2023 TKPOA Laminar Flow Aeration End of Season Report

Prepared Pursuant to
California Water Boards General 401 Water Quality Certification Order (SB14007IN) Requirements and Basin Plan Prohibition Exemption for the Tahoe Keys Property Owners Association Laminar Flow Aeration Trial Project, El Dorado County

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TAHOE KEYS
WATER QUALITY PROGRAM

2023 Laminar Flow Aeration Report

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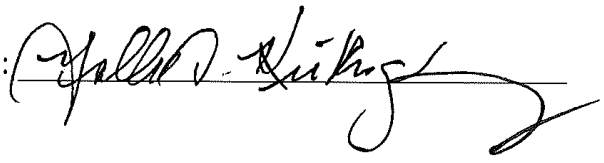
Signature: 

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1.0 INTRODUCTION

The Tahoe Keys Property Owners Association (TKPOA) has been working to create an adaptive, integrated plan to significantly reduce the biovolume of the aquatic invasive species (AIS) infestation in the Tahoe Keys lagoons. Since the 1980s, the TKPOA has been combating increasing amounts of invasive and nuisance aquatic vegetation, with harvesting and fragment collection being the main methods available for management. As the vegetation density has increased in the waterways, so has the accumulation of organic material at the benthic layer. This accumulation of detritus, referred to herein as the "muck layer", promotes aquatic vegetation growth and creates ideal conditions for harmful algal blooms (HABs) (Hoyer, et.al., 2017).

In 2019, the TKPOA implemented a Laminar Flow Aeration (LFA) project to reduce the muck layer and circulate the water column. LFA is a technology originally used for improving water quality in wastewater treatment plants by assisting in the organic breakdown of sludge. LFA has recently been adapted for water body restoration by accelerating a water body's natural capability to process nutrients, purge harmful gases like ammonia and hydrogen sulfide, precipitate iron, and manganese, and keep down algae growth.

LFA has been used successfully with shallow, warmer waters with minimal circulation at low elevation; however, it has not been fully evaluated in an area such as Lake Tahoe, which has deeper, colder water at a much higher elevation.

During the 2022 season, the TKPOA was approved to conduct the first year of the Control Methods Test (CMT), a three-year long project designed to test the effectiveness of multiple AIS management strategies such as LFA, UV-C, and herbicides. To complete the CMT project in 2022, several changes were made to the LFA project. Those changes remained in effect during 2023, Year 2 of the CMT Project.

2.0 OBJECTIVES FOR LFA SYSTEM

The WQ Department has been monitoring the LFA system for four years and will follow the sampling and monitoring guidelines in section 4.0 for the fifth year of operation to determine its performance. In accordance with the California Water Boards *General 401 water quality certification order (SB14007IN) Requirements and Basin Plan Prohibition Exemption for the Tahoe Keys Property Owners Association Laminar Flow Aeration Trial Project, El Dorado County* of the objectives for the LFA system are:

1. Increase Dissolved Oxygen (DO) levels at the sediment-water interface and throughout the water column to promote a healthy ecosystem and encourage chemical reduction of sediments.
2. Reduce organic matter in sediments around the LFA diffusers.
3. Circulate the water column to decrease the opportunity for Harmful Algal Bloom (HAB) occurrences.
4. Reduce the habitable environment for aquatic macrophyte growth.

Originally, the LFA project was intended to occur over the course of three years. Due to installation and monitoring logistics, and with the secondary purpose of incorporation into the Control Methods Test (CMT), it is expected that the LFA system will continue to operate continuously until the end of the CMT in 2025. The CMT project is an expansion on the fourth objective in

determining the lasting effects of a potentially less habitable environment for aquatic weeds in combination with other non-herbicide methods.

3.0 PROJECT CHANGES DUE TO CMT

In 2022, the CMT project incorporated the established LFA system into its methods for testing ways to control aquatic invasive species and renamed it Site 26. Certain adjustments needed to be made within the Site 26 LFA system to ensure integrity for both projects. These changes were still in effect during the 2023 monitoring season. The adjustments included creating a new control site (Site 7) and reducing the amount of monitoring locations and depths in Site 26. Due to the original control site, Site 6, being near CMT herbicide testing sites, it was decided to create a new control site, Site 7. This change was effective as of July 12, 2022. Lahontan State Water Boards requested that the control be switched back to Site 6 due to the lack of herbicide treatment on July 25, 2023.

Previously, Site 26 had six monitoring and sampling locations (LFA-F, LFA-G, LFA-H, LFA-I, Control Site 6) at five depths (Bottom, Q1, Mid, Q3, Surface). With the approval from Lahontan representatives, the monitoring and sampling requirements decreased to four locations (LFA-F, LFA-H, LFA-I, LFA-6/7) at two depths (surface and mid column) and a discontinuation of two parameters: phycocyanin and chlorophyll-a. These changes were to have locations and parameters coincide with CMT monitoring stations and requirements.

The CMT project also required the addition of two new LFA systems, Site 25, and Site 27, to be installed in the Tahoe Keys waterways. Site 25 is in a dead-end area (between Emerald Dr., the east side of Garmish Ct, and Venice Dr.) of the West Lagoon. Site 27 is in Lake Tallac (on the opposite side of Venice Dr. as Site 26).

Additionally, TKPOA and consultant Dr. Lars Anderson initiated several ways to monitor the efficacy of the LFA systems. These changes include the installation of two large metal plates (Sedimentation Target Plates) in 2022, the installation of fixed staff gauges in 2023, and implementing a new method to observe changes in organic matter year after year in 2023.

3.1 System Layouts

Clean-Flo International was sourced and granted the contract to design the LFA systems for the Tahoe Keys. Each site has been strategically designed based on site area and the air capacity of the system. Each system has a shed that houses a 7.1 horsepower compressor connected to a variable frequency drive which allows for adjustment of air output. A stainless-steel manifold connects the grouping of self-sinking air lines to the compressor. The air lines run from each shed out to the lagoons and are connected to microporous ceramic diffusers that release bubbles in an even distribution at the proper coordinates in accordance with the site design.

3.1.1 Site 26

The Site 26 LFA system was originally installed in 2019. Ten diffusers were placed throughout Site 26. The design was adjusted on August 12, 2020, due to a cyanobacteria bloom. The modified design moved two of the ten diffusers to reduce the overall test area and ideally increase the effectiveness of treatment. The compressor is housed inside TKPOA's groundwater well #2 building and airlines run under the bridge on Venice Drive, and out to their designated locations. Three sampling stations are used within the site (LFA-F, LFA-H, LFA-I).

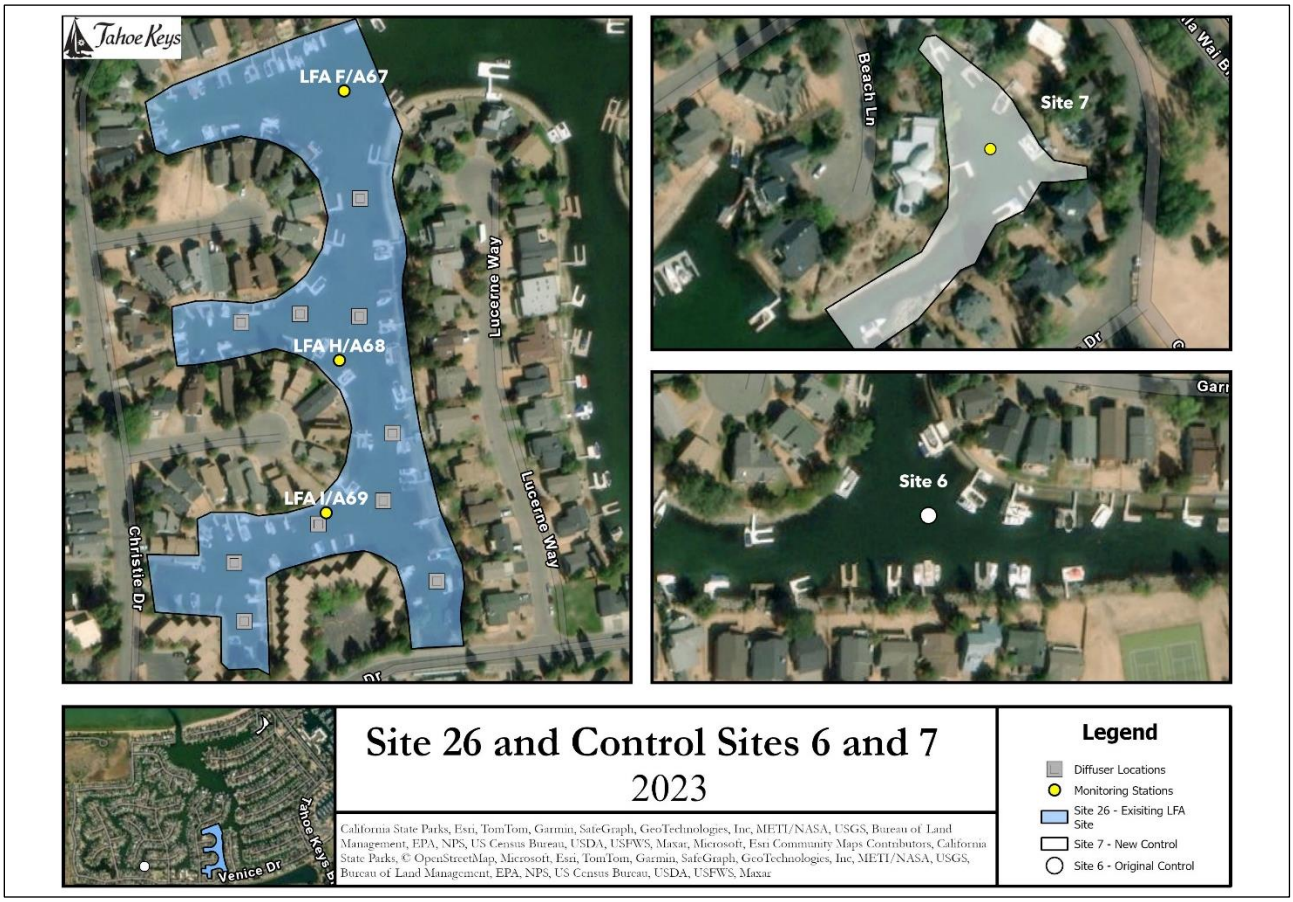

Figure 1. 2023 Site 26 and Control Sites 6 and 7

3.1.2 Sites 6 and 7

Site 6 is the original control site that was implemented with the Site 26 LFA system in April 2019. Site 6 was chosen as the control because it is a representative of these same conditions as Site 26. Due to Site 6 being near a CMT herbicide treatment area, it was decided to create a new control site, Site 7. Site 7 was used as the control for LFA during Year 1 of the CMT project. In 2023, Lahontan requested to re-establish Site 6 as the LFA control due to the discontinuation of herbicide treatment in the West Lagoon.

Site 7 is the new control site established in the 2022 season. It is in Spinnaker Cove around the corner of Beach Lane. The lack of movement and volume of aquatic weeds in this area perfectly reflect the issues that the LFA system is meant to address. There is no compressor or diffuser located on this site. A sampling station has been established in the center of the lagoon (LFA-7). This location was used for monitoring from July 12, 2022, to July 25, 2023.

3.1.3 Sites 25 and 27

Site 25 was designed with eight diffusers placed in the middle of the lagoon area (shown in Figure 3) and has been operating since November 16, 2022. One of the criticisms with Site 26 is the spacing between the diffusers. Site 25 is designed to address this concern and condense the diffuser

distance which over designs the system according to Clean-Flo International standard specifications. The two coves south of the site will not have any diffusers and are to be used as HAB control site areas. It is important to monitor if the LFA system has any negative effects in areas that previously have not been known to have issues. The compressor for this site is housed in a shed behind the Emerald Drive Pump House. The air lines run down into the lagoon, through the stormwater culvert, and out into the site.

Site 27 is in Lake Tallac with eight diffusers lined down the lagoon (shown in Figure 4). Since Lake Tallac does not have any docks or coves, this location best reflects the optimal location for an LFA system according to Clean-Flo International. The diffusers and air flow will not be inhibited by anything in the water, giving the most efficient treatment possible with this type of set up. This site has been running continuously since November 17, 2022. The compressor for Site 27 is in a shed behind the TKPOA groundwater Well #2 building. The airlines run a short distance down the bank into the water. Due to homeowner request, the Site 27 laminar flow aeration system was turned off for the winter of 2023-2024 on December 5, 2023, to allow Lake Tallac to ice over for recreational sports. It will be turned on again in Spring of 2024.

Figure 2. LFA and Control Sites Implemented in CMT Year 1

4.0 METHODS

Water samples were collected by TKPOA Water Quality staff according to the monitoring schedule created in accordance with the TKPOA and California State SWAMP Protocols. Sediment level and muck layer reduction is monitored and evaluated using both physical samples and with Lowrance hydroacoustic scanners in companion with the BioBase analysis software. The scanners use sonar technology to measure changes occurring in the underwater topography on a weekly basis and physical samples are taken twice each year.

4.1 Monitoring

Water quality monitoring – turbidity, pH, dissolved oxygen (DO), oxidation reduction potential (ORP), specific conductance (SPC), and temperature – took place bimonthly along with cyanobacteria samples. Nutrient samples were not taken this year for funding issues. Sediment samples were taken bi-annually, once in the spring and once in the fall. The annual macrophyte survey was conducted through Sierra Ecosystem and Associates and additional macrophyte surveys were conducted through a TRPA contractor for the CMT. Hydroacoustic scans occurred bimonthly to determine plant density and biovolume (refer to Table 1 for LFA monitoring schedule).

4.1.2 Equipment

Water Quality data was collected using the OTT Hydromet HL4 Sonde probe. This probe is a portable multiparameter meter custom designed for the parameters the WQ department is required to monitor. A HDS 7 Live Lowrance system with a 3 in 1 Active Imaging sonar transducer was used for hydroacoustic scanning throughout the Keys Lagoons. Sediment samples were taken with a sonar device dropped from the side of a work boat.

4.1.3 Calibration

Calibrations and QC checks are done routinely to ensure accuracy across all monitoring and sampling. The TKPOA Water Quality staff calibrated the Sondes probes weekly according to the manufacturer's instructions. On each specific day of sampling, DO was calibrated for more accurate readings as per the recommendations from the manufacturer. Calibration information was logged on to a calibration worksheet and then archived with the sampling data sheets for that event.

4.1.4 Parameters

The sites were measured for atmospheric and underwater parameters at each sampling station for each sampling day. Specific parameters are noted in Table 2.

4.1.5 Hydroacoustic Scans

Throughout the entirety of the Tahoe Keys, hydroacoustic scans were done biweekly. Adjustments to the BioBase (analytics software used) processing settings were made to account for better bottom tracking in dense vegetation as well as increased accuracy in biovolume heatmaps.

4.1.6 Muck Depth

Muck depth was monitored in multiple ways to determine the efficacy of the LFA systems. In August 2022, two large metal plates (Sedimentation Target Plates) were installed in Site 26 to aid hydroacoustic scanning efforts and muck depth measuring in fixed locations. Additionally, on September 28, 2023, fixed staff gauges were installed into each LFA site (25, 26 and 27) and the control site 7 at the estimated bottom of the muck layer and secured to a fixed piling. Staff also used measuring poles to attempt to manually measure the depth of the muck but noted that the muck layer is inconsistently spread throughout the site, reaffirming the need to install the fixed staff gauges to provide a consistent area to measure the changes in muck.

As a secondary efficacy study, microporous bags filled with composited muck from control Site 16 (CMT Control Site) were installed into each LFA site on October 24, 2023. Dr. Lars Anderson and TKPOA staff installed six muck bags per LFA and control site (25, 26, 27, 16 and 7). The bags of muck were secured onto a buoy in the middle of each site approx. one foot from the bottom of the water column. Samples of the muck bags' percent organic matter were analyzed prior to installation and will be analyzed Spring 2024, Fall 2024, and Spring 2025.

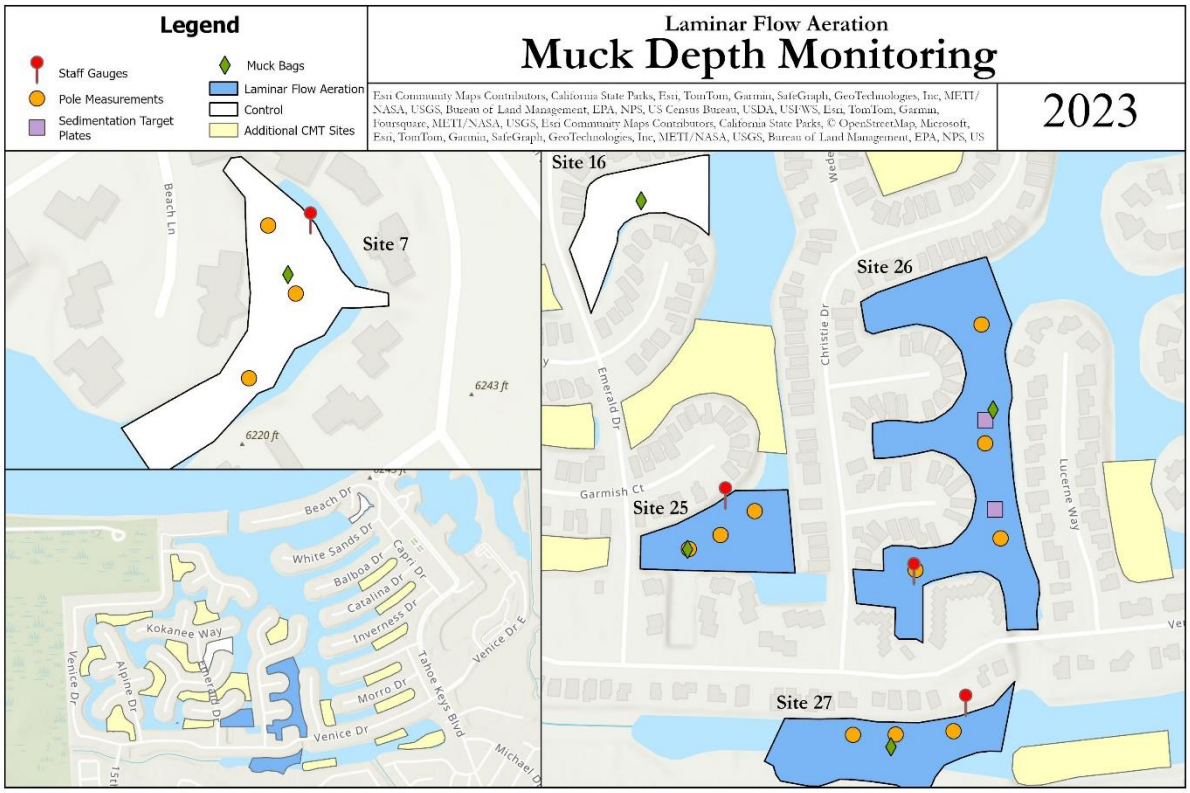

Figure 3. Muck Depth Monitoring Sites

TKPOA LFA Monitoring Schedule	
Year 5: April - November 2023	
Water	
WQ: Temp, DO, pH, Turbidity, SPC, ORP	Bimonthly - Tuesdays: 1100- 1400
Nutrients: Total Kjeldahl Nitrogen, Nitrate, Nitrite, Ammonia - Nitrogen, Orthophosphate, Total Phosphorus	Biannual – Spring / Fall 2023
Cyanobacteria: Anatoxin a, Saxitoxin Microcystin, Cylindrospermopsin,	Bimonthly - Tuesdays: 1100 - 1400
Sediment	
Sediment Surface Total Kjeldahl Nitrogen / Nitrate + / Nitrite Nitrogen / Ammonia / Orthophosphate	Biannual - Spring / Fall 2023
Aquatic Plants	
Plant Composition	Annual Macrophyte Survey
Plant Density/Biomass Hydroacoustic Scanning	Bimonthly - Tuesdays 1030-1400
Photosynthetically Active Radiation (PAR)	Bimonthly

Table 1. TKPOA LFA Monitoring Schedule

Parameter	Method of Measurement	Description
Time of Day	Visual	Time of sampling at each site
Air Temp (°F) Cloud Cover (%) Last Precipitation Wind Speed (mph) Wind Direction	Website	The National Weather Service Website is used to determine the weather at the Tahoe Keys on each sampling day.
Water Depth	Hydromet HL 4 Sonde Probe	Depth in meters of water at each site. Used to determine the mid and surface level sampling points in the water column.
Water Temperature	Hydromet HL 4 Sonde Probe	Measure of thermal energy in a substance, or a measure of how hot or cold a substance is. Temperature influences several other parameters and can alter the physical and chemical properties of water (Fondriest

		Environmental Inc. 2016)
Specific Conductance	Hydromet HL 4 Sonde Probe	Measure in micro-Siemens per centimeter (µS/cm) of dissolved ionic particles in the water. Acts as a good indicator of Total Dissolved Solids.
Dissolved Oxygen	Hydromet HL 4 Sonde Probe	Amount (mg/L) of oxygen present in water. An important parameter in water quality assessment due to its influence on aquatic organisms. (Fondriest Environmental Inc. 2016).
pH	Hydromet HL 4 Sonde Probe	Measure of acidity of a substance, with pH 7 being neutral.
Oxidation Reduction Potential	Hydromet HL 4 Sonde Probe	Oxidation Reduction Potential (ORP) recorded in millivolts. This is a key component in water quality to determine the health of an ecosystem.
Turbidity	Hydromet HL 4 Sonde Probe	Measurement of water clarity using Nephelometric Turbidity Units (NTU)

Table 2. Water Quality Parameters

4.2 Water Quality and Cyanobacteria Sampling

During the 2023 season, staff collected samples for cyanobacteria to comply with the project permits in accordance with the procedures instructed by Lahontan Regional Water Quality Control Board (LRWQCB) (Appendix A). Nutrient sample collection was modified in 2023 due to funding changes from Lahontan SWAMP. Samples were collected once in Spring 2023 and once in Fall 2023 as part of the CMT monitoring requirements.

4.2.1 Water Quality Sampling Procedure

a. Review the Sampling Checklist (Section 4.2.3).
b. Verify that all required sampling equipment is gathered.
c. Once on the boat with all necessary materials, AIS staff will collect and record the following general information onto the data sheet: date, sample collector, boat driver, start time of each sample, air temperature, cloud coverage, last precipitation, wind speed, and wind direction.
d. Measure constituents using a Hydromet HL4 Sonde. Hydromet monitoring protocol includes:
    - Lower the instrument to the desired depth in the water column, according to the data sheet (Mid and Surface).
    - Allow adequate time to ensure the HL4 data stabilizes before recording information onto the data sheet.
    - For each depth, record Hydromet reading for each parameter onto the data sheet.
    - Verify that all required data has been collected before moving on to the next site.

e. Data collected at each site surface and midpoint will include:
    - Depth (m), water temperature (℃), pH (su), dissolved oxygen (mg/L), oxidation-reduction potential (mV), Turbidity (NTU) and specific conductivity (uS/cm).
    - Visual Observations (i.e., the presence of algae, odor, fish, insects, or amphibians in a sample site etc.), if applicable.

4.2.2 Cyanobacteria Sampling Procedure

a. Review the Sampling Checklist (Section 4.2.3).
b. Sample Collector wears proper PPE.
c. Verify that all required sampling equipment is gathered.
d. Once on the boat with all necessary materials, AIS staff will collect and record the following general information onto the bottle: Sample ID Number (for contract laboratories), Sampling Date and Time, Site Name/ Station Code, Preservative (optional depending on sampling), Collector's Initials.
e. Holding the correct sample bottle, lower into the water column to desired depth.
f. Return the container to the surface quickly and, if necessary, pour out a small volume of the sample to allow for homogenization.
g. Quickly replace the cap and tighten securely.
h. Place in an iced cooler for preservation.

4.2.3 Sampling Checklist

a. Check the weather forecast for sampling day to determine if conditions are appropriate for sampling to occur.
b. Verify sampling materials delivery.
c. Verify, if applicable, that the selected analytical lab is scheduled to pick up samples the day after they are to be collected, as hold times on parameters (such as nutrients) require quick processing.
d. Calibration of the Hydromet HL4 Sonde should occur weekly and take place no later than a day prior to the scheduled sampling event. Sampling should not occur if calibration is not completed. Calibrate according to the manufacturer's instructions.

4.3 Laboratory Analysis

Samples sent for laboratory analysis went to three different certified laboratories. Cyanobacteria samples were sent to Bend Genetics, LLC in Sacramento, California. Sediment samples were sent to WetLab Environmental Testing Laboratory in Sparks, Nevada. Samples that were sent for laboratory analysis were for the following constituents:

4.3.1 Cyanobacteria

a. Anatoxin-A – A secondary, bicyclic amine alkaloid and cyanotoxin with acute neurotoxicity, produced by seven different genera of cyanobacteria.
b. Cylindrospermopsin – An alkaloid consisting of tricyclic guanidine coupled with hydroxymethyluracil. Zwitterionic, highly water-soluble molecule; resistant to high temperatures, sunlight, and pH extremes. Often released from cells into the surrounding

water, it bioaccumulates, particularly in organisms low in the food chain such as gastropods, bivalves, and crustaceans.

c. Microcystin – Cyclic non-ribosomal peptides produced by cyanobacteria, known to cause severe hepatic damage principally by inhibiting protein phosphatases. May be released into the surrounding water when cyanobacteria cells disintegrate. Typical environmental half-life of 10 weeks, the breakdown rate is increased under direct sunlight, at high environmental temperatures (>40^{o} C), and extremely low pH (<1) or high pH (>9).
d. Saxitoxin – Produced in freshwater and marine environments. In freshwaters, saxitoxins are produced by cyanobacteria in the genera *Anabaena* sp., *Aphanizomenon* sp., *Planktothrix* sp., *Cylindrospermopsis* sp., *Lyngbya* sp., and *Scytonema* sp. can accumulate in freshwater fish. Also known as paralytic shellfish poisons (PSPs).
e. Total Cyano (16S) – 16S rRNA is a genetic characterization of cyanobacterial strains. Quantitative polymerase chain reaction: process used to enumerate pathogens, algae, or specific genes responsible for production of undesirable compounds (i.e., 16S gene[1], microcystin, anatoxin-a).
f. Chlorophyll-a - A pigment found in algal/phytoplankton species and used to measure algal growth in a waterbody.

4.3.2 Sediments

a. Aluminum - Amount of aluminum in the sediment sample.
b. Phosphorus - Amount of all forms, dissolved and particulate, of phosphorus present in the sample.
c. Orthophosphorus - Dissolved inorganic phosphorus that is readily available for aquatic plants and algae.
d. Organic Matter - Total organic material present in the sample.
e. Ammonia - Measure of nitrogen in the form of NH4.
f. Total Solids - Measures the percentage of total solids in the sample.
g. Nitrate Nitrogen – Amount of nitrogen bound to a nitrate ion present in the sample.
h. Nitrite Nitrogen –Amount of nitrogen bound to a nitrite ion present in the sample.

5.0 RESULTS

Site 7 was used for the LFA control from May 10, 2023, until July 25, 2023. From July 25, 2023, onward Site 6 was used as the LFA control.

5.1 Water Temperature

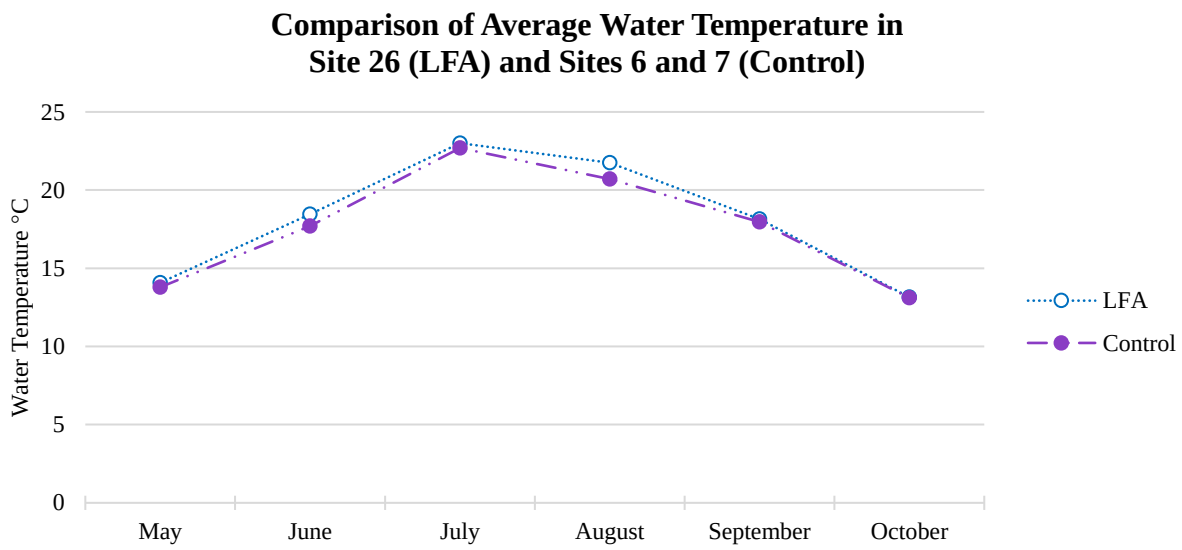

Figure 4. Comparison of Average Water Temperature in Site 26 and Sites 6 and 7.

5.2 Dissolved Oxygen

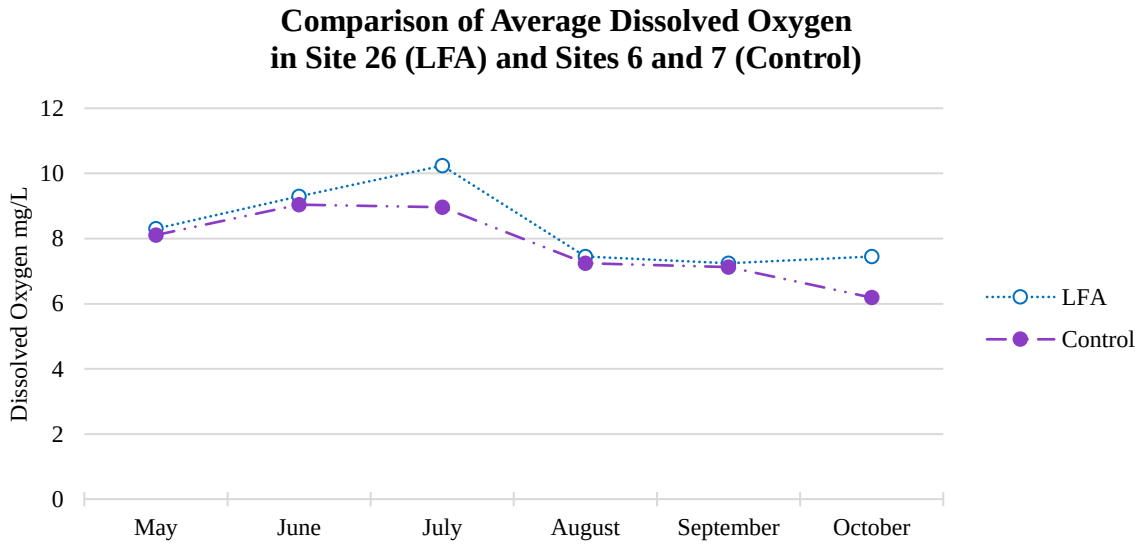

Figure 5. Comparison of Average Dissolved Oxygen in Site 26 and Sites 6 and 7.

5.3 Turbidity

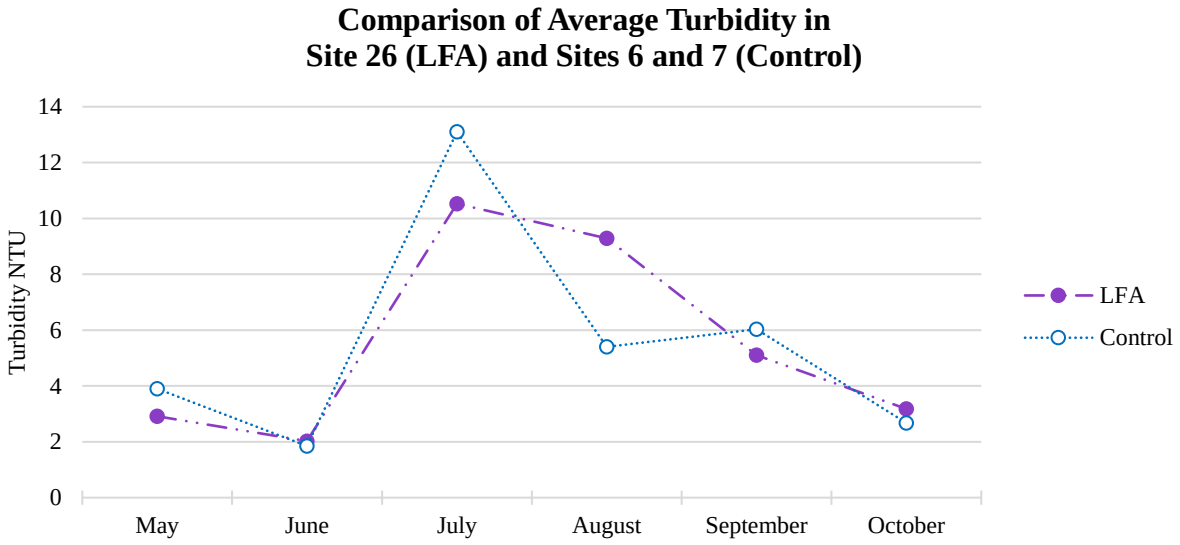

Figure 6. Comparison of Average Turbidity in Site 26 and Sites 6 and 7

Comparison of Median and Maximum Turbidity Levels in 2021, 2022, and 2023						
	2021		2022		2023	
Site	Median Turbidity (FNU)	Maximum Turbidity (FNU)	Median Turbidity (NTU)	Maximum Turbidity (NTU)	Median Turbidity (NTU)	Maximum Turbidity (NTU)
LFA F	2.92	10.81	1.50	3.50	3.6	18.8
LFA G	3.17	11.39	N/A	N/A	N/A	N/A
LFA H	4.21	9.68	2.25	9.50	4.2	19.6
LFA I	4.98	9.52	3.20	10.00	4.6	21.1
LFA J	5.46	10.51	N/A	N/A	N/A	N/A
Site 6	3.58	11.02	1.20	3.50	4.95	13.1
Site 7	N/A	N/A	5.80	10.70	3.90	8.1

Table 3. Comparison of Median and Maximum Turbidity Levels for Sites 26, 6, and 7.

5.4 pH

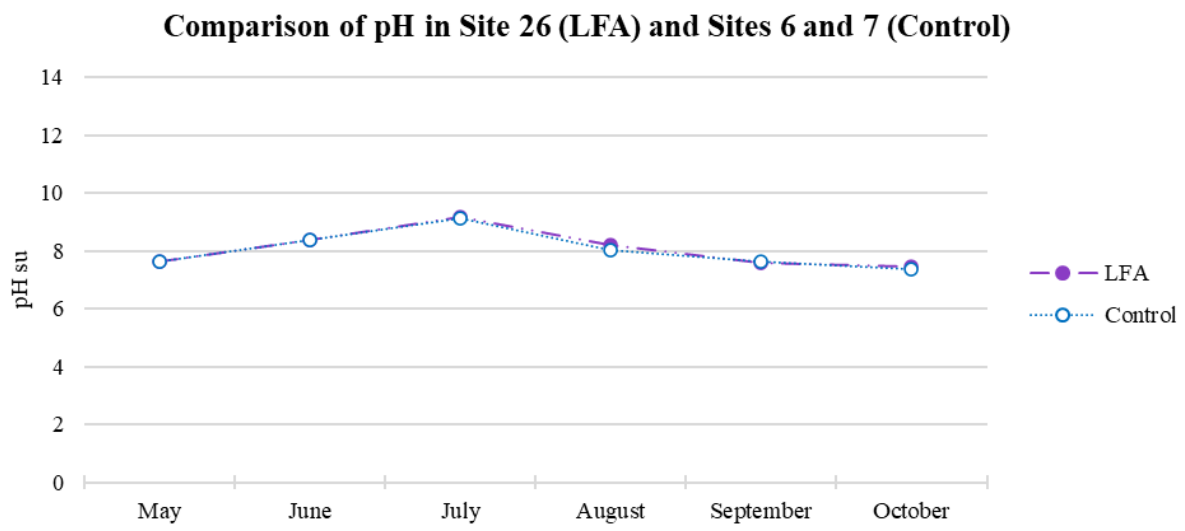

Figure 7. Comparison of pH in Site 26 and Sites 6 and 7.

5.5 Specific Conductivity

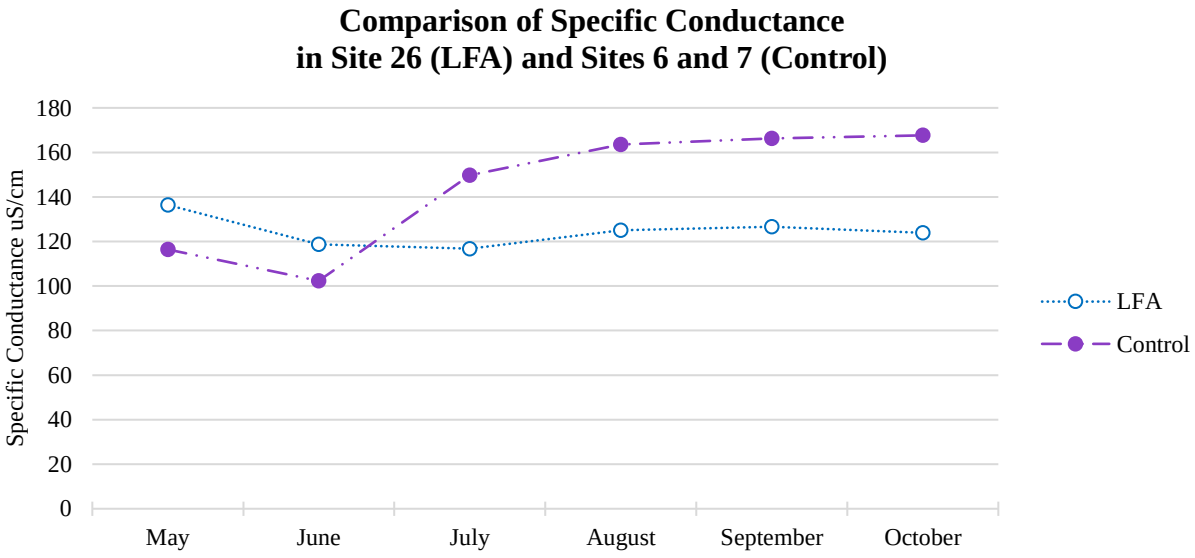

Figure 8. Comparison of Specific Conductance in Site 26 and Sites 6 and 7.

5.6 Oxidative Reductive Potential

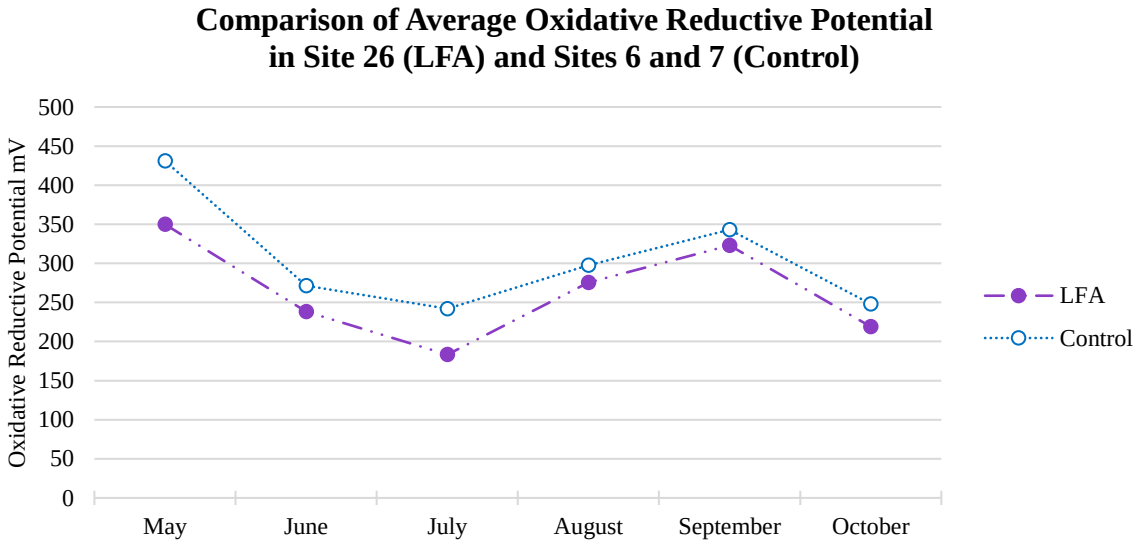

Figure 9. Comparison of Average Oxidative Reduction Potential in Site 26 and Sites 6 and 7.

5.7 Hydroacoustic Scans

Hydroacoustic scans were used to determine percent biovolume and plant height. The Tahoe Keys Lagoons experienced a dramatic increase in water level from 2022 to 2023. The approximate 4 ft rise contributed to the improved percent biovolume heat maps.

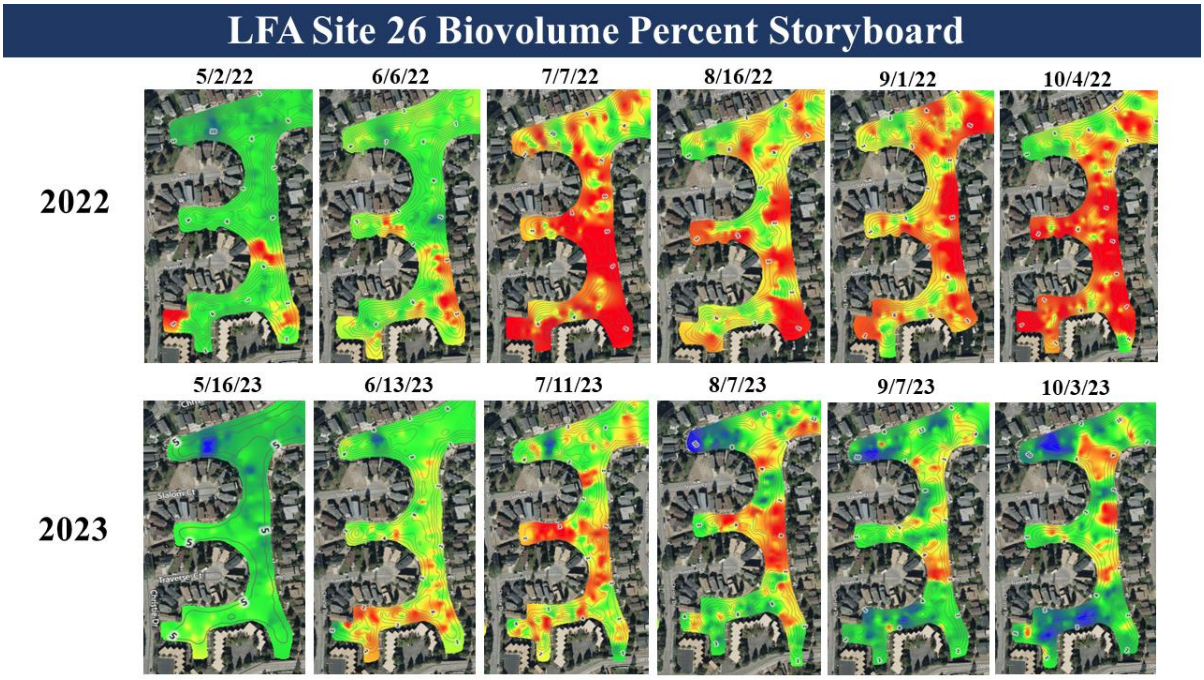

Figure 10. LFA Site 26 Biovolume Percent Storyboard for 2022 and 2023.

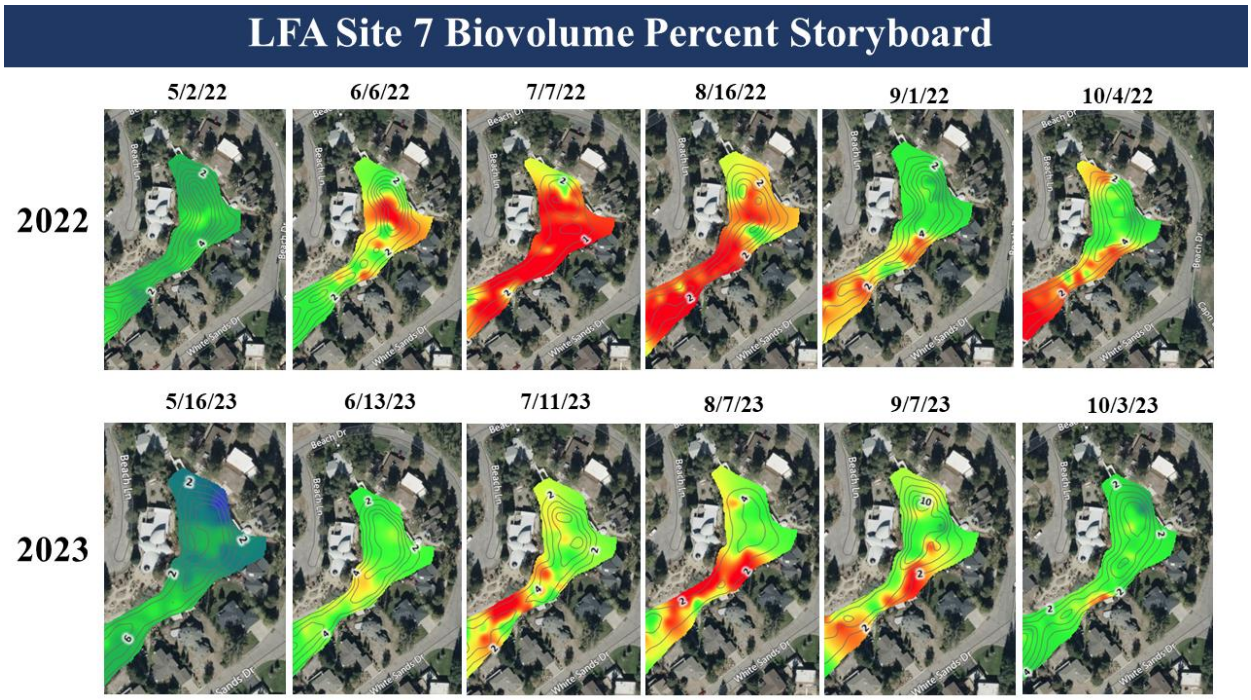

Figure 11. LFA Control Site 7 Biovolume Percent Storyboard for 2022 and 2023

5.8 Macrophyte Survey Results

An extensive third-party macrophyte analysis was done by Environmental Science Associates (ESA) to determine the effectiveness of LFA. Evaluations were made on biovolume, rake fullness, and vessel hull clearance. A complete report is available as Appendix E of the 2023 Annual Report for the CMT (Tahoe Keys, 2024). This third-party analysis will continue in 2024 to evaluate the same parameters for a year over year analysis on efficacy of the LFA systems.

5.9 Nutrient Results

Environmental Science Associates (ESA) did a third-party nutrient analysis to determine the effectiveness of treatments in the CMT project including LFA. A complete report is available as Appendix E of the 2023 Annual Report for the CMT (Tahoe Keys, 2024). This third-party analysis will continue in 2024 to evaluate the same parameters for a year over year analysis on efficacy of the LFA systems.

5.10 Cyanobacteria Results

Based on the California Cyanobacteria and HAB Network trigger levels for posting HAB advisory signs, Site 26 triggered a "caution" level on July 25, 2023. Lahontan Water Boards was immediately notified of the lab results and AIS technicians posted the appropriate signage around Site 26. Once staff received two consecutive non-detects and visual indictors dissipated, the caution signs were removed (October 25, 2023). See Appendix B for Caution Sign and Appendix C trigger levels for posting HAB signage.

Figure 12. Cyanobacteria 'paint' near site LFA-I

Site	Treatment Type	Date:	Anatoxin-a (µg/L) [RL: 0.15µg/L]		Cylindrospermopsin (µg/L) [RL: 0.05µg/L]		Microcystin/ Nod. (µg/L) [RL:	
			2022	2023	2022	2023	2022	2023
26 LFA H	Laminar Flow Aeration	July	0.16	1.77				
		August		0.26				
		September						
		October						
26 LFA I	Laminar Flow Aeration	July	11.72	3.67				
		August						
		September						
		October						
6	Control	July						
		August						
		September						
		October						

Table 4. Cyanobacteria Sampling Results for LFA H, LHA I and Site 6 in 2022 and 2023.

	No advisory | Total Microcystins: <0.8µg/L; Anatoxin-a: non-detect; Cylindrospermopsin: <1µg/L
	Toxin levels meet Caution advisory (Tier 1) | Total Microcystins: 0.8µg/L; Anatoxin-a: detected; Cylindrospermopsin: 1µg/L
	Toxin levels meet Warning advisory (Tier 2)| Total Microcystins: 6µg/L; Anatoxin-a: 20µg/L; Cylindrospermopsin: 4µg/L
	Toxin levels meet Danger advisory (Tier 3) | Total Microcystins: 20µg/L; Anatoxin-a: 90µg/L; Cylindrospermopsin: 17µg/L
	Nondetect of Toxins or Detected and Not Quantifiable
	No Sample Data Available

Figure 13.California Cyanobacteria and HAB Network trigger levels for posting HAB advisory signs.

5.11 Sediment Sampling Results

2023 % Organic Matter			
Location:	**Spring:**	**Fall:**	**% Change**
Site 25 LFA	12%	6%	- 50.83%
	14%	7%	- 48.57%
Site 26 LFA	13%	10%	- 25.38%
	13%	15%	+ 15.38%
Site 27 LFA	24%	8%	- 67.92%
	19%	13%	- 31.58%
Site 7 Control	17%	13%	- 23.53%
Site 17 Control	31%	3.4%	- 89.03%

Table 5. Sediment Sampling Results: 2023 Percent Organic Matter

6.0 DISCUSSION

The LFA project has four main objectives with the common goal of improving water quality in the Tahoe Keys lagoons. The objectives are:

1) Increase DO levels at the sediment-water interface and throughout the water column to promote a healthy ecosystem and encourage chemical reduction of sediments.
2) Reduce organic matter in sediments around the LFA diffusers.
3) Circulate the water column to decrease the opportunity for HAB occurrences, and
4) Reduce the habitable environment for aquatic macrophyte growth.

Determining if LFA has met its four objectives is difficult with the current historic data. Multiple variables over the seasons do not allow for accurate comparisons. For this reason, methods are being modified and procedures are being put in place using the CMT to make more accurate determinations for the efficacy of this method.

6.1 Objective 1

The overall fluctuation in DO for Site 26 was less when compared to the control. In the latter half of the season, the DO remained above control showing promise that this objective could be met.

6.2 Objective 2

Muck depth and sediment sampling will be key in determining validity of this objective. A new protocol for sediment sampling was implemented in 2023 to better understand the effects of LFA on organic matter. Initial results from 2023 sampling show a reduction in organic matter from

most sites including the control sites without diffusers. Therefore, it is inconclusive to say that the LFA system has a significant impact on percent organic matter reduction. Sampling will continue in 2024 and 2025 to determine the year over year changes. No enzymes have been utilized in conjunction with our LFA system as designed, due to permit restrictions. Therefore, the conclusions are based on results from aeration treatment alone.

6.3 Objective 3

Overall HAB levels throughout the West Lagoon were decreased from the 2022 season. HABs were detected at the "caution" level in Site 26 during July, but not again for the rest of the season. HABs were not detected in the now established Sites 25 and 27. More sampling is required to determine if the decrease in cyanotoxins was due to LFA treatment or from outside factors, such as increased water levels, or increased boat traffic/circulation.

6.4 Objective 4

Efficacy is being determined as part of the Control Methods Test evaluation. Using rake data and hydroacoustic scans relative abundance/ percent composition sitewide for the targeted invasive plants showed greater than the control sites. Additionally, adding non-herbicide control methods in conjunction with LFA treatments showed no improvement over control sites. More testing will be done in 2024 to further understand LFA's impact on plant growth.

7.0 2023 Recommendations for 2024 Season

7.1 Maintenance to LFA System

The TKPOA WQD staff recommends that repairs and general maintenance be made to the LFA system in Site 26, 27, and 25 prior to the summer of 2024. Repairs include fixing any tears in tubing, utilizing rebar to secure tubing, and conducting routine maintenance such as oil changes and cleaning of diffusers.

7.2 Utilizing a Data Collection Software to streamline Data Collection

For the 2023 season, AIS staff recommend upgrading data collection protocols from paper datasheets to electronic data collection devices utilizing a program such as Fulcrum. This upgrade will streamline data collection and QA/QC protocols.

8.0 Discontinued Reporting

The General 401 water quality certification order (SB14007IN) of the LFA trial project issued from Lahontan Regional Water Quality Control Board and Tahoe Regional Planning Agency expired in October 2021. Continued evaluation of the LFA systems within the Tahoe Keys has transitioned to the Control Methods Test NPDES five-year permit. LFA is a slow acting process and no conclusive determinations have been made under this trial. LFA will continue to be researched and new methods for muck evaluation will take place over the next two years. Further information in the subsequent years regarding the progress and efficacy of the LFA systems can be found in the CMT annual report published by March 1st or the Integrated Management Plan (IMP) update published annually by Jan 31st.

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11.0 REFERENCES

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Tahoe Keys Property Owner’s Association. (2023). *Tahoe Keys Lagoons Aquatic Weed Control Methods Test: Annual Report – Year 1* (Order No. R6T-2022-0004, NPDES No. CA6202201, WDID No. 6A091701001.

Appendix A.

LRWQCB Sample Bottle Collection Protocol

https://drive.google.com/file/d/0B40pxPC5g-D0T01OVUx4amhDaVk/view?resourcekey=0-YziwP3Sjox8LO2a2HH4BJQ

Appendix B.

Harmful Algal Bloom – Caution Advisory Signage

Appendix C.

CCHAB Trigger Levels for posting PLANKTONIC advisory signs.

Trigger Levels For Human and Animal Health				
Criteria*	No Advisory [a]	Caution (TIER 1)	Warning (TIER 2)	Danger (TIER 3)
Total Microcystins [b]	**< 0.8** µg/L	**0.8** µg/L	**6** µg/L	**20** µg/L
Anatoxin-a	**Non-detect** [c]	**Detected** [c]	**20** µg/L	**90** µg/L
Cylindrospermopsin	**< 1** µg/L	**1** µg/L	**4** µg/L	**17** µg/L
Cell Density of potential toxin producers	**< 4,000** cells/mL	**4,000** cells/mL	_____	_____
Site-specific indicator(s)	No site-specific indicators present	Discoloration, scum, algal mats, soupy or paint-like appearance. Suspected illness	_____	_____

* Action levels are met when one or more criteria are met.
[a] For de-posting, all criteria for no advisory must be met for a minimum of 2 weeks. General awareness sign may remain posted and healthy water habits are still recommended.
[b] Microcystins refers to the sum of all measured Microcystin congeners.
[c] Must use an analytical method that detects ≤ 1µg/L Anatoxin-a.