INTEGRATED MANAGEMENT PLAN FOR AQUATIC WEEDS FOR THE TAHOE KEYS LAGOONS

PREPARED PURSUANT TO
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION BOARD ORDER NO. R6T-2014-0059

Prepared by
Tahoe Keys Property Owners Association

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

UPDATE
JANUARY 2025

TABLE OF CONTENTS

1.0 INTRODUCTION

In accordance with its Waste Discharge Requirements (WDR) (Lahontan Regional Water Quality Control Board, Board Order No. R6T-2014-0059, issued July 17, 2014) (Lahontan 2014), Tahoe Keys Property Owners Association's (TKPOA) Integrated Management Plan (IMP) applies an integrated pest management approach to aquatic weed control by combining sound ecological principles and research of new technology with proven methods for aquatic plant control. Annually, TKPOA has completed and submitted an update of its IMP to Lahontan. This is the ninth update to the IMP.

To learn more about the history of the IMP development, the location, ecology and hydrology of the Tahoe Keys Lagoons, the aquatic invasive species (AIS) of concern, and the WDR-approved methods of plant control (along with their advantages and disadvantages), please refer to the first IMP submitted to Lahontan (TKPOA 2017e).

1.1 IMP GOALS AND OBJECTIVES

For reference, the goals and objectives of TKPOA's IMP, as established by its WDR (Lahontan 2014), are as follows:

Goal 1: Fulfill the objectives named in the 2014 WDR.

WDR Objectives:

- Eliminate the spreading of AIS from the Tahoe Keys to the greater Lake Tahoe.
- Enhance the overall water quality of the Keys Lagoons thereby improving Lake Tahoe water quality and associated clarity.
- Reduce habitat for non-native fish and enhance habitat for native fish in the Keys Lagoons.
- Restore and maintain established beneficial recreational uses, including water contact safety in the Keys Lagoons and commercial uses within neighboring Marina.
- Implement a combination of cost-effective control measures that are feasible for long-term management of aquatic invasive plants (AIP).

Goal 2: Continue to refine existing methods of aquatic plant control and to research new, safe, cost- effective methods to control aquatic invasive plants. Use established objective criteria to evaluate these methods and proposed effective, feasible methods for inclusion in updates to the IMP.

Objectives in support of Goal 2:

- Identify and confirm safety and success of new and novel aquatic invasive plant control methods by reviewing scientific literature and reports of these methods used under similar settings and operational conditions.

- Conduct and evaluate small-scale demonstrations of localized control methods in defined areas of the Keys Lagoons. These small-scale demonstrations may include methods not specified as control measures in the WDR but will be conducted under the appropriate authorization of permits issued by the Lahontan Board.

These goals and objectives provide the basis for the IMP activities undertaken to date, and for the activities planned for 2025.

2.0 AQUATIC WEED CONTROL ACTIVITIES IN 2024

The following sections summarize WDR-approved weed control activities. WDR-approved indicates the activity is included in TKPOA's 2014 WDR that TKPOA may undertake without additional consultation or permitting with Lahontan. The WDR-approved activities undertaken by TKPOA in 2024 include both mechanical harvesting and fragment collection. The WDR also directs TKPOA to employ best management practice (BMP) measures to limit the spread of viable plant fragments during aquatic weed harvest operations. Discussion includes the purpose of the activity, duration of the activity, location of the activity, and effectiveness of the activity. Effectiveness is considered in relation to the understood purpose of the activity and in relation to the success criteria established by TKPOA with the 2017 IMP (TKPOA 2017e).

In 2024, TKPOA primarily focused on implementation of Year 3 of the Control Methods Test Project (CMT). The third year included the continuation of follow up spot treatments using bottom barriers, ultraviolet light (UV-C), and Diver Assisted Suction Harvesting (DASH) along with Laminar Flow Aeration (LFA). These CMT activities were conducted under a separate permit and not as part of the WDRs. As a result, this chapter provides an overview of activities implemented in 2024 under the WDRs and conducted independent of the CMT.

2.1 HARVESTING

Since the 1970's, harvesting has been the primary method to help maintain navigable waterways and other beneficial uses such as contact and non-contact water recreation. One of the primary objectives of the harvesting is to maintain a minimum of three feet of vessel hull clearance in the channels to minimize the potential for weeds to be transported from the lagoons into Lake Tahoe by watercraft.

2.1.1 Mechanical Harvesting Implementation 2024

TKPOA initiated harvesting operations in early June 2024 and continued harvesting throughout the season through October 2024. During the season, TKPOA operated four mechanical harvesters, as well as up to four skimming vessels. Harvesting and fragment collection staff were hired early, and more resources were used to train and monitor them resulting in an increase in the efficiency of harvesting and fragment collection operations. The new method for calculating weed harvesting totals established in 2023 (refer to TKPOA IMP 2023) was expanded and staff attempted to get harvested amounts for specific areas in the lagoon system. This illustrated the zones that needed the most attention as well as enabling TKPOA to compare harvested CMT control zones with the other methods tested in the CMT. Changing the final calculations from cubic yards to tons has also proved beneficial in accuracy to better understand the rate of removal and capabilities of each harvester. The cubic yards measurement has been a standard long used by the TKPOA based on visuals by the harvester operators and the capacity of each machine. When TKPOA switched weed disposal methods in 2023 and began using South Tahoe Refuse Center (STR) as the disposal site, weight measurement data became available in tons. This provided a solid data point to base

calculations and removal rates on. After finding a standard correlation to convert cubic yards to tons, staff were able to apply the new formula to previous years data. Moving forward, all harvesting data will be reported in weight of tons.

2.1.2 Mechanical Harvesting Effectiveness for 2024

The total amount of biovolume removed from the Tahoe Keys via harvesting in 2024 was 689 tons. The skimmers following the harvesters removed an additional 168 tons (outlined in section 2.2.3) bringing the total amount of biovolume removed to 857 tons. This also included the Marina locations that have not been regularly harvested for several years past. Moving forward TKPOA and Suntex Marina intend to continue the partnership and use harvesting to keep the Marina channels open. With water levels still higher from heavy snowpack, this season had a slower start, mostly removing curlyleaf pondweed which does its first sprout in early spring. By August operations ramped up to removing large coontail blooms. Flowering Eurasian watermilfoil along the shoreline edge continues to be an issue that is difficult to harvest due to the shallow shoreline areas.

Figure 1 displays tons of plant material harvested by month since 2022 and Figure 2 displays harvesting totals (not including skimming contributions) from 2020 to 2024, respectively. On average, August seems to be when peak biomass removal occurs, usually around 25% of total biomass for the season. In 2024, 28% of the total weeds harvested were in August followed by 24% of the total weeds harvested in September. In 2022, to meet the requirements of the CMT permit, turbidity curtains placed throughout the West Lagoon affected harvesting operations in the beginning of the season, which is why 52% of total weeds were harvested in October.

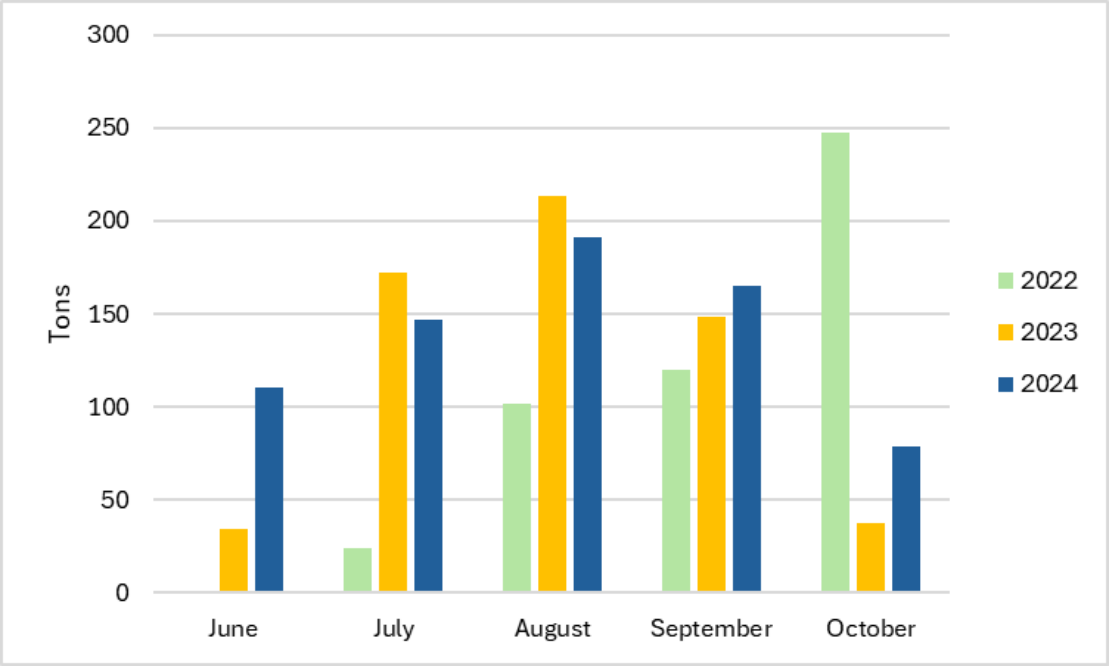

Figure 1. Tons of Plant Material Harvested by Month since 2021

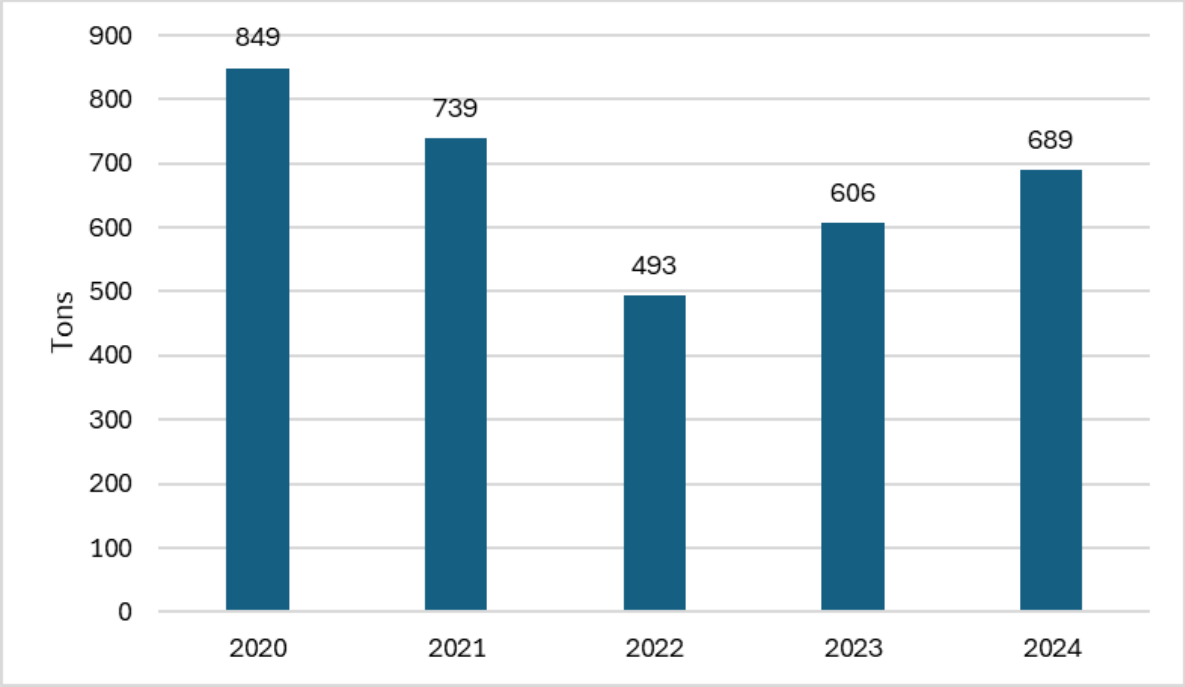

Figure 2. Comparison of Harvesting Totals 2020-2024

2.1.3 Harvester Maintenance

In 2024, TKPOA continued its maintenance standards for the harvesting vessels, established in 2023, to help ensure that at least four are fully operational throughout the season. Each TKPOA operator was responsible for weekly upkeep of their assigned harvester. This compared to the previous protocol of having a single mechanic responsible for keeping all harvesters operable.

2.1.4 Weed Disposal / TKPOA Corporation Yard

TKPOA License Agreement with the California Tahoe Conservancy (CTC) to permit use of the Dover Corporation Yard expired in December 2024. Since 2023, TKPOA has had an agreement with STR for disposing harvested weeds using their services. As a result, harvested aquatic weeds are no longer placed on the ground to dry, but are delivered directly to STR after being off-loaded from the harvesters.

Future operations at the Corporation Yard are still under consideration by TKPOA.

2.2 FRAGMENT CONTAINMENT

There are currently three methods for containment both in the channels and throughout the Lagoons: bubble curtains, Boat Back-Up Station and skimming. Each method has unique advantages and applications tailored to keep fragments from spreading into Lake Tahoe.

2.2.1 Bubble Curtains

Bubble curtains are an innovative technique used to create a physical barrier of bubbles in the water column to contain fragments within the Lagoons and stop from spreading into Lake Tahoe. In 2018, with funding support from The League to Save Lake Tahoe, divers hired by TKPOA installed the West Channel bubble curtain. Since the initiation of the program, TKPOA has installed a second line, creating a 'double bubble curtain', and has continually monitored and enhanced the operations of the bubble curtain. A double bubble curtain was subsequently installed in the East Channel in May 2022. Refer to Appendix A for a full history of bubble curtains in the Tahoe Keys Lagoons.

2.2.1.1 West Channel Bubble Curtains

The West Channel bubble curtains were redone in 2024 to streamline the air demand. After continued issues with compressors malfunctioning due to electrical constraints, TKPOA hired a dive contractor to redesign the bubble curtain underwater. Almost quadruple the necessary bubble tubing was found in the channel and irregular splicing of segments was assumed to make the system less efficient. The redesign and installation reduced the total number of segments for each bubble curtain into two lines, which allowed for a single compressor to be able to adequately supply the four air lines now in service. Since August, TKPOA has been able to maintain the 24/7 operations with no disruption of service at the West Channel bubble curtain.

2.2.1.2 East Channel Bubble Curtain

The East channel bubble curtain-maintained functionality 24/7 all year long except for one power outage incident in late March, which caused an off time estimated at 14 hours. TKPOA transferred ownership, operations, and maintenance of the East Channel bubble curtain to Suntex Marina in October 2024.

2.2.1.3 Bubble Curtain Effectiveness for 2024

In 2024, the methodology of efficacy monitoring for the bubble curtains was revised. A new SOP was written by TKPOA's consulting lead scientist, Dr. Lars Anderson, and approved by the Bubble Curtain Committee. This revised SOP was applied during both peak and off-peak boating season to better assess the system's performance under variable conditions. Crews followed transects across the inside (Lagoons side) and outside (Lake Tahoe side) of both channels with the bubble curtains operational and then again 72 hours later with the bubble curtains shut off. Each fragment collected was identified, weighed, counted, and measured. The first round, conducted during peak boating season, shows more fragments with the curtains being shut off rather than on. In contrast the second round, conducted during off-peak boating season, shows more

fragments collected while the curtains were on. The distribution of fragments collected between the inside and outside of the curtains showed no consistent pattern, often presenting more fragments on the Lake Tahoe side regardless of the bubble curtains' operational status. In total, only about 200 fragments were collected from both bubble curtains during each testing round, suggesting that the sample size is probably not sufficient to make any conclusions. More testing and some possible modifications to the SOP, such as transect location, will be necessary to better define a pattern and find meaningful results. Harvesting and skimming efforts were conducted regularly around the bubble curtain and Boat Back-Up Station with an estimated 9.4 tons of weeds removed from the area for the season.

2.2.2 Boat Back-Up Station

The Boat Back-Up Station involved placing visible signage for boaters exiting the Lagoons to place their boats in reverse before entering Lake Tahoe proper. This method aimed to remove aquatic weed fragments from propellers and keels, reducing the risk of transporting AIS from the Lagoons to the Lake and to promote better compliance with environmental best practices among boat operators. The TKPOA Boat Back-Up Station is a recurring, seasonal installation. Refer to Appendix A for a full history of the Boat Back-Up Station in the Tahoe Keys Lagoons.

2.2.2.1 2024 Implementation and Effectiveness

The buoys and directional signage (see Figure 3) were installed in the West Channel in May 2024 and removed late October 2024. For the 2024 season, TKPOA did not actively conduct visual monitoring of the Boat Back-Up Station, but based on TKPOA Water Quality staff observations, compliance and participation has increased overall since installed in 2016. Homeowners are continuing to take more responsibility and ownership of the Boat Back-Up Station by encouraging others to adhere to it.

Figure 3. Boat Back-Up Station Signage

2.2.3 Skimming

Skimming targeted surface-level containment using specialized 'dock boats' and crew members using nets and rakes to collect floating fragments preventing AIS dispersion within the Lagoons as well as into Lake Tahoe.

2.2.3.1 2024 Implementation and Effectiveness

In 2024, TKPOA implemented a strategic skimming schedule from mid-June through October 31st to follow one day behind the harvesters in the West Lagoon and East Lagoon. This allowed time for the fragments to clump and rise to the surface giving the skim team better groupings to collect. This proactive approach led to the successful collection of 168 tons of weeds, representing 24% of the total weed removal this season. Skimming efforts were used for removing the flowering Eurasian watermilfoil along the shallow shorelines that harvesting is unable to reach. There was notable efficiency observed in the West Channel and Boat Back-Up Station, key areas for preventing the spread of AIS into Lake Tahoe, with a total of 2.5 tons removed there alone. Figure 4 shows the amount of weeds removed using the skimming method since 2020. Due to the installation of turbidity curtains in the West Lagoon to comply with the CMT permit, skimming was limited in 2022.

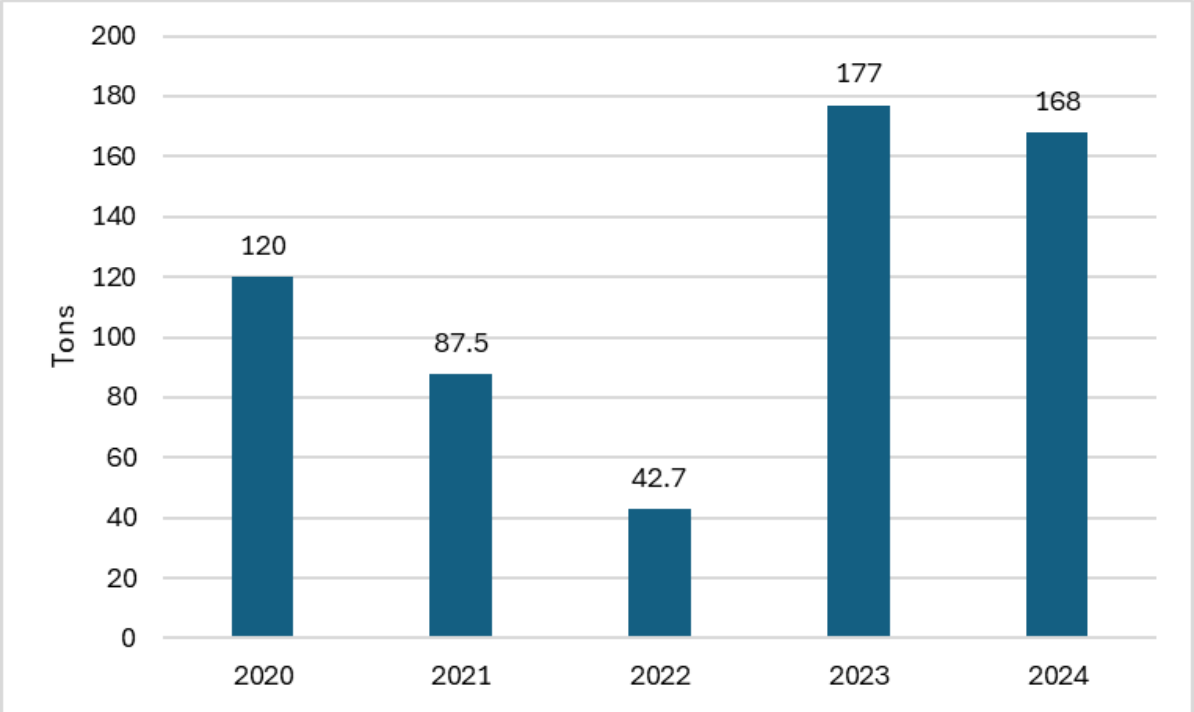

Figure 3. Comparison of Skimming Totals 2020-2024

3.0 NON-CHEMICAL CONTROL METHODS UNDER EVALUATION IN 2024

As part of TKPOA's goal to meet its WDR objectives, TKPOA went through a 5-year process to develop a plan and obtain the permits necessary to test the efficacy of a combination of methods, including aquatic herbicides, for bringing the invasive plants under control in the lagoons. As the plan developed through public and stakeholder review processes, the plan expanded to include UV-C and LFA. Approved by Lahontan and the Tahoe Regional Planning Agency (TRPA) in early 2022, Year 3 of the three-year CMT Project was completed in November 2024. The objective of these treatments is to determine if they can be utilized to sustain the 75% "knock back" of target weeds (Eurasian watermilfoil, curlyleaf pondweed, and coontail). Figure 5 shows the Year 3 CMT treatment map.

The four CMT non-chemical methods are briefly discussed in the following sections and will be extensively described in the CMT Year 3 Annual Report to be submitted to Lahontan and TRPA in March 2025:

- LFA
- UV-C
- Bottom Barriers
- Diver Assisted Suction Harvesting

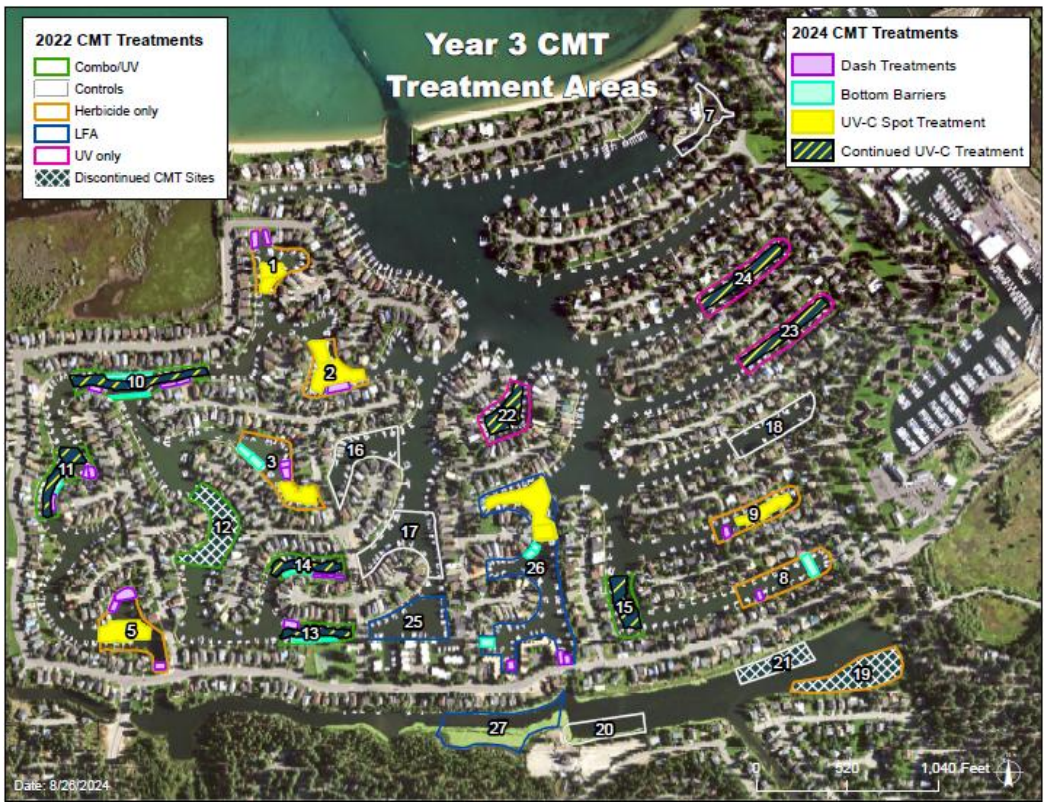

Figure 4. CMT Treatment Areas

3.1 LAMINAR FLOW AERATION (LFA)

LFA systems were first introduced in the Tahoe Keys Lagoons in 2018. The implementation was part of an experimental project aimed at improving water quality and reducing organic sediment layers in sections of the West Lagoon. In 2022, as part of the CMT Group A methods, LFA was expanded from one site to three sites and tested in combination with other CMT methods. Refer to Appendix A for a full history of the LFA project in the Tahoe Keys Lagoons.

3.1.1 2024 Implementation

In 2024, TKPOA had three LFA test sites within the Tahoe Keys Lagoons: 1) one in the West Lagoon that has been operating since late 2018 (also known as Site 26 of the CMT Project), 2) a second location in the West Lagoon that was installed in December 2022 (known as Site 25 of the CMT Project), and 3) a third location in the Lake Tallac Lagoon that was installed in December 2022 (known as Site 27 of the CMT Project). These LFA systems were known as Group B Methods within the CMT project.

Multiple methods to measure organic sediment layer thickness have been evaluated starting in 2023 and continuing throughout 2024. Pole measurements, staff gauges, and flat plates underwater were physical measurements taken in fall of 2024. Laboratory analysis was conducted on samples of organic sediment contained in mesh bags that were placed in all three LFA sites plus two control sites in fall of 2023. Two organic sediment bags were removed from each site in spring 2024 and another set-in fall 2024.

3.1.2 LFA Effectiveness

Laboratory analysis from this mesh bag study showed a reduction in phosphorus, percent organic matter, and nitrogen between spring and fall but there did not appear to be a significant difference between the control sites and the LFA-treated areas. For full results, please refer to CMT Year 3 Annual Report.

LFA presented several maintenance challenges. The systems required compressors and divers, along with significant land space and electricity, which are often unavailable in most common space lagoon areas. Additionally, the noise generated can be disruptive, leading to high sound reduction expenses with no acceptable solution found thus far. After 6 years at the longest-running site, there was no measurable change in the organic sediment layer. There was no evidence to suggest that these systems effectively reduce plant growth or organic sediment accumulation. While local sequestration may be occurring, it was not extensive enough to reduce overall plant growth.

3.2 ULTRAVIOLET LIGHT (UV-C)

UV-C treatment was first introduced experimentally in the Tahoe Keys Lagoons as part of an innovative strategy to control AIS. Starting in 2020, these trials aimed to explore the effectiveness of UV-C light in disrupting plant growth as a non-chemical method. The treatment specifically targets the DNA of plants, preventing reproduction and growth, thus offering a potentially sustainable solution to manage invasive species and maintain ecosystem health in the Lagoons. It became a Group A method in 2022 as part of the CMT. For a full history of UV-C use, refer to Appendix A.

3.2.1 UV-C Treatments Conducted During Year 3 of the CMT (2024)

In 2024, various UV-C treatment types were performed as a component of the CMT Project. These treatment types include a continuation of Year 1 UV-C treatment, such as UV-C only and continued UV-C treatments in former Year 1 UV-C/herbicide combination sites, and a new treatment intended to sustain the “knock back” of target weeds called UV-C Spot treatment. This treatment was applied to smaller areas within CMT sites with UV-C, then re-treating them three additional times. New to 2024, UV-C was also used as a follow-up treatment to bottom barrier removal at the end of the season. UV-C treatment occurred in 15 test areas throughout the lagoons from June 2024 through October 2024. A total of 11 acres were treated with the UV-C across all three methods repeated multiple times throughout the season (see Figure 5).

3.2.2 UV-C Effectiveness

UV-C was shown to be effective in reducing AIS abundance and at sustaining control in the years following. If treatment occurs based on curlyleaf pondweed growth cycle, it could be used to prevent the population of turions. It is the most effective mid channel, as near shore AIS abundance was not controlled in UV-C sites, suggesting other control methods need to be used for these areas. Physical features like docks, supporting poles, and boats made it difficult for

the UV-C boats to access near shore areas, as did environmental factors like water levels, near shore bottom terrain and inclement weather.

A major funding investment would be needed to use UV-C at full-scale throughout the lagoons. To place the arrays, close enough to the plants where water clarity was not an issue, UV-C boats were designed and built to meet specific needs of the Tahoe Keys Lagoons.

3.3 BOTTOM BARRIERS

Bottom barriers are a physical control method used in the Tahoe Keys Lagoons since 2010 to manage AIS by blocking sunlight, thus inhibiting photosynthesis and plant growth. These barriers consist of benthic mats that are laid directly on the lagoon bed. This strategy is used throughout the Tahoe Basin as part of AIS management methods. Refer to Appendix A for a full history of bottom barriers in the Tahoe Keys Lagoons.

3.3.1 Bottom Barrier 2024 Implementation

In 2024, bottom barriers were used to cover specific areas throughout the lagoons as part of Year 3 of the CMT Project. Divers secured the bottom barriers using rebar and anchors in nine test areas. For 2024, the total number of test sites was reduced so that areas could be extended for more coverage in a single location. A total of 0.89 acres of the lagoons were covered with bottom barriers from approximately June 2024 to October 2024. Refer to CMT Year 3 report for full results.

3.3.2 Bottom Barrier Effectiveness

Bottom barriers require sufficient time to be effective, making early season implementation ideal. With the current installation rate, it takes about one month to install one acre. If scaled up and more barriers were placed down at the beginning of the season, there would not be enough time for proper inhibition if barriers needed to be removed before winter as is the current practice. It is advisable to leave the barriers in place with potential removal one year later. There are also considerations regarding maintenance and burial issues as well as material cost and longevity of the barriers themselves. Under the current permit allowances of a maximum of five acres per year it would take a minimum of 22 years to cover the West Lagoon alone if bottom barriers were the only method used.

3.4 DIVER ASSISTED SUCTION HARVESTING (DASH)

DASH is a precise, non-chemical method for controlling aquatic weeds in the Tahoe Keys Lagoons. This technique involves divers manually removing AIS from the lagoon floor, which are then suctioned to the surface and removed. Introduced in the Tahoe Keys as a selective and minimal-impact approach, DASH targets specific areas heavily affected by AIS as well as hard to get places for other non-chemical methods, like underneath docks. This method was established as part of the Group B Methods within the CMT.

3.4.1 DASH 2024 Implementation

DASH was utilized in 2024 as part of the Year 3 CMT Group B methods. The dive crew hand-pulled target weeds from the bottom of the lagoons at the treatment sites and directed them towards a suction generating flow system. The suction system was used to transport the weeds into a container onto the boat at the surface. The weeds were then collected and analyzed to determine the percent composition of species pulled from that test area. A subset sample of weeds were held back from each DASH treatment location to roughly estimate how many turions from curlyleaf pondweed were removed by the method. This is important to understand not only the weed removal itself but the future weed repopulation that is being inhibited. Between July – October of 2024 there were 20 DASH test areas, and each area received two treatments, some sites received three treatments. New to 2024, DASH was conducted as an additional follow up treatment to certain sites after bottom barrier removal. A total of 1.71 acres were treated with DASH. Refer to CMT Year 3 report for full results.

3.4.2 DASH Effectiveness

The maximum square footage that one dive team can cover in a day is 3,000 sqft. The growing season for plants extends from May to the end of October. It is estimated that the maximum acreage that a single dive crew can manage in a season is eight acres total but it should be noted that each area would require repeated DASH to be most effective. If DASH was focused on only along the shorelines in the west lagoon at a total of 45 acres, it would take a minimum of six years to treat with only a single pass.

DASH is an effective method at physically removing turions, the reproductive structures of curly leaf pondweed, which enable the plant to survive through winter and regenerate in the spring. This should have a compounding effect in preventing future population growth.

4.0 DATA COLLECTION AND MONITORING

Since 2015, TKPOA has conducted a variety of routine surveys to monitor the spread of aquatic weeds in the Keys Lagoons as well as to comply with its WDR. These routine surveys include the following:

- Annual Macrophyte Survey –conducted in late June/early July
- Water Quality Sampling –conducted monthly beginning in June
- Hydroacoustic Scans – conducted twice monthly beginning in late May
- Algae Monitoring – conducted after the first visual identification of algae presence

4.1 MACROPHYTE SURVEY

The information below summarizes some of the key details from the 2024 Macrophyte Survey Report prepared by Sierra Ecosystem Associates (SEA) in accordance with Lahontan Board Order No. R6T-2014-0059 and submitted to Lahontan in January of 2025. Please refer to the 2024 Macrophyte Survey Report for additional information and details (TKPOA 2024a).

The 2024 point-intercept survey was conducted over the course of five days: July 8 - July 12, 2024. During the survey, a total of 672 points were sampled throughout the Keys Lagoons, including the East Lagoon (107 points), West Lagoon (489 points), and Lake Tallac (76 points). The survey data showed that curlyleaf pondweed along with native coontail, are the most prevalent species in the waterways of the Keys Lagoons.

In the East Lagoon, curlyleaf pondweed demonstrated an overall increasing trend in occurrence, reaching 52% of samples in 2024, despite fluctuations in previous years. This species now competes strongly in shallower areas, previously dominated by Eurasian watermilfoil, which saw a decline in occurrence. Coontail continues to be prevalent in deeper areas, maintaining a steady increase in occurrence.

The West Lagoon showed a similar pattern with curlyleaf pondweed increasing significantly from 44% in 2023 (TKPOA 2023a) to 66% in 2024, marking the highest occurrence rate since the start of data collection. This rise comes after the 2022 CMT treatments affected the species' spread, indicating a resurgence. Coontail also increased to 56%, and Eurasian watermilfoil rebounded to 40% in 2024.

Lake Tallac's ecosystem remains dominated by coontail, with a record high 95% occurrence in 2024. Eurasian watermilfoil and curlyleaf pondweed showed slight increases, while native plants like watershield and yellow pond-lily, though beneficial, can become nuisances. Watershield notably decreased from 53% in 2023 to 24% in 2024.

Overall, the survey underscores the dynamic shifts in aquatic plant populations within the lagoons, with curlyleaf pondweed notably expanding its presence, potentially displacing other

species. Additional details such as frequency of occurrence data and percent composition maps can be found in the 2024 Macrophyte Survey Report.

4.2 HYDROACOUSTIC SCANS

The application of hydroacoustic technology in the Tahoe Keys began in 2015 as part of TKPOA's efforts to develop an IMP for aquatic weed control. Traditional methods of plant monitoring, such as manual surveys and visual observations proved to be time-consuming, labor-intensive, and limited in spatial accuracy. Hydroacoustic scanning emerged as a superior alternative, enabling the TKPOA to obtain precise measurements of biovolume, plant canopy height, and the extent of aquatic vegetation across the lagoons.

Lowrance sonar technology operates by emitting sound waves that penetrate the water column and interact with underwater objects, such as aquatic plants. The reflected sound waves are analyzed to produce detailed maps and three-dimensional representations of the submerged vegetation. This data allows for a comprehensive understanding of plant distribution, growth patterns, and density, which are critical for evaluating the effectiveness of invasive plant control methods and identifying high-priority treatment areas. Refer to Appendix A for a full history of the use of hydroacoustic scans in the Tahoe Keys Lagoons.

4.2.1 2024 Implementation

Twice-monthly scans were performed in the West Lagoon and Lake Tallac. The East Lagoon and parts of Lake Tahoe were scanned once a month. Scanning of the West Lagoon included scanning all the CMT test areas. A comparison of hydroacoustic scans of the West Lagoon, East Lagoon, and Lake Tallac taken July and August 2021 - 2024 are shown in Figure 6 and Figure 7. This data includes preliminary measurements collected as part of the CMT, and the results can be found in the CMT Year 3 Annual Report.

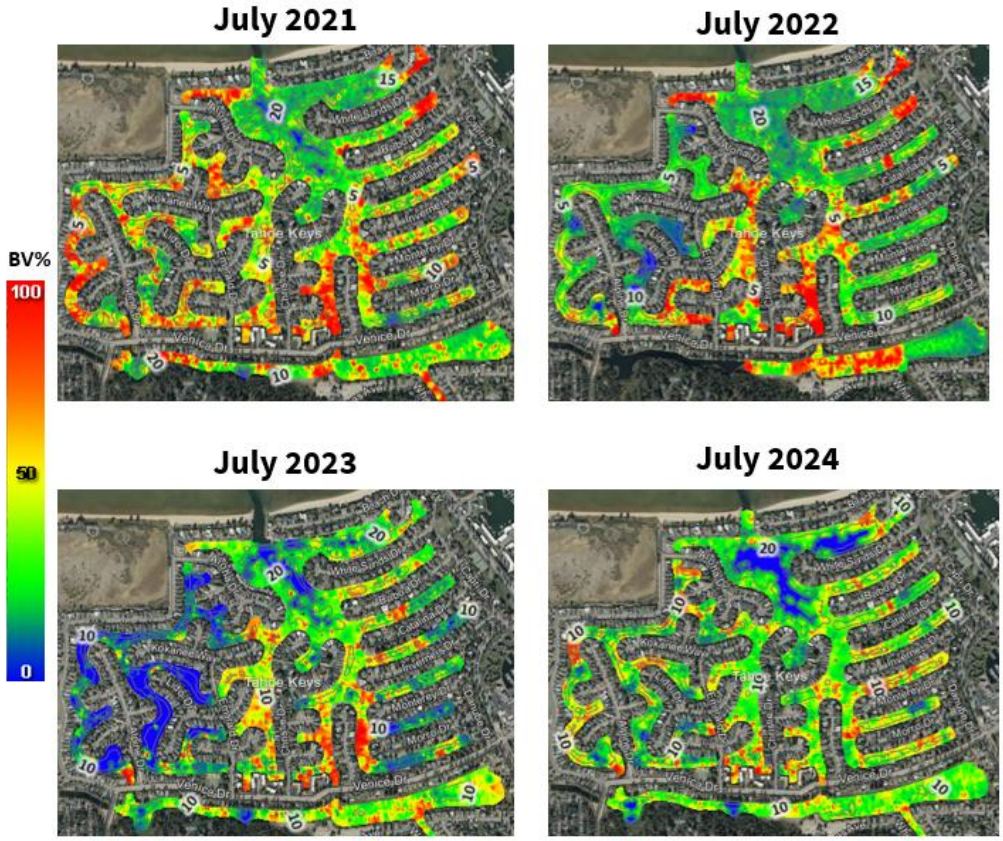

Figure 5. West Lagoon and Lake Tallac Hydroacoustic Scans (July 2021, July 2022, July 2023, and July 2024)

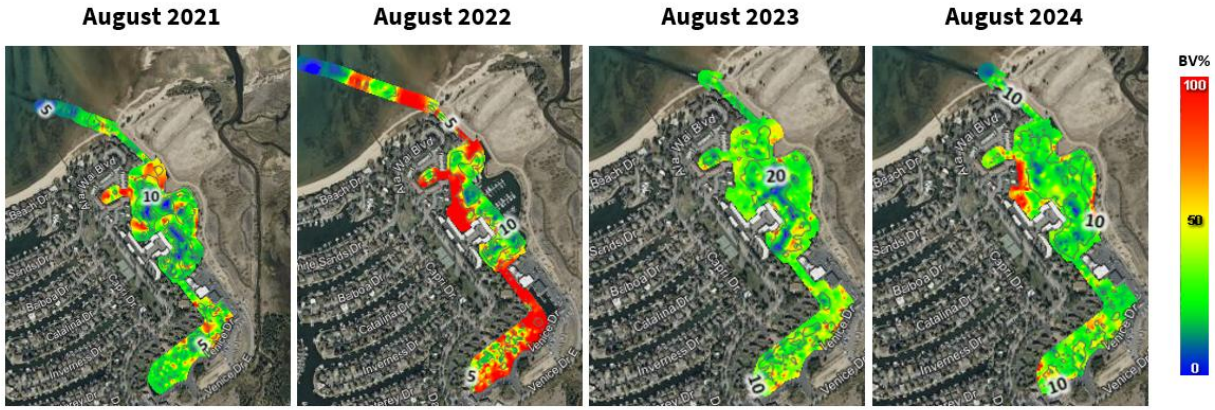

Figure 6. East Lagoon Hydroacoustic Scans (August 2021, August 2022, August 2023, August 2024)

4.3 ALGAL BLOOM MONITORING AND MANAGEMENT

TKPOA initiated systematic algal bloom monitoring in 2017 following the detection of harmful algal blooms (HABs) in the lagoons. Since then, monitoring activities have included visual inspections, targeted sampling for cyanotoxins, and laboratory analyses of water quality parameters. These efforts aim to identify bloom presence early, understand its drivers, and

develop strategies to mitigate its impacts. Refer to Appendix A for a full history of algal bloom monitoring and management in the Tahoe Keys Lagoons.

4.3.1 2024 Algal Blooms and Cyanobacteria Sampling

Cyanobacteria has been monitored throughout the lagoons since 2019 beginning with the LFA project and then as part of the CMT project. Cyanobacteria levels in 2024 remained moderate, like 2023. Blooms began in mid-July and dissipated at the end of September. With data from six consecutive years, it is generally concluded that in 2022 the stagnation of water behind the turbidity curtains magnified the HABs that normally occur in the lagoons every year and resulted in the high severity levels that were reported. Detailed results of the twice-monthly monitoring will be presented in the CMT Year 3 Annual Report.

4.3.2 Ultrasonic Units 2024 Implementation

In 2020, TKPOA began researching potential use of ultrasonic waves to manage algae within the Keys Lagoons. This concept was first proposed to TKPOA's Water Quality Committee (WQC) in 2018-2019 by TKPOA residents. According to current research, the use of ultrasound influences (i.e., reduces) the buoyancy of algae which plays a large role in algal metabolism resulting in its inability to obtain sufficient sunlight and nutrients. Most studies have been limited to laboratory data interpretation due to the complicated environmental conditions in the field (Park et al. 2017). TKPOA purchased two units in 2021 (Figure 8), with the intention of installation and testing during the peak of any cyanobacteria outbreaks.

Two ultrasonic units were first installed in June 2023 on a dock in CMT Site 5 and CMT Site 13, which are both dead end areas known to have large cyanobacteria blooms (see Figure 9). Both units were removed in October. They were reinstalled in June 2024 in the same sites for consistency and again removed in October 2024. Before use, the units were calibrated using factory settings as instructed by the equipment manual. The device was visually monitored throughout the season and HAB sampling occurred for analysis. The device was simple to install, unobtrusive, and will continue to be used in future seasons.

4.3.3 Ultrasonic Effectiveness

The effectiveness of the unit cannot be concluded at this time, as data analysis is ongoing, but will be described in future IMP updates.

Figure 7. Ultrasonic Unit in Site 5; Photo from TKPOA (TKPOA, 2023)

Figure 9. LG Sonic Unit Locations; **Map from TKPOA (TKPOA, 2023)**

5.0 DISCONTINUED WEED CONTROL STRATEGIES AND PROJECTS

Since the 2014 issuance of the WDR, TKPOA has evaluated, and in many cases, tested, innovative methods of aquatic weed control. The table (Table 1) below describes activities that have been tested and discontinued including the time of the activity's implementation, and the year of discontinuation. More details about each of these activities can be found in Appendix B.

In addition to the activities described in Table 1 below, there are a variety of additional aquatic weed control strategies that TKPOA has explored but not attempted due to determinations that the method was ineffective, technologically infeasible, economically infeasible, and/or not permissible by regulatory agencies or by federal or California state law. A detailed overview of all strategies TKPOA has considered (including biological control methods such as the introduction of milfoil weevils) can be found in Chapter 3.0 of the Amended Application for Exemption to the Basin Plan Prohibition on the Use of Pesticides for the Tahoe Keys West Lagoon Integrated CMT submitted to Lahontan by TKPOA in July of 2017. Considerations for all mechanical methods can be found in Evaluation of Mechanical Control Methods for Aquatic Weeds in the Tahoe Keys Lagoons (TKPOA 2017c).

The circulation and treatment system continues to be non-operational. The history of the current system can be found in Appendix A section 8.10. Evaluation of what kind of circulation will be needed for the lagoons to improve water quality, reduce harmful algal blooms, and restore more natural ecosystem functions in the lagoons are to be considered in the overall long-term plan.

Table 1. Discontinued Weed Control Strategies and Projects in Tahoe Keys Lagoons

Activity	Duration of Implementation	Discontinued	Rationale for Discontinuation
Rototilling/ Rotovating	1988	1988	Questionable efficacy and potential to increase infestations of curly-leaf pondweed are the main reasons TKPOA has not pushed harder for rotovating. In addition, disruption of hydrosoil by rototilling can lead to increases in turbidity above permitted threshold levels. In 2017, TKPOA proposed a test pilot for rotovation as a control method to Lahontan and TRPA, but the cost and extensive environmental review required, ultimately triggering CEQA/TRPA review, and potentially an EIR/EIS, were a deterrent to attempting a small-scale test. A synthesis of the discussion regarding rototilling and regulatory concerns is included in final notes from the June 14, 2017, regulatory meeting (available on request).
Dredging	2015	2016	The cost, regulatory challenges, and questionable efficiency of dredging as a long-term control method are the major deterrents for the use of dredging as an AIS control strategy. The West and East Channel are occasionally dredged to ensure navigation. The West Channel was most recently dredged in 2015. A detailed evaluation of dredging as an aquatic weed control method in the lagoons can be found in the CMT EIR/EIS.
Large Scale Bottom Barriers	2017	2017	Sediment buildup and regrowth of plants on top of the barriers (in the deposited sediment) has limited barrier effectiveness in most areas, though TKPOA has had success with installation of bottom barriers in Lake Tallac where there is minimal boat traffic. In Lake Tallac, there has typically been less sediment built-up on top of the barriers and plant growth was limited. TKPOA has observed that in areas with higher boat traffic, sediment builds up on top of the barriers more rapidly. TKPOA has generally concluded that using large-scale bottom barriers in densely infested areas with high boat traffic provides limited control of aquatic plants. In addition, large scale bottom barrier installation is expensive, approximately $71,250 for the 0.75-acre test project conducted in 2017.
Yellow Pond Lily Weed Abatement	1 month	2020	Deemed ineffective due to the high re-growth rate of Yellow Pond Lilies.

Floating Treatment Wetlands (FTW)	2020	2022	Deemed ineffective due to results from 2020 and 2021 monitoring.
Seabins	2019	2022	Temporarily discontinued until completion of the CMT Project. Deemed unsuitable for the West Channel due to swamping by boats and waves.
Internal Bubble Curtains	2020	2022	Temporarily discontinued until after completion of the CMT Project.
Information on discontinued aquatic weed control methods is available from the 2016 Mechanical Control Evaluation (TKPOA 2017c), 2016 Mesocosm Study (TKPOA 2017d), and the 2017 Non-Chemical Control Methods Test (TKPOA 2018d).			

6.0 PROPOSED PROGRAM FOR AQUATIC WEED CONTROL IN 2025

As the CMT concludes, the focus for 2025 will shift towards ensuring continued progress in aquatic weed management while forming large-scale application strategies. Insights gained from the data collected from the CMT will guide the development of long-term, large-scale approaches. Operations in 2025 will include ongoing initiatives such as baseline water quality monitoring, algal bloom management, operations of LFA system, reactivation of the bottom barrier homeowner program, continued use of UV-C treatments, expansion of the Boat Back-Up Station, selective DASH treatments, along with regular harvesting and skimming operations.

6.1 HARVESTING AND SKIMMING OPERATIONS

Harvesting and skimming operations will continue with the same methods as 2024. Modifications to the daily sheets for better tracking of biomass removal and harvested locations will be refined.

6.2 BASELINE WATER QUALITY MONITORING

In 2016, TKPOA initiated the Baseline Water Quality Sampling Program, and maintained the program annually until it was placed on pause for the CMT monitoring from 2022-2024. Additional information on the Baseline Water Quality Sampling Program can be found in the 2016 and 2017 Baseline Water Quality Sampling Evaluation of the Tahoe Keys Lagoons (TKPOA 2017b, TKPOA 2018c, TKPOA 2019c, TKPOA 2020c, TKPOA 2021b). The TKPOA Baseline Water Quality program will be re-instituted following completion of the CMT. This monitoring will also include an expanded monitoring of LFA sites, Lake Tallac sites, and other additional sites still to be determined.

6.3 ALGAE BLOOM MANAGEMENT

The ultra sonic devices will be deployed again in Sites 5 and 13, to add to the past two years data. HAB sampling will continue as well as sampling when visual signs of blooms appear. TKPOA will pursue finding a HAB/algae expert to help advise further action that can be taken to reduce the severity of the blooms and gain better understanding of how algae might behave if large scale weed removal was to occur.

6.4 BUBBLE CURTAINS

The West Channel bubble curtains will continue to run on a 24/7 basis all year long. Compressors for the bubble curtain areas will continue to be maintained according to manufacturer specifications to achieve a continuous run time throughout the year. Efficacy for the bubble curtains will be evaluated by the Bubble Curtain Working Group. After implementing the new efficacy monitoring protocol in 2024 some ideas to improve the method will be discussed and changes will be made to the current SOP to ensure accurate data is being collected for evaluation. Ideas for additional fragment collection around the bubble curtain will also be explored.

The East Channel bubble curtains have been transferred to the Marina's responsibility since October 2024, though TKPOA still plans to include it in the efficacy test in 2025.

6.5 UV-C

UV-C will continue being tested with a focused effort on the curlyleaf pondweed hotpots as outlined in the annual macrophyte survey. Additional UV-C technologies will be explored such as fixed location bulbs between dock and bulkhead spaces and a non-motorized vessel for dock slips.

6.6 LFA

LFA will continue beyond the CMT as this type of treatment usually takes many years to show results. The longstanding Site 26 and the Lake Tallac Site 27 will continue to operate. Site 25 LFA system will be turned off for 2025 until an adequate solution for the noise pollution from the compressors is addressed. The last of the organic sediment samples will be taken out in spring of 2025 and results will guide TKPOA towards next steps for assessing LFA effectiveness.

6.7 HOMEOWNER BOTTOM BARRIER PROGRAM

TKPOA will reestablish the Bottom Barrier Program for homeowners, originally established in 2015. For a full history of this program, refer to Appendix A.

6.9 ENHANCE BOAT BACK UP STATION

Due to the ease of implementation and the general compliance with using the Boat Back-Up Station, TKPOA has plans to bolster the area to target the Left and Right side of the lagoon areas closest to the West Channel entrance. TKPOA is also considering some sort of monitoring system, either dedicated staff as in years prior, or a camera system to enforce the level of compliance among boaters. TKPOA would also like to collaborate with Suntex Marina on implementing a Boat Back-Up Station in the East Channel.

6.10 DIVER ASSISTED SUCTION HARVEST (DASH)

DASH treatments will continue and expand into the East Lagoon. Focus will be on the shoreline and hard to reach areas of harvesting or UV-C. Curlyleaf pondweed hotspots will be the focus. With DASH on shoreline and UV-C down the middle of channels to try to eliminate the infestations in those locations.

6.11 ORGANIC SEDIMENT REMOVAL

Various options will be explored on how best to remove the organic sediment layer built up along the bottom of the lagoons. TKPOA will consult experts in suction dredging projects to explore feasible options in removing this substance that holds most of the nutrients within the waterways.

7.0 LIST OF PREPARERS

The following individuals prepared the text presented in this report.

NAME	COMPANY	ROLE
Kristine Lebo	Tahoe Keys Property Owners Association	Author, Data Analysis
Katie Terwilliger	Tahoe Keys Property Owners Association	Contributing Author, Data Analysis, GIS Mapping, Data Collection
Dr. Andrew Kopania	EMKO Environmental, Inc.	Consulting Author, Editor
Moire Breslin	Tahoe Keys Property Owners Association	Editor, Data Collection
Meghan Hoffmann	Tahoe Keys Property Owners Association	Data Analysis, GIS Mapping, Data Collection

8.0 APPENDIX A – HISTORY OF CURRENT METHODS

8.1 HISTORY OF HARVESTING

Aquatic plant harvesters are large machines that use a series of metal teeth to cut and remove aquatic plants in the upper portion of the water column, The teeth of the harvesters reach approximately five feet below the surface of the water. Historically, cut weeds have been collected and transferred to holding platforms and then trailered to the Dover Corporation yard for decanting. In 2023, cut weeds were transported directly from collection points to the South Tahoe Material Recovery Facility where the harvested aquatic biomass was mixed with other green waste. After a few days/weeks, the mixed green waste was hauled out of the Tahoe Basin for disposal at a contracted composting facility in Nevada. Mechanical harvesting offers immediate improvement of access and navigability to waterways for boating and other recreation and reduces the annual nutrient loading in the lagoons during die-off of the aquatic plants. The large harvesters operated by TKPOA have been efficient in clearing thousands of pounds of plant material in a relatively short time.

Since the 1970's, harvesting has been the primary method to help maintain navigable waterways and other beneficial uses such as contact and non-contact water recreation[1]. One of the primary objectives of the harvesting is to maintain a minimum of three feet of vessel hull clearance in the channels to minimize the potential for weeds to be transported from the lagoons into Lake Tahoe by watercraft.

In any given year, the schedule for harvesting is dictated to some degree by the timing of weed growth in relation to the boating season. The timing of weed growth is directly correlated with water temperature and light. Generally, once water reaches between 13°C – 15°C, the plants begin rapid growth (Smith et al. 1990, Anderson 2017). Therefore, in years following winters of drought, when the lake level is low and lagoon water temperature warms quickly in the spring, plant growth has occurred as early as mid- to late April, necessitating an earlier start to harvesting operations. In spring and early summer 2023, the lake level was high, and the lagoons warmed moderately slowly. TKPOA began harvesting in mid-June 2023, except for CMT project areas where minimal harvesting occurred. During the growing season, TKPOA continuously operates harvesters during working daylight hours (approximately 8am to 4:30pm daily). For many years, TKPOA's harvesting season extended through Labor Day. Beginning in 2019, TKPOA extended harvesting operations through October to remove as much plant material as possible from the lagoons before winter. This helps reduce nutrient recycling in the lagoons associated with plant decomposition.

To ensure that all the lagoons (West Lagoon, East Lagoon, and Lake Tallac) are harvested, TKPOA organizes its harvesting schedule by mapping the lagoons into sections and assigning

[1] TKPOA was required by the City of South Lake Tahoe to purchase and begin use of its first harvester in 1972. By 1982, TKPOA had already replaced the original harvester.

designated times for harvesting activities. This allows each section of the Tahoe Keys Lagoons to be harvested every 21 days. TKPOA also employs skimmer boats in the West and East Lagoons to collect weed fragments generated by the harvesting process. Generally, skimmer boats follow the harvester to "clean" a lagoon area after harvesting. In 2023, skimming activities were altered to follow the harvesters to "clean" each area after harvesting occurred, either the morning after, or later that same day. Harvesting and skimming schedules are created prior to the start of harvesting operations (updated monthly) and sent via email (E-Blast') to homeowners so that homeowners are aware when harvesting will occur near their docks. The schedule and updates are also posted on the TKPOA website.

TKPOA currently operates four hydraulically controlled harvesters. Obstructions such as docks, pilings, and moored boats prevent the use of large mechanical harvesters in smaller areas. The plants in target areas must be harvested multiple times during the growing season to maintain navigable conditions. Weed fragments collected by skimmers and harvesters in 2023 were transferred to trailers, hauled to and then mixed with green waste at the South Tahoe MRF, and then transported to a composting site outside the Tahoe Basin. In addition to the harvesters, four dock boats were used to collect (skim) fragments in the Tahoe Keys. The TKPOA Omni Cat, barges, and fragment collection boats used in previous years were deemed unnecessary for fragment collection in 2023 as the use of dock boats kept the fragment control operations on track throughout the season.

TKPOA maintains a robust fragment collection program associated with its harvesting operations. This program focuses on skimming the lagoons for viable plant fragments after the harvesters pass through. For several years, TKPOA has employed multiple small skimming boats, and since 2018 has also operated the Omni Cat (noted above), a passive trash/debris skimmer vessel designed for relatively sheltered waters. The vessel, 23' long and 8'3" wide, is manufactured with marine grade aluminum. In 2023, the decision was made to simplify the fragment collection program by using only dock boats for skimming. Due to the operational characteristics of the dock boats, the program has become more efficient. TKPOA has invested significantly in fragment control since harvesting began in the 1980s. In addition to investment in and deployment of skimmer boats and combined harvester/skimmer boats (like the Omni Cat, Tiger Cat and Aqua Harvester discussed above), TKPOA also collects fragments from the West Lagoon Boat Back-Up Station area and the West Channel bubble curtain area.

8.2 HISTORY OF BOAT BACK-UP STATION

The Boat Back-Up Station was deployed in 2016 (with funding support from The League to Save Lake Tahoe) just inside the West Channel of the West Lagoon as a method to reduce the transport of aquatic weed fragments from the lagoons into Lake Tahoe via watercraft. The Boat Back-Up Station is a designated area where a vessel headed toward Lake Tahoe from the lagoons is notified with signage to stop, reverse its propellers and back up approximately ten feet to dislodge any weed fragments attached to the boat's propeller(s) or sailboat's keel. TKPOA's Boat Back-Up Station project includes an education and outreach component with a

goal to educate homeowners and vacationers about AIS in the Tahoe Keys, including the potential impacts of transporting fragments out into Lake Tahoe.

8.3 HISTORY OF WEST CHANNEL BUBBLE CURTAIN

The West Channel bubble curtain produces a "V"-shaped barrier of bubbles in the water column. The "V" formation drives submerged plant fragments to the edges of the channel, where they can be collected and removed. The curtain of bubbles is created from perforated tubing running across the bottom of the channel that is connected to an air compressor. The air compressor constantly pushes air through the tubing, resulting in a sheet of bubbles that rise continuously to the surface. The intention of the bubble curtain is to contain stray plant fragments without impeding boating activity. A bubble curtain across the West Channel was first proposed by the TKPOA Stakeholder Committee[2] as a potential technology to impede the spread of plant fragments from the Keys Lagoons into Lake Tahoe proper.

In 2018, with funding support from The League to Save Lake Tahoe, divers hired by TKPOA installed the West Channel bubble curtain. Since the program's initiation, TKPOA has monitored and improved-upon bubble curtain operations.

In the spring of 2022, TKPOA installed a second bubble curtain in the West Channel, creating a double bubble curtain. The effectiveness of bubble curtains is dependent on the volume of air injected into the water column, the size of bubbles, and the number of diffuser lines. The installation of a second bubble curtain increases the bubbles present and provides additional protection, reducing the movement of fragments out to Lake Tahoe. Table 2 below identifies bubble curtain operational and functional challenges and solutions implemented to address these challenges.

The West Channel bubble curtains were operational in 2023. From June 21, 2023, to October 12, 2023, a total of 17.42 ft^3 of fragments were collected from the West Channel bubble curtain area.

Table 2. Bubble Curtain – Challenges and Solutions

Challenge	Solution
Each of the four air compressors used to operate the bubble curtain in 2019 failed at least once during the 2019 season. Replacement was required multiple times. By the end of the season, TKPOA had replaced	TKPOA concluded that investment in a significantly larger air compressor was required to maintain consistent operation of the bubble curtain. TKPOA purchased a 12.7 horsepower compressor with an

[2] From November 2018 until 2021, the Tahoe Keys Stakeholder Committee (SC) was a forum for collaborative discussion about the goals, design, and review of the Tahoe Keys CMT. Following an assessment in October 2018, the SC was established to guide and inform the development of the CMT Project. The SC activities were phased annually between 2018 and 2021 and included: 1) 2018 – understanding stakeholder interests; 2) 2019 – collaborative design of a Project; 3) 2020 – scientific analysis and public outreach; and 4) 2021 – development of draft permit conditions and monitoring protocols. Further information can be found in the 2021 Tahoe Keys Stakeholder Committee Final Report (TRPA 2021).

Challenge	Solution
eight air compressors. As a result of the compressor failures, the bubble curtain operated only intermittently over the course of the 2019 season.	output of 79 CFM in the early summer of 2020, built a new shed for the compressor, and installed the compressor in July of 2020. TKPOA has reported no compressor failure since installation of the new compressor.
During the 2019 season, TKPOA observed that the production of bubbles was impeded due to growth of aquatic weeds around the tubing.	TKPOA installed approximately 150 square feet of bottom barriers in the West Channel beneath the length of the bubble curtain tubing, and staff have observed a more consistent production of bubbles since. Bottom barriers may need to be removed and reinstalled on occasion to clear sediment and other debris that collects on the top of the barriers.
Fragments caught by the bubble curtain remained caught in the channel in front of the curtain and/or were pushed towards the edges of the channel by the bubbles. TKPOA identified the need for resources to remove collected fragments.	Beginning in 2018 and continuing through 2023, the TKPOA AIS Program instituted a new protocol to skim (with a skimmer boat) the south side of the bubble curtain (lagoon side) at least once each day during boating season to collect fragments. In addition, TKPOA installed a Seabin along the western bulkhead of the West Channel to attempt to continuously catch fragments pushed to the edge of the channel by the curtain. TKPOA Water Quality staff emptied the Seabin daily during boating season. However, wave action and changes in water level resulted in frequent dislodging of the Seabin. As such, TKPOA removed the Seabin from the West Channel in 2020.
Following monitoring in 2020 and 2021, TKPOA observed that fragments become trapped on the south side of the curtains, sink, and root at the base of the bubble curtain.	Three to four bottom barriers (10' x 20' or 10' x 25') will now be installed under each bubble curtain, in both the West and East Channels, to prevent rooting of fragments on the Channel floors.
The installation of the second line in 2022 for air bubbles (to create a double bubble curtain) exceeded the air volume capacity of the existing compressor, leading to insufficient airflow through the air lines.	TKPOA ordered a larger (variable frequency drive) compressor that had a delayed delivery due to supply chain issues. As of October 17, 2023, the West Channel has two fully operational compressors and a fully functional double bubble curtain. .
During the 2023 season there were electrical issues with the compressor for the East Channel bubble curtain, and it was not operational until November 16, 2023. There were significant delays in operating the compressor due to scheduling logistics with the power company and contractors, and shipping delays for various parts.	Due to incorrectly sized wiring and the electrical supply amperage being too low, the East Channel set-up has undergone a complete rewiring of the electrical system. A new pedestal and breaker box with appropriately sized breakers and wires were installed in 2023 with the appropriate amperage delivered from the supply line.

8.4 HISTORY OF EAST CHANNEL BUBBLE CURTAIN

In May 2022, TKPOA installed a second double bubble curtain in the East Channel. Funding for this East Channel bubble curtain unit came from The League to Save Lake Tahoe. Like that of the West Channel bubble curtain, monitoring was implemented for the new bubble curtain. The East Channel bubble curtain wasn't operational for most of the 2023 season due to

electrical issues. These issues were resolved, and the bubble curtain was turned on November 16, 2023. Since the issues mentioned above persisted throughout the season, the total volume of fragments was not determined for the East Channel bubble curtain.

8.5 HISTORY OF ALGAL BLOOM MONITORING AND MANAGEMENT

Cyanobacteria, or blue-green algae, are naturally occurring photosynthetic prokaryotes that can be found in almost all bodies of water. These organisms are the dominant primary producers on Earth, contributing more than 25% of photosynthesis worldwide. Cyanobacteria are true bacteria, often unicellular. However, they can grow into large colonies that may be visible to the naked eye, often referred to as a harmful algal bloom (HAB) (UC Berkeley 2006, Frontier 2015). Some cyanobacteria can produce secondary metabolites, such as cyanotoxins, which can be harmful to eukaryotes.

Exposure to cyanotoxins can cause allergic, respiratory, liver, kidney and nervous system reactions in mammals, and large blooms of cyanobacteria (not necessarily toxin-producing) can outcompete beneficial phytoplankton and cause a depletion of available oxygen in the water column (USGS 2012, Pearl and Otten 2013). Therefore, monitoring of cyanobacteria, especially for the presence of potentially toxic secondary metabolites, is important to protect both the health of the lagoon ecosystem as well as the health of residents and recreationists.

Cyanobacteria sampling in the Keys Lagoons was initiated in 2017, following the detection of a HAB in the West Lagoon in the late summer months. Since then, TKPOA has maintained a practice of visual observations for any algal blooms during regular maintenance activities (harvesting, skimming and other activities). In the event of an observed algal bloom, Water Quality staff collect surface water grab samples for lab analysis. Surface water grab samples are collected in a PETG plastic bottle and couriered on ice to Bend Genetics, LLC (an accredited lab in Rancho Cordova) for analysis within 24 hours. The May 2019 Standard Operating Procedures for Water Quality Sampling for the Tahoe Keys Lagoons (TKPOA 2019b) include protocols related to cyanobacteria sampling. In addition to sampling areas where a visual detection of a HAB is observed, Water Quality staff collect samples for lab analysis of cyanobacteria presence within the LFA study area just north of Venice Drive twice per month, regardless of any observed algal blooms[3].

8.6 HISTORY OF LAMINAR FLOW AERATION

In the Keys Lagoons, the accumulation of detritus at the bottom of the water column has been referred to as the ‘muck layer’ but is now referred to as the ‘organic sediment layer’. The organic sediment layer is a concern to TKPOA and Lake Tahoe Basin scientists as a source of nutrients that may help stimulate aquatic vegetation growth and improve conditions for HABs.

[3] Monitoring of the LFA area between 2019-2021 was required by Lahontan (SB14007IN) and TRPA (EIPIC2018-0008).

LFA was first recommended for testing as a macrophyte control method in Lake Tahoe by Stakeholder Committee members in 2017. LFA is a technology often used for improving water quality in water bodies where there is consistently low dissolved oxygen and a buildup of fine sediment (Restorative Lake Sciences, LLC 2012a, 2012b, 2016; Turcotte et al. 1991; University of Florida 2016). The technology uses microporous disks that are placed throughout the area to be treated. These disks are connected by self-sinking hoses connected to an air compressor. Air is pumped through the system creating an abundance of bubbles that create laminar flow and oxygenate the bottom of the water column where dissolved oxygen is typically the lowest. LFA has been used successfully with shallow, warmer waters with minimal circulation at low elevation; however, it has not been fully tested in conditions or an area such as Lake Tahoe, which has deeper, cold water at a much higher elevation (Restorative Lake Sciences, LLC 2012a, 2012b, 2016; Turcotte et al. 1991; University of Florida 2016).

Increasing the dissolved oxygen in the sediment layer promotes a reaction that converts (through oxygenation) ammonia into nitrite and then nitrate (EPA 2021). The process is believed to be in part responsible for the reduction in organic matter seen in other LFA studies. Organic matter, a combination of animal and plant detritus, contains carbon and nitrogen as carbohydrates, lipids, amino acids, and proteins. The increase in dissolved oxygen and the disruption of organic matter aids in hydrolysis of carbohydrates and lipids, and proteolysis of proteins to amino acids, which can lead to nitrification and denitrification.

In late 2018 and into early 2019, TKPOA Water Quality staff consulted with Lahontan to develop an LFA test and to obtain the required permits. In 2019, 11 diffusers with an air compressor and necessary power source were installed within a finger of the West Lagoon immediately north of Venice Drive in mid-April of 2019. In September 2020, a second LFA site with eight diffusers was installed in the West Channel but was removed after one year. The LFA sites included in the CMT consist of the 2019 LFA installation (CMT Site 26) plus two new LFA installations in 2022, one in the West Lagoon (CMT Site 25) and one in the Lake Tallac Lagoon (CMT Site 27). Data and results on the monitoring of these CMT test sites in Year 2 and Year 3 will be presented in the CMT Project Annual Report to be submitted to Lahontan and TRPA in March 2025.

8.7 HISTORY OF ULTRAVIOLET LIGHT (UV-C) EQUIPMENT TEST

UV-C light is a new aquatic weed control method that has been experimentally tested at nearby Lakeside Marina and within the Keys Lagoons since 2020. The initial design of the UV-C treatment vessel is shown below in Figure 10. Recent research indicates the use of UV-C light (short-wave electromagnetic radiation light) can damage the cellular structure and DNA of both aquatic weeds and their fragments (TRCD 2019). Therefore, the possibility of UV-C light as a control method for aquatic weeds in the Tahoe Keys and the greater Lake Tahoe Basin is of great interest.

Figure 10. 2022 UV-C Treatment Vessel
Photo Credit: John Paoluccio, Inventive Resources, Inc.

Preliminary experimental treatments of UV-C began within the Tahoe Keys Lagoons in 2020 at two locations, with data (including quadrat sampling and videos/pictures) collected by the University of Nevada, Reno (UNR).

UV-C treatments in 2022 were part of the CMT, and there were nine UV-C treatment sites, which is the largest UV-C tested area in Lake Tahoe to date. The first year of UV-C treatments for the CMT began in May 2022 and concluded at the end of October 2022. Data and results on the monitoring of these CMT test sites are presented in the CMT Project Year 1 Annual Report that was submitted to Lahontan and TRPA in March 2023.

8.8 HISTORY OF HYDROACOUSTIC SCANS

Hydroacoustic scanning of the Keys Lagoons has occurred regularly since 2015. Hydroacoustic scanning uses sonar technology to scan the bottom of a water body to determine and record the average surface water temperature, presence of plant matter, plant height, and biovolume. Biovolume is the volume of cells in a unit amount of water (normally quoted in cubic millimeters per liter). These data are then analyzed to determine the percent of the water column containing plant matter. By comparing the average percent of the water column containing plant matter to the total volume of the water body, the approximate amount of biomass (or biovolume) can be determined. Hydroacoustic data is also used to determine the average vessel hull clearance, which is the distance between the water surface and the top of the aquatic plant canopy.

8.9 HISTORY OF BOTTOM BARRIERS

Bottom barriers, also known as benthic barriers, physically suppress aquatic plant growth and restrict sunlight. Depending on the barrier material, gas exchange may also be restricted. Barriers are typically large sheets of an impermeable or semi-permeable synthetic or natural material that is placed directly on the plants and anchored in place with weight. Barriers are installed by diver hand crews and can be placed under docks or piers that otherwise may be difficult areas to treat with other methods. Synthetic barriers remain in place for at least 2-4 months and then are removed prior to winter.

In compliance with its WDR Order, TKPOA began a Bottom Barrier Program for homeowners within the Keys Lagoons in 2015. TKPOA's WDR permits the use of up to a total of five acres of bottom barriers within the lagoons in any season. In 2016, TKPOA proposed improvement measures to the program, including heavier weighting material for the barriers, use of professional divers for installation, and updating the TKPOA permit, Form 19. In addition, TKPOA received an increase in the number of bottom barriers from the Tahoe Resource Conservation District (TRCD). Additional background information on TKPOA's Homeowner Bottom Barrier Program can be found in the 2015-2022 Annual Reports submitted to Lahontan (TKPOA 2016a, TKPOA 2017a, TKPOA 2018a, TKPOA 2019a, TKPOA 2020a, TKPOA 2021a, TKPOA 2022a). The homeowner bottom barrier program is currently on hold until 2025 due to the CMT Project.

In 2022, TKPOA received Lahontan and TRPA approvals for the CMT Project, which include the testing of bottom barriers in Years 2 and 3 of the Project. The bottom barriers are one of the "Group B" control methods implemented in 2023. During Year 2 (2023) of the CMT, ten bottom barriers were installed in nine Year 1 CMT Group A Sites. Group A methods are large-scale treatments that were tested in 2022, whereas Group B methods are smaller site-specific, follow-up methods designed to treat regrowth of the invasive plants in the locations where Group A methods were successful in reducing biovolume of the target invasive plant species by at least 75%.

8.10 HISTORY OF CIRCULATION SYSTEM

The existing TKPOA water circulation and treatment system is a substantial piping and pumping network that was originally intended to provide circulation, treatment, and mixing of the Keys Lagoons to improve water quality by decreasing turbidity, removing nutrients, preventing stagnation and increasing mixing. The system includes the following main components:

- Five vertical pumps incorporated with culvert piping across Alpine Drive, Emerald Drive, and Christie Drive.
- Two large volume circulation pump stations.
- Tahoe Keys water treatment plant (WTP) and pump station.

- Approximately 7,800 feet of large diameter (48” and 24”) reinforced concrete pipe and welded steel circulation pipe along the perimeter of the Tahoe Keys with 18 distribution pipes (18” to 14” diameter) that circulate water into the various coves within the lagoons (R.O. Anderson 2016; Domenichelli & Associates, Inc. 2017).

The circulation and treatment system was shut down due to a cease-and-desist order from LRWQCB and has remained offline since the late 1990s. Restarting the system has been considered at various points and is part of the ongoing discussions around water quality. Testing and assessments need to be made regarding the system’s design, current state and function to determine the path forward whether reintroducing the system will achieve the water quality goals and standards set forth.

9.0 APPENDIX B – DESCRIPTION OF DISCONTINUED METHODS

9.1 SEABINS

A Seabin is a surface-skimming (pool skimmer-type) technology from Australia that actively collects debris floating on the water's surface. When a pump within the bin is switched on it creates a vortex that pulls debris into a collection net while allowing water to flow through the bin. When full, the collection net is removed from the unit and emptied.[4]

In 2019, TKPOA deployed a single Seabin in the West Channel along the western bulkhead (shown in Figure 11) and again in 2020 using a floating dock to anchor the Seabin. The addition of the floating dock was an effort to combat wave and wind disturbance that frequently swamped (caused the Seabin to sink to the bottom of the channel) or dislodged the Seabin from its platform anchor in 2019. However, despite the new floating dock, the Seabin was plagued with operational challenges caused by the frequent wind and wave disturbance and required significant maintenance (up to four times weekly). TKPOA Water Quality staff ultimately removed the Seabin in September of 2020 with a recommendation of utilization in areas with less wind and wave disturbance, or to invest in a wave attenuator to protect the Seabin to improve its effectiveness.

The Seabin project in the Tahoe Keys was placed on hold during the 2021 and 2022 seasons and was discontinued in 2023 due to the conditions of the West Channel being inadequate for the Seabin to properly function.

[4] Skimmer technology for collection of fragments was investigated in 2017 by TKPOA and reviewed in the Active and Passive Skimmer Evaluation report (TKPOA 2018b) submitted to Lahontan. In this report, the Seabin was identified as one of the most feasible active skimmers evaluated.

Figure 181. Seabin
Photo Credit: TKPOA

9.2 DOCK BUBBLERS

In 2020, TKPOA began researching the potential use of dock bubblers to manage algae within the Keys Lagoons. This concept was first proposed to TKPOA's WQC in 2018-2019 by TKPOA residents. The 2020 TKPOA Water Quality Special Assessment ballot initiative included funding for the purchase of five dock bubblers (e.g., Figure 12) for installation in the West Lagoon. Installation of dock bubblers in Spring 2021 was postponed due to a combination of low water and limited staffing.

In 2022, TKPOA temporarily installed a type of dock bubbler on homeowners' docks in CMT combination UV-C/herbicide treatment sites to assist with mixing and dissipation of herbicides. No data was collected, and the bubblers were removed in late 2022. Deployment of dock bubblers is planned in future years in areas that may be prone to algal blooms. Dock bubblers were not employed in 2023 but may be used in the future.

Figure 12 9. Dock Bubbler Example
Photo of a “Kasco Marine De-Icer Universal Dock Mount” (overtons.com)

9.3 ROTOVATING

Rototilling underwater or rotovating describes underwater tillage of aquatic plants. Like tilling on land, rototilling tills the hydrosoil to remove plants, particularly roots and rhizomes. This requires specialized machinery that can access aquatic weeds either from shore, or more typically, from a barge. The depth that the unit tills depend on the size of the tines used and typically rotovators till eight to 10 inches into the sediment or hydrosoil. Rotovators are not usually fitted to collect fragments of plants or rhizomes created by tilling.

Figure 10. Rotovator

9.4 FLOATING TREATMENT WETLANDS

Floating Treatment Wetlands (FTW) are artificial structures created with the goal of improving water quality. Woven from dense, recycled-plastic fibers, the islands provide a space for plants to quickly flourish and create biofilm. As plants establish themselves across the FTWs, the root structure mass increases and grows to deeper depths of the water column. Biofilm, also known as beneficial microbes, increases as plant structure increases. This biofilm rids the water of excessive nutrients, creating a cleaner and healthier body of water. In 2020, the AIS Program at TKPOA installed 15 Floating Treatment Wetlands in two locations within Lake Tallac (see Figure 14) to improve water quality conditions. This project acted as a pilot study to determine the effectiveness of FTW and if they are viable in the West Lagoon.

The project objectives were as follows

- Reduce nutrients and suspended solids within the water column.
- Protect and enhance habitat for native “non-nuisance” species in the Keys Lagoons.
- Protect recreation in the Tahoe Keys Lagoons which are available for public access and use.
- Help prevent public health issues through reducing an environment for harmful and dangerous algae blooms as well as mosquito infestations.
- Improve the City of South Lake Tahoe’s storm water management.

It was determined that FTW’s were ineffective in achieving all the above. More details on the monitoring SOP and results can be found in the 2020 Lake Tallac Control Projects Report (TKPOA 2020b).

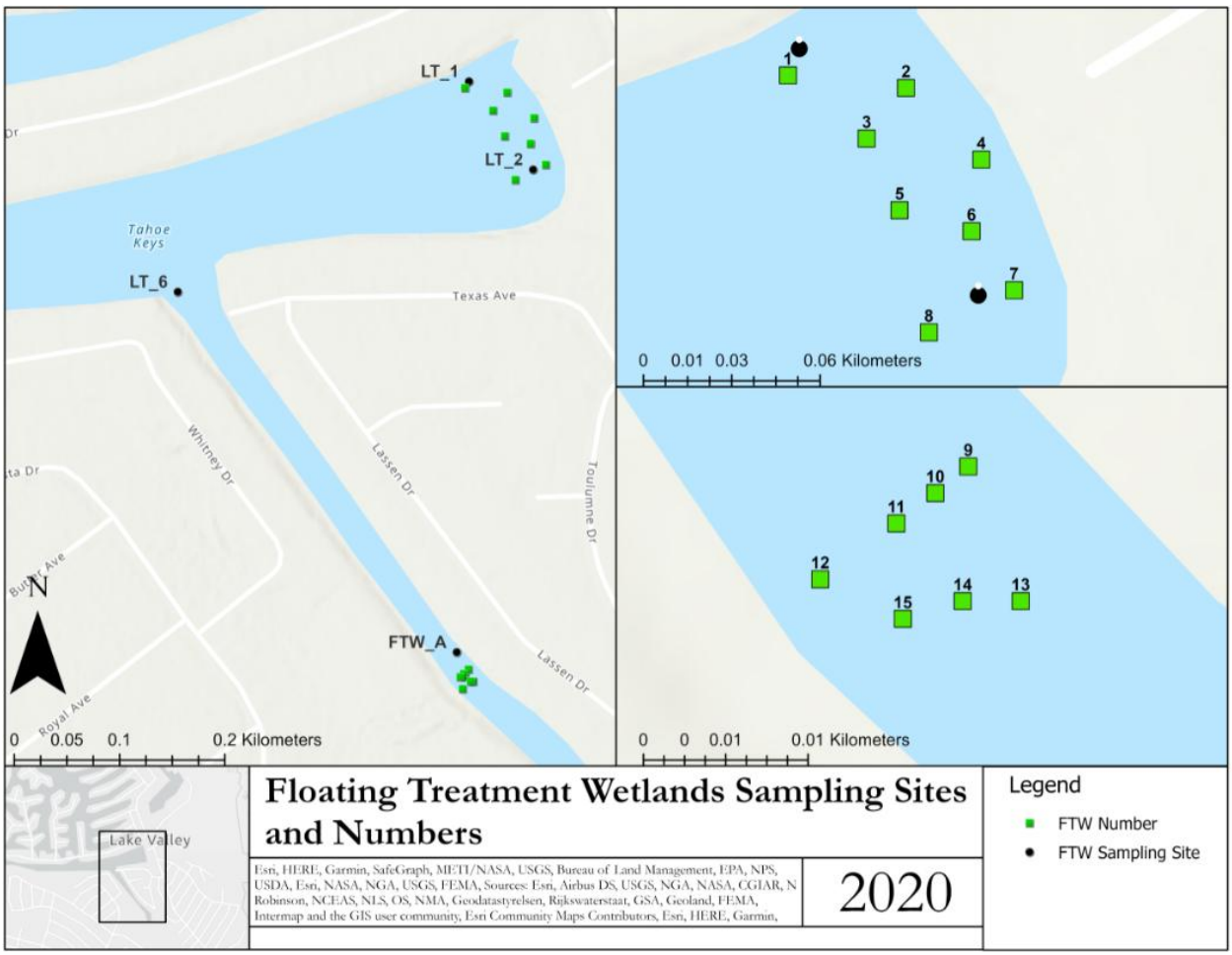

Figure 14. Map of Floating Treatment Wetland Sites

10.0 APPENDIX C – ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

°C	Celsius
µS/cm	microsiemens per centimeter
µg/L	micrograms per liter
AIS	Aquatic Invasive Species
BMPs	Best Management Practices
chl-a	chlorophyll-a
CMT	Control Methods Test
DO	Dissolved oxygen
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FTW	Floating Treatment Wetlands
HAB	Harmful Algal Bloom
IMP	Integrated Management Plan
Keys Lagoons	Tahoe Keys Lagoons
LFA	Laminar Flow Aeration
Lahontan	Lahontan Regional Water Quality Control Board
LRWQCB	Lahontan Regional Water Quality Control Board
mg/L	milligrams per liter
mV	Millivolts
NTU	Nephelometric Turbidity Unit
ORP	oxidation reduction potential
P	orthophosphorus
PC	PhytoCyanin
PPM	Parts Per Million
SC	Stakeholder Committee
SPC	specific conductance
TKN	Total Kjeldahl nitrogen
TKPOA	Tahoe Keys Property Owners Association
TN	total nitrogen
TRPA	Tahoe Regional Planning Agency
TRCD	Tahoe Resource Conservation District
UNR	University of Nevada, Reno
UV-C	Ultraviolet Light Treatment
WDR	Waste Discharge Requirements
WC	Waterways Committee (previously Water Quality Committee)
WTP	Water Treatment Plant
YPL Removal Project	Yellow Pond Lily Removal Project

11.0 REFERENCES

California Code of Regulations, Title 14, Section 15364

Domenichelli & Associates, Inc. 2017. Tahoe Keys- Potential Cost v. Benefit and Condition Assessment Approach of the Existing Hydraulic Circulation System. Technical Memorandum to the Tahoe Keys Property Owners Association.

Frontier 2015. Bullerjahn, George S. and Anton F. Post. Physiology and molecular biology of aquatic cyanobacteria. Frontiers Research: Physiological and molecular ecology of aquatic cyanobacteria.

Lahontan Regional Water Quality Control Board (Lahontan) 2014 (July). Water Quality Certification and Waste Discharge Requirements for TKPOA.

Lahontan 2018. Laminar Flow Aeration Test Projects. North Lahontan Region. October 2018. http://www.waterboards.ca.gov/lahontan/water_issues/programs/tahoe_keys_weed_control/docs/LFA_eorpt_Oct_2018.pdf

Paerl and Otten 2013. Paerl, Hans W. and Timothy G. Otten. Harmful Cyanobacteria Blooms: Causes, Consequences, and Controls. Microbial Ecology, Vol 65(4), pp 995-1010.

Park 2017. Park, J., J. Church, Y. Son, K.T. Kim, and W.H. Lee. Recent advances in ultrasonic treatment: Challenges and field applications for controlling harmful algal blooms (HABs). Ultrasonics Sonochemistry 38, pp. 326-334.

Restorative Lake Sciences, LLC 2012a. Laminar Flow Aeration: A sustainable Lake Improvement Option. The Michigan Riparian. Winger 2012.

Restorative Lake Sciences, LLC 2012b. Evaluation of Laminar Flow Aeration and Bioaugmentation for Improvements to the South Basin of Austin Lake, Kalamazoo County, Michigan. Prepared for Austin Lake Improvement Board

Restorative Lake Sciences, LLC 2016. Overall Trends in the Efficacy of Inversion Oxygenation Aeration and Bioaugmentation as a Treatment for Sediment Floc Reduction, Nuisance Algae Reduction, Water Quality Improvements, and Other Observed Ecological Benefits, in Lake Apopka, Florida. August 15, 2016.

R.O. Anderson 2016. Treatment Options and Engineering Controls for Aquatic Invasive Plant Mitigation. Prepared for the Tahoe Keys Property Owners Association.

Smith 1990. Smith, C.S. and J.W. Barko. Ecology of Eurasian watermilfoil. Journal of Aquatic Plant Management, 28(2), pp. 55-64.

TKPOA 2016a. 2015 Bottom Barrier Monitoring Report.

TKPOA 2017a. 2016 Bottom Barrier Monitoring Report.

TKPOA 2017b. 2016 Baseline Water Quality Report for the Tahoe Keys Lagoons. Prepared by Sierra Ecosystem Associates.

TKPOA 2017c. Evaluation of Mechanical Control Methods for Aquatic Weeds in the Tahoe Keys Lagoons. Prepared by Sierra Ecosystem Associates.

TKPOA 2017d. 2016 Mesocosm Study: Effect of Four Herbicides on Eurasian watermilfoil (Myriophyllum spicatum), Curlyleaf pondweed (Potamogeton crispus), Coontail (Ceratophyllum demersum) and Elodea (Elodea canadensis). Prepared by Dr. Lars Anderson and Sierra Ecosystem Associates.

TKPOA 2017e. Integrated Management Plan for Aquatic Weeds for the Tahoe Keys Lagoons. Prepared by Sierra Ecosystem Associates.

TKPOA 2018a. 2017 Bottom Barrier Monitoring Report.

TKPOA 2018b. Evaluation of Active and Passive Skimmers for Macrophyte Fragment Collection. Prepared by Sierra Ecosystem Associates.

TKPOA 2018c. 2017 Baseline Water Quality Report for the Tahoe Keys Lagoons. Prepared by Sierra Ecosystem Associates.

TKPOA 2018d. Non-Chemical Combination Control Methods Test Summary Report for the Tahoe Keys Property Owners Association. Prepared by Sierra Ecosystem Associates.

TKPOA 2019a. 2018 Bottom Barrier Monitoring Report.

TKPOA 2019b. (May) Standard Operating Procedures for Water Quality Sampling for the Tahoe Keys Property Owners Association.

TKPOA2019c. Tahoe Keys Aquatic Invasive Species Program End of Season Report.

TKPOA 2020a. 2019 Bottom Barrier Monitoring Report.

TKPOA 2020b. Lake Tallac Control Projects Report.

TKPOA 2020c. Tahoe Keys Aquatic Invasive Species Program End of Season Report.

TKPOA 2021a. 2020 Bottom Barrier Monitoring Report.

TKPOA 2021b. Tahoe Keys Aquatic Invasive Species Program End of Season Report.

TKPOA 2022a. 2021 Bottom Barrier Monitoring Report.

TKPOA 2023a. Tahoe Keys 2023 Aquatic Macrophyte Survey Report. Prepared by Sierra Ecosystem Associates.

TKPOA 2024a. Tahoe Keys 2024 Aquatic Macrophyte Survey Report. Prepared by Sierra Ecosystems Associates.

TRCD 2019. Tahoe Keys Aquatic Weed Control Methods Test – Scoping Report. Prepared for TRPA and Lahontan.

TRPA and Lahontan 2020. Tahoe Keys Lagoons Aquatic Weed Control Methods Test – Draft EIR/EIS.

TRPA 2021. Tahoe Keys Stakeholder Committee Final Report. December 2021.

Turcotte, A., Déry, C.V., and K.F. Ehrlich. 1991. Manipulation of microbial ecosystems to control the aquatic plant Eurasian watermilfoil. University of Sherbrook, Biology Department.

US Environmental Protection Agency (EPA) 2021. Ammonia. CADDIS Vol 2. Accessed January 24, 2022. Available at: https://www.epa.gov/caddis-vol2/ammonia#:~:text=Ammonia%20also%20exerts%20a%20biochemical,ammonia%20into%20nitrite%20and%20nitrate.

United States Geological Survey (USGS) 2012. Summary of Cyanobacteria Monitoring and Assessments in USGS Water Science Centers. http://water.usgs.gov/coop/products/gw/cyanobacteria.studies.WSCs.09122012.for.web.pdf

University of California, Berkeley 2006. Introduction to the cyanobactria: Architects of Earth's Atmosphere. http://www.ucmp.berkeley.edu/bacteria/cyanointro.html

University of Florida 2016. Final Report Evaluation of Remediation Projects at Lake Apopka. August 15, 2016.