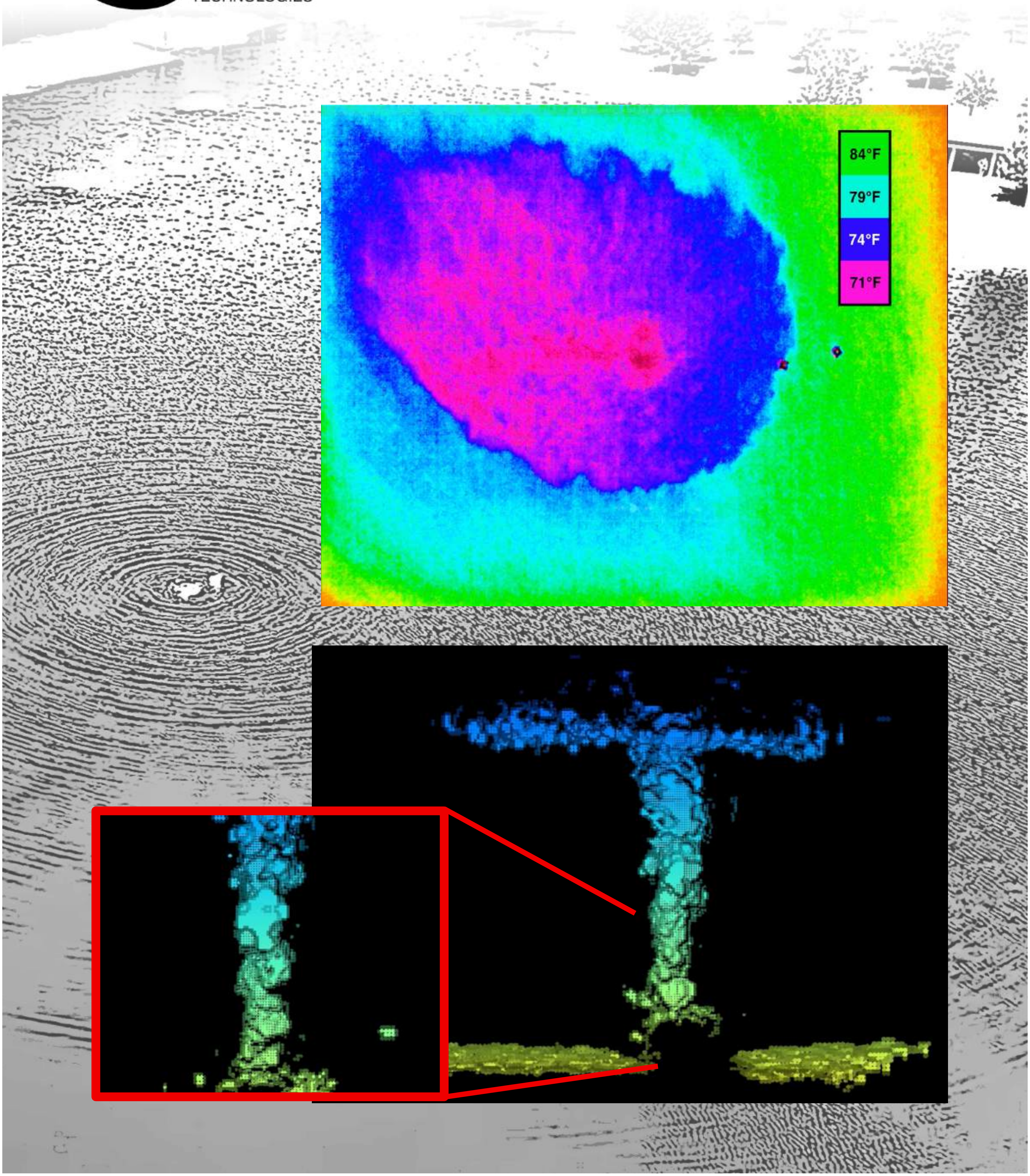
Applying Big Bubble Circulation Pumps and Small Bubble Diffusers Effectively



Study Participants and Roles

Independent Certifying Professional Observer

Bradley Mills, PG
Independent Professional Geologist

Mr. Mills observed all field procedures including instrumentation installation, aeration system operation, and data collection. He is responsible for verifying that the testing methods, instrumentation setup, and field conditions are accurately represented within this report.

Field Operations, Boat Support, and Sonar Operation

Echo Ocean Science LLC

Eddie Majzlik and his team at Echo Ocean Science provided vessel support, assisted with deployment and positioning of field instrumentation, and operated the sonar system throughout each test condition.

Project Sponsor and Technical Team – Big Bubble Technologies, Inc.

Brett Kellgren – President
Jerry Kellgren, Ch.E. – Chief Engineer
John Kellgren – Chief Financial Officer

The Big Bubble Technologies team coordinated study objectives, supplied aeration equipment, and prepared the technical interpretation and narrative of the results contained in this report.

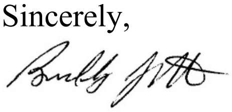
Certification of Testing Procedures and Data

I observed the field testing described in this report including:

- Installation of instrumentation
- Operation of the aeration systems
- Collection of temperature, dissolved oxygen, thermal imagery, and sonar data

To the best of my knowledge and professional judgment the testing procedures, test apparatus, and field conditions are accurately described in this document and the datasets presented herein are a true and accurate representation of the measurements collected during the study.

Sincerely,



Bradley Mills, PG
Independent Professional Geologist

License No.: ______LA #632_____________
Date: ______December 9, 2025___ ________

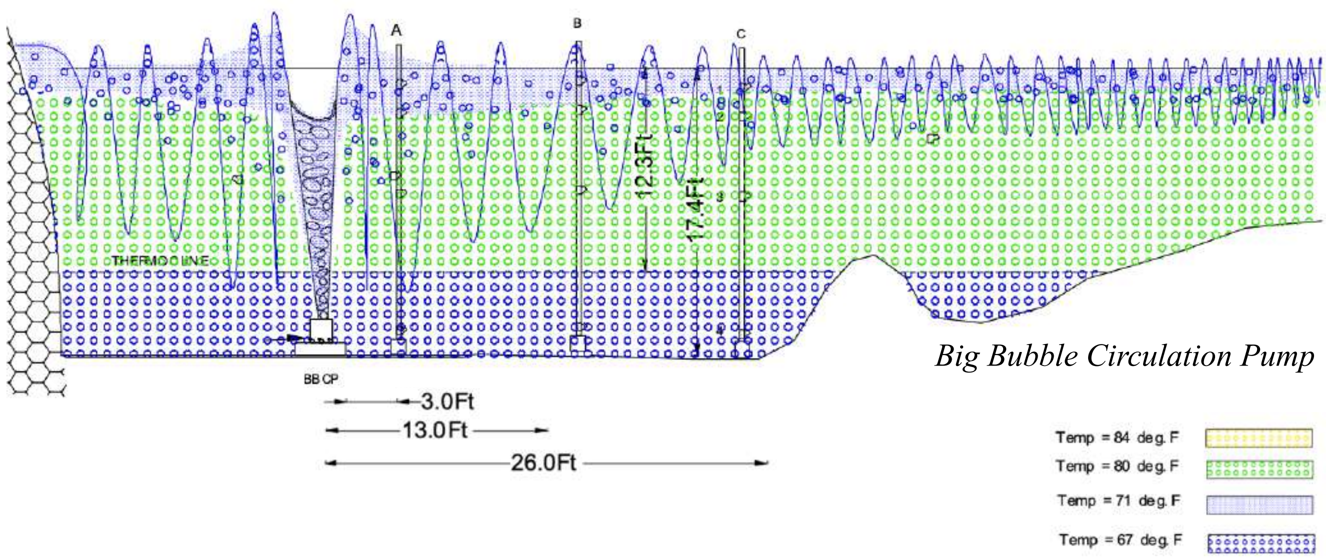
Executive Summary

This study was conducted to validate the performance of the Big Bubble Technologies patented Big Bubble Circulation Pump in a real-world lake environment and to better understand how it complements traditional small-bubble diffuser systems commonly used in pond and lake aeration.

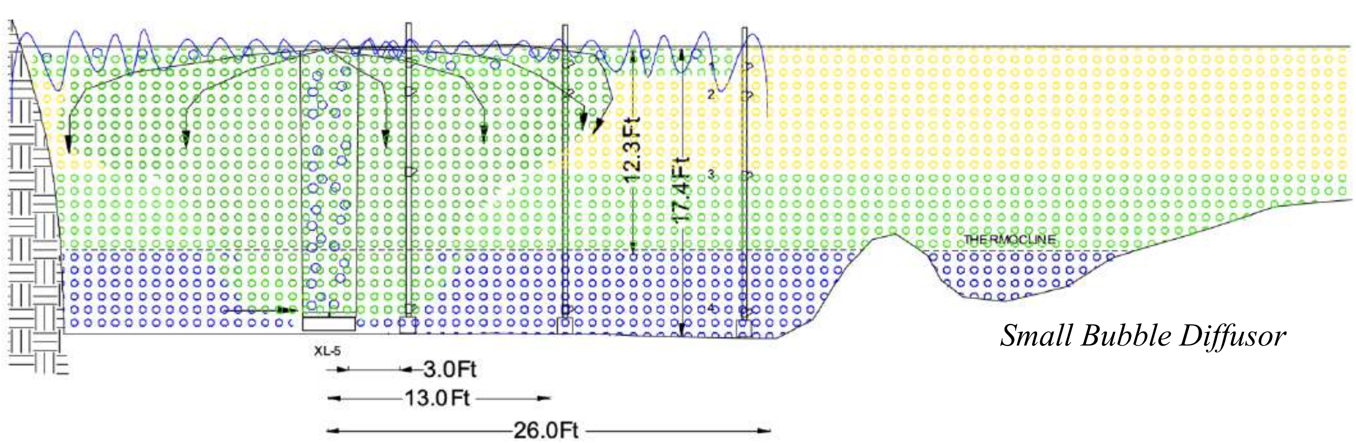
Both systems were evaluated for their influence on circulation patterns, dissolved oxygen distribution, and thermal structure. Testing was conducted at a controlled site using identical compressors, airflow, and airline configurations.

Results demonstrate that each technology plays a distinct and valuable role in lake management. The Big Bubble Circulation Pump supports multi-acre oxygenation and surface exchange through large-scale circulation while the small-bubble diffuser excels at targeted destratification and deep-water oxygenation. When used together the two approaches can form a comprehensive whole-lake aeration system that balances vertical and horizontal oxygenation needs.

The following cross-sectional illustrations summarize the circulation patterns, thermal responses, and areas of influence observed during operation of the Big Bubble Circulation Pump and the small-bubble diffuser. These diagrams integrate temperature data, fixed-position multimeter readings, thermal drone imagery, and sonar-based plume characterization collected during the field study.



Big Bubble Circulation Pump



Small Bubble Diffusor

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Acronyms

BBCP – Big Bubble Circulation Pump

CFM – Cubic feet per minute

DO – Dissolved Oxygen

ORP - Oxidation-reduction potential

PPM – Parts per million. A measure of oxygen saturation

PH – "Potential of hydrogen" and represents the concentration of hydrogen ions in a liquid

PSI - Pounds per Square Inch. How many pounds of pressure (force) are in an area

RGB – Red, green, blue. Format for a standard camera

1. Methodology

1.1. Study Design

Testing was performed to evaluate:

- Temperature and dissolved oxygen (DO) profiles
- Thermal structure, plume geometry, and surface circulation
- Ecological and mechanical implications: water circulation, methods of oxygenation, and stratification

Three conditions were examined sequentially:

1. Control (no aeration present)
2. Big Bubble Circulation Pump Operation
3. Small-Bubble Diffuser Operation

Testing was conducted at a controlled site using identical compressors, airflow, and airline configurations.

Each test phase lasted approximately one hour and thirty minutes during which all sensors operated continuously at identical depths and intervals.

1.2. Test Site

The study was conducted at a private, ten-acre lake in Gordonville, Texas with depths ranging from 8-17 ft. This lake was originally designed, constructed, and consulted on by Bob Lusk and Mike Otto (Otto, M., & Lusk, B. (2016–2017). *Building Gordonville Parts I–III.* Pond Boss Magazine.).

This site was selected for its stable hydrology, defined seasonal thermocline, and access to power for continuous operation. The lake's size and depth profile provided optimal conditions to observe both localized destratification and multi-acre surface circulation effects.

1.3. Multimodal Analysis

Fixed-position multimeters (optical DO sensors) collected data at multiple depths mounted on a weighted vertical instrument pole to maintain alignment and stability in the water column. (*see 3.1. Instrumentation: Fixed-Position Multimeters*).

A handheld multimeter (electrochemical DO sensor) with a 25-foot cable was used to measure temperature (Temp.), dissolved oxygen (DO), pH, and oxidation-reduction potential (ORP) for calibration verification and spot sampling during testing as a reference. (*see 3.2. Instrumentation: Handheld Multimeter*)

Thermal Drone (Light-Based Imaging) Thermal imagery was recorded using an RGB thermal drone to observe surface temperature variations, surface water movement, ripple-field formation, and large-scale circulation patterns. (*see 3.3. Instrumentation: Thermal / RGB Drone*)

Sonar Imaging (Sound-Based Analysis) 3D sonar scans using reflected sound waves were collected during the active operation of each aeration system to visualize bottom-to-surface water movement, ripple propagation, subsurface plume geometry, and vertical recirculation patterns. (*see 3.4. Instrumentation: Sonar Imaging*)

Data from all three methods were synchronized and analyzed collectively to evaluate overall aeration effectiveness and to characterize how circulation, subsurface oxygenation, atmospheric oxygenation, thermal response, and ripple propagation can be optimized by using each aeration method in combination where it best addresses site-specific conditions.

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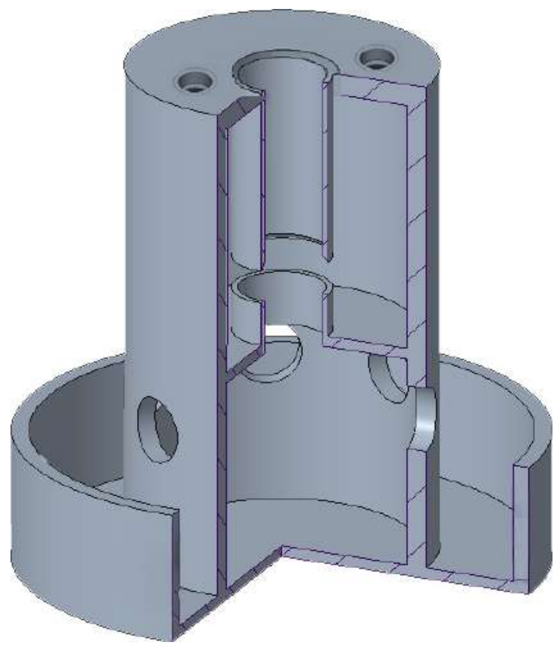
2. Aeration Systems

2.1. Big Bubble Circulation Pump

Big Bubble Technologies patented 14” Big Bubble Circulation Pump. Air is released from a single 4-inch chamber producing sequential 5-inch bubbles which expand further as they accelerate to the surface. 2.5 minimum CFM



2.2. Small Bubble Diffusor

Vertex XL5 AirStation Aeration Diffusers: Five 9" diameter flexible EPDM membrane diffusers arranged in a quincunx pattern, each producing millions of fine 500 to 3000-micron bubbles. 2.5 minimum CFM

2.3. Compressors and Airlines

Two 3/4 HP Brookwood compressors operating at 230 V, 5.4 CFM, 25 Max PSI within a QuietAir cabinet, cooled by two 290 CFM fans.

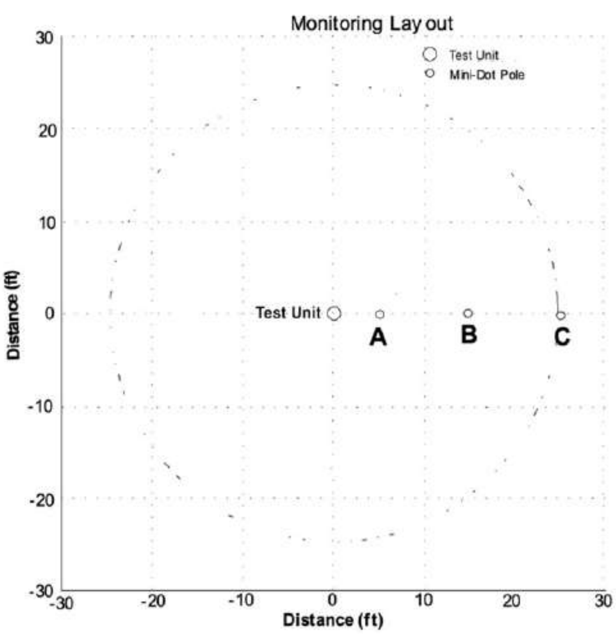
Airflow was delivered through 700 ft of weighted 5/8-inch airline.

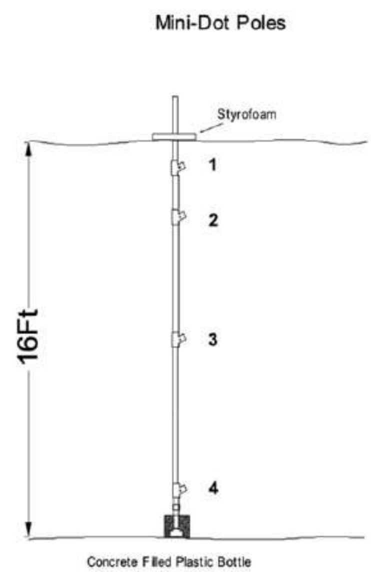
3. Instrumentation

3.1. Fixed-Position Multimeters

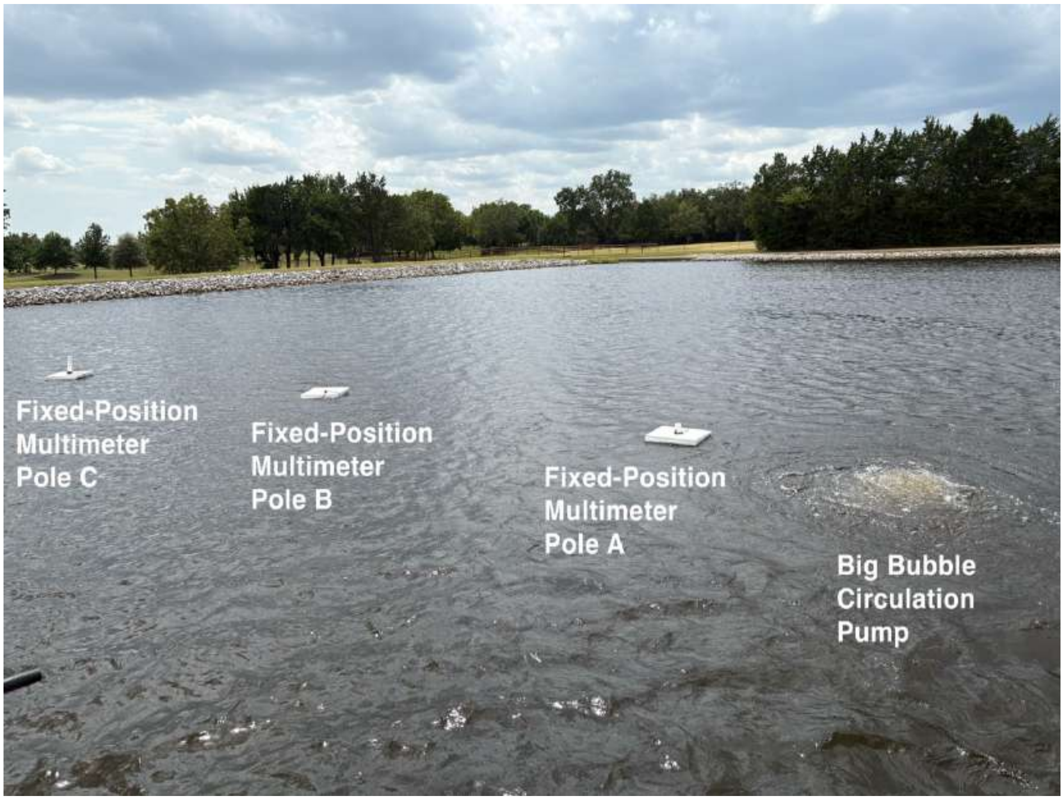
PME miniDOT dissolved oxygen and temperature loggers were continuously operated while mounted on instrument poles.

Instrument poles were positioned surrounding the test units, with each pole stabilized by a weighted anchor and a surface foam float. Each pole held 2-4 miniDOT loggers spaced along a 16-ft vertical profile to measure temperature and dissolved oxygen. The poles were arranged at various distances from the test units for consistent multi-depth data collection.



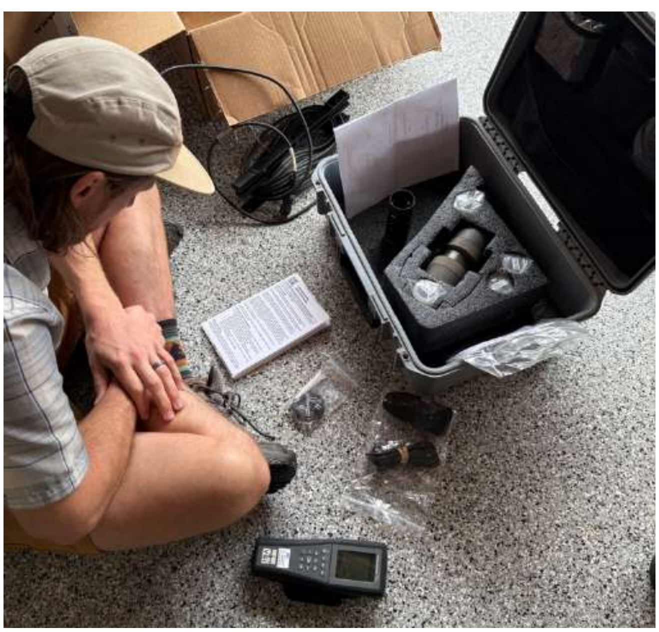


Field Note on Sensor Positioning: It is noted that due to dynamic environmental factors there is some slight variation from the nominal distances of 3ft, 13ft, and 26ft radii for the fixed-position pole placement



3.2. Handheld Multimeter

A YSI Pro Plus Quatro pH/ORP/Cond/Temp/DO handheld multimeter was used to corroborate fixed-position multimeter readings and to conduct manual measurements directly within the aerator bubble columns.



3.3. Thermal / RGB Drone

DJI Mavic 3 Enterprise Thermal (and RGB) Drone for visual and thermal surface imagery.

RGB Sensor: DJI Mavic 3E: 4/3 CMOS, Effective pixels: 20 M, 4K: 3840×2160@30fps
Thermal Sensor: Uncooled VOx Microbolometer, 640×512@30fps

3.4. Sonar Imaging

Coda Octopus Echoscope 3D Sonar for plume visualization and characterization of vertical/horizontal movement.

4. Observations

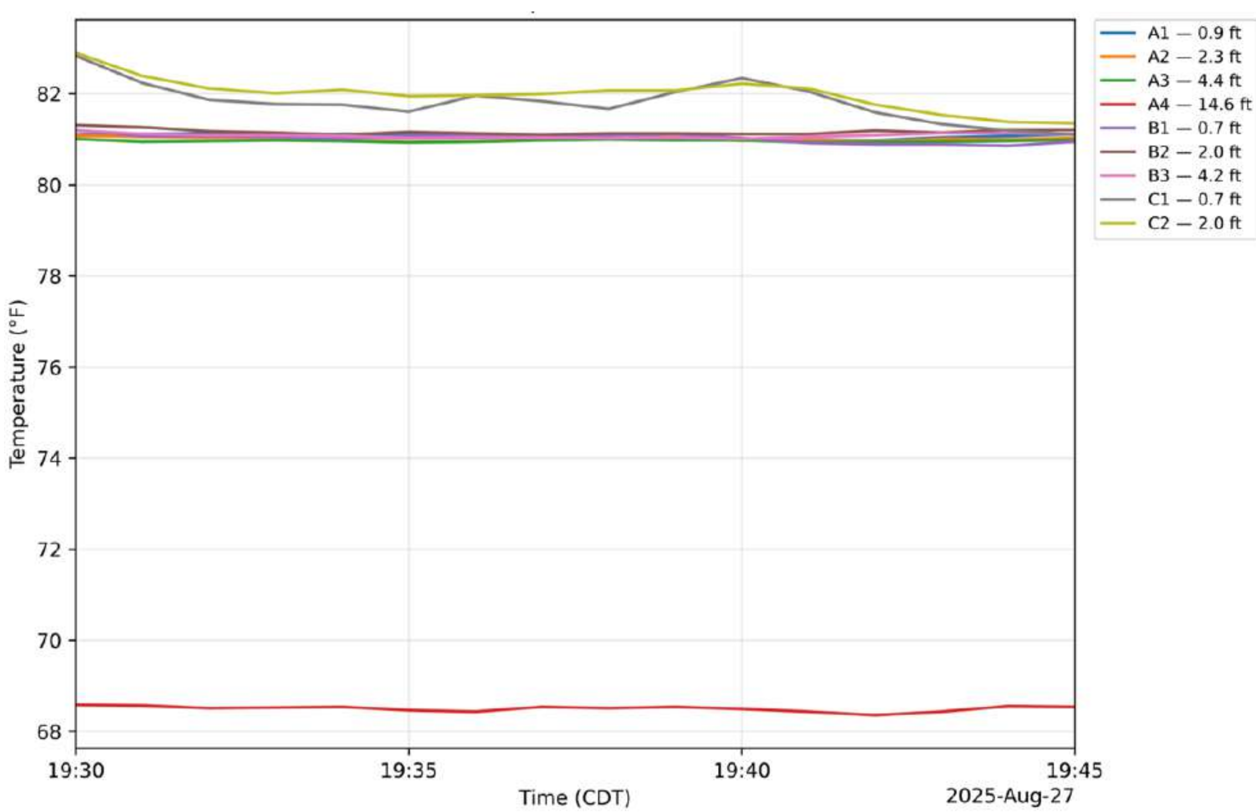
4.1. Control (no aeration present)

Handheld multimeter readings taken one foot below the surface:

- **Temperature:** 81°F
- **Dissolved Oxygen:** 5.1 ppm
- **Oxidation-Reduction Potential:** 179 mV
- **pH:** 6.4

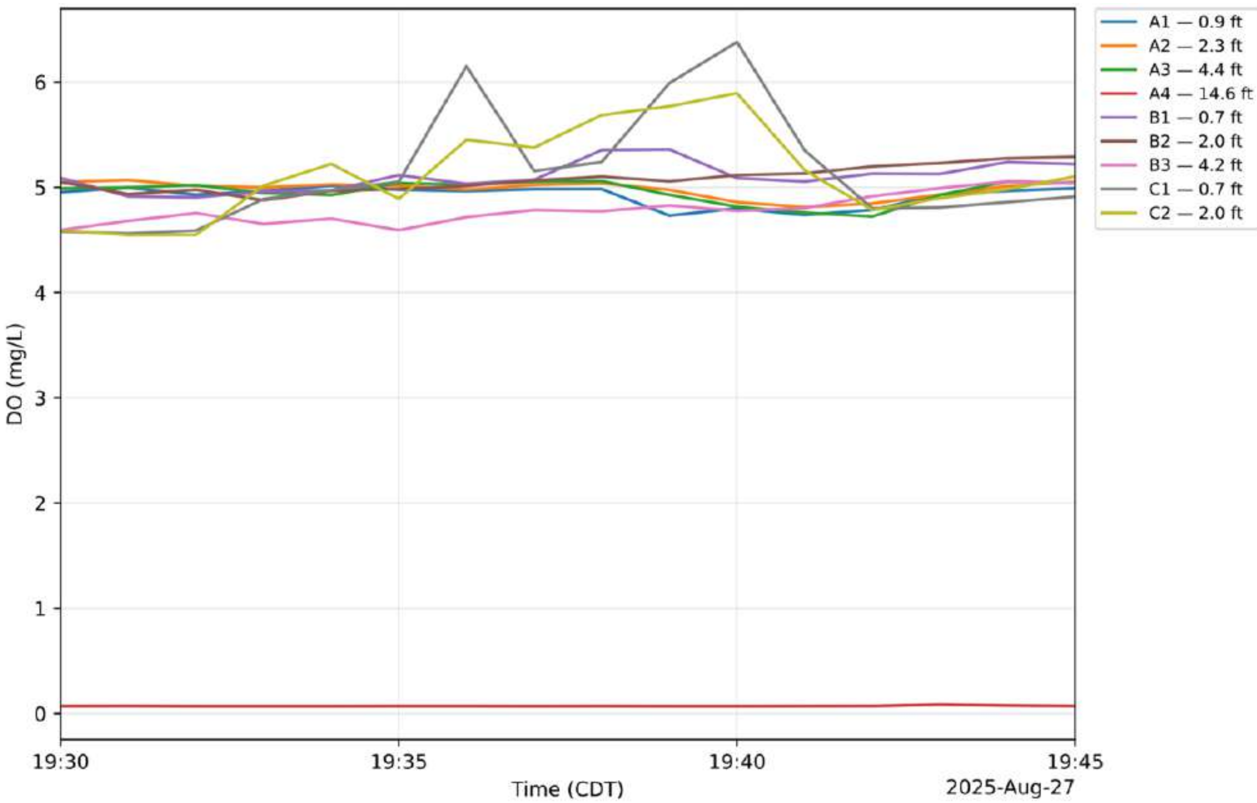
Fixed-position multimeters A1–C2:

- **Temperature:** Stratified layers—surface 82–84°F, thermocline at ~12–14 ft, bottom 67°F.



Fixed-position multimeters A1–C2 (continued):

- **Dissolved Oxygen:** Upper layers ~5 mg/L; bottom (A4) anoxic (<0.5 mg/L).



- **Water Movement:** Stable stratification; no vertical or horizontal mixing observed.

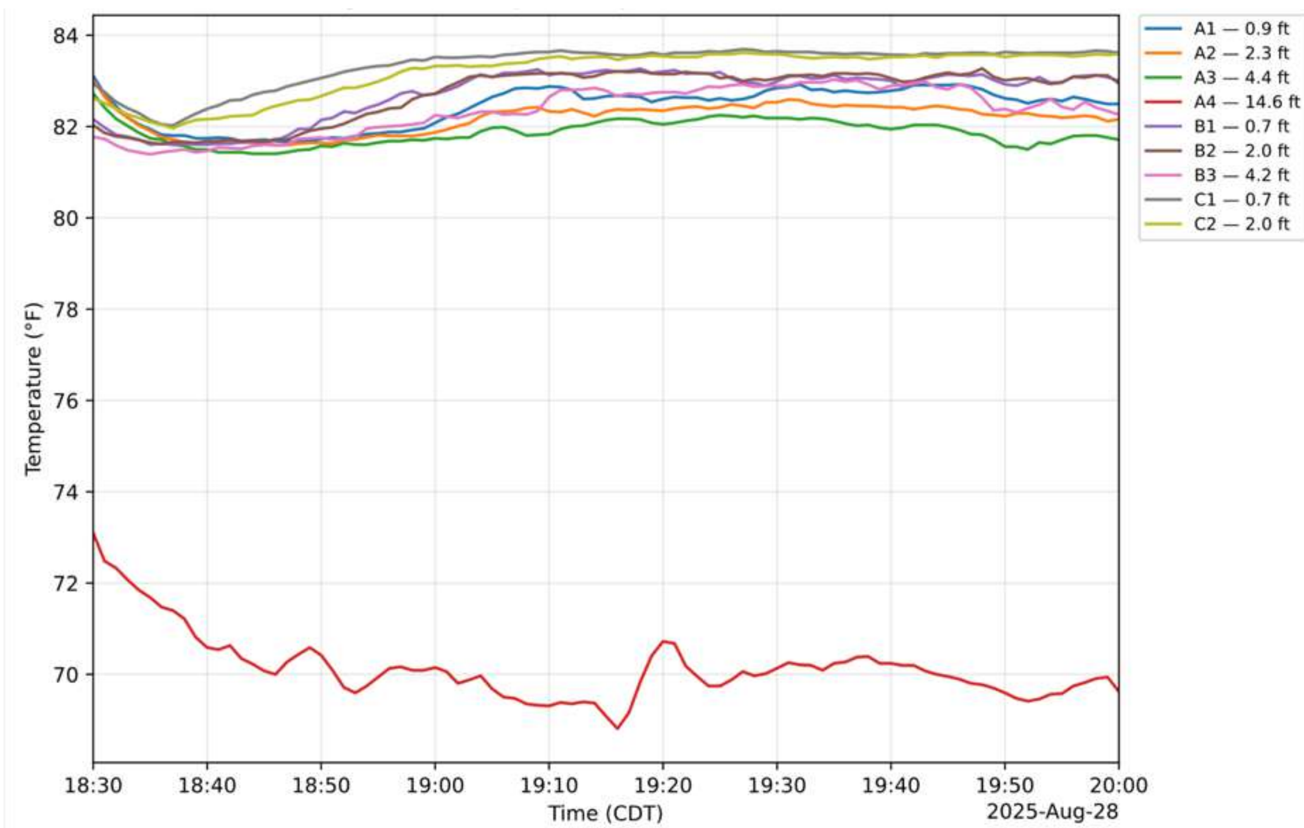
4.2. Big Bubble Circulation Pump Operation

Handheld multimeter readings taken one foot below the surface within the bubble column:

- **Temperature:** 71°F
- **Dissolved Oxygen:** 1.1 ppm
- **Oxidation-Reduction Potential:** 23 mV
- **pH:** 6.5

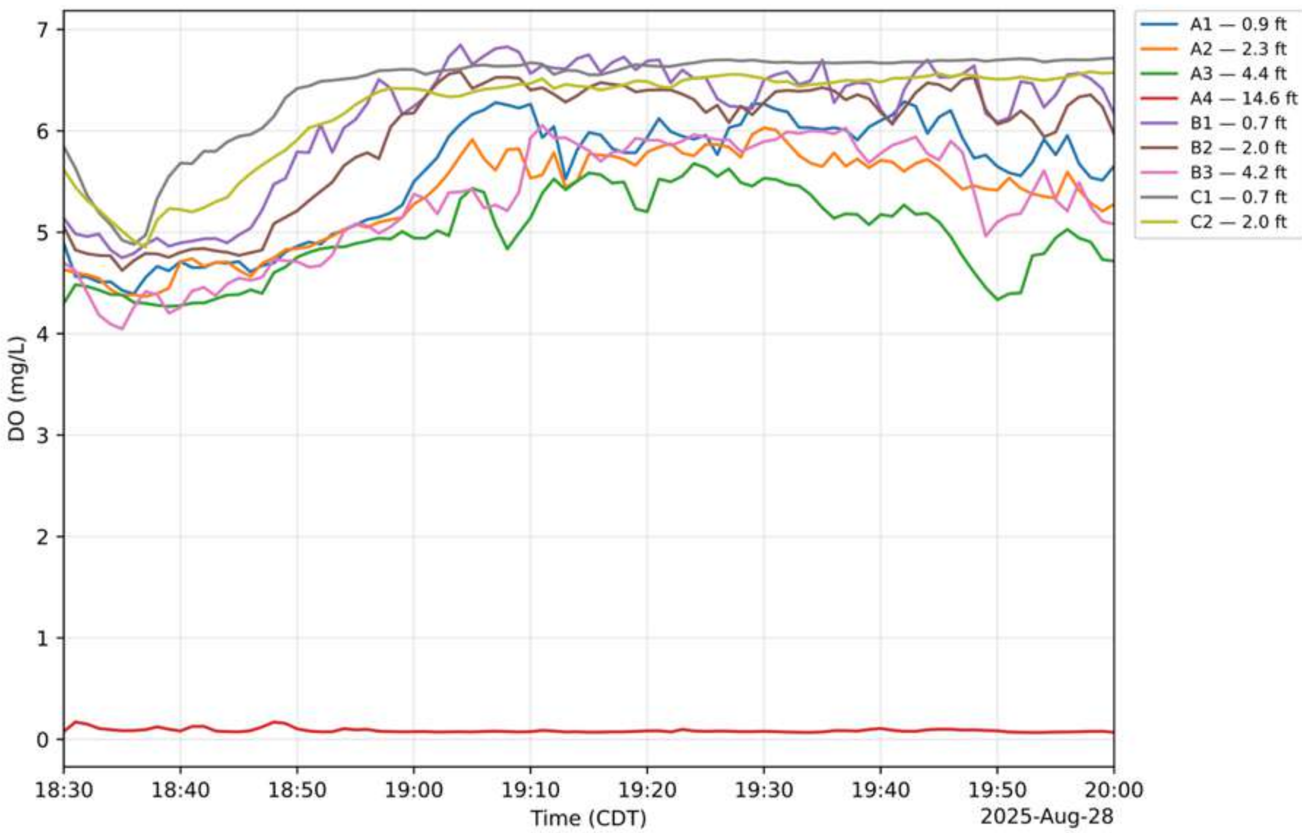
Fixed-position multimeters A1–C2:

- **Temperature:** Minimal change across all fixed-position multimeter locations. Bottom temperature remained stable (69–70°F) indicating no destratification. The thermocline remained intact

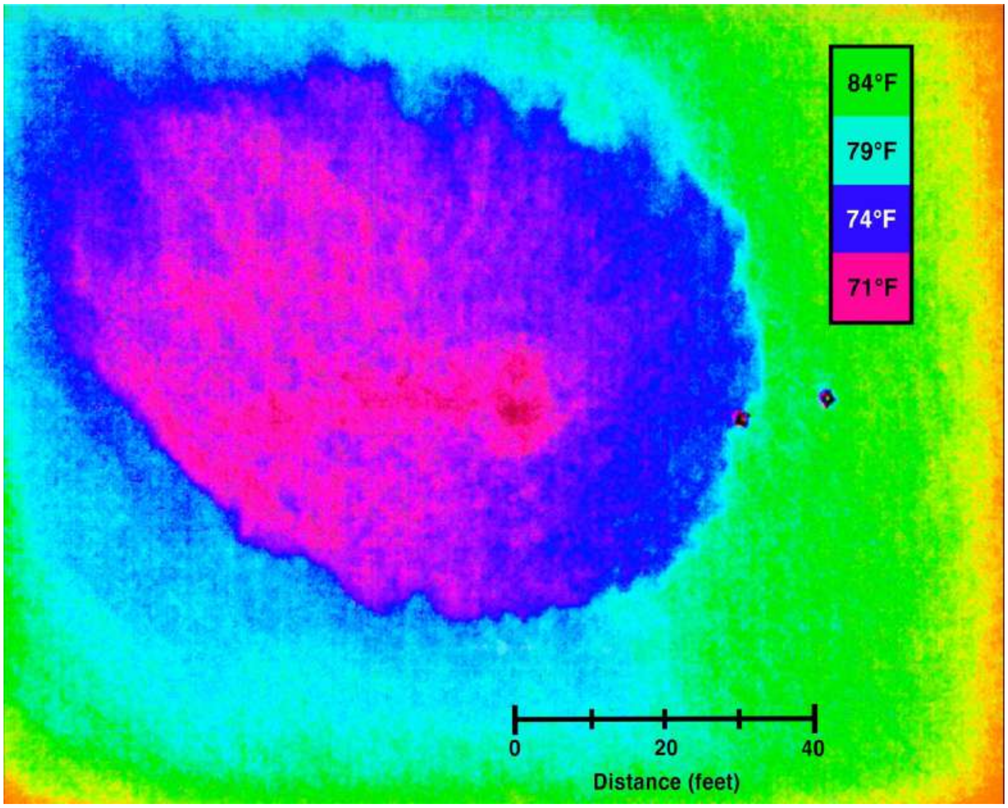


Fixed-position multimeters A1–C2 (continued):

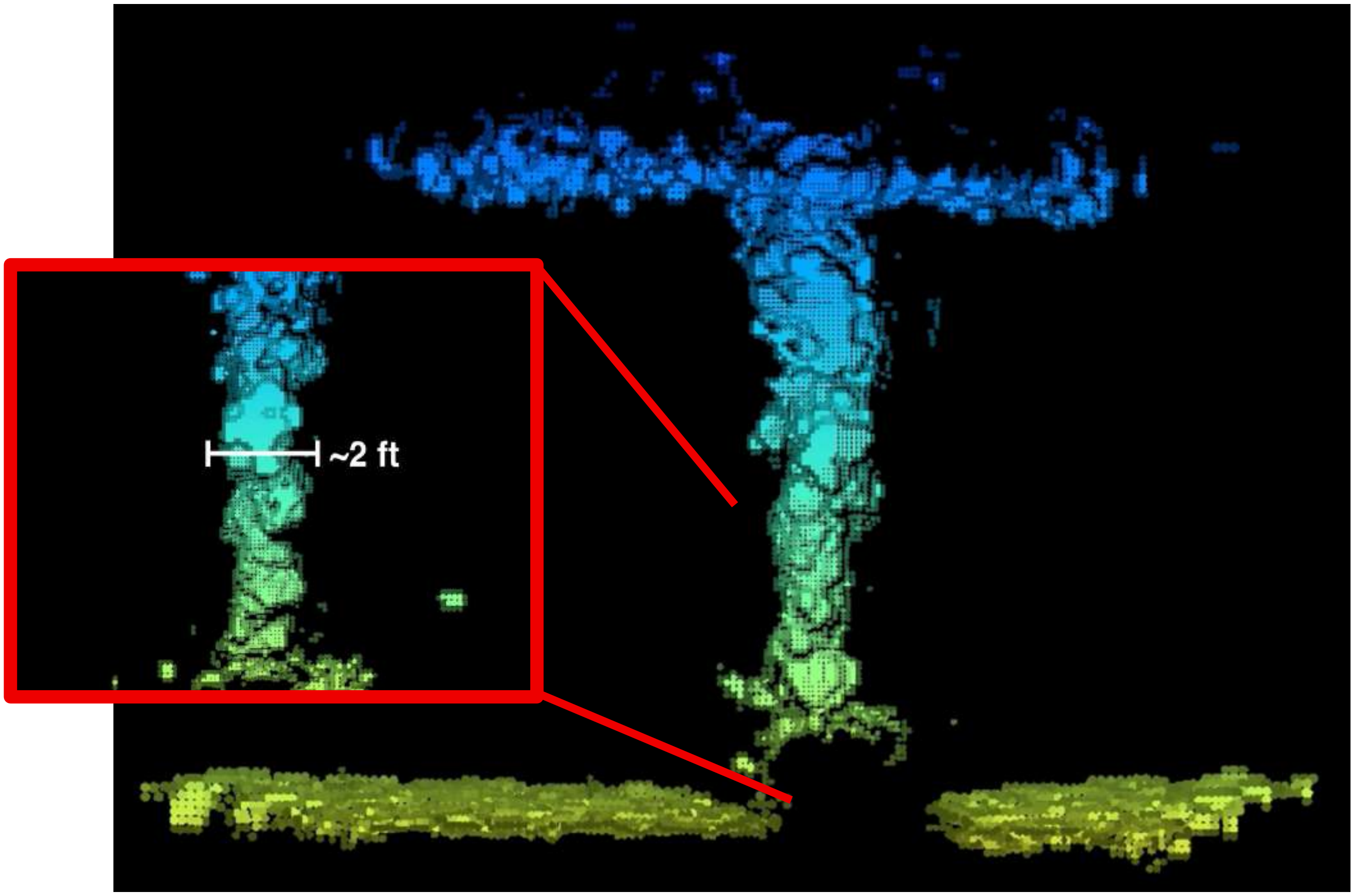
- **Dissolved Oxygen:** Uniform increase across all monitored sites (e.g., from ~4.5 to ~6.5 mg/L) indicating broad horizontal oxygenation via surface exchange.



- **Thermal / RGB Drone:** Large ripple field (>100-ft radius). Large smooth cold region with uniform pink (~71°F) and blue (~74 °F) and gradients. The consistent coloration suggests low thermal variability and stable cooling conditions. The 71°F temperature of the pink area indicates cold bottom water being pumped to the surface.



- **Sonar Imaging:** Narrow column of large bubbles with minimal side entrainment generating strong lateral surface spreading and horizontal circulation.



- **Water Movement:** Bubbles rising through the water create surface-lifting turbulence measuring 5-7 inches above the water creating a piston effect that generates deep ripples of unmixed cooler bottom water extending beyond 100 feet. This motion sustains broad surface agitation and enhances direct oxygen absorption from the atmosphere.

Conclusion: The Big Bubble Circulation Pump creates significant horizontal surface movement and agitation which promotes atmospheric oxygen absorption over a wide area without vertically mixing the water column. Dissolved oxygen levels at the fixed-position sensors showed significant increases across the monitoring zone while measurements directly within the bubble column remained low indicating cold low-oxygen water being pumped from the bottom to the surface.

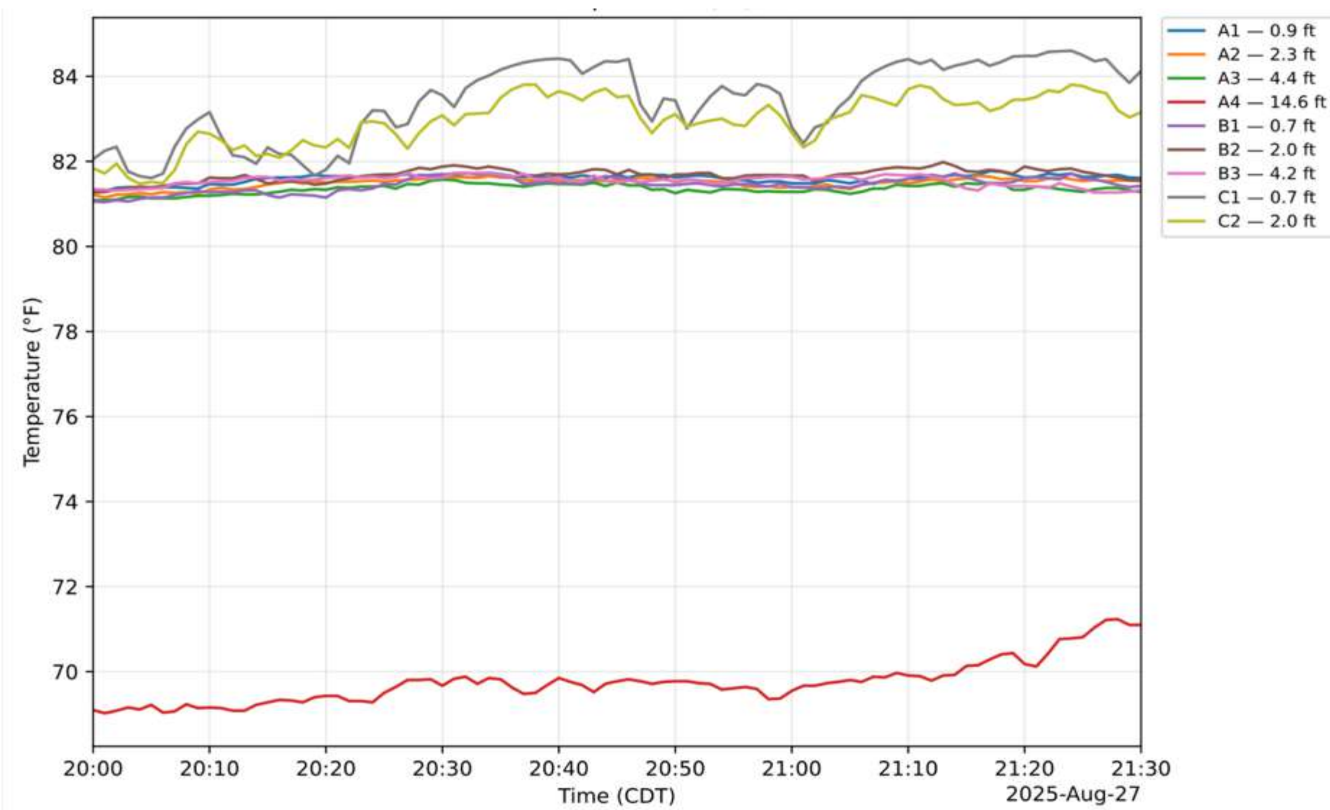
4.3. Small-Bubble Diffuser Operation

Handheld multimeter readings taken one foot below the surface within the boil:

- **Temperature:** 81°F
- **Dissolved Oxygen:** 6.9 ppm
- **Oxidation-Reduction Potential:** 392.5 mV
- **pH:** 6.4

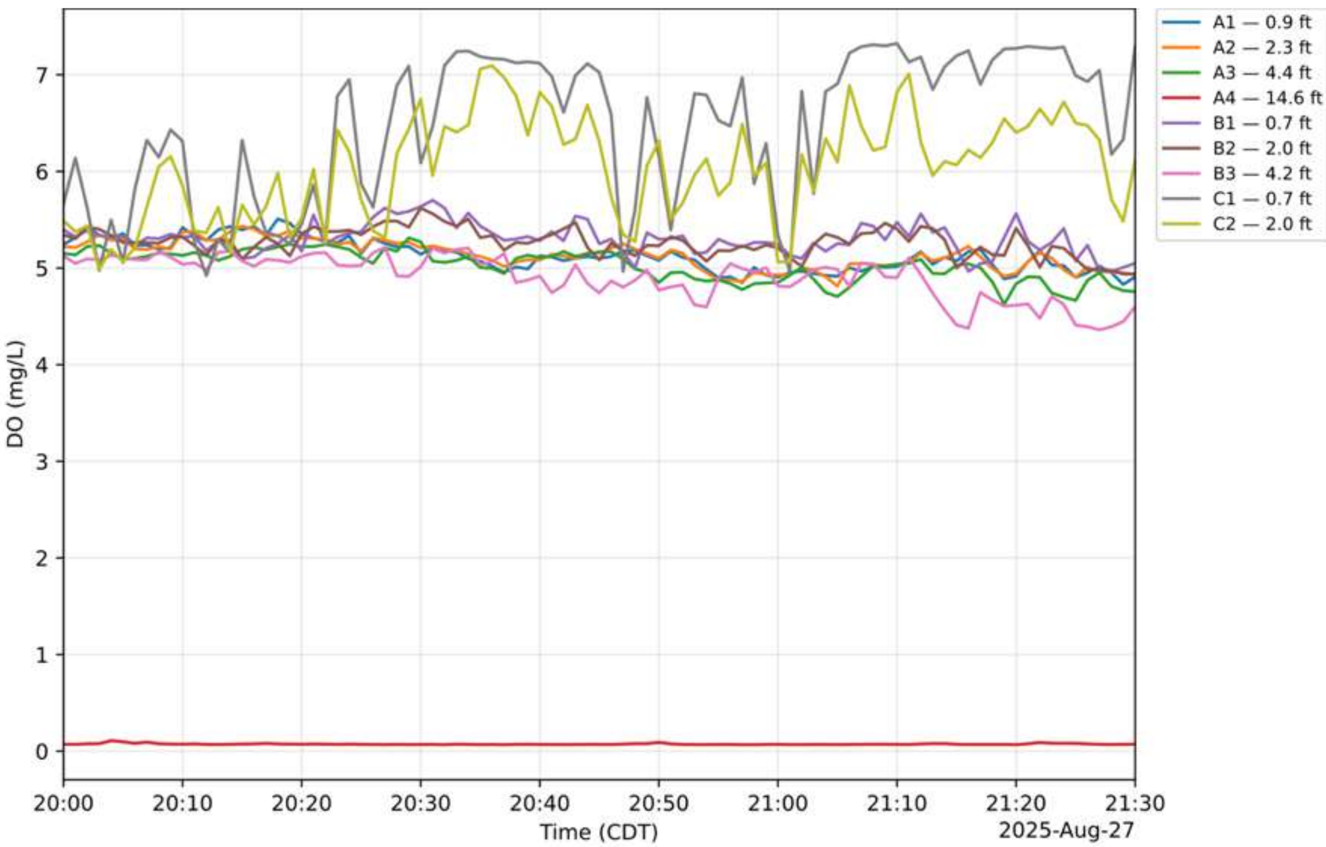
Fixed-position multimeters A1–C2:

- **Temperature:** Minimal to no change across fixed-position multimeters A1-A3, B and C. Bottom temperature (A4) increased from 68.5°F to 71.5°F indicating destratification as warmer surface water mixed downward.

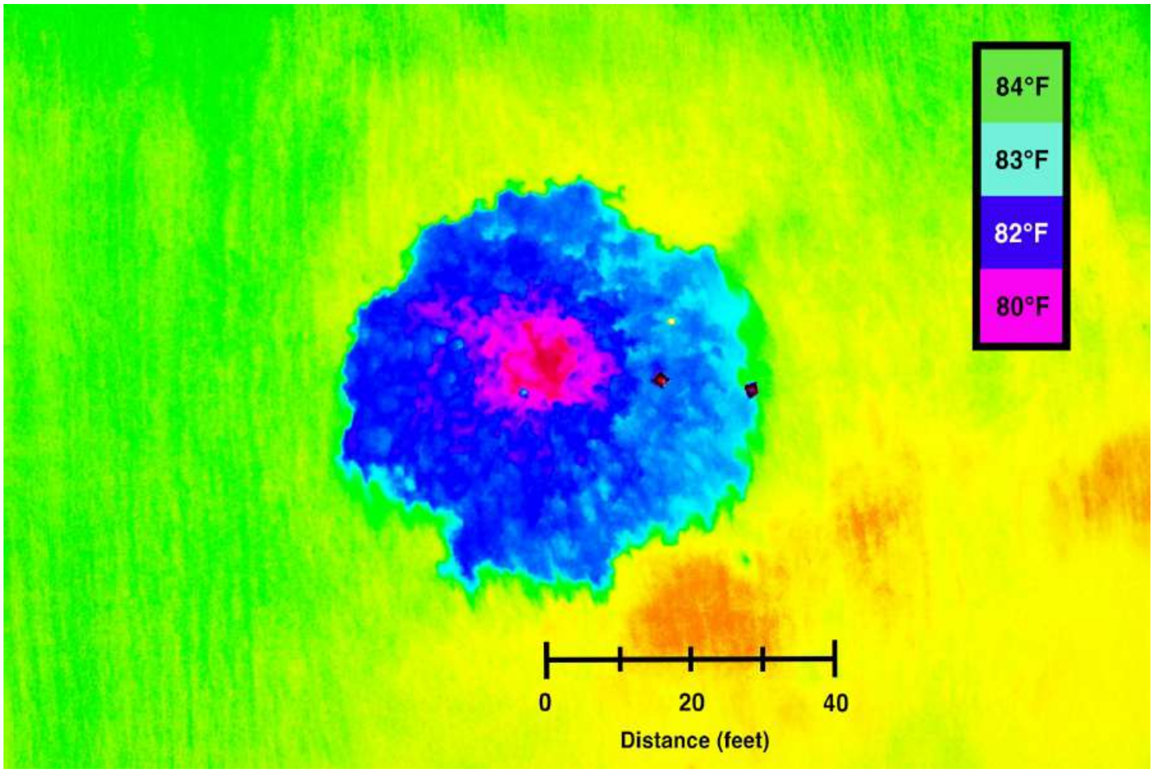


Fixed-position multimeters A1–C2 (continued):

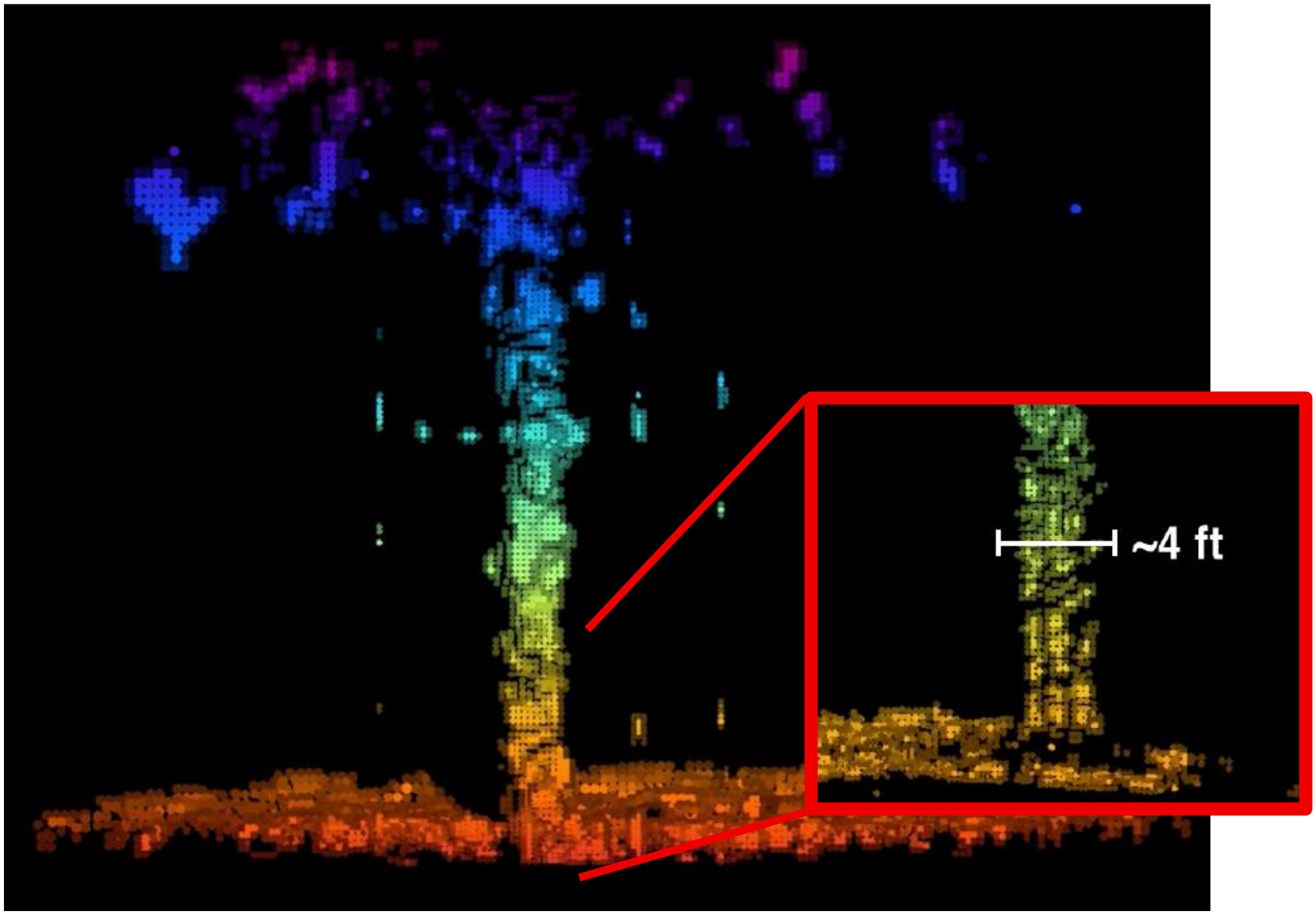
- **Dissolved Oxygen:** Fixed-position multimeter distances A (~3 ft) and B (~13ft) showed minimal change throughout the test period indicating limited influence from the diffuser's fountain-like plume. In contrast, fixed-position multimeters at location C (~26 ft) recorded sporadic increases in dissolved oxygen consistent with surface ripple effects.



- **Thermal / RGB Drone:** Localized boil (~5 ft radius) with ~20 ft surface spread. Small fragmented cold area with visibly splotchy and pink (~80 °F) and blue (~82 °F) regions. The uneven texture indicates high thermal variability and mixing present. The 80 °F pink core indicates that a limited amount of cold bottom water is being entrained into the vertically mixing column and blending with the surrounding warmer (~81–84 °F) water.



- **Sonar Imaging:** Wide column with upward entrainment with a local return downflow and minimal lateral surface spreading (the "fountain" effect).



- **Water Movement:** The "fountain" effect produces a concentrated "boil" within a 5-foot diameter core with diminishing ripples extending 20–30 feet. These smaller ripples create patchy mixing zones where pockets of cold oxygen-absorbing water are dispersed among warmer surface water resulting in limited and localized atmospheric gas exchange.

Conclusion: The small-bubble diffuser creates vertical mixing and effectively destratifies thermal layers. Dissolved oxygen levels at the fixed-position multimeter locations showed minimal change with a significant increase observed within the bubble column itself which is consistent with localized oxygen transfer from dissolving bubbles.

5. Conclusion of Observations

The observations from thermal imagery, sonar, fixed-position loggers, and handheld measurements show that the Big Bubble Circulation Pump and the traditional small-bubble diffuser influence lake conditions in different but complementary ways. Each system interacts with the water column through distinct physical mechanisms that shape how temperature, dissolved oxygen, and circulation respond during operation.

The Big Bubble Circulation Pump acted primarily as a horizontal circulator driving broad-area atmospheric oxygen absorption. Its large sequential bubbles formed a narrow vertical column with minimal entrainment while preserving stratification throughout the testing period. The upwelled water produced a wide surface layer that spread cold bottom water outward more than 100 feet with extensive ripple fields continuing across multiple surface acres. This oscillating movement enhanced atmospheric oxygen absorption resulting in consistent wide-area increases in dissolved oxygen without altering the thermal structure. These findings highlight the pump's utility in systems where maintaining stratification is desirable such as during warm seasons or where dispersed horizontal oxygenation and surface cooling are management priorities.

In contrast, the small-bubble diffuser demonstrated its characteristic role as a vertical mixing and destratification tool. Its plume entrained deeper water upward while simultaneously drawing warmer surface water downward. This produced measurable mixing in the lowest fixed-position multimeter positions and a rise in bottom temperatures indicating the early stages of destratification. Oxygenation near the diffuser was concentrated within the plume itself with limited horizontal influence beyond roughly 20-30 feet. These results reflect the diffuser's strength in localized mixing, deep-water oxygenation, and addressing anoxic bottom layers particularly in systems where breaking the thermocline is an intended management strategy.

These two systems illustrate a spectrum of aeration strategies:

The Big Bubble Circulation Pump excels at large-scale surface exchange, horizontal circulation, and broad distribution of oxygen without disturbing thermal layers.

Small-bubble diffusers are well suited for targeted destratification, deep-water oxygenation, and localized improvement of bottom conditions.

The study reinforces that no single system addresses all lake management needs. Instead, each approach contributes meaningfully to different ecological and operational goals. When used together they can form a comprehensive whole-lake aeration program. This complementary use of technologies allows managers to balance vertical and horizontal mixing, tailor oxygenation strategies to seasonal conditions, and support long-term ecological stability.

6. Operational Considerations and Maintenance

The Big Bubble Circulation Pump and Small-bubble diffusers together can create a complementary approach, but when operated on the same manifold it is important to consider the pressure drop differences. The small-bubble diffusers typically operate with around a .5-5 PSI pressure drop which can vary depending on biofilm buildup, water depth, and diffuser condition. In contrast, the Big Bubble Circulation Pump is designed for minimal blockage generally resulting in a negligible pressure drop of about 0.1 PSI.

A flow meter or valve adjustment should be used while visually inspecting the bubble output to maintain balanced airflow when systems share a common supply line. This ensures proper air distribution and consistent performance across varying depths and line lengths.

Maintenance frequency in a hybrid system largely depends on the ratio of small-bubble diffusers to Big Bubble Circulation Pumps.

The Big Bubble Circulation Pump has a simple open design with no moving parts and minimal potential for organic material buildup or blockage. Therefore, systems weighted more heavily toward small-bubble diffusers require more regular inspection, cleaning, and replacement cycles.

In contrast, as the number of small-bubble diffusers increases, so does the likelihood of organic plugging, membrane fatigue, hole formation, or mechanical failure over time. Each diffuser represents a potential point of restriction or damage that can alter airflow balance across the system.