

Pokegama Lake Nanobubble Treatment

Pilot Project findings and why the Interagency Task Force has concerns

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What is the Nanobubble Taskforce?

In early 2025, an interagency team comprised of water quality managers, lake ecologists, clean water specialists, fish biologists, aquatic plant and environmental specialists and hydrologists, known as the Nanobubble Task Force was organized to bring together technical expertise across multiple agencies when evaluating emerging aeration technology, including nanobubbles, and to help guide the State's approach to their potential use in Minnesota's public waters.

Pokegama Lake Nanobubble Treatment- Pilot Project:

In 2025, a nanobubble aeration system was installed in Pokegama Lake to evaluate whether the technology could improve water quality. The system was installed in the shallow northern basin of the lake where Pokegama Creek discharges and water then flows into the main area of the lake (*i.e.*, open water). There is partial separation between the two basins. According to the manufacturer, the nanobubble system delivers extremely small gas bubbles that slowly dissolve into the water column. The distributor submitted a sampling and monitoring plan for the pilot project proposal and selected the northern basin as the treatment area while three open water locations in the main area of the lake served as "control" sites. Monthly water and sediment samples were collected from the two areas between June and October.

Nanobubble Task Force Determination

The stated objectives of the pilot nanobubble treatment from the distributor claimed it would improve water clarity, reduce muck accumulation, lower internal phosphorus loading from the lake sediment, and decrease the severity and extent of algal blooms. We believe that the data is inconclusive regarding the stated goals and objectives in the 2025 study period.

The following is a summary of the key analytical findings from our technical review.

- 1. Study Design:** The Pokegama Lake pilot study had design limitations that prevented the findings from being conclusive. One primary issue is that the treatment area and the control area are incomparable environments. Comparing water quality from sites with fundamentally different depths, nutrient loading, mixing dynamics etc., affect every water quality parameter collected. While this does not invalidate the monitoring data it does not support the claims of observed improvements from the nanobubble treatment.
- 2. Unreported or Inadequately Reported Conclusions:** Some conclusions drawn in the report are inconsistent with the reported data. Where the data and the conclusion point in different directions, those inconsistencies were not acknowledged or explained. Several reported claims cited as evidence of treatment effectiveness could not be verified from the reported data values or were misleading. Some examples include:
 - **Muck Reduction-** The report claimed the muck accumulated 1,544 times more slowly in the treatment area than the control area. The 1,544 number was produced by dividing one larger measurement by another very small measurement, it was essentially zero. Mathematically dividing any value by a near-zero denominator produces a large ratio and this misconstrues the

magnitude of actual change/treatment within the basin. When we evaluated the sediment data directly, the “muck” content in the treatment area was essentially unchanged before during or after nanobubble treatment.

- **Water Clarity:** The report concluded that water clarity declined less in the treatment area than in the control area and claimed evidence of improvement because of nanobubble treatment. When we evaluated the actual measurements, the control area (open water) started significantly clearer than the treatment area (small bay) and remained clearer both during treatment and after treatment ended. However, water clarity did not improve in the treatment area, it was less clear than the untreated control area throughout the study period. The smaller percentage decline (~ 40%) in treatment reflects a lower pre-treatment baseline, not a treatment-induced improvement.

3. Resource Concerns: The pilot study did not produce evidence of lasting improvements in water quality or ecological benefits from the treatment. Many of the water chemistry data returned to pre-treatment conditions the month after the nanobubble system was shut down. This convergence was consistent across parameters and occurred in both the control and treatment areas simultaneously. This pattern is consistent with seasonal lake dynamics rather than a sustained treatment effect.

- **Environmental:** The study was unable to demonstrate that the treatment had no negative impact on the lake's ecology. The report lacked an explanation regarding the mechanisms driving the shift in algal communities and used citations that do not support the mechanisms they are claiming. Because the treatment and control areas were not comparable, it is difficult to determine whether reported changes in water quality parameters and aquatic communities were the result of the treatment, natural variation, or pre-existing differences between the sites.

Why this is difficult. We recognize the difficulties and challenges inherent in lake restoration. Although initial claims indicate the potential for nanobubble technology as a possible solution, the 2025 Pokegama Lake Pilot Project did not demonstrate its promoted effect in this study. Unresolved issues identified in this study must be addressed before any further deployment can be responsibly considered.

Lake systems are complex and influenced by many factors. Lake water quality is complex and can be driven by several factors such as weather, watershed inputs, lake physical characteristics, internal biological processes, seasonal changes, and other processes that vary from year to year. This makes it difficult to isolate the effects of any single treatment. Pokegama Lake's water quality challenges are driven primarily by decades of nutrient and organic matter loading from the Pokegama Creek watershed. No in-lake treatment technology can produce lasting improvement without also addressing those external sources. Watershed-level management is an essential foundation for the restoration and protection of Pokegama Lake.

Emerging technologies require careful and consistent evaluation. New technologies, including nanobubbles, often come with promising claims. These claims must be evaluated using reliable, repeatable data collected under natural lake conditions. It is also important that we verify that the treatments are not harming the lake or its ecosystem. The Task Force supports the use of pilot studies to evaluate these new technologies. A pilot study is most useful if it is designed to answer the question of whether the technology used made significant improvements in the water quality parameters measured, and no impacts to the lake's ecosystem resulted. The Pokegama Lake Pilot Project, as it was designed, had some significant challenges that made it difficult to reach the conclusion that the treatment was effective. The challenges included a treatment and control area that were not matched to allow reasonable comparisons, a short, one-season timeframe, a lack of sufficient baseline data, and reported findings were inconclusive.

Lake associations and communities need clear, unbiased information. Nanobubble systems are actively being marketed to lake associations across Minnesota. This technology is promoted to improve water quality and reduce sediment “muck” accumulation. Based on our review of the 2025 Pokegama Lake Pilot Project, we cannot verify that these outcomes were demonstrated at this time. Lake associations and communities should be able to find and rely on competent scientific studies that demonstrate when a specific technology can deliver consistent, reliable results and avoid harm to the lake and its ecosystem before making significant financial investments.

Nanobubble technology is a significant financial investment. These systems are expensive and will require ongoing operational and maintenance costs over the life of the system. All aeration permits require annual DNR review, and renewal is not guaranteed. Any financial commitment should consider the possibility that continued operation may not be authorized. Any entity considering this technology should carefully evaluate the evidence before committing significant resources that may have little to no benefit.

The regulatory framework is adapting. The Minnesota DNR does not currently authorize nanobubble systems for general use in public waters outside of pilot project proposals. Our shared goal is the long-term health of public waters in Minnesota. While the potential of new aeration technology is on the horizon, our priority is ensuring any lake management treatment is protective of the resource and its ecosystem services. Unfortunately, the data from our recent review is inconclusive on whether these treatments are achieving their stated goals. We will continue to evaluate future pilot projects, determine whether they are appropriate, and what monitoring and reporting requirements are necessary to protect MN waters.