2022 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

Tahoe Keys
PROPERTY OWNERS ASSOCIATION
356 Ala Wai Boulevard South Lake Tahoe CA 96150
530-542-6444 tahoekeyspoa.com

TAHOE KEYS
WATER QUALITY PROGRAM

2022 Laminar Flow Aeration Report

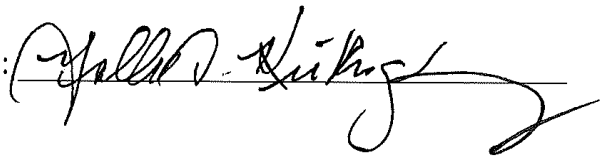
Prepared by

Kristine Lebo
TKPOA Water Quality Manager / AIS Management Coordinator

Meghan Hoffmann
Water Quality Supervisor

Erin Harkins
Moire Breslin
TKPOA AIS Technicians

Submitted by: **Hallie Kirkingburg**, General Manager

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 tested in an area such as Lake Tahoe, which has deeper, cold 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). This is a three year long project designed to test the effectiveness of multiple AIS management strategies such as LFA, UV-C, and herbicides. In order to complete the CMT project in 2022, several changes were made to the LFA 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 IN 2022

The CMT project incorporated the established LFA system into its methods for testing ways to control aquatic invasive species. From 2022 onward, this test area will be referred to as Site 26. Certain adjustments needed to be made within the Site 26 LFA system to ensure integrity for both projects. Site 7 was established as the new control site for LFA. This was a joint decision made with TKPOA and representatives at Lahontan State Water Boards since the previous control site (Site 6) was located in close proximity to CMT test areas. This change was effective as of July 12, 2022.

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. Due to supply chain issues, the new systems were installed late season during November 2022. Site 25 is located in a dead-end area (between Emerald Dr., the east side of Garmish Ct, and Venice Dr.) of the West Lagoon. Site 27 is located in Lake Tallac (on the opposite side of Venice Dr. as Site 26). Some diffusers were reused from the previous West Channel LFA project (discontinued and uninstalled in 2021); and additional diffusers were purchased from Clean-Flo International. Each new LFA system required construction of a shed with appropriate sound proofing to house the system compressors. TKPOA WQD received ACC approval on September 19th, 2022, and sent out notification letters to our homeowners potentially affected by noise. All construction followed TKPOA BMPs. Visual turbidity monitoring was done prior to, during, and following the installation of both LFA systems by TKPOA WQ staff.

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-7) at two depths (surface and midcolumn) and a discontinuation of two parameters: phycocyanin and chlorophyll-a. These changes were to have locations coincide with CMT monitoring stations and requirements.

In August 2022, two large metal plates were installed in Site 26. These are part of a preliminary method design to use hydroacoustic scans for monitoring and tracking muck depth more consistently. A sediment sampling method was also established and will be used to measure the percentage of organics within the muck layer.

It is also important to note that outside of the regularly scheduled maintenance for the Site 26 LFA system, the air tubing needed multiple repairs using diver assistance due to prop strikes from the low water year.

3.1 System Layout

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.

Figure 1. 2022 LFA Project Map

3.1.1 Site 26 System Layout

The Site 26 LFA system was originally installed in 2019. Ten diffusers were placed throughout Site 26 (shown in Figure 2). 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).

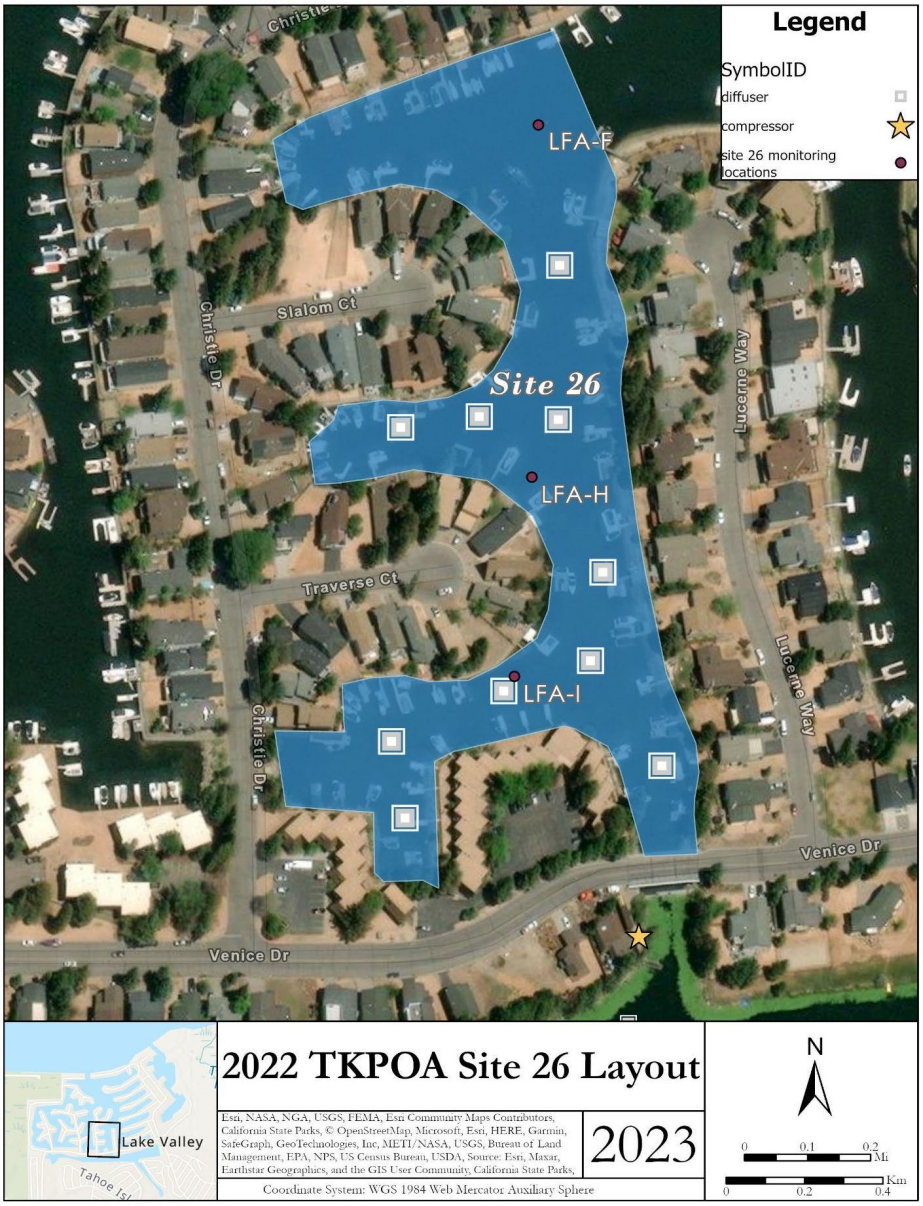

Figure 2. Site 26 Diffuser Locations

3.1.2 Site 25 System Layout

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. Sampling stations have not

yet been established using GPS. The coordinates will be noted before monitoring takes place in spring 2023.

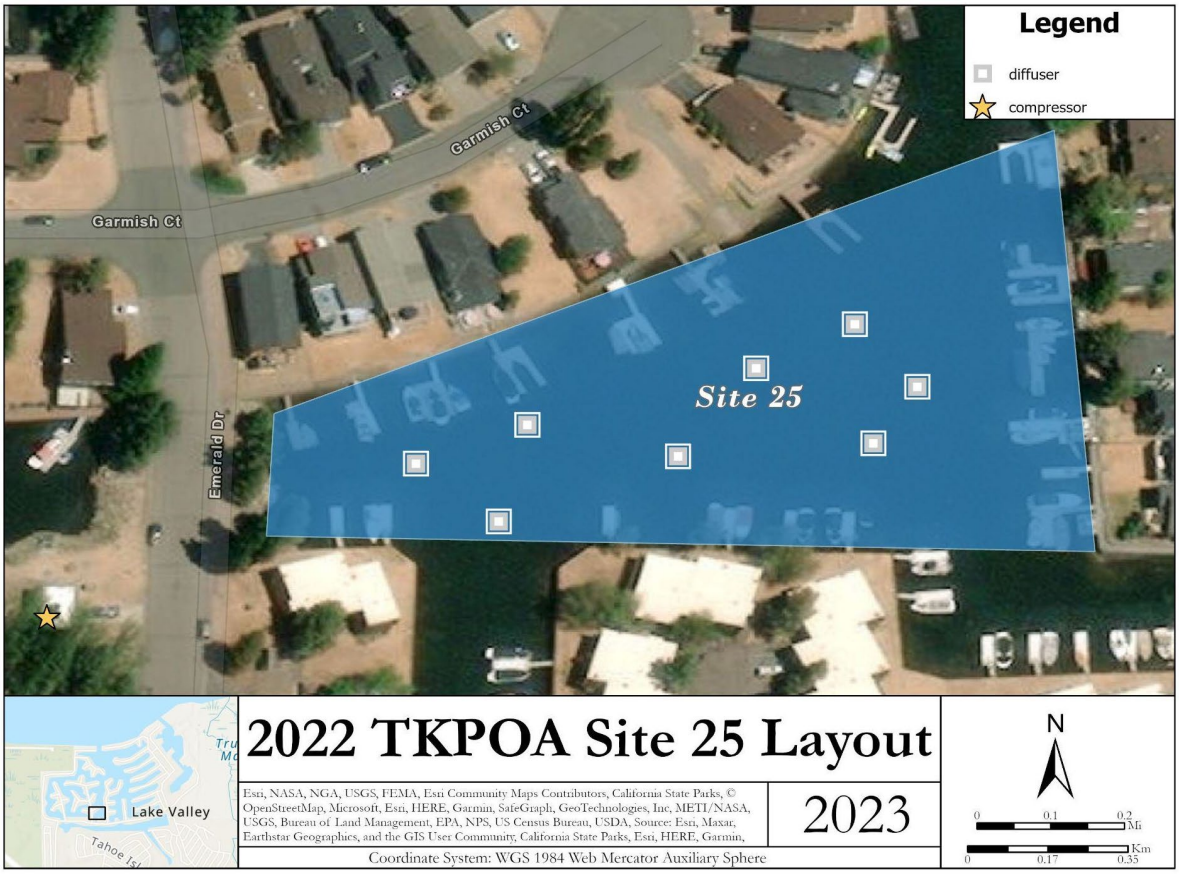

Figure 3. Site 25 Layout

3.1.3 Site 27 System Layouts

Site 27 is located in Lake Tallac with eight diffusers lined down the lagoon (shown in Figure 4). Since Lake Tallac doesn't 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 located in a shed behind the TKPOA groundwater well #2 building. The airlines run a short distance down the bank into the water. Sampling stations have not yet been established using GPS. The coordinates will be noted before monitoring takes place in spring 2023.

Figure 4. Site 27 Layout

3.1.4 Site 7 Layout

Site 7 is the new control site established in the 2022 season. It is located in Spinnaker Cove around the corner of Beach Lane (shown in Figure 5). 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).

Figure 5. Control Site 7 Monitoring Location

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 while nutrient samples – total nitrogen (TN), orthophosphate (P) and cyanobacteria samples – were taken monthly. Sediment samples were taken once this year by the WQ staff with Dr. Lars Anderson to develop a protocol for this method. Going forward sediment samples will be taken bi-annually, once in the spring and once in the fall for each year. 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. On August 30, 2022, large metal plates were installed flush with the muck layer at the bottom of the water column for Site 26 adjacent to monitoring sites LFA-H and LFA-I. The intention is that these plates will create a distinction within the scanning software to determine on a more frequent basis the changes occurring in the muck depth.

TKPOA LFA Monitoring Schedule	
Year 4 - April - November 2022	
Water	
WQ: Temp, DO, pH, Turbidity, SPC, ORP	Bimonthly - Tuesdays: 1100- 1400
Nutrients: Total Kjeldahl Nitrogen, Nitrate, Nitrite, Ammonia - Nitrogen, Orthophosphate, Total Phosphorus	Monthly - Tuesdays: 1100 - 1400
Cyanobacteria: Anatoxin a, Saxitoxin Microcystin, Cylindrospermopsin,	Monthly - Tuesdays: 1100 - 1400
Sediment	
Sediment Surface Total Kjeldahl Nitrogen / Nitrate + / Nitrite Nitrogen / Ammonia / Orthophosphate	Biannual - Spring / Fall 2022
Aquatic Plants	
Plant Composition	Annual Macrophyte Survey
Plant Density/Biomass Hydroacoustic Scanning	Bimonthly - Tuesdays 1030-1400

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 (in parts per million) 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. Surface, mid-point, and bottom were collected during the season to monitor effects of plant biomass on overall pH.
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 2022 season, staff collected samples for nutrients and cyanobacteria to comply with the project permits in accordance with the procedures instructed by Lahontan Regional Water Quality Control Board (LRWQCB) (Appendix A). Samples for nutrients require field filtration and were conducted by TKPOA Water Quality staff using the method instructed by Babcock

Laboratories. Sediment samples were conducted from a TRPA contractor in 2022 due to permitting requirements from the CMT project.

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 and Nutrient 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. For nutrients: triple rinse the collection bottles before collecting the actual sample, filling roughly three-quarters of the bottle. For cyanobacteria do not rinse the sample container.
g. Return the container to the surface quickly and, if necessary, pour out a small volume of the sample to allow for homogenization.
h. Quickly replace the cap and tighten securely.
i. 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. Nutrient samples were sent to Babcock Laboratories in Riverside, California and the trial of sediment samples were sent to WetLab Environmental Testing Laboratory in Sparks, Nevada. Pigment samples were analyzed at the Lahontan Regional Water Quality Control Board's South Lake Tahoe, California, location. Samples that were sent for laboratory analysis were for the following constituents:

4.3.1 Nutrients

a. Orthophosphorus – Dissolved inorganic phosphorus that is readily available for aquatic plants and algae.
b. Total Phosphorus – Amount of all forms, dissolved and particulate, of phosphorus present in the sample.
c. Nitrate-Nitrogen – Amount of nitrogen bound to a nitrate ion present in the sample.
d. Nitrite-Nitrogen –Amount of nitrogen bound to a nitrite ion present in the sample.
e. Total Kjeldahl Nitrogen – Measure of ammonia and organic forms of nitrogen.
f. Total Nitrogen – Sum of all forms of nitrogen, including Nitrate-Nitrogen, Nitrite-Nitrogen, and TKN.

4.3.2 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.

4.3.3 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 6 was used for the LFA control from 6/2/2022 until 7/12/2022. From 7/12/2022 onward Site 7 was used as the LFA control.

5.1 Water Temperature

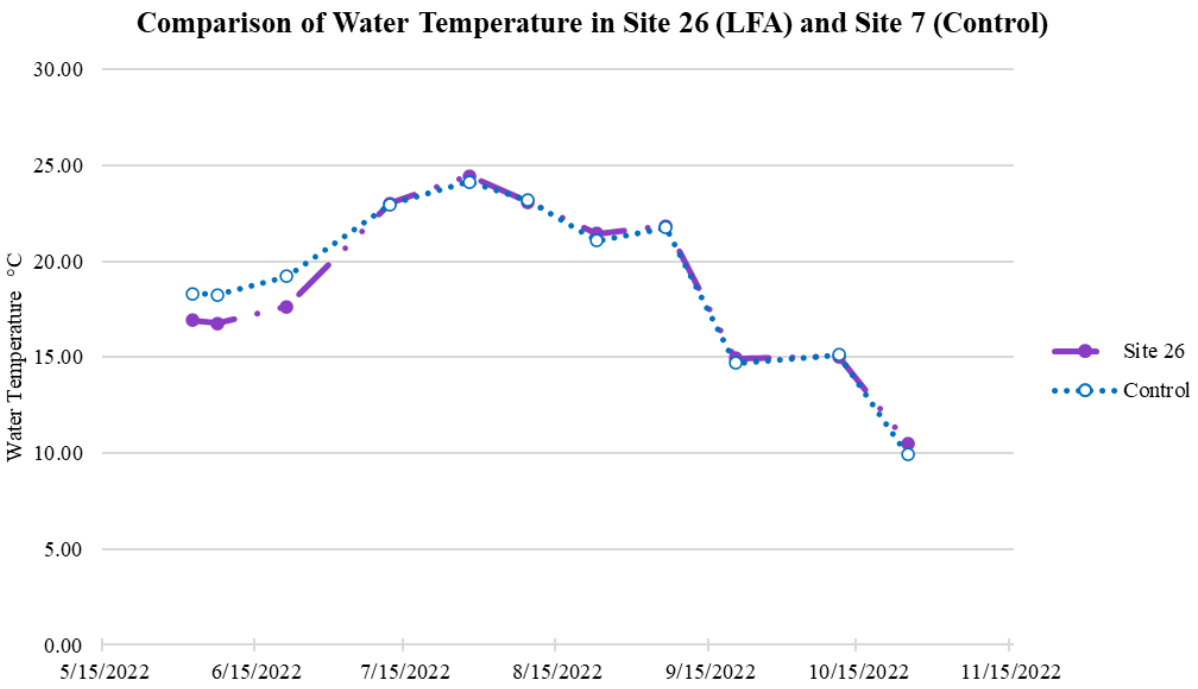

Figure 6. Comparison of Water Temperature in Site 26 (LFA) and Site 7 (Control)

5.2 Dissolved Oxygen

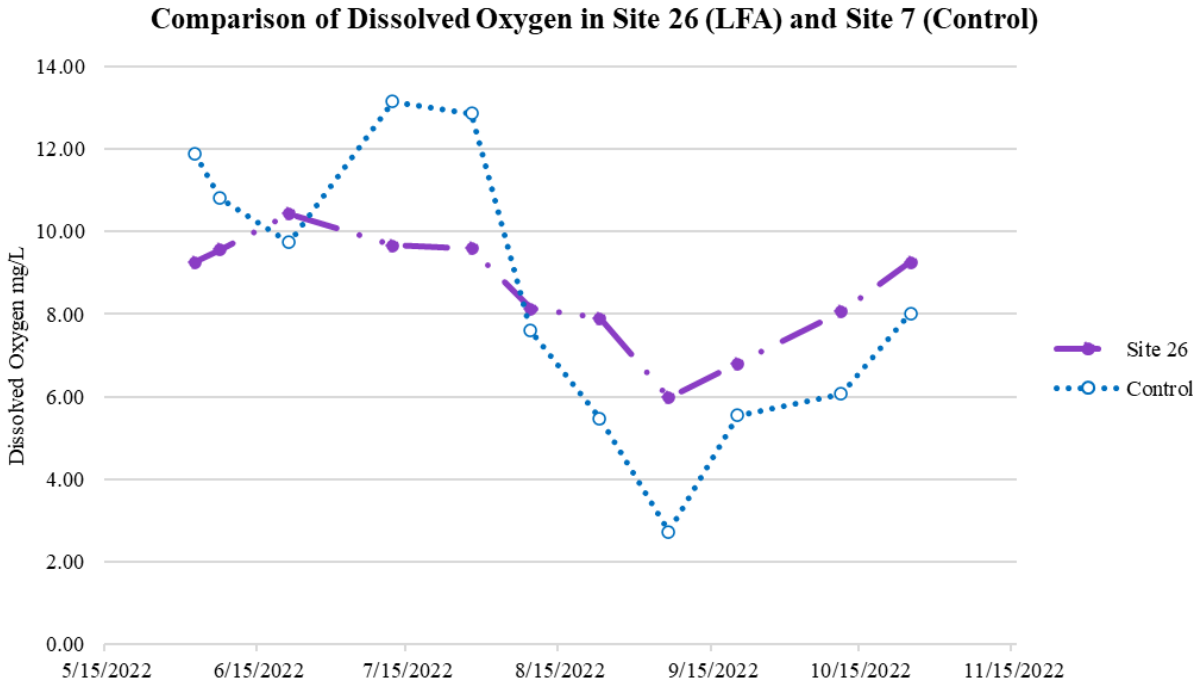

Figure 7. Comparison of Dissolved Oxygen in Site 26 (LFA) and Site 7 (Control)

5.3 Turbidity

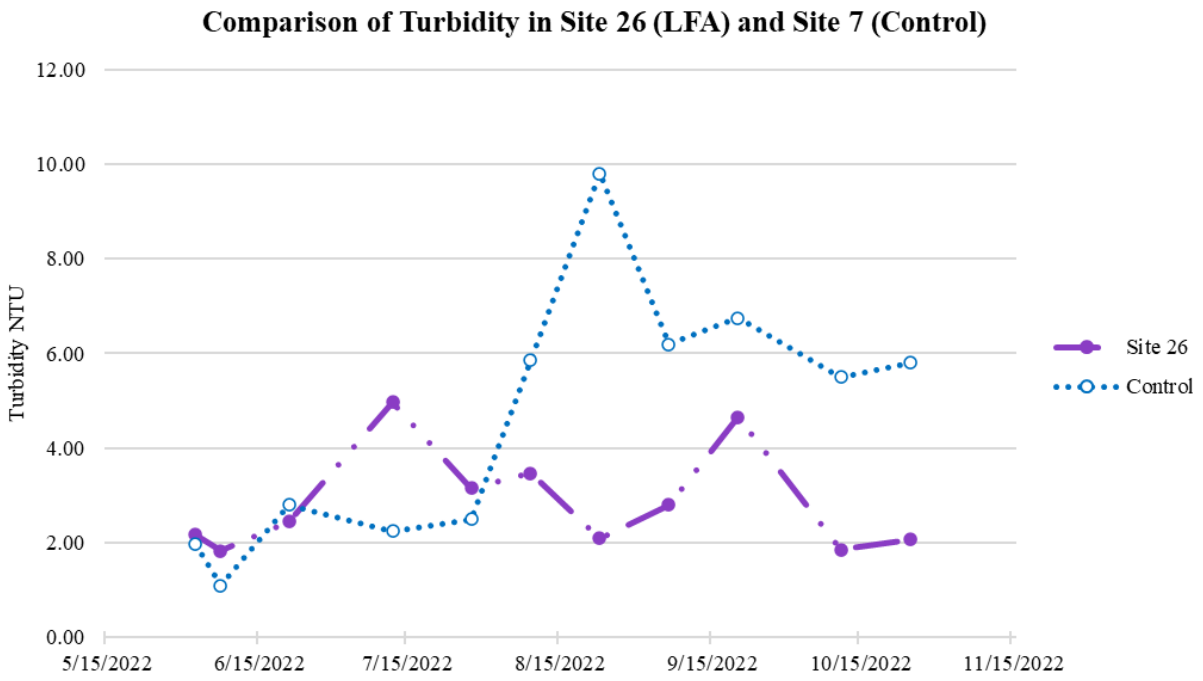

Figure 8. Comparison of Turbidity in Site 26 (LFA) and Site 7 (Control)

Comparison of Median and Maximum Turbidity Levels in 2020, 2021, and 2022						
	2020		2021		2022	
Site	Median Turbidity (FNU)	Maximum Turbidity (FNU)	Median Turbidity (FNU)	Maximum Turbidity (FNU)	Median Turbidity (NTU)	Maximum Turbidity (NTU)
LFA F	1.70	3.78	2.92	10.81	1.50	3.50
LFA G	1.74	4.28	3.17	11.39	N/A	N/A
LFA H	2.30	5.46	4.21	9.68	2.25	9.50
LFA I	2.59	6.24	4.98	9.52	3.20	10.00
LFA J	2.58	5.02	5.46	10.51	N/A	N/A
Site 6	2.40	5.20	3.58	11.02	1.20	3.50
Site 7	N/A	N/A	N/A	N/A	5.80	10.70

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

5.4 pH

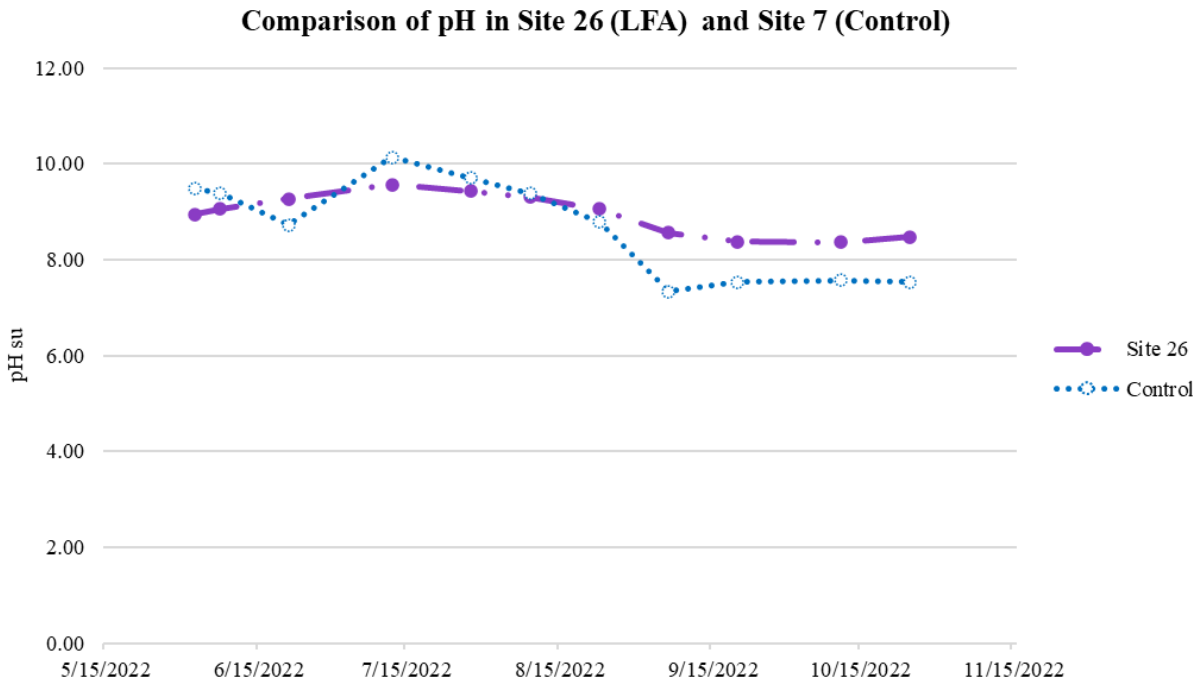

Figure 9. Comparison of pH in Site 26 (LFA) and Site 7 (Control)

5.5 Specific Conductivity

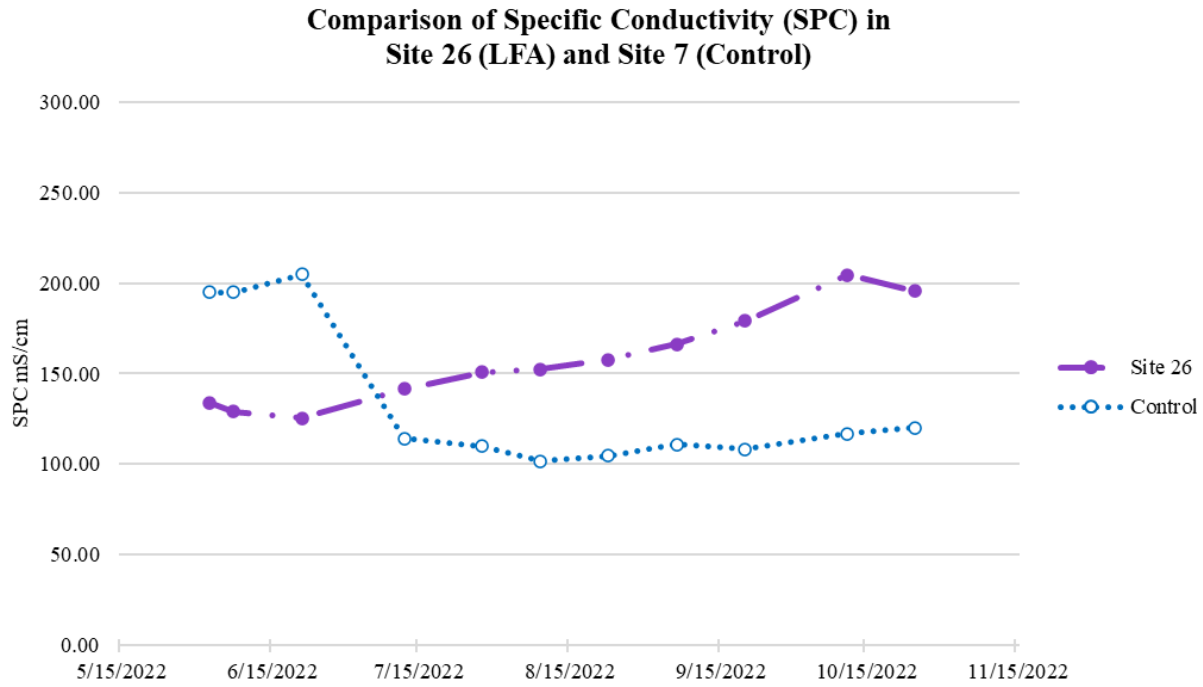

Figure 10. Comparison of Specific Conductivity in Site 26 (LFA) and Site 7 (Control)

5.6 Oxidative Reductive Potential

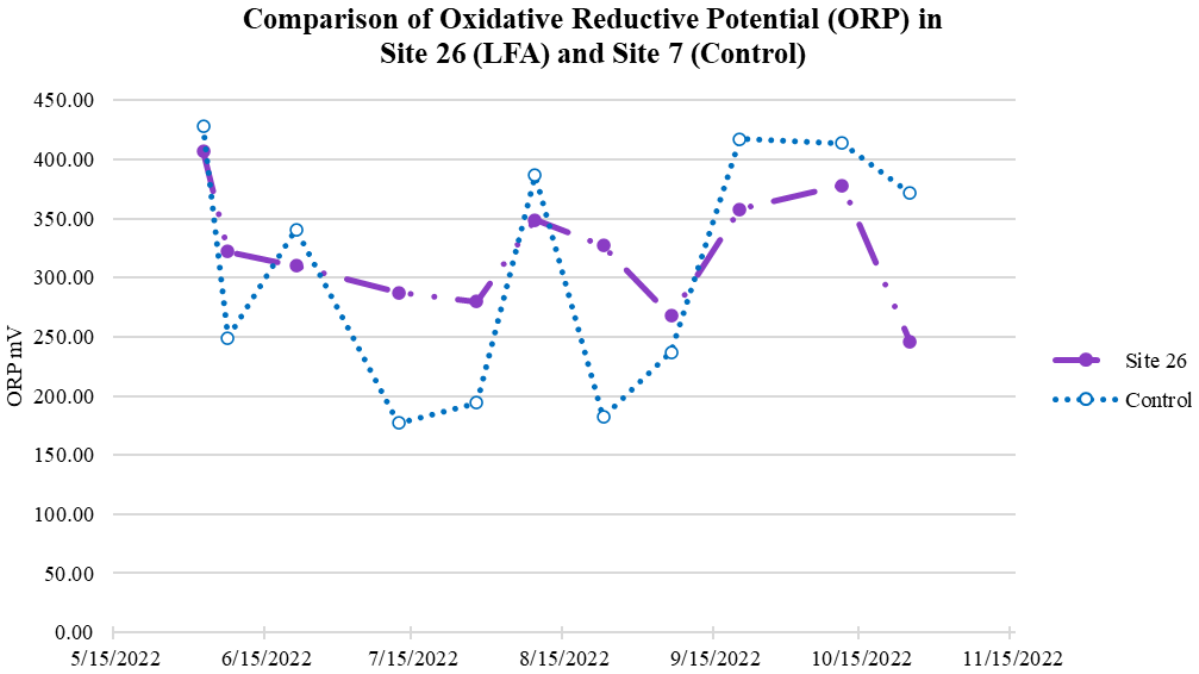

Figure 11. Comparison of Oxidative Reductive Potential in Site 26 (LFA) and Site 7 (Control)

5.7 Hydroacoustic Scans

Hydroacoustic scans were used to determine percent biovolume and plant height. Due to dense vegetation, the scans are decided to host inaccurate results for muck depth. A new method will be tested in 2023 using metal plates to help validate the scans for a more consistent reading of muck depth.

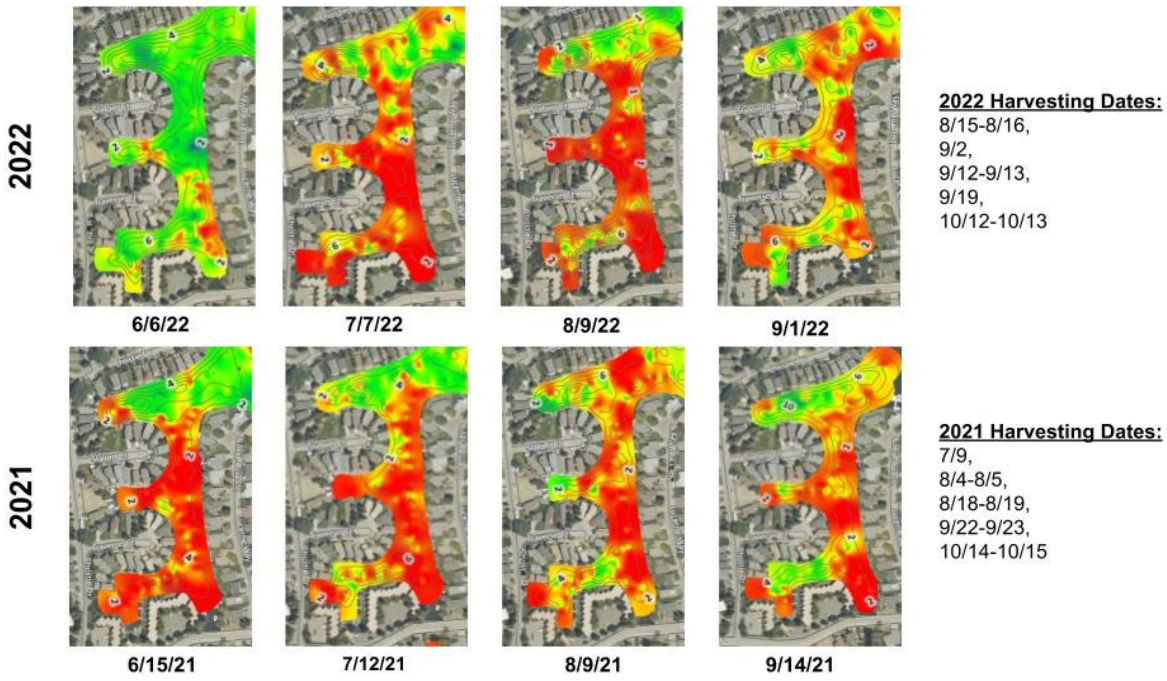

Figure 12. LFA Site 26 Biovolume Percent Storyboard for 2021 and 2022.

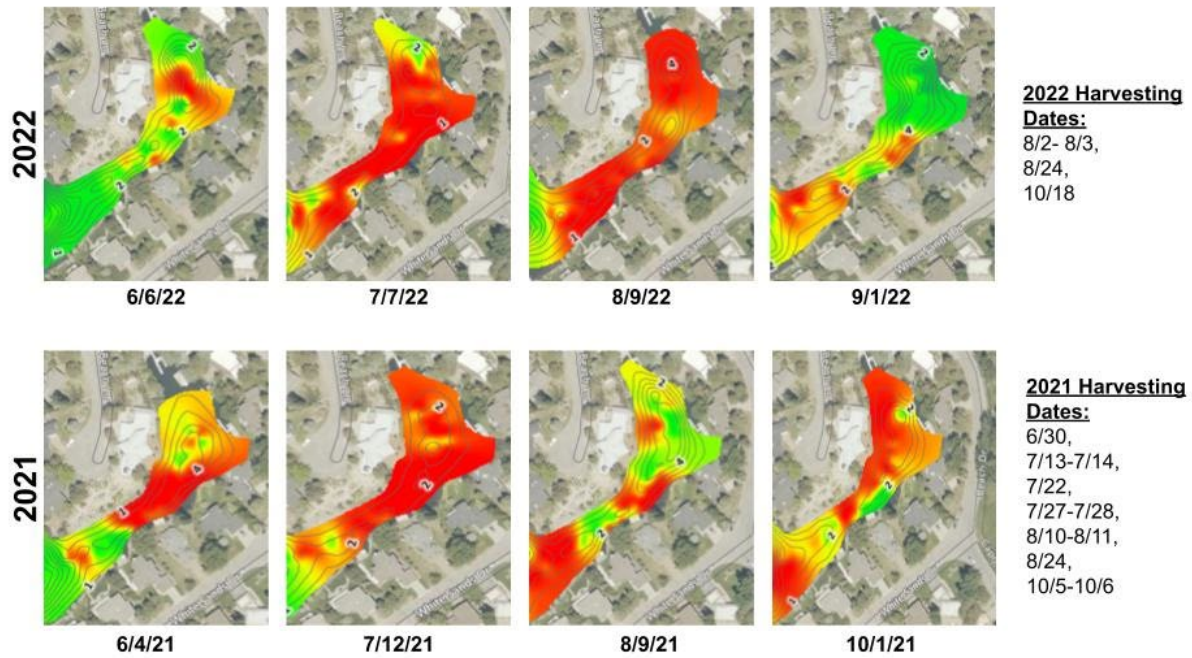

Figure 13.. LFA Control Site 7 Biovolume Percent Storyboard for 2021 and 2022

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 2022 Annual Report for the CMT (Tahoe Keys, 2023). This third-party analysis will continue in 2023 to evaluate the same parameters for a year over year analysis on efficacy of the LFA systems.

5.9 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 12, 2022, in LFA-H and LFA-I. Lahontan Water Boards was immediately notified of the lab results and AIS technicians posted the appropriate signage around Site 26. See Appendix B for Caution Sign and Appendix C trigger levels for posting HAB signage.

Figure 14. Cyanobacteria 'paint' near site LFA-I on July 12, 2022

Date of Sampling:	Site:	CY Species Present?	Anatoxin a (ug/L)	Cylindrosperm (ug/L)	Microcystin (ug/L)	Saxitoxin (ug/L)	Chlorophyll a	Phenophytin a
6/7/2022	LFA F	N	ND	ND	ND	ND	0.76	0.89
	LFA H	Y	ND	ND	ND	ND	1.93	2.39
	LFA I	Y	ND	ND	ND	ND	4.26	4.61
	Site 6	N	ND	ND	ND	ND	0.77	0.75
7/12/2022	LFA F	Y	ND	ND	ND	ND	1.44	1.34
	LFA H	Y	0.16	ND	ND	ND	6.45	5.85
	LFA I	Y	11.72	ND	ND	ND	631.4	386.7
	Site 7	Y	ND	ND	ND	ND	1.32	1.38
8/9/2022	LFA F	Y	ND	ND	ND	ND	3.78	4.22
	LFA H	Y	ND	ND	ND	ND	4.08	4.4
	LFA I	Y	ND	ND	ND	ND	11.01	10.3
	Site 7	Y	ND	ND	ND	ND	2.15	2.4
9/6/2022	LFA F	Y	ND	ND	ND	ND	2.88	2.93
	LFA H	Y	ND	ND	ND	ND	3.98	4.89
	LFA I	Y	ND	ND	ND	ND	4.21	4.29
	Site 7	Y	ND	ND	ND	ND	3.15	3.01
10/11/2022	LFA F	Y	ND	ND	ND	ND	6.90	5.38
	LFA H	Y	ND	ND	ND	ND	4.87	4.51
	LFA I	Y	ND	ND	ND	ND	5.41	5.23
	Site 7	Y	ND	ND	ND	ND	10.04	9.30

Table 4. Cyanobacteria Sampling Results for Site 26 and Site 7 in 2022

5.10 Nutrient Sampling

5.10.1 LFA F:

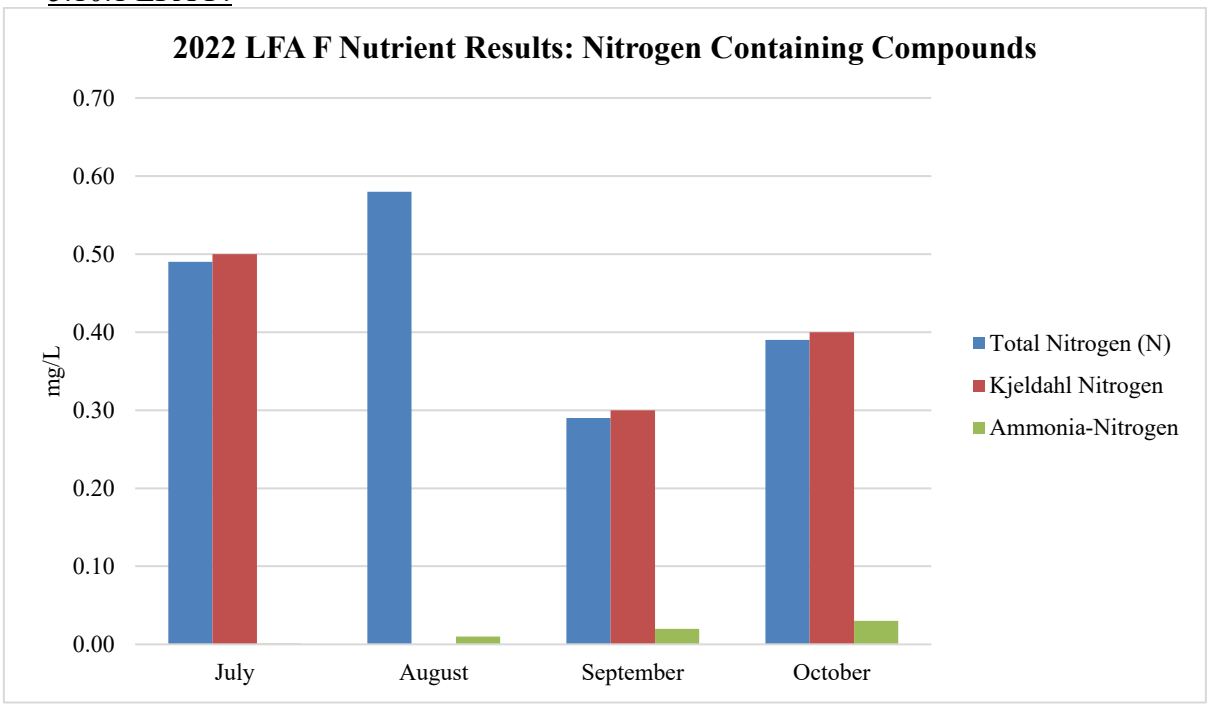

Figure 15. LFA-F Nutrient Results: Nitrogen Containing Compounds

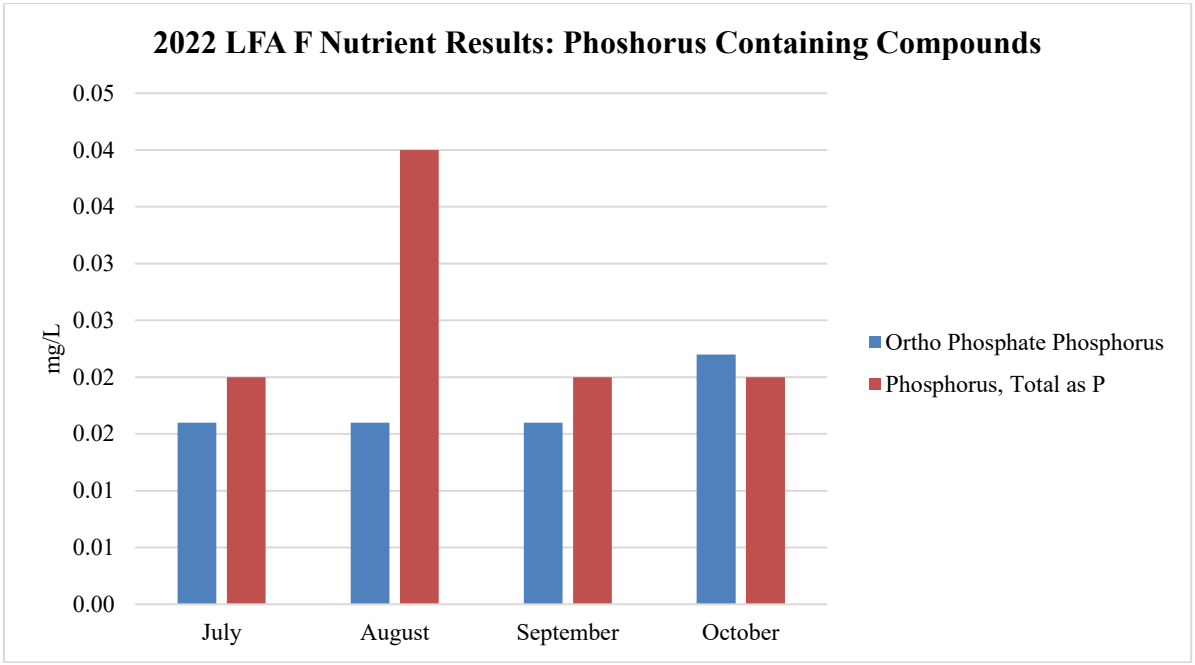

Figure 16. LFA-F Nutrient Results: Phosphorous Containing Compounds

5.10.2 LFA H:

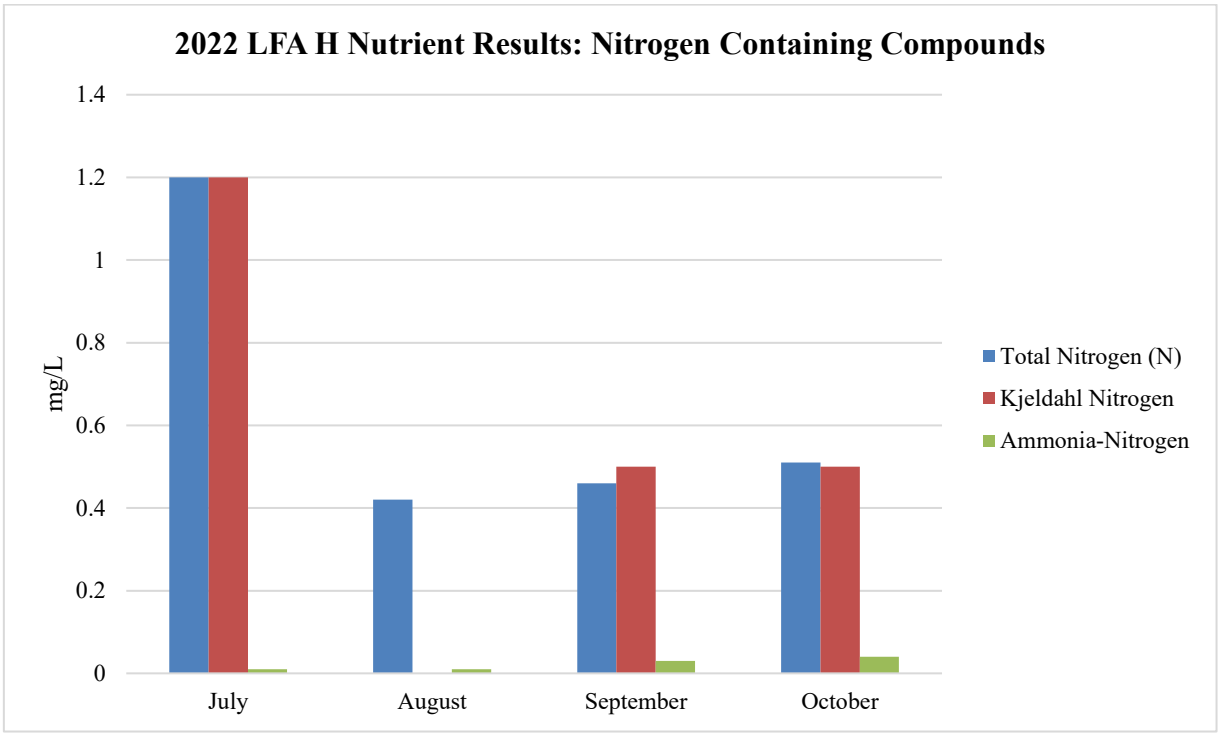

Figure 17. LFA-H Nutrient Results: Nitrogen Containing Compounds

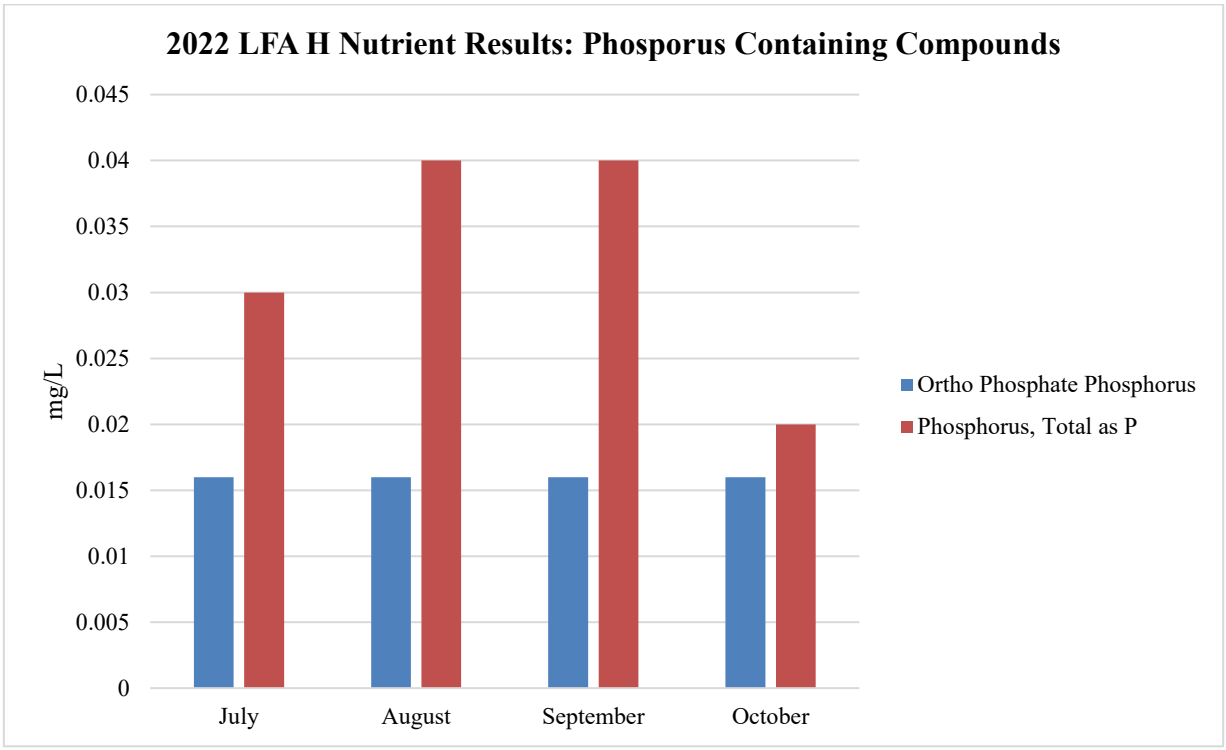

Figure 18. LFA-H Nutrient Results: Phosphorous Containing Compounds

5.10.3 LFA I:

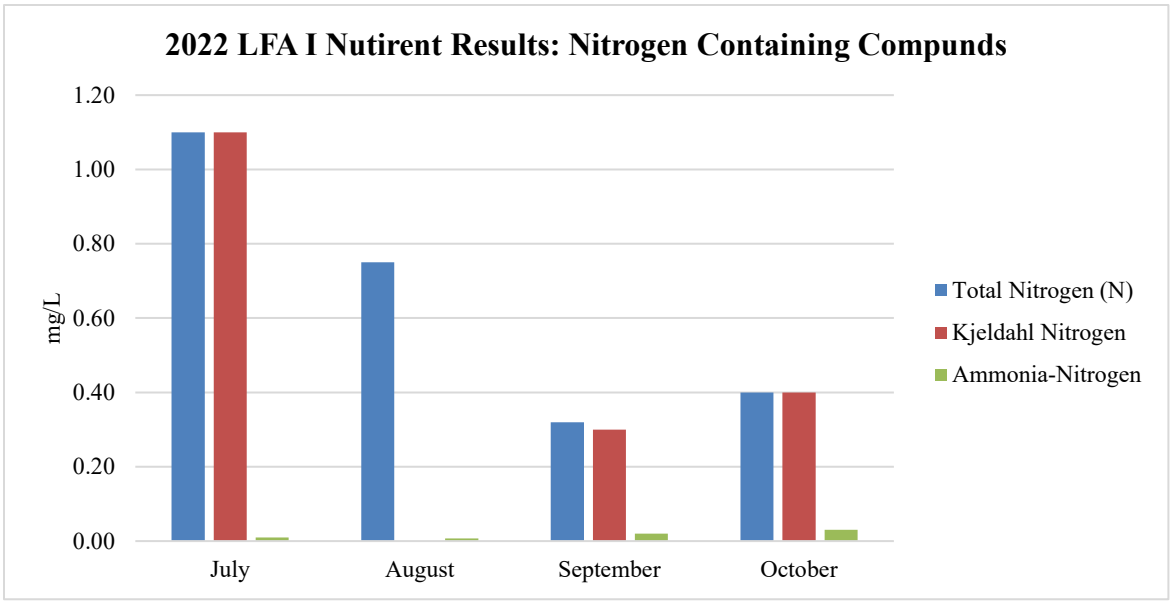

Figure 19. LFA-I Nutrient Results: Nitrogen Containing Compounds

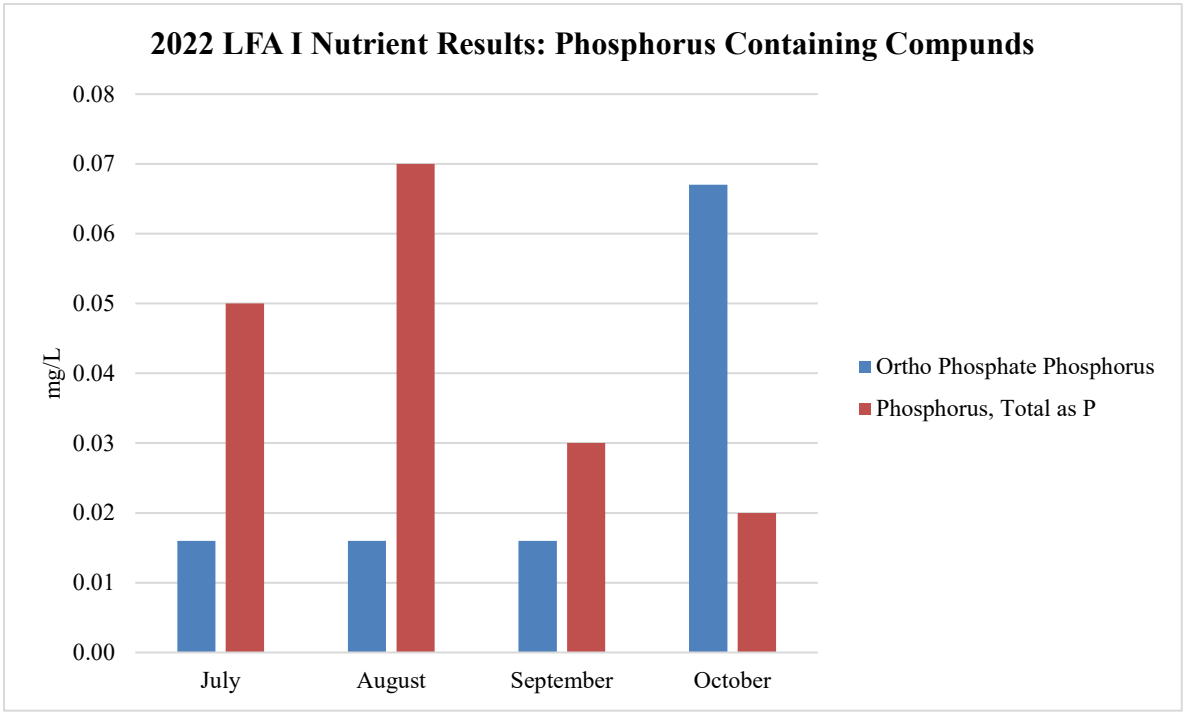

Figure 20. LFA-I Nutrient Results: Phosphorous Containing Compounds

5.10.4 Site 7:

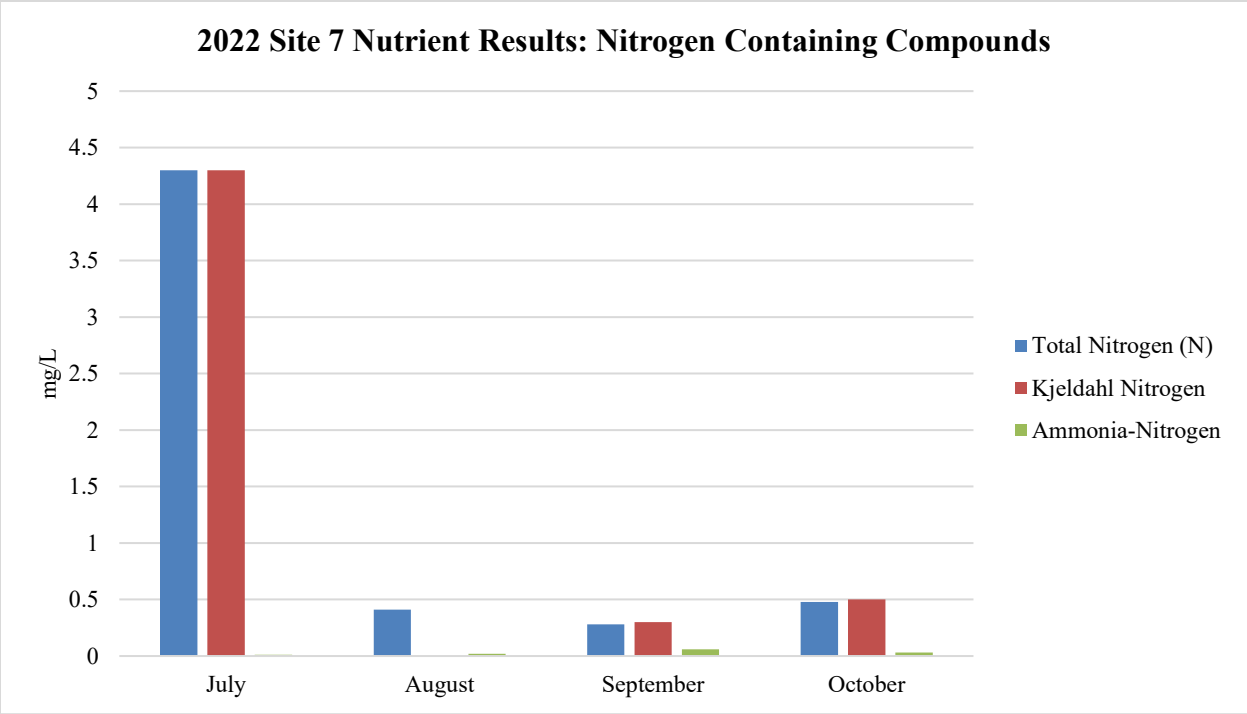

Figure 21. Site 7 Nutrient Results: Nitrogen Containing Compounds

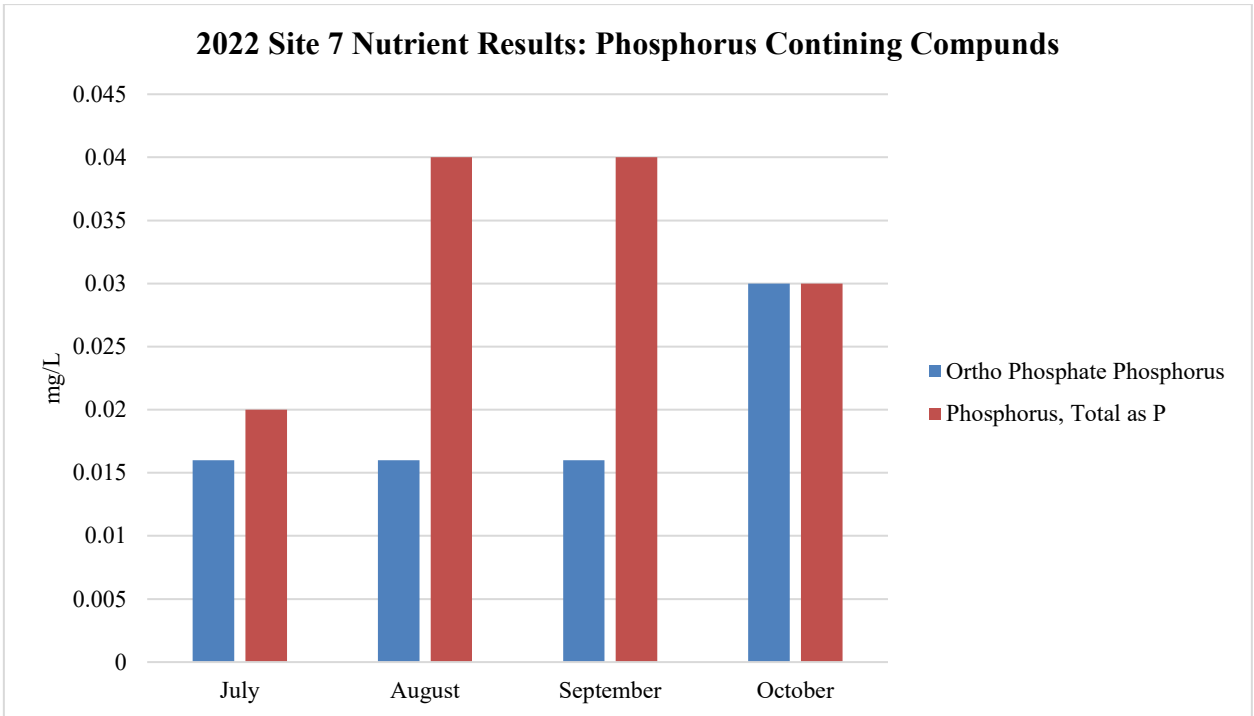

Figure 22. Site 7 Nutrient Results: Phosphorous Containing Compounds

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 the 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. There are no results for 2022 to make a determination presently. A new protocol for sediment sampling will be implemented in 2023 to better understand the effects of LFA on organic matter.

6.3 Objective 3

Overall HAB levels throughout the West Lagoon were increased for the 2022 season. This is thought to be due to setbacks during the first year of the CMT. 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. Monitoring in 2023 will help determine if there are any changes in HAB levels and whether the LFA sites improve or maintain lower levels of HABs than seen throughout the rest of the lagoons. There is also an effort to determine if an increase in HABs is due to the new site installations or if the LFA system could in fact facilitate HAB growth in dead end areas.

6.4 Objective 4

Results for 2022, in the macrophyte survey and hydroacoustic scans, indicate there are not any significant reductions in macrophyte growth when compared against the control site. More years of data will be needed to determine the real efficacy of LFA, as it is expected to take time for an LFA type process to make noticeable changes in the environment. Several factors could account for the biovolume seen in 2022. First, there was an overall decrease in mechanical harvesting with the ongoing CMT project. Secondly, there were several distinct tears in the LFA tubing. This resulted in reduced airflow in the diffusers, meaning decreased efficiency altogether in the test site. Thirdly, the 2022 season was a lower water year in comparison to the 2021 season, though it should be noted that both seasons were considered low water years. Shallow water depths in dead end areas – like in Site 26 – create an environment where plants easily fill the available water column.

7.0 2022 RECOMMENDATIONS FOR 2023 SEASON

7.1 Utilizing Metal Plates to Increase Hydroacoustic Scan Accuracy

In 2023, WQD staff plan to utilize the metal plates as a standard for increasing hydroacoustic scan accuracy and to aid in monitoring muck depth. These plates are flush with the muck layer and the scan should note changes in height thus determining muck depth changes.

7.2 Maintenance to LFA System

The TKPOA WQD staff recommends that repairs be made to the LFA system in Site 26 prior to the 2023 season and routine maintenance for the two new sites, 25 and 27. Repairs include fixing any tears in tubing, utilizing rebar to secure tubing, and conducting routine maintenance such as oil changes and cleaning of diffusers.

7.3 Increase Homeowner Communication

TKPOA WQD recommends improving homeowner communication about LFA systems and the importance of lifting propellers in LFA treatment areas. Better education for homeowners and seasonal staff on diffuser locations as well as where the tubing runs, might decrease the need for future repairs.

7.4 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 ACKNOWLEDGEMENTS

The League to Save Lake Tahoe
Jesse Patterson, *Chief Strategy Officer*
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Sabrina Rice, *Environmental Scientist*

Sierra Ecosystem Associates
Rick Lind, *President*
Rayann La France, *Administrative Services Manager*
Aria Pauling, *Assistant Environmental Scientist*

Environmental Science Associates
Toni Pennington, *Aquatic Biologist*

Clean Flo
Brian Kling, *President*
David Grote, *Operations Manager*

9.0 LIST OF PREPARERS

The following individuals prepared the text presented in this report.

Name	Role
Kristine Lebo TKPOA	Principle in Charge Contributing Author Data Analysis
Meghan Hoffmann TKPOA	Contributing Author Data Collection Data Analysis
Erin Harkins TKPOA	Contributing Author Data Collection Data Analysis GIS Mapping
Moire Breslin TKPOA	Contributing Author Data Collection
Benjamin Hale	Data Collection
Renae Lewis	Data Collection

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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.