is not just in Province Lake. It does NOT come from pollution, septic systems etc.. It has been around for billions of years.
Proper nutrient levels and other conditions are what create a bloom. It is a bacteria, but has also been called blue green algae as it looks and somewhat acts like an algae.
HAB stands for Harmful Algal Blooms.

Waterbody Management Measure (from EPA)	Description	Effectiveness	Limitations	Case Studies	Info	PL Options
Physical Controls						
Aeration	Aerators operate by pumping air through a diffuser near the bottom of the waterbody, resulting in the formation of plumes that rise to the surface and create vertical circulation cells as they propagate outwards from the aerator. This mixing of the water column disrupts the behavior of cyanobacteria to migrate vertically in addition to limiting the accessibility of nutrients.	Successfully implemented in small ponds and waterbodies. May also provide more favorable growth conditions for competing organisms.	Generally more efficient in deeper water columns. Also highly dependent upon the degree of stratification and the air flow rate.	Lake Carmi, Vermont. Installed in 2019 at a cost of over $1.0M	1375 acre lake with deep spot of 33 feet and average depth of 20 ft. System is now being removed in 2024 as the blooms increased and were worse than before.	Could be done in PL. Was tried in past- 1975 ran aeration and 1976 didn't aerate. Took measurements of key water attributes. No blooms either year. No discernable difference in water quality; except turbidity worse. PL not stratified and dissolved oxygen is fine. Expensive and lots of maintenance. Would require approval from NH DES.
Hydrologic manipulatic	Manipulation of inflow/outflow of water in the system to disrupt stratification and control cyanobacterial growth.	Easy to implement in controlled systems (i.e., reservoirs, dams, treatment facilities).	Requires sufficient water volume and the ability to control flow. Oftentimes can be expensive. Unintended consequences for other aquatic organisms are likely.			Not an option as PL can't control in and out flow
Mechanical mixing (cir	Mechanical mixers are usually surface-mounted to disrupts the behavior of cyanobacteria to migrate vertically in addition to limiting the accessibility of nutrients.	Successfully pump water from the surface layer downwards or draw water up from the bottom to the surface disrupting the bloom.	Individual devices have limited range; areas further away may remain stratified and provide a suitable environment for growth.			Not an option for PL as not a stratified lake
Reservoir drawdown/d	Reservoirs and other controlled waterbodies can draw down the water level to the point where cyanobacteria accumulations are exposed above the waterline. Subsequent desiccation and/or scraping to remove the layer of cyanobacteria attached to sediment or rock is required, in addition to the reinjection of water into the system.	Easy to implement in controlled systems (i.e., reservoirs, dams, treatment facilities).	Can have a significant impact on other aquatic organisms in the system. May be expensive and requires a significant input of resources.			Not an option as PL can't control in and out flow
Surface skimming	Cyanobacterial blooms often form surface scums, especially in the later stages of a bloom. Oil-spill skimmers have been used to remove cyanobacteria from these surface scums. This technique is often coupled with the implementation of some coagulant or flocculant.	Useful method for blooms that are in later stages and have formed surface scums.	This technique cannot be effectively employed until the later stages of a bloom, at which point many of the harmful aspects of a bloom have materialized. Requires proper equipment prior to implementation.			Possible, but most blooms have cyano specks throughtout the water column and blooms. Would require involvement with NH DES
Ultrasound	An ultrasound device is used to control HABs by emitting ultrasonic waves of a particular frequency such that the cellular structure of cyanobacteria is destroyed by rupturing internal gas vesicles used for buoyancy control.	Successfully implemented in ponds and other small waterbodies. A single device can cover up to 8 acres. Non-chemical; inexpensive.	Also disrupts cellular functioning of green algae. Effectiveness are dependent upon waterbody geometry and cyanobacteria species. Further research of method is required.	Long Pond, MA/NH. Installed 5 in rafts in 2021. Very limited success and if conditions are real strong, the units fail to keep up.	Small 121 acre pond.	One version expensive another cheap. Very visible, but a potential hazard with all the "rafts". No guarantee of working. Would impair recreational use. Removing, storage, install and maintenance an issue. Untested I large lakes. Would require approval from NH DES
Chemical Controls						
Algaecides	Algaecides are chemical compounds applied to a waterbody to kill cyanobacteria and destroy the bloom. Several examples are: Copper-based algaecides (copper sulphate, copper II alkanolamine, copper citrate, etc.); Potassium permanganate; Chlorine; Lime	Wide range of compounds with a history of implementation. Relatively rapid and well-established method. Properties and effects of compounds are typically well-understood.	Risk of cell lyses and the release of toxins. Thus, is often used at the early stages of a bloom. Certain algaecides are also toxic to other organisms such as zooplankton, other invertebrates, and fish.	C4 Canal, Martin County FL	Small water bodies	Copper sulfate used in PL in 1965 & 1967 and thought to have helped but unclear it was direct cause and effect. Short term (weeks) effectiveness. Multiple applications increases cost. Copper builds in sediment can be toxic to aquatic organisms. Would require permitting from NH DES.
Barley straw	Barley straw bales are deployed around the perimeter of the waterbody. Barley straw, when exposed to sunlight and in the presence of oxygen, produces a chemical that inhibits algae growth. Field studies suggest significant algistatic effects. Several causes for the observed effects have been suggested; however, the exact mechanism of this process is not well understood.	Studies have shown that decomposed barley straw inhibits the growth of cyanobacteria *Microcystis sp.*	Does not kill existing algae, but inhibits the growth of new algae. May take anywhere from 2 to 8 weeks for the barley straw to begin producing active chemical. Potential to cause fish kills through the deoxygenation of the waterbody due to decay.			Cheap, would be visible. Possibly put some at inlets in some mesh bags to see if anything happens? Would require approval from NH DES.
Coagulation	Coagulants are used to facilitate the sedimentation of cyanobacteria cells to the anoxic bottom layer of the water column. Unable to access light, oxygen, and other critical resources, the cells do not continue to multiply and eventually die.	Several studies have shown that cells can be coagulated without damage; however, further research is required. Successfully implemented in several treatment facilities.	Subject to depth limitations. Coagulated cells become stressed over time and lyse, releasing toxins to the waterbody.			Probably won't work for long period due to shallow nature of PL. Not stratified. Very costly as well. Would require approval from NH DES.
Flocculation	Flocculants are used to facilitate the sedimentation of nutrients to the anoxic bottom layer of the water column, thereby limiting nutrient levels in the waterbody and inhibiting cyanobacterial growth.	Successfully implemented in larger lakes and ponds.	Subject to depth limitations.	Nippo Lake NH (2021)	Most recent NH lake treated. A little over 50 Acres treated at a cost of approx. $400K. Total lake is 85 acres with a max depth of 54 feet and mean depth of 20 feet. Significant amount of phosphorus came from sediment on bottom.	Probably won't work for long period due to shallow nature of PL. Not stratified. Very costly as well. Looking into an Alum Light option with NH DES. Would require annual applications of light dose to strip nutrients from column. Effectiveness is untested. Permits and approval from NH DES required.
				East Pond, ME - associated with Belgrade Lakes - Lake characteristics similar to PL except deeper- Treatment in 2018 by Virginia-based SOLitude	Bloom free as of 2023; 670 acres treated; 1828 ac lake with max depth 27 ft; mean depth 16 ft; dam controlled, spring feed. 50% phosphorus load from sediment. $1 million for treatment.	
Phosphorus and Water Filter systems (Not on EPA list)	Small Filter; Water filteration plant			Quebec- 8 acre pond- Filter; MN water filteration plant	Experimental filter in Quebec; MN Water filtration plant	Mostly just being studied in university settings. Would require approval from NH DES.