Lina Upham
Purchasing & Risk Manager/Deputy City Clerk
City of Marco Island, 50 Bald Eagle
Marco Island, Florida, 34145
lupham@cityofmarcoisland.com

March 31, 2023

Subject: Request for Information (RFI) related to the best value technology methods to improve water quality and/or increase dissolved oxygen in the Marco Island waterways (canals).

Florida Keys Aeration, along with partners Naturalake Biosciences and Gantzer Water LLC, is pleased to submit this request for information (RFI) related to the best value technology methods to improve water quality and/or increase dissolved oxygen in the Marco Island waterways (canals). Our team's approach is to provide a well-engineered, scientifically sound system that will solve low-oxygen issues and all oxygen-derived water quality issues.

With that said, we believe a marine version of oxygen saturation technology (OST) made by Naturalake Biosciences, engineered by Dr. Paul Gantzer, is the technically preferred approach to Marco Island Canal systems. Oxygen levels are automated (system turns on or off) based on a programmed-in-canal oxygen range of, say, 12-15 mg/L dissolved oxygen (DO) right at the sediment-water interface and in the bulk water. This in-canal automation provides substantial electrical savings (only operating when needed). Live tracking of oxygen conditions in the canal ensures performance and when maintenance is needed. OST is a simple modular design and can be scaled up to handle any size canal. The higher oxygen levels the system achieves will provide the best water quality results for the Marco Island Canal systems.

We hope the following submission is informative and delivers a comprehensive explanation of our team's expertise in water quality/oxygen management knowledge.

Please contact us with any questions.

Sincerely,

Our Team:

Scott Gardner
Florida Keys Aeration
Ph: 786-548-7703
info@flkeysaeration.com
www.flkeysaeration.com

Patrick Goodwin M.S., CLM
Technical Sales Consultant

PO Box 8682 | Madison, WI 53708
Patrick.G@naturalake.com
naturalake.com
O: 888.757.9577
C: 904.434.6799

"Safer water and better lives through pioneering biosciences"

Paul Gantzer, Ph.D., P.E.

163 Rainbow Dr. #6331
Livingston, TX 77399
cell: 206.999.1878
www.gantzerwater.com
Paul.Gantzer@gmail.com

What level of oxygen is needed in the Marco Island Canals?

Oxygen is arguably the most important water quality parameter governing overall canal health. It's required to sustain aquatic life and is directly related to a multitude of water quality parameters and overall aesthetics. The United States has national and state dissolved oxygen (DO) criteria for aquatic and marine life, which are centered around maintaining the minimum amount of DO to sustain life. For example, the United States Environmental Protection Agency (USEPA) DO criteria for aquatic and marine life is: "DO Shall not average less than 5.0 mg/L in a 24-hour period and shall never be less than 4.0 mg/L.". Many states have adopted this criterion, including Florida. Some changes have been made by the Florida Department of Environmental Protection (FDEP) to account for naturally occurring low DO regions and switched from mg/L to percent saturation. However, these changes further lower the oxygen minimums. When water is managed to the minimum, you can expect minimum results. The original studies done during the clean water acts of the 1970s (where our national DO criteria were derived) show that managing DO levels to this minimum of 5 mg/L DO provides moderate production impairment to aquatic and marine life. These same impacts are true for water quality and aesthetics. We should be managing not to the minimum DO levels but rather to the desired DO levels. If we are to assign the desired DO level to a water body, we must first define it based on its effect on a given parameter. Two definitions can be identified based on 1) aquatic life and 2) water quality and aesthetics, which are as follows:

1) **Desired DO for marine life** - is the level at which no production impairment occurs across all life.

   The United States Environmental Protection Agency (USEPA) has established the desired DO level for aquatic and marine life, and it is 6.5 mg/L for non-salmonid water (warm water fisheries), However, 6.5 mg/L does not protect the invertebrates that are also present, and therefore 8 mg/L applies as the desired DO for marine life in Marco Island Canals.

2) **Desired DO for water quality and aesthetics** – is the level at which the maximum reduction in pollutant(s) can be achieved that is not detrimental to aquatic life.

   The higher the oxygen level, the better the water quality and aesthetics. This is because a higher oxidative state drives better water chemistry and allows for more oxygen penetration downward into lake sediments, often the primary source of water quality issues in the first place. If we are to keep with the desired oxygen definition, the level at which the maximum reduction in pollutant(s) can be achieved that is not detrimental to aquatic life; then it would be between 15 – 25 mg/L DO, not exceeding 25 mg/L to ensure no oxidative stress will occur to aquatic life (Colt 2006). Setting DO to these levels would provide the maximum water quality improvements and reduce/eliminate:

   - Harmful Algae Blooms (HABs)
   - Phosphorus re-cycling from the sediments
   - Ammonification from sediments
   - Metal like iron, manganese, and mercury re-cycling from the sediments
   - Organic muck decomposition
   - Taste and Odor

- Aesthetics water clarity and color
- Fecal Coliform

Adding oxygen to water and achieving desired DO levels:

There are several methods employed to combat low oxygen levels and oxygen-related water quality issues. Although there are several water quality management strategies that are designed to add oxygen to the water column, there are only four main types of systems: 1) air-lift aerator, 2) mechanical axial pump, 3) direct gas sparging, and 4) saturation technologies. A general overview of each is provided and reviewed for its applicability to Marco Island Canals.

1) **Air-lift aerators** consist of a simple structure where air is introduced at the bottom of a pipe-like structure, positioned in the water column near the bottom (Figure 2). As the air-water mixture rises, oxygen from the (air) bubble dissolves into the water. At the top of the structure, any remaining bubbles are vented to the atmosphere while the oxygenated water returns to a pre-determined depth through a separate structure often identified as a downcomer. Oxygen transfer efficiencies are low and typically range between 20 and 25 percent. Physical surface structures would not allow boat access nor would the system meet desired oxygen levels, and therefore this strategy is not applicable to Marco Island Canals.

Figure 1: Example of Air-lift aerators showing schematic (left), install (middle), and operation (right).

2) **Mechanical axial pump systems** are a common technique for water column circulation that uses an axial flow pump. These are either "top-down" or "bottom-up" systems and are targeted at homogenizing water by distributing the oxygen produced by algae from the upper waters to the bottom of the reservoir or canal.

   Examples of such systems include ResMix™ developed by WEARS, Australia, and SolarBee™ by Medora Corporation (Dickinson, ND; Figure 2). These mechanical mixers require a floating platform, frame support for an electric motor, gearbox, driveshaft, and impeller. Additionally, this apparatus requires an effective anchoring system, especially for applications that have large fluctuations in water surface elevation, as well as shore supplied power via water-proof cabling. The ResMix™ units have a minimum working depth of approximately ten (10) feet and, although they come with a variable frequency drive, they have a maximum circulation capacity. The SolarBee™ circulators use a large impeller, approximately three feet in diameter that rotates slowly (< 100 rpm). Water is drawn up from an expandable shroud that can be lowered to a desired depth and distributed over a circular deflector plate at the surface to promote a 360-degree outward flow pattern. Physical surface structures would not allow boat access nor would the system meet desired oxygen levels, and therefore this strategy is not applicable to Marco Island Canals.

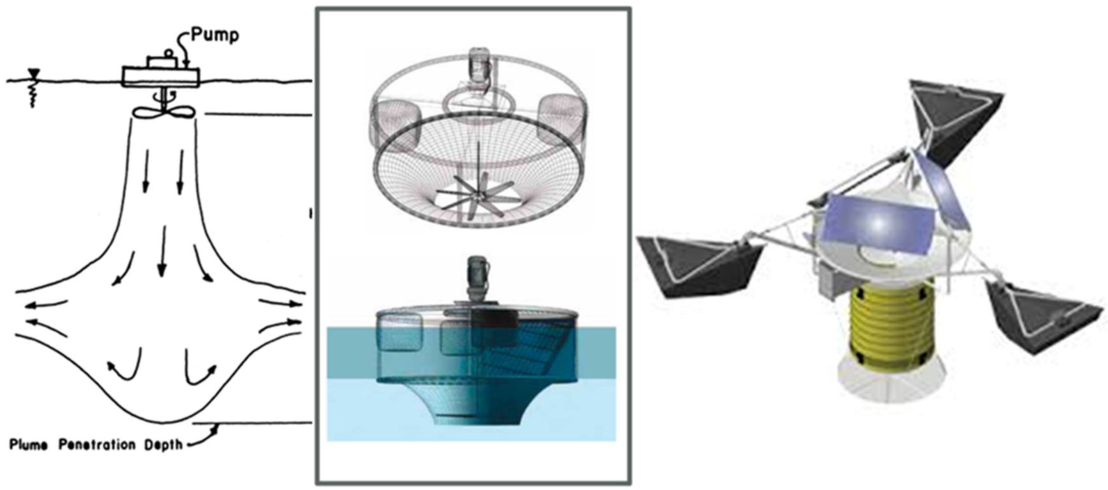


Figure 2: Example of axial pump systems showing down flow mixers ResMix™ 1000 *(top down; left) and* SolarBee™ *(bottom-up; right).*

3) **Direct gas sparging (diffuser) systems** (Figure 3) use a weighted supply pipe to carry the gas to an engineered structure, located on or near the bottom to release small bubbles directly to the water column. Diffuser systems can use compressed air or pure oxygen gas. Compressed air systems are generally used to destratify the water column. Pure oxygen systems are intended to increase oxygen levels in the bottom waters while preserving thermal stratification. Using pure oxygen to destratfy is an enormous waste of money as the bulk of injected oxygen would degas to the atmosphere. Oxygen diffuser systems are highly efficient and are often the preferred option for water bodies that are deeper than 60ft. The injected oxygen bubbles are almost entirely dissolved before reaching the surface when injected at depths > 60ft, eliminating the need for pumps and electricity.

Air diffuser systems intended for destratification, when properly designed, can be very effective at disrupting the thermal structure, thus maintaining near isothermal conditions throughout the water column. However, because of bubble size, rise velocity, and scant oxygen transfer in the plume, re-oxygenation of the water column is heavily dependent upon surface wind-driven re-aeration (Cook et al., 2005; Figure 4). Destratification systems have generally prevented the bottom waters from being anoxic; however, DO values between 1 and 2 mg/L are common. Likewise, in addition to barely maintaining the bottom water oxic, the operation of destratification systems has been observed to lower the oxygen content of the entire water column. If mixing occurred after the development of low oxygen, a significant amount of phosphorus and nitrogen could be released to surface waters, stimulating an algae bloom and worsening water quality. Many examples of limited oxygen capabilities can be found in the Florida Keys. One example is a 14-acre canal at Ocean Reef, where ~200 CFM air was injected through 86 ceramic diffusers along the canal (switched to plastic due to biofouling). The system maintains < 2mg/L and has bad odors and poor water quality. Direct gas sparging would not meet desired DO levels in the canals and therefore is not applicable to Marco Island.

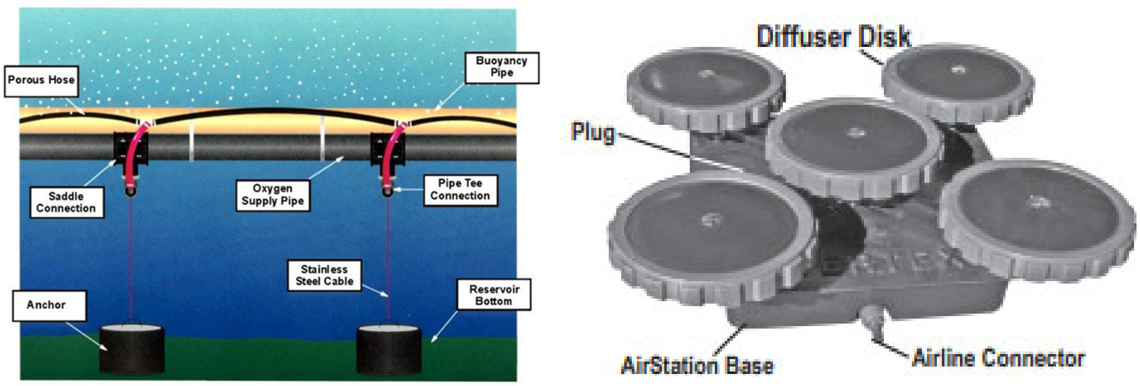
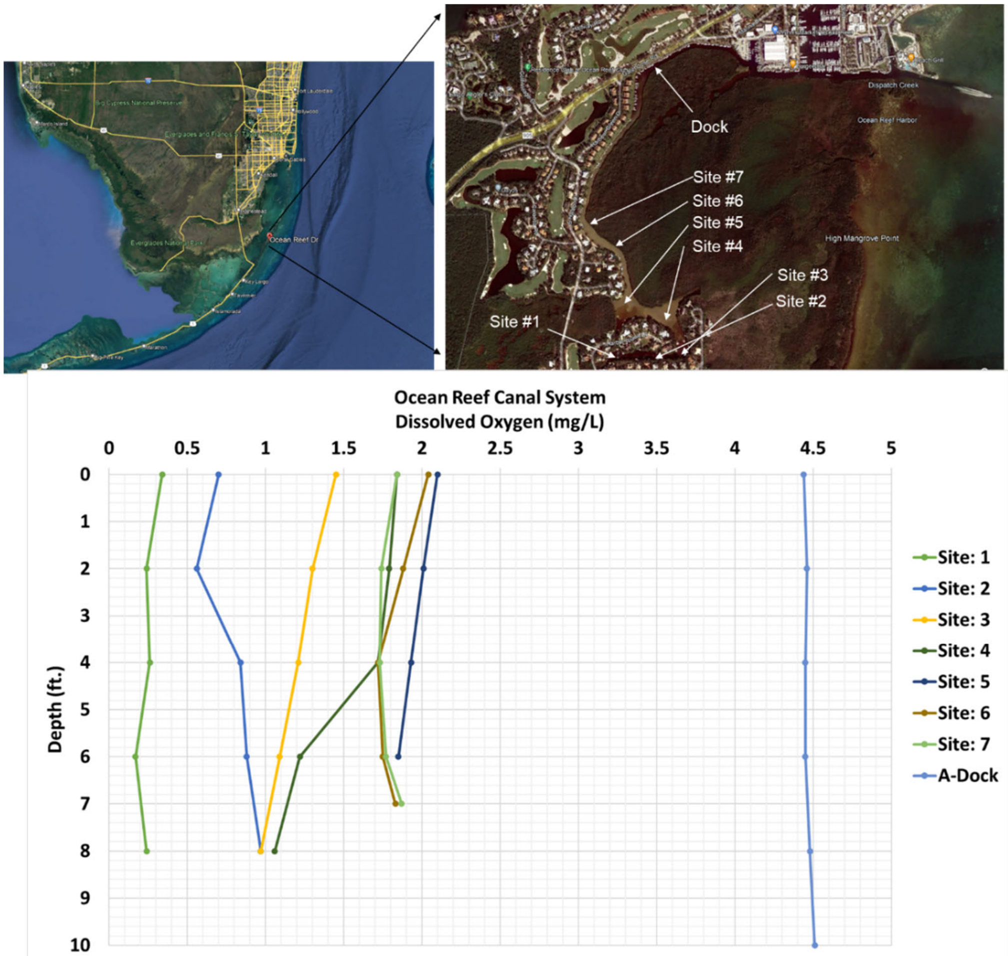


Figure 3: Example of direct gas sparging diffuser systems showing line-diffuser (left) and point diffuser (right).



Dock
Dispatch Creek
Ocean Reef Harbor
Site #7
Site #6
Site #5
Site #4
High Mangrove Point
Site #3
Site #2
Site #1
Ocean Reef Canal System
Dissolved Oxygen (mg/L)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Depth (ft.)
0
1
2
3
4
5
6
7
8
9
10
Site: 1
Site: 2
Site: 3
Site: 4
Site: 5
Site: 6
Site: 7
A-Dock

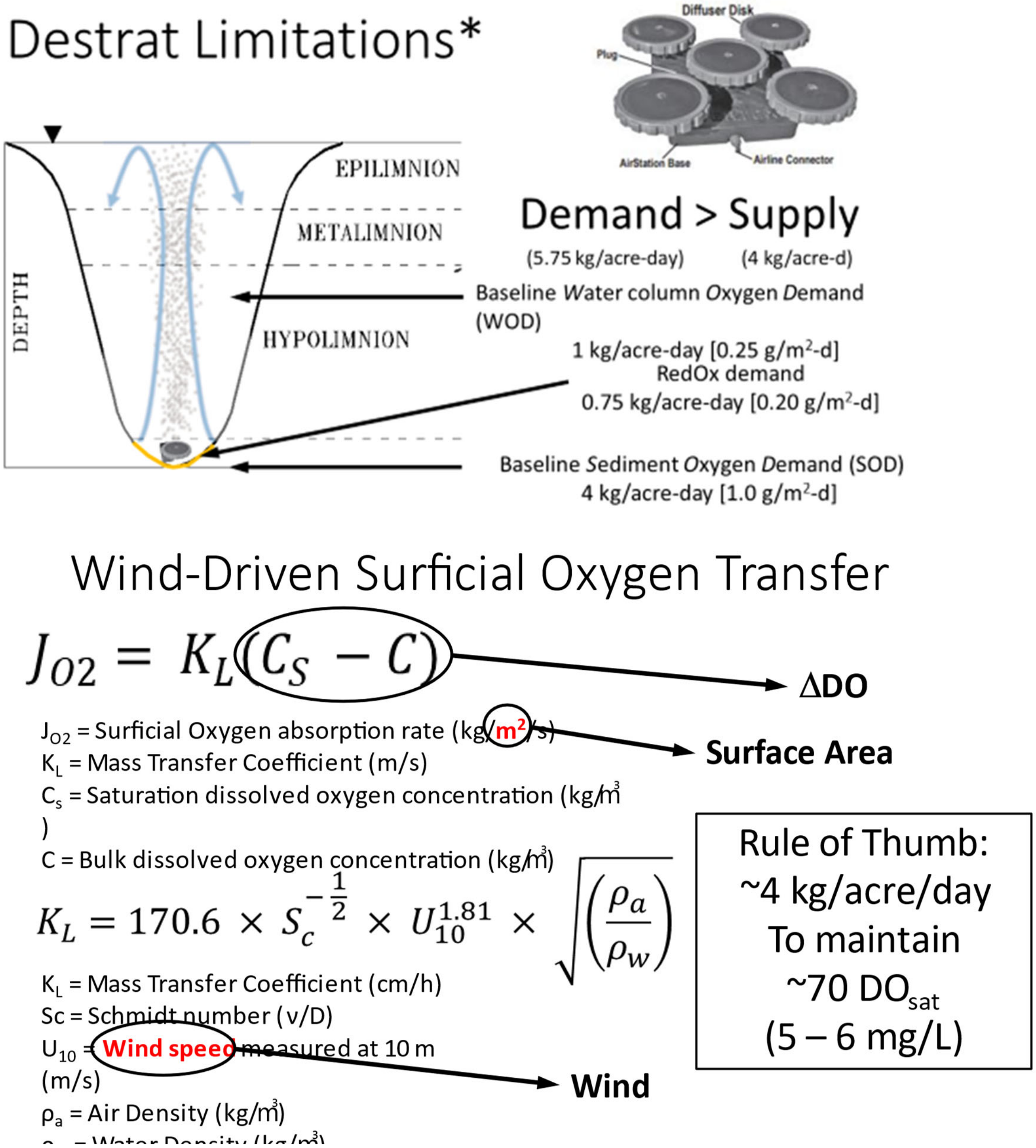
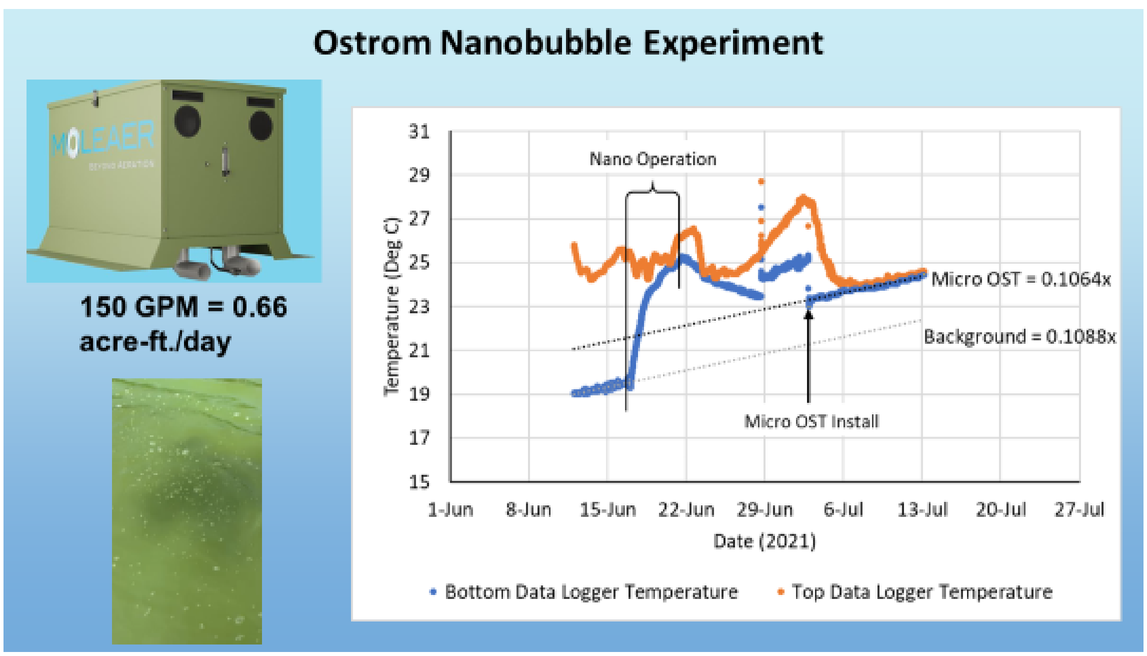


Figure 4: Destrat limitations.

4) Saturation technologies involve removing water from a waterbody via a pump, injecting oxygen, and then discharging the oxygen-enriched water back to the water column (Figure 5). Saturation systems to manage anoxia, typically use pure oxygen and can achieve oxygen transfer efficiencies greater than 90%. Saturation systems are most effective in shallower applications; depths less than 60 feet. The suction and distribution headers for a saturation oxygenation system are designed to prevent induced turbulence to prevent sediment resuspension and to preserve thermal stratification. Technologies like nanobubbles are not true side-stream saturation, as larger bubbles induce mixing at discharge, which promotes induced oxygen demands. The purpose of saturation systems is to maintain high oxygen levels right over the sediments, like an oxygen blanket. This strategy is implemented to drive the oxic/anoxic boundary below the sediment-water interface to effectively combat oxygen-derived water quality issues.

   There are a few variations of saturation technologies like nanobubbles which are not true saturation systems (meeting the above criteria), In fact, nanobubbles are highly inefficient in adding oxygen to water (mass oxygen transfer per unit energy) and wouldn't be able to meet desired oxygen levels. Nanobubbles also cause turbulence from moving too much water (required for gas exchange) and from not being able to generate a monodispersed nanobubble (larger bubbles at discharge). This unwanted mixing prevents the oxygen blanket from occurring and would not allow for oxygen to reach the sediments.



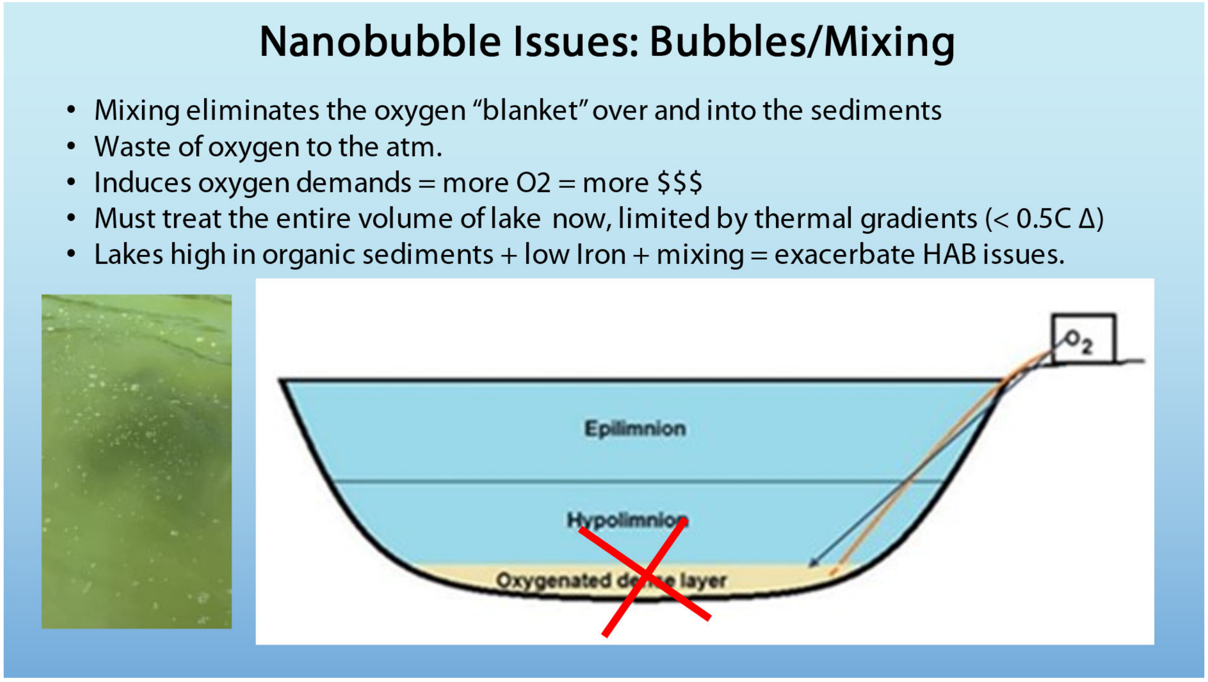


Figure 5: Nanobubble issues.

There is only one commercially sold true saturation technology called Oxygen Saturation Technology that has no bubbles at discharge (all gas is dissolved in solution), allowing for no mixing of thermal layers or sediment perturbation that would cause increases in oxygen demand. OST has the highest mass oxygen transfer at the lowest cost. This patented industrial-grade system is manufactured and sold through Naturalake Biosciences. As of now, there is only a lake version of the unit where the components sit on the bottom of the lake (Figure 6). This current lake version would have to be modified for marine environments to reduce bio-fouling and remove all components in the canal except the headers. Some shore-based OST systems are in operation and would be similar to what a marine-grade unit would need to be. OST would be the preferred approach for the Marc Island Canal system because it can maintain desired DO levels, is scalable (can treat 100s of acres of water per unit), and provides live oxygen and temperature data with automation for electrical cost savings. An example of automation is provided in Figure 6, where DO was programed on the bottom to stay between 8-12 mg/L DO. A recent lake installation is also provided in Figure 7.

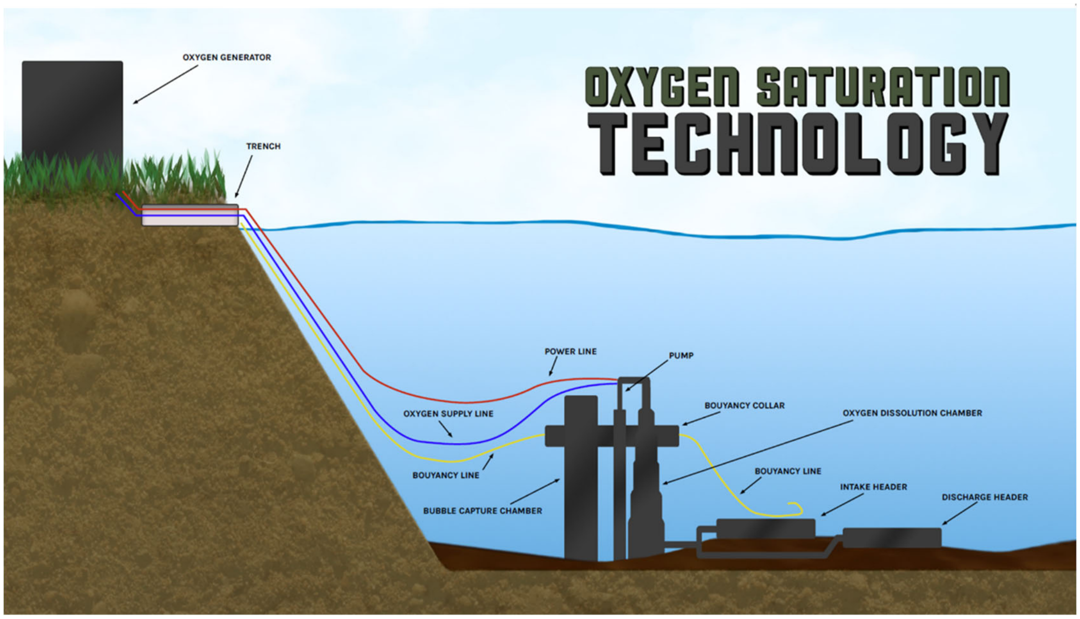


Figure 6: Example schematic of the side-stream saturation system installed in Virginia

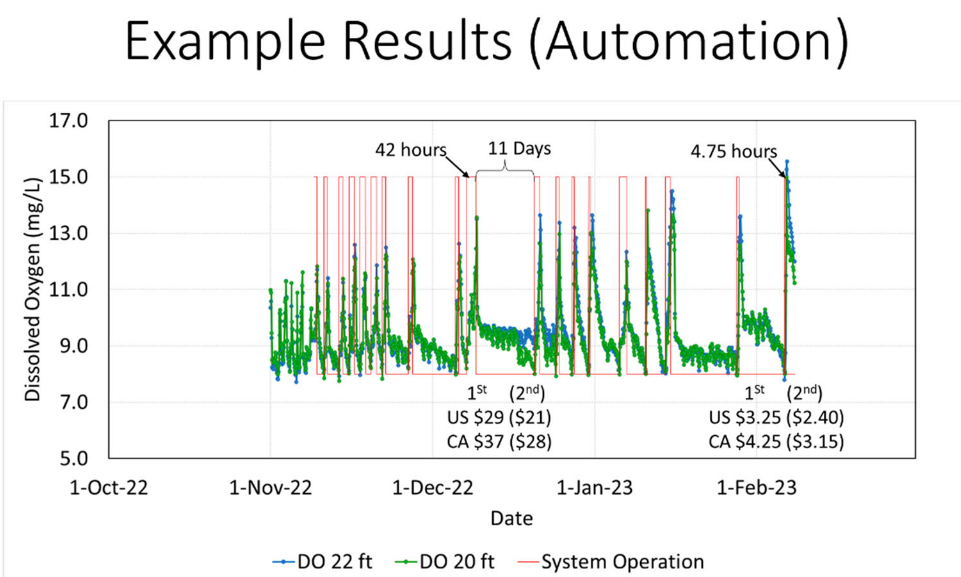


Figure 7: Example OST automation.

Recent lake Install found here: https://www.linkedin.com/feed/update/urn:li:activity:7046618598504607744/

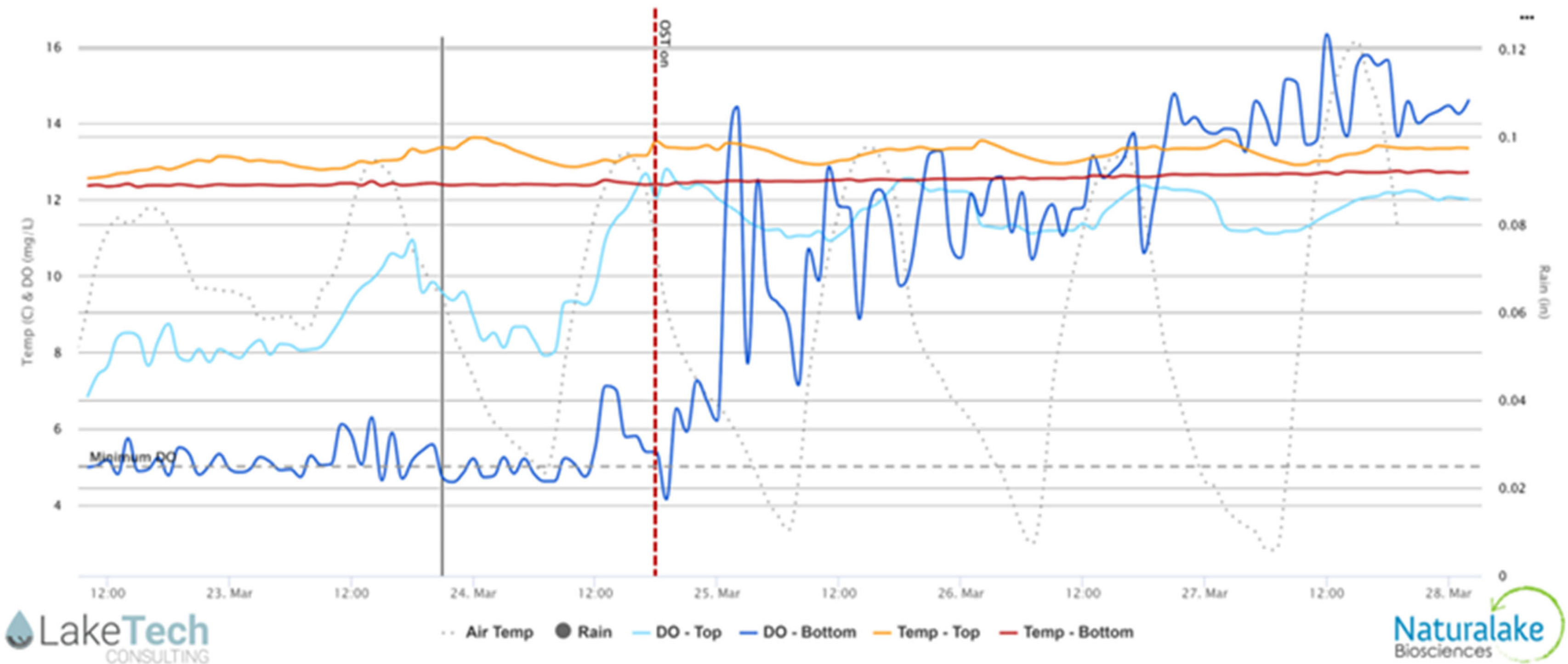


Figure 7: Example OST results after installation.

Colt, J. 2006. Water quality requirements for reuse systems. Aquacultural Engineering **34**: 143–156.

McArley, T. J., E. Sandblom, and N. A. Herbert. 2021. Fish and hyperoxia—From cardiorespiratory and biochemical adjustments to aquaculture and ecophysiology implications. Fish and Fisheries **22**: 324–355.

USEPA. 1986. Quality criteria for water 1986. EPA 440/5-86-001, US Environmental Protection Agency, Washington, DC.