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

TAHOE KEYS INTEGRATED WEED MANAGEMENT PLAN

Update

JANUARY 2024

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Prepared for
Tahoe Keys Property Owners Association

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

°C	Celsius
µS/cm	microsiemens per centimeter
µg/L	micrograms per liter
AIS	Aquatic Invasive Species
ACD	Architectural Control Department
BMPs	Best Management Practices
CCHAB	Cyanobacteria and Harmful Algal Bloom Network
chl-a	chlorophyll-a
CMT	Control Methods Test
COVID-19	Coronavirus
DO	Dissolved oxygen
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Environmental Science Associates
FTW	Floating Treatment Wetlands
FNU	Formazin Nephelometric Unit (Turbidity)
HAB	Harmful Algal Bloom
IMP	Integrated Management Plan
Keys lagoons	Tahoe Keys Lagoons
LFA	Laminar Flow Aeration
Lahontan	Lahontan Regional Water Quality Control Board
Lakeside Pilot Project	UV-C Light Plant Control Pilot Project at Lakeside Marina
mg/L	milligrams per liter
MMRP	Mitigation Monitoring and Reporting Plan
MTS	Marine Taxonomic Service
mV	Millivolts
NPDES	National Pollutant Discharge Elimination System
NPS Plan	Nonpoint Source Water Quality Management Plan
ORP	oxidation reduction potential
P	orthophosphorus
PC	PhytoCyanin
PPM	Parts Per Million
RFU	Relative Fluorescence Unit
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 Light Treatment	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

1.0 INTRODUCTION

In June of 2016, the Tahoe Keys Property Owners Association (TKPOA) Water Quality Committee (WQC) (whose name was changed to Waterways Committee in 2023) released its first Integrated Management Plan (IMP) for Aquatic Weeds for the Tahoe Keys Lagoons (IMP) to address the escalating problems of uncontrolled aquatic weed growth. The first update to the IMP was submitted to Lahontan Regional Water Quality Control Board (Lahontan) in Fall 2016. TKPOA's 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. 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), TKPOA has completed and submitted an update of its IMP each year to Lahontan. This is the eighth update to the IMP.

This annual update to the IMP generally follows the format of the prior updates, specifically those for 2020, 2021, and 2022. The update focuses on describing current and ongoing activities, and on TKPOA's approach to control aquatic weeds in the Tahoe Keys Lagoons (Keys lagoons or lagoons) in 2023. To learn more about the history of the IMP development, the location, ecology and hydrology of the 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 2017h).

1.1 2023 Update Integrated Management Plan Organization

This year's update is organized as follows:

- Chapter 1.0: Introduction
- Chapter 2.0: An overview of the weed control activities implemented by TKPOA in 2023, including both standard weed control activities (e.g., harvesting) and testing and monitoring activities associated with Year 2 of the Control Methods Test (CMT) Project conducted in 2023 [e.g., Ultraviolet Light (UV-C), bottom barriers, Diver Assisted Suction Harvesting (DASH), and laminar flow aeration (LFA) treatments and combinations thereof] as authorized by Lahontan on January 13, 2022 (Order No. R6T-2022-0004, NPDES No. CA6202201) and approved by the Tahoe Regional Planning Agency on January 26, 2022
- Chapter 3.0: A summary description of discontinued weed control strategies and projects and associated rationale
- Chapter 4.0: A description of TKPOA's program for aquatic weed control in 2024
- Chapter 5.0: References

1.2 IMP Goals and Objectives

For easy 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 spreading of AIS from the Tahoe Keys to greater Lake Tahoe
- Enhance the overall water quality of the Keys lagoons and Keys Marina 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 and Keys Marina
- Restore and maintain established beneficial recreational uses, including water contact safety in the Keys lagoons and commercial uses in the Keys Marina
- Implement a combination of cost-effective control measures that are feasible for long-term management of aquatic invasive plants

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 2024, both through Year 3 of the CMT Project and separate from the CMT Project.

2.0 AQUATIC WEED CONTROL ACTIVITIES IN 2023

In 2023, TKPOA primarily focused on implementation of Year 2 of the CMT Project. The second year included follow up spot treatments using bottom barriers, UV-C light, and Diver Assisted Suction Harvesting (DASH) within Year 1 CMT Group A sites to determine if the first reduction, or "knock down", of target aquatic weeds can be maintained. In addition, LFA and UV-C only testing was continued at selected sites in Year 2 to assess the capability of those methods to achieve the levels of AIS control identified for the CMT.

This chapter provides an overview of activities, conducted independent of the CMT, implemented during 2023. 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 2017h).

This chapter is divided into five sections:

- Section 2.1 Aquatic Invasive Species Control (WDR-approved weed control activities)
- Section 2.2 Algal Bloom Management
- Section 2.3 Nutrient Management
- Section 2.4 Data Collection and Monitoring
- Section 2.5 Aquatic Invasive Species Control Methods Under Evaluation

Table 1, below, provides a summary list and status for all AIS control activities undertaken by TKPOA in 2023.

Table 1. List of 2023 AIS Control Activities

AIS Control Activity
CONTINUED IN 2023
Skimmer (up to 4 vessels operational)
Boat Backup Station (West Lagoon)
Harvester (4 harvesters operational)
West Channel Bubble Curtain
East Channel Bubble Curtain (operational at end of 2023 season)
DISCONTINUED OR POSTPONED IN 2023
Bottom Barrier (Homeowner Program) (postponed due to CMT)
Baseline Water Quality Sampling (Entire Lagoons) (postponed due to CMT)
Seabins (Discontinued)
CMT ACTIVITIES (Lahontan Order No. R6T-2022-0004, NPDES No. CA6202201)
Replicate Bottom Barrier Treatments
Replicate DASH Treatments
Replicate UV-C Spot Treatments
Replicate UV-C-Only Treatments (Continued from 2022)
Replicate UV-C Combination Treatments (Continued UV-C Portion from 2022)
Replicate LFA Treatments (Continued from 2022)
Baseline Water Quality Sampling (CMT Treatment and Control Sites)

2.1 Aquatic Invasive Species Control (WDR-Approved Weed Control Activities)

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 2023 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. Consistent with this direction, TKPOA implements a robust fragment control program as part of its WDR-approved AIS control activities.

2.1.1 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 5 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 ~~to~~, 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 period.

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 slow. TKPOA began harvesting in mid-June 2023, except for CMT

[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.

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 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 (see Section 2.1.1.1). 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 (4) 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 (4) 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 Skimmer Boat Fleet

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.

2.1.1.1 Mechanical Harvesting Approach for 2023

Winter snowpack in 2023 was very high, resulting in above average spring and summer water levels in Lake Tahoe and the Tahoe Keys lagoons. As a result, the lagoons reached optimal

temperatures for weed growth in early June. TKPOA initiated harvesting operations in early June 2023 and continued harvesting throughout the season through October 2023. During the season, TKPOA operated four mechanical harvesters, as well as up to four (4) skimming vessels. In 2023, 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.

2.1.1.2 Mechanical Harvesting Effectiveness for 2023

Over the past few decades, the volume of weeds harvested has significantly increased from approximately 100 cubic yards (yds^3) in 1984 to approximately 8,500 yds^3 in 2021.[2] Due to harvesting limitations from the CMT Project, the total amount of biovolume removed in 2022 and 2023 was reduced from the previous years. The total amount of biovolume removed from the Tahoe Keys via harvesting in 2022 and 2023 was 5,824 yds^3 and 4,910 yds^3. Both reductions are largely a result of the CMT and presence of treatment sites that did not need harvesting during the 2022 and 2023 seasons. Also in 2023, TKPOA implemented a new, more conservative procedure for measuring harvested weeds. The new measurement procedure resulted in a roughly 30% reduction in estimated harvesting volume vis-à-vis historical data (see Figure 1).

[2] Prior to 2017, there was no standard protocol for reporting the amount of weeds harvested per year, resulting in some over reporting. Since 2017, TKPOA has adhered to a standard protocol for quantifying harvested weeds.

Figure 1. Measurement Adjustments for Harvested Weeds

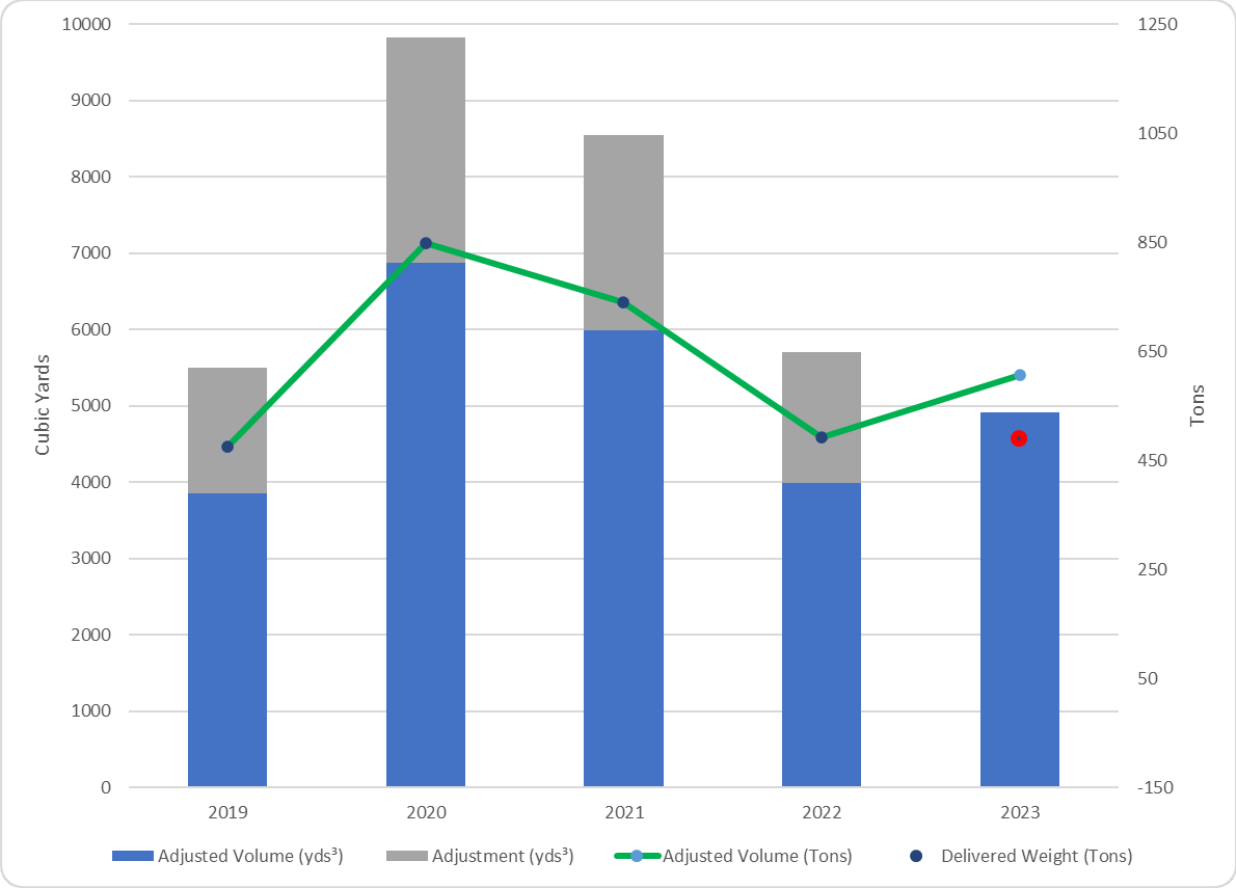


Figure 1 displays cubic yards of plant material harvested by month since 2019 and Figure 2 displays harvesting totals from 2012 to 2023, respectively. In 2019 and 2020, TKPOA extended the harvesting season through October 31, a scheduling differentiation from previous years when harvesting and fragment collection ended shortly after Labor Day. In 2020, approximately 72% percent of the total weeds were harvested in the months of September and October. In 2021, peaks of removed biomass were in the months of July and October (approximately 60% of the total biomass removed). During the 2022 season, peak biomass removal occurred in August (26% of the total weeds harvested) and October (52% of the total weeds harvested). In 2023, peak biomass removal occurred in July (28% of the total weeds harvested) and August (35% of the total weeds harvested).

TKPOA extended the harvesting season after TRPA consultant nutrient modeling in the summer of 2019 indicated that the majority of total phosphorus in the West Lagoon and East Lagoon is the result of decaying plant matter (Lahontan/TRPA CMT Draft EIR/EIS, Appendix F; EMKO 2019a and 2019b).[3] TKPOA determined that extending harvesting later into the season

[3] Study completed by Environmental Science Associates (ESA), in combination with adjustments from EMKO Environmental, Inc. (EMKO 2019a) as background data gathered during preparation of the EIR/EIS for the Control Methods Test.

could help improve water quality by reducing the biovolume of plants left in the water through the winter, thereby reducing the major source of phosphorous-loading to the water. The nutrient-modeling was completed by ESA, a third-party consultant hired by TRPA. ESA's studies were associated with data collection efforts to support the environmental document (a joint EIR/EIS) prepared for TKPOA's Control Methods Test (CMT) Project. ESA's nutrient model is included as Appendix F of the Draft EIR/EIS and is available on the TahoeKeysWeeds.org website here (beginning on page 233 of 394 in the PDF document): http://www.trpa.ort/wp-content/uploads/Tahoe-Keys-DRAFT-Appendices-A-H.pdf.

In 2023, TKPOA completely overhauled its maintenance standards for the harvesting vessels to help ensure that at least four are fully operational throughout the season. A new protocol was put into place whereby each TKPOA operator is now responsible for weekly upkeep of their assigned harvester. This compares to the previous protocol of having a single mechanic responsible for keeping all harvesters operable. In 2023, there was a decrease in the number of available staff performing harvesting operations, however, the improved harvesting schedules, staff training, and utilization of an additional harvester kept harvesting operations on track for the 2023 season.

Figure 2. Cubic Yards of Plant Material Harvested by Month since 2019

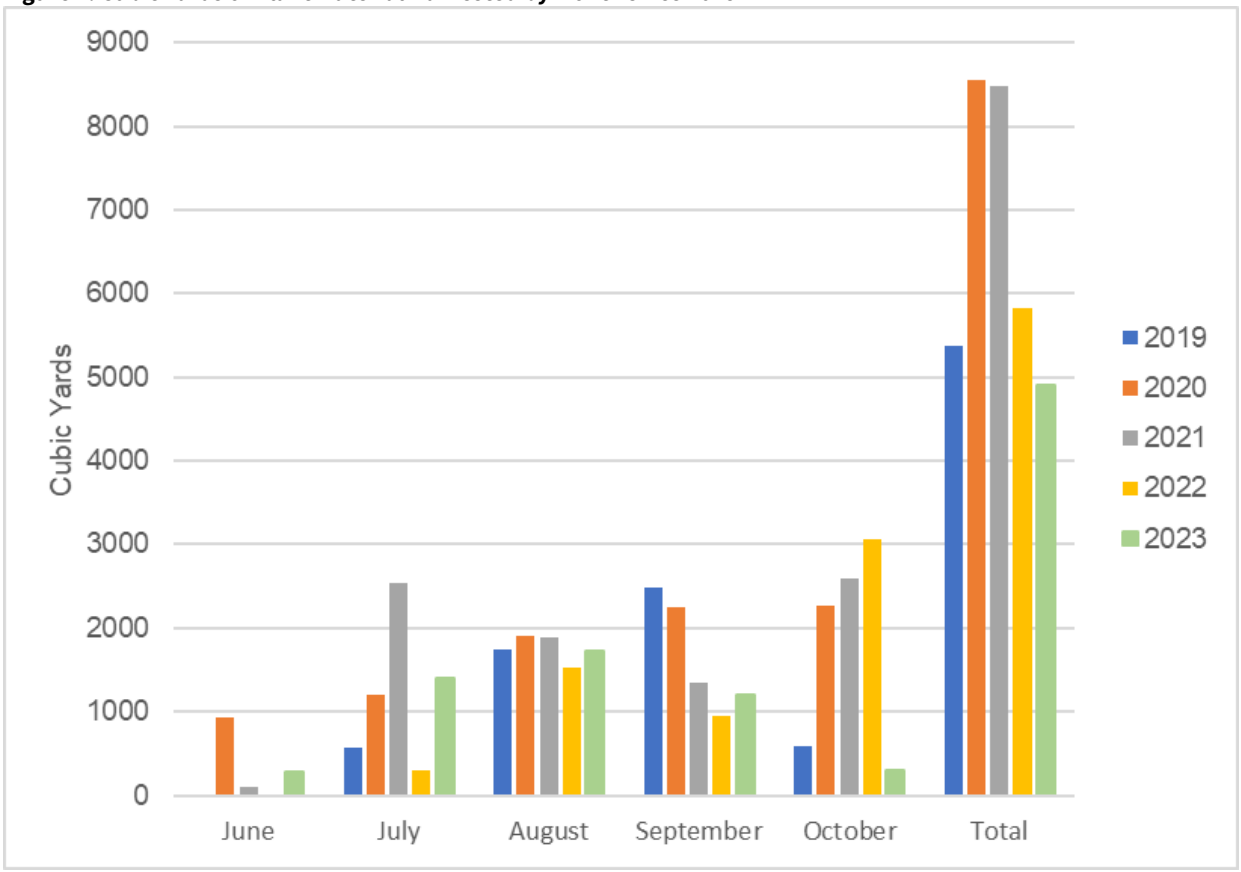
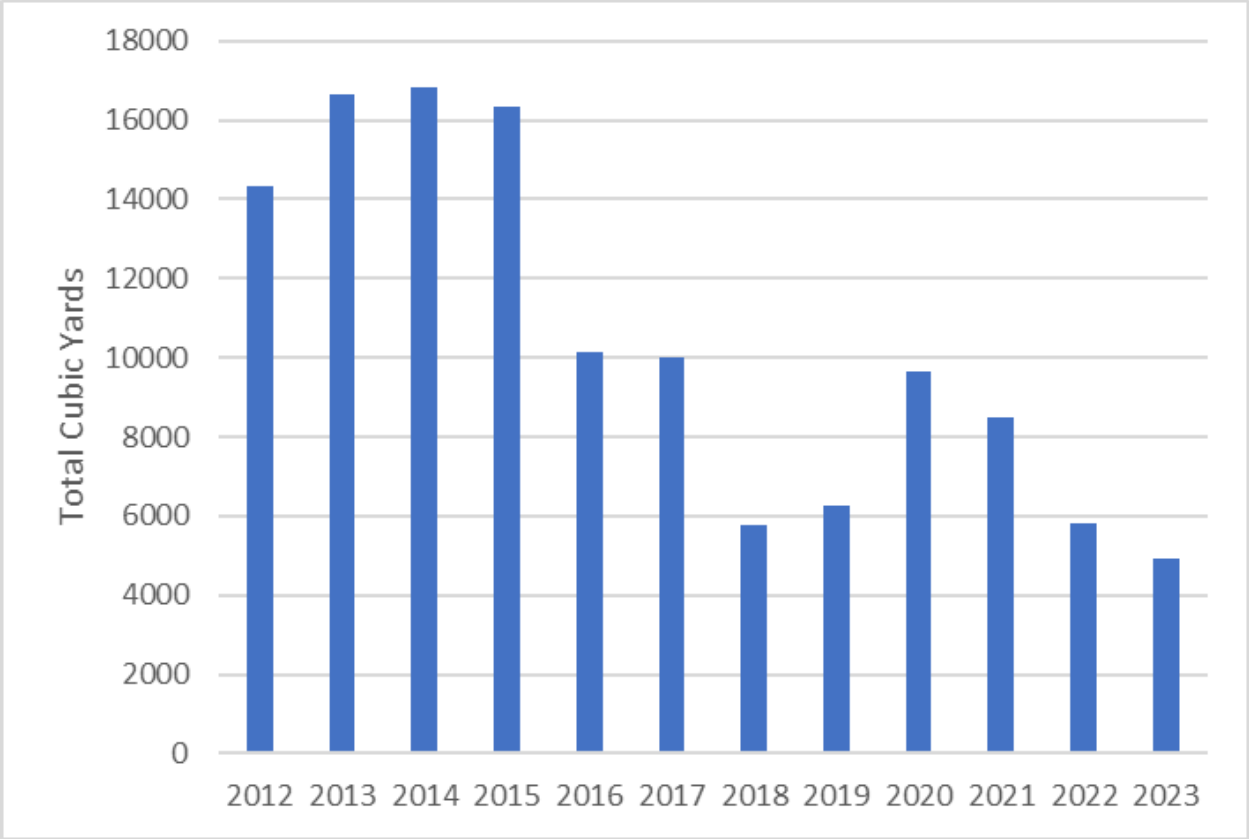


Figure 3. Comparison of Harvesting Totals 2012-2023



2.1.2 Homeowner 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%.

2.1.2.1 Homeowner Bottom Barrier Program Approach for 2023

Unlike previous years, TKPOA did not actively implement the Homeowner Bottom Barrier Program in 2023. Given the spatial extent and scope of the CMT Project, implementation of the bottom barrier program was put on hold.

2.1.2.2 Homeowner Bottom Barrier Program Effectiveness for 2023

As previously mentioned, the TKPOA Homeowner Bottom Barrier Program was not implemented in 2023. The Program is anticipated to be reinstituted in 2025 following completion of the Control Methods Test.

2.1.3 Fragment Collection and Control

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 in Section 2.1.1 and in prior year updates to the IMP), TKPOA also collects fragments from the West Lagoon boat back-up station area and the West Channel bubble curtain area. The boat back-up station has been in use since 2016 and the West Channel bubble curtain was installed and implemented in 2019. The West Channel bubble curtain was improved, and a new bubble curtain was installed by TKPOA in the East Channel, in 2022.

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 10 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. The 2023 boat back-up station is a reoccurring, seasonal installation. The buoys and directional signage were installed in the West Channel in June 2023 and removed in October 2023.

For the 2023 season, TKPOA did not actively conduct visual monitoring of the Boat Backup Station, but when on-water, staff generally observed compliance and participation from homeowners. A total of 3.99 ft^3 of fragments were collected from the Boat Backup Station throughout the 2023 season.

Figure 4. Boat Backup Station Signage[4]

Photo credit: TKPOA

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

[4] A new sign was implemented in 2020 to improve outreach.

first proposed in by the TKPOA Stakeholder Committee[5] 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 eight air compressors. As a result of the compressor failures, the bubble curtain operated only intermittently over the course of the 2019 season.	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 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.

[5] 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
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.

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 (The League). Similar to 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.

Internal Bubble Curtain

Based on positive feedback regarding the effectiveness of the West Channel bubble curtain in 2019, TKPOA budgeted for bubble curtains within the lagoons in 2020 with the intention of reducing the spread of fragments in and around the lagoons. Three new locations for internal bubble curtains were proposed in 2020. A bubble curtain at the West Lagoon pumphouse was identified to help prevent weed fragments from being drawn into the circulation system in the

future when it resumes operation. During TKPOA's evaluation of the circulation system during the 2019 season, staff identified that weed fragments repeatedly clogged the intake gate.

The internal bubble curtains were placed on hold in 2021, due to a combination of low water conditions, limited staffing, and preparations for the proposed CMT Project in 2022. The curtains again were not deployed in 2022 or 2023 due to the demands on resources required to implement the CMT Project. Resumed testing of the internal bubble curtains is anticipated in 2025, following completion of the CMT.

2024 Bubble Curtain Approach

Compressors for the bubble curtain areas will continue to be maintained according to manufacturer specifications in order to achieve a continuous run time throughout the year. Efficacy for the bubble curtains will be evaluated in the Bubble Curtain Working Group and changes to daily monitoring will occur once a new method has been defined. Transfer of East Channel bubble curtain ownership and operations and maintenance to Suntex Marina will occur once terms are established and agreed upon by both parties.

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.[6]

In 2019, TKPOA deployed a single Seabin in the West Channel along the western bulkhead (shown in Figure 5) 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 Seabins to properly function.

[6] 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 5. Seabin

Photo Credit: TKPOA

Fragment Collection Approach and Effectiveness

TKPOA Water Quality Staff collected fragments from the boat back-up station and West Channel bubble curtain daily during the 2023 boating season, excluding the times staff were unable to conduct on water work due to weather or scheduling. Water Quality staff recorded the volume of fragments cumulatively collected from the boat back-up station and bubble curtain sweep using a 1ft^3 measuring box. Water Quality staff collected a total of 21.4 cubic feet (ft^3) of fragments from the skimmer sweeps of the boat back-up station and West Channel bubble curtain, which is a decrease from 38.4 ft^3 in 2022. 41 ft^3 of fragments were collected in the previous year (2021). This reduction is due to higher water levels, an increase in the effectiveness of fragment collection, and CMT treatments. Figure 6 shows the combined quantity of fragments collected each month from the boat back-up station and bubble curtains from June to October 2023.

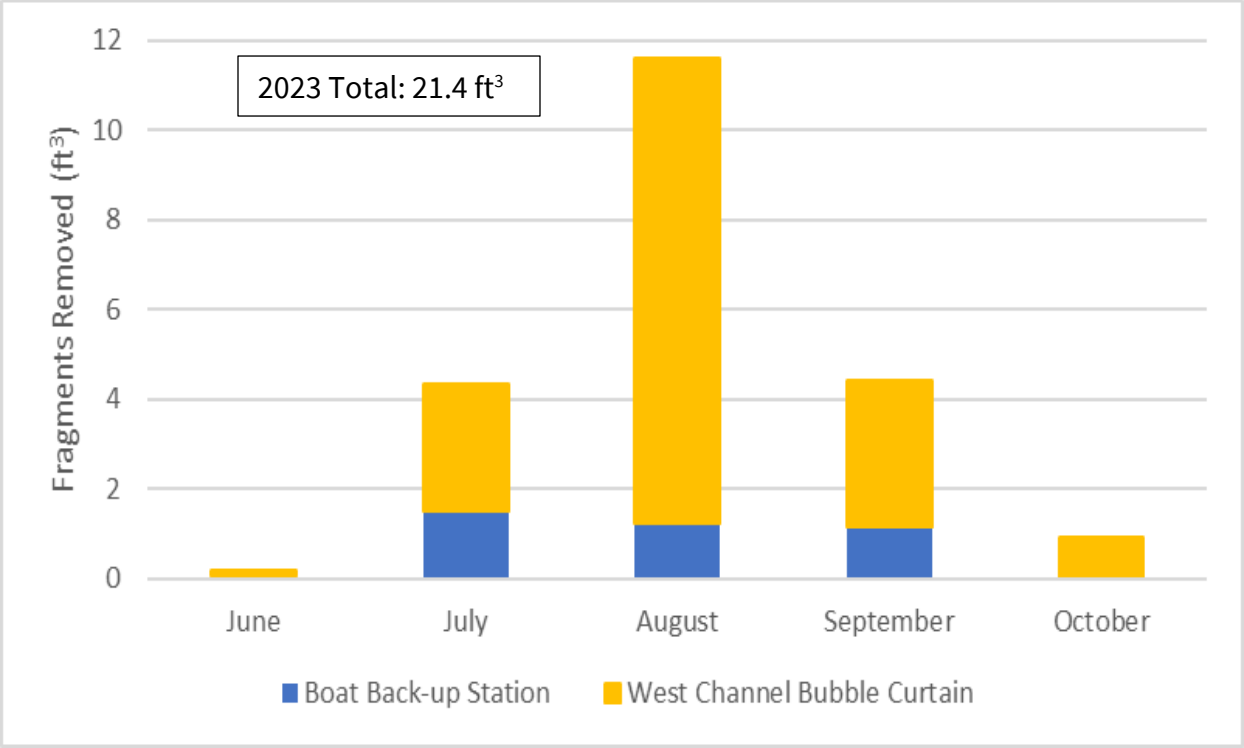
Boat Backup Station Compliance

Unlike prior years, Water Quality staff did not monitor the number of boaters complying (i.e., backing up their boat) at the boat back-up station in 2023. In previous years, Water Quality staff

observed and tracked use of the boat back-up station every Friday as well as during heavy boating traffic days, including holidays (i.e., week of Memorial Day, July 4, and Labor Day). In 2021, TKPOA Water Quality Staff observed and recorded boating compliance on July 30. During these observation periods, Water Quality staff recorded the number of boats using the station versus the number of boats ignoring the station.

Based on TKPOA Water Quality staff observations, compliance and participation has increased overall since it was installed in 2016. Homeowners are also taking more responsibility and ownership of the Boat Backup Station by encouraging others to adhere to it. This data could be biased due to the presence (and visibility) of Water Quality staff near the station.

Figure 6. Cubic Feet of Fragments Collected and Removed by Water Quality Staff Each Month (2023 Season)



2.2 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 considered to be 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 Laminar Flow Aeration (LFA) study area just north of Venice Drive twice per month, regardless of any observed algal blooms[7].

2.2.1 2023 Algal Blooms and Cyanobacteria Sampling

In previous years, cyanobacteria were primarily monitored as part of the LFA project. Beginning in 2022 and continuing into 2023, cyanobacteria was monitored throughout the CMT as well. Compared to 2022, there was significantly less cyanobacteria present in the Tahoe Keys lagoons in 2023. In 2023, cyanobacteria blooms began in mid-July and dissipated at the end of September and were much less severe than 2022. Results of the twice monthly monitoring will be presented in the CMT Annual Report to be submitted to Lahontan and TRPA in March 2024. Cyanobacteria sampling for the LFA Project coincided with CMT sampling in CMT Sites 26 and 6.

2.2.2 Control Measures

Following the HABs that have occurred in the Keys lagoons since 2017, TKPOA has initiated exploration of and investment in control measures to reduce algal blooms and associated water quality issues. Using information provided by TKPOA residents as well as the CMT Project Stakeholder Committee, TKPOA is evaluating dock bubblers, ultrasonic units, laminar flow aeration, and future possible use of the Tahoe Keys water circulation system for algal management. Brief descriptions of each of these potential control methods follow.

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

2.2.2.1 Dock Bubblers

In 2020, TKPOA began researching 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 (5) dock bubblers (e.g., Figure 7) 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 7. Dock Bubbler Example

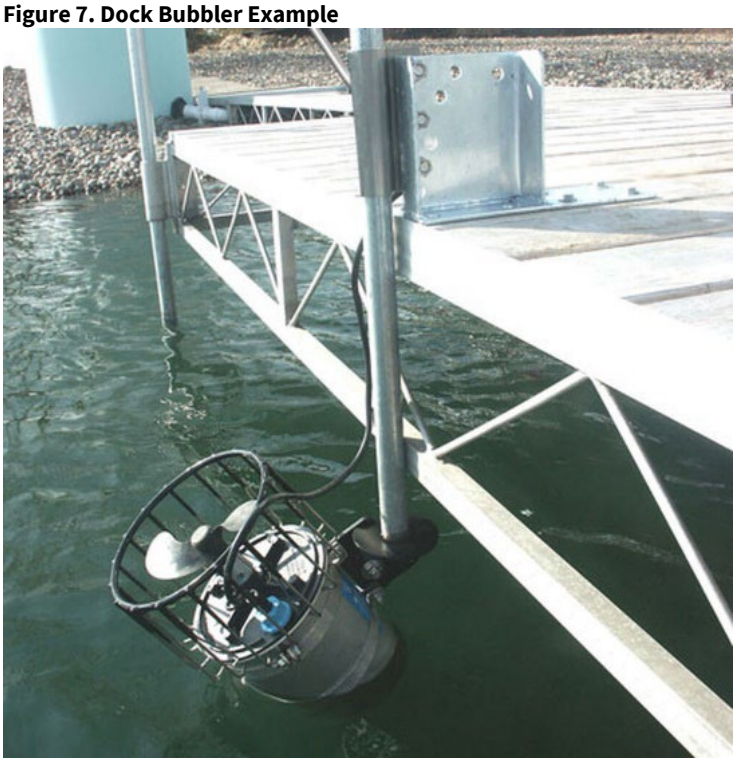


Photo of a "Kasco Marine De-Icer Universal Dock Mount" (overtons.com)

2.2.2.2 Ultrasonic Units

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 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 (2) units in 2021 (Figure 8), with the intention of installation and testing

during the peak of any cyanobacteria outbreaks. Unhealthy AQI values and mandatory emergency evacuations associated with the Caldor Fire prevented installation of the units in August and September 2021.

Two ultrasonic units were 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 2023 and will be re-installed in spring 2024. Before use, it was 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. The effectiveness of the unit cannot be concluded at this time but will be described in future IMP updates.

Figure 8. Ultrasonic Unit in Site 5

Photo from TKPOA (TKPOA, 2023)

Figure 9. LG Sonic Unit Locations

Map from TKPOA (TKPOA, 2023)

2.2.2.3 Laminar Flow Aeration

LFA is a technology often used for improving water quality in water bodies where there is consistently low dissolved oxygen and a buildup of sediment. TKPOA has three LFA test sites within the West Lagoon: 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).

LFA treatment is one of the Group A control methods of the CMT. Results of 2023 LFA treatments and monitoring will be included in the CMT Year 2 annual report to be submitted to Lahontan and TRPA in March 2024. The LFA system in Site 27 was manually turned off for the winter in December 2023 and will be turned back on in March 2024 or when the ice melts. This system was shut off due to winter recreational needs for homeowners residing around Lake Tallac Lagoon. The LFA system in Site 26 has not been operational since October 2023 due to compressor issues. The Site 26 compressor was sent in for repairs in November 2023, and it is expected to be operational in 2024. The Site 25 LFA system will remain operational throughout the season.

2.2.2.4 Water Circulation System

The existing TKPOA water circulation system is a substantial network of underground piping and valves, culvert lift stations, and two main pump stations. The system was originally designed to circulate and treat water within the Keys lagoons to improve water quality by decreasing turbidity, removing nutrients, preventing stagnation, and increasing mixing. TKPOA tested operation of the system for a short period in 2020 for the first time in over 15 years. Further details can be found in Section 2.3.2 of this update.

2.3 Nutrient Management

The primary pollutants of concern identified in the WDR are those containing nitrogen and phosphorous. Nitrogen and phosphorous compounds decrease water clarity and increase growth of aquatic weeds. The primary source of nitrogen compounds to Lake Tahoe and the lagoons is atmospheric deposition, 57% (TERC 2015), while the primary sources of phosphorus compounds are more varied and include contributions from stormwater runoff (from urban and non-urban areas), atmospheric deposition, and decaying plant matter. For several years TKPOA, Lahontan, and TRPA (TRPA 2014) assumed that runoff from TKPOA's landscapes was a primary contributor of phosphorus to the lagoons. TKPOA has made substantial progress to address its own potential contribution to phosphorus-loading of the lagoons, including a ban of phosphorus fertilizers in 2015. TKPOA also implements a robust Nonpoint Source Water Quality Management Plan (NPS Plan) to minimize water pollution caused by uncontrolled run-off of nitrogen- and phosphorous-containing nutrients from City streets and TKPOA landscapes.

More recent studies have identified that decaying aquatic plant matter is the primary contributor of phosphorus to the Keys West Lagoon. This finding was highlighted in a 2019 report prepared by the third-party environmental consulting firm ESA based on a study developed by ESA Principal Associate, Dave Tomasko, PhD. Tomasko's study, which included development of a phosphorus loading model, determined that the large majority (at least 75%) of total phosphorous in the West Lagoon is the result of decaying plant matter. Phosphorus loading from decaying plant matter is a smaller component of the total phosphorus loading to Lake Tallac, around 30% of the total, as Lake Tallac also receives substantial phosphorus loading from City of South Lake Tahoe stormwater, as well as from shallow groundwater inflow (USACE 2003; EMKO 2019b).

2.3.1 Nonpoint Source Water Quality Management Plan

The NPS Plan (prepared by TKPOA in accordance with Board Order No. R6T-2014-0059 and submitted to Lahontan in January of 2024 (TKPOA 2024)) is the primary document guiding TKPOA's institutional control, education, and outreach to homeowners related to AIS. TKPOA implemented the NPS Plan in 2016 in response to the WDR and to help support aquatic plant control methods in the IMP. The NPS Plan identifies land-based activities in the Tahoe Keys

that have the potential to discharge nutrients and other pollutants into surface water, describes actions undertaken by TKPOA to reduce such contributions to surface water, and recommends site-specific management practices that can be implemented to reduce or prevent future nutrient loading of the lagoons. These include homeowner installation of BMPs, such as rain gardens, to reduce the inputs of nitrogen and phosphorus (primary pollutants of concern) to the surface waters. Table 3 provides an overview of NPS Plan activities that occurred in 2023. Please refer to the complete 2023 NPS Plan update for additional information and details.

Table 3. 2023 NPS Plan Activities

Activities		Date
Stormwater and Erosion Control Best Management Practices	Single-family home BMP promotion	Ongoing throughout 2023
	Enforced compliance with water conservation rules and active ban on the use of phosphorus-containing fertilizers	Ongoing throughout 2023
	Enforcement of Boat Washing Covenants, Conditions and Restrictions	Ongoing throughout 2023
Outreach and Education Activities	Lake and Lagoon Friendly Landscaping	Passive Implementation in 2023
	Lunch and Learn	Discontinued in 2023
	Eyes on the Lake Training	Ongoing in 2023
	TKPOA and KeysWeedsManagement.org website maintenance and updates	Ongoing throughout 2023
	Outreach & Education Program	Ongoing throughout 2023
	Social Media Outreach (Instagram)	Ongoing throughout 2023
Staff Training	Water Quality and Common Area landscape maintenance staff training, courses, certifications, and webinars	Ongoing throughout 2023
Tahoe Keys Water Company Long-Term Facilities Plan	SCADA meter monitoring	Ongoing throughout 2023
	Master Landscape Plan updates	
	Stormwater drainage improvements	

2.3.2 Circulation and Treatment 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; and
- 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 eighteen

distribution pipes (18” to 14” diameter) that circulate water into the various coves within the lagoons (R.O. Anderson 2016; Domenichelli & Associates, Inc. 2017).

In 2020, at the direction of the TKPOA Board of Directors, Water Quality staff evaluated reactivating the water circulation system as a potential means of reducing nutrient concentrations in the water column and mitigating algae blooms. As part of the evaluation, a phased start-up of the system was initiated the week of July 20, 2020. TKPOA, in accordance with WDR requirements, collected YSI data and water quality grab samples at six (6) sampling sites prior to turning the system on, and also collected YSI data and water grab samples while the system was functioning. The six (6) sites sampled included the four (4) sample sites required in accordance with the WDR, plus two additional sites. TKPOA collected samples from the six sampling sites on July 16, 2020, prior to turning on the system, and also on July 22, 2020, when the system was running.

At each of the six water quality sampling sites, grab samples and YSI data were collected. The YSI is used to determine the depth of water as well as depth at which the sample pump is placed to collect the grab samples. YSI data collected included:

1) depth (meter),
2) pH,
3) dissolved oxygen (mg/L),
4) turbidity (FNU),
5) temperature (°C),
6) Oxidation Reduction Potential (mV),
7) Chlorophyll (RFU)
8) Phycocyanin (RFU), and
9) specific conductivity (measured as µS/cm).

Grab samples were collected in labeled bottles and delivered to WETLab in Sparks, NV. Parameters included orthophosphate, ammonia, Total Phosphorus, Total Nitrogen, Nitrate-Nitrogen, Nitrite-Nitrogen, and Total Kjeldahl Nitrogen (measured in milligrams per liter or mg/L). Additional grab samples were collected for cyanotoxins and chlorophyll-a. These samples were sent to Bend Genetics, LLC.

Prior to operation of the water system pumps, grab samples showed Orthophosphate, Ammonia, Nitrate-Nitrogen, and Nitrite-Nitrogen were non-detectable. These readings did not change following running of the water circulation system. Total Phosphorus ranged from non-detect to 0.024 mg/L, Total Nitrogen from non-detect to 0.34 mg/L, and Total Kjeldahl Nitrogen from non-detect to 0.34 mg/L. However, following the system being switched on, an increase was seen in Total Phosphorus, Total Nitrogen and Total Kjeldahl Nitrogen, ranging between 0.025-0.045 mg/L, 0.35-0.53 mg/L, and 0.35-0.52 mg/L, respectively. Grab samples related to cyanotoxins showed that prior to running the system, detectable levels of anatoxin-a were present in scattered areas of the lagoons. However, after running for a few days, levels rose in

other areas such that areas with outflows all had detectable levels of anatoxin-a. It should be noted that circulation system sites sampled prior to operation of the system included circulation system sites E, W, 3, 13, and 14, while locations during operation included Circulation system sites 1, 14, and W and water quality sites 6, 8, 14 and 17. Overall results of the sampling suggest the circulation system was successfully circulating water in affected portions of the lagoon, including cyanotoxins such as anatoxin-a.

The test also identified that mechanical improvements were needed to enable the water circulation pumps to function effectively, as electrical or other mechanical failure occurred for some of the pumps. In addition, the test identified that weed fragments were pulled toward the pump station intake grates, in some cases amassing enough volume to reduce or eliminate function of the intake pumps.

In July of 2020, then Water Company Manager, Dan Larson, provided an overview of the circulation system to the WQC and then the TKPOA Board of Directors. The presentation included a summary of the history of the circulation system's operation.

TKPOA plans to further evaluate the circulation and treatment system in the next few years as part of its long-term plans to help control aquatic invasive plants, improve water quality, reduce harmful algal blooms, and restore more natural ecosystem functions in the lagoons. This includes the work performed in 2023, wherein TKPOA initiated planning on the Long-Term Water Quality Improvement Project. If approved by the TKPOA Board, this Project will include partnering with the TRPA, Lahontan, U. S. Forest Service, and other stakeholders in the Tahoe Basin to conduct a series of technical reviews on lagoons stormwater nutrient and pollutant inflow/outflow, potential improvements to aquatic and terrestrial habitats (Tahoe Keys Lagoons and Pope Marsh), the possible redesign and reoperation of the water circulation and treatment system, and more.

2.3.3 TKPOA Corporation Yard

TKPOA holds a License Agreement with the CA Tahoe Conservancy to permit use of the Dover Corporation Yard. TKPOA was granted a second one-year extension to the Agreement, which will allow use of the current facilities until December 1, 2024. Current and future operations at the Corporation Yard are still under consideration by TKPOA, with relocation options including a lot on Venice Drive near the Tahoe Keys Marina and TKPOA's Texas Avenue circulation and treatment plant lot.

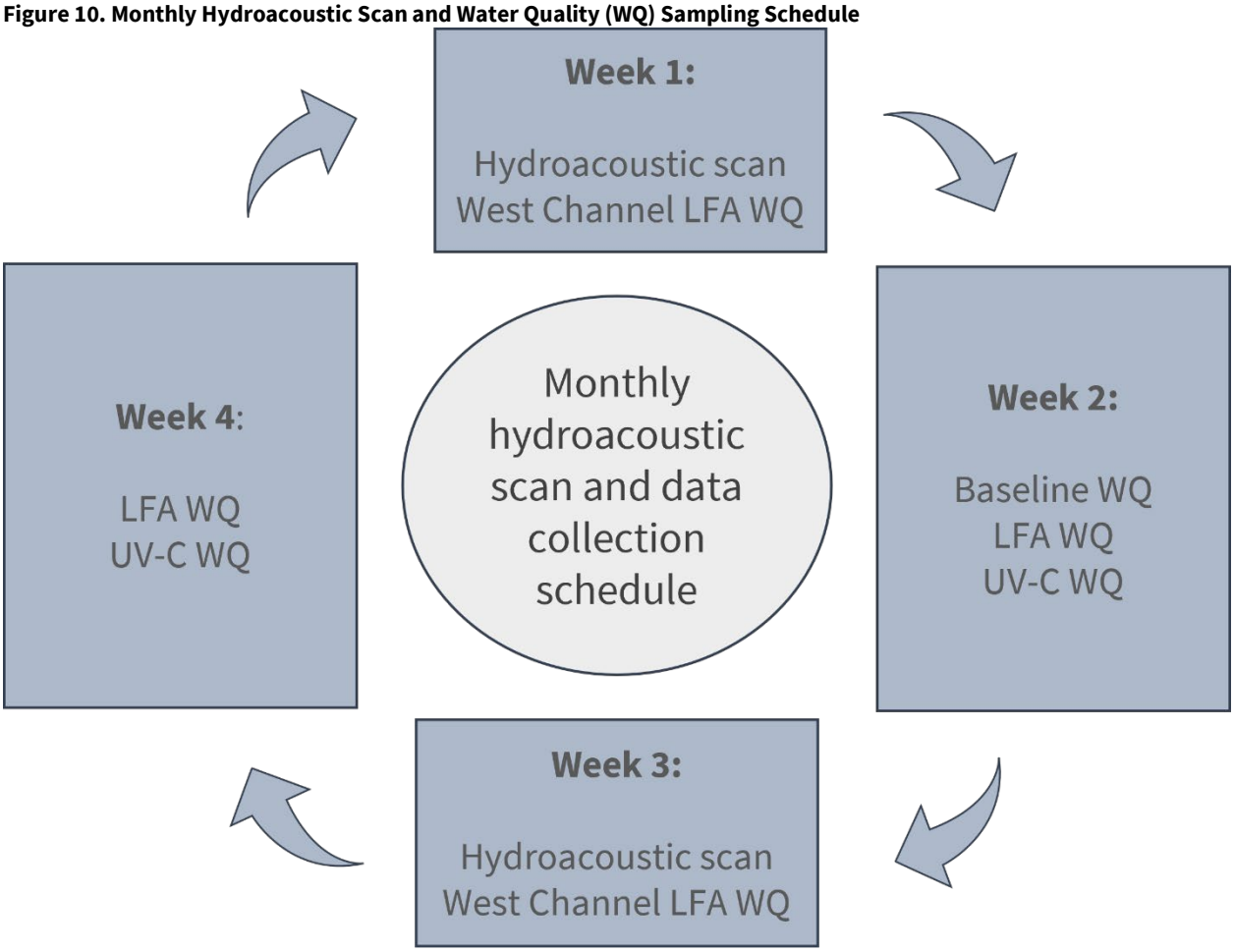
2.4 Data Collection and Monitoring

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 – initiated annually in 2015 and conducted in late June/early July
- Water Quality Sampling – initiated annually in 2016 and conducted monthly beginning in June
- Hydroacoustic Scans – initiated annually in 2016 and conducted twice monthly beginning in late May

The routine water quality sampling and hydroacoustic scans were conducted by TKPOA Water Quality staff every other week beginning in late May. Figure 10 indicates the schedule on a four-week cycle. UV-C light monitoring was added in 2022 as part of the CMT Project and continued into 2023.

Figure 10. Monthly Hydroacoustic Scan and Water Quality (WQ) Sampling Schedule



2.4.1 Macrophyte Survey

The information below summarizes some of the key details from the 2023 Macrophyte Survey Report prepared by TKPOA in accordance with Lahontan Board Order No. R6T-2014-0059 and

submitted to Lahontan in January of 2024. Please refer to the 2023 Macrophyte Survey Report for additional information and details (TKPOA 2023b).

A total of 735 points were sampled throughout the Keys lagoons in 2023, including the East Lagoon (109 points), West Lagoon (560 points), and Lake Tallac (66 points). The survey data showed that curlyleaf pondweed along with native coontail, are the most prevalent species in the waterways of the Keys lagoons. Until CMT treatments began in 2022, curlyleaf pondweed showed an increasing trend of occurrence lagoons-wide, especially in the West Lagoon.

The increasing spread and growth of curlyleaf pondweed stalled in 2022 in the West Lagoon and Lake Tallac where CMT treatments occurred. This reduction in occurrence of curlyleaf pondweed was somewhat maintained in 2023 with minor fluctuations and some resurgence. In the East Lagoon, there was a notable reduction in occurrence of curlyleaf pondweed in 2023. This reduction may have been caused by the unusually high-water levels and lower water temperature caused by an above average snowmelt.

Overall, data show that curlyleaf pondweed is spreading into more competitive locations, may be displacing other aquatic plant species in the East Lagoon, and appear to be diminishing in abundance in and adjacent to certain CMT treatment areas. Additional details such as frequency of occurrence data and percent composition maps can be found in the 2023 Macrophyte Survey Report.

2.4.2 Invasive New Zealand Mudsnail Discovery

New Zealand mudsnails are invasive aquatic snails that are found in 22 states across the country. They are approximately the size of a grain of rice (2-6mm) and have the ability to colonize in new environments quickly due to a lack of natural predators (TRPA, 2023). When consumed, the snails pass through fish digestive systems unharmed. Mudsnails impact aquatic ecosystems by eating algae and outcompeting native benthic invertebrate communities.

In the fall of 2023, divers from Marine Taxonomic Services (MTS) discovered invasive New Zealand mudsnails in Lake Tahoe. As a result, TRPA assembled an incident team to determine the extent of the infestation and next steps for preventing the spread of the snails (TRPA, 2023). On November 1, 2023, Environmental Science Associates (ESA), a contractor for the CMT, performed a survey for New Zealand mudsnails in the Tahoe Keys (TKPOA, 2023). Four sampling locations within the lagoons were chosen, and snails were present in all four of the locations.

TKPOA representatives meet with CMT Project partners on a weekly basis and provide updates on the status of the mudsnails when applicable. TRPA is developing new dredging BMPs and public education materials and is updating lake-wide boat cleaning protocols to minimize the

spread of invasive New Zealand mudsnails. These requirements will be implemented by TKPOA as part of its homeowner education program for contractors operating within the Tahoe Keys.

2.4.3 Baseline Water Quality Monitoring

In 2016, TKPOA initiated the Baseline Water Quality Sampling Program, and has maintained the program annually, although certain parameters have not been monitored in recent years. Water quality monitoring for the program has included monitoring with the use of a YSI ProDSS handheld device as well as occasional water grab samples for nutrient composition analysis. 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 2017c, TKPOA 2018c). Baseline water quality monitoring from 2022 to 2024 will be performed as part of the CMT Project, and data and results from monitoring can be found in the CMT annual reports submitted to Lahontan and TRPA in March of their prospective years.

2.4.4 Expanded Water Quality Sampling

In addition to the baseline water quality sampling program, in previous years TKPOA undertook additional WQ samples, expanding the water quality data collection program. This program included the following:

1) Within the LFA test sites once every two weeks,
2) At 14 sampling locations in Lake Tallac once every month, and
3) At six (6) sample sites when and if the water circulation system is operational.

A map of 2021 baseline, LFA, and other water quality sampling stations was produced and can be found in the 2022 IMP update.

However, as previously mentioned, water quality sampling in 2023 was conducted as part of the data collection for the CMT. Results of CMT water quality monitoring will be available as part of the CMT annual report to be submitted to Lahontan and TRPA in March 2024.

The TKPOA Baseline Water Quality program will be re-instituted following completion of the CMT.

2.4.5 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 (See Table 4). 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.

Table 4 shows a comparison of 2022 and 2023 average biovolume percentages derived from hydroacoustic scans. The percent plant biovolume column depicts the percentage of the water column taken up by vegetation when vegetation exists. Areas that do not have any vegetation are not taken into consideration for this calculation. The percent water biovolume column depicts the average percentage of the water column taken up by vegetation regardless of whether vegetation exists. In areas where no vegetation exists, a zero value is entered into the calculation, thus reducing the overall biovolume of the entire area covered by the survey.

Table 4. Comparison of 2022 and 2023 West Lagoon Percent Biovolume

	Year	% Plant Biovolume	% Water Biovolume
June	2022	27.9	25.3
		33.3	29.5
	2023	29.8	23.2
		33.4	33.4
July	2022	38.3	34.5
		74.2	69.0
	2023	39.2	28.7
		40.9	24.7
August	2022	45.6	38.3
		38.8	31.3
	2023	35.2	19.5
		39.5	16.5

In 2022, scanning by TKPOA Water Quality staff followed previous protocols established in prior year monitoring. Twice-monthly scans were performed in the West Lagoon and Lake Tallac, whereas the East Lagoon and Lake Tahoe were scanned once a month. Scanning of the West Lagoon included scanning of the CMT test areas. A comparison of hydroacoustic scans of the West Lagoon, East Lagoon, and Lake Tallac taken August 2021, August 2022 and August 2023 are shown in Figure11, Figure 12, and Figure 13, respectively. This data includes preliminary data collected as part of the CMT, and the results can be found in the CMT annual report to be submitted to Lahontan and TRPA in March 2024.

The hydroacoustic scans for 2021 through 2023 show differences in the percent of the water column containing plant matter at the same approximate time each year. The percent of the water column containing plant matter in the snapshots is affected by the intensity and location of where mechanical harvesters were operating in the days and week prior to the scan, as well

as water year conditions (overall depth of lagoon waters) and the time of year relative to plant growth (e.g., early August for 2021, early August for 2022, and August 2023).

The hydroacoustic scans for 2021, 2022, and 2023 used a down-scan setting for the sonar channel and a 1.3-foot minimum vegetation depth. The vegetation depth of 1.3 feet accounted for shallower depths seen in certain areas of the Keys for water year conditions experienced in 2021 and 2022.

Figure 11. West Lagoon Hydroacoustic Scans (August 2021, August 2022, and August 2023)

Figure 12. East Lagoon Hydroacoustic Scans (August 2021, 2022, and 2023)

Figure 13. Lake Tallac Hydroacoustic Scans (July 2020, 2021, and 2022)

2.5 Aquatic Invasive Species Control Methods Under Evaluation

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 TRPA in early 2022, Year 2 of the three-year CMT Project was completed in November 2023.

The purpose of Year 2 of the CMT Project was to test the effectiveness of small-scale, non-chemical, Group B methods to maintain 75 percent 'knock-back' of target plants that was achieved at Group A test sites in Year 1. Group B methods include bottom barriers and DASH, although larger scale LFA and UV-C light treatments from Year 1 were also continued at many locations in 2023. The UV-C light treatment method was also used as a Group B method in Year 2 for smaller "spot treatments" at certain Year 1 sites (see section 2.5.2.3). The same Year 2 treatments will also be deployed in Year 3 to assess whether the 75 percent biovolume reduction can be sustained over time.

The CMT is both unique and complex not only in its highly collaborative approach, but also because it is the first ever permitted use of aquatic herbicides in Lake Tahoe. Aquatic herbicides specifically target invasive plant species and have been proven effective in other high elevation lakes throughout the country. The CMT is also unique with its first large scale testing of UV-C treatment systems.

The four 2023 CMT methods are briefly discussed in the following sections and will be extensively described in the CMT Year 2 annual report to be submitted to Lahontan and TRPA in March 2024:

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

2.5.1 Laminar Flow Aeration

In the Keys lagoons, the accumulation of detritus at the bottom of the water column is referred to herein as the "muck layer." The muck 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.

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 the 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 were 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 will be presented in the CMT Project annual report to be submitted to Lahontan and TRPA in March 2024.

2.5.2 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 14. 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 light as a control method for aquatic weeds in the Tahoe Keys and greater Lake Tahoe Basin is of great interest.

Figure 14. 2022 UV-C Treatment Vessel

Photo Credit: John Paoluccio, Inventive Resources, Inc.

UV-C Project in the Tahoe Keys Lagoons (2020-2022)

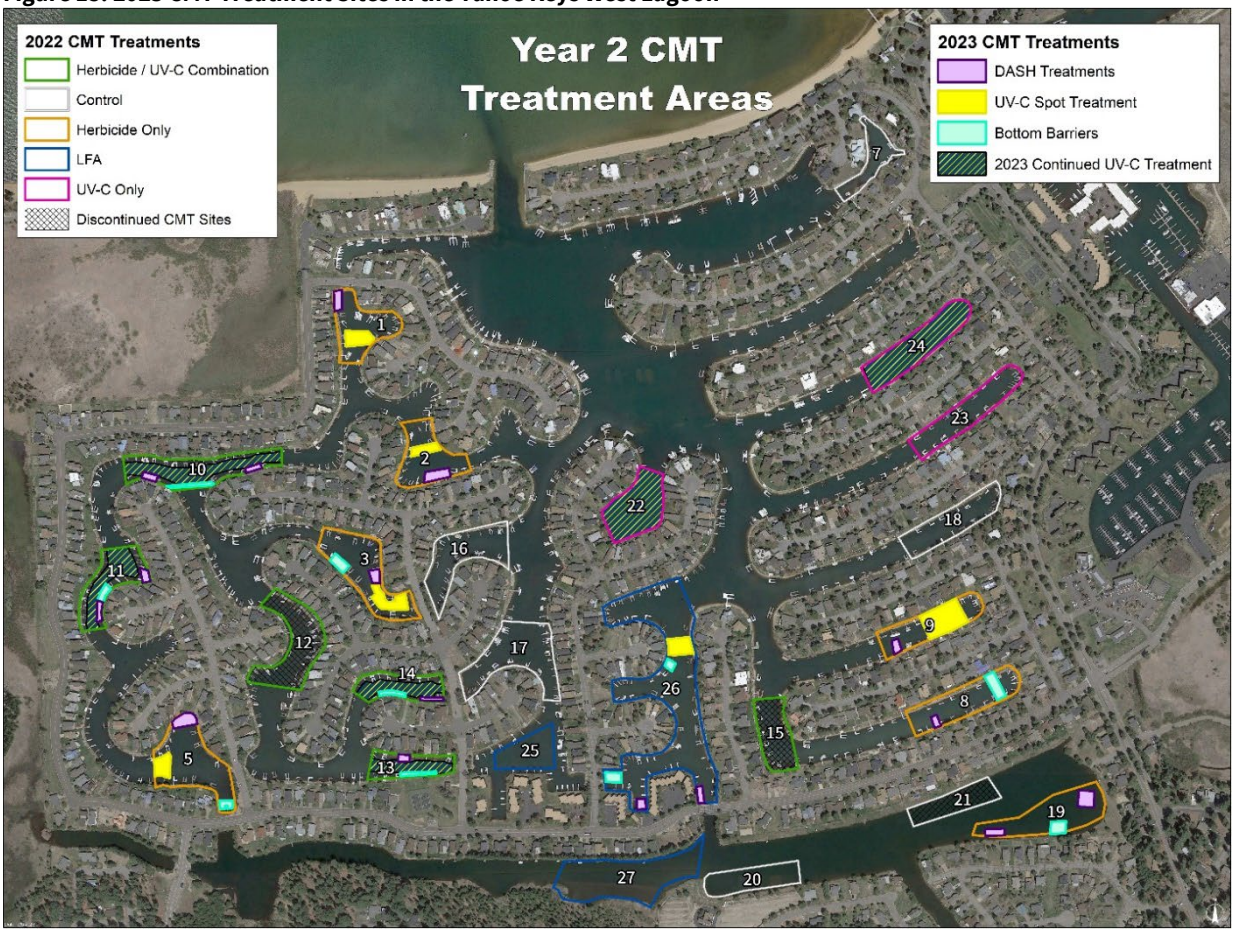
Preliminary experimental treatments of UV-C began within the Tahoe Keys lagoons in 2020 at two locations, with data (including quadrat sampling and videos/pictures) collected by the University of Nevada, Reno (UNR). Results of the 2020 exposures are not currently available. The same locations treated in 2020 were treated in 2021.

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.

UV-C Treatments Conducted during Year 2 of the CMT (2023)

In 2023, 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 UV-C combination, and a new treatment intended to sustain the “knock back” of target weeds called UV-C Spot treatment. UV-C Spot treatment occurred in six (6) test areas throughout the lagoons from June 2023 through October 2023. This treatment was applied to smaller areas within CMT sites with UV-C, then re-treating them three additional times. A total of 1.52 acres were treated with the UV-C Spot method (see Figure 15). Data and results on the monitoring of these CMT test areas will be presented in the CMT Year 2 annual report to be submitted to Lahontan and TRPA in March 2024.

Figure 15. 2023 CMT Treatment Sites in the Tahoe Keys West Lagoon



2.5.3 Aquatic Herbicide

Two types of aquatic herbicides were tested in Year 1 of the CMT (in 2022). Both types are target plant-specific herbicides. The first is Endothall, which is a contact herbicide that targets all three invasive aquatic species (Eurasian watermilfoil, curlyleaf pondweed, and coontail). The second is Triclopyr, which is a systemic herbicide that targets only Eurasian watermilfoil.

All aquatic herbicide treatments were completed in late May 2022 and are not intended to be applied again for the remainder of the CMT Project. Data and results on the monitoring of these CMT test sites are presented in the CMT first annual report submitted to Lahontan and TRPA in March 2023.

2.5.4 Aquatic Herbicide/UV-C Light Treatment Combination

To further explore the efficacy of UV-C, the CMT Project incorporated the concept of using herbicides in the shallow, limited space zones of the lagoons while using UV-C in the mid-channel navigational portions of the lagoons. Six (6) test sites were used to test the combination treatment method. Data and results from Year 1 are presented in the CMT annual

report submitted to Lahontan and TRPA in March 2023.

Due to logistical challenges, UV-C light was not applied as prescribed to all combination test sites in Year 1 of the CMT Project. As a result, a continuation of Group A UV-C treatments occurred in 4 of 6 combination test sites in Year 2 to ensure that the areas received their prescribed treatments. As previously mentioned, no herbicides were applied in Year 2. Data and results on the monitoring of these CMT test areas will be presented in the CMT Project Year 2 annual report to be submitted to Lahontan and TRPA in March 2024.

2.5.5 Additional Year 2 Follow-up Treatments

Bottom Barriers

In 2023, bottom barriers were used to cover specific areas throughout the lagoons as part of Year 2 of the CMT Project. The objective of this treatment (and the other spot treatments) is to determine if it can be utilized to sustain the 75% "knock back" of target weeds (Eurasian watermilfoil, Curlyleaf pondweed, and coontail). By blanketing the bottom of the lagoons, aquatic plants no longer have access to essential resources that are needed for growth. Divers secured the bottom barriers using rebar and anchors in ten (10) test areas. A total of 0.73 acre of the lagoons was covered with bottom barriers from approximately June 2023 to September 2023. Data and results on the monitoring of these CMT test areas will be presented in the CMT Year 2 annual report to be submitted to Lahontan and TRPA in March 2024.

Diver Assisted Suction Harvesting

DASH was also utilized in 2023 as part of the CMT to maintain the 75% reduction in target weeds. 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 on the DASH boat at the surface. The weeds were then collected and analyzed to determine the percent composition of species pulled from that particular test area. There were sixteen (16) DASH test areas and each area received two treatments. Both treatments occurred in all designated areas from July 2023 to September 2023. A total of 1.14 acres were treated with DASH. Data and results on the monitoring of these CMT test areas will be presented in the CMT Year 2 annual report to be submitted to Lahontan and TRPA in March 2024.

3.0 DISCONTINUED WEED CONTROL STRATEGIES AND PROJECTS AND ASSOCIATED RATIONALE

Since the 2014 issuance of the WDR, TKPOA has evaluated, and in many cases tested, innovative methods of aquatic weed control. The below table describes activities that have been tested and discontinued including the time of the activity's implementation, and the year of discontinuation. More detail about each of these activities can be found in the IMP Updates for previous years.

In addition to the activities described in Table 4 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.

Table 5. Discontinued Aquatic Control Strategies

Activity	Duration of Implementation	Discontinued	Rationale for Discontinuation
Rototilling/ Rotovating	One year	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.

Activity	Duration of Implementation	Discontinued	Rationale for Discontinuation
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. There was 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 2018.
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 2017d), 2016 Mesocosm Study (TKPOA 2017g), and the 2017 Non-Chemical Control Methods Test (TKPOA 2018d).

4.0 TKPOA 2024 PROPOSED PROGRAM FOR AQUATIC WEED CONTROL

With the exception of the annual harvesting and fragment containment and collection (e.g., boat back-up station) activities described above, TKPOA 2024 resources will be focused on Year 3 of the CMT Project. Specific efforts will also be placed on coordinating with The League on improving, maintaining, and gathering data on the effectiveness of the existing West Channel and East Channel double bubble air curtains to help limit fragment drift into Lake Tahoe proper.

4.1 CMT Project Year 3 Activities

Year 3 of the CMT will include: 1) testing of small-scale, site-specific Group B treatments at multiple sites using bottom barriers, diver assisted suction harvesting, and UV-C spot treatments, 2) continuation of Group A UV-only treatment at certain UV-only Year 1 test sites, 3) continuation of the LFA systems operations, and 4) starting and in some cases continuing UV treatment in the mid-channels of the CMT Year 1 combination UV/herbicide treatment sites.

No herbicides will be applied in Year 3. The combination of continuing both Year 1 "Group A" methods and follow-up "Group B" methods in Year 3 were both addressed as part of the CMT Project as approved by the Lahontan Water Board and TRPA Environmental Impact Report/Environmental Impact Statement and permits. This also reflects the "adaptive management" approach of the CMT Project.

The selection of the Year 3 CMT Group B method test locations will be based on the results of Year 2 treatments, a comparison of 2022 and 2023 aquatic invasive plant data at those sites, and results of aquatic plant surveys to be performed Spring 2024. In most cases, the same Year 2 Group B test areas will likely be used in Year 3 depending on whether the 75% knock back was maintained in that particular area. The continuation of Group A UV-C treatments will be at most of the same locations as the Year 1 Group A UV-C sites that were repeated in Year 2. LFA treatments will continue at the same three sites as CMT Year 1 and Year 2 operations. This adaptive management approach was anticipated as part of the design and strategy of the CMT and is necessary because it is difficult to predict where and how widespread the target species may reappear within the CMT treatment sites.

4.2 Effectiveness Monitoring and Adaptation

When the IMP was drafted in 2016, it included a plan to establish an Adaptive Management Review Committee. While a formal Adaptive Management Review Program was never initiated, many aspects of the protocol and process for adaptive management have been, and continue to be, implemented. TKPOA has continued to implement approved control methods (mechanical and cultural), monitor macrophyte growth and water quality, research new methods for AIS control, coordinate with TRPA and The League, and report to the TKPOA

Governing Board, Lahontan Water Board, and to the TKPOA Waterways Committee. These review and reporting processes have resulted in refinements and improvements to existing approved control methods, and, in the case of the CMT Project, have directly influenced the testing and future course for invasive plant management in the Keys lagoons and broader Lake Tahoe.

Following the CMT, the next phase of AIP control will include the Lagoons-wide Weed Treatment Project. TKPOA plans to kick-off the Lagoons-wide Weed Treatment Project in parallel with its existing AIS Program. The Project's focus will be on continuing to reduce AIP weeds in the Tahoe Keys lagoons by implementing the control method treatments that were tested and determined to be successful during the CMT. A treatment plan application will be prepared in 2024 and 2025 as results of the CMT are analyzed and conclusions on the efficacy of the control methods become better known.

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