August 14, 2023

City of Lake Elsinore
130 South Main St.
Lake Elsinore, CA 92530

Attention: Mr. Adam Gufarotti

Subject: **Moleaer Nanobubble Technology Assessment Letter**

Dear Mr. Gufarotti,

We have reviewed the proposal, product material, and case studies provided by Moleaer Advanced Nanobubble Technology (Moleaer) and are glad to offer our thoughts on its viability for Lake Elsinore as summarized below.

Lake Elsinore has been plagued by chronic cyanobacteria algal blooms resulting from excess nutrients nitrogen and phosphorus, primarily as a result of internal sediment nutrient recycling. Not only do these blooms release toxins that are harmful to humans, the high algal biomass in the lake causes regular periods of very low dissolved oxygen leading to occasional fish kills. These low oxygen conditions near the bottom of the lake also facilitate the flux of phosphorus from the sediment, thereby continuing and exacerbating the cycle.

The Moleaer technology produces nanobubbles 70-120 nanometers (nm) in size, 2500 times smaller than a grain of salt, that possess special properties due to their size that allow them to stay in solution and react with organic particles in unique ways. Research over the past decade has shown that nanobubbles can have a positive influence on water quality in applications such as wastewater treatment, groundwater remediation, sludge treatment, and surface water improvement given the right environmental conditions[1,2,3,4]. Moleaer also participated in the Lake Elsinore Algal Biomass Reduction Pilot Study performed in Lake Elsinore in the Fall of 2022. A smaller unit supplied with ambient air only was used for this pilot study inside an enclosed mesocosm. This study found that the Moleaer unit was successful at increasing dissolved oxygen and lowering turbidity within the enclosure relative to that observed in the lake outside the enclosures. Nutrient and algae concentrations however remained relatively similar within and outside the enclosure during this pilot study. Algae bloom conditions were extreme during the pilot study increasing the challenge for any technology, and the Moleaer unit was only injecting ambient air as opposed to ozone or oxygen at this time.

Nanobubbles have been shown to improve water quality in surface waters degraded by cyanobacterial algal blooms through several means. Due to their high surface to volume ratio nanobubbles are much more efficient at increasing dissolved oxygen concentrations is the water. This not only benefits the aquatic organisms due to higher dissolved oxygen levels in the water column, but also serves to increase oxygen near the bottom decreasing the flux of phosphorus from the sediment. Nanobubbles can also reduce algal bloom cell densities by oxidizing (lysing) the cell membrane of the algae. This oxidation can be somewhat effective when ambient air nanobubbles are used but is more so when ozone nanobubbles are used.

[1] NCCOS Validates Nanobubble Technology for Remediation of Harmful Freshwater Algal Blooms - NCCOS Coastal Science Website (noaa.gov)
[2] Fundamentals and applications of nanobubbles: A review - ScienceDirect
[3] Applications of micro–nano bubble technology in environmental pollution control - Xiao - 2019 - Micro & Nano Letters - Wiley Online Library
[4] Nanobubble Technologies Offer Opportunities To Improve Water Treatment | Accounts of Chemical Research (acs.org)

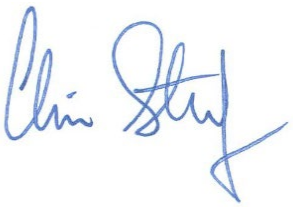
Moleaer proposes to implement two containerized ozone nanobubble generating systems pumping a combined 5,000 gallons per minute to the eastern shore of Lake Elsinore just north of Elm Grove Beach. This system is claimed to deliver 1 kilogram of ozone per hour of operation and treat an approximately 70-acre area of the lake. They also propose to monitor the area of the lake being treated with several buoy data loggers, both prior to and during nanobubble generation, to quantify the impact of the nanobubbles on lake water quality, in addition to mapping potential changes in sediment hardness (i.e., bottom sludge).

Given the recent research and advances in nanobubble technology, the system that Moleaer is proposing for use in Lake Elsinore appears promising with several caveats. Moleaer does note in their proposal that this system is intended to provide "localized" treatment, meaning that for any improvements in water quality or sediment hardness observed, it will likely be limited to the area of nanobubble discharge. From what we know, these types of nanobubble treatment systems have not been utilized on a lake as large as Lake Elsinore, and having a cyanobacterial bloom as dense and chronic as Lake Elsinore. It is possible that given the size of Lake Elsinore, the lake mixing pattern due to frequent high afternoon winds, and known potential for exponential growth of cyanobacteria, that the effectiveness of the nanobubbles may be muted. It will be important to have independent review of the water quality data gathered from the lake during operation of the Moleaer units to determine their effectiveness.

We recognize the demonstrated potential that nanobubbles have to improve water and sediment quality in Lake Elsinore and also the challenges given the size and unique geographic and environmental conditions of the lake. We support the proposed study which we believe has been well thought out with a solid plan to demonstrate effectiveness through monitoring. The project will provide valuable data on the capability of the Moleaer nanobubble technology and its potential for scaling up to more lake-wide use. We also recognize that no single technology even if effective and scaled up, will provide the "magic bullet" that will solely rid Lake Elsinore of algal bloom issues. Based on prior demonstrations and ultimate results of this study we believe the Moleaer technology could play a significant role in a multi-pronged approach that will be needed to sustain the lake in an ecologically healthy condition.

If you have any questions, please contact me at your convenience. We look forward to continuing our work with the City of Lake Elsinore on these important projects.

Sincerely,



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