Integrated Weed Management Plan
For
The Tahoe Keys Lagoons
PUBLIC REVIEW DRAFT

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Prepared for

Tahoe Keys

Tahoe Keys Property Owners Association
South Lake Tahoe, California

Prepared by

sea

Sierra Ecosystem
Associates

In association with
Dr. Lars Anderson

TAHOE KEYS INTEGRATED
WEED MANAGEMENT PLAN

KeysWeedsManagement.org

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Tahoe Keys Property Owners Association
Integrated Weed Management Plan

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EXECUTIVE SUMMARY

This Integrated Weed Management Plan for the Tahoe Keys Lagoons presents a strategy to control and manage invasive and nuisance aquatic plants. The Plan was developed in response to the increasing need to control aquatic plants in the Tahoe Keys lagoons for safety, for navigation in the waterways, to enhance habitat for native species, improve water quality, and to minimize the potential to spread invasive and nuisance aquatic plants from the lagoons to Lake Tahoe. The Plan integrates the range of control methods best suited to the Tahoe Keys lagoons and provides an adaptive management approach to respond to changing conditions. The Plan also includes background information about the plant and animal species found in and around the Tahoe Keys lagoons, the hydrology of the area, and a summary of the control work that has been done to date in the Tahoe Keys lagoons.

Nuisance non-native and native aquatic plants have been observed in marinas and other recreational areas in Lake Tahoe and in the Tahoe Basin. The excessive growth of these nuisance plants interferes with navigation when plants become entangled in propellers and keels and plants can entangle swimmers or divers and compromise safety. Dense coverage of aquatic plants can degrade the water quality and the aquatic habitat by making the ecosystem less favorable for native organisms that are adapted to the pristine water of Lake Tahoe.

An aquatic plant survey was completed for the Tahoe Keys lagoons in 2014. The survey showed that there was nearly complete aquatic plant canopy coverage in many areas of the Tahoe Keys lagoons and that non-native species including Eurasian watermilfoil and curlyleaf pondweed were a major component of this infestation. With this proliferation of aquatic plants, the Tahoe Keys Property Owners Association now spends more than $400,000 annually to cut and remove aquatic plants from the waterways by using mechanical harvesters and disposing of the plant waste off-site. Harvesting has met with limited success in controlling growth of the plants and generates plant fragments that can spread within Tahoe Keys lagoons and to Lake Tahoe. Therefore to improve management of nuisance aquatic plants, the Tahoe Keys Property Owners Association's Water Quality Committee has developed a comprehensive Plan that integrates proven aquatic plant control methods. The Plan has the following overarching Goal and five supporting Objectives.

The Goal of the Plan is:

To help protect the ecology, to enhance the recreational and aesthetic qualities, and to maintain the commercial uses of Lake Tahoe by controlling nuisance aquatic plants in the Tahoe Keys lagoons.

The Objectives which will guide the implementation of the Plan are:

1) *Minimize the potential to spread aquatic invasive plants from the Tahoe Keys lagoons to Lake Tahoe.*
2) *Enhance habitat for native fish, waterfowl, and other native wildlife species and reduce habitat for non-native, warm-water fish in the Tahoe Keys lagoons.*
3) *Restore recreational uses in the Tahoe Keys lagoons and commercial and institutional uses in the Marina Lagoon.*
4) *Establish a long-term management program which:*
    - Uses the best available technologies to monitor conditions in the Tahoe Keys lagoons to reduce maintenance inputs and costs.
    - Utilizes feasible, cost-effective methods to control invasive and nuisance aquatic plants in the Tahoe Keys lagoons.
5) *Assist the Tahoe Region in achieving goals for reductions in greenhouse gas emissions, as described in the Sustainable Communities Action Plan, by minimizing the air quality impacts of aquatic plant maintenance actions.*

The Tahoe Keys Property Owners Association is committed to helping solve the regional problem of the proliferation of aquatic plants, a problem which threatens the water quality and the aesthetics of Lake Tahoe. This Plan describes how proven methods can be integrated to control aquatic plants found in many areas throughout the Tahoe Keys lagoons. This integrated approach provides the best opportunity to protect and enhance the beneficial uses of the waters of the Tahoe Keys lagoons. Prior to implementation, the Plan will undergo thorough public and resource agency review and permitting. Once implemented, aquatic plant control work will be subject to monitoring and reporting to ensure compliance with the permit requirements.

This Plan complements the recently developed Comprehensive Implementation Plan for the Control of Aquatic Invasive Species within the Tahoe Basin, which was developed with the Tahoe Resource Conservation District, the California Tahoe Conservancy, and the Lake Tahoe Aquatic Invasive Species Coordinating Committee to address the problems associated with a wide range of invasive organisms that are found in the Tahoe Basin, or which are a threat to become established in the Basin. Priorities of this Plan, to control the growth and spread of two aquatic plants, Eurasian watermilfoil and curlyleaf pondweed, are in agreement with priorities identified in the Comprehensive Plan to control the same species.

This Plan was several years in the making and is the result of a collaborative process engaging stakeholders and representatives of federal, state, and local agencies to identify a strategy to control aquatic plants in the waterways of the Tahoe Keys lagoons. The Plan was developed with direction from and review by a panel of nationally recognized experts in the fields of aquatic plant and animal biology, with input from a technical review group comprised of members of several agencies and organizations in California and Nevada, and with contributions from residents of the Tahoe Keys and the public. A special thank you is extended to these experts, specialists, and interested citizens for their assistance.

1.0 BACKGROUND AND NATURAL SETTING

1.1 Location and Area Description

Tahoe Keys and Lake Tahoe - Copyright 2006 Regents of the University of California. Photo used by permission

Lake Tahoe is a unique alpine lake on the California-Nevada border. The Lake is known worldwide for its outstanding blue waters and was designated an Outstanding National Resource Water by the State of California and the US EPA in 1980. The Lake offers many recreational opportunities and is enjoyed year round for its scenic beauty.

The Tahoe Keys is a multi-use development situated at the southern end of Lake Tahoe on approximately 372 acres of land. The development features 1,529 homes and townhomes, marinas, and a commercial center. There are three primary man-made water features in the Tahoe Keys: the Main Lagoon, the Marina Lagoon, and Lake Tallac. These three water features are considered the Tahoe Keys lagoons, referred to throughout this document. (Figure 1).

The surface area of the water of the Tahoe Keys lagoons is approximately 172 acres in size, or 0.3 square miles, a very small percentage of the surface area of Lake Tahoe, which is approximately 192 square miles. The Tahoe Keys lagoons have two narrow, direct connections to Lake Tahoe: the West Channel connects the Main Lagoon and the East Channel connects the Marina Lagoon. These channels provide the only direct boat access to Lake Tahoe from the Tahoe Keys lagoons. Lake Tallac is connected to the Main Lagoon at a weir site between the two water bodies. Lake Tallac also has an intermittent connection to Lake Tahoe via Pope Marsh during high water events.

The Tahoe Keys lagoons differ from Lake Tahoe in several ways. The Tahoe Keys lagoons have shallow waters, approximately 20 to 30 feet at maximum depth, as compared to the deep waters of Lake Tahoe measured at 1,645 feet at the deepest point. The waters of the Tahoe Keys lagoons are typically warmer than the water of Lake Tahoe during the spring and summer months, but can be cooler during the fall and winter months. The waters of the Tahoe Keys lagoons are typically more turbid than the clear waters for which Lake Tahoe is famous. Lastly, the bottom layer of the Tahoe Keys lagoons is composed of fine sediments, a remnant of the past when the area was a marsh, as opposed to the coarse, decomposed granite often found at the bottom of Lake Tahoe.

Figure 1. Overview Map of Keys Lagoons and Lake Tallac

The Tahoe Keys development has seven types of landowners:

- Private homeowners
- The non-profit Tahoe Keys Property Owners Association
- The Tahoe Keys Beach and Harbor Association
- Lagoon, Inc. which owns Lake Tallac
- The Tahoe Keys Marina and Yacht Club
- TKV Properties Holdings LLC, which owns commercial property known as Tahoe Keys Village
- The State of California, which owns land to the east and southeast of the Tahoe Keys development under the auspices of the California Tahoe Conservancy (CTC), one of 10 conservancies in the State of California

The Tahoe Keys development includes beaches, swimming pools, tennis courts, basketball courts, a pedestrian pier to Lake Tahoe, boat docks, channels connecting the waterways to Lake Tahoe, and park areas. Ancillary facilities of the development include water wells and a potable water distribution system, a water treatment facility, and lagoon water circulation system.

The Tahoe Keys lagoons provide boating access to Lake Tahoe and the waters of the Tahoe Keys lagoons are used by the residents and visitors to the area for recreational boating, both by power boating and non-motorized boating and for recreational fishing. The aesthetic values of the Tahoe Keys lagoons include the waterways and views of the surrounding mountains which are key attractions for residents and visitors alike.

The Main Lagoon of the Tahoe Keys contains the majority of private residences in the overall development and has many interconnected waterways and coves. The Main Lagoon is controlled by 700 individual private property owners who belong to the Tahoe Keys Property Owners Association (TKPOA). The TKPOA itself also has an ownership interest in the Main Lagoon.

The Marina Lagoon contains both residences and commercial space. This is the location of the Tahoe Keys Marina, a privately-owned boat launching facility which is the largest full-service marina at Lake Tahoe. The Tahoe Keys Marina provides boat services, fueling, mooring, and launching services to the general public, Tahoe Keys property owners and renters, boat rental and charter and other recreational companies, marine construction companies, law enforcement, and agencies and universities for research activities on Lake Tahoe.

The Marina Lagoon area is owned by:

- The Tahoe Keys Marina and Yacht Club
- Individual property owners of the Tahoe Keys, who are members of the TKPOA
- TKPOA, which holds in common individual docks used by owners of townhomes in the Tahoe Keys development
- The Tahoe Keys Beach and Harbor Association (TKB&HA) which maintains 266 boat docks for their members
- The California Tahoe Conservancy, which owns the area known as the Turning Basin at the northeast edge of the Marina Lagoon

The commercial center at the Marina Lagoon known as Tahoe Keys Village is owned by TKV Properties Holdings LLC. This parcel is adjacent to the Marina Lagoon, but does not have ownership in the Marina Lagoon.

Lake Tallac is located at the southern edge of the Tahoe Keys development and is owned by Lagoon, Inc. Parcels adjacent to Lake Tallac are owned by private property owners who are also members of the TKPOA.

The federal government controls the waters of Lake Tahoe and the US Forest Service controls areas to the south and to the west of the Tahoe Keys development.

The TKPOA is responsible for maintaining the common areas of the Tahoe Keys development and maintains navigation in the waterways of the Tahoe Keys lagoons.

Ownership interests are summarized in Table 1 and Figure 2.

Table 1. Summary Table - Tahoe Keys Water Features and Ownership

Water Feature	Surface Area (Acres)	Property Ownership	Connection to Lake Tahoe
Main Lagoon	110	• 700 Private Owners • TKPOA	West Channel
Marina Lagoon	32	• Tahoe Keys Marina and Yacht Club • Tahoe Keys Property Owners (Individuals) • Tahoe Keys Property Owners Association (Docks held in common for owners of townhomes) • Tahoe Keys Beach and Harbor Association • California Tahoe Conservancy	East Channel
Lake Tallac	30	• Lagoon, Inc.	Pope Marsh

Source: Lahontan Regional Water Quality Control Board

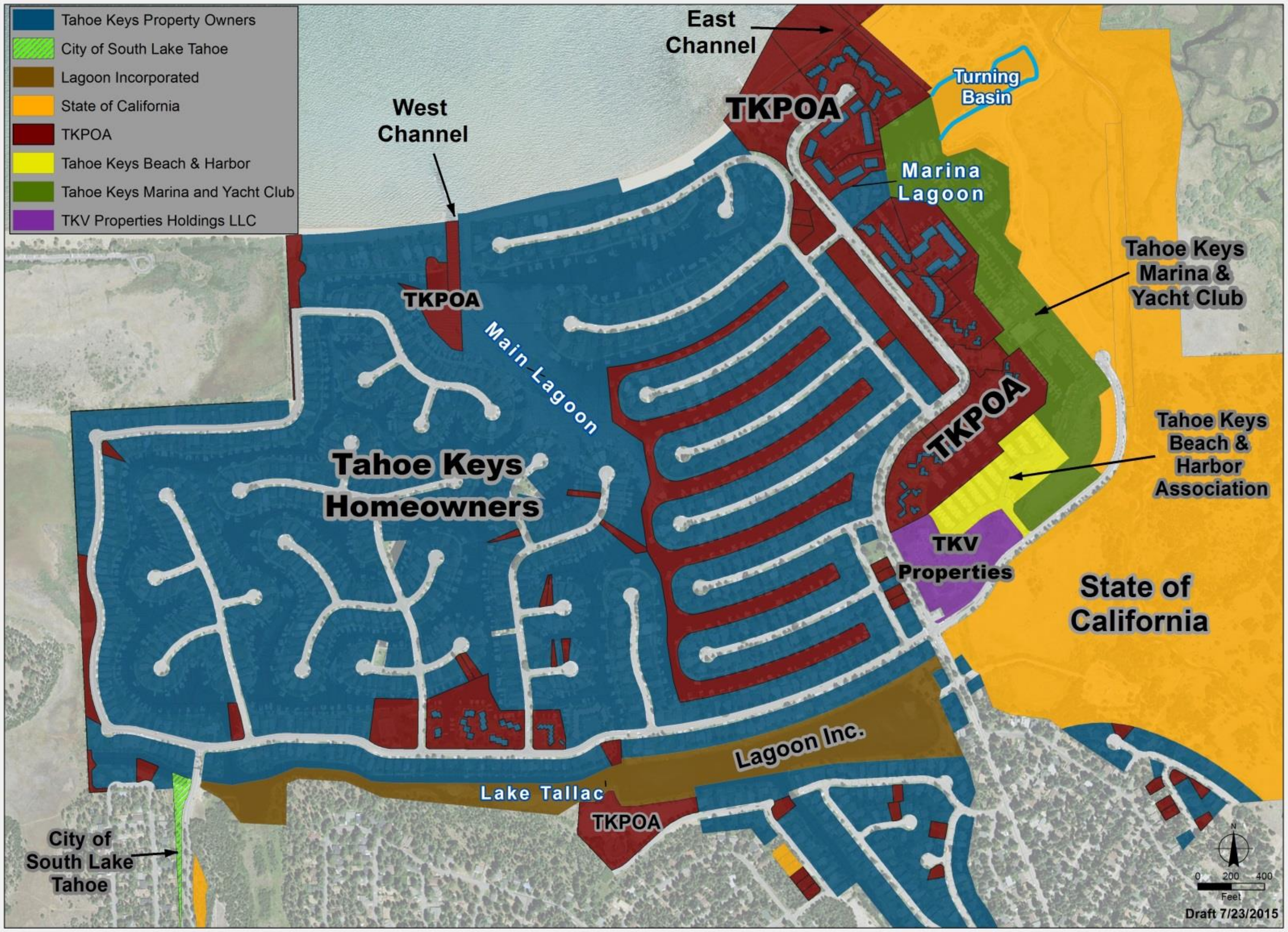


Figure 2. Property Ownership Map (*Source: TKPOA*)

1.2 Hydrology of the Tahoe Keys

The Tahoe Keys and Keys Marina were constructed in the 1960s on the Upper Truckee River Marsh by excavating the lagoons and capping the soil with sand to form stable building bases. In conjunction with construction of the Tahoe Keys, the Upper Truckee River was diverted to a channel on the east side of the Tahoe Keys Marina (USGS 2000).

The three water bodies of the Tahoe Keys lagoons each have a connection to Lake Tahoe. The Main Lagoon has smaller lagoons and coves with residential docks and is connected to Lake Tahoe by the West Channel. The Tahoe Keys Marina Lagoon is connected to Lake Tahoe via the East Channel. Lake Tallac Lagoon normally discharges into Pope Marsh but also can drain into the Main Lagoon when gates located under Venice Drive are lowered during flood conditions in Lake Tallac.

Figure 3. Aquatic Features Surrounding the Tahoe Keys

The Tahoe Keys watershed is approximately 372 acres or 0.6 square miles, as compared to the much larger watershed of Lake Tahoe at 501 square miles. There are 63 inlet streams to Lake Tahoe, but no natural surface water channel discharges into the Keys. Lake Tallac intercepts most upland runoff that flows towards the Keys and this water body in turn discharges to Pope Marsh. With this barrier to the south and the Upper Truckee River to the east, only a negligible amount of storm water runoff reaches the Tahoe Keys from lands that are not part of the Tahoe Keys development. The majority of the watershed that discharges surface flows into the Tahoe Keys lagoons is developed residential property. Runoff is directed to a storm drain system owned and operated by the City of South Lake Tahoe under a Municipal Separate Storm Sewer System Permit.

1.3 Seasonal Patterns of Water Movement

The Tahoe Keys lagoons experience seasonal inflow and outflow of water to and from Lake Tahoe. Since the contributing watershed to the Tahoe Keys lagoons is small compared to that of the Lake, during periods of stormwater runoff and snowmelt, the water surface level in the Lake rises faster, causing water to flow into the lagoons from the Lake. Conversely, as runoff into the Lake diminishes, the Lake level begins to lower and water from the Tahoe Keys lagoons flows out into the Lake. In addition to this seasonal pattern, some mixing of waters between the Tahoe Keys and Keys Marina and the Lake may occur from thermal gradients and wind.

The mean net annual evaporation from Lake Tahoe has been estimated in the range of 21 inches (DRI 2011) to 51 inches (TERC 2015). Lake levels are also influenced by the release of water at the Truckee River dam in Tahoe City which augments flows into the Lower Truckee River.

The Tahoe Keys lagoons are directly connected to Lake Tahoe at the West and East channels. Under typical conditions, the rate of water flow out of the Keys slows as the season progresses from late summer (August to September) to fall (September to October). A detailed assessment of water movement in the Main Lagoon was completed by Dr. Lars Anderson in 2011 (Anderson 2011a). The tracking dye, Rhodamine WT, was used as a surrogate to simulate herbicide movement, dissipation and residence time. Residence time is also referred to as flushing time and refers to the average time water, or a dissolved substance in water, is contained in a lake or reservoir. The study showed that narrow coves, or dead-end sites, had long residence times, greater than 30 days, regardless of the season. These dead-end sites experienced rapid diurnal mixing of the water as cooler, denser surface water sank overnight. In contrast, open water sites had shorter residence times than the dead-end coves. During the summer, residence times in open water sites lasted hours and in the fall, the residence times were in the range of weeks (Figure 4).

Figure 4. Rhodamine Dye Study Results

Water exchange patterns between the Tahoe Keys lagoons and Lake Tahoe, via the East and West channels, has also been studied by researchers from UC Davis. One study investigated water temperature differences and determined that thermal stratification and the resultant density differences of water were strongly linked to exchange flows during most months of the year, as compared to other influences, such as wind currents. This study estimated residence times of the open water areas of the Main Lagoon to be between 2 to 3 days, and residence times in the Marina Lagoon to be between 5 and 6 days (La Plante 2008).

As part of a study modeling potential microbial contamination of the recreational waters of Lake Tahoe, a simulated release of 24,000 neutrally-buoyant particles from outside the Tahoe Keys lagoons was studied (Schladow 2014). The modeling results determined that such particles had the potential to reach the near shore areas southeast and southwest of the Tahoe Keys lagoons within 24 hours. The study also determined that after 24 hours, the majority of the particles would be found above 5 meters in depth, with some particles reaching 10 to 12 meters in depth. The model was intended to simulate the release of herbicide from outside the Tahoe Keys lagoons to determine if such a release would reach potable water intakes located to the east and north, which were assumed to be at 15 meters in depth for purposes of the modeling exercise. The simulated release did not take into account factors that are known to affect the environmental fate of herbicide molecules such as photolysis and microbial degradation, hydrolysis, or adsorption.

1.4 Biological Communities of Lake Tahoe and Tahoe Keys Lagoons

The Aquatic Ecosystem of the Tahoe Basin

The Tahoe Basin contains a complex ecosystem with both stream and lake aquatic environments that support fish, benthic invertebrate, bird, and plant species.

Lake Tahoe's aquatic ecosystem has changed over time and the current aquatic flora and fauna assemblage is largely the result of human influence. In the 1800's, the lake's aquatic animal communities were relatively simple, with 12 orders of zoobenthic taxa, six zooplankton species, and eight fish taxa (Miller 1951, Frantz and Cordone 1970, Vander Zanden et al. 2003, and Chandra 2009). Over the last 130 years, through a series of species introductions, landscape disturbances such as deforestation, road building and other development, the biological assemblage and the diversity of aquatic species of the region has been dramatically altered resulting in what we see today. The aquatic animal communities of Lake Tahoe now consist of six zoobenthic taxa, five zooplankton species, and 14 fish taxa (Figure 5; TERC 2014).

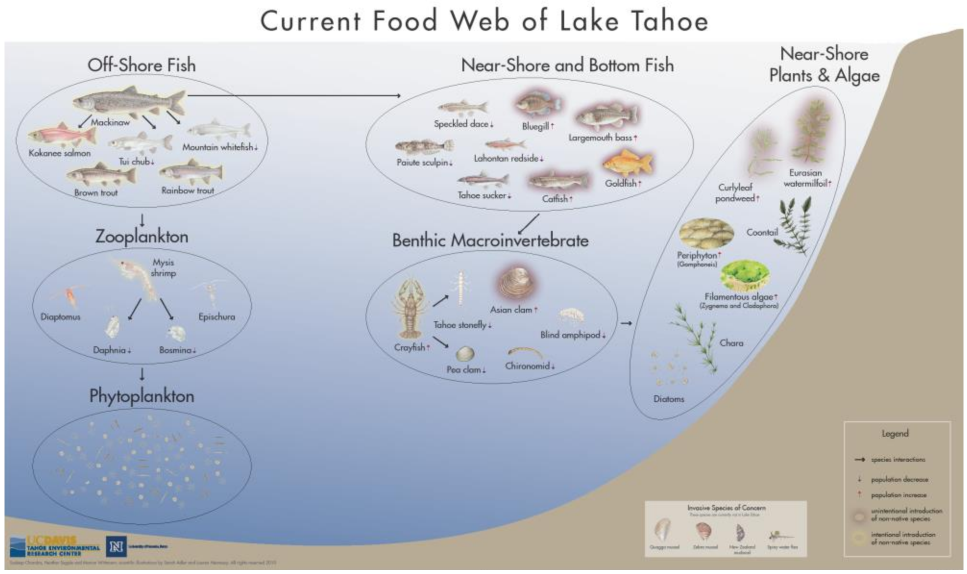


Figure 5. Current Food Web of Lake Tahoe (Source: TERC, UNR)

Populations of native fish that were once abundant in the region have decreased by perhaps as much as ten-fold since the 1960s (Thiede 1997) or, as in the case of the Lahontan cutthroat trout, have been extirpated. Non-native fish such as largemouth bass and bluegill have become more common. The decline in native populations could be attributed to several causes such as increased water temperature and habitat degradation, caused in part by increased spread of invasive plants, which could modify conditions so as to promote warm-water non-native fish (Chandra 2009).

Fish of Lake Tahoe and the Tahoe Keys Lagoons

Warm-Water Fish

Several non-native warm-water fish have been introduced to the Tahoe Basin for the purposes of sport fishing and other fish species have been introduced through disposal of aquarium species into the waters. These non-native fish species include largemouth and smallmouth bass, bluegill, black crappie, brown bullhead catfish, golden shiner, common carp and goldfish. Baseline information on the composition of warm-water fisheries in the Lake Tahoe basin, including the Tahoe Keys lagoons, was collected by University of Nevada at Reno (UNR) and California Department of Fish and Wildlife (CDFW) from 2011-2014 as part of the three-year Aquatic Plant Management Research Project (Ngai 2014) and by UNR and the Nevada Division of State Lands (NDSL) from 2006-2008 (Chandra 2009). Largemouth bass, bluegill and brown bullhead were the most prevalent species captured in the UNR-CDFW study. The UNR-CDFW study did not find a significant difference in spatial distribution of warm-water fishes in various locations in the Tahoe Keys lagoons but did determine that the distribution was extensive.

Cold-Water Fish

Native and non-native cold-water fish in the Tahoe Basin include Mountain whitefish, Tahoe sucker, Lahontan sucker, speckled dace, redside shiner, Lahontan Tui chub, Paiute sculpin, Kokanee salmon, brown trout, rainbow trout, and mackinaw. In the UNR-CDFW and UNR-NDSL studies, the following native and cold-water fish were captured in the Tahoe Keys lagoons: Mountain whitefish, Lahontan redside, Lahontan speckled dace, Tahoe sucker, brown trout, rainbow trout and Lahontan Tui chub. Tahoe sucker was the most prevalent species captured in the UNR-CDFW study. Overall, the abundance of native and cold-water fish remains relatively low in the Tahoe Keys lagoons mainly due to the warm-water environment.

Benthic Biota

The most comprehensive information available on Lake Tahoe's benthic biota comes from a study that was completed by Frantz and Cordone in 1963 (USDA 2000). The signal crayfish (*Pacifastacus leniusculus*) is perhaps the most visible and best-known species in the benthic invertebrate community in Lake Tahoe. Even though crayfish are preyed upon by several fish species, birds, and various mammals, including humans, the population appears stable.

There are several endemic deep water benthic macroinvertebrates including the Lake Tahoe benthic stonefly, associated with deep water plant communities of algae, mosses and liverworts, and two species of blind amphipods, the Lake Tahoe Amphipod and Lake Tahoe Stygobromid. None of these benthic species are listed as threatened or endangered nor are they listed as USFS Species of Special Concern but they are important indicator species for the ecology of Lake Tahoe.

Avian Species

Common merganser (*Mergus merganser*)

This resident species can be readily identified by its long, slender, bright red bill and short crest at the back of the head. Adult males have a glossy green head and neck and black upper back while females have a reddish brown head and neck but throat is white. This bird bears horny “teeth” and a hooked tip, useful for catching the various kinds of fishes taken for food. Mergansers dive and swim readily under the surface when searching for prey. Groups of females and young are frequently observed along rivers or secluded lakeshores; they are always nervous and swim quickly away from humans (Storer et al 2004).

Mallard (*Anas platyrhynchos*)

Another resident species of Lake Tahoe, the male mallard is easy to spot with his glossy green head, narrow white collar and tail with up-curled feathers. The female of the species is mottled brown, lighter below with feathers pale-edged. This type of duck typically prefers shallow water such as creeks, ponds, and marshes. They are surface feeders, tipping “bottom up” to reach food plants under shallow water. They are common on quiet waters on almost any lake or smooth stream, particularly those margined with aquatic plants (USDA 2015; Storer et al 2004).

Canada goose (*Branta canadensis*)

This is the most common goose in North America. It has a black head and neck with a distinctive white "chinstrap" stretching from ear to ear. It is a locally common resident, especially at lakes and parks around human activity. They are often seen swimming on large lakes or streams or feeding on short grasses in lush meadows. Elevated nesting platforms were installed in the Pope Marsh area in 1976 to improve local nesting success of the Canada goose. These long-necked, noisy birds are very abundant during the summer and are readily viewed by visitors (USDA 2015; Storer et al 2004).

California gull (*Larus californicus*)

The California gull is often spotted at Lake Tahoe beaches and is the same gull seen on Pacific Ocean beaches. Adults have a white head, neck, tail and undersurface, and a pale gray back with black wing tips. Adults often visit Lake Tahoe. Typical of most gulls, the California gull is a true scavenger and feeds on garbage, insects, plant material, and fish (USDA 2015; Storer et al 2004).

Ring-billed gull (*Larus delawarensis*)

The Ring-billed gull is smaller than the California gull. It has a black stripe around its bill and paler gray back. Although not as common as the California gull, it too, is often seen at Tahoe beaches.

Cliff swallow (*Petrochelidon pyrrhonota*)

These highly colonial swallows commonly nest in the spaces under building eaves or bridges near the water margin. Cliff swallows have a bright forehead and are dark bluish-brown except for an orange rump and creamy white forehead, light gray under and dusky red on sides of face. (Storer et al 2004)

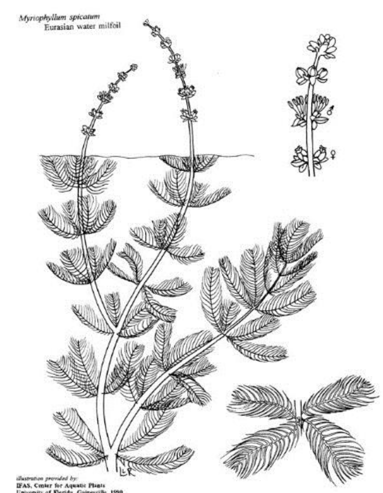
Osprey Photo - Courtesy "Mike" Michael Baird

Osprey (*Pandion haliaetus*)

Also known as the "Fish Hawk", the osprey has a characteristic crook in its wing, giving it a gull like appearance that is different from other raptors. It is blackish-brown above, with most of its head white, except for a dark mask behind the eye, is white underneath, with a banded tail and long wings with dark spots at the wrist. An array of tiny spikes on each footpad helps the bird carry slippery, struggling fish to distant dining perches. Typically observed near sizable bodies of water, these large, rangy hawks do well around humans (Storer et al 2004).

<u>Aquatic Plants Commonly Found in the Tahoe Keys Lagoons</u>

The five most common aquatic plant and algal species that have been found in the Tahoe Keys lagoons are described in detail in this section.



<u>M. spicatum</u>

Eurasian watermilfoil (*Myriophyllum spicatum* L.) and Northern watermilfoil (*M. sibiricum)*

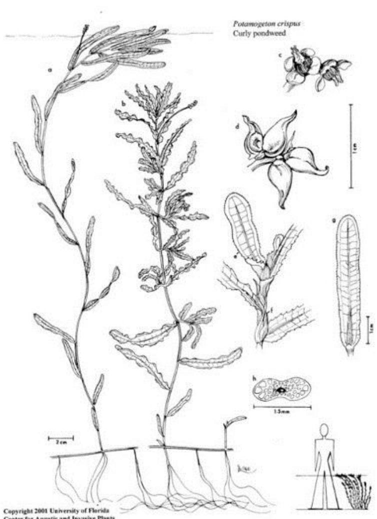
This species is the most widespread aquatic nuisance plant in the United States. The plant can form a dense canopy at the surface of the water, out-competing other aquatic plants. Heavy infestations can lead to decreased levels of dissolved oxygen under the canopy and changes in pH, both of which can alter aquatic ecosystems by decreasing native species diversity.

Eurasian watermilfoil is an evergreen perennial plant which roots in sediment and grows completely underwater, typically at 15 foot depth but has been found as deep as 30 feet. The leaves are pinnately compound with 14 to 24 pairs of leaflets in groups of four at each stem node. Flowers form on short stems above the water surface and flowers produce up to four nutlets or seeds each. Eurasian watermilfoil can form numerous viable seeds which can disperse readily and can spread by forming new root crowns from rhizomes growing in the sediment.

Eurasian watermilfoil is very similar in appearance to the native aquatic species, northern watermilfoil (*M. sibiricum*) and hybridization between the two species can occur. Both species spread readily by stem fragments formed naturally by abscission from the main plant or by breakage caused by wave action or feeding by waterfowl. These species can travel in boat ballasts but introduction through the aquarium trade is also a contributor to its spread.

Curlyleaf Pondweed (*Potamogeton crispus* L.)

This species is found in all of the lower 48 states and is considered naturalized throughout this range.



P. crispus

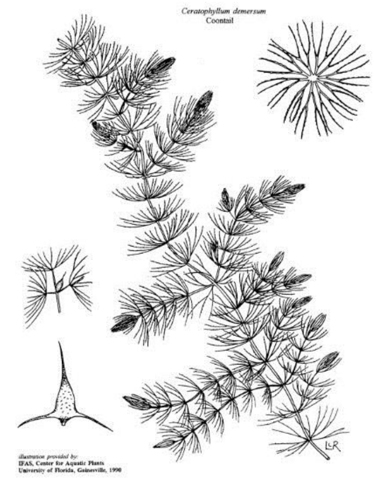
Curlyleaf pondweed is a rooted perennial with a fast growth rate. The plant stem is very thin and long and can entrap swimmers. Curlyleaf pondweed aggressively out-competes native submerged vegetation. The plant has wavy-edged leaves which are green early in the growing season and turn red at the water surface. The leaves are oblong, one to three inches long, and are in an alternate arrangement along the stem. Curlyleaf pondweed typically is found in more shallow waters at three to six feet depth but can be found in clear waters as deep as 20 feet.

Curlyleaf pondweed reproduces primarily by turions and rhizomes but can also spread by stem fragments or seeds. Turions are modified reproductive buds that form prior to plant senescence in early summer. Seed germinations rates are low for this species. This species can overwinter with some green growth remaining above the sediment, thus giving these plants an advantage when temperatures rise and growth resumes in the spring. The spread is attributed to boating and fish hatchery activity (Stuckey 1979).

Curlyleaf pondweed forms dense mats at the water's surface which inhibits navigation and recreation. The dense mats limit light from reaching native vegetation and can inhibit oxygen exchange along the water column. These conditions reduce the populations of fish or aquatic invertebrates and can create conditions that promote mosquito habitat by removing predators and obstructing water flow.

Coontail (*Ceratophyllum demersum L.*)

This native aquatic plant is found nearly world-wide and throughout California up to 6,500 feet in elevation. In natural areas, coontail is considered beneficial and provides food and shelter to other aquatic species. It can develop very dense mats which inhibit water flow, interfere with recreation, and promote mosquito habitat.



C. demersum

Coontail is a submersed plant that lacks true roots. It can exist as a free-floating plant or it can form modified stems and anchor itself to other aquatic plants. Young plants readily detach from soil.

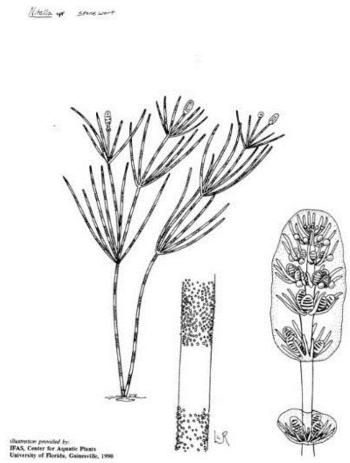
Coontail plants have slender stems with single branches at nodes. The leaves are dark green, forked, with small-toothed margins. Coontail reproduces vegetatively, by stem fragments and turions, and by seed, although in cold water, plants produce few to no seeds (DiTomaso 2003).

Common Elodea (*Elodea canadensis*)

Elodea is a native to North America and can inhabit waters to 8,500 feet. Elodea is an important component of aquatic ecosystems where it furnishes habitat and forage, although elodea can become a problem in nutrient-rich aquatic systems with elevated iron and phosphorous levels.

E. canadensis

Elodea grows best in water less than 15 feet under high light conditions. Although certain conditions, such as high water clarity, can allow for higher survival in deeper conditions. It is a rooted aquatic plant that readily creates stem fragments that can be transported to new locations. Seedlings are rare. Elodea has dark green leaves, typically found in opposite pattern or three-whorled pattern at stem nodes. Turions can form at terminal growing tips (DiTomaso 2003).



Multicellular algae

Multicellular algae

Nitella species and *Chara* species are multicellular algae that appear to be rooted aquatic plants. Several species of the genus *Nitella* are found in the Tahoe Keys lagoons. *Nitella* is native and is common throughout North America. It is an anchored green algae with branched filaments that have one or more forks. It is generally found anchored to the substrate.

Several species of the genus *Chara* are found in the Tahoe Keys and Keys Marina. *Chara* is a green algae common in the western United States. The algae filaments have whorled branches and can be more than 12 inches long.

Filamentous algae

Filamentous algae are single celled organisms that form long chains or filaments. These filaments can form long strands and intertwine forming mats. Filamentous algae usually float to the surface and form large mats. Often there will be many species of filamentous algae present. Filamentous algae are not known to be a direct food resource for wildlife. Algae can also cause oxygen depletion that can increase the likelihood of fish kill (Lembi 2009).

Special-Status Species in the Tahoe Basin

Several sensitive species are known to be present in the Tahoe Basin, but there are no recorded occurrences of these species within the Tahoe Keys lagoons (CNDDB 2015). Brief descriptions of the sensitive species in the region are given in this section.

Lahontan Cutthroat Trout (*Oncorhynchus clarkii henshawi*)

Lahontan cutthroat trout (LCT) is a member of the Salmonidae (trout and salmon) family, and is thought to be among the most endangered western salmonids.

Lahontan cutthroat trout was listed as endangered in 1970 and reclassified as threatened in 1975 (USFWS 2014) and is considered extirpated from Lake Tahoe.

Like other trout species, LCT are found in a wide variety of cold-water habitats including large terminal alkaline lakes, alpine lakes, slow meandering rivers, mountain rivers, and small headwater tributary streams. Generally, LCT occur in cool flowing water with available cover of well-vegetated and stable stream banks, in areas where there are stream velocity breaks, and in relatively silt free, rocky riffle-run areas.

The LCT is endemic or native to the Lahontan basin of northern Nevada, eastern California, and southern Oregon. LCT currently occupies between 123 to 129 streams within the Lahontan basin and 32 to 34 streams outside the basin, totaling approximately 482 miles of occupied habitat. Self-sustaining populations of the species occur in 10.7 percent of the historic stream habitats and 0.4 percent of the historic lake habitats (USFWS 2014).

In the Lake Tahoe Basin, there have been attempts to reestablish both stream and lake populations. Many of the planted fish are consumed by non-native trout and LCT is considered to be extirpated from Lake Tahoe due to this predation. On-going maintenance is required in the headwaters of the Upper Truckee River (TERC 2014; CDFW 2015). Two LCT were captured in the Upper Truckee River in 2011 during a survey conducted by the US Forest Service. These fish were determined to be hatchery fish released by the Nevada Department of Wildlife earlier that year (USFS 2013).

Tahoe Yellow Cress (*Rorippa subumbellata*)

The Tahoe yellow cress is a federal candidate species for listing and is a California listed endangered plant. The habitat for this plant is coarse sand and sandy soils (often among cobbles or boulders) of active beaches, stream inlets, beach dunes, and backshore depressions, generally within a few feet of the local water table, in the shore zone of Lake Tahoe at elevations of 6,223 to 6,230 feet. It occupies a narrow three meter-wide band on the shores of Lake Tahoe, where it apparently requires an interaction of soil moisture, low competition from other plant species and coarse sandy soil texture. This habitat is nearly eliminated during periods when high lake levels are maintained, but in drought years, when lake levels drop, the shoreline habitat is substantial (Pavlik 2002). The Tahoe Keys lagoons have fine-textured sediment in the bottom of the waterways, not the coarse sandy soils associated with Tahoe yellow cress habitat. There are several known populations of Tahoe yellow cress outside of the Tahoe Keys lagoons (Figure 6). The California Tahoe Conservancy has installed signage in the area to educate the public about this special-status plant and its habitat.


Tahoe Yellow Cress Photo Credit: USFWS

Figure 6. Tahoe Yellow Cress Occurrences near Tahoe Keys Lagoons

Willow flycatcher (*Empidonax traillii*)

The willow flycatcher is listed in California as endangered. It is a small bird that breeds in wet shrubby thickets and riparian woodland, particularly with willow and buttonbush (AOU 1998). It is a spring and summer resident in montane riparian areas and wet meadows from 2,000 to 8,000 feet in elevation. Breeding populations tend to occur in isolated mountain meadows of the Sierra Nevada and Cascades (Craig 1998). No suitable habitat for willow flycatcher is found in the Tahoe Keys lagoons, but suitable habitat is found in the nearby area.

Bald eagle (*Haliaeetus leucocephalus*)

A state endangered species, bald eagles prefer habitat near large areas of open water such as rivers, large lakes, and seacoasts. They tend to use areas away from human disturbance (Snyder 1993). The Tahoe Keys lagoons do not provide favorable habitat for nesting or areas for hunting, but bald eagles perch in large snags and living trees in the area.

Sierra Nevada yellow-legged frog (*Rana sierrae*)

A state threatened and federally endangered species, Sierra Nevada yellow-legged frog is patchily distributed at high elevation lakes and slow-moving streams typically above 6,000-foot elevation in the Sierra Nevada range north of the Kern River watershed, and over the eastern crest of the Sierra into Inyo and Mono counties at the southern-most extent (USFWS 2013). The Tahoe Keys lagoons do not provide suitable habitat for this species.

Bank swallow (*Riparia riparia*)

The bank swallow is listed as a state threatened species. It prefers nesting in vertical banks and bluffs with alluvial soil often near rivers and lakes with erosional forces. The Tahoe Keys lagoons do not provide suitable habitat for this species.

1.5 Aquatic Invasive Species of Concern in the Tahoe Basin

Like numerous other recreational lakes, Lake Tahoe is experiencing an increase in the presence of non-native plant and animal aquatic invasive species (AIS) (Getsinger 2014; TRPA 2014). Non-native organisms have great potential to harm the natural ecosystems of the Basin and to harm the economy of the region through impacts due to loss of recreational opportunities and increased costs for maintenance to boats and piers. Non-native species also change the nutrient load of the water and can have detrimental effects on water quality and clarity.

The Lake Tahoe Region AIS Management Plan (TRPA 2014) (Regional Plan) states that over 30 non-native aquatic species of plants and animals have been introduced into the Tahoe region. There are an additional 17 species of plants and animals that, if introduced to the region, could become established and reach nuisance levels. Control and eradication of all invasive species is coordinated through the Tahoe Regional Planning Agency (TRPA). Tables 2 and 3 summarize the invasive species identified in the Regional Plan:

Table 2. Established Non-native Species in the Tahoe Region

Type	Name	Scientific Name
Plants	curlyleaf pondweed	*Potamogeton crispus*
	Eurasian watermilfoil	*Myriophyllum spicatum*
	rock snot	*Didymosphenia geminate*
Introduced fishes	largemouth bass	*Micropterus salmoides*
	smallmouth bass	*Micropterus dolomieui*
	bluegill	*Lepomis macrochirus*
	brown bullhead	*Ameiurus nebulosus*
	black Crappie	*Pomoxis nitromaculatus*
	brook trout	*Salvelinus fontinalis*
	brown trout	*Salmo trutta*
	Kokanee salmon	*Oncorhynchus nerka*
	lake trout	*Salvelinus namaycush*
	rainbow trout	*Oncorhynchus mykiss*
Other Species	Asian clam	*Corbicula fluminea*
	signal crayfish	*Pacifastacus leniusculus*
	American bullfrog	*Rana catesbeiana*
	gill maggot	*Salmincola californiensis*

The following species have the potential to become established if introduced into the Lake Tahoe region:

Table 3. Non-native Species Not Yet Established in the Lake Tahoe Region

Type	Name	Scientific Name
Aquatic Plants	Brazilian Egeria	*Egeria densa*
	fanwort	*Cabomba caroliniana*
	giant salvinia	*Salvinia molesta*
	hydrilla	*Hydrilla verticillata*
	oxygen weed	*Lagarosiphon major*
	parrot feather	*Myriophyllum aquaticum*
	South American spongeplant	*Limnobium laevigatum*
	water chestnut	*Trapa natans*
	yellow flag iris	*Iris pseudacorus*
	yellow floating heart	*Nymphoides peltata*
Other Species	New Zealand mudsnail	*Potamopyrgus antipodarum*
	quagga mussel	*Dreissena bugensis*
	zebra mussel	*D. polymorpha*
	spiny waterflea	*Bythotrephes longimanus*
Fishes	white Crappie	*Pomoxis annularis*
	northern pike	*Esox lucius*
	mosquitofish	*Gambusia affinis*

2.0 PURPOSE OF THE INTEGRATED WEED MANAGEMENT PLAN

Photo Courtesy of Community Ink

Aquatic plants have been observed in many locations in Lake Tahoe and in the Tahoe Basin. They can serve an important role in the aquatic ecosystem, but left unchecked, they can interfere with navigation and can degrade water quality. The section describes the role of aquatic plants and the conditions in the Tahoe Keys lagoons which led to the development of the Plan.

2.1 The Role of Aquatic Plants in the Ecosystem

Submerged plants are critical to a well-structured fish assemblage. They not only provide protection for small fish from predators but also provide habitat for large numbers of invertebrates for small fish to eat. Submerged plants provide an important food source for many species of waterfowl in the form of vegetation-dwelling invertebrates or the plants themselves. Submerged plants affect water quality. They can oxygenate the water and can provide for long-term storage of nutrients and carbon.

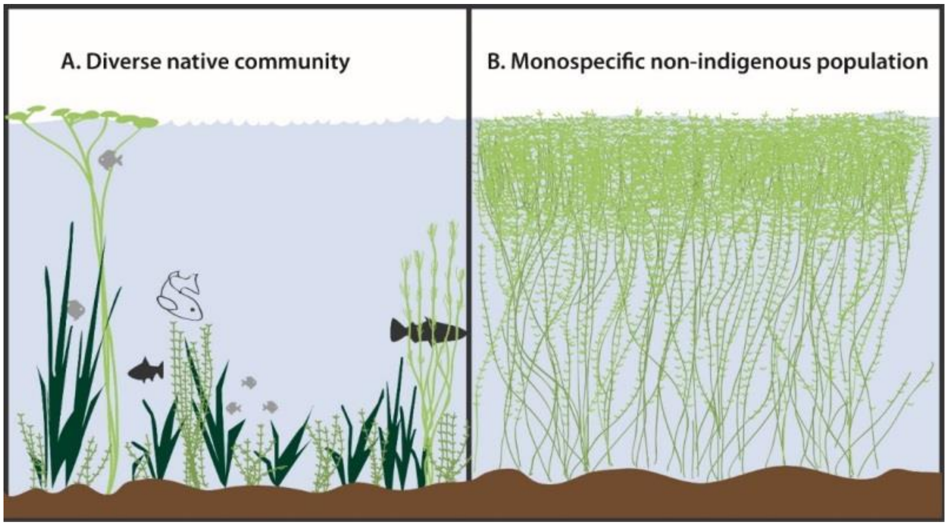


Figure 7. Healthy vs Unhealthy Aquatic Ecosystem

Left unchecked, aquatic plants can create a dense canopy that adversely affects water quality, changes habitat conditions for native fish, impedes water flow in the water body, disrupts navigation, creates hazardous conditions, and discourages recreational use of the waters. As the plants grow, nutrients are moved from the anchoring sediments to the water column containing the plants. This process is called nutrient pumping and can lead to an undesirable nutrient load in the water. Nutrient loading, especially in terms of nitrogen and phosphorous, can lead to the eutrophication of the aquatic ecosystem to the point where algal growth can dominate and decrease water clarity and quality (Donaldson 2009).

Figure 8. Example of Algal Growth

Uncontrolled aquatic plant growth creates a continuing source of plant propagules that could allow plants to be spread and become established in new areas where this cycle of nutrient pumping and eutrophication would be repeated.

2.2 Status of Aquatic Plants in Lake Tahoe

Eurasian watermilfoil was confirmed in Lake Tahoe over 30 years ago (Anderson 1996) and curlyleaf pondweed was confirmed in 2003 (Anderson 2003). Surveys of Lake Tahoe have shown that size and locations of the infestations of the two plants has changed somewhat over time, but that the overall trend shows that infestations of these plants have increased substantially.

There have been numerous attempts to control these non-native aquatic plants in Lake Tahoe and the Lake Tahoe Basin. This work is typically done as a cooperative effort between agencies such as the California Department of Parks and Recreation, the Tahoe Resource Conservation District (TRCD), and TRPA with assistance from private entities such as the TKPOA and marina operators.

In 2014, TRCD proposed the Lake-wide Aquatic Plant Control Project (TRCD 2014). The initial study for this project reported that, in addition to the Tahoe Keys lagoons, there were 14 sites in Lake Tahoe with a total of 12 acres with infestations of either Eurasian watermilfoil, curlyleaf pondweed, or a combination of both. These infested areas threaten water quality of Lake Tahoe, recreational uses of the Lake, and habitat disruption for native species of Lake Tahoe. In addition to the known areas of infestation, a number of sites have been identified as being at a high risk of infestation for Eurasian watermilfoil (Wittmann 2015).

2.3 Aquatic Plants and Their Impacts on the Waters of the Tahoe Keys Lagoons

In the Tahoe Keys lagoons, maintenance activities and costs to remove nuisance aquatic plants to keep the waterways safe and navigable have increased dramatically over the years due to an increasing volume of plants produced. Current management costs are in the range of $400,000 per year and harvest methods have been ineffective as evidenced by removal volumes which have increased to over 17,000 cubic yards per year (Figure 9).

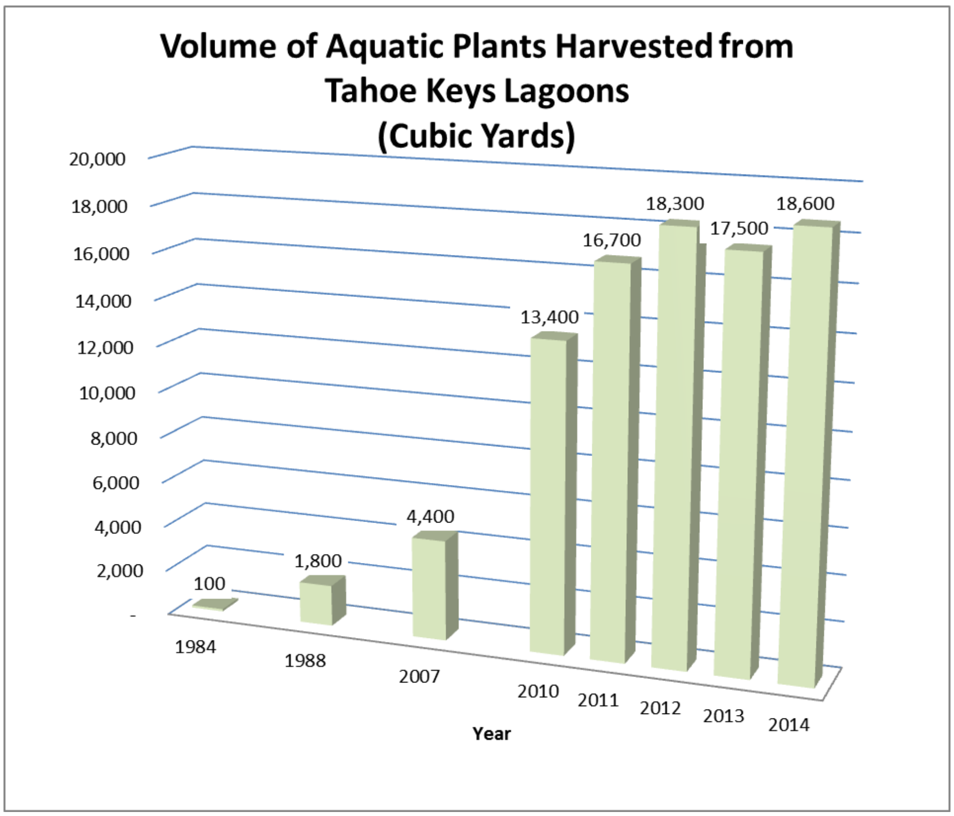


Figure 9. Volume of Plants Harvested from the Tahoe Keys Lagoons

While mechanical harvesting is the primary method of aquatic plant control, other methods to remove aquatic plants from the waterways of the Tahoe Keys lagoons have been used. Floating, solar-powered vertical circulation devices known as Solar Bees© were installed at four locations in the Marina Lagoon from 2008 to 2010. No decrease of the growth of coontail, Eurasian watermilfoil, or curlyleaf pondweed was detected. In 2008, a study of Solar Bees©, including bioassays of both plant tissue and sediments, showed no effect on the growth of Eurasian watermilfoil under greenhouse conditions (Anderson 2005). The TKPOA has also collaborated with TRCD and TRPA in the Tahoe Keys Aquatic Plant Management Research Project from 2011 to 2013 (TRCD 2014a). The purpose of this project included determining the efficacy and feasibility of non-chemical control of Eurasian watermilfoil and curlyleaf pondweed using benthic or bottom barriers to suppress aquatic plant growth. The study found that the bottom barriers provided short-term control of aquatic plants over a limited area but that this method allowed aquatic plants to quickly recolonize an area that had been treated.

In addition to affecting the waters of the Tahoe Keys lagoons and Marina, nuisance aquatic plants can be transported from the immediate area into the waters of Lake Tahoe where they may establish additional areas of infestation which could require control.

2.4 Existing Conditions in the Tahoe Keys Lagoons: Results of the 2014 Aquatic Plant Survey

In the summer of 2014, a study was undertaken to establish the composition and density of aquatic plants in the Tahoe Keys lagoons (TKPOA 2014a). This study established a baseline to which future studies of control methods can be compared.

Figure 10. 2014 Aquatic Plant Survey Area

The survey found that the aquatic plant canopy was nearly completely closed in certain areas and was dominated by native coontail and non-native Eurasian watermilfoil. Aquatic plant occurrences are commonly reported as presence or absence of a species found in a sample and, as is often the case in the Tahoe Keys lagoons, more than one aquatic plant species existed in the same location. Table 4 summarizes the results of the sampling as the frequency that a species occurred in the samples taken. Overall in the Tahoe Keys lagoons in 2014, coontail was the most prevalent species and was found in 65% of the 1,308 samples. Eurasian watermilfoil was also prevalent and was found in 61% of those samples.

The 2014 survey also showed that coontail has a tendency to inhabit deeper water than Eurasian milfoil: in 2014, the aquatic plant canopy in the Marina Lagoon was dominated by native coontail, which was found in 69% of the samples, and that Eurasian watermilfoil dominated the aquatic plant canopy in the Main Lagoon and was found in 72% of the samples taken there. This slight change in composition could be due in part to the fact that the Marina Lagoon was deeper than the Main Lagoon at the time of the survey. A bathymetric survey of the Tahoe Keys lagoons was not completed during the 2014 Aquatic Plant Survey, however the depths at which samples were taken was recorded and this data show that the water depth in the Tahoe Keys lagoons ranged from approximately 1 to more than 20 feet (Figure 11).

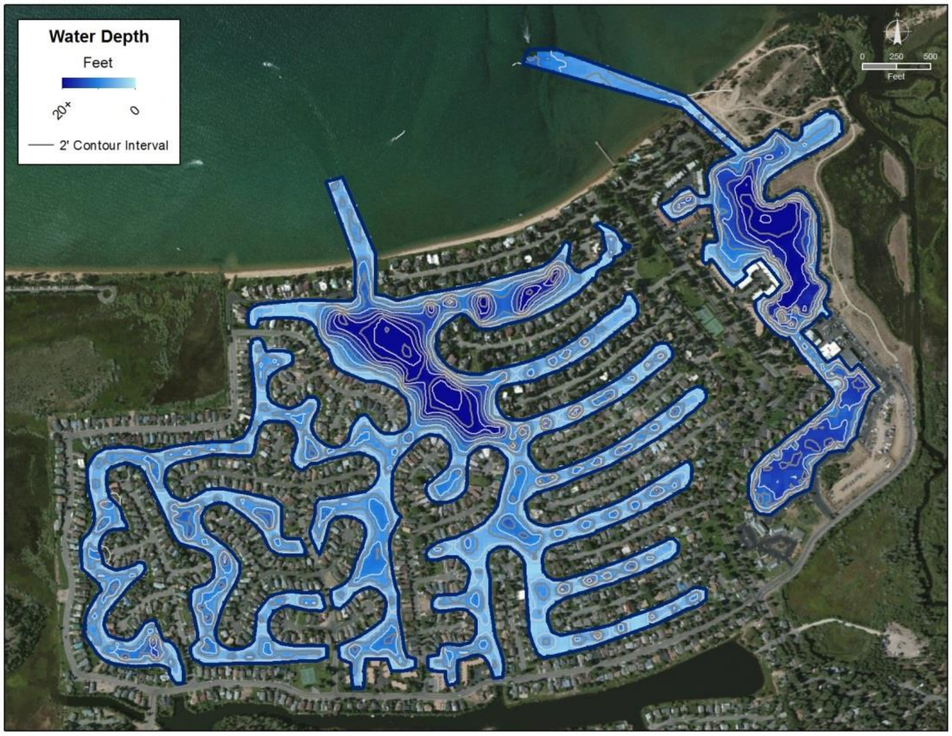


Figure 11. Sampling Depths of 2014 Aquatic Plant Survey

Table 4. Summary of 2014 Aquatic Plant Survey Results - Frequency of Occurrence by Percentage of All Samples

	Location		
Species:	Tahoe Keys Lagoons, Overall	Main Lagoon (683 samples)	Marina Lagoon (625 samples)
Coontail	65%	61%	69%
Eurasian watermilfoil	61%	72%	50%
Common Elodea	31%	41%	20%
Curlyleaf pondweed	10%	18%	2%
Filamentous algae	24%	17%	32%

The results of the 2014 study were compared to composition data taken in 2009 and 2011 in the Main Lagoon. This comparison showed a shift in species composition from being dominated by native coontail to Eurasian watermilfoil. This shift in species could be driven by lowered water levels that are a result of the three-year regional drought or other changes which could have promoted the growth of Eurasian watermilfoil over other plant species. The study also showed a significant drop from previous reports of occurrences of Andean watermilfoil, a native species, to nearly non-detect levels. This species may have been out-competed by the invasive plants that have found more favorable conditions in the Keys and Keys Marina.

2.5 Problem Statement

The Tahoe Keys lagoons are used by many people for recreation and scenic enjoyment and the area provides a broad range of activities and opportunities to enjoy Lake Tahoe. Excessive growth of aquatic plants has impaired the waterways of the Tahoe Keys lagoons and the dense canopy of aquatic plants has reached nuisance status. The maintenance required keeping the waterways safe and navigable and the associated costs of this maintenance have increased dramatically over the years due to the increased volume of aquatic plants which must be removed. Aquatic plants can be transported from the immediate area of the Tahoe Keys lagoons by wave action, currents, on boats, or by wildlife to new areas where they may become established and create new populations of aquatic plants that require control. A plan that provides for long-term management of aquatic plants is needed to maintain recreational safety, improve water quality, and to improve habitat for native species of the Tahoe Keys lagoons. Implementing such a plan will protect the beneficial uses of the waters of the Tahoe Keys lagoons.

The Tahoe Keys Property Owners Association is leading the Tahoe region by identifying populations of nuisance aquatic plants and developing an effective management plan for the Tahoe Keys lagoons and which can be adapted for use throughout the area. This Plan was developed and will be implemented through collaboration with regional resource agencies, other land owners within the Tahoe Keys, and local non-profit organizations to achieve the highest level of control possible.

The Plan has a single over-arching goal with five supporting objectives.

The Goal of the Plan is:

> *To help protect the ecology, to enhance the recreational and aesthetic qualities, and to maintain*

the commercial uses of Lake Tahoe by controlling nuisance aquatic plants in the Tahoe Keys lagoons.

The Objectives which will guide the implementation of the Plan are:

1) Minimize the potential to spread aquatic invasive plants from the Tahoe Keys lagoons to Lake Tahoe.
2) Enhance habitat for native fish, waterfowl, and other native wildlife species and reduce habitat for non-native, warm-water fish in the Tahoe Keys lagoons.
3) Restore recreational uses in the Tahoe Keys lagoons and commercial and institutional uses in the Marina Lagoon.
4) Establish a long-term management program which:
   - Uses the best available technologies to monitor conditions in the Tahoe Keys lagoons to reduce maintenance inputs and costs of aquatic plant management.
   - Utilizes feasible, cost-effective methods to control nuisance aquatic plants in the Tahoe Keys lagoons.
5) Assist the Tahoe Region in achieving goals for reductions in greenhouse gas emissions, as described in the Sustainable Communities Action Plan, by minimizing the air quality impacts of aquatic plant maintenance actions.

Objectives Described

Objective 1*: Minimize the potential to spread aquatic invasive plants from the Tahoe Keys lagoons to Lake Taho*e.

Aquatic plants are known to readily spread by plant propagules, which include both sexual reproductive structures, such as seeds, and vegetative structures and viable fragments. Nuisance aquatic plants have infested marinas throughout Lake Tahoe. Under this objective, the Plan strives to reduce one of the potential sources of these propagules, those from the Tahoe Keys lagoons, by reducing the population and density of nuisance aquatic plants. The Plan also addresses reducing the numbers of viable plant fragments generated in two ways: with improved plant harvesting techniques and by reducing the acreage treated with mechanical harvesters.

Objective 2: *Enhance habitat for native fish, waterfowl, and other native wildlife species and reduce habitat for non-native, warm-water fish in the Tahoe Keys lagoons.*

The density of aquatic plants in the Tahoe Keys lagoons has shifted the benthic habitat toward supporting introduced species of warm-water fish, such as bass and bluegill, to the detriment of native fish, such as the Lahontan redside and Mountain whitefish among others. Under this objective, the Plan strives to reduce the plant canopy formed by non-native and nuisance aquatic plants that harbor the non-native fish species.

Objective 3: *Restore recreational uses in the Tahoe Keys lagoons and commercial and institutional uses in the Marina Lagoon*.

Aquatic plants can cause adverse effects to navigation when they become entangled in boat rudders and are a potential safety hazard to swimmers. During the summer months, ongoing maintenance operations to keep the waterways open disrupt boating activities and impact the visual aesthetics of the Tahoe Keys lagoons. Under this objective, the Plan strives to improve boating and recreational access of the Tahoe Keys lagoons by both establishing and maintaining adequate vessel hull clearance to allow for safe boating and by minimizing removal work which disrupts recreational activities.

Objective 4: *Establish a long-term management program which: uses the best available technologies to monitor conditions in the Tahoe Keys lagoons to reduce maintenance inputs and costs; and utilizes feasible, cost-effective methods to control nuisance aquatic plants in the Tahoe Keys lagoons*.

By using best available technology to assess conditions, personnel and resources can quickly be directed to where they are needed most. Under this objective, the Plan strives to improve control work by consistently utilizing accurate survey methods, such as hydroacoustic sampling, which can report real-time data so that control work can be effectively scheduled. By using Global Positioning System (GPS) equipment, maps can be made that show where work has been completed and reference points established to allow objective evaluation of the control work.

Objective 5: *Assist the Tahoe Region in achieving goals for reductions in greenhouse gas emissions, as described in the Sustainable Communities Action Plan, by minimizing the air quality impacts of aquatic plant maintenance actions.*

Reducing the inputs required to achieve acceptable levels of aquatic plants benefits the environment in many ways. Under this objective, the Plan strives to improve the air quality of the Tahoe Basin by decreasing the contribution to greenhouse gas accumulation caused by burning fossil fuels. Currently, the primary method of control of aquatic plants is by using mechanical harvesters that burn diesel fuel. The harvested plants are then removed off site in trucks that also burn diesel fuel. This Plan proposes decreasing the acreage treated by this method which will dramatically decrease the amount of fossil fuels burned by both the mechanical harvesters and the trucks used to haul waste off-site.

3.0 METHODS OF AQUATIC PLANT CONTROL

Photo Courtesy of Community Ink

The long-term approach to aquatic plant control in the Tahoe Keys lagoons must integrate all of the methods determined to be feasible to achieve acceptable levels of aquatic plants in the waterways and to reach the Goal and fulfill the Objectives of the Plan. All feasible and effective methods will be used throughout the Tahoe Keys lagoons. The specific control methods used each year will be adjusted in response to the regular monitoring and review of conditions that are part of the adaptive management process, which is essential to maintaining successful control of the nuisance and invasive aquatic plants in the Tahoe Keys lagoons.

3.1 Non-chemical Control Methods

Non-chemical methods to control nuisance aquatic plants include: physical and mechanical, biological, and cultural techniques. This section describes these methods in the context of their potential use and feasibility in the Tahoe Keys lagoons as well as their advantages and disadvantages.

Any method to control the growth or eradicate nuisance plants will require pre- and post- control work monitoring to meet environmental protection compliance standards and to assess efficacy. The costs, effort, and logistics of monitoring actions will vary depending upon the method used. Optimal control of nuisance plants can be achieved when multiple approaches are deployed.

Physical and Mechanical Methods

Physical and mechanical methods remove the target organism or reduce resources required by that organism. Physical control means the use of manual labor, with or without the aid of tools or implements.

Hand-pulling

Aquatic plants can be removed from waterways by pulling out the plant, including the roots and other regenerative plant parts, and then capturing and disposing of the plant material in a suitable manner. Hand-pulling is best used in small-scale removal projects in shallow water where the plants can easily be identified and reached. In waters deeper than three feet, hand-pulling requires divers to reach and remove rooted plants. Success is dependent on the sediment type, visibility and proper identification of species. Some species can easily fragment and produce small pieces that are not easily captured and removed (SFEI 2004).

Advantages

- If all regenerative plant parts are removed during treatment, this method can greatly reduce regrowth in the treated area.
- In shallow waters, hand-pulling can be an effective and comparatively inexpensive method to remove nuisance aquatic plants.
- In deeper waters, using trained divers can be effective in reducing the biomass of nuisance aquatic plants.
- If water clarity is good, impacts to non-target species, such as native plants and animals, can be minimized during treatment.

Disadvantages

- This is a slow and labor-intensive method of control.
- Reduced visibility in turbid water can impede removal of nuisance, target plants.
- Using trained divers with specialized scuba equipment increases the cost of hand-pulling and is generally not deemed appropriate for deep waters with dense canopies of aquatic plants due to unsafe diving conditions.

- Turbidity could increase to unacceptable levels when sediments are disturbed as the plants are pulled from the sediment.
- Increased nutrient levels in the water could result if significant amount of decaying plant material is left behind.
- Plant fragments and propagules that are not captured during treatment can drift from the area or can re-infest the treated area.

Application of the Method

Volunteer groups around the Tahoe basin are seasonally recruited and trained to remove non-native aquatic plants from shallows around the lake and from streams flowing in to Lake Tahoe. Volunteer hand-pulling is an on-going activity in the Tahoe Basin and is supported by the League to Save Lake Tahoe.

Suitability to Tahoe Keys Lagoons

The waters of the Tahoe Keys lagoons are typically deeper than three feet and are not safely accessible for hand-pulling work except by trained scuba divers. The dense aquatic plant canopy creates unsafe diving conditions. The nuisance plants can easily fragment and may contain vegetative propagules; therefore, hand-pulling may actually spread viable plant parts to adjacent sites or can re-infest the cleared sites. The sediment layer in the Tahoe Keys lagoons could easily be disturbed by hand-pulling resulting in increased turbidity levels.

Hand removal of fragments lodged on shorelines could be beneficial in reducing the dispersal of plant propagules. Plant fragments that drift to areas behind docks and piers could be removed by hand from these areas, using rakes or screens, to complement other management actions.

Diver-Assisted Suction Removal

This method requires divers using specialized equipment to remove nuisance plants from the treated area. Qualified divers or snorkel crews carefully dislodge rooted plants from the sediment and guide them into a suction device mounted on a floating platform or barge. The plants are taken to the surface and are trapped in a sieve on the barge. Water taken up by the process is returned some distance from where the diver is working. The sediment is not removed directly by this action. Pumps used to create the hydraulic suction are mounted on barges and the divers manipulate the suction hose to stay away from direct contact with the sediment. Typically, trapped plants are bagged and removed for disposal off site.

Advantages

- A skilled diver can avoid removing non-target plants and most non-target animals (except those attached to the plants) making this a selective control method.
- Thorough operations can be extremely effective in removing all or nearly all viable plant propagules.
- Eradication can be complete after two to three treatments during the growing season.

Disadvantages

- Divers must carefully dislodge plants while avoiding direct removal of sediment.
- The process can cause unacceptable increases in turbidity, requiring that operations cease until turbidity declines below thresholds established by the permit issued for the control work.
- Installing screening devices such as turbidity curtains may be required to isolate the treatment area which would increase the cost of the method.
- There are potential hazards to divers from low visibility in the water, boat traffic, and inadvertent impacts include fish mortality.
- Diver-assisted suction removal is costly. Estimates are approximately $20,000 or more per acre.
- Treatment may be temporary if aquatic plant propagules enter from another site.

Application of the Method

In Emerald Bay, Eurasian watermilfoil has been nearly eradicated in an area approximately 6.5 acres in size over a three-year period by repeated diver-assisted suction removal paired with hand-pulling and installation of bottom barriers. Increases in water turbidity have not been a major problem in Emerald Bay due to the coarse sediment. Diver safety was assured by excluding boating activity during treatment operations. Diver-assisted suction removal has also been used successfully outside of California in many locations including Puyallup, Washington (Puyallup 2015) and the State of New Hampshire (New Hampshire 2008).

Figure 12. Diver Assisted Suction, Emerald Bay

Suitability to Tahoe Keys Lagoons

Diver-assisted suction removal will be useful in select sites in the Tahoe Keys lagoons. The unconsolidated, fine sediment found throughout the Tahoe Keys lagoons increases the likelihood that turbidity could quickly increase above threshold levels allowed under permits, which would impede operations. Turbidity curtains would need to be installed to retain suspended material in the treatment area and poor visibility could present a problem during operations. Treatment areas would need to be temporarily closed to boat traffic to ensure diver safety. All plant material removed would need to be disposed of off-site.

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 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. Synthetic barriers may be polyethylene, PVC, or woven material permeable to gasses but not to light. Natural barriers made of jute have also been used. Jute barriers are typically left to decompose over a one to two year period, which eliminates removal costs, but can promote re-infestation if silt and plant propagules are deposited on the jute material. Optimal placement is in spring before plant growth is excessive.

Bottom barriers can be used in conjunction with other control methods, such as mechanical harvesting or chemical control.

Figure 13. Jute Bottom Barrier

Advantages

- Bottom barriers offer direct effective control of aquatic plants where they are growing and potentially over several growing seasons if left in place.
- Bottom barriers can be placed under docks or piers that otherwise may be difficult areas to treat with other methods.
- Once in place, bottom barriers afford immediate relief from the impacts of excessive, nuisance aquatic plants.

Disadvantages

- Plant growth is suppressed only as long as barriers are in place. Once removed, plant densities can return to pre-treatment levels if plant propagules re-infest the treated area.

- Control is non-selective for nuisance as well as native plants.
- There have been reports of aquatic plants recolonizing through natural jute barriers but this appears to be uncommon. Aquatic plants can also recolonize in sediment deposited on the top of the barrier.
- Bottom barriers cover the benthic habitat, which results in a temporary loss of habitat for benthic macroinvertebrates while vegetation is decomposing, due to an increase in ammonia and a decrease in dissolved oxygen. Studies have shown that populations of these invertebrates can quickly recover after barriers are removed (Ussery 1997, TRCD 2014).
- Bottom barriers can be dislodged by wave action from boating activity.
- Large-scale placement requires using trained divers, which makes it comparatively expensive. Cost estimates to install benthic barriers in the Tahoe Keys lagoons ranged from $65,000 to $100,000 per acre treated (TRCD 2014).

Application of the Method

Bottom barriers have been widely used in the US and at Lake Tahoe, including use in a three-year study of control methods of aquatic plants in the Tahoe Keys (TRCD 2014). The study report stated that nuisance aquatic plant growth was suppressed in the short term (less than one year) but recolonization over the subsequent two growing seasons resulted in aquatic plant densities similar to what was found in untreated areas. Bottom barriers have also been used effectively to control Eurasian watermilfoil at Emerald Bay on Lake Tahoe.

Suitability to Tahoe Keys Lagoons

Bottom barriers are a suitable method to control aquatic plants in the Tahoe Keys lagoons. Results from the TRCD study in the Tahoe Keys lagoons showed that barriers should be installed early in the growing season and that the barriers can be dislodged by wave action, either from wind or boats. Because reestablishment can occur via plant fragments from outside the treated area, the larger the area covered by the barrier, the more effective the control. The Waste Discharge Requirements (WDR) issued to the TKPOA by the Lahontan Regional Quality Control Board (LRWQCB, or Lahontan Water Board) currently allow a maximum of five acres of bottom barriers to be installed at any time in the Tahoe Keys lagoons and require their removal at the end of the growing season (LRWQCB 2014). The TKPOA has developed a permitting system for individual homeowners to install bottom barriers around private docks in the Tahoe Keys lagoons.

There are limitations to the use of bottom barriers in the Tahoe Keys lagoons. As compared to Emerald Bay, the water is relatively shallow and there is often a high level of recreational boat traffic. Bottom barriers can be readily dislodged by wave action even in areas where the boat speeds are slow. Once installed, bottom barriers should be inspected regularly and re-secured if needed.

Mechanical Control

Mechanical control requires the use of specialized machinery that is designed to cut, dislodge or severely damage plants. Plants are cut at a specified depth and typically are removed off site. In some cases, cut plant fragments are masticated and left in place.

Mechanical methods are non-selective: all plants within the targeted area are subject to removal, cutting or other physical disruptions. Harvesting is widely used and has been the primary means of control in the Tahoe Keys lagoons.

Mechanical Cutting and Harvesting

This is the most common method used to control nuisance aquatic plants. Equipment commercially sold ranges from small hand-held cutting devices to large boat-mounted, hydraulically-controlled cutting, conveyance and transport systems. The small systems are useful around individual docks or very small swimming areas with space constraints. The small systems generally do not incorporate a way to collect plant fragments that are generated. The larger, boat-mounted systems typically have removal systems to collect plant fragments and are the most practical for large areas (several acres) such as the Tahoe Keys lagoons. Large systems both cut and remove the plants as part of the same operation. Cut plants are off-loaded to an on-shore carrier and taken off-site for disposal. Depending on site conditions, these machines can cut the plants approximately five to 10 feet below the surface of the water. Obstructions such as docks and pilings prevent the use of large mechanical harvesters. Regardless of the size of the machine used, the plants in target areas must be harvested one or more times during the growing season to maintain acceptable conditions.

Costs of mechanical harvesting are in the range of $2,300 per acre, including disposal costs.

Figure 14. Mechanical Harvester

Advantages

- Mechanical harvesting offers the immediate improvement of access to the waterway for boating and other recreation after harvesting work is completed. With large systems, harvesting can remove thousands of pounds of plant material from a waterway. For example, in the Tahoe Keys lagoons, approximately 10,000 to 20,000 cubic yards of plant material is removed and hauled off-site annually.
- Mechanical harvesting does not require a permit and there are no requirements for monitoring.
- Efficient mechanical harvesting operations can remove some nutrients sequestered in the harvested plant biomass at the rate of approximately three pounds of nitrogen per ton fresh weight of harvested material.

Disadvantages

- All mechanical methods create viable plant fragments and release viable plant propagules that can disperse to uninfested areas by waterfowl, wind and water movement, and boat traffic.

- Harvesting is a non-selective operation that does not discriminate nuisance plants from beneficial plants. This lack of selectivity can negatively impact desirable, native aquatic species.
- The physical actions from these operations can cause direct harm to fish, amphibians and invertebrates and other organisms through injury or mortality or by removing cover to protect native fish from prey. These impacts are directly related to the scale of operations and to the abundance and occurrence of non-target organisms in the treatment area.
- Mechanical harvesting can impact water quality by increasing turbidity and releasing nutrients usually bound in the sediment.
- Mechanical cutting is conducted during the early rapid growth phase and continuing growth period of the plants throughout the summer. Cutting plants during these periods can stimulate their growth and also cause more lateral growth or side-branching to occur which results in a denser plant canopy.
- Disposal costs can be expensive. Often plant material must be hauled to locations remote from the harvested area and disposal costs can constitute a large part of the budget.
- The fuel used to run harvesters and associated vehicles adds to the overall carbon footprint of the maintenance operation which has air quality impacts.

Application of the Method

Mechanical harvesting has been used for a number of years in the Tahoe Keys lagoons. The method is used widely in many waterways in California and the United States.

Suitability to Tahoe Keys Lagoons

Mechanical harvesting has been the primary means of control used in the Tahoe Keys lagoons and it is anticipated that some harvesting will continue to be used as part of the integrated management approach. The WDRs issued to the TKPOA specify that Best Management Practices (BMPs) be developed for controlling plant fragments generated by mechanical harvesting.

Harvesting methods in the Keys lagoons were analyzed in the 2014 study, “Characterization of Aquatic Plant Fragments in the Tahoe Keys Lagoons” (TKPOA 2014b). The results of this study showed that harvesting increases numbers of fragments by 50 to 100% and increases the size of fragments that are found compared to pre-harvest samples. Recommendations and modifications for standard mechanical harvesting machines were made in the 2014 study and will be assessed as part of the Plan. These include: modifying cutting bar depth, improving the methods of collecting fragments during operations, removing fragments from dead-end coves and down-wind sites, selecting harvest sites according to prevailing winds, as well as using real-time information on aquatic plant conditions in the Tahoe Keys lagoons to efficiently direct harvesting machines to problematic areas.

Rotovating

Hydraulically operated rotovator machines have been used to manage Eurasian watermilfoil in some lakes in Canada, but rarely in the US. Rotovating is typically used in small areas, such as swimming zones with few obstructions and where the primary concern is safety, rather than preservation of native habitat. A rotating, solid tine head is lowered to the bottom and physically tills the sediment to a depth of several inches, dislodging the roots and rhizomes. Much of the plant material floats to the surface where it must be removed by screens and suction systems. These operations typically require temporary installation of turbidity curtains around the treatment area to contain the disturbed silt and to entrap cut plant fragments to prevent infesting the surrounding area. The physical disturbance of the sediment greatly affects any benthic organisms either by directly killing them or destroying the habitat. Estimates for aquatic plant control using rotovating range from $1,700 to $2,000 per acre, not including disposal costs.

Advantages

- Immediate improvement of access to the waterway for boating and other recreation after work is completed.
- Rotovating can remove some nutrients sequestered in the harvested plant biomass.
- Reproductive structures in the sediment layer are removed.

Disadvantages

- This method is non-selective: all benthic organisms in treatment area are impacted.
- Plants are fragmented during process and may be left behind or can float out of treatment area.

- Disturbance of the sediment can lead to unacceptable increases in turbidity which in turn requires that operations cease until turbidity returns to acceptable levels.
- The use of turbidity curtains to isolate silt and particulate matter increases the cost of control.

Suitability to Tahoe Keys Lagoons

Due to the severe impact of rotovating on the sediment and benthic organisms and the associated increase in turbidity, this type of device is not suitable for use in the Tahoe Keys lagoons. Installing turbidity curtains would interfere with intended recreational use. There are also many obstructions, such as boat docks, that would limit the area that could be thoroughly treated by the rotovating machines.

Bottom Sweepers

These devices are dock-mounted, electrically-driven systems that use a rotating arm that drags along the sediment. The system is usually installed and operating in early spring so that the rotating arm can periodically sweep over newly sprouted plants, thus maintaining a relatively clear area beneath the path of the sweeper. Bottom sweepers can provide relief from aquatic plants in small areas adjacent to docks, but require a fixed mounting surface, such as a pier or dock. Although it disturbs the surface of the sediment, the impacts are not nearly as severe as the other physical management methods.

Advantages

- Immediate improvement of access to the waterway for boating and other recreation after work is completed.
- Little sediment disturbance compared to other methods.

Disadvantages

- Objects such as other piers and anchor chains for buoys will interfere with its operation.
- Some turbidity increases can occur when sediment is disturbed.
- Treatment area is limited to several feet in size.
- Treated area is in a fixed location.

Suitability to Tahoe Keys Lagoons

Due to the limited size of the treated area, the problems associated with interfering structures and the inability to deploy this in open coves areas, bottom sweepers have little practical use in the Plan.

Aeration and Mixing

Physical mixing of water can improve dissolved oxygen levels and affect nutrient loading which can otherwise result in increased algal and plant growth. Water recirculation can be achieved with fountains or with elaborate piped systems. These are typically used in small ornamental aquatic features where the scale and volume of water can be moved reasonably well without large costs for electricity. Individual aerators can be deployed in small lakes and ponds and these may reduce the amplitude and frequency of algal blooms. There are also specific devices on the market that are designed to increase vertical water movement and create less favorable conditions for algal blooms.

Advantages

- Aeration can help reduce algal growth.
- Systems are typically affordable and can be solar powered.

Disadvantages

- Rooted plants primarily derive nutrients from the sediment layer, not the water column.
- Circulation systems can exasperate the spread of small aquatic plant propagules.
- Circulation systems require maintenance to ensure adequate performance.
- Devices must be properly flagged and lighted at night to avoid boating hazards.

Suitability to Tahoe Keys Lagoons

The primary problem in the Tahoe Keys lagoons is rooted plants, not algae. Water circulation systems could increase the growth of rooted aquatic plants by promoting transfer of plant propagules throughout the lagoons. The Solar-Bee © system was deployed as a test operation at four locations in in the Tahoe Keys several years ago. There was no significant or discernable effect on rooted plants in any of the locations where it was deployed.

The Tahoe Keys lagoons have an existing water circulation system originally installed to clarify the turbid water. The system consists of three main pumps to move water throughout the lagoons and five transfer pumps to move water from different areas of the lagoons to the main pumps. The system was operated for several years and was discontinued when turbidity was reduced to acceptable levels. Since that time, it has been proposed that the system could be used to move water from the lagoons to Lake Tallac, which overflows into Pope Marsh. The system has a maximum capacity of 24,000 gallons per day at a rate of 53.5 cubic feet per second at the Main Lagoon and a maximum capacity of 5,000 gallons per day at a rate of 11.1 cubic feet per second (at the Marina Lagoon. Using the existing system, water could be drawn into the lagoons from Lake Tahoe through the East and West channels then be discharged into Lake Tallac. Overflow from Lake Tallac would flow into Pope Marsh and eventually return to Lake Tahoe.

Advantages

- Cooler water with reduced nutrient levels from Lake Tahoe could potentially slow the growth rate of the nuisance aquatic plants and could reduce algal growth.
- Introduction of fresh water from Lake Tahoe could improve the aesthetic qualities of the water in the Tahoe Keys lagoons.
- Discharge to Pope Marsh might increase the wetland area and enhance habitat for wildlife.
- Pope Marsh could potentially filter nutrients that otherwise might enter Lake Tahoe.

Disadvantages

- The decreased growth rate of the nuisance aquatic plants would likely not be discernable. Temperatures of the waters in the Tahoe Keys lagoons would need to drop by 7 to 10 ^{0} Fahrenheit to affect growth rates of aquatic plants. Reducing the water temperature sufficiently would be very expensive, upwards of $3,300/week in order to exchange approximately one-third the volume of the Tahoe key lagoons (not including additional maintenance costs or water quality monitoring costs).
- Decreasing the nutrient load of the Tahoe Keys lagoon waters would likely not affect the nutrient status of the

nuisance aquatic plants of the Tahoe Keys lagoons, which are rooted in the sediment.

- Height of existing pump inverters would need to be adjusted for the system to operate as described. This would add significantly to the cost of deploying this method.

The US Forest Service currently has no plans to the change the management of Pope Marsh. The TKPOA would need to consult with USFS on the use of this method. Significant environmental analysis and review would be required to assess the impact to Pope Marsh and to determine what additional permitting would be necessary.

Biological Control

Biological control is the use of one or more live organisms to suppress a population of a target pest. Typically, herbivores or pathogens found in the native range of the target pest are examined for potential use to control the target. The criterion for release of a control organism, whether it is an insect or pathogen, is the presence at the treatment site of strict host specificity, so that the control organism does not have an effect on other species than the target. There are strict federal and state guidelines and review processes that are used to ensure that biological control agents are safe for introduction. Discovery, testing and permitted release of such organisms can take five to 10 years.

Several biological control methods have been used to impede the growth of non-native aquatic plants. The watermilfoil weevil, *Euhrychiopsis lecontei*, is native to North America and has been reported to feed and reproduce on both native Northern watermilfoil and non-native Eurasian watermilfoil. Water hyacinth weevils, *Neochetina eichhorniae* and *N. bruchi*, have been used to control populations of water hyacinth.

Another biological control agent for aquatic plants is the herbivorous fish, grass carp or white amur (*Ctenopharyngodon idella*), a strict herbivore native to Asia which should not be confused with the Northern American carp or the Asian carp. Grass carp is a non-selective feeder and can consume several types of aquatic plants. Grass carp would not be a suitable control method for the Tahoe Keys lagoons that have direct connection to Lake Tahoe because it would be difficult to prevent its migration out of the treatment area. As a non-selective feeder, grass carp would have a detrimental effect on the benthic habitat. At this time, CDFW is not issuing permits to release grass carp in Region 2, where the Tahoe Keys lagoons are located.

There has been considerable research on the potential use of the fungal pathogen *Mycoleptidiscus terrestris*, but no products are commercially available at this time to control aquatic plants.

Advantages

- Biological control has the potential to suppress the growth of aquatic plants that impact water quality.
- If the biological control agent can maintain a low level of the host population on which it depends, there is little need for additional inputs for the control system to keep functioning.
- Once permits for release are obtained, there is typically no need for intensive water quality monitoring.

Disadvantages

- Few biological control agents are approved for use against the nuisance aquatic pests found in the Tahoe Keys lagoons at this time. None are available for curlyleaf pondweed or coontail.
- CDFW is not issuing permits for the release of grass carp in the Lake Tahoe region.
- Regardless of the biological control agent, efficacy depends on environmental conditions and physiological responses of the agent and host, all of which are highly variable factors. This includes temperature tolerance, including overwintering temperatures, number of generations produced per season and susceptibility of the host.
- There may be predators that reduce populations of the agent below efficacious levels.
- Common disturbances in the Tahoe Keys lagoons, such as wave action from the high-level of boat traffic and from mechanical harvesters, could discourage the establishment of a sufficient population of insects, such as the watermilfoil weevil, to offer effective control.

Suitability to Tahoe Keys Lagoons

At this time, no suitable biological control agents have been identified that would provide effective control of the aquatic plants found in the Tahoe Keys lagoons. If appropriate agents are identified, biological control could be added as a component of the Plan through the Adaptive Management Protocol or through the periodic updates of the Plan. Suitable areas for biological control could include Lake Tallac Lagoon and relatively quiet areas, such as behind docks. After introduction, careful monitoring would be needed to determine if sufficient numbers of insects survive and offer acceptable control of Eurasian watermilfoil in these areas.

Cultural Control

Cultural control means implementing practices that reduce establishment of a nuisance species or that change conditions to impede the growth of that species. Cultural control includes using management practices that result in resource reduction so that growth of an unwanted species is inhibited. Cultural control also includes education and outreach to the public about the impacts of these species and how to modify standard practices or human behaviors that otherwise would inadvertently exacerbate conditions to promote unwanted species. Finally, cultural control can include implementing programs that result in early detection of unwanted species to prevent introduction or re-introduction of a species.

Resource Reduction

Control of nuisance aquatic plants can be achieved by reducing the availability of resources essential to aquatic plant growth and reproduction. These essential resources include adequate water, light availability, and availability of carbon and nutrients such as phosphorous and nitrogen. Nutrient reduction is particularly effective in reducing algal blooms.

Water availability or De-watering

Rooted, submersed aquatic plants depend on water for structural support, nutrients, gas exchange, and for optimal temperature for growth. Lowering the water level, causing water stress by exposing the plants to air, causes otherwise submersed plants to dry quickly. During periods of high temperatures, exposed shoots and leaves will die if water stress lasts a sufficient period of time. Water stress during the winter may freeze tissues sufficiently to kill the exposed leaves and shoots. Rhizomes, roots, seeds and some vegetative propagules may be tolerant to desiccation. Water stress may only kill the top growth and allow re-establishment to occur when water levels rise. This is a non-selective method that may affect native plants and animals normally associated with aquatic plant populations.

Advantages

- If the water level can be managed, this method can reduce biomass of aquatic plants without the need for additional controls, such as harvesting equipment.
- Plants are 95% water and when dessicated, little residue remains.

Disadvantages

- This method is non-selective and all plants and animals would be impacted. There would likely be effects on non-target species as well as the target nuisance plants.
- This method requires that water be kept out of the treatment area at the optimal time to kill the plants and then be returned to restore uses of the site. This means restricting access and use of the area during treatment, which may not be acceptable.
- Pumping and refilling may be needed, which increases energy costs. Alternatively, refilling may occur from surface runoff, groundwater infiltration, snowmelt, or opening gate structures.
- Water draw-down during high temperature coincides with high demand for use for boating.
- Dewatered sites in high temperature periods may also result in malodorous conditions due to decomposition of plants and animals.

Suitability to Tahoe Keys Lagoons

This approach has been successfully used in irrigation canals and during partial drawdowns of lakes to expose shoreline plants. The natural patterns of runoff during snowmelt would make this approach difficult in the Keys lagoons and Keys Marina because runoff water enters from many points in the watershed. In particular, the water level of the West Channel that connects the Keys lagoons to Lake Tahoe is affected with rising Lake levels.

Some areas of the Keys may be amenable to dewatering during early fall when water levels are naturally low and water is exiting the Tahoe Keys lagoons. Coves in the southern most area of the Main Lagoon or Lake Tallac may be suitable for this method, since they are shallow and are first to drain at the end of summer. Late summer dewatering also would have the least effect on recreational uses, especially after Labor Day. Actively dewatering the Tahoe Keys lagoons could interfere with the recreational use of the facility.

Dewatering the Tahoe Keys lagoons could damage bulkheads due to loss of support and could damage docks and piers. Infrastructure to dewater the treatment area and maintain that state will be required, which would increase the cost of this method.

Light Availability or Shading

Submersed aquatic plants are typically able to grow and reproduce under very low light conditions. However, growth can be impaired if light is reduced sufficiently by deep water, by high turbidity or by use of selective dyes sold and permitted for the purpose of reducing the spectrum of light available to the plants.

Water depths of over 15 feet typically discourage aquatic plant growth. Deepening small ponds and canals by dredging has been effective in reducing impacts of rooted plants. Growth reductions can also be achieved by increasing shade from trees planted in the proper orientations along shorelines. Growth of rooted plants and algae in small ponds and lakes can be reduced by using commercially available dyes (SFEI 2004). One product, sold as "Aquashade", is approved for use by the EPA, Cal-EPA and the CDPR.

Advantages

- Reducing available light can result in sustained management and suppression of aquatic biomass and reproductive capacity of some aquatic plant species.
- Increasing shade does not require special permits and can be implemented relatively easily.

Disadvantages

- Excavation to increase depth of the water usually requires a permit and can be expensive. The costs of sediment disposal must be considered along with the cost of operations.
- Excavation can result in turbidity levels that impact non-target species.

- Excavation is not feasible near bulkheads which were not designed to withstand greater water depths.
- Excavation is non-selective: all organisms associated with the plants as well as sediment are removed.
- Tree planting to increase shade takes many years for the trees to reach maturity and provide adequate canopy to block light available to submersed vegetation.
- At maturity, large trees could block views.
- Commercial dyes must be re-applied regularly during the growing season in order to maintain the concentration needed to block light. Dyes must be used early in the growing season before plants have reached heights that are not affected by lowered light levels.

Suitability to Tahoe Keys Lagoons

The effect of reduced light on biomass is routinely seen in the West Channel area of Main Lagoon, which is greater than 20 feet in depth. Aquatic plants never reach the surface in this area and coontail dominates the plant canopy near the bottom.

Reducing the available light sufficiently to result in reduced aquatic plant growth in the shallower Tahoe Keys lagoons would be difficult for a number of reasons:

- Dredging operations to deepen the coves to over 15 feet would be costly. Dredging would affect the integrity of bulkheads at the perimeters of the lagoons.
- Due to the highly developed shorelines in the Tahoe Keys lagoons, locating suitable planting sites for new trees to increase shade would be difficult. While there may be some suitable sites, the vast majority of planting sites to shade the water are in private backyards and not in common areas under the control of the TKPOA.
- Commercial dyes used in early spring in some coves could provide some level of aquatic plant control. This approach could be explored based on water movement studies to determine the frequency of dye use, possible efficacy, and cost.

Nutrient Availability

Reducing available nutrients is very effective for management of nuisance algal blooms, but is less effective on rooted plants. Algae are suspended in the water column and depend on water-borne nutrients but rooted plants obtain sufficient nutrients from the sediment layer. The primary target nuisance aquatic plants in the Tahoe keys lagoons rely almost exclusively on nutrients from the sediment.

Inactivation of existing phosphorous in the water column can be achieved by applying chemicals such as aluminum, iron, or calcium compounds. Rooted plants are typically limited by available nitrogen, but there are no compounds that readily bind nitrogen in the sediment layer. It is important to limit introduction of additional nutrients, particularly phosphorous, from fertilized landscapes via natural run-off or irrigation run-off.

Advantages

- Reducing run-off from fertilized landscapes can be easily achieved through improved irrigation management and other practices such as buffer strips.
- Reducing nutrient inputs via runoff will lessen the likelihood of sustained algal blooms.

Disadvantages

- Reduced nutrient availability will not, in itself, control the growth of nuisance aquatic plants.
- The addition of compounds to sequester nutrients such as phosphorous would require permitting and monitoring. Repeated applications would likely be necessary, depending on conditions. Phosphorous in sediment layer would still available to aquatic plants.
- The cost of removing nutrient-laden sediments is high, would require permits, and impair the use of the coves during operations.

Suitability to Tahoe Keys Lagoons

The nuisance aquatic species of the Tahoe Keys lagoons are rooted plants which can derive necessary nutrients from the underlying sediment. Reducing nutrients in the water column by applying chemicals to sequester the nutrients would require permits, which are costly, and would require additional monitoring after application, which also adds to the cost of the method. Given these factors, reducing nutrient availability in the water column through other means, such as Best Management Practices, will likely achieve reduced levels of nutrients with other beneficial impacts to water quality.

Management Practices

Best Management Practices (BMPs) are guidelines for landscape maintenance which help keep landscapes visually attractive while conserving resources and protecting the environment.

Best Management Practices include minimizing the amount of fertilizer applied to lawns and gardens to the quantity needed for healthy plants and reducing or eliminating phosphorous fertilizer. Reducing overspray and run-off from irrigation keeps the fertilizer in place in the garden and out of the environment and reduces the need to re-apply fertilizer. Choosing plants that have low fertilizer and low water-use requirements also help protect the environment because these plants need fewer resources for a healthy landscape.

Best Management Practices also include redirecting stormwater run-off to berms, swales, detention ponds, appropriate drainage sites, or other structures which filter the stormwater to remove sediment, pollutants, and contaminants before the stormwater reaches the waterway.

Utilizing BMPs can result in decreasing the amount of nutrients entering the water and decreasing the amount of sediment deposition in the water, both of which can help decrease the rate of aquatic plant growth.

Advantages

- There are standard BMPs that are considered to be beneficial to watersheds and there are many resources available to help develop specific BMPs for the Tahoe Keys lagoons.
- BMPs can help alleviate conditions that otherwise would promote growth of unwanted plant species.

Disadvantages

- BMPs by themselves do not offer sufficient control over unwanted aquatic plants.
- Modifying behaviors and entrenched practices can be difficult in certain situations.
- Compliance with BMPs can be difficult to monitor.

Suitability to Tahoe Keys Lagoons

Developing and utilizing BMPs for the Tahoe Keys lagoons are important to the success of the Plan. Successful implementation of BMPs will reduce the contributions of landscaping maintenance and stormwater run-off to the problems of aquatic plant growth and will engage and educate the residents of the Tahoe Keys to take measures to reduce the proliferation of aquatic plants in the Tahoe Keys lagoons.

Many standard BMPs have been implemented by the TKPOA maintenance staff for common areas, such as median strips and larger open areas. In addition to these standard BMPs, the WDRs issued to the Tahoe Keys Property Owners Association (LRWQCB 2014) require that a Nonpoint Source Water Quality Plan (NPS Plan) be developed. This NPS Plan, which is a separate requirement in the WDRs from the Integrated Weed Management Plan, will include writing BMPs specific for the common area in the Tahoe Keys which address irrigation efficiency and management practices for fertilizer use and a monitoring program to demonstrate compliance. There are numerous resources available to assist in writing BMPs for the Tahoe Keys lagoons, including information available from TRCD and TRPA.

Enforcement of BMPs for private properties in Tahoe Keys will be codified in the Architectural Control Rules Brochure (ACRB), issued by the Architectural Control Committee (ACC) of the TKPOA. Violations of the ACC rules result in penalties such as fines or restrictions imposed on the property owner.

Education and Outreach

The objective of education and outreach is to elevate the level of awareness by the general public of the problems of invasive species. Educating the users of waterways about these problems can prevent introductions of new species or re-introductions of species designated for control. Education and Outreach can also include informing the public about management practices, such as proper irrigation and fertilizer use, which can be adapted from the BMPs for use on private property.

Numerous agencies and organizations in the Tahoe Basin have collaborated on programs and materials for outreach and education, including TRCD, TRPA, the League to Save Lake Tahoe, and CDFW and have developed flyers, posters, and other informational material that could be used by the TKPOA or which could serve as models to develop materials specific to the Tahoe Keys lagoons.

Education and outreach can be as simple as posting signs or providing literature to interested parties. Alternatively, workshops and community workdays can be scheduled which engage and empower the public as part of the control effort.

Educational materials can be general in nature or can be tailored to meet the needs of specific groups, such as landscape technicians.

Advantages

- Education and awareness of the problems associated with aquatic plants can foster cooperation with the general public to help control their proliferation.
- Education and awareness promote early detection of new invasive plants so that resource agencies can take action under a Rapid Response plan.

Disadvantages

- Education and outreach by themselves do not provide adequate control measures for aquatic plants. They must be used in conjunction with other methods to control growth of and prevent re-establishing nuisance aquatic plants.
- Depending on the materials used, educational brochures and workshops can be somewhat expensive.

Suitability to Tahoe Keys Lagoons

Education and outreach to the public are essential to the success of the Plan. The TKPOA retains control of the management of only certain areas of the Tahoe Keys lagoons. Therefore, educating the homeowners, the landscape professionals who maintain private gardens and yards, and the visitors to the Tahoe Keys lagoons on how they can prevent the proliferation and spread of aquatic plants will support the other control work.

Table 5. Summary of Non-chemical Methods of Aquatic Plant Control

Method	Advantages	Disadvantages	Notes
Diver-assisted suction removal	• Can be selective against target species • Majority of plants and plan propagules can be removed from treated area	• Can cause unacceptable increases in turbidity • Slow: less than 1 acre can be treated at a time • Relatively expensive	Plant disposal costs not typically included in estimates. Useful in small-scale applications.
Bottom Barriers	• Direct, immediate control of aquatic plants • Can be used in areas otherwise difficult to treat, such as around piers or docks	• Non-selective control • Non-target organisms affected • Control is temporary • Relatively expensive	Useful in small-scale applications
Mechanical Harvesting	• Provides immediate improvement in treated areas • Does not require additional permitting • Some nutrients are removed from water to decrease regrowth of aquatic plants • Large areas can be treated relatively quickly	• Control is short-term and non-selective • Non-target impacts include harming fish • Water turbidity can be temporarily increased • Plants in treated areas tend to grow back more quickly	This method will continue to be used in the Tahoe Keys lagoons.
Rotovating	• Disrupts roots and rhizomes • Large obstruction-free areas can be treated relatively quickly	• Can spread large numbers of plant fragments • Non-selective against plants and benthic organisms • Can cause unacceptable increases in turbidity • Method is comparatively expensive	

Summary of Non-chemical Methods of Aquatic Plant Control (cont.)

Method	Advantages	Disadvantages	Notes
Aeration and Mixing	• Can help reduce algal growth • Could improve the aesthetic qualities of the water in the Tahoe Keys lagoons • Cold water could reduce growth rate of aquatic plants	• Not likely to reduce the growth rate of aquatic plants in the Tahoe Keys lagoons which are rooted plants • Difficult to reduce temperatures sufficiently to reduce the growth rate of aquatic plants • Can increase the spread of aquatic plant propagules • Systems require on-going maintenance and can be expensive to run • Devices can be hazardous to boaters if not properly flagged	Aeration typically used to address algae problems, not growth of aquatic plants. Discharge to Pope Marsh would require extensive environmental review and additional permitting.
Biological Control	• Could provide selective control once aquatic plant biomass has reached acceptable levels • Can be target-specific	• No suitable products known for the Tahoe Keys lagoons • Release of organisms such as grass carp would be difficult to permit	Biological control of aquatic plants is still in research and development stage. If suitable products are developed, they could be included in the Plan at a later date.
Cultural Control	• Methods such as resource reduction through BMP implementation are relatively easy to do • Some methods can be relatively inexpensive	• Methods such as water draw-down can be difficult, disruptive to recreational activities, detrimental to fish and wildlife habitat, and expensive • Can be difficult to demonstrate efficacy	Cultural controls typically support other control methods

3.2 Chemical Control of Aquatic Plants

Chemical control of aquatic plants with registered aquatic herbicides is a widely used method in the United States. Aquatic herbicides are used to control Eurasian watermilfoil, curlyleaf pondweed and other nuisance aquatic plants in California (Clear Lake, Big Bear Lake, and the Sacramento-San Joaquin Delta), and in lakes in the states of Washington, Minnesota, and Florida, to name a few of the many locations where herbicides are routinely applied to public waterways.

Aquatic herbicides control aquatic vegetation without harming fish or wildlife. Herbicides that have been approved for use in aquatic systems have been extensively studied for efficacy and potential impacts to the aquatic ecosystem such as toxicity to non-target organisms. This section briefly describes the regulation and registration of herbicides, the types of herbicides available to control aquatic plant growth, their efficacy, and concerns of herbicide use.

A more thorough discussion of aquatic herbicides is given in Appendix E.

<u>Regulatory Authorities</u>

The distribution, sale, and use of all herbicides are regulated by the US Environmental Protection Agency (EPA) through the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and by the California Environmental Protection Agency (CalEPA) through the Department of Pesticide Regulation (DPR).

Aquatic herbicides undergo additional scrutiny prior to being registered for use to ensure environmental safety. As part of the approval process, the registrant of an herbicide must test the active ingredient and the formulation of the herbicide for the potential to harm human health and the environment. These tests include human and ecological toxicity studies, as well laboratory and field studies to analyze the fate of the active ingredients in water, plants, fish, and soil as a result of the intended use of the aquatic herbicide.

There are many herbicide products registered for use in the United States and there are approximately 12 active ingredients that are approved for use in aquatic herbicide products in the state of California. Regulation of aquatic herbicides falls under the authority of the Federal Clean Water Act and this regulation is delegated in California to the State Water Resources Control Board and the regional water quality control boards which approve aquatic herbicide through the National Pollutant Discharge Elimination System (NPDES) permit system and which approves the Aquatic Pesticide Application Plan (APAP) required for aquatic herbicide use. Applicators of aquatic herbicides must be trained and certified by the DPR and must maintain current knowledge of regulations through continuing education.

Types of Herbicides

Herbicides for both terrestrial and aquatic use can be categorized in two major groups: contact and systemic. Contact herbicides directly damage the plant tissues at the point of contact and can quickly kill a target plant. Systemic herbicides are first absorbed by the plant, then are distributed, or translocated, throughout the plant where they disrupt normal plant cell functions (Netherland 2009).

Contact Herbicides

These herbicides directly affect the plant tissues and the active ingredient does not travel through the tissues of the plant. Typically, contact herbicides act very rapidly, within minutes to a few hours, depending on concentration and target plant susceptibility but generally do not provide long-term control of aquatic plants. Plant tissues that are not damaged by contact herbicides can regrow. Contact herbicides must remain in the treated area for a sufficient amount of time and at a sufficient concentration in order to kill the plant tissues. Depending on the aquatic herbicide used, this contact time ranges from a few hours to a few days.

Systemic Herbicides

These herbicides are absorbed by plant tissues and move through the water or food transporting structures to other parts of the plant where they have deleterious effects on normal plant cell functions, such as disrupting photosynthesis, protein synthesis, or growth regulation. This movement of the active ingredient is called translocation. Typically systemic herbicides require longer contact time with the treated plants than contact herbicides, and require more time to completely kill the target plant. The advantage of systemic type herbicides is that they usually provide longer lasting control: translocation of the active ingredient affects the plants' ability to re-grow and can often inhibit the plants' ability to produce flowers and vegetative propagules.

Herbicide Application Methods

Aquatic herbicides are delivered as concentrated liquids or as solid granules or pellets. The herbicide product can be applied to the water or to the sediment surface where it can be absorbed by the roots and rhizomes. The volume of water in the treatment area must be known in order to correctly determine the amount of herbicide product to apply to control a particular nuisance aquatic plant.

In some situations, combinations of herbicides may give better control of aquatic plants by providing a broader range of modes of actions and active ingredients. For optimal efficacy of aquatic herbicides, the characteristics of the product, physical and biological conditions of the treatment site and susceptibility of the target plant must be understood. This concept is summarized in Figure 15.

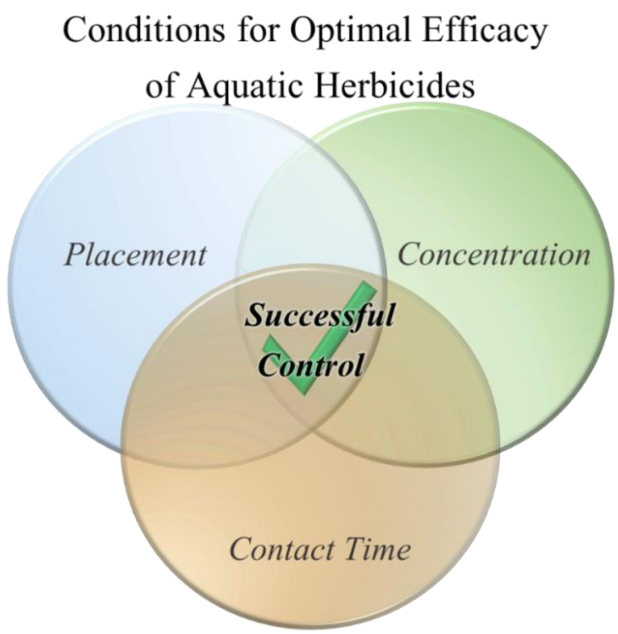


Figure 15. Herbicide Efficacy (Source: K. Getsinger, L. Anderson)

Environmental Fate

There are many physical and biological variables that can affect the environmental fate of herbicides. Physical processes such as diffusion and dispersion can be influenced by wind or water currents as the compound moves from the application area where it is in high concentration to areas of low concentration. The formulation of the aquatic herbicide can affect the release rate of the active ingredient so that the application can be tailored to match site-specific conditions and to minimize movement away from the treated area.

Herbicides can be affected by chemical processes of volatilization, hydrolysis, and adsorption to soil or sediment particles as well as degradation by ultraviolet light and microbes. These processes impact how well the herbicide works on the target plant.

Monitoring Herbicidal Control Methods

Monitoring methods used to assess efficacy, non-target effects and environmental fate of aquatic herbicides must be tailored to the application method, the specific product used, and the use of the site and the water at which the product is applied.

Herbicide concentrations can be monitored quickly and accurately at the application site and in the surrounding body of water. Affordable testing systems such as enzyme-linked immunoassays (ELISA) are available for several of the aquatic herbicides approved for use in California and analysis can be completed in a timely manner to ensure that concentrations for efficacy have been met and to meet regulatory requirements.

In addition to monitoring for efficacious levels of herbicides, additional monitoring is necessary to ensure that potential sensitive uses of water, such as potable, domestic and commercial uses, irrigation, and livestock watering, are protected. There are several intakes of surface water for direct, potable use in Lake and monitoring in proximity to these intakes and at sites on potential pathways to those sites would be included as part of the overall monitoring program.

Water sampling stations must be properly positioned to capture information on the dispersion on the active ingredient and to detect residues outside of the treatment area. Depending on the type of product and application methods, herbicide residues may be dispersed vertically across the water column or be localized near the sediment layer. The location and depth of water sampling as well as frequency and analytical testing parameters will be determined based on type of herbicide applied and in consultation with the Lahontan Water Board. Monitoring typically includes the following:

(1) Dissolved oxygen (surface and bottom)
(2) pH (surface and bottom)
(3) Temperature (surface and bottom)
(4) Turbidity (surface and bottom)
(5) Nutrients (Nitrates and phosphorous, surface and bottom)

In addition to the tests listed above, testing for photosynthetically active radiation (PAR) at the water surface, mid-depth and at the bottom would measure for impacts to the plant canopy and habitat as a result of aquatic plant management.

Water samples must be handled properly to maintain their integrity and to assure quality control. Crews must be properly trained and supervised in all sampling techniques and chain of custody requirements. It is unlikely that herbicide residues will contact groundwater sources in the area due in part to their adsorption to soil particles which limits movement away from the application site. As a precaution, pre- and post-application water samples will be taken at one or more potable water pump stations within the Tahoe Keys. The duration of sampling will be determined in consultation with the South Tahoe Public Utility District, local water purveyors, and the Lahontan Water Board.

Concerns of Herbicide Use

Non-target Impacts

There is a low risk of acute impacts to the aquatic ecosystem when aquatic herbicides are applied by trained applicators following the herbicide label criteria. The aquatic herbicides registered for use in the US and in California are relatively non-toxic to fish and humans because their modes of action affect plant processes, such as photosynthesis, which are not found in animal organisms. None of the registered aquatic herbicides are classified as carcinogens.

As discussed above, physical variables can cause an herbicide to move from the site of application. Prior to application, weather conditions such as wind and temperature, must be monitored to ensure that the herbicide does not physically move outside of the treatment area and affect non-target organisms.

Herbicide Resistance

Another important consideration in using any herbicide is the risk of inducing resistance in the target plant population. Herbicide resistance has been well-documented in terrestrial plants and has also been demonstrated in aquatic plant species. It is a result of continued exposure to the same active ingredient and the same mode of action which does not completely eradicate the target plant population. The surviving plant population then becomes a source of plants that resist the active ingredient. The potential to develop herbicide resistance can be reduced by using different herbicides

Summary of Chemical Control of Aquatic Plants

Aquatic herbicides can be effective in controlling the growth of unwanted vegetation. Aquatic herbicides are used in many aquatic plant management plans and can be integrated with a variety of control methods. When properly used by trained applicators, herbicides effectively control aquatic plants without harming fish or benthic organisms, wildlife, or humans. Proper use of approved aquatic herbicides can result in sustained control of aquatic plants lasting over several growing seasons, reducing the need for employing additional control methods.

Aquatic herbicides must go through a rigorous testing process before they can be registered with the US EPA and the California EPA for use in aquatic systems. These approved herbicides pose no significant threat to the environment or public health when used in accordance with labelling instructions. As part of the registration and approval process, the US EPA also identifies application restrictions for the herbicide.

Advantages

- Approved aquatic herbicides allow managers to target specific plant species and avoid impacts to non-target species.
- Herbicides offer rapid, and, in many cases, long-lasting control.
- Herbicide treatments are cost-effective methods to control plants.
- Monitoring methods for residual herbicide in water surrounding the treatment area ensure safety.

Disadvantages

- Herbicides must be handled carefully. Applications must be made by trained crews that are under the supervision of state-certified applicators to ensure that herbicides are handled safely and applied in the proper dose.
- Herbicides with limited target-specificity are not as effective if more than one plant species is present. In these instances, combinations of herbicides may be needed for control which could incrementally increase costs of control.
- A rotation of herbicides with different active ingredients is needed to avoid developing herbicide resistance in the target plant population.
- Herbicides must be applied at the proper time during the growing season for best control. This requires monitoring of the stage of growth of the target plants.
- Some herbicides have non-target effects on benthic organisms.
- Some herbicides can persist in the water.
- Rapid death of vegetation can temporarily lower the dissolved oxygen in the water of the treated area.
- Loss of vegetation after treatment can temporarily reduce habitat for fish and benthic organisms.

Suitability to the Tahoe Keys lagoons

There are several registered aquatic herbicides that have been shown to control the nuisance aquatic species of the Tahoe Keys lagoons and which can be safely used in combination with other control methods such as bottom barriers, mechanical harvesters, or diver-assisted suction. The contact aquatic herbicide endothall has been used to control curlyleaf pondweed, coontail, and Eurasian watermilfoil. The systemic aquatic herbicides imazamox and penoxsulam have been registered for use on Eurasian watermilfoil and curlyleaf pondweed. Additional detail on aquatic herbicides that would be suitable for use in the Tahoe Keys lagoons is given in Appendix E.

The dead-end coves of the Tahoe Keys lagoons comprise nearly 70% of the areas that are infested with nuisance aquatic plants. The Rhodamine WT studies that were conducted (Anderson 2011) indicate that aquatic herbicides could be effectively used at these sites. The residence times in the dead-end coves is approximately 30 days which would facilitate maintaining adequate concentrations and contact time of aquatic herbicide in the treated area.

4.0 ENVIRONMENTAL REVIEW AND PERMITTING

Photo Courtesy of Hypeit, Inc.

The Plan must comply with existing environmental protection regulations and must be reviewed by state, regional and federal agencies and the general public for comment. Concerns raised during the review process must be addressed before the Plan can be approved and implemented by the Tahoe Keys Property Owners Association (TKPOA).

In order to implement elements of the Plan, the TKPOA will be required to obtain permits to conduct those associated activities. The permitting agencies may impose specific conditions to be met during implementation, such as monitoring for special status species or conducting water quality monitoring. This section describes the anticipated steps required for approval and implementation of the Plan.

4.1 Environmental Review under the California Environmental Quality Act and National Environmental Policy Act

Several government regulatory agencies have jurisdiction over Lake Tahoe. Since the Plan has the potential to affect water quality, the Lahontan Water Board has primary permitting authority over Plan activities, which means that it is the most appropriate state agency to prepare an Environmental Impact Report (EIR) to analyze the Plan, according to the requirements of the California Environmental Quality

Act (CEQA). The EIR will analyze and disclose all significant environmental effects associated with the activities conducted under the Plan. CEQA requires that environmental effects be avoided, minimized, or mitigated. In order to mitigate for unavoidable environmental impacts, the EIR will describe mitigation measures, Plan alternatives, and mitigation monitoring. As part of the CEQA review, the lead agency will conduct public scoping meetings and will solicit comments from the public and other relevant agencies. Further, the lead agency must respond to the comments received and share the rationale of the decision making process used to approve the Plan.

Both California and Nevada border Lake Tahoe and projects that may impact the Lake must be analyzed by a federal agency to satisfy the National Environmental Policy Act (NEPA). The US Army Corps of Engineers (USACE) has jurisdiction over federal waters, making it the most appropriate agency to prepare an Environmental Impact Statement (EIS) to analyze the Plan. The EIS is similar to the EIR, and the two documents will be developed in conjunction.

Finally, the Plan must be reviewed by TRPA. This agency was created to ensure environmental thresholds are being met and that projects comply with the established Tahoe Regional Plan. Certification by TRPA of the NEPA documents and subsequent permit applications will be required.

4.2 Permitting

After the environmental review is completed, implementation of the Plan may require permits from several agencies. The TKPOA would apply for and receive all necessary permits prior to implementation of the Plan.

<u>Bottom Barriers</u>

The Lahontan Water Board has issued a Water Quality Certification as part of the WDR to the Tahoe Keys Property Owners Association for the use of bottom barriers. Use of this method of control is currently limited to 5 acres under the terms of the WDR.

The USACE regulates the addition and removal of fill or other material from the floor of waters of the US. Therefore, the USACE may require the TKPOA to file a Pre-Construction Notification to operate under a Nationwide Permit to place bottom barriers in the Tahoe Keys lagoons. If the need arises to install more than 5 acres of bottom barriers, the

TKPOA may need to apply for an Individual Permit from the USACE, depending on the total acreage.

CDFW regulates projects that could impact aquatic or riparian species. The TKPOA is required to notify CDFW before beginning any bottom barrier treatments. CDFW may require that TKPOA apply for a Lakebed Alteration Agreement permit that will impose conditions on the bottom barrier placement program.

Herbicide Application

In 2011, the Lahontan Water Board amended the Water Quality Control Plan for the Lahontan Region (Basin Plan) by adopting a Waste Discharge Prohibition for pesticides with Exemption Criteria for the use of aquatic pesticides in certain circumstances. In order to grant any exemption, the project must satisfy the criteria for protecting public health and safety or ecological integrity, and a project proponent must provide to the Lahontan Water Board sufficient information to determine if the project is consistent with the provisions of federal and state anti-degradation regulations for water quality (LRWQCB 2011). TKPOA will apply to the Lahontan Water Board for an exemption and for permits required for the use of aquatic herbicides.

Aquatic herbicide applications are considered discharges and are covered under the State Water Resources Control Board's Statewide General National Pollutant Discharge Elimination System (NPDES) Permit (General Permit). In order to obtain coverage under this General Permit, the TKPOA will be required to file a Notice of Intent to apply the herbicide; prepare an Aquatic Pesticide Application Plan (APAP); and submit the required fees. The APAP will fully describe: the treatment area and surrounding areas; the herbicidal active ingredients to be used and any materials, known as adjuvants, which would be used to enhance the herbicidal active ingredients; the monitoring and reporting program; the BMPs that will be implemented during the application of the herbicide. The monitoring plan in the APAP must be specifically designed to ensure the protection of potable water sources and will describe proper response times to mitigate impacts to potable water intakes. Monitoring will include sufficient water sampling and analysis to determine the levels, locations, and dissipation of the residues of the applied aquatic herbicides. Mitigation described in the APAP will include deploying barriers to prevent the movement of residues of the applied aquatic herbicides from the Tahoe Keys lagoons. Monitoring and mitigation are described in fuller detail in Chapter 5, Recommended Plan Implementation.

Diver-assisted Removal

Diver-assisted removal of aquatic plant material can disturb sediments which lead to an increase in the turbidity of the water. While this action has no net change of bottom material volume, it is a maintenance removal of nuisance vegetation and therefore an action covered by USACE Nation Wide Permit number 27. Whenever a project is regulated under this permit, a Water Quality Certification is also required per Section 401 of the Clean Water Act. It is also likely that a CDFW Lake and Streambed Alteration Agreement will be required for this activity.

Agency Consultation on Federal or State Special Status Species

A state-listed endangered species, the Tahoe yellow cress, has been recorded in the vicinity of the Tahoe Keys. For this reason consultation with CDFW may be required to implement the Plan. Tahoe Keys lagoons do not provide suitable habitat for this species and it is unlikely that surveys or mitigations will be required.

5.0 RECOMMENDED PLAN IMPLEMENTATION

Photo Courtesy of Hypeit, Inc.

This section describes the proposed implementation of the Plan for the years 2016 through 2020. The recommended strategy integrates four methods of aquatic plant control and supports these methods with focused surveys for aquatic plants throughout the Tahoe Keys lagoons and developing education and outreach materials for the public. The outreach materials will include developing best management practices (BMPs) that can be used by homeowners that are similar to those used by the TKPOA maintenance crews to reduce fertilizer use and run-off.

This section also describes how to evaluate the control methods for efficacy using a defined list of performance criteria in order to report the results annually to both the Lahontan Water Board and the interested public.

5.1 Management Considerations

Moderate levels of aquatic plants serve an essential role in natural lake systems in keeping water clear and for providing habitat for fish and wildlife. The Tahoe Keys is a shallow lake system as compared to Lake Tahoe as a whole. Shallow waterbodies can readily be impacted by the introduction of non-native plants or the release of nutrients from

sediment. Aquatic plant management methods should provide relief from the negative impacts of non-native and nuisance aquatic plants while encouraging growth and sustainability of beneficial native plants and promoting suitable habitat for native aquatic organisms.

Identifying the appropriate management recommendations for the Tahoe Keys lagoons requires sufficient understanding of the physical characteristics of the Tahoe Keys lagoons, the morphology, the hydrology, the recreational uses of the waterways, and the surrounding land use. All of these factors influence aquatic plant growth, location and intensity of aquatic plant infestations. The same factors also influence the selection and timing of control methods.

The Adaptive Management protocols of the Plan (Chapter 6) will specify evaluation of control methods. Adaptive Management will be used to refine control methods in order to sustain effective control of aquatic plants in subsequent years.

5.2 Plan Implementation

Initially, the TKPOA management will rely on currently approved control methods, which will undergo refinement to improve their efficacy. Focused surveys for plant infestations will be conducted as part of the initial phase and the TKPOA management will begin the public outreach and education components of the Plan.

As described in Chapter 4 (Permitting), the TKPOA must apply to the Lahontan Water Board for an Exemption and permits for the use of aquatic herbicides. When the Exemption is granted and permits obtained, TKPOA will begin training of personnel on how to comply with permit requirements and selecting a certified applicator with experience using the approved herbicides. Herbicide use will be initially limited to less than 50 acres in the first year of permitted use in order to gather detailed information on efficacy, impacts to non-target species, herbicide dissipation and water quality.

A summary table and associated site maps (Figures 17 through 20) showing the proposed control methods at specific locations throughout the Tahoe Keys lagoons are provided below. The sites have been selected and delineated in sufficient detail to provide a consistent frame of reference for management action, associated monitoring and to facilitate adjustments in management actions. The areas treated with approved aquatic herbicides may result in a sustained reduction in growth of target aquatic plants such that additional control methods may be unnecessary. The frequency of use of non-chemical control methods may vary yearly. This reduction of use is reflected in the proposed implementation plan. However, the actual use of any control method will be verified and determined through monitoring and reporting that is part of the adaptive management process.

It is important to note three details of the proposed implementation plan. First, the control methods are integrated across the entire system of the Tahoe Keys lagoons. The most suitable method deployed will be based on the physical site conditions and the conditions of the target aquatic plants present. Next, the sequence of methods shown in the proposed implementation plan are based in part on the anticipated efficacy of aquatic herbicide treatments from prior years which are likely to result in decreased need to use non-chemical control methods such as diver-assisted suction or installation of bottom barriers in some areas. Finally, no aquatic herbicide applications are planned for locations immediately adjacent to channels that connect the Tahoe Keys lagoons to Lake Tahoe in order to create a buffer zone in the deep water areas for monitoring of aquatic herbicide residues and water movement.

Focused Surveys

The hallmark of this Plan is utilization of the most current and effective technology for quantitatively monitoring nuisance aquatic plant populations, hydroacoustic sampling, for focused surveys of current conditions in the Tahoe Keys lagoons. Hydroacoustic sampling applies refined methods of SOund Navigation And Ranging (SONAR) that are specifically adapted to detect and quantify submerged aquatic plant locations, density and their height from the bottom sediments. Hydroacoustic sampling gives accurate, real-time measurements of the volume of plant material present which is expressed as biovolume and enables the rapid analysis and documentation of Vessel Hull Clearance (VHC) which is the distance from the tallest plants to the water surface. Using quantifiable metrics and the most effective and current control technologies will result in application of the most effective and efficient combination of aquatic plant control methods.

Focused aquatic plant surveys will evaluate and report the following:

- The percent coverage and species composition of aquatic plants in the Tahoe Keys lagoons.
- Hydroacoustic surveys will determine:
    - The biovolume of aquatic plants (surrogate for biomass)

    - The vessel hull clearance (VHC), or vertical distance from water surface to mean, tallest plant canopy
- The dimensions, bathymetry, and water volume in each cove.
- Temperature data will be continuously logged from the bottom of at least 10 representative cove sites.

As part of the survey work, fixed sampling stations will be established in each cove and in the open areas of the lagoons using landmarks, GPS reference, and photo points so that the same site can be compared in subsequent years. Typical measurements at these stations will include: temperature (surface and bottom), dissolved oxygen (mid-depth and bottom), turbidity (mid-depth), and pH (mid-depth). Sampling will be conducted between 9:00 a.m. and noon, or will be done automatically at 30-minute intervals throughout the day. Modifications in sampling may be made in conjunction with physical control methods or as part of pre- and post- herbicide applications.

Harvesters

The mechanical harvesting method of plant control will be refined in several ways. First, plant fragment production by the harvesters will be assessed bi-weekly by tracking the harvesters throughout the lagoons using GPS. A boat-mounted netting screen will capture plant fragments as deep as 12 to 18 inches. The number and type of species of fragments will be reported and analyzed to assess adjustments to harvesting protocols as part of the Adaptive Management aimed at improving harvesting methods to reduce fragment generation and dispersal.

Bottom Barrier Placement

The TKPOA has developed an in-house permitting and tracking system for property owners seeking to install bottom barriers at their private docks. Use of bottom barriers will be evaluated annually as part of the Adaptive Management Protocols and as part of the required reporting for the Plan. Recommendations for installation of bottom barriers will be based on efficacy, environmental conditions such as water level and extent of aquatic plant infestation. Should a recommendation to install more than 5 acres of bottom barriers result from the Adaptive Management review, the TKPOA would apply for the appropriate permits and perform the environmental review required to increase the area of the Tahoe Keys lagoons treated with bottom barriers. The growing season for invasive aquatic plants coincides with the recreational boating season of the Tahoe Keys lagoons. Regular inspection of bottom barriers installed in shallow waters will be necessary to ensure they do not become dislodged by wave action and that they are effectively controlling aquatic plant growth.

Diver Assisted Suction Removal

In specific sites where water depth is typically less than six feet and where there is open access to streets, removal of target aquatic plants will be achieved with diver-assisted suction methods, as described in Chapter 3 (Methods). Due to the high cost of this method, only sites that are unlikely to become re-infested within two years will be treated with this method. Through the Adaptive Management protocols of the Plan, this method may be replaced by other methods, such as permitted herbicide applications, or if extremely low water levels facilitate, other physical methods such as de-watering.

Public Outreach

An essential component of the Plan is public awareness and understanding of the methods used and the science-based rationale for selection of the approaches taken. In addition to informing the public about the Plan, BMPs scaled to private properties will be developed to work in conjunction with those used in the common areas maintained by TKPOA.

Public outreach is a continuous process that requires multiple types of communications, media and events in order to convey facts about the program and to provide periodic updates on progress in achieving the goals of the Plan.

Public outreach and education about the Plan will include:

- Writing Informational brochures for the Tahoe Keys that describe how BMPs can be used at their property.
- Convening workshops on identifying aquatic plants and installing bottom barriers at private properties.

- Scheduling volunteer events to hand remove aquatic plants, if deemed appropriate and if water levels allow safe access.
- Providing a means for homeowners and renters to contact TKPOA management about suspected non-native plant infestations.
- Posting information about harvester action and aquatic plant removal on the TKPOA website.
- Scheduling and organizing informational workshops about aquatic herbicides and the Plan.

Application of Approved Aquatic Herbicides

Application of an approved aquatic herbicide in the Tahoe Keys lagoons is dependent upon approval by the US EPA of the amended Water Quality Control Plan for the Tahoe Basin, as described in Chapter 5. The proposed use of an approved herbicide was developed as part of this Plan in anticipation of this approval. Any use of an approved aquatic herbicide requires that an application for an exemption to the aquatic pesticide prohibition be submitted for review and consideration by the Lahontan Water Board.

Herbicide selection will be determined from the list of registered herbicides with known efficacy on the aquatic nuisance plants present in the Tahoe Keys lagoons and which have very low toxicity toward non-target organisms. The selection will be made in consultation with the Lahontan Water Board. Detailed protocols for water quality sampling and maintaining water quality objectives would be developed in conjunction with the NPDES permit application for herbicide use.

Specific criteria for selection of a proposed aquatic herbicide product would include:

- One or more of the nuisance aquatic plants found in the Tahoe Keys lagoons is listed on the registered label for the product. This ensures that data have been provided and reviewed showing efficacy for the listed species in sites typical of those in the Tahoe Keys lagoons.
- Documented efficacy of the product in similar aquatic conditions, as evidenced through peer-reviewed publications, state and federal agency reports, state and federal agency

recommendations, or documentation from other lake management projects.

- Ability to rapidly and accurately analyze and report the concentration of the active ingredient level in the waters of the treatment area. This assures that the level of active ingredient in the treatment area will be known as quickly as is practicable.
- Products must be compatible and complementary to other tools that are part of the Plan.

In 2015, there were 12 active ingredients approved by the US EPA and California EPA for use in aquatic plant control. Five of the approved active ingredients are proposed in this Plan for use in the Tahoe Keys lagoons and are listed in Table 6. The most efficacious and selective products available will be selected to match the aquatic plant conditions and locations as determined by the most current survey of the lagoons, and will be selected on their limited impacts to non-target organisms, including humans, waterfowl, and fish.

The proposed products contain active ingredients with different modes of action and by varying their use over time the likelihood of developing resistance in the target plants will be minimized. When additional, suitable active ingredients are approved for aquatic applications in California, these may be considered for inclusion in the IWMP through the Adaptive Management protocols or through updates of the Plan and in compliance with all permits.

Table 6. Proposed Herbicides by Active Ingredient

Active Ingredient	Type	Setback Distance from Potable Water Intake	Typical Application Rate(s)	Water Use Restrictions as indicated on Product Label	Notes
Fluridone	Systemic	No minimum	6-20 ppb	Potable water intakes: do not apply at rate greater than 20 ppb within 1,320 feet (0.25 mile) of any functioning potable water intake. Fishing, Recreation, Livestock/Pet Consumption: No restriction.	• Target species: coontail, common elodea, pondweed species, milfoil species • No restrictions on swimming, fishing, livestock watering at $\leq$ 150 ppb • Duration of exposure needed for control: 6-8 weeks
Triclopyr	Systemic	200 to 2600 feet depending on rate and area treated	0.5 – 2.5 ppm	Potable water intakes: Setback distance based on application rate and acreage treated. 300 feet is minimum distance. See label. Fishing, Recreation, Livestock/Pet Consumption: No restriction.	• Targets: milfoil species • Duration of exposure needed for control: 48 – 72 hours

Proposed Herbicides by Active Ingredient (cont.)

Active Ingredient	Type	Setback Distance from Potable Water Intake	Typical Application Rate(s)	Water Use Restrictions as indicated on Product Label	Notes
Endothall	Contact	600 feet	0.75 – 5.0 ppm	Potable water intakes: setback distance from functioning potable water intake must be equal to or greater than 600 feet. Fishing, Recreation, Livestock/Pet Consumption: No restriction.	• Target species: broad-leaf plants including curlyleaf pondweed, coontail, Eurasian watermilfoil • Duration of exposure needed for control: 24-48 hours
Imazamox	Systemic	0.25 mile	50 – 500 ppb	Potable water intakes: may be applied to potable water sources up to 500 ppb 0.25 mile from intake. Fishing, Recreation, Livestock/Pet Consumption: No restriction.	• Target species: curlyleaf pondweed, Eurasian watermilfoil • Coontail less susceptible • No restrictions on swimming, fishing, livestock watering • Duration of exposure needed for control: 2 – 4 weeks
Penoxsulam	Systemic	No restrictions listed on label	5 – 200 ppb	Potable water intakes: Setback distance is greater than or equal to 600 feet. Fishing, Recreation, Livestock/Pet Consumption: No restriction.	• Target species controlled: Eurasian watermilfoil, curlyleaf pondweed • Duration of exposure needed for control: 2 – 4 weeks

Herbicide Application

Application sites will be chosen in areas that were analyzed in the Rhodamine WT dye study or which have similar characteristics with regard to anticipated water movement and proximity to Lake Tahoe. Applications will be made at times and locations that preclude movement from the Tahoe Keys lagoons to Lake Tahoe. In locations that can accommodate them, impermeable barriers (made of polyethylene or PVC) may be installed to prevent dissipation of active ingredient away from the treatment area and to maintain required contact time for the target plants. Combinations of active ingredients with different modes of action will be considered for application to provide a broad range of control and to further minimize the potential for herbicide resistance to develop over the duration of the Plan. Recommendations of which herbicides to apply will be made by the Pest Control Advisor working with the Qualified Applicator overseeing the treatment.

Herbicide Monitoring

To protect human health, the environment, and to comply with requirements of the California Department of Pesticide Regulation, application of any approved herbicide will be overseen by qualified applicators certified by the State of California. All compliance measures will be taken to inform property owners and renters regarding location, timing and duration of herbicide applications. Required signage and other required formal notifications will be made and documented. This public outreach and communication will continue throughout the application and assessment period, and site visits will be scheduled for interested stakeholders to observe pre- and post-application conditions.

Pre- and post-application water sampling and analysis will be completed and samples will follow standard chain-of-custody procedures. Herbicide application will be tailored to selected sites after aquatic plant surveys have been completed. Each site will be evaluated thoroughly for efficacy, non-target affects, and comparison to mechanical harvesting in terms of inputs and control of plants in order to optimize herbicide use.

Contingency and Mitigation Plans

Even the best field plans can become compromised by unanticipated events and circumstances. Unanticipated problems can affect both non-chemical and chemical control management methods and include mechanical failures and malfunctions or weather events. These problems can cause delays or cessation of operations or can lead to failure of management of the site. Malfunctions and failures create conditions that require immediate attention and mitigation.

Any recommended control method must be conducted only by personnel adequately trained to perform those activities and must be supervised by individuals who are certified, licensed, or otherwise authorized to implement the activity. For all implementation operations a 24-hour central reporting phone tree will be established for rapid communication between TKPOA managers and appropriate staff. Contingency plans and actions are summarized in Table 7 below:

Table 7. Summary of Contingency Plan Actions

Control Method	Unexpected Event	Required Actions
Aquatic Herbicide	Accidental spill or other unplanned introduction to water or on ground	• Halt operations • Use GPS to flag or mark location • Notify Plan Coordinator • Install containment curtains • Use absorbent barriers or materials as needed on spill
	Residues exceed permitted level or residue anticipated to move to unpermitted location	• Halt operations • Install containment curtains to prevent movement from application site • Notify Plan Coordinator • Determine cause • Reassess methods if necessary
	Injury or accident to applicator	• Halt operations • Contact emergency medical provider as needed • Notify Plan Coordinator
Bottom Barrier	Barrier becomes dislodged	• Flag area with warning markers or buoys • Notify property owner • Notify Plan Coordinator • Remove or re-anchor barrier within 24 hours • Determine cause of failure
	Turbidity exceeds permitted level	• Halt installation • Notify Plan Coordinator • Install turbidity curtain
Diver-assisted Suction Removal	Turbidity exceeds permitted level	• Halt operations • Notify Plan Coordinator • Install turbidity curtains • Evaluate operational methods
	Diver injury or accident	• Halt operations • Use standard SCUBA emergency notification procedure • Contact emergency medical provider as needed • Notify Plan Coordinator • Evaluate operational methods

Evaluating and Reporting

Regardless of the plant control method used at a specific location, monitoring of water quality parameters as required by permits issued for implementation of the Plan will be completed at each area before and after treatment and reported. In addition to water quality sampling, other performance metrics will be measured pre- and post-treatment and will be summarized to evaluate the control methods used. These performance metrics are described more fully in the Adaptive Management Section.

Tahoe Keys and Lake Tahoe - Copyright 2006 Regents of the University of California. Photo used by permission

The results of all the aquatic plant control work will be summarized on an annual basis reported to the Lahontan Water Board. An annual public meeting will be convened to discuss results of the report.

Putting it all Together: Full implementation of the Plan

In accordance with the WDRs issued by the Lahontan Water Board, the Plan must be in effect starting in 2016. The TKPOA will begin using all approved methods and refining methods, such as improving the mechanical harvesting techniques and utilizing state-of the-art reporting to describe the locations, types, and amounts of aquatic plants throughout the Tahoe Keys lagoons.

A summary of all the aquatic plant control methods that are proposed for use throughout the Tahoe Keys lagoons is shown below in Table 8. The table describes sites and the proposed methods of control at each site, and is keyed to the accompanying maps. This proposed implementation plan integrates aquatic plant control methods across the Tahoe Keys lagoon system. Certain control methods are proposed at each site, but multiple compatible control methods could be used at any of the sites if that is warranted by the conditions of any given year. Multiple control methods could be used in sequence as well, if needed.

The recommended implementation of the Plan over time is based on certain rationales and anticipated outcomes.

- In 2016, no herbicide use is planned. Non-chemical methods and improved mechanical harvesting methods will be used, including using boats to collect fragments and GPS to track harvesting machines to increase efficiency of harvest routes.

- In 2017, a small number of sites are slated for treatment with approved aquatic herbicides. These sites are primarily dead-end coves with the greatest distances from the channels that connect to Lake Tahoe. This approach will allow for initial assessment of herbicide efficacy and to confirm projected movement and dissipation of herbicides from the Rhodamine WT study.
- In 2018, the scale of approved aquatic herbicide is similar to 2017 and it is anticipated that there will be a reduced need for mechanical harvesting as a result of the 2017 control work.
- In 2019, approved herbicides will be used on approximately 80 acres. This is contingent upon determining the efficacy of prior years' work, results of movement and dissipation studies, and plant conditions in 2019. The total acreage treated may vary but will not exceed 80 acres.
- In 2020, it is anticipated that there will be a reduced need for aquatic herbicides, but applications may be made in areas not treated since 2017. Actual control treatment in 2020 may vary from what is proposed here and is based on results from the prior years and evaluation through the adaptive management process, which could indicate fewer sites being treated with aquatic herbicides or using small-scale diver-assisted suction removal or installation of bottom barriers.

Table 8. Summary of Proposed Methods by Year, Area, and Site

Control Method: Summary by Acreage		2016	2017	2018	2019	2020
Harvesting (Hv)		132	122	70.3	34.2	27
Bottom Barriers (B)*		4.9	1.9	0.5	0.5	0
Diver-Assisted Suction Removal (D)		4.2	3.2	0	2.2	0
Herbicide (He) or Herbicide with Impermeable barrier (He-Ip)		0	38.9	47.4	79.7	44.7
Control Method: Summary by Site, Size in Acres		**2016**	**2017**	**2018**	**2019**	**2020**
1	6.3	Hv	Hv	He	-	He
1a	0.6	Hv	Hv	-	-	He
1b	0.6	Hv	He	-	-	
1c	0.6	Hv	He	-	-	He
2	0.5	B	-	B	B	
3	0.28	B	B	He	-	He
4	0.75	Hv	Hv	He-IP	-	He IP
5	2.75	D, B (D = 1 acre; B = 1.75 acre	Hv	Hv	He, IP	
6	4.0	Hv	Hv	Hv	Hv	Hv
7	8.7	Hv	Hv	He		He
8	19.23	Hv	Hv	Hv	He	
9	1.5	D	He		He	
10	20.3	-	Hv	He-IP	-	He- IP
10a	2.82	-	Hv	He-IP	-	He- IP
10b	1.0	D	D	He-IP	-	He- IP
11	23.0	Hv	Hv	Hv	Hv	Hv
12	7.19	Hv	Hv	Hv	He- IP	
12a	0.75	B	He-IP		He- IP	
13	3.17	Hv	Hv	He	-	
14	3.0	Hv	Hv	Hv	He	

Summary of Proposed Methods Implemented by Year, Total Area, and Site (con't.)

Control Method: Summary by Site, Size in Acres		2016	2017	2018	2019	2020
15	3.0	Hv	He		He	
16	2.75	Hv	He		He	
17	2.33	Hv	He	-	He	-
18	2.6	Hv	He	-	He	-
19	2.12	Hv	Hv	Hv	Hv	-
20	3.39	Hv	Hv	Hv	Hv	-
21	1.49	Hv	He-IP	-	He	-
22	1.66	Hv	Hv	Hv	Hv	-
23	1.3	Hv	Hv	He IP	-	He- IP
24	1.14	Hv	Hv	He	-	He
25	0.68	B	B	He	-	He
26	0.20	B	B	He	-	He
27	2.76	Hv	He	-	He	-
27a	0.3	D	He	-	He	-
27b	0.35	D	He	-	He	-
28	5.8	Hv	Hv	-	He- IP	-
29	4.0	Hv	Hv	Hv	He- IP	-
30	3.31	Hv	He	-	He	-
31	2.27	Hv	He	-	He	-
32	3.91	Hv	He	-	He	-
33	3.72	Hv	He	-	He	-
34	6.67	Hv	He	-	He	-
35	0.75	B	B	He-IP		-
36	1.17		D	-	D	-
37	1.02		D	-	D	-

Key:
B = Bottom barrier | D = Diver-assisted suction removal | He = Herbicide (Approved) | IP = Impermeable partition installed (e.g. polyethylene or PVC material) | Hv = Harvester

Note: Actual use of any method will depend on (1) results of current year's Plant Survey (2) Lake Tahoe water level and seasonal conditions; and (3) evaluation of previous year's work implementing the IWMP. Yearly adjustments will be made to management schedules and procedures through the Adaptive Management protocols of the IWMP to optimize effectiveness and environmental protection.

Figures 19 through 23 show the locations of the proposed aquatic plant control methods throughout the Tahoe Keys lagoons by year from 2016 to 2020.

Summary

Adaptive Management is an important element of the Plan. As refinement and optimization of feasible methods are developed, adjustments will be made to insure that the most effective methods are used. Potential new or improved technologies for control and monitoring will be evaluated as they are identified.

Once all aquatic plant management methods have been optimized for the Tahoe Keys lagoons, the TKPOA will be able to fully integrate all feasible control methods for aquatic plant control. Full implementation will include additional detailed monitoring and evaluation to develop a final program for control that can be continued through 2020. Depending on the response to management approaches deployed, an update of the Plan may be necessary to address changed conditions such as overall lake water level, temperature profiles, aquatic plant distribution and abundance. Such adjustments are necessary and are an essential strategy of a successful management program.

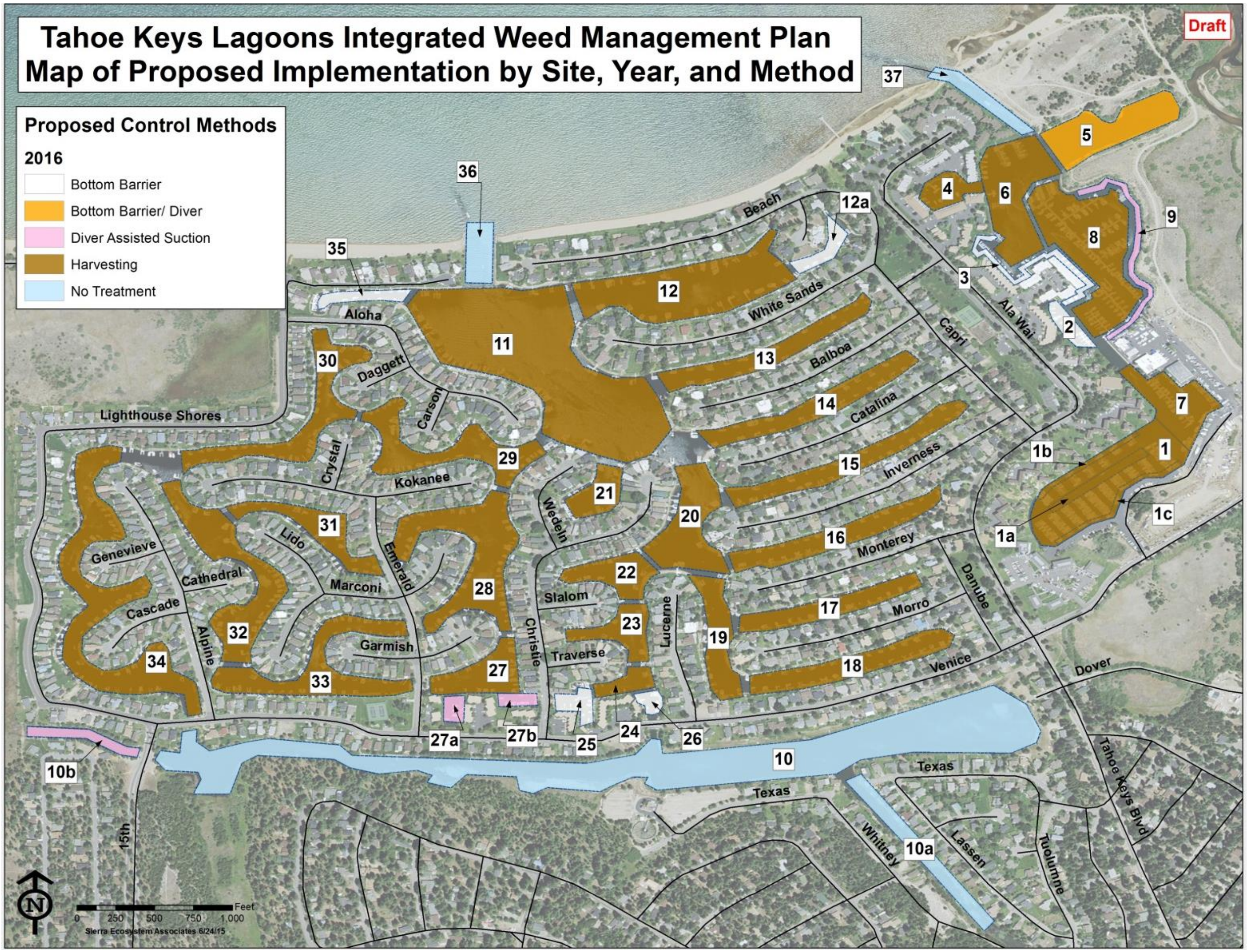


Figure 16. Proposed Aquatic Plant Control Methods, 2016, Tahoe Keys Lagoons, Overall

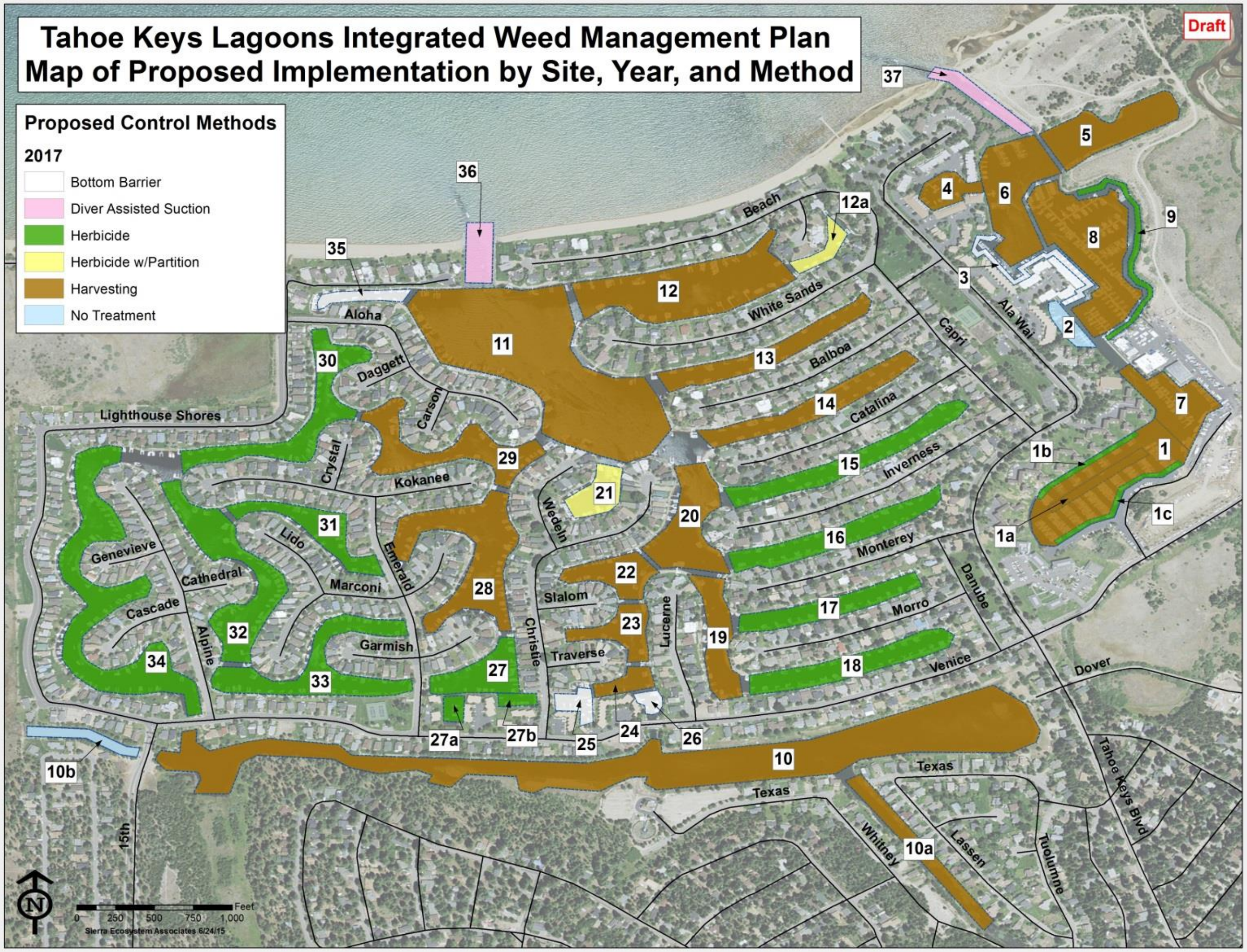


Figure 17. Proposed Aquatic Plant Control Methods, 2017, Tahoe Keys lagoons, Overall

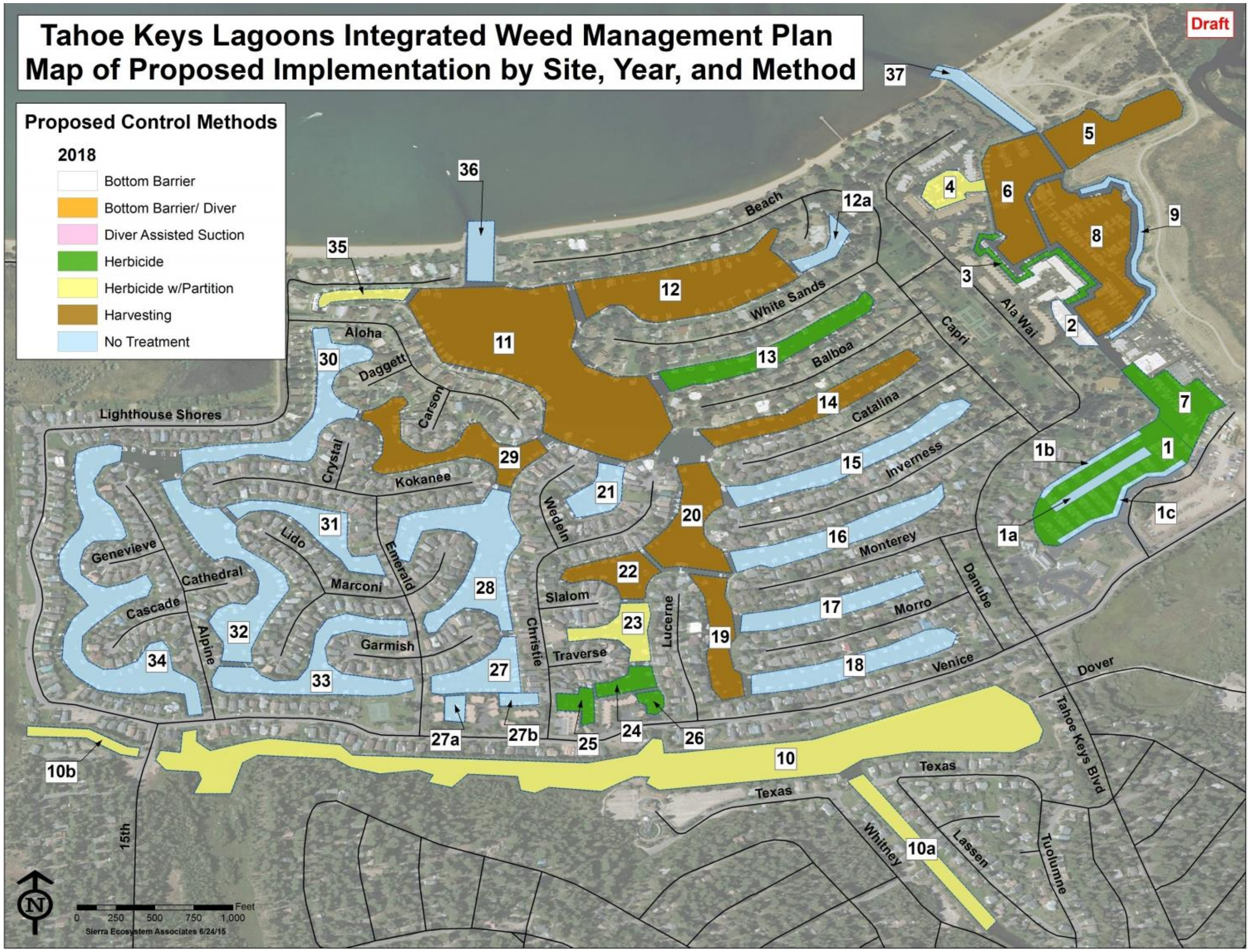


Figure 18. Proposed Aquatic Plant Control Methods, 2018, Tahoe Keys Lagoons, Overall

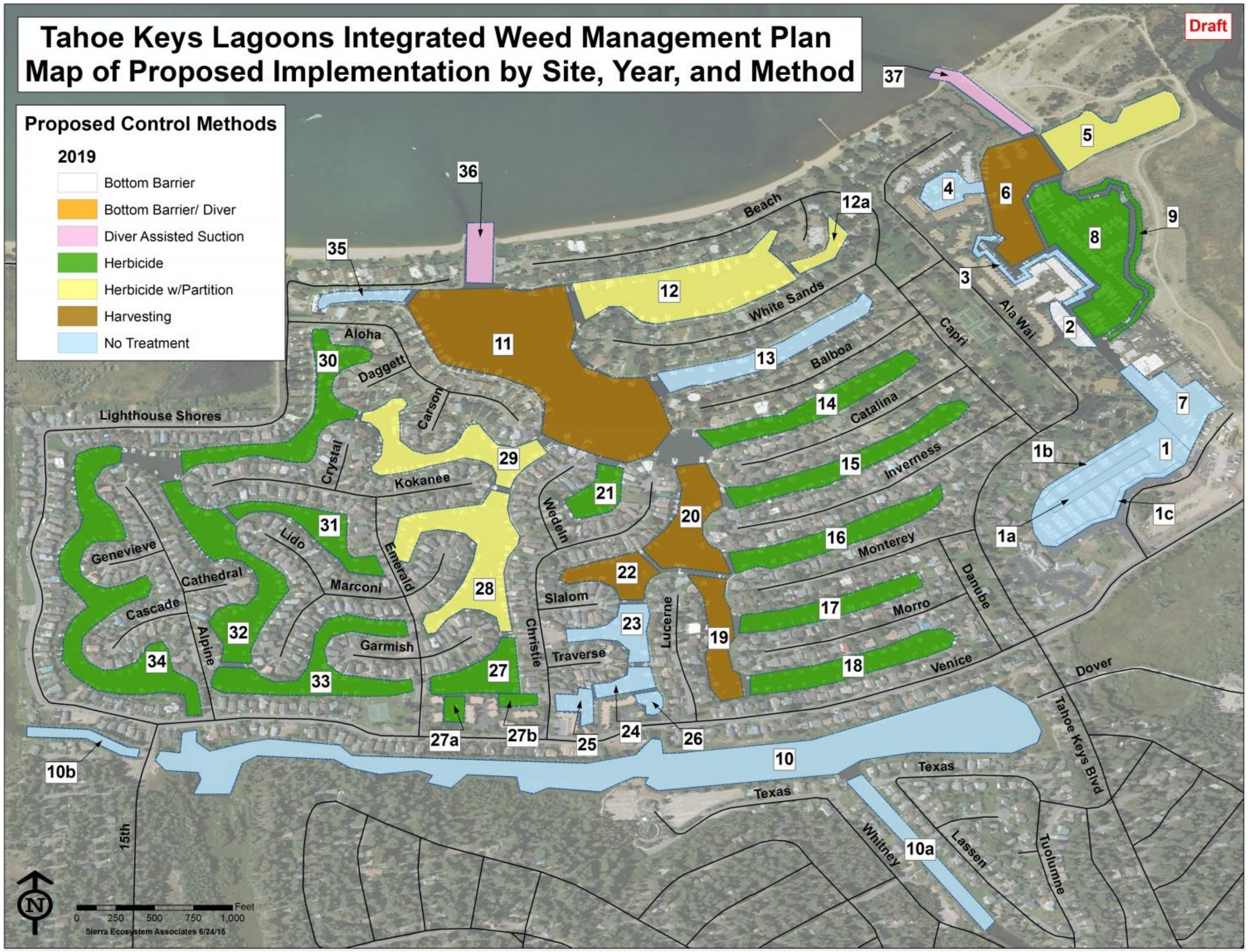


Figure 19. Proposed Aquatic Plant Control Methods, 2019, Tahoe Keys Lagoons, Overall

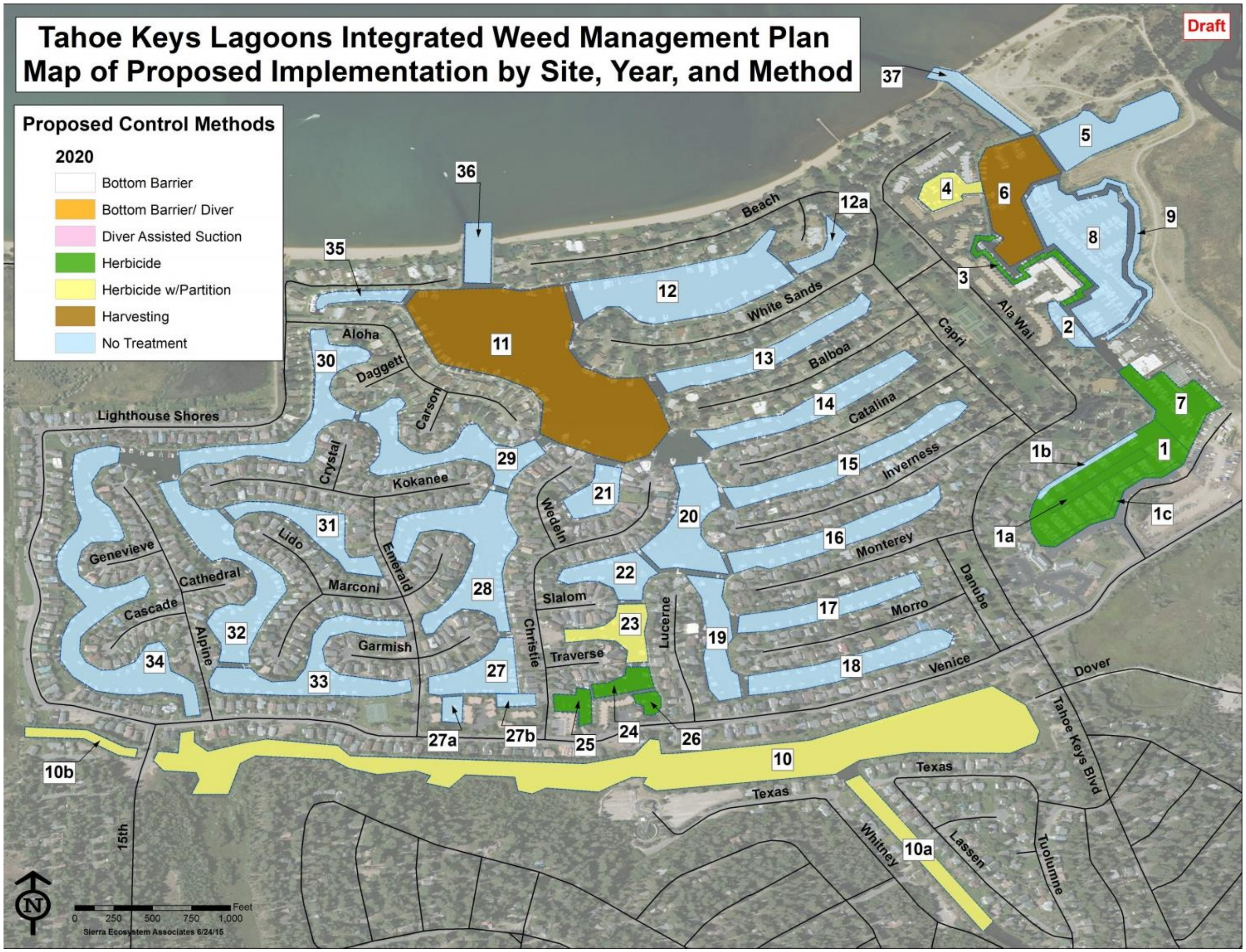


Figure 20. Proposed Aquatic Plant Control Methods, 2020, Tahoe Keys Lagoons, Overall

6.0 ADAPTIVE MANAGEMENT AND EVALUATION OF EFFICACY

Photo Courtesy of Community Ink

6.1 Adaptive Management

This Plan has been developed to provide the managers of the Tahoe Keys lagoons as well as the residents of the Tahoe Keys a clear strategy to control nuisance aquatic plants. Priorities for control must remain flexible to adapt to changing conditions and an iterative process between actions and efficacy in order to fulfill the Goal and Objectives of the Plan.

The Plan is a working document that will guide management of nuisance aquatic plants and an established review schedule is necessary so that adjustments can be made as needed. This review may be part of the reporting requirements of permits issued for aquatic plant control work.

An Aquatic Plant Control Advisory Committee composed of residents of the Tahoe Keys, managers of the TKPOA, Tahoe Beach and Harbor Association, the Tahoe Keys Marina, Lagoon Partners Inc., the California-Tahoe Conservancy, and resource agencies will be established. The responsibilities of this committee will be:

- Reviewing the plant survey information to track efficacy of control
- Making recommendations on next steps for control work
- Ensuring that the stated Goal and Objectives of the Plan are being met
- Acting as spokespeople to explain the control work to the residents and other interested members of the public

The review should also assess the compatibility of the control work with normal activities in the area, and the cost of treatment.

6.2 Evaluate Efficacy of Control Work

A consistent and systematic approach to monitoring the populations of nuisance aquatic plants is required to determine the efficacy of the treatment methods and is essential to adaptive management. Using established protocols ensures that surveying methods will be consistent year to year and across all treated areas.

The survey data must be summarized in a written report for review by the Aquatic Plant Control Advisory Committee. To aid in this review, an index will be created which reports the aquatic plant population in an objective manner so that treated locations can be compared to each other.

Two levels of surveying will be established. The first level, Stage 1, will be used while aquatic plant canopies are dense and pose problems to navigation and recreational use. Stage 1 evaluations will help determine which control methods are the most effective. Once aquatic plant populations have been brought to acceptable levels, the second level of surveying, Stage 2, will be used to widely survey the Tahoe Keys lagoons to detect and locate new populations or re-introductions of aquatic plants so that control work can be conducted in a timely manner to prevent an infestation. These area-wide surveys of the Tahoe Keys lagoons should be conducted every few years. The Stage 2 surveying should rely on the protocols and reporting methods developed for Stage 1 Surveying and Reporting.

All surveys will target submerged aquatic plants in the treated areas of the Tahoe Keys lagoons. The surveys will be timed to coincide with peak growing period and biomass accumulation for Eurasian watermilfoil, curlyleaf pondweed, and coontail. This time period for surveys will vary from year to year depending on climatic conditions but will typically take place during mid- to late summer.

The following information will be collected at each observation point:

- Sample date and time
- Water depth and surface elevation
- Presence or absence of macrophytes
    If present:
    - The relative plant density will be recorded
    - The species composition of the sample taken will be determined
- The volume of aquatic plants and the vessel hull clearance will be determined by hydroacoustic sampling
- Location of observation point with GPS coordinates

In addition to the aquatic plant population surveys to assess conditions, monitoring will be conducted to evaluate efficacy of the aquatic plant control methods used throughout the Tahoe Keys lagoons, as described in the Recommended Plan Implementation in Chapter 5. The monitoring metrics for efficacy of control methods will be:

- Biovolume of aquatic plants present: this is a measure of the quantity of aquatic plants present and will be determined using hydroacoustic sampling methods. The performance metric is a reduction of 70% from pre-treatment volumes.
- VHC (Vessel Hull Clearance): this is a measure of the distance between the tallest plant and the water surface which will be determined using hydroacoustic sampling methods. The performance metric for VHC will be 4 to 6 feet, and is site-specific, depending upon location and boat traffic.
- No adverse non-target effects. Aquatic plant control methods used should have minimal impact to non-target organisms, such as fish and other benthic organisms.
- Measurable increase in native plants as a percentage of all aquatic plants: geo-referenced point sampling will be done by taking physical samples to determine which aquatic plants are present and their relative abundance and results compared to pre-treatment levels.
- Reduction in fragment production. Reducing the number of plant fragments is an important Objective of the Plan and will be met by improving harvesting techniques to capture fragments and by

reducing the total acreage that is treated by mechanical harvesting. The performance metric is a reduction of 50% from pre-treatment levels

- Reduced use of fossil fuels for aquatic plant management. Reducing the production of greenhouse gases needed for aquatic plant control is another important Objective of the Plan. With improved control methods, it is anticipated that fewer acres will require treatment with mechanical harvesters, which burn fossil fuels, and a smaller volume of plant material will be hauled off-site.

Performance criteria for effective aquatic plant control have been selected and are summarized in Table 9. The rationale for selecting the criteria is that current operations are:

- Failing to reduce populations and volumes of nuisance aquatic plants such that recreational use of the Tahoe Keys lagoons is impaired.
- Creating a large number of viable aquatic plant fragments than have the potential to disperse to other locations within the Tahoe Keys lagoons and to Lake Tahoe and are stimulating re-growth of aquatic plants.
- Leaving areas that are difficult to reach untreated, such as areas behind docks and piers. These unmanaged and uncontrolled areas serve as refuge for non-native fish and provide sources of re-infestation through growth and production of viable plant fragments.

The performance criteria are based on the projection that integrating all approved methods will maintain VHC for safe navigation and recreation in the Tahoe Keys lagoons, improve habitat for native benthic species, minimize the potential to spread aquatic plant fragments, and reduce impacts to non-target organisms. The performance criteria to be met as a percentage of the total area treated by a control method is summarized in Table 9. For example, with improved Mechanical Harvesting and Fragment Capture, acceptable performance criteria are that in 20% of the area treated, there will be a reduction in biovolume of target plants of 70%, that the required VHC will be met in 10% of treated area, and that there will be no adverse non-target effects in 70% of the treated area.

Table 9. Summary of Performance Criteria

Control Method:	Improved Mechanical Harvesting and Fragment Capture	Approved Aquatic Herbicide Application	Bottom Barrier Installation	Diver-assisted suction
Metric:				
Biovolume of target plants reduced by 70%	20%	75%	5%	<2%
VHC sustained June to October	10%	85%	60%	60%
No adverse non-target effects	70%	95%	70%	70%-80%
Measureable increase in native plants as percentage of all aquatic plants	10%	70%	50%	100%
Reduction in fragment production by 50%	5%	95%	70%	100%
Reduced use of fossil fuels for aquatic plant management	5%	80%	70%	95%

Table 10 shows how the performance criteria and other monitoring parameters will meet the Goal and Objectives for the Plan:

Goal: *To help protect the ecology, to enhance the recreational and aesthetic qualities, and to maintain the commercial uses of Lake Tahoe by controlling nuisance aquatic plants in the Tahoe Keys lagoons.*

Table 10. Success Matrix

Objective	Monitoring Parameters	Success Criteria
Minimize the potential to spread aquatic invasive plants from the Tahoe Keys lagoons to Lake Tahoe.	○ Quantify fragment production and export from the Tahoe Keys lagoons before and after modification of harvesting practices and equipment.	○ Demonstrate reduced fragment and propagule export from Tahoe Keys lagoons after modifying harvesting practices and equipment. ○ Reduced acreage treated with mechanical harvesting that otherwise would produce propagules.
Enhance habitat for native fish, waterfowl, and other native wildlife species and reduce habitat for non-native, warm-water fish in the Tahoe Keys lagoons.	○ Focused surveys for aquatic plants. ○ Water quality	○ Reduced biomass or reduced volume of non-native aquatic plants in the Tahoe Keys lagoons. ○ Increased ratio of native to non-native plants. ○ Meet LRWQCB Water Quality Objectives.
Restore recreational uses in the Tahoe Keys lagoons and commercial and institutional uses in the Marina Lagoon.	○ Vessel Hull Clearance ○ Customer Satisfaction Surveys	○ Improved Vessel Hull Clearance ○ Improved satisfaction by users
Establish a long-term management program which: ○ Uses the best available technologies to monitor conditions in the Tahoe Keys lagoons to reduce maintenance inputs and costs. ○ Utilizes feasible, cost-effective methods to control nuisance aquatic plants in the Tahoe Keys lagoons.	○ Hydroacoustic surveys for plant volume ○ GIS-based maps of infestations ○ GIS-based maps of control work ○ Maintenance costs	○ Improved vessel hull clearance. ○ Reduced biomass and volume of aquatic plants. ○ Reduced maintenance inputs and costs. ○ Maps of real-time conditions and maintenance activities available to Tahoe Keys residents.
Assist the Tahoe Region in achieving goals for reductions in greenhouse gas emissions, as described in the Sustainable Communities Action Plan, by minimizing the air quality impacts of aquatic plant maintenance actions.	○ Carbon footprint of maintenance activities.	○ Reductions in use of fossil fuels with reduced acreage treated with mechanical harvesters.

7.0 PUBLIC INVOLVEMENT

The TKPOA Water Quality Committee has sought guidance on aquatic plant control options from recognized experts in the science of aquatic invasive species, from regional stakeholders, and interested members of the public. Comments and recommendations were received and thoroughly considered in the development of the Plan. Advice and guidance provided by these participants were essential to the development of the Plan. The members of the Water Quality Committee express their deep appreciation to those who devoted time and energy to this project.

Public involvement in the Plan came from four groups and contributions from each group are described here:

1. Expert Review Panel members:
    - Joe DiTomaso, Ph.D., UC Davis Cooperative Extension, Panel Chairperson
    - Sudeep Chandra, Ph.D., University of Nevada, Reno
    - Joel Trumbo, California Department of Fish and Wildlife
    - Patrick Akers, Ph.D., California Dept. of Food and Agriculture
    - Kurt Getsinger, Ph.D., US Army Engineer Research and Development Center

The Expert Review Panel worked closely with Dr. Lars Anderson to evaluate all aquatic plant control methods to determine their suitability and potential efficacy in the Tahoe Keys lagoons.

2. Technical Review Working Group members:

Mollie Hurt, Nicole Cartwright (TRCD), Jesse Patterson (League to Save Lake Tahoe), Aaron Park (USACE), Dennis Zabaglo (TRPA), Angela Calderaro, Angie Montalvo (CDFW), Dan Sussman (LRWQCB), Edward Hard (CDBW), Jacques Landy (US EPA), LeeAnne Mila (El Dorado County Dept. of Agriculture), Sarah Muskopf (USFS), Russell Norman (SWRCB), Penny Stewart (California-Tahoe Conservancy), Madonna Dunbar, A. Gregory Reed (TWSA), Andrea Seifert (NV Div. of Environmental Protection), Geoff Schladow (TERC), Harold Singer (Sierra Club), Jason Ramos (CA State Lands Commission), Jennifer Lukins (Lukins Brothers Water Company), Kim Tisdale (NV Div. of Wildlife), Tyler Alves (South Tahoe PUD), Harry Dotson (TKPOA Water Quality Committee), Kenneth Rollston (Lagoon Partners, Inc.).

The Technical Review Working Group reviewed the drafts of the Plan and provided numerous helpful comments and suggestions.

3. Environmental Review Working Group members:

Dennis Zabaglo (TRPA), Angela Calderaro, Angie Montalvo (CDFW), Bruce Warden (LRWQCB) Nicole Cartwright (TRCD), Aaron Park (USACE)

The Environmental Review Working Group reviewed the draft plan and collaborated on how to efficiently and effectively undertake the review through CEQA, NEPA, and the TRPA Environmental Improvement Program.

Public involvement and oversight by recognized experts in the field of aquatic invasive species are essential to the success of the Plan and will continue through the Adaptive Management protocols.

A summary of the comments received from the Technical Review Working Group on aquatic plant control methods is given below with a brief explanation of their suitability to the Plan.

Table 11. Summary of Comments Received

Comment or Suggestion from Technical Review Working Group members	Response
***Mechanical Removal*:**	
Dewater the Tahoe Keys lagoons to remove aquatic plants. **Consider installing permanent locks at each end of the channel (for dewatering.)**	The drought conditions of 2015 present what is likely a unique opportunity wherein areas of the Tahoe Keys lagoons have in effect been dewatered, thereby exposing aquatic plants that were once submerged. This natural event may help reduce plant populations in the shallow coves by killing plants and their roots. However, even in low water years, large areas of the Keys remain sufficiently deep to support the target aquatic plants. Therefore, efficacy of this control method would be limited. As described in Chapter 3, dewatering the Tahoe Keys lagoons as a method to control aquatic plants would interfere with the intended recreational uses of the Tahoe Keys lagoons. It would be very expensive to physically isolate areas to be dewatered and then to pump water out and keep areas sufficiently dry to kill the target nuisance plants. Dewatering is non-selective and other benthic organisms would be negatively impacted during drawdown. Dewatering also would pose a risk to the bulkheads along the perimeters of the lagoons.

Summary of Comments Received (cont.)

<table>
<tr><th>Comment or Suggestion from Technical Review Working Group members</th><th>Response</th></tr>
<tr><td>Use “rotovating” to remove plants, roots and rhizomes</td><td>This method is discussed in more detail in the Mechanical Control Methods section of the Plan. Rotovating has been used in ditches, ponds and small waterways where the primary goal was creating plant-free swimming areas and where preservation and sustaining native habitat was not an objective. The following are the reasons this method has not been included in the Plan:

• There are docks and piers found throughout the Tahoe Keys lagoons which would be obstacles to the rotovating machines and would limit the area in the Tahoe Keys lagoons that could be treated with this method.
• Rotovating disturbs the sediment layer causing an increase in turbidity of the water. Requirements of permits issued to undertake aquatic plant control specify turbidity limits and when the limit is reached, work must cease until acceptable levels are again reached.
• Rotovating creates many small plant fragments which can migrate from the treatment site unless an adequate screening method is used to capture them.
• Rotovating is non-selective: It mechanically injures native vegetation, invertebrates, and imperils fish. These impacts are counter to the goals and objectives of the IWMP.</td></tr>
</table>

Summary of Comments Received (cont.)

Comment or Suggestion from Technical Review Working Group members	Response
Cultural Control:	
Aerate and circulate the waters of the Tahoe Keys lagoons to reduce temperatures, reduce nutrient availability, and to oxygenate the waters.	The nuisance aquatic plants in the Tahoe Keys lagoons exist in the colder waters of Lake Tahoe, although not at the densities found in the waters of the Tahoe Keys lagoons. These plants are also known to overwinter under ice and snow. Reducing the temperature of the water has not been proven as a method of aquatic plant growth in lakes. Since the near-shore waters of Lake Tahoe already support growth of Eurasian watermilfoil and curlyleaf pondweed, the introduction of lake water would not be expected to impede nuisance growth of aquatic plants. The primary target aquatic plants in the Keys obtain the majority of their nutrients from the sediments, not from the water. Water circulation alone will not reduce the growth of the nuisance aquatic plants. However, reduction in overall nutrient loading is beneficial because it will help prevent algal blooms, particularly in years with low snowpack. An important component of the Plan is to educate homeowners about how they can help alleviate nutrient accumulation in the Tahoe Keys lagoons with judicious application of phosphorous –free fertilizers and reducing irrigation run-off from their properties, as has been done for the common areas that are planted and maintained by the TKPOA. Lack of oxygen in the waters of the Tahoe Keys lagoons has not been a documented problem and there are many fish species and benthic organisms that thrive in the lagoons, indicating sufficient oxygen. Temperature reduction, diluting nutrients in the waters of the Tahoe Keys lagoons with water from Lake Tahoe, and increasing oxygen levels are not in themselves proven methods for rooted aquatic plant control. Reducing on-going nutrient accumulation may help reduce the rate of plant growth, and this method of control is contained in the Plan.

Summary of Comments Received (cont.)

Comment or Suggestion from Technical Review Working Group members	Response
Install floating water treatment "islands" to take up excess nutrients in the waters of the Tahoe Keys lagoons.	Demonstration projects constructing "Floating islands" have been completed for stormwater retention ponds and wastewater treatment lagoons. The projects showed that the floating islands could remove significant amounts of nitrogen (in the form of ammonia) and nitrates from wastewater, could remove phosphorous, and could reduce the levels of total suspended solids. Floating islands would create obstructions that would not be compatible with the recreational uses of the Tahoe Keys lagoons and there are few locations where they could be installed. It has not been demonstrated that stormwater or irrigation run-off contribute to the nutrient levels in the waters of the lagoons to the extent that this problem cannot be addressed by other means such as with the best management practices for landscape maintenance that are an important part of the Plan. As part of the Adaptive Management of the IWMP, design and construction of floating islands could be considered if a design that is compatible with multiple uses of the Tahoe Keys lagoons is identified or if they could be safely installed without negatively impacting recreation.

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9.0 ACRONYMS AND GLOSSARY

AIS: Aquatic Invasive Species
AISCC: Aquatic Invasive Species Coordinating Committee
ACC: TKPOA Architectural Control Committee
BMP: Best Management Practice
CalEPA: California Environmental Protection Agency
CDBW: California Division of Boating and Waterways
CDFA: California Department of Food and Agriculture
CDFW: California Department of Fish and Wildlife
CDPR: California Department of Pesticide Regulation
CEQA: California Environmental Quality Act
CESA: California Endangered Species Act
COC: Chain of Custody
CSLC: California State Lands Commission
CTC: California Tahoe Conservancy
DO: Dissolved Oxygen
EIP: Environmental Improvement Program
EIR: Environmental Impact Report
EIS: Environmental Impact Statement
EPA: United States Environmental Protection Agency
ESA: Federal Endangered Species Act
FIFRA: Federal Insecticide, Fungicide and Rodenticide Act
GPS: Global Positioning System
HACCP: Hazard Analysis and Critical Control Plan
IWMP: Integrated Weed Management Plan
LBWC: Lukins Brothers Water Company, Inc.
LCT: Lahontan Cutthroat Trout
LRWQCB: Lahontan Regional Water Quality Control Board or Lahontan Water Board
LTAISCC: Lake Tahoe Aquatic Invasive Species Coordination Committee
NAWWG: Nearshore Aquatic Weed Working Group
NDEP: Nevada Division of Environmental Protection
NDOW: Nevada Division of Wildlife
NDSL: Nevada Division of State Lands
NEPA: National Environmental Policy Act
NPDES: National Pollutant Discharge Elimination System
O & M: Operation and Maintenance
PAR: Photosynthetically Active Radiation
PCAC: Plant Control Advisory Committee
QA/QC: Quality Assurance/Quality Control
RWQCB: Regional Water Quality Control Board
SEA: Sierra Ecosystem Associates
SLT: City of South Lake Tahoe

STPUD: South Tahoe Public Utility District
SWRCB: State Water Resources Control Board
TERC: Tahoe Environmental Research Center
TKB&HA: Tahoe Keys Beach and Harbor Association
TKPOA: Tahoe Keys Property Owners Association
TLOA: Tahoe Lakefront Owners Association
TRCD: Tahoe Resource Conservation District
TRPA: Tahoe Regional Planning Agency
TWSA: Tahoe Water Suppliers Association
UCD: University of California, Davis
UNR: University of Nevada, Reno
US EPA: United States Environmental Protection Agency
USACE: United States Army Corps of Engineers
USAERDC: US Army Engineer Research and Development Center
USDA: United States Department of Agriculture
USFS: United States Forest Service
USFWS: United States Fish and Wildlife Service
VHC: Vessel Hull Clearance
WDR: Waste Discharge Requirements
WQC: TKPOA Water Quality Committee

10.0 GLOSSARY

Adjuvant	A material added to aid or modify the action of an herbicide. Typical adjuvants help herbicides stick to plant surfaces or help disperse herbicides evenly.
Adsorption	Adhesion of atoms, ions, or molecules to a surface.
Assemblage	A collection or gathering of things having the same distinctive features which identify them from the others.
Bathymetry	The measurement of water depth at various places in a body of water or the information derived from such measurements.
Benthic	Relating to the bottom under a body of water.
Biomass	The mass of living matter in a specific area or habitat.
Biovolume	The volume of living cells or plants in a unit volume of water.
Chemical control	Pest control using pesticides, including herbicides.
Cultural control	A component of integrated pest control management which includes practices that reduce establishment, reproduction, dispersal, and survival of the target species which are not mechanical or chemical in nature. Cultural control can include changing human behaviors that otherwise would promote pest species.
Eutrophication	Excessive nutrients in a body of water which leads to dense growth of algae and death of animal life due to lack of oxygen.
Half-life	The time required for a specific property to decrease by half.
Lentic	Pertaining to or living in still water.
Mechanical control	Pest control practices which directly harm the target species or make the environment unsuitable for that species.
Nutrient Load	The quantity of nutrients entering an ecosystem in a defined period of time. Of particular concern are the amounts of nitrogen and phosphorus. Nutrient loading is affected by inputs from non-point sources such as surface runoff, erosion, and atmospheric deposition.
Nutrient pumping	Processes by which nutrients are moved from the underlying sediment to the water column above.
Propagule	A vegetative structure that can become detached from a plant and give rise to a new plant.
Residence time	The average time water, or a dissolved substance in water, is contained in a lake or reservoir. The average time a water molecule spends in body of water.
Resource reduction	Management practices that reduce the amount of resources needed, such as reducing water use, minimizing fertilizer use, or otherwise reducing the inputs to a system to decrease the impacts from the management on the natural environment.
Rhizome	A horizontal underground stem that can produce both shoots and roots.
Systemic	Affecting the entire organism; affecting an entire system.
Turbidity curtain	Also known as silt curtains, these floating barriers are commonly used in marine construction projects to control the silt and sediment in the water body.
Turion	An overwintering bud that can become detached and remain dormant in the water.
Translocation	Biological process wherein dissolved material is transported from one part of a plant to another part of the same plant.

Appendix A
Tahoe Keys 2014 Aquatic Plant Survey

Tahoe Keys Property Owners Association

Tahoe Keys 2014 Aquatic Plant Survey

Draft September 15, 2014

Tahoe Keys 2014 Aquatic Plant Survey

Prepared for

Tahoe Keys Property Owners Association

Draft September 15, 2014

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TAHOE KEYS 2014 BASELINE AQUATIC PLANT SURVEY REPORT

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1.0 OVERVIEW OF STUDY SITE

The survey area is The Keys residential subdivision inland waterways and coves and the Keys Marina, which consist of 144 acres of water surface accessible from Lake Tahoe through two boating channels (East Channel and West Channel). The area was developed on a man-modified, former wetland and includes 1,194 single family residential units and 335 townhouse residential units in addition to several common areas (LRWQCB 2014).

There are three main lagoons that are maintained as part of the Tahoe Keys: Marina Lagoon (East Basin), Main Lagoon (West Basin), and Lake Tallac Lagoon (southern border of The Keys). For this survey, only the Marina Lagoon and the Main Lagoon were sampled as they are directly linked to Lake Tahoe through the East and West channels, respectively.

1.1 Overview and Purpose of 2014 Aquatic Plant Survey

Native and non-native aquatic plants can be found in Lake Tahoe, but are limited primarily to near-shore zones where temperatures (due to shallow water), environmental nutrients, and urban stormwater contribute to favorable habitat conditions. Over the last few decades and more recently as part of the Lake Tahoe Aquatic Invasive Species (AIS) Program, increased efforts have been made to assess and implement control measures to reduce populations of invasive, non-native plants because they displace native plants, negatively affect water quality, and create habitats for other non-native species including warm-water fish.

The purpose of this 2014 baseline survey was to identify the distribution and relative (percentage) composition of aquatic plants throughout the Tahoe Keys and Marina areas. The results of the survey are compared to previous surveys conducted in 2009 and 2011 to identify changes in the areal distribution and percentage make-up of the aquatic plants. The 2014 survey was also to establish a baseline against which future years' surveys could be compared, which is required by the Lahontan Regional Water Quality Control Board (LRWQCB) waste discharge requirements (WDRs) that were issued for the Tahoe Keys in July 2014.

Eurasian Watermilfoil (*Myriophyllum spicatum*) and curlyleaf pondweed (*Potamogeton crispus*) are of special concern because they are non-native, highly invasive, and a key focus of the Tahoe Keys Property Owners Association's (TKPOA) current effort to develop an Integrated Management Plan (IMP) for the long-term control of invasive aquatic plants within The Keys and the Keys Marina waterways. Native aquatic plants including coontail (*Ceratophyllum demersum*) were also surveyed to establish baseline composition and distribution for comparison to future surveys.

Curlyleaf pondweed, Eurasian watermilfoil and coontail spread vegetatively and by seed. Vegetative spread is of particular concern. Fragments of Eurasian watermilfoil and curlyleaf pondweed can develop roots at nodes and can colonize where there is suitable substrate. Coontail, which has no true roots, spreads vegetatively by fragments. As the plants begin to establish the colony, they cycle nutrients for growth from the water and substrate. The plants lose leaves and die back at the end of the season, releasing nutrients into the water column and depositing particulate organic material on the substrate. The end result is an accumulation of biomass that affects the loading of phosphorus and nitrogen in the water column promoting nuisance plant establishment (Donaldson 2009). Vegetative plant parts can be spread by wave action, wind, or by attaching to a boat or swimmer and, being deposited in a hospitable site, start a new colony. In the case of curlyleaf pondweed, specialized dormant buds called turions are formed in the spring to early summer and detach from the plant when mature or disturbed by physical movement. The turions sink and typically sprout in fall. This deposition can take place near the original plant or after travelling a considerable distance while still attached to dislodged or cut shoots of curlyleaf pondweed.

Coontail is a native and spreads vegetatively as very small fragments or large clumps of plants. In nutrient rich areas, which includes natural and anthropogenic sources for the Tahoe Keys, it can form dense colonies that are anchored in the mud, entangled in other rooted vegetation, or floating freely (WSDE 2001). Dense canopies of coontail can create a problem for boaters by fouling propellers, rudders of sailboats, clogging cooling intakes and also pose a public safety threat to swimmers who may become entangled in the dense weeds.

Other native plant species that can be found in the Tahoe Keys include stonewort (*Nitella spp*.), Canadian waterweed (*Elodea canadensis*), filamentous algae (*Spirogyra spp*.), leafy pondweed (*Potamogeton foliosus*), water buttercup or "crows feet" (*Ranunculus* aquatilus), Richardson's pondweed (*Potamogeton richardsonii*), neddle spikerush (*Eleocharis acicularis*), and Andean watermilfoil (*Myriophyllum quitense*).

Native and non-native aquatic plants were largely absent within the Tahoe Keys and Marina waterways when they were first constructed over 50 years ago. By the 1980s, the aquatic plants reportedly were well established throughout the waterways, and there are only a few small areas today where there are no plants. Besides AIS and public safety concerns as noted above, the plants are also a nuisance to boating recreation and operations, they negatively affect the aesthetics of the waterways, and they also negatively affect native fish habitat, foraging conditions for raptors, and habitat conditions for waterfowl. The results of the 2014 comprehensive survey will help inform the preparation of the IMP and serve as a benchmark to which future management actions to control the plants can be measured.

1.2 Summary of 2014 Survey Results

The 2014 baseline survey included sampling and identifying all species within the East and West basins and providing a synthesis report of all findings. This report focuses primarily on the distribution of Eurasian watermilfoil, coontail, and curlyleaf pondweed. It also makes comparisons to past surveys, where applicable, to identify the spread, if any, of these plants.

The survey showed that, within the East and West basins, there is near complete plant coverage with the majority of the plant population consisting of Eurasian watermilfoil and coontail. Eurasian watermilfoil was found in higher densities in shallower waters near bulkheads and shorelines whereas coontail was found in higher densities in deeper channels.

When compared to previous surveys (2009 and 2011), the survey data shows that the relative abundance of Eurasian watermilfoil has been increasing over the years. The relative abundance of coontail and curlyleaf pondweed has been fluctuating over the years, which may be due to a variety of causes including variations in harvesting, changing nutrient conditions, and water level fluctuations. Some variations in sampling methods and sample locations between the surveys may also contribute to the variability.

2.0 METHODOLOGY

This section discusses the timing of the survey work, the manner of data collection, and the analysis methods used to interpret the data.

2.1 Timing of Survey Work

The survey was conducted on June 25, 26, 27, 30 and July 1. This is typically when all aquatic plant species are both evident and identifiable in this region. This time period was also chosen in order to coincide with germinating, sprouting, flowering or fruiting stages of the various species. Due to the short growing season in Lake Tahoe and the germination and sprouting timing of the aquatic plants of focus, only one period of data collection was considered sufficient to assess relative abundance.

Previous surveys were conducted in April of 2011 and May of 2009. During these times plant species are present and identifiable, but may not be flowering. These two previous surveys also differ from the 2014 survey in that they included limited sections of different coves within the East and West basins.

It should also be noted that 2014 is considered a drought year. Lake level for June 2014 averaged 6,224ft. In April of 2011 average lake level was 6,226 ft, and in May of 2009 average lake level was 6,224 ft (USGS 2014). Lower lake levels can result in higher densities of submersed plants and encourage some plants that require more light than is typically available during high water years.

2.2 Survey Data Collection

The survey focused primarily on submersed and floating-leaf aquatic plants in the littoral zones of the surveyed areas in the Tahoe Keys and Keys Marina. The Tallac Lagoon, fringe wetlands, and emergent species were not sampled.

Surveys were conducted by plunging a double-tined pole mounted “thatch” rake into the water to the bottom, twisting the attached vertical pole when retrieving the rake, and then identifying the plant species in the sample. Based on visual estimates, the percent species composition of rake sample was recorded at each georeferenced data point. Surveys included GPS locations of each rake toss and a visual estimate of percentage of each species found. Sample locations were evenly spaced along a somewhat linear transect that represented the conditions of the area and were accessed by boat. Water depth was also determined using reference marks on the pole attached to the sampling rake.

Floating plants, such as *Lemna* (duckweed), are not well sampled with the method used in this survey. However, *Lemna* was the only floating type aquatic plant observed and it was rare. In addition, due to curlyleaf pondweed‘s tough, less leafy stem and resistance to fragmenting, it may have been less efficiently sampled than Eurasian watermilfoil or coontail using the thatch rake.

2.3 Biomass Data Collection

Biomass data was collected using the sampling rake at selected sites throughout the Tahoe Keys. For each sample, net fresh weight was recorded after a 30-second drip time. Each biomass sample was weighed in kilograms using a digital scale (accurate to 0.05 kg). The wet weight of the empty sampling rake with its rope was recorded and deducted from the gross weight to determine the fresh weight of the plants on the rake.

2.4 Data Analysis

The spatial data were analyzed using ArcGIS 10.2 with Spatial Analyst. The composition maps created are thematic heat maps showing the distribution of a species based on percent of composition. The composition data was interpolated into a raster surface from points using an Inverse Distance Weighted (IDW) technique. IDW uses data points to predict the values of unsampled locations by weighting the surrounding values by distance. This tool interpolates the composition percentage of the data points into a surface that accurately displays the species composition and distribution within The Keys.

To compare the 2014 survey data with past (2009 and 2011) survey data, the current data were simplified to species presence or absence. This was then used to calculate the percent of occurrence for each species in eight (8) different coves (that were sampled in both the 2009 and 2011 surveys) by dividing the number of times a species occurred by the total number of samples for that area. For example, in 2011 the percent of occurrence for Eurasian watermilfoil in a specified sampling area was 66%. This means that 66% of the time it can be found in a sample within that area.

Correlation analyses were performed using the statistical package R version 3.1.1. The relationship between species composition and water depth was analyzed. The Pearson product-moment correlation coefficient (r) was calculated. This r coefficient is the most common measure of dependence between two quantities in which values of up to 1 (positive correlation) or -1 (negative correlation) are calculated and have the strongest association. A value close or equal to 0 indicates little or no association.

3.0 RESULTS

This section reviews the data collected and the initial analysis for the East and West basins. It also briefly reviews the biomass data collected and how collection techniques can be refined for future surveys.

3.1 Overview

A total of 625 samples were taken in the East Basin and 683 samples were taken in the West Basin. Of the 1308 samples taken, 69 included biomass measurements. As noted earlier, the Tahoe Keys now has almost complete aquatic plant coverage. Very few data points were collected with no species presence (Figure 1).

Figure 1. 2014 Aquatic Plant Survey Area

A total of nine aquatic, flowering plant species and one macro-alga were documented in this survey. Table 1 displays the submersed aquatic plant species found in the Tahoe Keys. Species composition maps showing the relative occurrence of each species independently are presented in Appendix A. Figure 2 shows percentages of species found throughout the study area.

Table 1. Submersed Aquatic Plant Species Found in the Tahoe Keys

Scientific Name	**Common Name**	**Code**	**Native (Y/N)**
Ceratophyllum demersum	Coontail	CeDe	Y
Myriophyllum spicatum	Eurasian Watermilfoil	MySp	N
Nitella spp.	Stonewort	NiSp	Y
Elodea Canadensis	Canadian Waterweed	ElCa	Y
Potamogeton crispus	Curlyleaf Pondweed	PoCr	N
Spirogyra spp.	Filamentous Algae	FiAl	Y
Potamogeton foliosus	Leafy Pondweed	PoFo	Y
Potamogeton richardsonii	Richardson's Pondweed	PoRi	Y
Eleocharis acicularis	Needle Spikerush	ElAc	Y
Myriophyllum quitense	Andean Watermilfoil	MyQu	Y

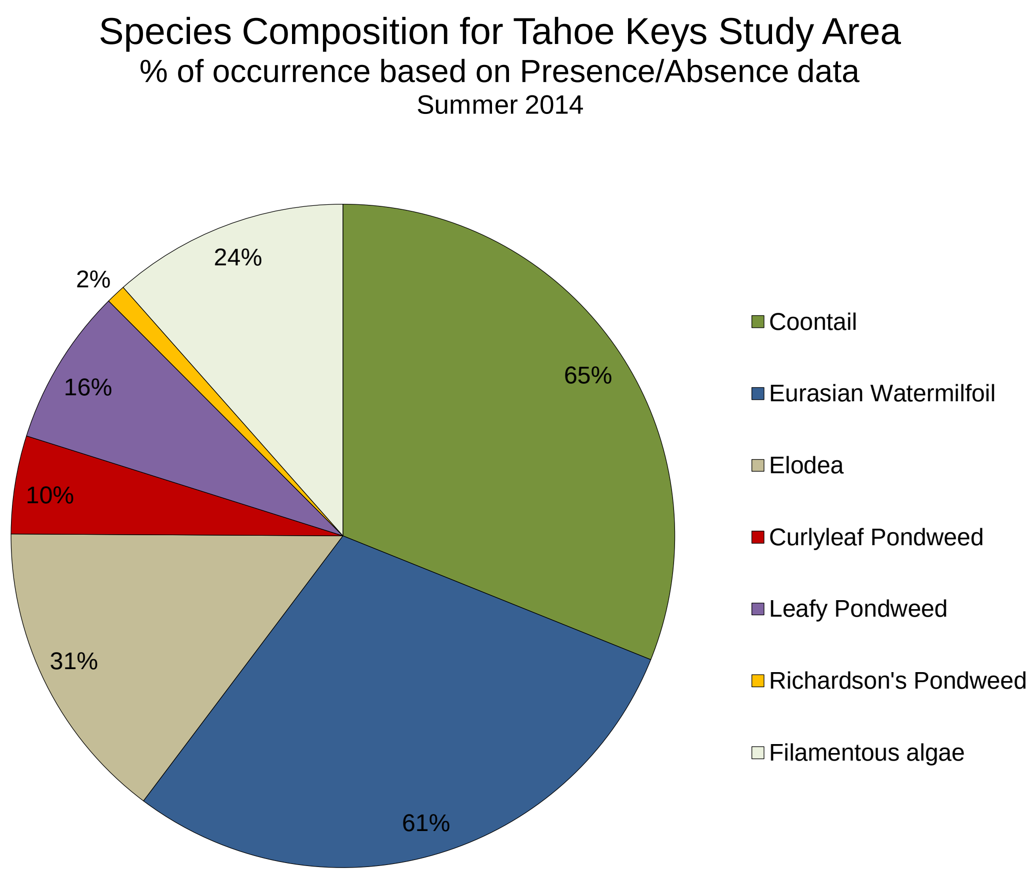

Figure 2. Species Composition for Tahoe Keys Survey Area (Presence/Absence)

3.2 Marina (East Basin)

Eight of the nine species found in the sampling area were found in the East Basin. These include coontail, Eurasian watermilfoil, Elodea, curlyleaf pondweed, leafy pondweed, Richardson's pondweed and needle spikerush. Only trace amounts of needle spikerush were found and amounted to less than one percent. Two types of algae, Nitella and filamentous algae, were also found in the East Basin. Of the species found in the East Basin, the ones with the highest percent of occurrence are coontail at 69%, Eurasian watermilfoil at 50%, filamentous algae at 32%, and Elodea at 20%. Percent of occurrence for all species in the East Basin are displayed in Figure 3.

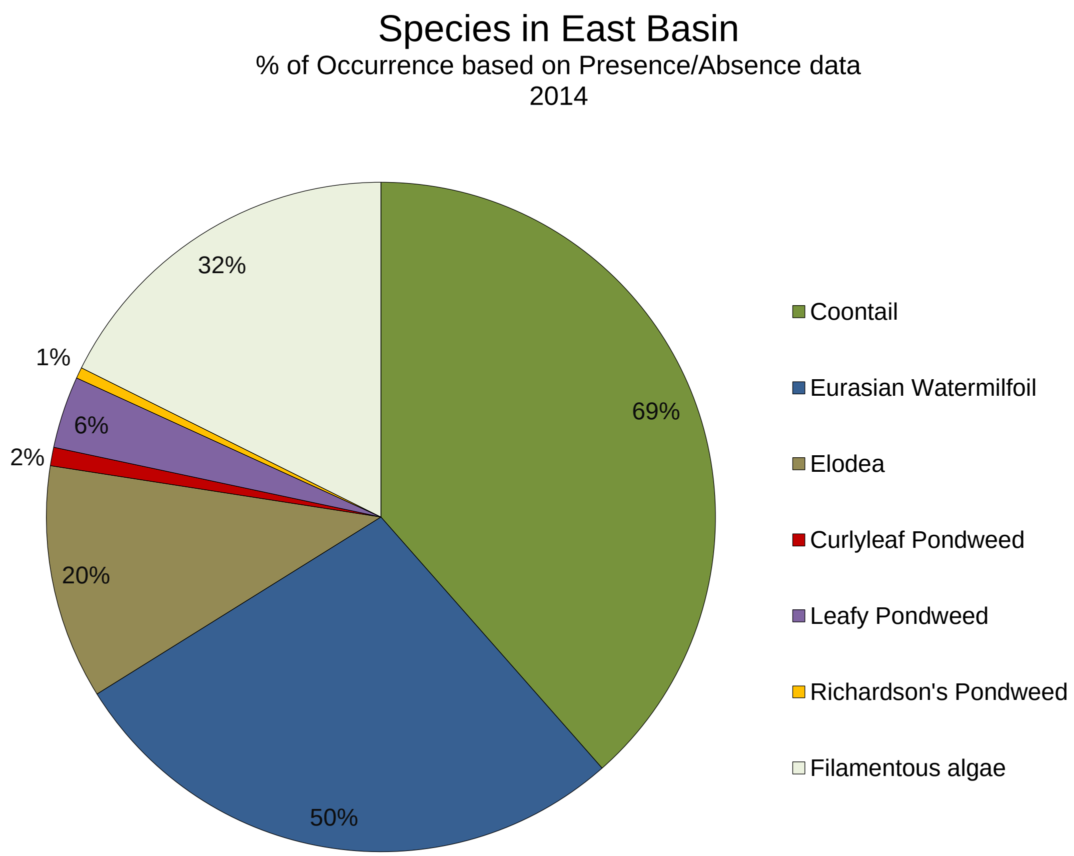

Figure 3. Species in East Basin (Presence/Absence)

Eurasian watermilfoil was primarily found in shallower waters near bulkheads as depicted in Figure 4. Coontail was found mostly in deep waters and channels. Traces of filamentous algae were found throughout the basin with a higher concentration on the east side of the main boat ramp dock in the East Basin (Marina). Elodea was found in relatively small percentages sporadically throughout the basin. Curlyleaf pondweed was only found in a few places in the East Basin in which the water was shallower such as in the turning basin in the northeast portion of the survey area. Appendix A presents species-specific composition maps for this area.

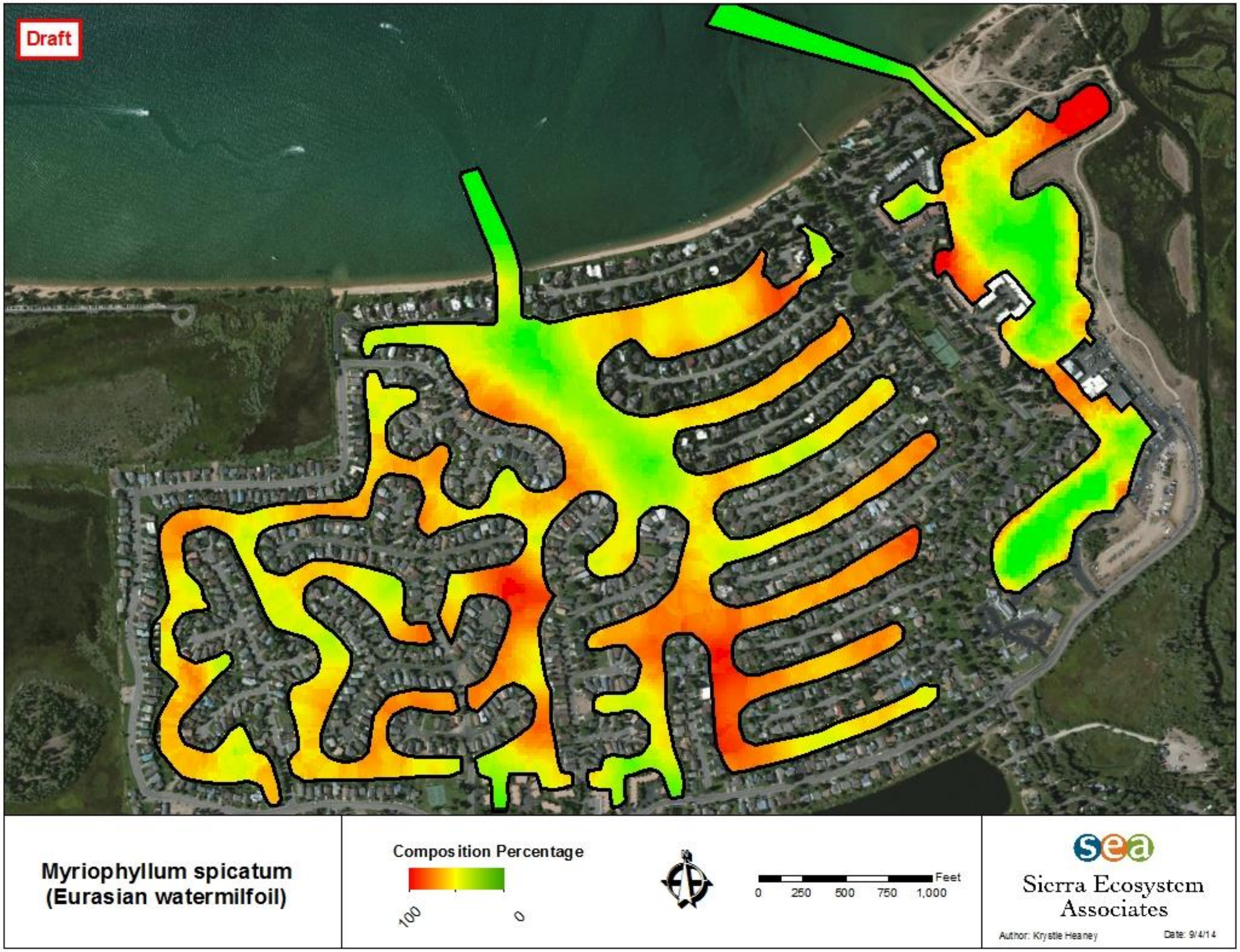

Figure 4. Milfoil Composition Map

3.3 Keys (West Basin)

All of the species of the survey can be found in the West Basin. Of these species the most prevalent were coontail at 61%, Eurasian watermilfoil at 72% and Elodea at 41%. Curlyleaf pondweed was observed in bands along the coves off the main channel but was probably not as effectively sampled compared to Eurasian watermilfoil and coontail. Percent of occurrence for all species in the West Basin are displayed in Figure 5.

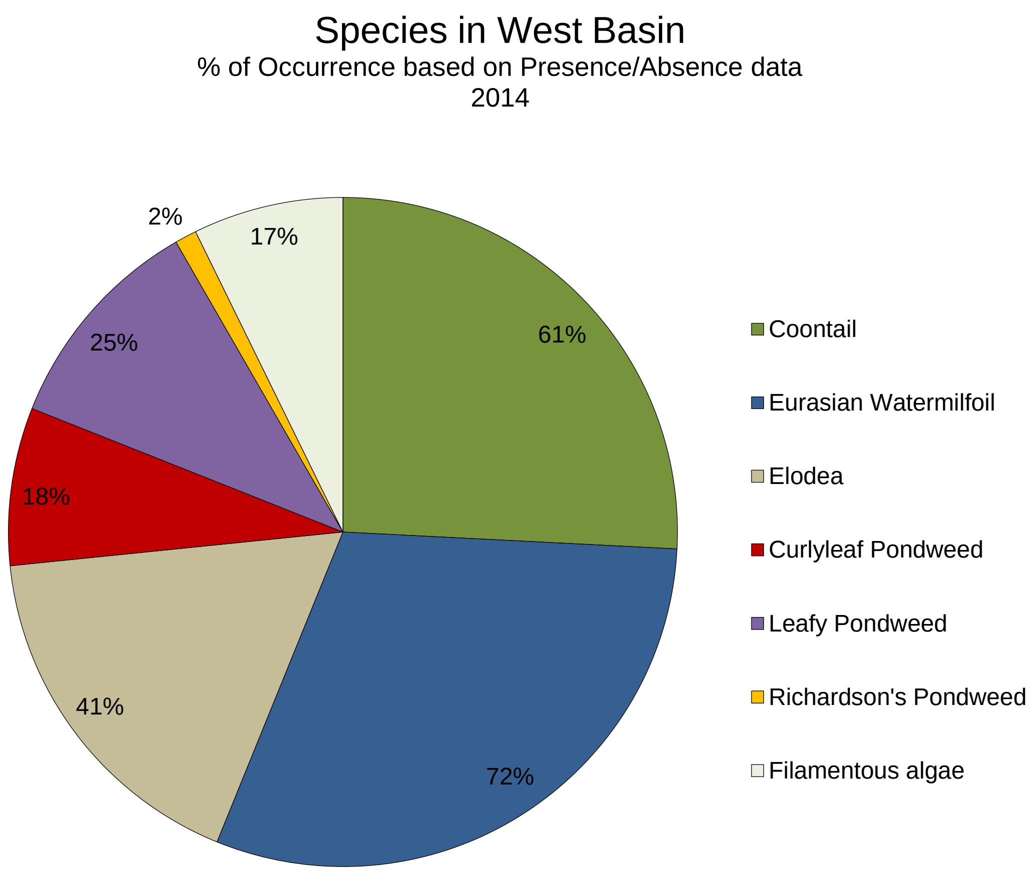

Figure 5. Species in West Basin (Presence/Absence)

Eurasian watermilfoil occurrences were found more often and in higher composition percentages throughout the West Basin while coontail was found in the deeper channels. The water in the West Basin is generally shallower than the East Basin which creates more improved habitat for invasive species such as Eurasion watermilfoil (Smith and Barko 1990). As with the East Basin, *Elodea* was found sporadically throughout the basin.

4.0 DISCUSSION AND ANALYSIS

Of the nine aquatic species that were found in the Tahoe Keys, the most frequently collected were Eurasian watermilfoil and coontail. Observations also include a prominent population of curlyleaf pondweed in the West Basin but, due to the sampling technique and plant structure characteristics, this plant was likely underrepresented by the data.

When compared to previous years, the population of Eurasian watermilfoil appears to be increasing while the population of coontail is decreasing. The increased presence of Eurasian watermilfoil in the Tahoe Keys is of particular concern. A denser population increases the possibility of the species spreading to other areas around Lake Tahoe. The decrease of coontail may be attributed to the lower than normal lake level recorded in June 2014, as there is a strong positive correlation between water level and the density of coontail, which is described in Section 4.1 below.

4.1 Species Composition

The distribution of the plant species is clearly stratified with Eurasian watermilfoil inhabiting the shallower waters near the shore and coontail almost completely dominating the deeper channels. In addition, Eurasian watermilfoil and curlyleaf pondweed were observed more often in the West Basin than in the East Basin. Based on correlation analysis between depth and species density, the increased presence of Eurasian watermilfoil is likely due to the shallower depths of channels in the West Basin, which has an average depth of 6.4 feet whereas the East Basin has an average depth of 9.6 feet. The higher occurrence of curlyleaf pondweed in the West Basin may be attributed to the decreased amount of boating activity and disturbance (Moore 2008). Other native species were found sporadically throughout the two basins.

A correlation analysis was conducted to determine the relationship between depth and percent composition for coontail and Eurasian watermilfoil. It was found that, the deeper the water, the higher the percent of coontail ($r=0.70$) (Figure 6) and the shallower the water, the higher percent of Eurasian watermilfoil ($r=-0.63$) (Figure 7). Both r coefficients indicate a strong correlation between depth and species composition. Eurasion watermilfoil has a moderately strong negative correlation with depth while coontail has a strong positive correlation with depth. This means that as water levels in The Keys drop, the population of Eurasian watermilfoil may outcompete the native coontail. Figure 8 displays an example of this depth correlation in a portion of the East Basin.

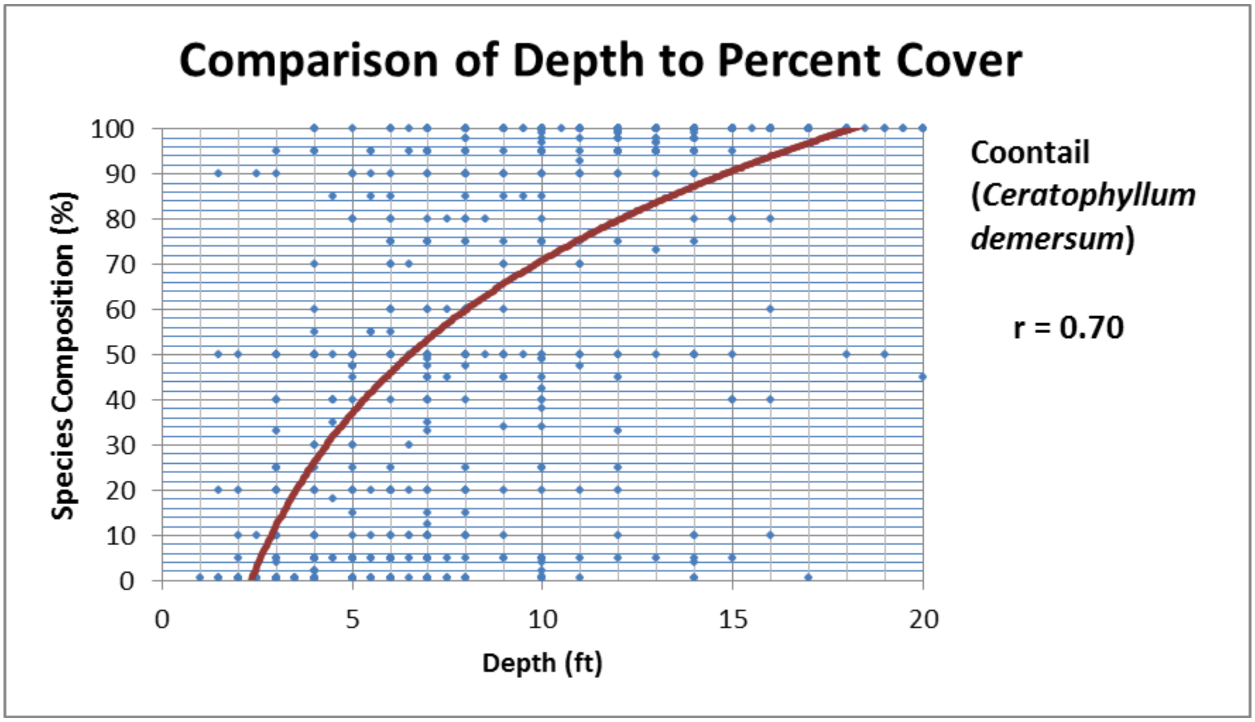

Figure 6. Correlation Analysis – Coontail

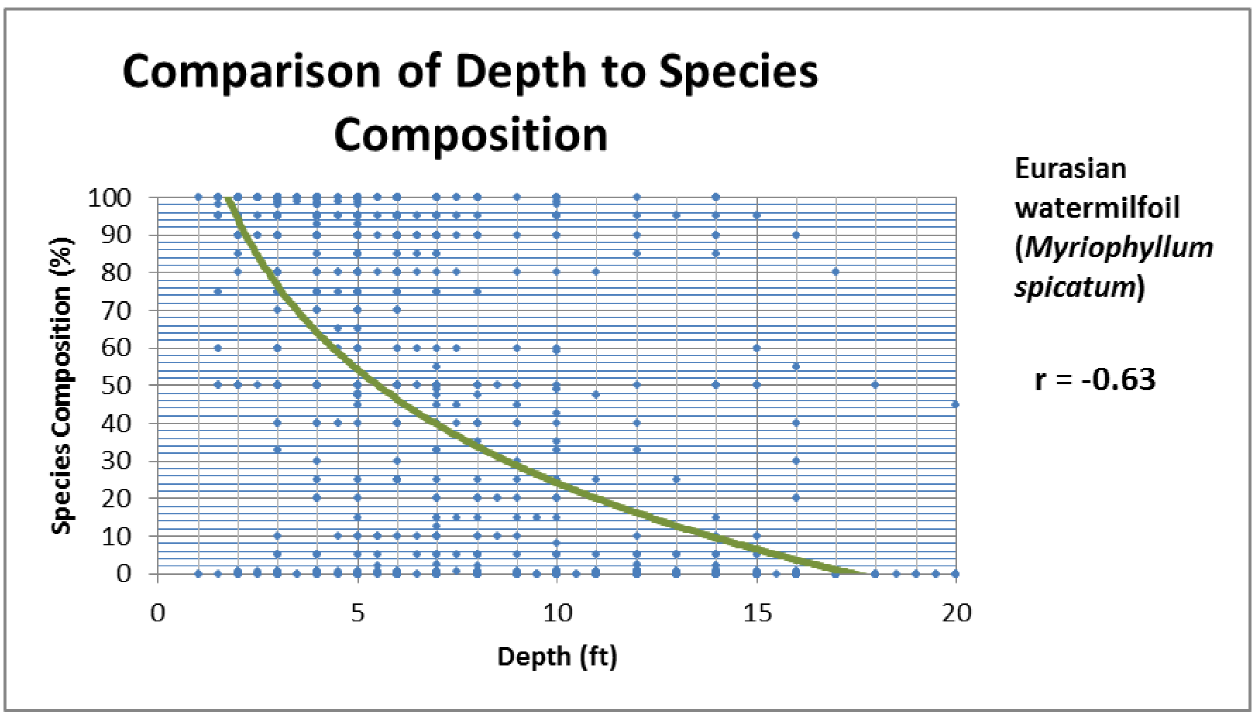

Figure 7. Correlation Analysis – Eurasian Watermilfoil

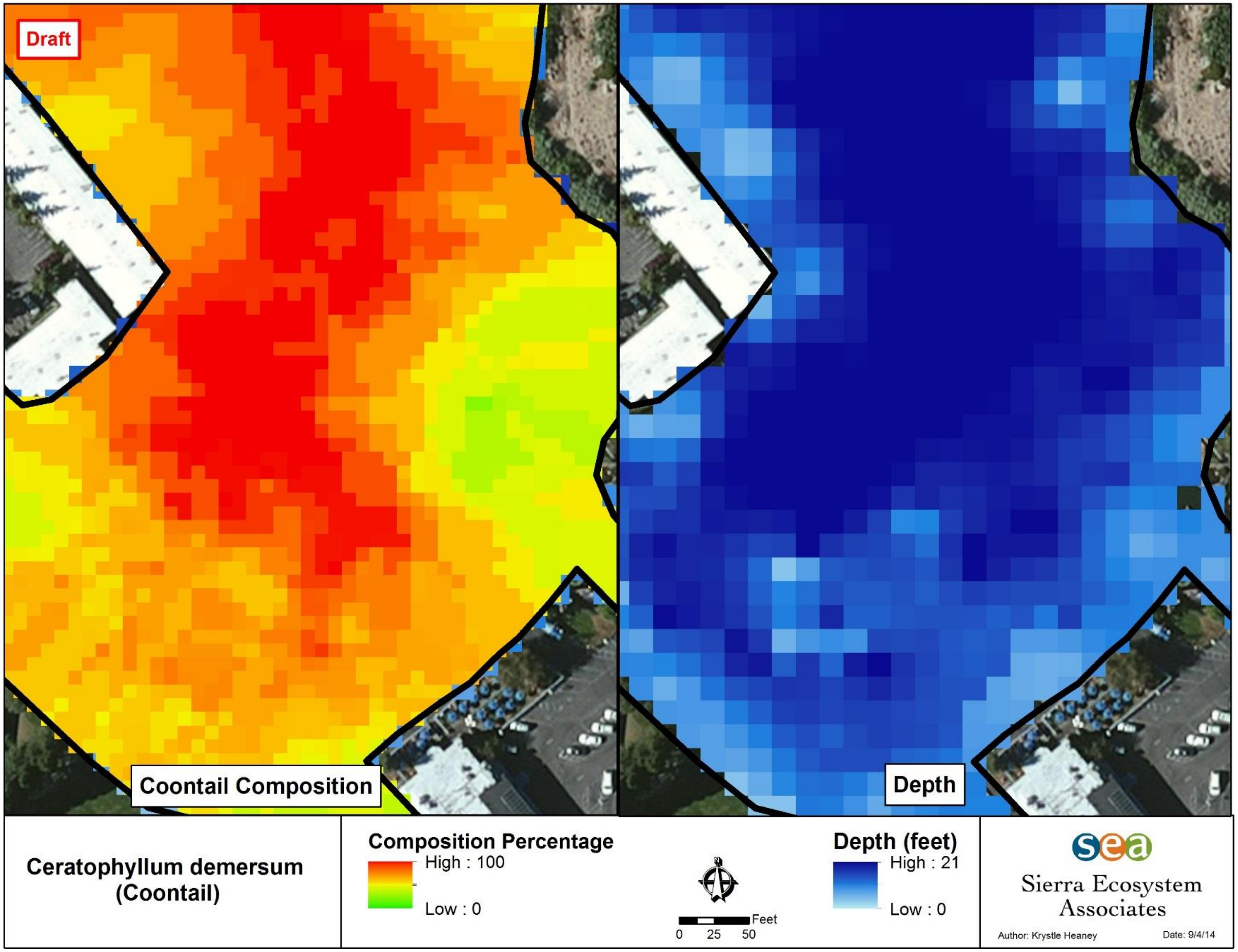

Figure 8. Comparison of Depth and Coontail Composition

The dense aquatic plant coverage in The Keys can be attributed to the shallow waters, naturally occurring nutrients in the substrate, and the deposition of nutrients by spreading plant populations. This type of environment typically supports dense populations of submersed invasive plants, such as Eurasian watermilfoil, and nuisance levels of native plants such as coontail. Development and sustained species composition and densities such as this adversely affect the local Tahoe Keys ecosystem as well as the water quality of the adjacent lake proper.

The compositions of different coves vary slightly as can be seen in Appendix B. The charts created for each cove represent the size of the population of a species relative to other species found at that site. The percentages displayed are the percent of occurrence.

4.2 Biomass Sampling

Biomass sampling was conducted to help develop sampling methods for future surveys. As surveys become more comprehensive, a higher detail of analysis can be conducted and provide better estimates for the amount of aquatic plant biomass that is located in the Tahoe Keys. Sampling points can be seen in Figure 9.

In some instances, the weight of the sample was negligible and no reading could be made. The smallest sample that could be recorded is shown in Figure 10. Heavier samples, such as the one shown in Figure 11, were often associated with a larger percentage of coontail. This can be attributed to coontail's stronger structure and higher canopy growth.

Figure 9. Biomass Sampling Points

Figure 10: Small Biomass Sample


Figure 11: Large Biomass Sample

4.3 Historical Data Comparison

The previous years' data allows estimates to be made about the change in species composition within the Tahoe Keys. The ability to compare this data is limited by the smaller scale of the studies conducted previously and the limited information recorded about the samples. In order to make the most valid statements regarding year to year conditions, the 2014 data was constrained to the percentage of presence – absence type data for each area as was recorded the previous years. Figure 12 displays cove designations for comparison.

Figure 12. Cove Designations

Previous surveys were conducted in the Tahoe Keys in 2009 and 2011. Samples were taken using the same methodology as the current survey. For analysis, only the presence or absence of species in a designated cove was considered. The number of times a species was present in a location was divided by the number of samples for that site which provided the percent of occurrence for each species. For example, in 2011 the percent of occurrence for Eurasian watermilfoil in Cove A was 66%. This means that 66% of the time it can be found in a sample.

Species occurrence from 2009 to 2014 in Figure 11 shows how Eurasian watermilfoil has increased in composition over time, while coontail has decreased. This could be due, in part, to the shallower water levels created by low precipitation levels of the past winter. Comparisons between years of all species can be found in Appendix C.

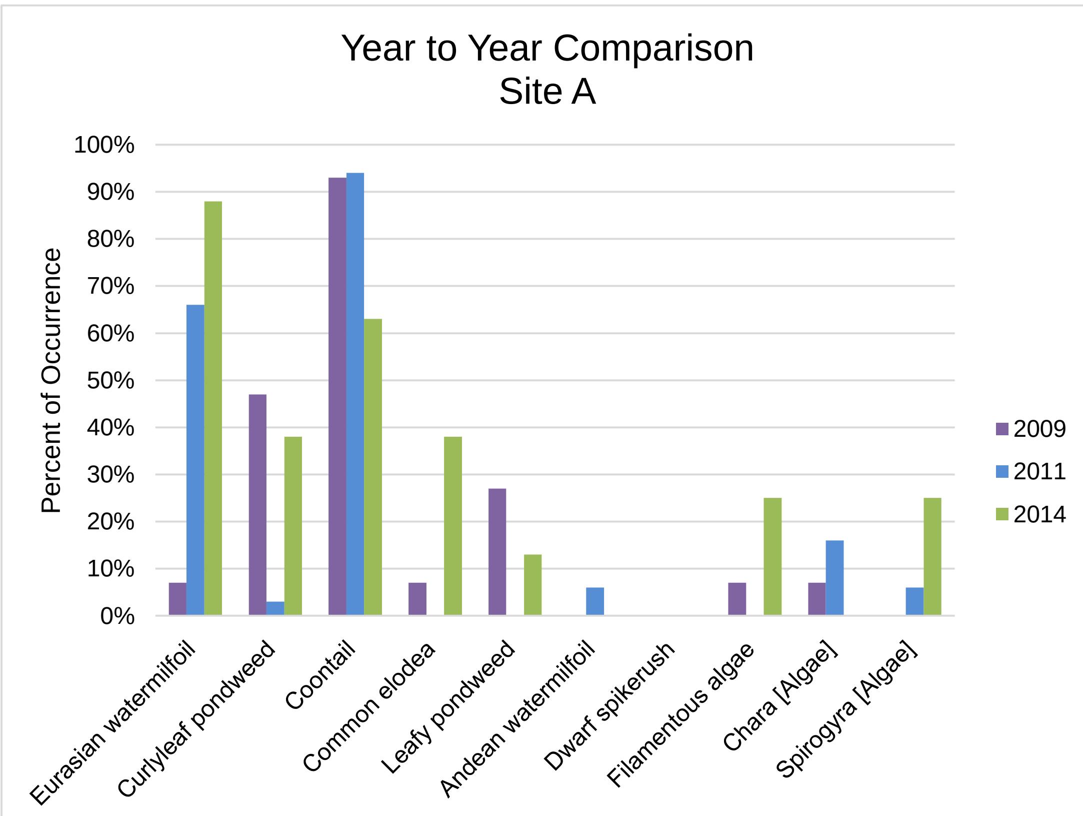

Figure 13. Cove A: Year to Year Comparison

5.0 CONCLUSIONS

Invasive non-native and nuisance native aquatic plants continue to be a problem in the Tahoe Keys. Without proper management, this problem will continue to grow and invasive aquatic plants will increasingly take the place of the native plant species. Only one occurrence of a native milfoil was recorded during the survey, meaning that the invasive has effectively outcompeted the native. While Eurasian watermilfoil is the most prominent invasive in the Tahoe Keys, the presence of curlyleaf pondweed is of equal concern. It can withstand deeper waters and has been found in multiple locations along the south shore of Lake Tahoe.

The native population of coontail also continues to be a problem due to the nutrient rich natural substrate and modified environment created by an abundance of aquatic plant species. This native plant will also require management to ensure public access and safety, as well as native fish and wildlife use, of the Tahoe Keys.

The combination of non-native and native nuisance plants has created near complete aquatic plant canopy coverage in most of the Tahoe Keys. Due to this extensive coverage, control methods will need to be put in place for the entirety of the East and West basins with an emphasis on managing the spread of Eurasian watermilfoil and curlyleaf pondweed.

For future surveys, the methodology for the designated coves of interest will need to be altered. Additional sample points will be required to obtain a more accurate representation of the populations in those areas. Additional data, such as water clarity and temperature, should also be obtained to provide a better understanding of the overall water quality conditions in the Tahoe Keys.

6.0 LIST OF PREPARERS

The following individuals prepared the text presented in this report.

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Rayann C. La France SEA	A.A. Human Services Folsom Lake College	Document Editing/ Formatting

7.0 REFERENCES

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Appendix A
Species Density Maps

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Appendix A
Species Density Maps

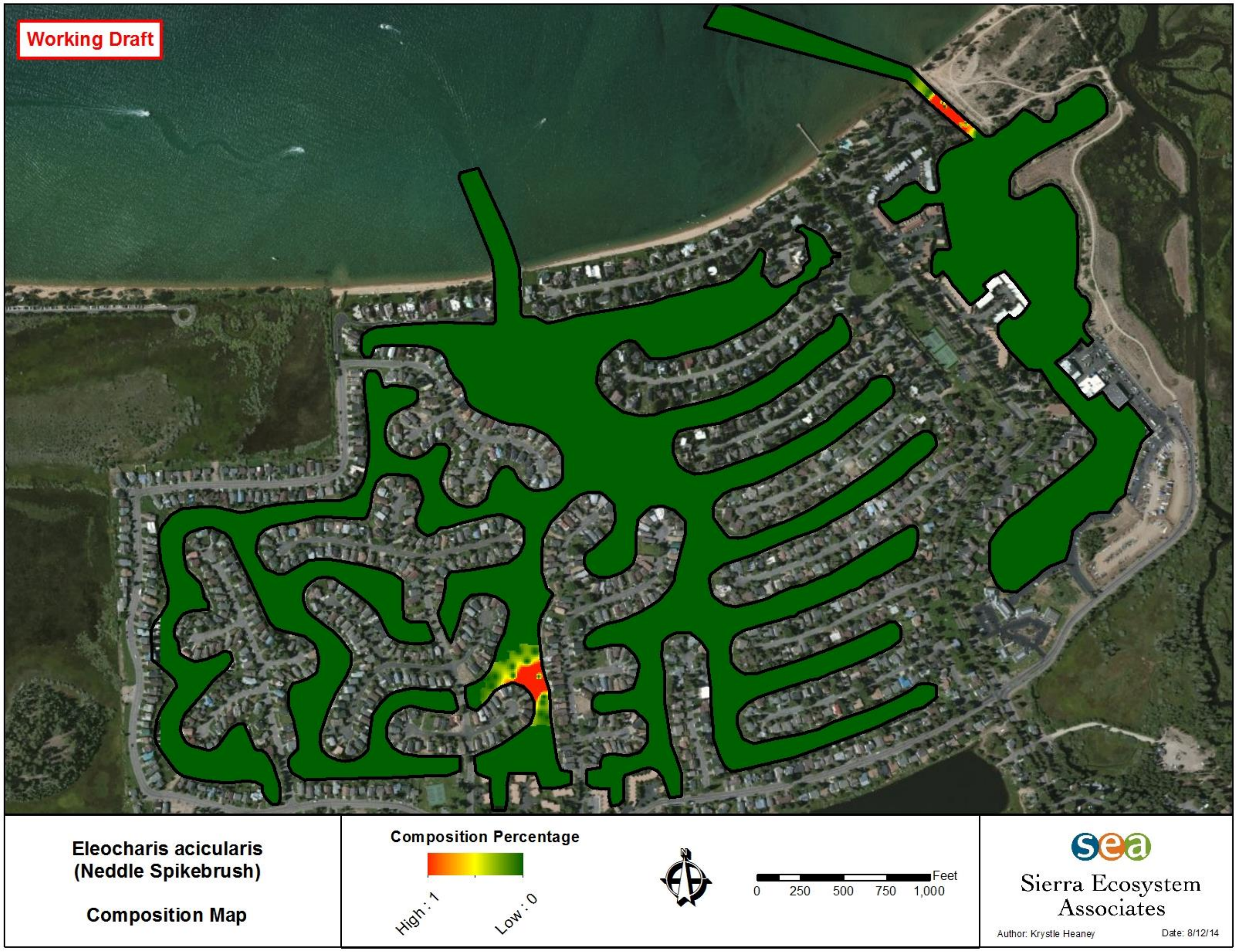

Figure A 1. Eleocharis acicularis (Neddle Spikebrush)

Appendix A
Species Density Maps

Figure A 2. Elodea canadensis (Elodea)

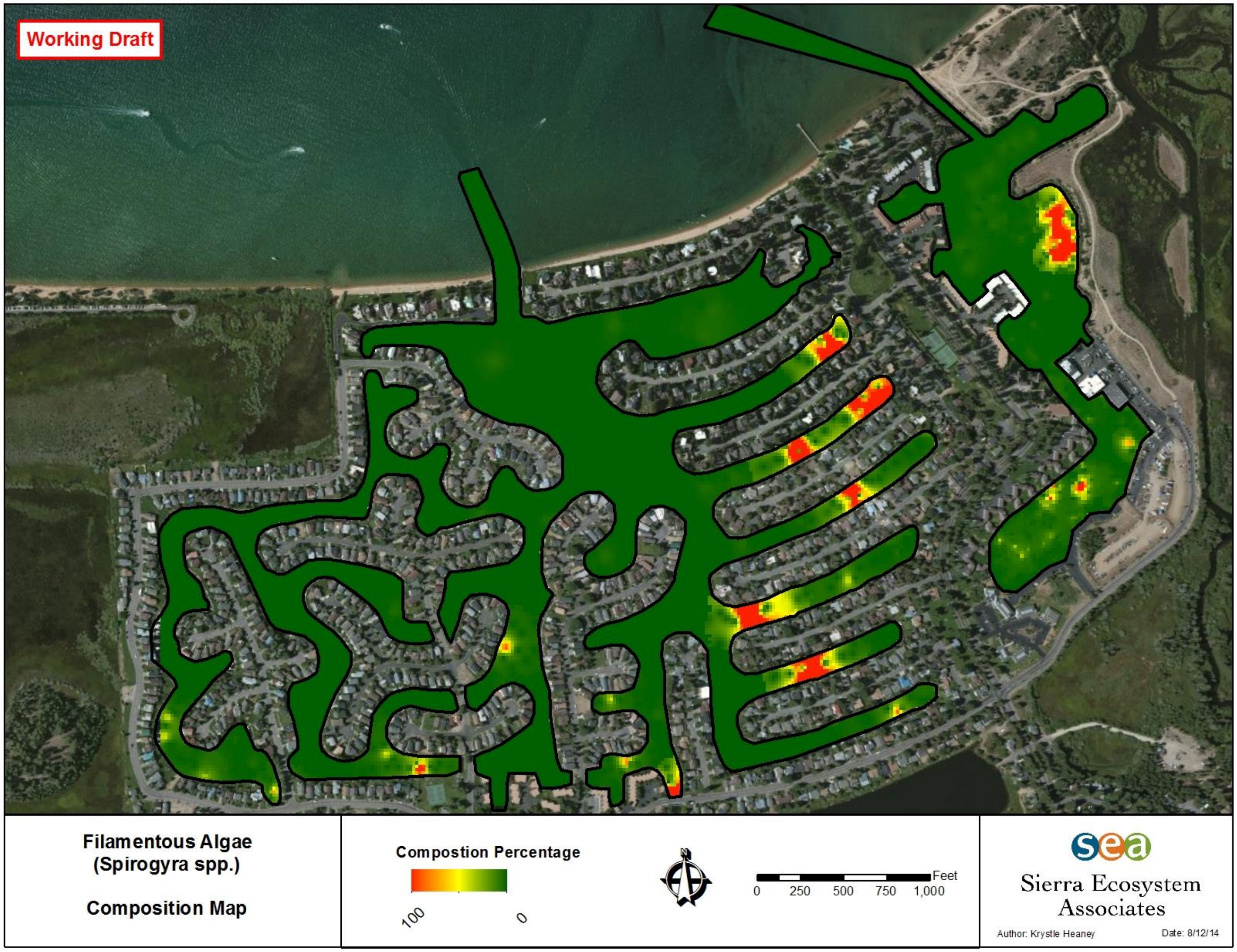

Figure A 3. Spirogyra spp. (Filamentous Algae)

Appendix A
Species Density Maps

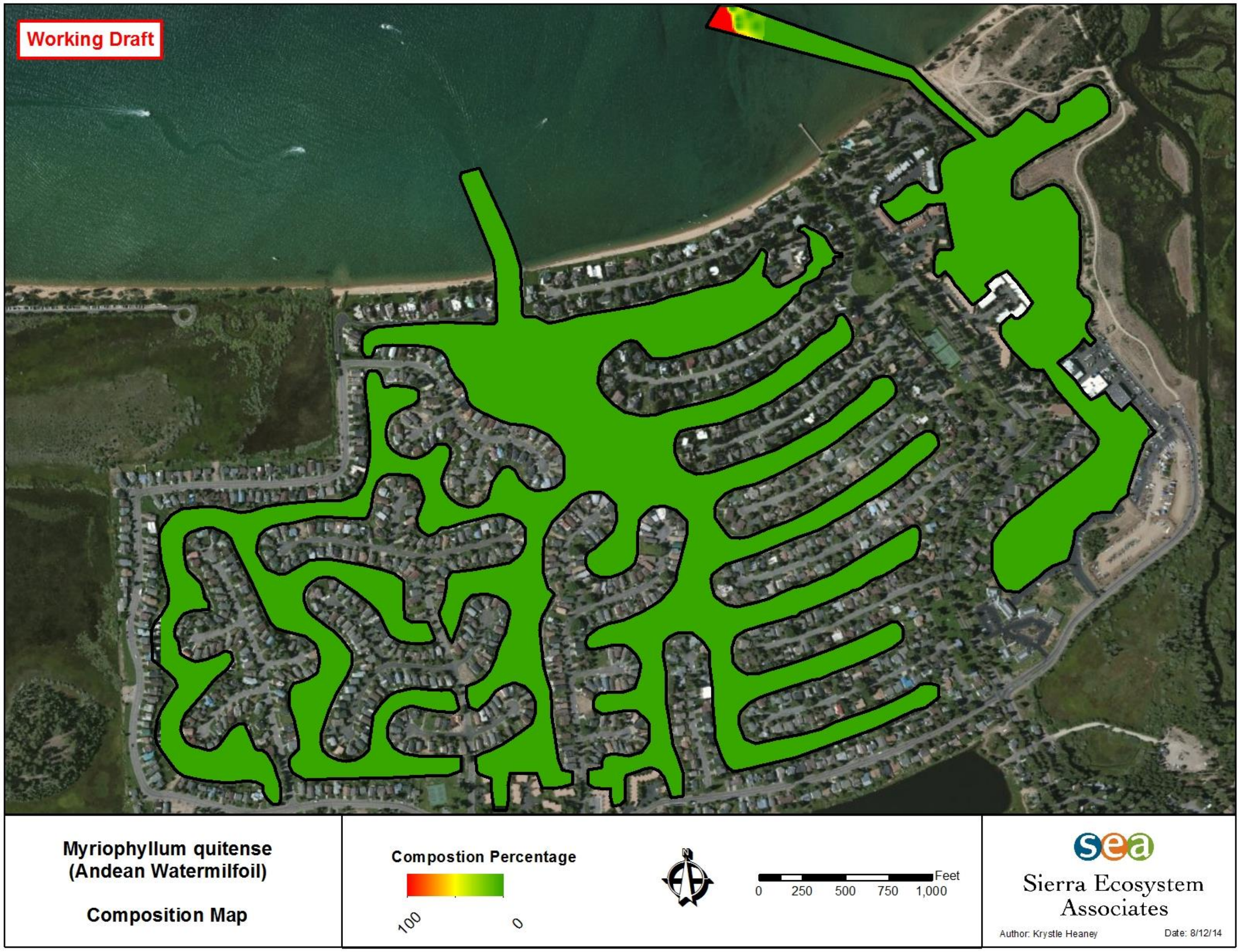

Figure A 4. Myriophyllum quitense (Andean Watermilfoil)

Appendix A
Species Density Maps

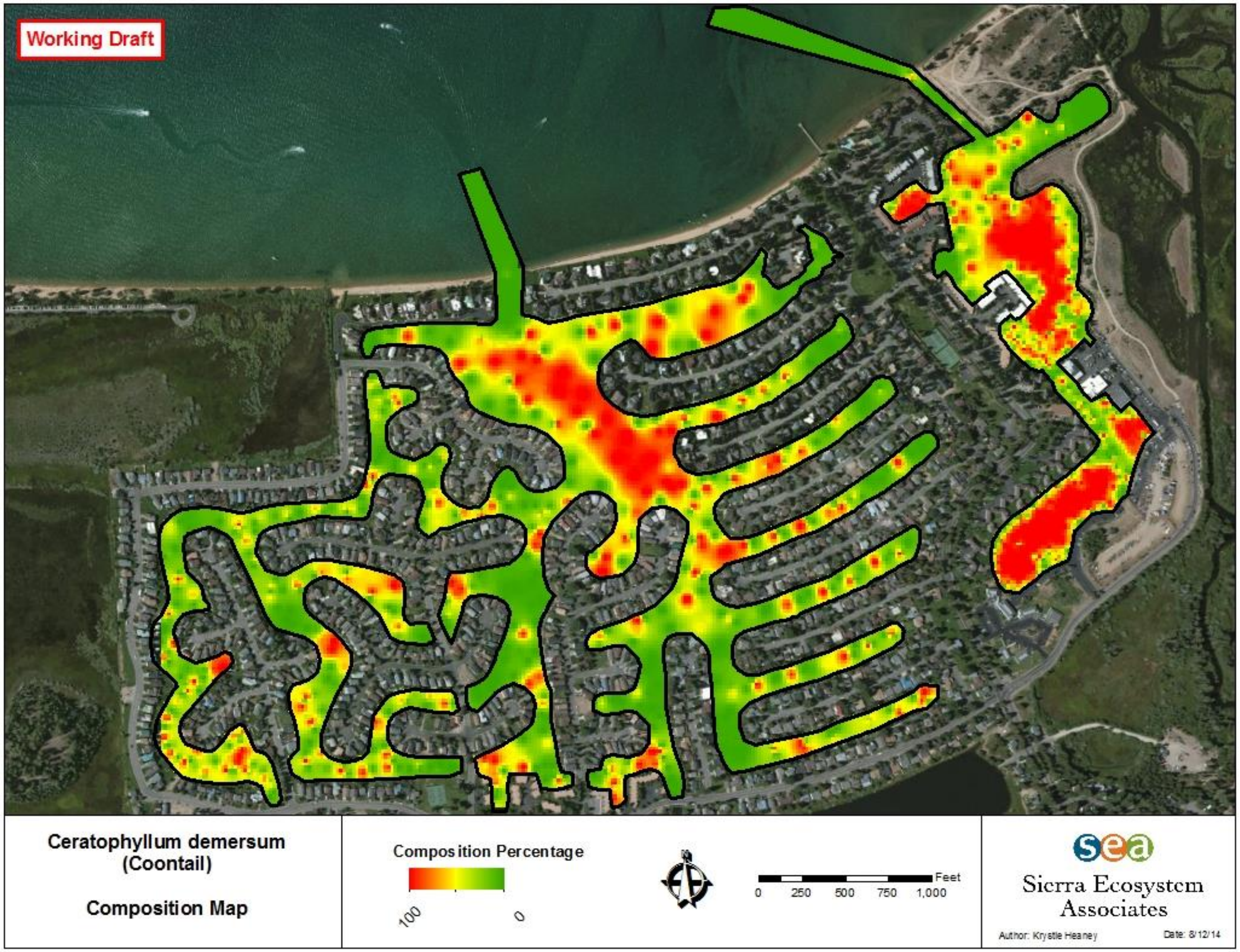

Figure A 5. Ceratophyllum demersum (Coontail)

Appendix A
Species Density Maps

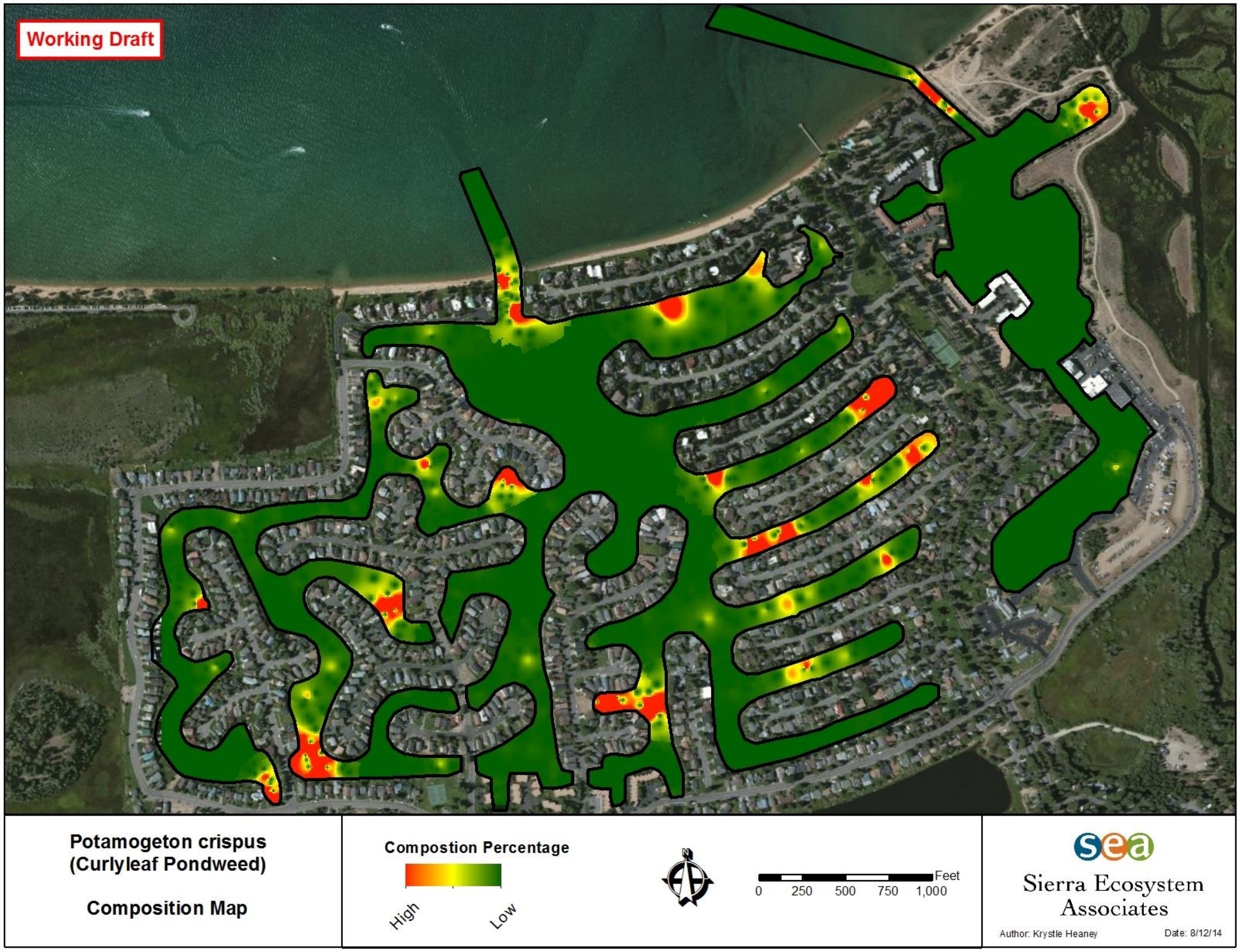

Figure A 6. Potamogeton crispus (Curlyleaf Pondweed)

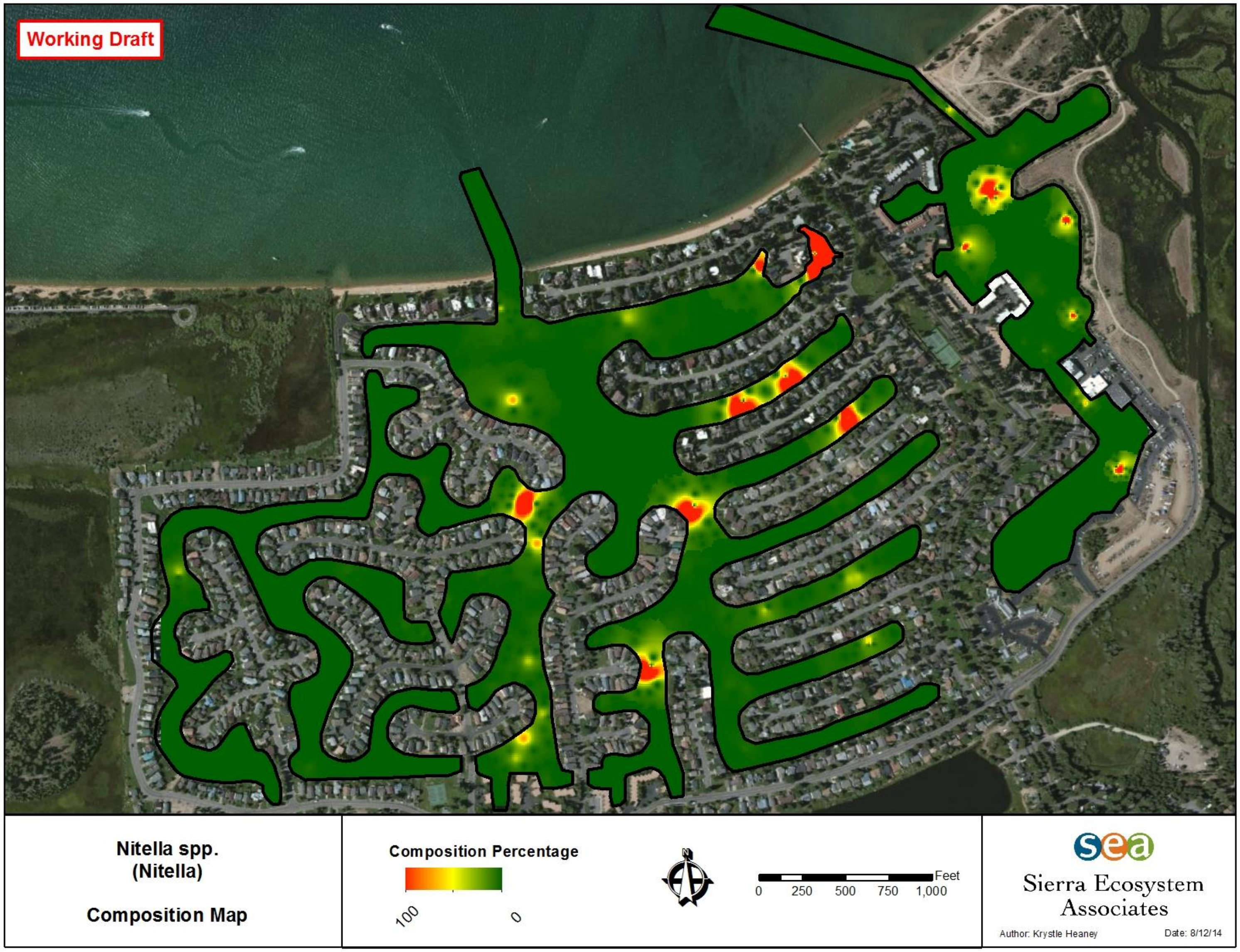

Figure A 7. Nitella spp. (Nitella)

Figure A 8. Potamogeton foliosus (Leafy Pondweed)

Appendix B
Species Composition Charts

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Species Composition Charts

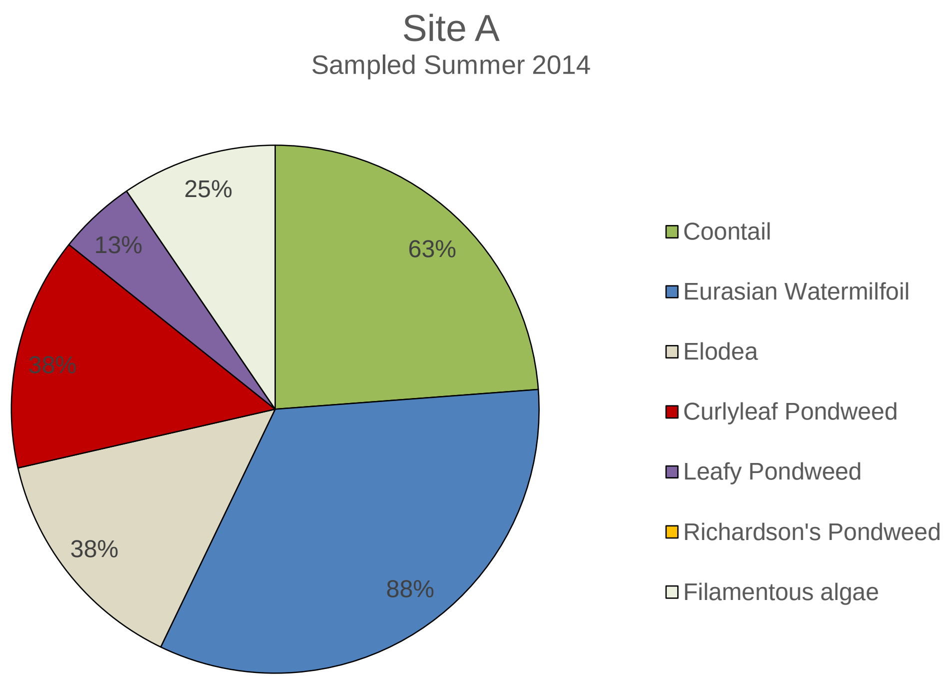

Figure B1. Species Composition: Site A

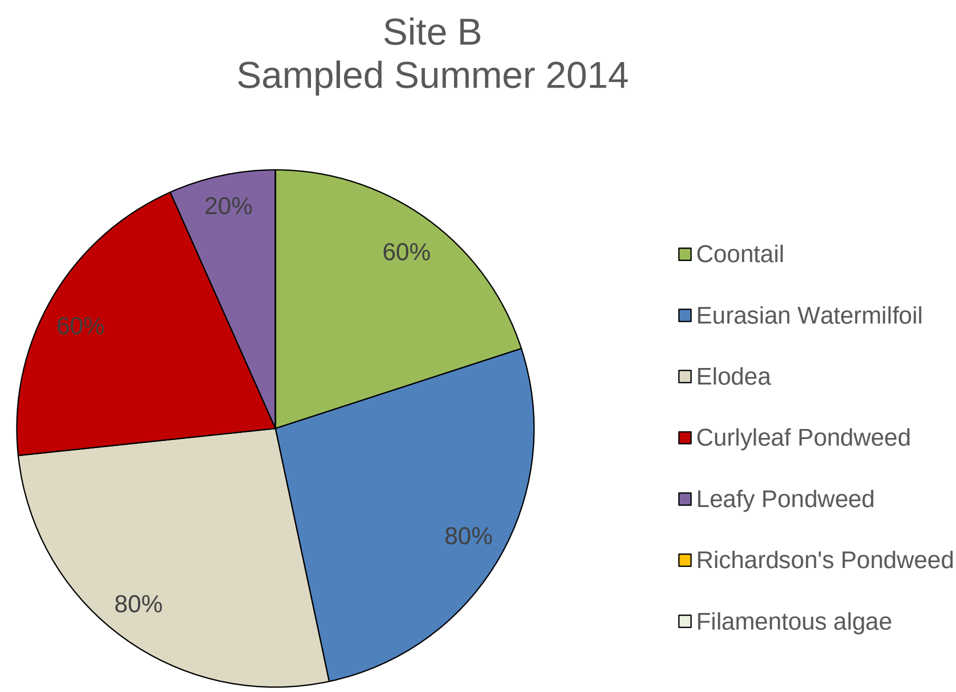

Figure B2. Species Composition: Site B

Appendix B
Species Composition Charts

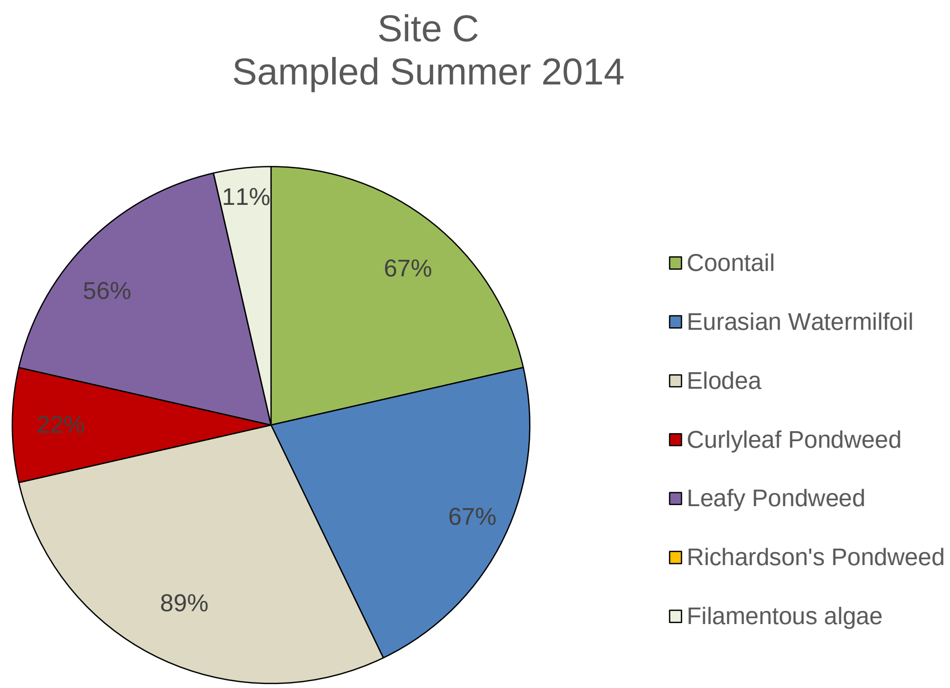

Figure B3. Species Composition: Site C

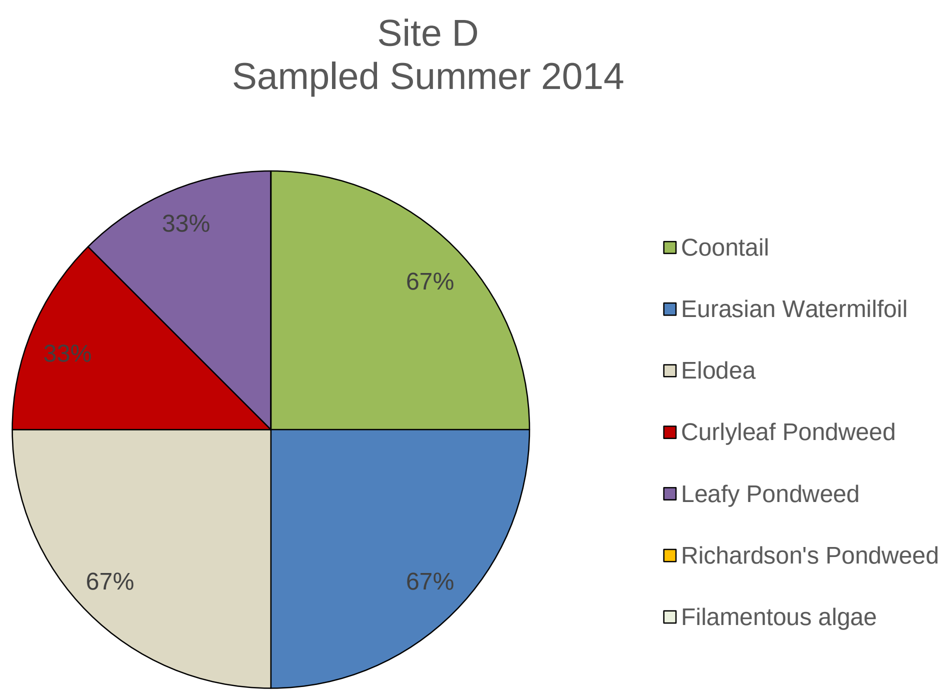

Figure B4. Species Composition: Site D

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Species Composition Charts

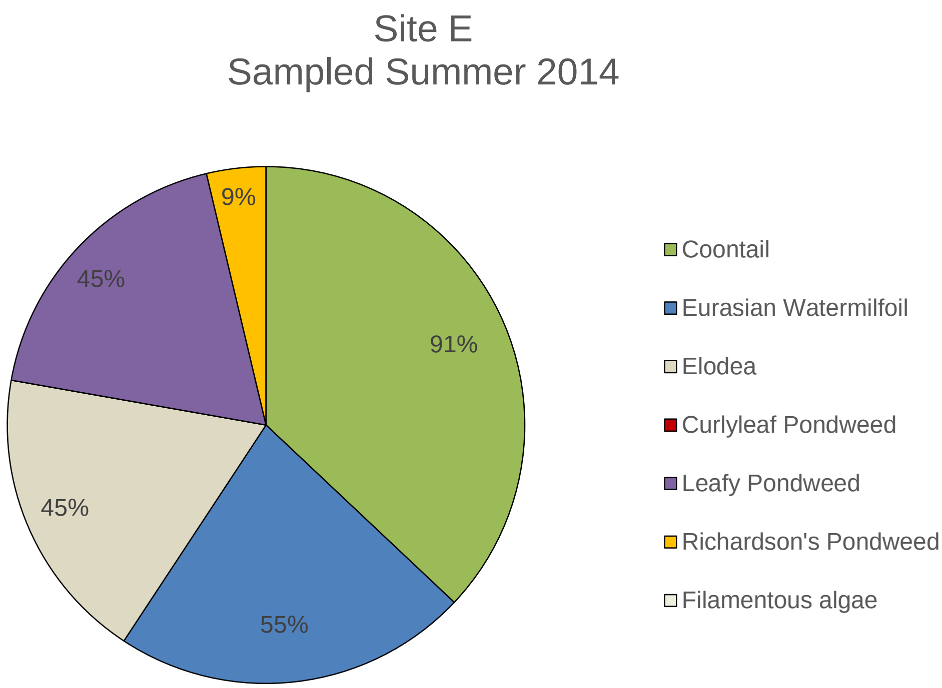

Figure B5. Species Composition: Site E

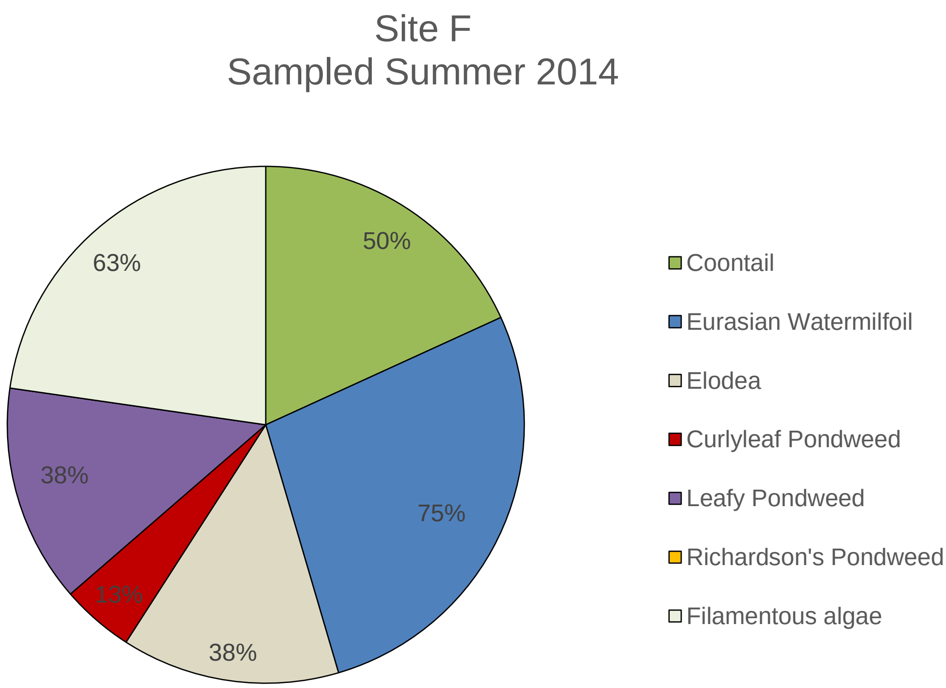

Figure B6. Species Composition: Site F

Appendix B
Species Composition Charts

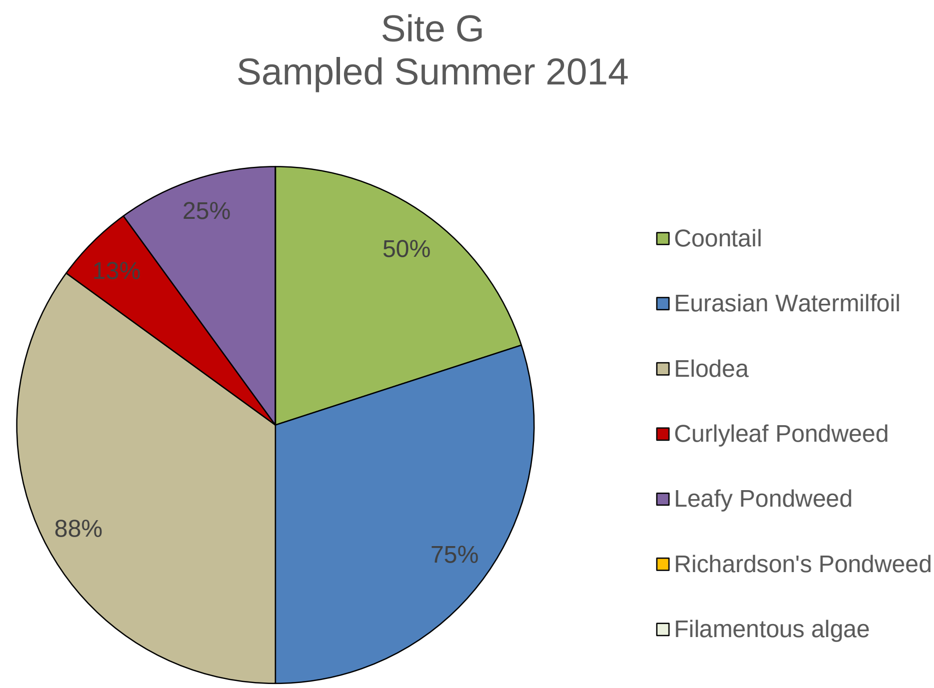

Figure B7. Species Composition: Site G

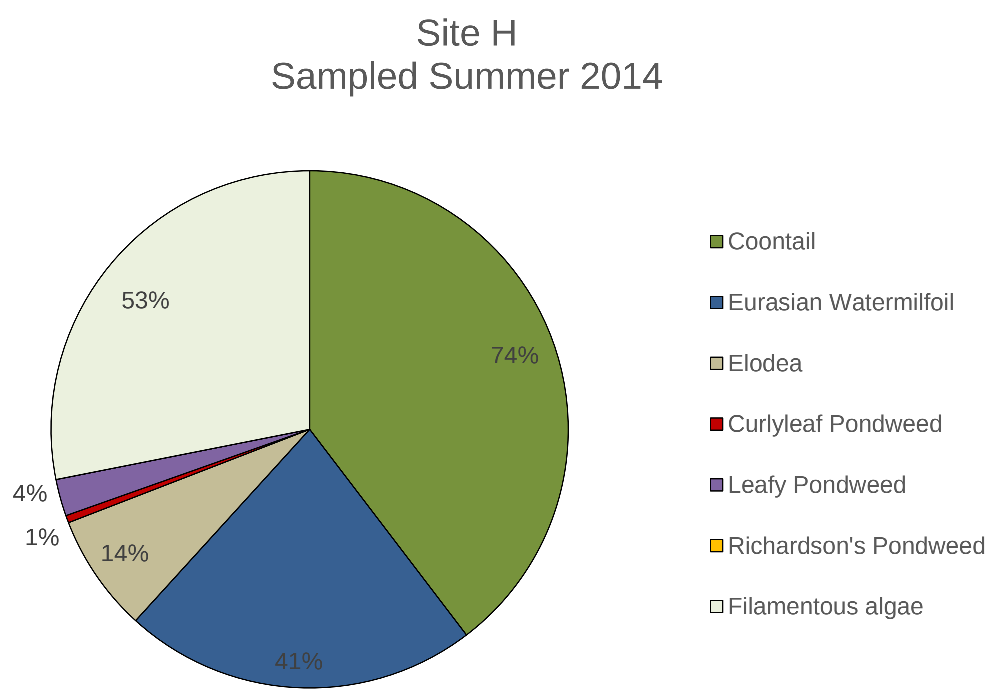

Figure B8. Species Composition: Site H

Appendix C
Year to Year Comparisons

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Year to Year Comparisons

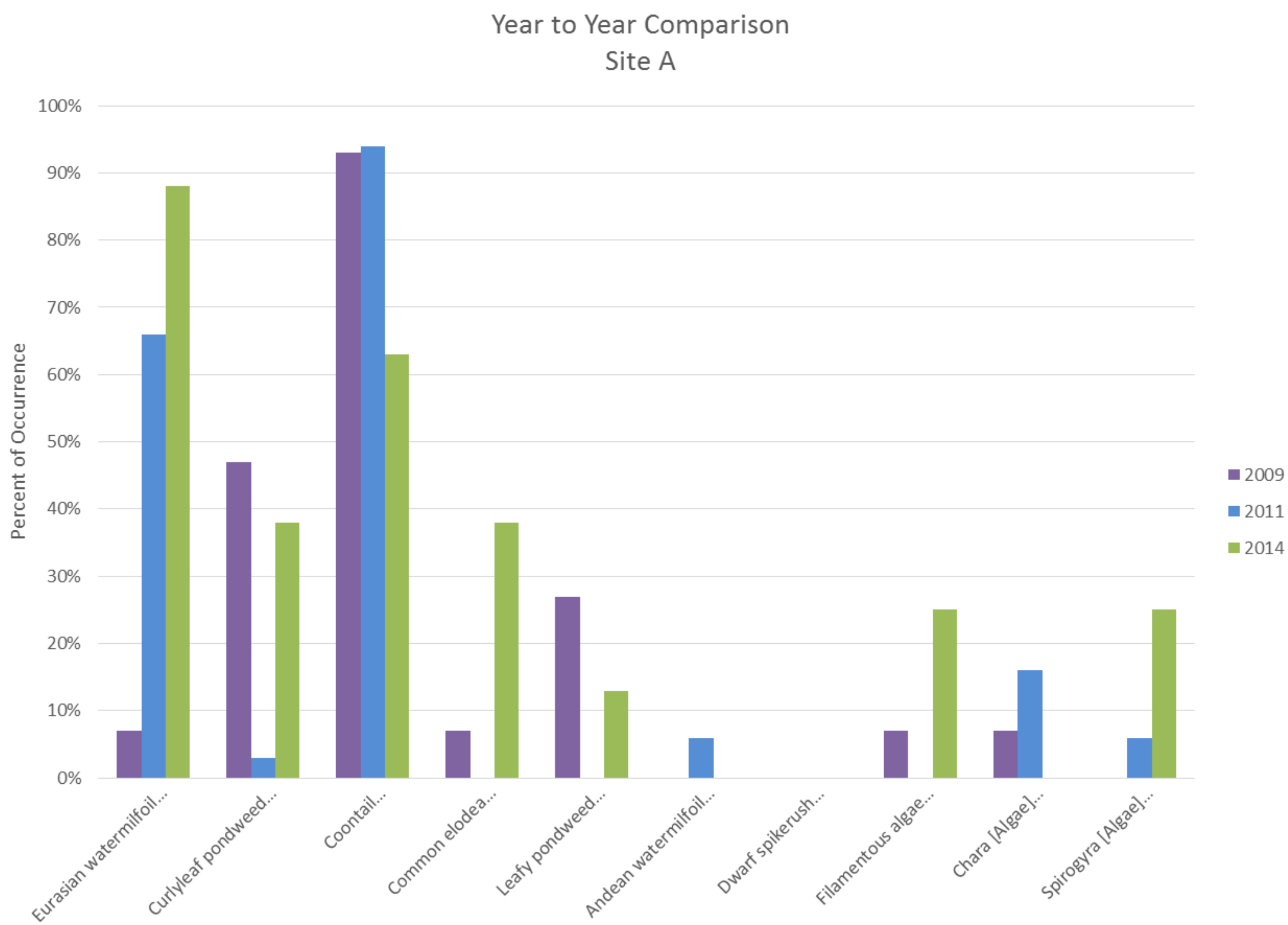

Figure C1. Year to Year Comparison: Site A

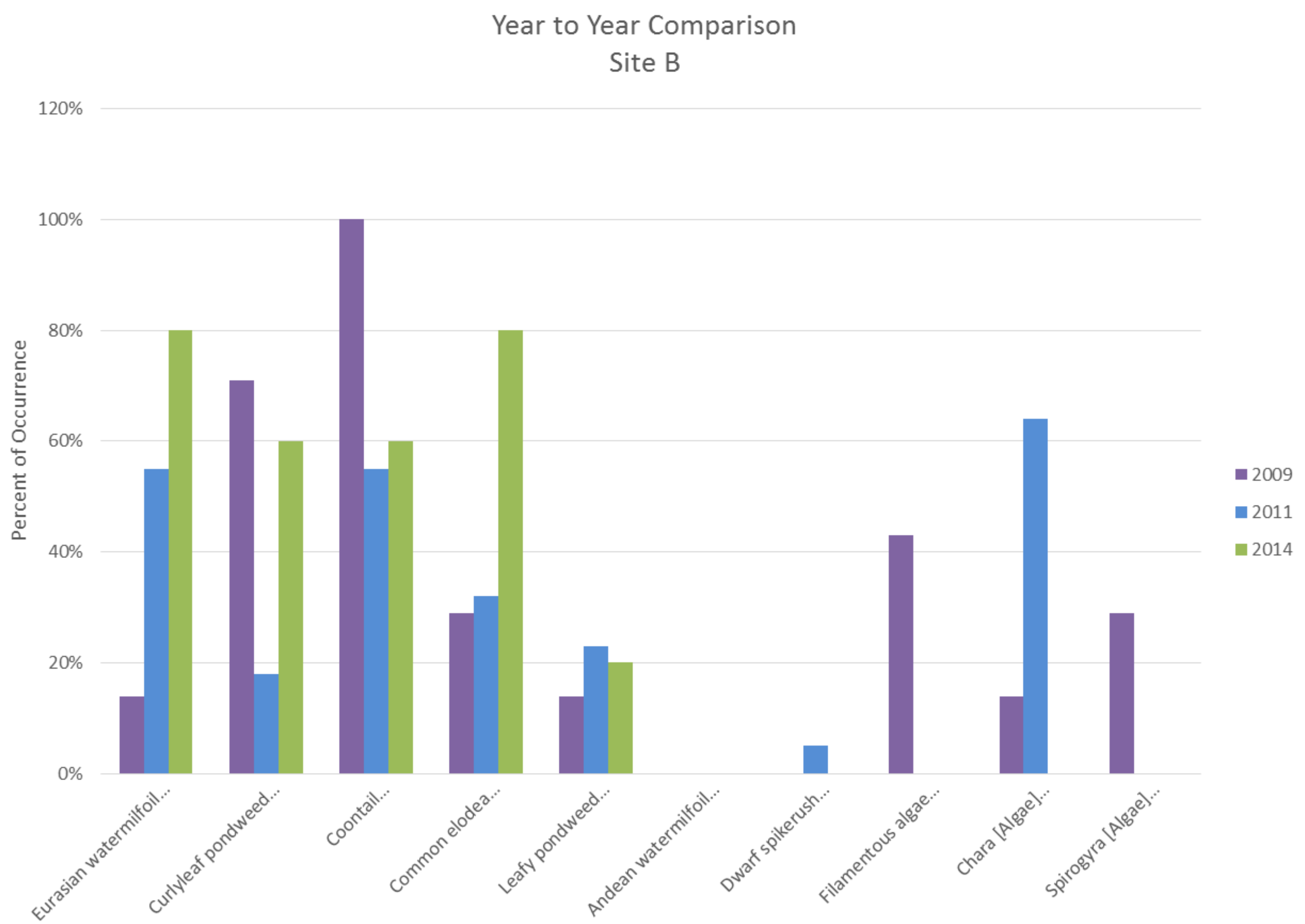

Figure C2. Year to Year Comparison: Site B

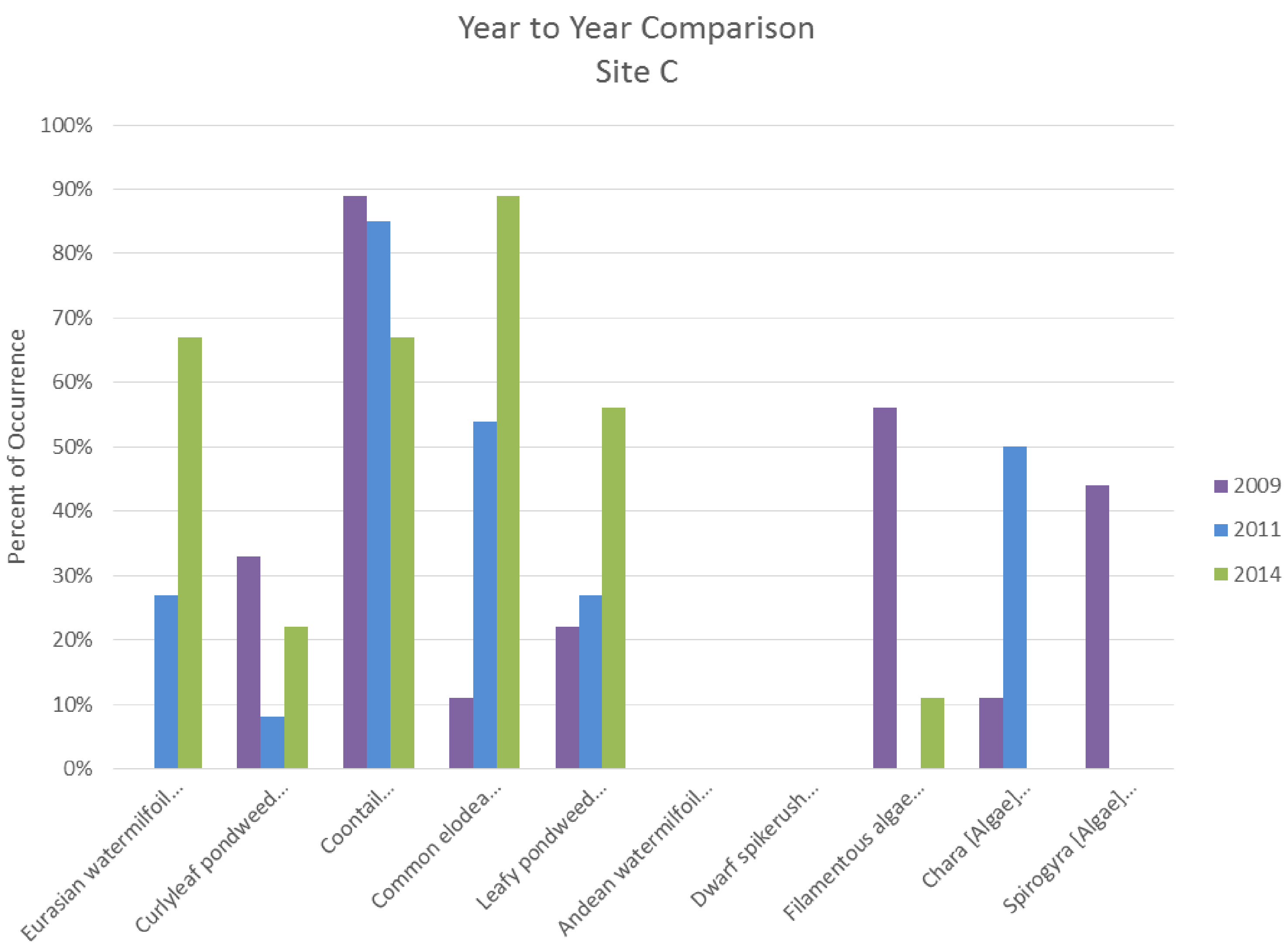

Figure C3. Year to Year Comparison: Site C

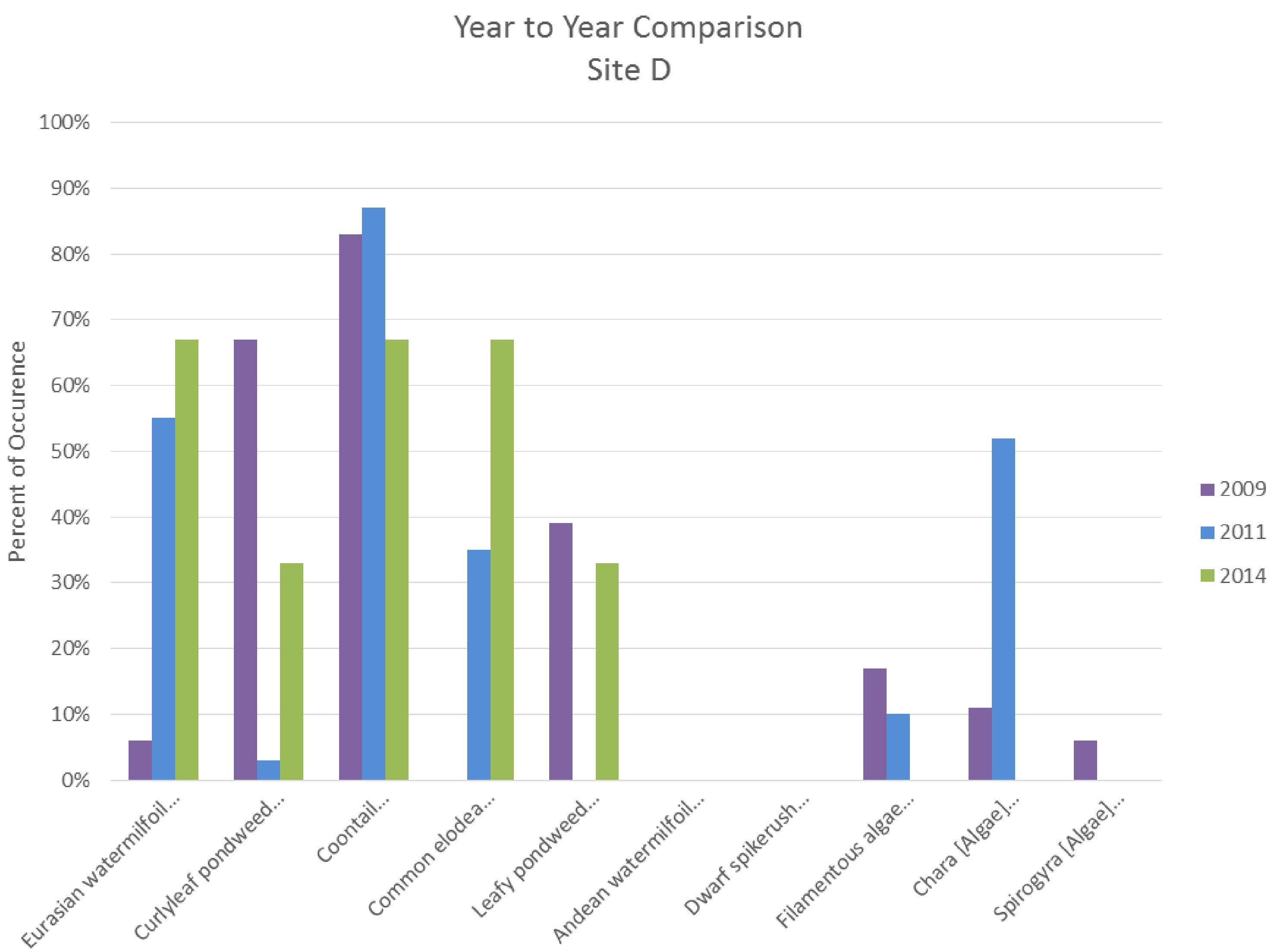

Figure C4. Year to Year Comparison: Site D

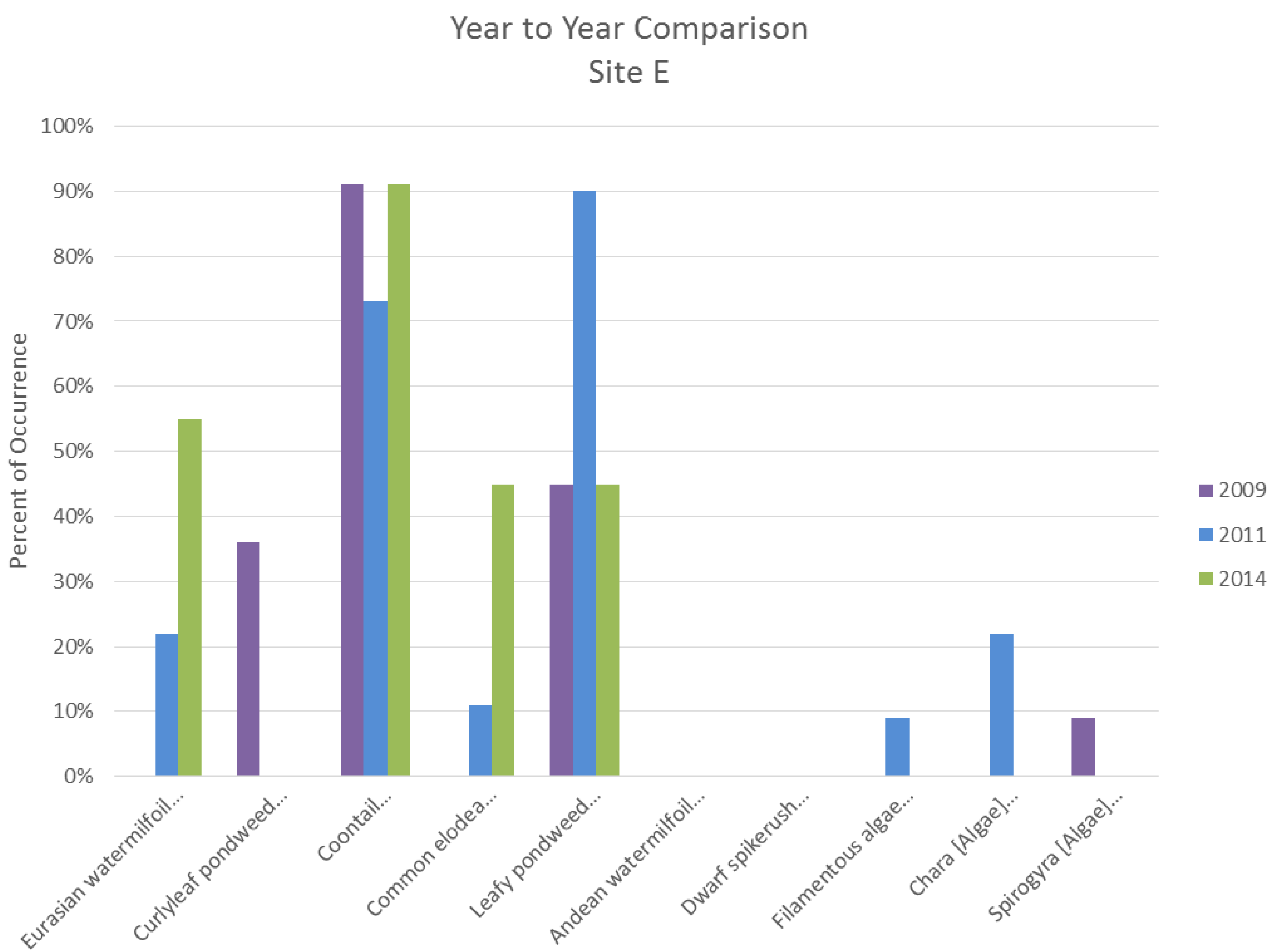

Figure C5. Year to Year Comparison: Site E

Appendix C
Year to Year Comparisons

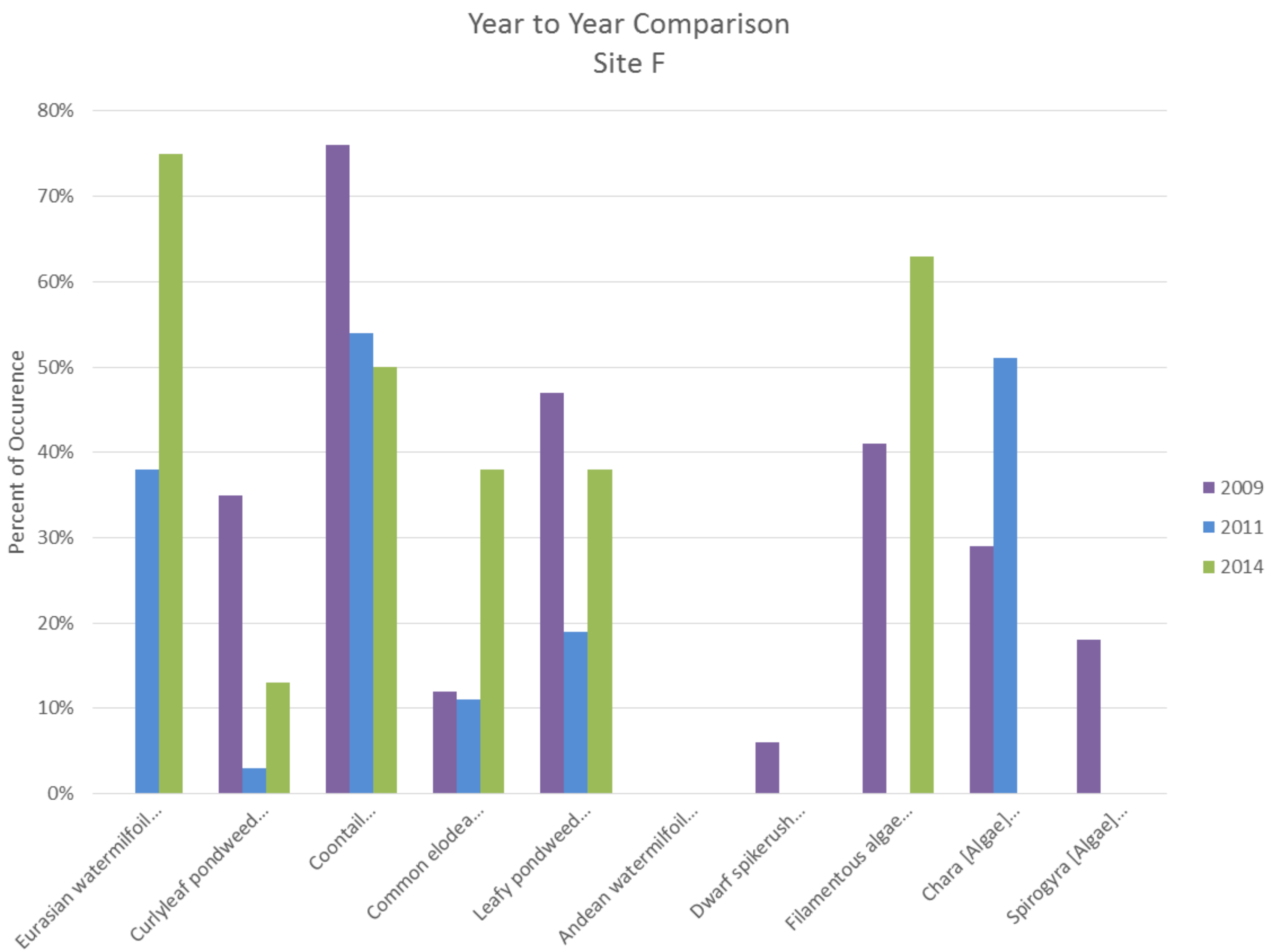

Figure C6. Year to Year Comparison: Site F

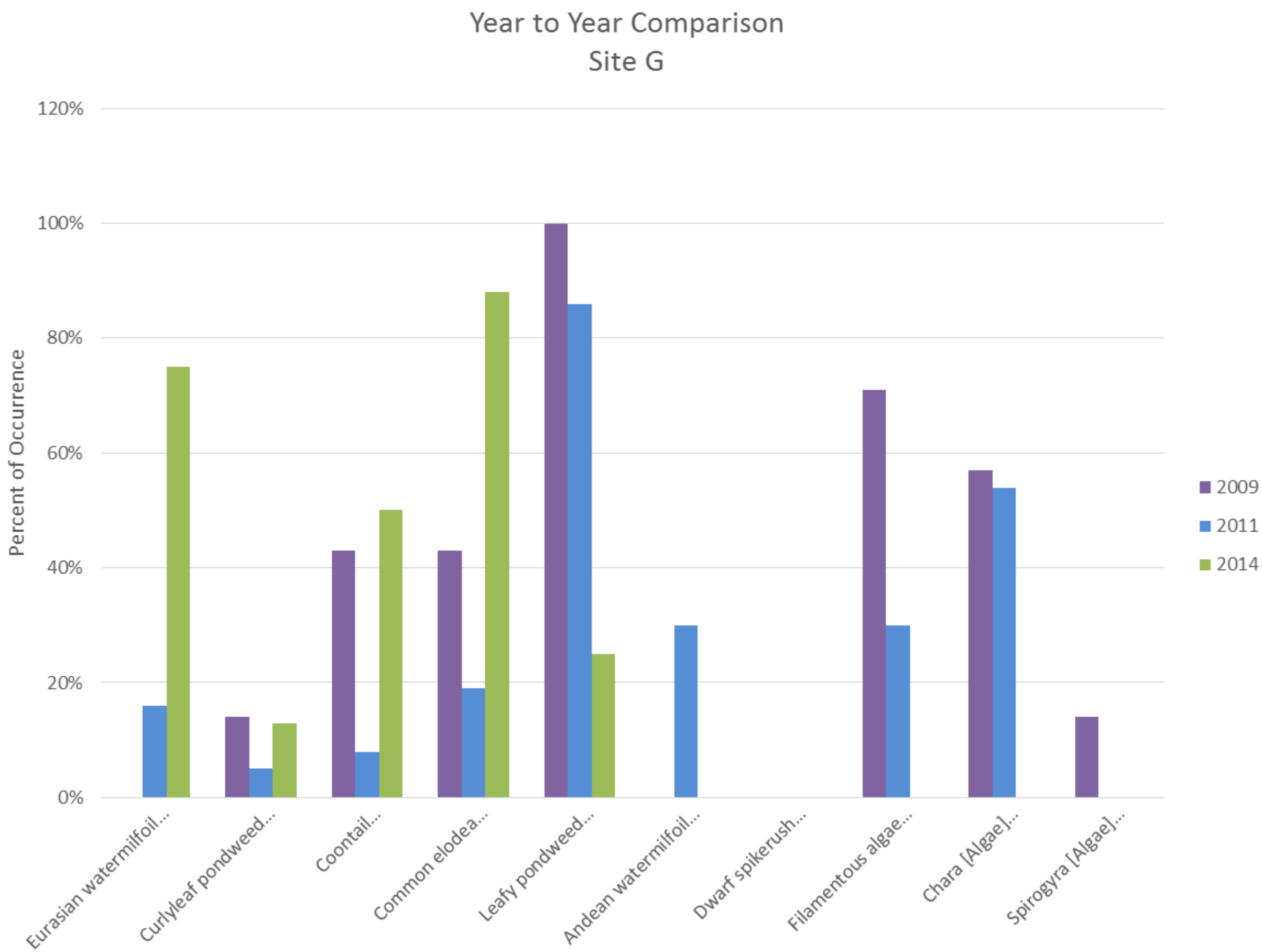

Figure C7. Year to Year Comparison: Site G

Appendix D
Biomass Sampling Data

	Percent Composition (%)											
Way Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	MyQu	Depth (ft)	Weigth (kg)
1346	100	0.5									7	5.22
1347	10	90			0.5						5	2.72
1348	40	60				0.5					5.5	3.1
1349	5	95									5	2.52
1350	0.5	100									5.5	2.82
1351	80	20									9	3.14
1352	10	90					0.5				6	3.92
1353	10	80					10				5.5	4.18
1354	10	80			0.5		10				6	3.46
1355		100			0.5						3	3.34
1356	100										10	4.46
1357	100										10.5	4.86
1358	25	25		25	25						3.5	2.4
1359	0.5						100				10	2.5
1360	0.5			0.5			100				9	3.08
1361	60	40									7	3.78
1362	5	15			0.5		80				9	3.3
1363	90	5					5				8	3.24
1364	0.5	100	0.5				0.5				7	3.16
1365		90	10								9.5	2.46
1366	100										17	6.6
1367	100										18	3.6
1368	100										18	2.84
1369	100										15	3.52
1370	100	0.5		0.5	0.5						9	4.08
1371	40	0.5				60					9	3.08
1372	100										11	3.44
1373	95			5							7.5	4.28
1374	100			0.5							11	4.7
1375	100										11	4.28
1376	100			0.5		0.5					10	3.88
1377		100		0.5							5	3.3
1378		100		0.5							5.5	3.32
1379	100					0.5					11	3.62
1380	100					0.5					9	5.08
1381		100									3.5	2.96
1382		100									3	2.78
1383	100					0.5					10	4.12
1384	100					0.5					7	4.32
1385	0.5	100									4	2.8
1386		100									4	2.86
1387	100					0.5					10	5.18
1388	100					0.5					9	4.24
1389	0.5	100									3	2.8

Appendix D
Biomass Sampling Data

	Percent Composition (%)											
Way Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	MyQu	Depth (ft)	Weigth (kg)
1390	0.5	100									5	2.84
1391	100					0.5					9.5	2.96
1392	100			0.5		0.5					7	5
1393	100										11	2.72
1394	75	25									10	2.92
1395		40			10		50				10	2.92
1396		95					5				4	3.32
1397		90		5			5				5	3.38
1398	60	35		5							8	3.8
1399	5	95		0.5							5	3.52
1400		100		0.5							3	3.26
1401		95		5							3	2.82
1402		0.5	100								7	2.8
1403	0.5	100									7.5	2.78
1404		10	10	60	20						8.5	4.43
1405								100			9.5	
1406										100	10	
1407		0.5		10	90						9	2.94
1408		85		10	5						7	2.92
1409		2.5		2.5				95			7	2.82
1410	0.5	60		40							7.5	2.94
1411		0.5									7	2.78
1412		15	5	80							7	2.9
1413		5	0.5	95	0.5						8	3.26
1414		20		80							8	3.24

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
1	95	5								4
2	30	40		30						4
3	5	95								4
4	4	95		1						3
5	80	15		1						5
6	18	80		2						4.5
7	70	30								6
8	90	1				0.5				10
9	100									12
10	50	50								7
11	100	0.5								8
12	100									9
13		100								4
14	20	80								4
15		99		1						3
16	50	50								4
17		100								3
18		95		5						3
19		95		5			0.5			3
20		95		5						3
21	5	95								4
22	95					5				10
23	100					0.5				12
24	100					0.5				12
25	100									12
26	100									10
27	100									10
28	99	1								12
29	50	50								3
30		100								3
31	100									9
32	100									12
33	100					0.5				9
34	100					0.5				10
35	100									10
36	100					0.5				9
37	100					0.5				9
38	100						0.5			8
39	100									9
40	100									13

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
41	100					0.5				13
42	100					0.5				13
43	100					0.5				13
44	100					0.5				14
45	100					0.5				12
46	100									15
47	75	25								6
48	80	20								8
49	0.5	100								7
50	100					0.5				14
51	100					0.5				15
52	100					0.5				12
53	95					5				13
54	100					0.5				12
55	100					0.5				15
56	100					0.5				13
57	100					0.5				13
58	95					5				12
59	100					0.5				14
60	100					0.5				15
61	100					0.5				11
62		100		0.5						3
63		100								3
64		100								3
65		100								14
66	100	0.5				0.5				15
67	100					0.5				13
68	100					0.5				13
69	100									16
70	75	25				0.5				8
71										13
72	100					0.5				12
73	98					2				11
74										15
75	100	0.5		0.5						14
76		100								6
77	0.5	100								5
78										16
79	100					0.5				12
80	100					0.5				13

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
81	100	0.5				0.5				14
82	100									13
83	100					0.5				13
84	100									14
85	100					0.5				15
86	100					0.5				14
87	100					0.5				13
88		100		0.5						4
89		100								4
90		95		5						4
91	100					0.5				14
92	100					0.5				14
93	100									13
94	100					0.5				14
95	100					0.5				13
96	100					0.5				12
97										16
98	100									13
99		100								6
100	0.5	100								7
101	25	75								5
102	100									16
103										16
104	100									16
105	100					0.5				12
106	98					2				12
107	100					0.5				13
108	100					0.5				14
109	100					0.5				14
110	100	0.5								13
111	100									13
112	100					0.5				13
113	98					2				14
114	100					0.5				11
115		100								6
116		100								3
117		100								6
118	50	50								14
119	100									15
120	100					0.5				14

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
121	95	5								13
122	100									14
123	97					3				13
124	100									16
125		100								6
126		100								5
127		100								7
128	100					0.5				15
129	100					0.5				16
130	95	5								13
131	99					1				14
132	100									15
133	100									15
134	100					0.5				14
135	100									14
136	100									14
137	97					3				13
138	100					0.5				14
139	75					25				14
140		100								5
141	5	95								5
142	20	80								4
143	100					0.5				13
144	95					5				13
145	98					2				13
146	98	0.5				2				12
147	100					0.5				13
148	100					0.5				14
149	100					0.5				14
150	100					0.5				14
151	100					0.5				14
152	100									13
153	97					3				10
154		50		50						4
155	0.5	100								3
156		100		0.5						3
157	73	25				2				13
158	100									16
159	100					0.5				15
160	100					0.5				14

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
161	100									14
162	100					0.5				13
163	100					0.5				13
164	100					0.5				13
165	100					0.5				15
166	95					5				10
167	5	95								6
168		100								6
169		95		5						6
170	90					10				13
171	100					0.5				13
172	100					0.5				15
173	100					0.5				16
174	0.5	100				0.5				5
175		100				0.5				6
176	100					0.5				13
177	100					0.5				14
178	98					2				13
179	100									12
180	5	95								6
181	10	90								6
182	20	75		5						6
183	100									13
184	100									16
185	95					5				14
186	95					5				13
187	100					0.5				13
188	98					2				14
189	50					50				13
190	100					0.5				14
191	50	50								14
192	70						30			11
193		100								4
194		95		5						3
195		100								4
196	100					0.5				12
197	100					0.5				16
198	100					0.5				14
199	10	85		5						6.5
200	100					0.5				15

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
201	100									15
202										
203	20	70		10						6
204		100								3
205	45	45		10						5
206	100					0.5				14
207	100					0.5				16
208	100					0.5				14
209	100					0.5				13
210	100					0.5				13
211	100					0.5				13
212	95					5				13
213	100					0.5				13
214	100	0.5								10
215	100	0.5								13
216	100	0.5								13
217	100									12
218	75	25		0.5		0.5				7
219		100								3
220	100					0.5				10
221	100					0.5				10
222	100					0.5				12
223	100					0.5				12
224	5	95								10
225		100								5
226		100								6
227		100								9
228		100								5
229	5	95								10
230	49	49				2				10
231	100									14
232	99	1				0.5				12
233	100					0.5				12
234	1	99								10
235	95	5								12
236	100					0.5				10
237	95	5				0.5				10
238		100								14
239	33	33		33		1				7
240		100								10

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
241		100								5
242	95			5						14
243	95	5								14
244	100									15
245	90	10								14
246	10	90								14
247	95	5								10
248	98	1		1						14
249	100					0.5				15
250	98	2								14
251	5	95								4.5
252	4	95		1						10
253	100					0.5				8
254		99				1				3
255		99		0.5						5
256	100									10
257		100								12
258	95	5								14
259	100									14
260	100					0.5				14
261	90					10				14
262	80	15					5			14
263	100	0.5								8
264		100								8
265	45	5	50							12
266	5	95								13
267										10
268										15
269	38	60		2						10
270										7
271	5	95	0.5				0.5			10
272										12
273										12
274	10	85					5			14
275	99						1			10
276		100								10
277	93	5				2				11
278	70	0.5					30			11
279	90						10			8
280	35	40		5			20			7

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
281	40	40					20			7
282	100					0.5				11
283		60		40						9
284	95			5						8
285	95	2.5		2.5						12
286										
287	50	50		0.5						15
288	100					0.5				15
289	40	59		1		0.5				10
290		90		10						4
291		100								3
292		90		10		0.5				3
293	25	75				0.5				3
294	5	90		5		0.5				5
295	25	75				0.5				3
296		95					5			3
297		100				0.5				4
298	0.5	100								4
299										3
300	5	95								4
301	33	33		34						3
302		100								4
303										4
304		100								3
305		100								4
306	50	45				5				9
307	20	60		20						7
308	45	50		5						7
309	20	80								6
310	40	50					10			15
311										
312										
313		50					50			14
314		95		5						6
315		90	10							10
316		90	5	5						10
317		95		5						8
318		100		0.5						8
319	0.5	100				0.5				8
320	20	40		40						12

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
321										
322										
323	45	45	2	2			6			20
324	98	2								14
325	50	50								18
326	100									18
327	100									18
328	100									17
329	100									17
330	10	90		0.5						4
331	100									15
332	100	0.5								17
333	100					0.5				16
334	100	0.5								17
335										17
336	0.5	100								4
337	0.5	95		5						4
338	98	0.5					2			14
339										16
340			0.5							16
341	80	20								16
342	100					0.5				14
343	10	85		5						12
344	100	0.5	0.5							12
345	95	5					0.5			12
346		100		0.5						4
347	2	98		0.5						4
348	90	8		2						10
349	100					0.5				15
350	2	98								4
351	100									16
352	2	93		5						4
353	98			2						10
354	55	40		5						4
355	47.5	47.5		5						5
356		95		5						3
357	0.5	98		2						4
358		98		2						5
359		100								4
360										4

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
361	5	95								6
362	98	2								8
363	100			0.5						14
364	95	0.5		5						10
365	100									10
366	100									17
367	100									17
368	49	49		2			0.5			10
369	100									12
370	100									14
371										15
372	100			0.5						16
373	100									17
374	100									17
375	100									17
376	100									14
377										5
378	100									17
379	100									15
380	100									17
381	100	0.5				0.5				16
382		40		60						16
383	4	95	1							14
384	100									14
385		90		10						6
386										8
387	5	90		5						4
388	2	98								10
389		80	20	0.5						17
390			100							16
391	100									17
392	100									16
393		100								5
394	0.5	100								10
395	100									15
396	100									16
397	100									16
398	100									17
399	100									17
400	100									17

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
401	100									15
402	100									15
403	100									15
404	100									16
405	100					0.5				18
406										14
407	5	90	0.5	5						14
408	50			50		0.5				14
409	100									20
410	5	5	90							15
411	100					0.5				18
412										16
413		90		10						12
414	100									16
415	100					0.5				18
416	100									18
417	100									20
418										16
419	10	90								16
420	100									16
421	40	55		5						16
422	100					0.5				16
423	80	10		10						15
424	100					0.5				17
425	100					0.5				18
426	100					0.5				17
427	100					0.5				17
428	100									17
429	100									17
430	100					0.5				17
431	100									16
432	100									16
433	100									16
434	100									17
435	100					0.5				17
436	100					0.5				17
437				50		50				12
438	50			10		40				12
439	33	33	34			0.5				12
440	90					10				12

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
441	95					5				12
442	100					0.5				14
443	100									16
444	100									17
445	100									16
446	50					50				14
447	25					75				12
448	75					25				12
449	5	90		5						9
450	100	0.5								16
451	20	80								10
452	60	30		10						16
453		100								8
454	100									15
455		100								3
456	100									17
457	100					0.5				16
458	100									14
459	0.5	95		5						6
460	5	90		5						7
461		100								3
462	0.5	100								3
463		100		0.5						4
464		95		5						4
465		95		5						15
466			100							16
467		100		0.5						3
468		100								2
469	0.5	100								2
470		100								3
471										2
472										2
473		100								3
474		100								3
475		100								5
476		95		5						4
477		100								4
478		100								4
479		93	0.5		2		5			5
480		100								3

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
481		100								3
482		100								3
483		98		2						3
484	100	0.5								10
485		100								2
486	0.5	100		0.5						4
487										2
488	75	20		5			0.5			9
489	90	10		0.5		0.5				12
490	100					0.5				12
491	20	80				0.5				11
492	50	50					0.5			8
493		95			5		0.5			5
494		80			0.5		20			5
495		25			75					5
496			0.5							2
497		100								3
498	10	90								4
499	50	48		2						5
500	50	50		0.5						6
501	0.5	100		0.5						2
502	50	50		0.5						4
503		100		0.5						3
504		100		0.5						4
505		100								3
506	0.5	100								3.5
507		100		0.5						3
508	0.5	50		50						3
509		100		0.5						3
510		100		0.5						3
511		100								6
512	60		20	20		0.5				7
513	50	50				0.5				8
514		100								3
515		100								2.5
516	50	50								3
517	100	0.5								12
518	80	20								10
519	90	10								7
520	25	0.5		75						6

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
521		100								2
522		100								3
523	100	0.5		0.5						10
524		100								4
525	20	80								3
526	100	0.5								8
527	100	0.5		0.5						4
528	100	0.5								4
529	90	0.5		10						3
530		100								2
531		100					0.5			5
532	100	0.5								12
533	100									12
534	100			0.5		0.5				6
535	10	90								3
536	100									12
537	100									12
538	40	60								6
539	0.5	100		0.5			0.5			2
540		100								2
541	40	60								3
542	47.5	47.5		0.5	5					7
543	100	0.5		0.5						5
544	100									14
545		100								3
546	0.5	100								2
547	0.5	100								4
548		100								4
549	100									10
550	100									12
551	100									11
552	75	20		5						10
553		75		25			0.5			7
554	47.5	47.5		5						11
555	50	50					0.5			7
556		100		0.5						3
557			0.5							17
558			0.5							17
559	100									17
560	100									16

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
561	100									15
562	50	50				0.5				12
563	5	95		0.5						10
564		0.5		100						10
565		40		50			10			9
566	95			5		0.5				7
567	100					0.5				15
568	100					0.5				17
569	5	95		0.5						12
570	10	90			0.5					7
571	50	50	0.5	0.5						7
572		15		70			15			8
573	5			0.5	90		5			9
574	85				10		5			6
575										6
576							0.5			6
577										5
578								100		5
579								100		6
580										7
581										9
582										6
583								100		5
584										4.5
585										4.5
586								0.5		4
587										3.5
588										3
589		0.5		50				50		4
590		100								4
591										2.5
592									0.5	3
593										3.5
594			0.5							3
595									0.5	3
596			0.5							2.5
597		50					50			2.5
598				95			5			3.5
599							100			4.5
600							0.5			5

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
601										3
602										5
603										6
604										5.5
605										3
606										3
607										3
608		75		0.5				5		4
609		100		0.5						6
610		100		0.5						6
611			100							3
612		35		25			40			10
613		5	0.5	90			5			10
614		25		75						9
615	12.5	12.5		75						7
616										6
617										5
618										5
619										5
620										6
621										6
622	0.5									5
623										5
624										5
625										4
626										3
627							100			4.5
628		50		50						6
629				25	75		0.5			9
630										10
631	50			50						19
632	100									20.5
633	100									21
634	100									16
635	100									19.5
636	100									15
637	100									18.5
638	100									18
639	100									14
640	100									15.5

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
641	100									14
642	100									20
643	100									18
644	100									18
645	100									19.5
646										17
647	100	0.5	0.5							10
648		100	0.5	0.5	0.5					7
649	100									19
650	100					0.5				16
651	0.5	100								14
652	100									15
653	100									19
654	40	60								15
655	0.5	100								14
656		100								10
657	10	90					0.5			8
658	100									14
659	10	90		0.5						8
660	100					0.5				16
661	5	95								5
662	0.5	80					20			5
663		95					5			4
664	10	0.5	90							8
665			95	0.5	5					6
666	20		60	20			0.5			8
667		0.5	100							4
668	0.5	100	0.5							3
669		100		0.5						4
670	10	80		5	5					7
671		70	20		10					5
672	5	75		10	10		0.5			6
673	100			0.5						20
674	100									18
675	100					0.5				18
676	100									20
677	100					0.5				17
678	100									20
679	0.5	100								8
680	20	80								6

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
681		95	5							6
682		75			25					5
683	45	50		5						10
684	5	95								4
685	10	10		70			10			5.5
686		90		5	5					5
687	0.5	40		60						3
688		95		0.5			5			5
689		5		95						4
690		5		95						3
691	20	10		70						3
692	90						10			1.5
693	10			90						2
694	0.5	100		0.5						5
695	95			0.5			5			12
696	0.5	99	0.5							3.5
697	0.5	95		5						4
698	0.5	95		5						1.5
699	0.5	100								5
700	0.5	100		5						5.5
701		100								6
702		100								5
703		100								3
704		100		0.5						4.5
705	5	90		5						6
706		100								4.5
707		100								4
708	30	65		5						5
709		100		0.5						2
710	25	70			5					4
711		100		0.5	0.5					2
712						80	20			2
713		50		50						3
714		50	50							4
715		100	0.5							3.5
716	0.5	100								3.5
717		50	50							2
718	100									9
719		100		0.5						4
720	100			0.5						8

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
721	95			5	0.5					12
722	100									12
723	100	0.5								12
724	95				5					13
725	100									14
726	0.5	95		5						6
727		100					0.5	0.5		5.5
728							50	50		5.5
729	100									15
730	100					0.5				16
731	100					0.5				15
732	95					0.5	5			15
733	90			5	5					10
734		0.5	100							12
735	50		50							10
736					50	50				9
737	34				33	33				9
738		0.5		0.5	100					3
739		100								3
740		95		5						3
741		100								2
742		100								3
743	75			25			0.5			6
744		100								3
745	25	75			0.5					3
746		100								2
747		100								2
748	50	50								5
749		100								3
750		100								2
751		60		0.5	40					5
752		100								3
753	50	50								3
754		100								2
755	0.5	100								3
756		100								5
757		100			0.5					4
758		95		5						4
759		100								2
760		100	0.5							3

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
761		70		5	25			0.5		5
762		100					0.5			3
763		90		5	5		0.5			5
764	0.5	80	0.5	10	10		0.5			3
765		100		0.5	0.5					4
766	95						5			12
767		40		30	30					3
768	98						2			12
769	0.5	99	0.5				1			4
770							100			11
771		95			5					3
772	50					50				11
773	5	95	0.5							4
774	75	25				0.5				11
775		95		5						3
776	95	0.5			5	0.5				11
777		50			50					6
778	100				0.5					11
779		50			50					5
780	100			0.5		0.5				11
781	95	0.5		0.5	0.5		5			4
782		95					5			3
783		100								3
784		100	0.5							3
785		100								3
786	100			0.5						8
787		90		5	5		0.5			5
788		95		5	0.5					4
789		85		5				10		5
790		100								3
791	0.5	100		0.5						3
792		100								4
793		100								3
794	100					0.5				11
795		80			20					6
796	100				0.5					11
797		95	5							2
798	90		5			5				11
799		100					0.5			2
800	100		0.5			0.5				10

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
801		75		20		0.5	5			3
802	85				10	5				10
803	0.5	90	5		5					3
804	25					75				10
805		100	0.5							2.5
806	50	40		10						8
807		100					0.5			4
808		100								3
809		100								4
810		80			20					5
811		100								2
812		90	10							2
813	0.5	100	0.5	0.5						4
814		95		5						1.5
815	95			5						7
816		100								4
817	100					0.5				10
818	0.5	100								3
819	95				5					12
820	50	50	0.5							4
821	5					95				11
822	0.5	100		0.5						4
823	90				10					14
824		100								2
825	100				0.5					13
826		100	0.5							2
827	50	50			0.5					6
828		50		50						2
829		90	0.5				10			3
830		100								3
831	0.5	100								5
832		100								3
833		100	0.5					0.5		3
834	5	95								3
835		60					0.5	40		5
836	100			0.5		0.5				8
837	10	90								3
838	90						10			9
839	40	60								3
840	90					10				11

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
841	30	70								4
842	100				0.5					10
843	55	2		5			40			5.5
844							100			12
845	90	10								5.5
846	100									12
847	0.5	100								5
848	100	0.5								11
849		50		50						3
850		100		0.5			0.5			6
851	0.5	95		5			0.5			2
852		95		5			0.5			1.5
853		80					20			6
854	0.5	95		5						3
855	10	90	0.5							6.5
856		100		0.5						1.5
857	0.5	90					0.5	10		6
858	50	50		0.5						4
859	42.5	42.5		10	5		0.5			10
860	0.5	100	0.5							3
861		100		0.5	0.5					2
862		100					0.5			2
863		100				0.5		0.5		2
864		100		0.5	0.5		0.5			3
865	0.5	100						0.5		3
866							100			5
867					0.5	99	0.5			4
868		0.5					100			5
869				0.5			100			5
870	90			10						6
871	0.5	90					0.5	10		6
872	100									7
873	20	70						10		5
874	35	60		5						4.5
875	55			15			30			6
876	95	0.5		5						5.5
877	100									7
878	5			5			90			5
879	0.5	100								2.5
880		90		0.5			10			2

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
881	0.5	100								2
882	20						80			8
883	80						20			8
884						10	90			6.5
885	50			50			0.5			7
886	100									7
887	100									8
888		98			2					1.5
889	10				0.5		90	0.5		5
890		0.5			0.5		50	50		6
891					100					7
892	0.5	0.5		0.5			70	30		5.5
893	50		0.5		50					5
894	0.5	100		0.5						1.5
895					90	5	5			7
896		100								3
897	50	50					0.5			5
898		0.5								7.5
899		50	50							2
900		85		10				5		7
901		100	0.5							2.5
902	10	90								2.5
903	49	49		0.5	0.5		0.5			7
904	70			30						9
905		99		0.5						4.5
906	98			2						8
907	60	10		0.5			30			8
1001		100			0.5					3
1002		100								4
1003	20	80								2
1004		100	0.5							5
1005		100	0.5	0.5						2.5
1006		50	50							1.5
1007		70	0.5	30			0.5			6
1008	100									17
1009	100	0.5								15
1010	100									11
1011	100			0.5						10
1012	100			0.5						10.5
1013	80	15		5						7.5

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
1014	0.5	50		50						6.5
1015		100								5
1016	100									6.5
1017	5	95		0.5						7
1018	100					0.5				8
1019	50	50								6
1020	100									10
1021	20	80		0.5						6
1022		100								1.5
1023	80	20		0.5						8.5
1024	20	80				0.5				5.5
1025	90	0.5	10							2.5
1026										2.5
1027		100		0.5						5
1028		100	0.5							6
1029		5		0.5			95			7.5
1030	80	0.5		5			15			6
1031	5	90					5			6
1032		100	0.5							2.5
1033	50	50								8.5
1034		20		80	0.5		0.5			4
1035		70		30						3
1036	90	5					5			5
1037			0.5							1
1038		100			0.5		0.5			8
1039		90		0.5			0.5			8
1040		0.5					0.5			2
1041	100			0.5						6
1042		100								3
1043	0.5			0.5			95			6
1044	40			25			35			4.5
1045		0.5		0.5	0.5					2
1046	80	20			0.5					5
1047	70	10		20						6.5
1048	40	40		20						4.5
1049	95	5		0.5						3
1050	100									11
1051	50	50	0.5		0.5					2
1052	45	45	5	0.5			5			7
1053		90	10							2

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
1054	20	80			0.5		0.5			9
1055	0.5	100	0.5				0.5			7
1056		85	5	10	0.5		0.5			2
1057	75	20		5						7
1058	90	10							0.5	5
1059		100								3
1060			0.5							1
1061		85		10	0.5		5			5
1062		90		10						6.5
1063		100		0.5			0.5			6
1064		50					50			8
1065		95					5			7.5
1066	10	90	0.5							7
1067	0.5	90	5		5		0.5			7
1068	5	5					90			8
1069		90		5	0.5	10				6.5
1070	90	5		5						9
1071		100								3
1072	0.5	75		25						8
1073		100	0.5	0.5						7.5
1074		95		5						7
1075	0.5	100		0.5						3
1076	5	95		0.5						6
1077	50	50								7
1078	50	50		0.5						6.5
1079		95		5			0.5			4.5
1080	0.5			100	0.5					7
1081		100		0.5						1.5
1082		95	0.5	5			0.5			6
1083	85			0.5	0.5		15			9
1084	95	0.5		5			0.5			7
1085	95			5			0.5			9
1086	0.5	95	0.5	5	0.5					6
1087	5	55		40			0.5			7
1088	5	90		5						5
1089	5	95	0.5	0.5						7
1090		100	0.5							2
1091	100			0.5						9.5
1092		0.5		0.5						3
1093	50	50		0.5						6

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
1094		100								2
1095	85	10		5		0.5				5.5
1096	20	80								4
1097	47.5	47.5		5						8
1098		100		0.5						1.5
1099	0.5	95		5						2
1100	5	90		5						5.5
1101		100					0.5			6
1102	0.5	100		0.5						2.5
1103		75		25						4.5
1104	0.5	90		10						4
1105	5	95		0.5	0.5					5
1106		50		0.5			50			5
1107		75		25						4
1108	50	50		0.5	0.5		0.5			4
1109		75		25						1.5
1110	20	80		0.5						6
1111	50	50		0.5	0.5		0.5			6
1112		100	0.5		0.5					4
1113	50	50								4
1114	100			0.5						6
1115		100			0.5	0.5				2
1116	47.5	47.5	0.5	5						5
1117		100	0.5	0.5						4
1118		65		25			10			4.5
1119	5	80		15			0.5			7.5
1120	15	75		10						5
1121	75	25			0.5		0.5			10
1122	50	50		0.5			0.5			1.5
1123	0.5				95		5			10
1124	50						50			9.5
1125	95	0.5			5					10
1126		100			0.5		0.5			2
1127	50	50			0.5					9
1128	85	10		5	0.5					4.5
1129	80	10			0.5		10			7
1130		100			0.5					2
1131	85	15			0.5					9.5
1132		100		0.5			0.5			2
1133		0.5					100			10

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
1134		15		5			80			10
1135	5	95		0.5			0.5			5.5
1136	100				0.5					10
1137	60	40					0.5			6
1138	5	95								6.5
1139	5	95		0.5						4
1140	0.5	100								6
1141	75	25								6
1142		95		5						4
1143	0.5	100								4
1144	95	5								5.5
1145	20	80								5
1146	50	50			0.5					5
1147	60	40		0.5						6
1148	47.5	47.5		5			0.5			5
1149	0.5	100			0.5					1.5
1150	95	5		0.5						6.5
1151	20	60		20						1.5
1152	5	90					5			7
1153		100					0.5			2
1154	5	95								4
1155	60	40								8
1156		100								3.5
1157	50	50				0.5				7
1158		100								3
1159	95					5				8
1160		100					0.5			2.5
1161	40	40		20						4.5
1162					5		95			5
1163		90		10		0.5				4
1164							100			6
1165	10	90								3
1166		90					10			6
1167	0.5					20	80			5
1168		33		33			34			7
1169		85		15						5
1170	90	10								8
1171	0.5	100								3.5
1172	90			10						8
1173	0.5	100								3

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
1174	100									7
1175	10	80					10			3
1176	20				80					7
1177		100	0.5		0.5					4
1178	100									11
1179		100								3
1180	5				95					10
1181	0.5	100								4
1182	100									13
1183	30	40		30						5
1184	100									13
1185	0.5	100								1
1186	90			0.5	10					11
1187	10	90								7
1188	0.5	0.5		50			50			11
1189		90		5	5					5
1190	100									12
1191	70	25		5						4
1192	0.5						100			10
1193	0.5	75		25						4
1194							100			10
1195		90		5			5			5
1196	50						50			11
1197	5	90		5						2
1198	50			5			45			10
1199	25	25		25			25			10
1200		100		0.5	0.5					2
1201	5			5			90			7
1202	70	0.5					30			9
1203		100		0.5						2.5
1204	5	90		5						6
1205		95					5			6
1206	0.5	100		0.5						3
1207		90	5	5						2.5
1208	60			40						6
1209		100		0.5			0.5			3
1210		100								3
1211	0.5	100		0.5						3
1212		100								3
1213		60		10			30			3

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
1214		100					0.5			4
1215	80	10		10						6
1216	100			0.5						4
1217	100			0.5						8
1218	90				5		5			8
1219	0.5	100								5
1220	100									10
1221		100								3
1222	10	90								4
1223	20	80								5
1224	0.5	100								4
1225	5	95				0.5				4
1226	0.5	100								4
1227	90	10								5
1228	0.5									17
1229	5	90		5						3
1230	100									18
1231	100									10
1232	100									10
1233	0.5	100				0.5				7
1234	10	90								3
1235	20	80								3
1236		80		10		10				3
1237		50			50					3
1238		95		5						2
1239	50	20			30	0.5				4
1240	60	30		10						4
1241	75				20		5			8
1242	50	50								3
1243	100									15
1244										3
1245	100					0.5				10
1246	0.5	90		5		5				4
1247	100									13
1248	20	80								6.5
1249	100									9
1250		100		0.5			0.5			2.5
1251	95	5								7
1252	0.5	100								3
1253	95					5				8

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Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
1254		100								4
1255	95					5				10
1256		100								3
1257	60	40								7.5
1258	0.5						100			10
1259	0.5	100								3
1260	25			25			50			8
1261		85		15						4
1262	95			5						7
1263	0.5			5			95			7
1264	0.5	0.5					100			7
1265		100		0.5						3
1266	90	5		5						8
1267							100			10.5
1268		95		5			0.5			3
1269	100	0.5								10
1270		95		5						3
1271	20	20					60			8
1272	40	50		5	5					5
1273	45	50		5						9
1274	0.5	98		2						3
1275		0.5					100			7
1276	5	90		5						6
1277	10	20		30			40			7
1278	0.5	100		0.5						5
1279	45	40			5		10			9
1280	10						90			9
1281	0.5	100		0.5						2.5
1282	40						60			8
1283	5	95			0.5					6
1284	50						50			9
1285	0.5	100								5.5
1286	60	15		25						9
1287	5	95		0.5						3
1288	50	0.5					50			8
1289	50	50		0.5	0.5					8
1290	0.5	100								2
1291	90	5		5						8
1292	100						0.5			7
1293		0.5		100						3

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
1294		90		5			5			7.5
1295	5	90		5						6
1296	40	10					50			7
1297	30	60			10		0.5			6.5
1298	45	45			10					7.5
1299										
1300	55			5			40			5.5
1301		95			5					2
1302		80		20	0.5					3
1303	50	0.5		50						4.5
1304	0.5	85		10	5					6
1305	75			20	5					7
1306		95		5			0.5			3
1307		10			0.5		90			7
1308	90						10			7
1309	0.5	100					0.5			3.5
1310		95		5						4
1311	15	5		80						7
1312	0.5	95		5						2.5
1313		100								3
1314	20	25		50			5			6
1315	50	0.5		40			10			8
1316		75			25					5
1317	5	80		15						4.5
1318	70	25		5						6
1319	10	75		15						7
1320		90		5			5			6
1321	5	90		5			0.5			7
1322	40	50		5			5			7
1323	15	40		40	5					8
1324		50		50						3
1325	60	15		20	5					7
1326	90	10		0.5	0.5					9
1327	50	50								7
1328	40	20					40			10
1329		100		0.5						2.5
1330	75			15			10			10
1331		100								4
1332	85	0.5		5	5		5			8
1333		40					60			8

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
1334		95		5						4
1335	0.5	0.5		100						4
1336		0.5			100					4
1337		0.5		5			95			7
1338	40	50		10						7
1339		40	60							6
1340		100								3
1341	10	90								6
1342	50	30		20						9
1343		100			0.5					4
1344	34	33		33						10
1345		80		20						5
1385	0.5	100								4
1386		100								4
1387	100					0.5				10
1388	100					0.5				9
1389	0.5	100								3
1390	0.5	100								5
1391	100					0.5				9.5
1392	100			0.5		0.5				7
1393	100									11
1394	75	25								10
1395		40			10		50			10
1396		95					5			4
1397		90		5			5			5
1398	60	35		5						8
1399	5	95		0.5						5
1400		100		0.5						3
1401		95		5						3
1402		0.5	100							7
1403	0.5	100								7.5
1404		10	10	60	20					8.5
1405								100		9.5
1406										10
1407		0.5		10	90					9
1408		85		10	5					7
1409		2.5		2.5				95		7
1410	0.5	60		40						7.5
1411		0.5								7
1412		15	5	80						7

Appendix E
Composition Sampling Data

Way_Pt	CeDe	MySp	NiSp	ElCa	PoCr	FiAl	PoFo	PoRi	ElAc	Depth_ft
1413		5	0.5	95	0.5					8
1414		20		80						8

Appendix B
Tahoe Keys Aquatic Plant Management Research Project
Final Report

TAHOE
RESOURCE CONSERVATION DISTRICT
870 EMERALD BAY ROAD SUITE 108 • SOUTH LAKE TAHOE, CA 96150 • 530.543.1501 PH • 530.543.1660 FAX

2013 FINAL REPORT
TAHOE KEYS AQUATIC PLANT MANAGEMENT RESEARCH PROJECT

March 6, 2014

Submitted To:
Tahoe Regional Planning Agency
Patrick Stone
128 Market Street
Stateline, NV 89449

Tahoe Keys Property Owners Association
General Manager/Water Quality AIS Subcommittee
356 Ala Wai Boulevard
South Lake Tahoe, CA 96150

Prepared By:
Tahoe Resource Conservation District
Jim Brockett
870 Emerald Bay Road, Ste. 108
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The 2013Final Report provide the results and accomplishments of the Tahoe Keys Aquatic Plant Management Research Project during the 2013 calendar year, which represents the third and final year of this three-year research project. The purpose of this research project was to provide a scientific basis for operational management of invasive and nuisance aquatic plants at Lake Tahoe, specifically in the Tahoe Keys lagoons. This was accomplished through three objectives:

1. Conduct a comprehensive literature search and produce an annotated bibliography on methods for management of aquatic invasive plants and potential non-target effects pertinent to Lake Tahoe and the Lake Tahoe Basin.
2. Determine efficacy and feasibility of currently available non-chemical methods for management of *Myriophyllum spicatum* (Eurasian watermilfoil) and *Potamogeton Crispus* (Curlyleaf pondweed) in typical infestations within the Tahoe Keys lagoon areas.
3. Monitor pre- and post- non-chemical treatment benthic invertebrate communities in areas of the Tahoe Keys targeted for aquatic plant management to evaluate changes after testing methods of non-chemical treatments.

Project Summary:

Year 1 (2011):

In 2011, benthic barriers were placed in six different locations throughout the Tahoe Keys lagoons and water movement was studied in three areas using a non-toxic fluorescent dye. A full report of project activity in 2011 can be found in the *2011 Tahoe Keys Aquatic Plant Management Research Project Report* dated December 15, 2011. The locations of barrier placement sites and dye application areas are shown in the following diagram:

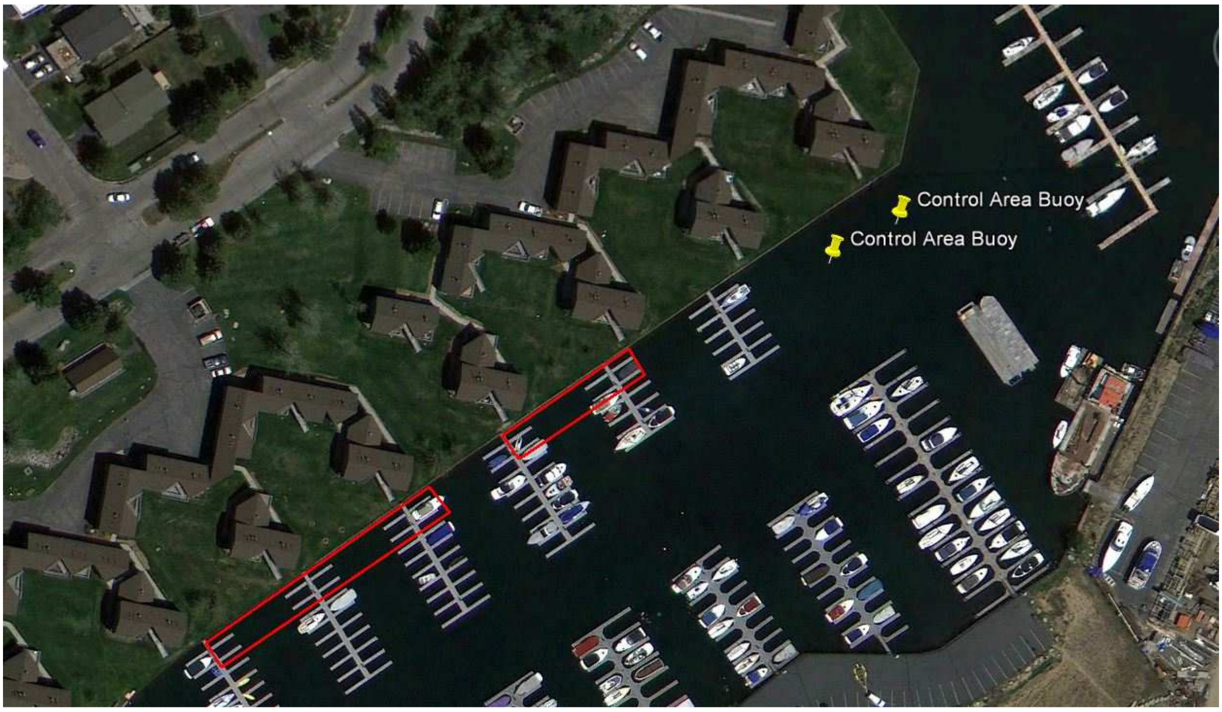
Barrier sites were selected to minimize interference with recreational uses and to represent a mix of submerged aquatic plants that include curlyleaf pondweed, Eurasian watermilfoil, and nuisance coontail. Two bottom barrier materials were used in this project for comparison of their effectiveness in controlling plant populations: a synthetic material composed of a woven plastic tarp with holes for permeability and a jute material that is a woven sheet of natural plant fibers.

Year 2 (2012):

A full report of project activity in 2012 can be found in the *2012 Tahoe Keys Aquatic Plant Management Research Project Report* dated March 14, 2013. Deployment of all bottom barriers was originally planned to occur in 2011; however barrier deployment at two of the jute barrier sites (Site 1 and Site 4) was postponed until 2012. This was a result of a relatively late start date (July 22, 2011) in 2011.

The maps below show the location and detail of sites 1 and 4.

Tahoe Keys Sites 1 and 4



Site 1 Detail

Site 4 Detail

Jute barriers were deployed at Site 1 and Site 4 in May 2012, and the following table summarizes all barrier deployment and removal conducted in 2011 and 2012:

	Material	Planned SF	Actual SF	Deployed	Removed
Site 1	Jute	9,200	11,400	5/21 – 5/23, 2012	n/a
Site 2	Synthetic	8,600	8,600	7/27 - 8/2, 2011	9/28/2011
Site 3a	Synthetic	7,500	7,500	8/8 - 8/11, 2011	9/29/2011
Site 3b	Jute	6,900	6,900	8/22 - 8/24, 2011	n/a
Site 4	Jute	10,000	11,250	5/17 – 5/21, 2012	n/a
Site 5	Synthetic	7,300	7,300	7/22 - 7/26, 2011	9/26/2011
Site 6	Synthetic	13,000	7,000	8/2 - 8/5, 2011	9/27/2011
Site 7	Jute	10,300	10,300	8/25 - 8/26, 2011	n/a
Jute Total		36,400	39,850		
Synthetic Total		36,400	30,400		

In addition to benthic barrier placement and removal, additional significant activity associated with the Tahoe Keys Aquatic Plant Management Research Project conducted during CY 2011 and 2012 includes:

- Literature search with respect to aquatic invasive plant control
- Benthic macroinvertebrate study
- Dye dissipation study

Please refer to the annual reports for those years for details.

Year 3 (2013):

2013 was the final year of the Tahoe Keys Aquatic Plant Management Research Project.

The primary activities of the Tahoe Keys Aquatic Plant Management Research Project in CY 2013 were:

1. Jute barrier ballast removal
2. Aquatic plant recolonization survey
3. Continued warm water fish control pilot study

Jute Barrier Ballast Removal

The jute barriers that were deployed in 2012 required ballast weight to hold the material to the lake bottom. Re-bar rods were used rather than sandbags in 2012 to avoid any impact from unwashed sand in the sandbags. Unwashed sand can result in the release of fine particles into the water column that are known to impact water quality and water clarity.

In May, 2012, approximately 220 pieces of 10 foot long re-bar were used to hold the jute material to the lake bottom at sites 1 and 4. Billowing jute was observed at site 4 in July of 2012, and an additional 100 pieces were deployed at site 4 in July 2012.

In July 2013, contract divers retrieved all re-bar from sites 1 and 4. The jute material was not completely decomposed, however it was significantly reduced and its integrity was weak. Silt and plants covered approximately 80% of all jute surface at both sites and it was determined that the ballast weight could be safely removed with no risk of the jute billowing up and potentially interfering with watercraft traffic.

No issues were encountered during re-bar removal.

Aquatic Plant Recolonization Survey

An aquatic plant recolonization study was conducted by Dr. Lars Anderson in September 2013. A full copy of this report will be provided under separate cover.

From Dr. Anderson's report:

> Summary
>
> 1. The most consistent pattern in macrophyte distribution is the predominance of *C. demersum* in areas with water depths >10 ft. at least within those sites sampled, and particularly in Site 1 (Table 1). For example, *M. spicatum* accounted for about 52% of the all plants found near the bulkhead in Site 1, but less than 3% in samples taken 25-30 ft away from the bulkhead in deeper water (>12 ft deep).
>
> 2. There appears to be no significant differences in relative abundance of the species within the barrier areas and in areas adjacent to those sites. However, there appears to be some increasing trend in presence of *E. canadensis* within some of the bottom barrier areas. Due to the high variability within sites, this is probably not significantly different and may be due to the late season and diminished abundance of *M. spicatum* and possibly *P. cripus*.

3. Only one small fragment of *P. crispus* was found in the entire sampling effort. Since the biomass of this plant typically declines in late summer, its absence isn't surprising.

4. The few pieces of jute found in a few samples were decaying rapidly and were permeated with sediment.

5. Regardless of the prior barrier deployment, there was an abundance of macrophyte growth in all sites, including the presence of emergent spikes with inflorescences) on *M. spicatum* in near-shore areas of some sites.

Warm Water Fish Pilot Control Project Summary:

Warm water fish control conducted by the California Department of Fish and Wildlife continued in CY 2013. Results from this effort will be provided at a later date under separate cover.

Turbidity Monitoring:

Turbidity and water quality monitoring for the Tahoe Keys Aquatic Plant Management Research Project was completed as required by the Lahontan Regional Water Quality Control Board, Section 401 Water Quality Certification conditions as follows:

Turbidity resulting from the project must not exceed either condition 1 or 2, whichever is the greater limit:

1) Turbidity must be 3 Nephelometric Turbidity Units (NTU) or less, or
2) Turbidity must be no more than 10% above background turbidity, determined by measurements made within one hour before project activity and one-half hour after.

Turbidity monitoring was conducted throughout the project when required, and there was no activity in 2013 that required turbidity monitoring.

Recreational Impact:

Boat traffic in the areas where work was conducted was minimal during all three years of project activity. Project locations were selected at or near the ends of lagoon channels to avoid watercraft interference. At no time during the project were residents with boat slips in the work area actively using their boats and this project had no impact on recreational boating.

Literature Search:

Details of the literature search described above can be found in the *2011 Tahoe Keys Aquatic Plant Management Research Project Report* dated December 15, 2011.

Dye Dissipation Study:

In 2011 there were two injections of Rhodamine WT (fluorescent dye) in the Tahoe Keys lagoons to address the following objectives:

1. Determine Fate and Movement of Herbicide Surrogate
2. Determine the retention time and movement of the water-soluble fluorescent dye Rhodamine WT as an indicator of residence time and movement of aquatic herbicides.
3. Compare retention time and movement of Rhodamine WT in several typical aquatic weed infested locations including: Tahoe Keys marine, Ski Run, Lakeside Marina and adjacent near-shore, Meeks Bay, and weed-infested site adjacent to the Truckee dam.
4. Use data from this dye study to develop proposed aquatic herbicide evaluation protocols and monitoring protocols (e.g. location and timing of pre- and post-herbicide application water sampling).
5. Use data from this dye study to help understand potential dispersal patterns for plant propagules (stem fragments, turions) and invasive clam/mussel larvae.
6. Provide summary report of results and recommendations

The results of the dye studies are provided in detail in the *2012 Tahoe Keys Aquatic Plant Management Research Project Report* dated March 14, 2013.

Benthic Macroinvertebrate (BMI) Monitoring:

The final stage of benthic macroinvertebrate monitoring associated with the Tahoe Keys Aquatic Plant Management Research Project was conducted in November 2012. The final BMI report from the University of Nevada, Reno can be found in the *2012 Tahoe Keys Aquatic Plant Management Research Project Report* dated March 14, 2013.

Conclusions:

This three-year project has given us the opportunity to investigate the efficacy of mechanical control methods of aquatic invasive plants, water movement patterns, and benthic impacts in the Tahoe Keys lagoons. We hope that these data will help to inform an integrated aquatic plant management plan in the Tahoe Keys.

The Tahoe Keys lagoons comprises approximately 174 acres of surface water. During the past three years, we were able to test the treatment of aquatic plants with bottom barriers of approximately 0.75 acre using jute bottom barriers and approximately 0.75 acre using synthetic benthic bottom barriers. There were no observable impacts to the benthic macroinvertebrate community or to recreational boating activity due to project activity. Contract divers were employed to deploy and recover bottom barriers in the Tahoe Keys and the cost of these barrier treatments were approximately:

- Synthetic barriers: $100K per acre
- Jute barriers: $65K per acre

Synthetic barriers and jute barriers were both effective at suppressing submerged aquatic plants in the short term of less than 12 months. However, plant recolonization rates showed that after a period of 12-24 months, the plant density within the treatment areas was similar to the density in untreated areas. Therefore, bottom barriers may be useful in preventing the growth of aquatic plants around a dock or within a boat slip for the duration that the barriers are in place. In order to be an effective treatment for control aquatic plants in the Tahoe Keys lagoons, the entire infestation area would need to be treated in order to prevent or reduce recolonization from adjacent areas.

While a direct extrapolation of the per acre costs to deploy barriers may preclude inclusion of potential savings associated with scales of magnitude, a rough estimate for a comprehensive benthic barrier treatment throughout the entire Tahoe Keys lagoons is approximately $17.4M with synthetic barrier treatment or $10.44M with jute barrier treatment. It is estimated that current harvesting costs for the Tahoe Keys are $260,000 per year. If barrier treatment were to be used in place of mechanical plant harvesting, financial ROI could occur in approximately 67 years for synthetic barriers and 43.5 years for jute barriers. However, prior control work has shown that multiple years of barrier treatment are required to control most aquatic invasive plant infestations. Barrier treatment in the second and potentially even third year of comprehensive control tends to require less effort as plant density is reduced but additional years of barrier treatment could extend the financial ROI for the Tahoe Keys to in excess of 100 years. It should be additionally noted that even when localized eradication is achieved, the seed bed of aquatic invasive plants can persist for long periods of time and where localized control is conducted, multiple years of diver-assisted removal may be necessary to ensure that the plant population is not able to reestablish.

Mechanical treatment of aquatic invasive plants (bottom barriers and diver-assisted removal) in other areas of Lake Tahoe has proven to be very effective – even to the point of localized eradication. However, the areas where invasive plant control effectiveness has been high are in open-lake locations such as Emerald Bay and Lakeside Beach. Control results in enclosed, man-modified areas like marinas have been less effective at reducing plant infestations over the long-term. This is due to differences in substrate (very silty in enclosed areas and sandy in open-lake areas), plant density (typically higher in enclosed areas), and recolonization rates (higher likelihood in closer proximity to untreated areas). As a result of these factors, it is likely that mechanical methods alone (bottom barriers and diver-assisted removal) would not be effective as an aquatic plant control strategy in the Tahoe Keys.

Summary:

The 2013 project efforts in the Tahoe Keys lagoons included completion of barrier ballast material removal, survey and analysis of aquatic invasive plant recolonization, and continued warm water fish pilot control activity. Tahoe RCD has provided effective project oversight from 2011 through 2013 to achieve the identified project objectives.

This project demonstrated excellent cooperation, communication and coordination among agencies, contractors and the Tahoe Keys POA. Regular coordination meetings have been highly effective and on-site oversight provided real-time information to project managers about logistical challenges. There were no substantive complaints from homeowners during this project.

Appendix C
Waste Discharge Requirements
Issued to the Tahoe Keys Property Owners Association

CALIFORNIA
Water Boards

EDMUND G. BROWN JR.
GOVERNOR

MATTHEW RODRIQUEZ
SECRETARY FOR
ENVIRONMENTAL PROTECTION

Lahontan Regional Water Quality Control Board

July 18, 2014

TO ALL INTERESTED PERSONS:

ADOPTED BOARD ORDER NO. R6T-2014-0059, FOR WATER QUALITY CERTIFICATION AND WASTE DISCHARGE REQUIREMENTS FOR TAHOE KEYS PROPERTY OWNERS ASSOCIATION, WDID NO. 6A090089000

Enclosed is a copy of Board Order No. R6T-2014-0059 that was adopted at the Regional Board meeting held in South Lake Tahoe, CA on July 17, 2014.

Amber Wike

Amber Wike
Office Technician

Enclosure

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION

BOARD ORDER NO. R6T-2014-0059

WDID NO. 6A090089000
FOR

WATER QUALITY CERTIFICATION AND WASTE DISCHARGE REQUIREMENTS FOR TAHOE KEYS PROPERTY OWNERS ASSOCIATION

El Dorado County

FINDINGS of the California Regional Water Quality Control Board, Lahontan Region (Water Board):

1. Dischargers

   The Tahoe Keys Property Owners Association (TKPOA) submitted a complete Report of Waste Discharge and National Pollutant Discharge Elimination System (NPDES) application on January 22, 2014, for the Tahoe Keys properties in the Main Lagoon and Marina Lagoon. For the purposes of these Waste Discharge Requirements (WDR), the TKPOA is referred to as either TKPOA or the "Discharger" and its properties are referred to as the "Facility." General Location of the Facility is depicted in Attachment A, and Tahoe Keys Main Lagoon and Marina Lagoon monitoring stations are given in Attachment B.

2. Permit History

   The first permit established for the Facility was Board Order No. 6-75-048 (NPDES Permit No. CA0102750) adopted on March 27, 1975. The permit has been updated three times: Board Order No. 6-87-077 (NPDES Permit No. CA0102750) adopted on July 10, 1987; Board Order No. 6-92-082 (NPDES Permit No. CA0103021) adopted on September 10, 1992; and, Board Order No. 6-98-035 (NPDES Permit No. CA0103021) adopted on June 4, 1998. Cleanup and Abatement Order No. 6-1999-0008 was issued on April 27, 1999, that required TKPOA to abate future violations of effluent limitations for aluminum. All previous permits addressed the lagoon and marina circulation system as well as its treatment plant that was constructed primarily to reduce lagoon turbidity post-construction, but is no longer used. The Water Board issued a NPDES permit (Board Order No. R6-2004-0024; NPDES Permit No. CA0103021) for a five-year term, as allowed by federal law, on June 9, 2004, addressing the main lagoon and marina lagoon circulation system and requiring TKPOA to submit and implement a nonpoint source management plan. This Permit did not allow use of the water treatment plant.

3. Reason for Action

In 2008, the United States Environmental Protection Agency (USEPA) added a new rule to the Code of Regulations (CFR) on "water transfers." 40 CFR section 122.3 states the following:

"*The following discharges do not require NPDES permits:*

(i) Discharges from a water transfer. Water Transfer means an activity that conveys or connects waters of the United States without subjecting the transferred water to intervening industrial, municipal or commercial use. The exclusion does not apply to pollutants introduced by the water transfer activity itself to the water being transferred."

The new rule made an NPDES permit unnecessary for the discharge of water from the lagoon and marina to Lake Tahoe. Because of this rule change, the Water Board is replacing the NPDES permit with WDR under the California Water Code. The WDR addresses water discharges related to operating the circulation system and require implementation of a new non-point source pollution reduction strategy.

The objective of this WDR is to protect the beneficial uses of receiving waters by requiring both water- and land-based management actions to reduce all potential sources of pollutants. Water-based sources are to be covered primarily in the Integrated Management Plan (IMP). Land-based sources include (i) stormwater discharges through shared stormwater collection and treatment facilities system, which are maintained by TKPOA yet the discharge is covered by the City of South Lake Tahoe General Municipal Stormwater NPDES Permit, and (ii) surface flows and percolating groundwater that may flow directly to Tahoe Keys Lagoon or Marina. The Nonpoint Source Water Quality Management Plan (NPS Plan), which is required by this Order, will focus on the latter land-based direct sources not captured by the stormwater system (item ii above).

4. Description of Facility and Discharge

The Tahoe Keys residential development is situated on 372 acres of land and inland waterways accessible to Lake Tahoe. Common properties include private beaches, clubhouse, swimming pools, tennis courts, basketball court, navigable waterways, boat docks, pier, and park lands. Public service facilities include administrative offices, water wells and distribution system, corporation yard, and a lagoon water treatment and circulation facility (located at 2100 Texas Avenue in the City of South Lake Tahoe).

The Tahoe Keys Lagoons are comprised of three principal man-made water features: the Main Lagoon, the Lake Tallac Lagoon, and the Marina Lagoon. The Facility located is shown in Attachments A and B. Information regarding each of the three lagoons is shown in Table 1 (from TKPOA Report of Waste Discharge

(ROWD). TKPOA harvests aquatic weeds in the TKPOA Lagoon, the areas of the Marina Lagoon owned by TKPOA, the California Tahoe Conservancy (CTC), Tahoe Keys Marina (TKM), and the Tahoe Keys Beach and Harbor Association (TKB&HA) under the provisions of a settlement agreement.

Tahoe Keys is a non-profit 1,529 member common interest residential subdivision development in the City of South Lake Tahoe (CSLT), El Dorado County, encompassing 1,194 single family residential units and 335 townhouse residential units, headquartered at 356 Ala Wai Boulevard, South Lake Tahoe, CA. The Tahoe Keys property owners are represented by the TKPOA which is also responsible for the common properties. TKPOA operates and maintains the Tahoe Keys lagoons, which are located on TKPOA member's private property and its common properties.

The TKPOA area of jurisdiction is unique at Lake Tahoe because the entire area has a dense development of residential uses on land that is a man-modified, former wetland situated within the edge of Lake Tahoe. All properties within the TKPOA area drain to waters that are directly connected to Lake Tahoe.

Lagoon	Surface Area, Acres	Lagoon Property Ownership (listed in order of area owned)	Connection to Lake Tahoe
Main Lagoon	110	• ≈ 700 private owners • TKPOA Common Area	West Channel
Marina Lagoon	32	• Tahoe Keys Marina • TKPOA Common Area • Tahoe Keys Beach and Harbor Association • California Tahoe Conservancy	East Channel
Lake Tallac Lagoon	30	• 1 Major private owner (Lagoon Partners, Inc.) • ≈ 120 private owners • TKPOA Common Area	Via Pope Marsh

The lagoon water treatment and water circulation facilities were built for water quality improvements following construction of the Tahoe Keys project. The lagoon water treatment facility using chemical coagulation and clarification is no longer operated, and its operation is not included in this permit, though the water circulation facility is operational and is included in this permit. The lagoon water circulation system is depicted in Attachment B, and consists of an intake (W) from the Main Lagoon, 17 outfalls in the Main Lagoon (C1-C6 and 1-5; 8-13), two outfalls into the Marina Lagoon (6 and 7) and one intake from Marina Lagoon (D). The Monitoring and Reporting Program has provisions to increase the frequency of monitoring if and when the circulations system is operated.

Management actions are needed to reduce the potential discharge from non-point sources, such as landscaping irrigation runoff, fertilizers, pesticides, herbicides, rodenticides, mechanical aquatic weed harvesting and maintenance of private stormwater facilities.

Chapter 5.18 of the Lahontan Basin Plan, Total Maximum Daily Load for Sediment and Nutrients, Lake Tahoe, El Dorado and Placer Counties states:

> **Introduction:** *Lake Tahoe is designated an Outstanding National Resource Water by the State Water Resources Control Board and the Unites States Environmental Protection Agency due to its extraordinary deep water transparency. However, the lake's deep water transparency has been impaired over the past four decades by increased fine sediment particle inputs and stimulated algal growth caused by elevated nitrogen and phosphorus loading.*

The Lake Tahoe TMDL Implementation Plan has a goal to "reduce fine sediment particle, phosphorus, and nitrogen loads to Lake Tahoe." This permit with the goals of minimizing inputs of nitrogen, phosphorus, and sediments into Lake Tahoe and its tributaries.

Constituents of concern in the Tahoe Keys lagoons include sediment, water temperature, dissolved oxygen, ammonia, nitrate, total nitrate, total phosphorus, soluble reactive phosphorus, and aquatic invasive species. Water temperature is an important parameter for rates of internal loading of nitrogen and phosphorus and for growth of aquatic invasive species and native plants that interfere with navigation (NAV) beneficial uses. Ammonia, nitrate, total nitrogen, total phosphorus, soluble reactive phosphorus are important sources of plant-available nitrogen and phosphorus nutrients in the water column.

The high rates of aquatic plant growth within the Tahoe Keys lagoon and marina suggest that these constituents of concern are present at relatively high concentrations within its sediments and indigenous waters. Some potential sources of nutrients include natural and upstream sources of nutrients and pollutants, which can contribute to surface water pollution via nonpoint source (NPS) runoff, irrigation practices, pet waste, and lawn and home care practices such fertilizer use. Sources of sediment may include eroded and exposed soils; road deicers and traction abrasives; vehicle use, washing and maintenance. Therefore, plans to address these potential sources and associates monitoring requirements are established in this Order.

5. <u>Authorized Disposal Site</u>

TKPOA disposes of harvested aquatic weeds outside the Lake Tahoe Basin for recycling at Full Circle Compost in Gardnerville, Nevada. This is done to avoid additional nutrient loading in the Lake Tahoe Basin. Other disposal sites are acceptable so long as they are outside the Lake Tahoe Basin.

6. <u>Disposal Practices</u>

Aquatic plants are harvested summer through fall. Harvested plants are temporarily placed in windows for drying at the TKPOA corporation yard, and then are taken to the disposal site outside of the Lake Tahoe basin. The temporary harvested plant storage will not exceed 90 days for each batch harvested to meet waste disposal requirements and to not create a nuisance from odors. Harvested aquatic plants will be properly contained on site and while in transport to prevent the dispersal of propagules.

7. Stormwater

The CSLT operates a series of storm drains and drop inlets that discharge to Tahoe Keys Main Lagoon, Lake Tallac Lagoon, and the Marina Lagoon. Stormwater enters local waters on an intermittent basis and the Water Board authorizes stormwater discharges within the CSLT city limits under the Municipal Stormwater permit (Order No. R6T-2011-0101) issued to the CSLT. Under its Municipal Stormwater permit, the CSLT is responsible for all stormwater within its jurisdiction, which includes the stormwater from private properties in the TKPOA area.

TKPOA maintains some stormwater facilities which drain directly to the lagoons and these are hereafter referred to as “shared stormwater facilities.” One such facility is the shared stormwater collection and drainage system located in the Cove 3C parking lot, draining 0.3 acre, which drains both CSLT stormwater and TKPOA Cove 3C parking lot stormwater into the Marina Lagoon via a common drain pipe. TKPOA and the CSLT have chosen to coordinate to ensure the shared stormwater facilities are sufficient to meet CSLT’s average annual fine sediment and nutrient load reduction requirements. Should any private or shared stormwater facility be identified within the TKPOA facility, it is responsible of CSLT under its Municipal Stormwater permit and it is the responsibility of TKPOA to coordinate with CSLT as above.

Other stormwater and irrigation runoff from both TKPOA common area properties and private properties discharge to CSLT storm drains via city streets, run off directly to surface water, or perchlorate into groundwater. Nonpoint source discharges from private properties and common areas may affect surface and groundwater. In private backyards, this may occur without entering the frontage groundwater. In private backyards, this may occur without entering the frontage storm drain systems (CSLT storm drains).

8. Site Hydrology

Under normal weather, precipitation, and stormwater flow conditions, no upland tributaries to Lake Tahoe directly enter the Tahoe Keys Main Lagoon or the Marina Lagoon, though under flood conditions, the gates may be opened to allow flow from Lake Tallac Lagoon into the Main Lagoon for flood prevention purposed. Lake Tahoe is directly connected to Tahoe Keys Main Lagoon via the West Channel and the Marina Lagoon via the East Channel. When lake level is rising, Lake Tahoe waters enter the lagoons, and the opposite occurs when lake level is dropping; surface water from the lagoon and marina flows out into Lake Tahoe. The estimated annual average water balance for the Tahoe Keys Lagoons is shown in Table 2 (from TKPOA ROWD).

Table 2: Tahoe Keys Lagoon Water Balance

	Source/Cause	Area, Acres	Average Annual Amount, Feet	Runoff Factor	Quantity Ac. Ft.	Portion of Total
Inflows	TK Precipitation[1]	372	1.7	0.4	254	45%
	Upland Precipitation[2]	0	1.7	0.5	0	0%
	Lake level rise[3]	100	2.5	NA	250	45%
	Irrigation Runoff[4]	82	6.7	NA	54	10%
	Inflow Subtotal				558	
Outflows	Evaporation[5]	100	3.3	NA	325	58%
	Discharge to Lake Tahoe	NA	NA	NA	233	42%
	Outflow Subtotal				558	
Net					0	

1. Annual average precipitation for South Lake Tahoe.
2. Lake Tallac intercepts upland runoff and discharges to Pope Marsh.
3. Annual average change in Lake Tahoe lake level (2003-2009).
4. Assumes 0.1 inch of irrigation runoff per watering, 4 watering events per week, 5-month watering season. Note that the portion of irrigation runoff reaching the lagoons via the City of South Lake Tahoe stormwater system is unknown.
5. Annual average pan evaporation is 36 inches for the Lake Tahoe Basin. 10% has been added to account for higher surface temperatures in the Tahoe Keys Lagoons.

9. Site Hydrology

Anecdotal recounts of historic lot construction report the Tahoe Keys land was created by a combination of excavating and pushing up wetland soils to form base for lots and capping the lots with a sand layer to provide a stable pad for building construction. The Tahoe Keys residential and townhouse lots no longer exhibit a natural wetland, though groundwater levels within the Tahoe Keys land substrate have been observed to fluctuate in response to changes in groundwater gradients caused by deep percolation of precipitation or irrigation, or lake elevation variations.

10. Basin Plan

The Water Board adopted a *Water Quality Control Plan for the Lahontan Region* (Basin Plan) on March 31, 1995, and adopted Basin Plan Amendments on July 12, 2000. The Basin Plan recognizes Lake Tahoe as Outstanding National Resource

Water (ONRW). This Order implements the Basin Plan, as amended.

The Basin Plan contains numeric and narrative water quality objectives applicable to all surface and ground waters within the Lahontan Region. The State Water Board adopted a policy to protect existing high quality waters (SWRCB Resolution No. 68-16). The federal regulations contain a similar anti-degradation policy. (40 Code of Federal Regulations § 131.12).

11. Receiving Waters

The Main Lagoon and the Marina Lagoon are hydrologically connected to Lake Tahoe via the West and East Channels, respectively. Groundwaters within the facility also may receive discharge of wastes by infiltration from non-point sources such as fertilizer nutrients from landscaping activities.

12. Beneficial Uses – Surface Waters

The receiving waters for flows originating from the Facility are the surface and ground waters of the Lake Tahoe Hydrologic Unit, South Tahoe Hydrologic Area (Ca. Dept. of Water Resources HU No. 634.10). The TKPOA Main Lagoon and the Marina Lagoon are hydrologically connected to Lake Tahoe and associated minor surface waters of the United States via constructed navigational channels and ground water flow.

Lake Tahoe is designated as an Outstanding National Resource Water (ONRW), for which no permanent or long-term degradation in water quality is allowable. The beneficial uses of Lake Tahoe and its associated minor surface waters and wetlands, as set forth and defined in the Basin Plan, include:

a. Municipal and domestic supply;
b. Agricultural supply;
c. Ground water recharge;
d. Freshwater replenishment;
e. Water-contact recreation;
f. Non-water-contact recreation;
g. Navigation;
h. Commercial and sport fishing;
i. Cold freshwater habitat;
j. Wildlife habitat;
k. Preservation of biological habitats of special significance;
l. Migration of aquatic organisms;
m. Spawning, reproduction and development of fish and wildlife;
n. Preservation of rare and endangered species;
o. Water quality enhancement; and
p. Flood peak attenuation/flood water storage.

13. Title 27 Exemption

Wastes consisting of harvested aquatic weeds are temporarily held at the TKPOA corporation yard, but are disposed of permanently off-site (see Finding 5). As no wastes are disposed of on-site, the Facility does not meet the definition of a "disposal site[1]" in California Public Resources Code Section 40122 and is therefore exempt from Title 27 dealing with land disposal of wastes. (California Water Code Section 13172).

14. Water Quality Baseline Data

The baseline data given in Table 3 is needed for comparison with future operations during use of the circulation system, when monitoring is required under the Monitoring and Reporting Program. The overall purpose is to assess the effectiveness of landscape and other management practices within the NPS Plan on achieving improvements in water quality relative to applicable Water Quality Objectives.

Table 3: TKPOA Annual Average Water Quality, 2007-2013[1]

Year	Total Nitrogen (TN), mg/L	Total Phosphorous (TP), mg/L	Total Dissolved Solids (TDS) (mg/L)	pH	Turbidity (NTU)
2007	0.28	0.030	74	9.16	0.75
2008	0.15	0.033	84	7.67	1.46
2009	0.33	0.043	87	9.15	7.97
2010	0.20	0.019	101	8.87	1.20
2011	0.18	0.023	71	8.31	1.72
2012	4.57	0.019	no data	8.88	no data
2013	0.24	0.026	81	7.97	1.88
WQO	**0.15**	**0.008**	**60**	**7.0 - 8.4**	**3.00**

1 Data from TKPOA Self-Monitoring Reports under prior NPDES Permit. WQO = Lahontan Basin Plan Water Quality Objectives, Chapter 5 including Table 5.1-3. TN is the sum of nitrate nitrogen + nitrite nitrogen + Total Kjeldahl Nitrogen. Lake Tahoe is Clean Water Act Section 303(d) listed as impaired for Total Nitrogen (TN), Total Phosphorus (TP), and sediment.

Tahoe Keys Lagoon and Marina Lagoon are physically connected to Lake Tahoe and have no site-specific water quality objectives (WQOs) of their own, so Lake Tahoe WQOs apply.

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1 "Disposal site" or "site" means the place, location, tract of land, area, or premises in use, intended to be used, or which has been used, for the disposal of solid wastes.

Annual Average TN, TP, and TDS equal or exceed WQOs in all years; Annual Average pH exceeds the WQO in 4 of 7 years, but all samples were taken during daylight hours when actively photosynthesizing plants remove carbon dioxide from the water, raising the pH. Turbidity is below the WQO in all years except 2009, which resulted from one unusually high turbidity reading of 99 NTU among 16 samples.

15. Aquatic Plant Growth

The Lahontan Basin Plan water quality objectives for "Biostimulatory Substances" states that:

> *Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect the water for beneficial uses.*

Aquatic Invasive Species (AIS) have affected aquatic ecosystems and caused economic damage across the United States:

- The US Environmental Protection Agency (USEPA, 2012)[2] reports the following concerning AIS:

  > *"Invasive species are one of the largest threats to our terrestrial, coastal and freshwater ecosystems, as well as being a major global concern. Invasive species can affect aquatic ecosystems directly or by affecting the land in ways that harm aquatic ecosystems. Invasive species represent the second leading cause of species extinction and loss of biodiversity in aquatic environments worldwide. They also result in considerable economic effects through direct economic losses and management/control costs, while dramatically altering ecosystems supporting commercial and recreational activities."*

- The National Oceanic and Atmospheric Administration (NOAA, 2011)[3] likewise states:

  > *"Non-native species - including plants, animals, and pathogens - are considered to be one of the greatest threats to coastal ecosystems. They have adversely impacted local economies, important fisheries, sensitive coastal ecosystems, and human health. Invasive species can aggressively spread in coastal ecosystems causing considerable impacts."*

Excessive growth of aquatic plants within the Facility impairs beneficial uses of water, such as Cold Freshwater Habitat (COLD), Navigation (NAV), Water Contact Recreation (Rec-1), Non-contact Water Recreation (Rec-2) and possibly Rare,

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[2] Web Link: http://water.epa.gov/type/oceb/habitat/invasive_species_index.cfm
[3] Web Link: http://stateofthecoast.noaa.gov/invasives/welcome.html

Threatened, or Endangered Species (RARE). The excessive aquatic plant growth has caused several adverse effects to cold water ecosystems: impaired navigation of vessels, potential health and safety risk associated with entanglement of swimmers in aquatic vegetation and lack of visibility of submerged swimmers, impairment of fishing and aesthetic quality, and increased predation of native fish species by invasive fish species.

Terms Defined:

Aquatic Invasive Plant Species-non-native aquatic plants, such as Eurasian Milfoil and Curly Leaf Pondweed

Aquatic Weeds-includes aquatic invasive plant species and other, unwanted, native species such as Coontail.

Aquatic Plants-includes all native, non-native, and invasive aquatic plant species.

Harvested Aquatic Weeds: TKPOA removes significant quantities of N and P from the system by harvesting aquatic weeds and disposing them outside the Lake Tahoe Basin.

Recalcitrant (or Stable) Organic N and P: A small fraction of aquatic vegetation dies and settles to the lagoon bottom becoming stable sediment organic matter, effectively immobilizing its N and P. Rates of N and P immobilization depend on a number of site-specific environmental factors such as parent organic source, temperature, and dissolved oxygen.

As part of this Order, TKPOA will increase its institutional control, education and outreach measures to reduce inputs of N and P from landowner activities.

Non-Chemical Control of Aquatic Invasive Plant Species

TKPOA has been proactively assessing the efficacy of non-chemical controls of AIS such as use of jute mats to suppress aquatic plant growth. The Tahoe Keys lagoons were the site of a three-year Tahoe Resource Conservation District Study, “Tahoe Keys Aquatic Plant Management Research Project,” which began in 2011. The goal was to determine efficacy and feasibility of currently available non-chemical methods for management of *Myriophyllum spicatum* (Eurasian watermilfoil) and *Potamogeton Crispus* (Curlyleaf pondweed) in typical infestations within the Tahoe Keys lagoon areas. The approach was to monitor benthic invertebrate communities in areas of the Tahoe Keys targeted for aquatic plant management pre- and post- non-chemical treatment to evaluate changes after non-chemical treatments. Jute and synthetic barriers to aquatic plant growth were placed on the bottom in six locations to restrict aquatic growth. Synthetic barriers were removed after 7-9 weeks. The jute barriers were left in place until they decomposed. Final results were completed March 6, 2014.

Installation of bottom barriers by TKPOA on common areas or by private parties on privately-owned properties (the “project”) may continue under this permit in compliance with the requirements of Attachment E, “Best Management Practices for Bottom Barrier Installation for Invasive Weed Control.” As part of this Order the Water Board grants TKPOA Water Quality Certification, provided requirements in this Order, including Attachment E are followed. This project is eligible for a California Environmental Quality Act (CEQA, Finding 22) categorical exemption under California Code of Regulations title 14, section 15333, "Small Habitat Restoration Projects."

Hand-pulling of invasive aquatic weeds is encouraged. If continued use of mechanical aquatic weed harvesting is proposed, then TKPOA must develop and implement best management practice control measures to limit the spread of viable plant fragments. This Order requires submission and implementation of an Integrated Management Plan (IMP) to address aquatic invasive plant species management.

Chemical Control of Aquatic Invasive Plant Species
This permit does not authorize the use of chemical control for aquatic invasive or nuisance plants.

16. Water Quality Certification for Using Bottom Barriers to Perform Small Habitat Restoration

Pursuant to California Code of Regulations (CCR) Title 23, Section 3831, "Water Quality Certification" is a certification that any discharge or discharges to waters of the U.S., resulting from an activity that requires a federal license or permit, will comply with water quality standards and other appropriate requirements. "Activity" means any action, undertaking, or project-including, but not limited to, construction, operation, maintenance, repair, modification, and restoration-which may result in any discharge to a water of the United States in California. "Water quality standards and other appropriate requirements" means the applicable provisions of Sections 301, 302, 303, 306, and 307 of the Clean Water Act (33 USC Sections 1311, 1312, 1313, 1316, 1317), and any other appropriate requirements of state law. Based upon the information provided by TKPOA and the requirements of this Order, it is our determination that the CWA Section 401 Water Quality Certification for bottom barrier installation for aquatic weed control provided under this Order would ensure that bottom barrier projects proposed by TKPOA would comply with water quality standards and other appropriate requirements.

The Army Corps may issue a federal permit for installation and maintenance of bottom barriers under Section 10 of the Clean Harbors Act. Section 10 of the Rivers and Harbors Act (33 U.S.C. 401 et seq.) regulates aquatic activities - not discharges (such as installation or removal of pilings and buoys), and requires authorization from the U.S. Army Corps of Engineers (Army Corps) for the construction of any structure in or over any navigable water of the United States, the excavation/dredging or deposition of material in these water or any obstruction or alteration in a "navigable water." Structure or work outside the limits defined for navigable waters of the U.S. require a Section 10 permit if the structure or work affects the course, location, condition, or capacity of the water body.

Army Corps may permit the bottom barrier work proposed by TKPOA with a Nationwide 27 (Aquatic Habitat Restoration, Establishment, and Enhancement Activities) permit or Nationwide 3 (issued for maintenance type activities) permit. The Army Corps has previously issued nationwide permit (NWP) 27 for AIS control projects that involved bottom barriers in Lake Tahoe.

17. Justification for Granting a Prohibition Exemption for the Barrier Placement below the High-Water Rim of Lake Tahoe

To protect beneficial uses and achieve water quality objectives for the waters of Lake Tahoe and its tributaries, the Water Quality Control Plan for the Lahontan Region (Basin Plan) contains the following discharge prohibition:

> *"The threatened discharge, attributable to human activities, of solid or liquid waste materials including soil, silt, clay, sand, and other organic and earthen materials, due to the placement of said materials below the high-water rim of Lake Tahoe or within the 100-year floodplain of any tributary to Lake Tahoe, is prohibited."*

An exemption to the prohibition may be obtained if the project makes all of the required findings:

a. *The project is necessary for environmental protection;*

   The primary purpose of the bottom barrier placement is to control aquatic invasive species and aquatic weeds. Removal of the invasive species has been shown to re-establish the natural, pre-existing conditions.

b. *There is no reasonable alternative, including relocation which avoids or reduces the extent of encroachment in the below the highwater rim of Lake Tahoe; and*

   Since the bottom barrier placement by its very nature is located at the bottom of the Tahoe Keys Main Lagoon or Marina Lagoon, there is no reasonable alternative. Hand-pulling, suction dredged-assisted removal, and cutting by marine harvesters may not be as effective as bottom barrier placement in areas similar to the Tahoe Keys Lagoons.

c. *Impacts are fully mitigated.*

To minimize impacts generated from the project area, the project proponent will implement Best Management Practices (BMPs) given in Attachment E, which are designed to fully mitigate impacts. Installed bottom barriers accumulate a layer of sediment. If not removed at the end of growing season this sediment provides a new bed on which aquatic plants can establish. Failure to remove barriers after the growing season reduces the long term effectiveness of bottom barriers as a plant control methodology, makes future removal subject to increased turbidity issues, and may constitute the barriers becoming or being considered waste.

Projects allowed by this Order must not exceed a total of five acres of bottom barriers.

18. <u>Integrated Management Plan for Aquatic Invasive Weeds (IMP) Objectives</u>

TKPOA contracted with a consultant to develop an outline of the Integrated Management Plan for Aquatic Invasive Weeds (IMP) within an Interagency stakeholder group process. The IMP is to address the control and monitoring of aquatic invasive weeds in the Tahoe Keys Main Lagoon, Lake Tallac Lagoon, and Marina Lagoon. The IMP may address terrestrial and internal nutrient loading issues directly, or these may be addressed in separate documents, such as the Nonpoint Source Water Quality Management Plan (see Finding 18 and Order No II.B).

Objectives of the IMP are to:

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

The general approach of IMP implementation, adaptive management and public education and outreach is to:

1. Determine priority areas for control work and implement adaptive management by:

   a. Surveying Tahoe Keys Main Lagoon and Marina Lagoon initially and thereafter annually for weed types and biomass. Creating accurate maps

and summarize findings initially and thereafter in annual reports.
b. Obtaining initial input from Water Board staff, thereafter annually evaluating effectiveness of management practices, and modifying the IMP accordingly.
c. Adjusting implemented maintenance operations based on annual evaluations.

Inform and engage the homeowners through education and outreach by:

a. Developing educational brochures and press releases about the IMP.
b. Promoting best management practices for homeowners on reducing nutrient loading, preventing re-introduction of aquatic invasive weeds.
c. Informing the homeowners about TRPA's required best management practices for all properties
d. Promoting the boat inspection program.

The Monitoring and Reporting Program contains the requirements for the Aquatic Plant Monitoring Plan, which are consistent with the IMP. The general approach used in the Aquatic Plant Monitoring Plan is to survey Tahoe Keys Lagoon and Marina Lagoon annually for weed types and biomass, create accurate maps and summarize findings in annual report.

19. <u>NPS Water Quality Management Plan (NPS Plan) Approach & Objectives</u>

The NPS Plan approach consists of developing and implementing BMPs in TKPOA common areas and an outreach and education program for the private property owners to implement BMPs.

The objectives of the NPS Plan are: 1) to identify and evaluate land-based activities being conducted in the Tahoe Keys community that may be sources of pollutants (including nutrients) that have the potential to be discharged into surface waters and 2) to identify and implement site-specific management practices to reduce or prevent pollutants (including nutrients) associated with activities being conducted in the Tahoe Keys community from discharging into surface waters. To achieve these objectives, this Order requires TKPOA to develop and implement a NPS Plan to minimize impacts to the water quality of the receiving water.

TKPOA is currently employing the following Landscape Best Management Practices:

- Installed TRPA-approved runoff control BMPs at TKPOA Common Areas and approximately 30% of single-family properties TKPOA will continue to conduct outreach to encourage increased BMP implementation with a goal of 100% compliance.
- Using low or no phosphorus fertilizers on the common area and townhouse landscaping and using a minimum amount of fertilizers necessary to maintain landscaping.

- Managing the irrigation of common area and townhouse landscaping to limit runoff and deep percolation.
- Educating members regarding the impact of over fertilizing and over watering on water quality through articles in the Keys Breeze newsletter each spring.
- Implementing a voluntary water conservation program where landscape irrigation on single- family properties is recommended to every other day.

The NPS Plan formalizes these and other BMPs to minimize controllable NPS nutrient loading to surface and ground waters. \

Attachment D lists types of management practices that should be considered for control and reduction of pollutants from the Tahoe Keys common areas. Additional considerations for private residential neighborhoods include, but are not limited to, the following:

1. Develop and annually disseminate educational materials to residential property owners addressing the following topics:

   a. Water-conserving landscape irrigation techniques to reduce individual water usage and to maximize efficiency and water uptake by plants (e.g. drip irrigation).
   b. Proper fertilization practices.
   c. Pursue institutional changes (such as modification of Covenants, Conditions & Restrictions (CCRs)) to provide more options for landscape practices or turf alternatives that may reduce residential NPS N and P sources.
   d. Implementation of hydrologic source controls (aka BMP retrofit) in the BMP toolkit[4] such as pervious pavement, infiltration basins, infiltration trenches, subsurface infiltration, rain barrels and cisterns, rain gardens, and filter strips.

2. Reporting on success of education and outreach efforts by follow-up survey.

20. Antidegradation Requirements

In 1980, pursuant to federal antidegradation regulations (40 Code of Federal Regulations § 131.12), the State Water Resources Control Board designated Lake Tahoe as an Outstanding National Resource Water (ONRW). The Water Board has considered state and federal antidegradation requirements pursuant to 40 CFR 131.12 and State Water Resources Control Board Resolution No. 68-16. In accordance with these requirements, this Order does not allow permanent or long-term degradation of surface waters.

21. California Water Code Section 13241 Relating to Water Quality Objectives

When issuing a WDR, Water Code section 13263 requires that the Regional Board

[4] Tahoe Regional Planning Agency (TRPA), 2012. Best Management Practices Handbook. Web link: http://www.tahoebmp.org/bmphandbook.aspx

must, after a hearing, prescribe requirements as to the nature of any proposed discharge, with relation to the conditions existing in the disposal area or receiving waters upon, or into which, the discharge is made. The requirements must implement the Basin Plan, and take into consideration the beneficial uses to be protected, the water quality objectives reasonably required for that purpose, other waste discharges, the need to prevent nuisance, and the provisions of California Water Code Section 13241. This Order has met all these requirements, and has taken into consideration the following factors, as specified in Water Code section 13241:

(a) Past, present, and probable future beneficial uses of water. The findings of this Order identify past, present, and probable future beneficial uses of water, as described in the Basin Plan. This Order does not authorize alteration of the beneficial uses of the surface and ground water from discharges authorized by this Order.

(b) *Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto.* The findings of this Order concerning geology, hydrogeology, and hydrology provide general information on the hydrographic unit. This Order does not authorize actions that are likely to negatively affect local ground water quality in the area of the facility.

(c) Water quality conditions that could reasonably be achieved through the coordinated control of all factors that affect water quality in the area. Factors that could affect water quality within the Facility include: 1) discharge of stormwater from TKPOA common areas; 2) nonpoint source discharges from private properties and common areas to surface- and groundwater; and 3) internal loading of N and P from sediments to surface waters of Tahoe Keys Lagoon and Marina. This Order in conjunction with the CSLT Municipal Stormwater Permit and other voluntary measures will result in improved water quality conditions within the Tahoe Keys Lagoons, Lake Tahoe and groundwater.

(d) Economic considerations. TKPOA will be required to perform limited water quality monitoring of stormwater discharges and ambient water quality within the Tahoe Keys Lagoons if the water circulation system is activated. Monitoring costs are expected to be lower than under the prior NPDES permit because the prior permit monitoring established the background water quality conditions.

(e) The need for developing housing within the region. Build-out of housing within the Facility is essentially complete, though environmental impacts of any additional building will be subject to review and approval by the Tahoe Regional Planning Agency, El Dorado County, and the Water Board.

(f) The need to develop and use recycled water. This provision does not apply to this Facility.

22. Protection of Drinking Water

Lake Tahoe has a designated Municipal and Domestic Supply (MUN) beneficial use and is used as a source of drinking water by local municipalities and lakefront homeowners.

Water Code section 106.3 states that:

> *"It is hereby declared to be the established policy of the state that every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes."*

The discharges authorized under this permit will not adversely affect drinking water quality.

23. CEQA Compliance

This WDR involves operation of an existing facility and, as such, is exempt from the provisions of the California Environmental Quality Act (CEQA, Public Resources Code 21000, et seq.) in accordance with Title 14, California Code of Regulations, Chapter 3, Section 15301. There is no expansion of the permit beyond what was previously allowed.

Non-chemical control of aquatic invasive species and weeds, such as the use of bottom barriers, is categorically exempt from the provisions of CEQA under 14 CCR § 15333, Small Habitat Restoration Projects.

The "project" consists of installation and maintenance of bottom barriers that is principally carried out with hand labor and not mechanized equipment, and is "not to exceed a lifetime total of five acres in size to assure the maintenance, restoration, enhancement, or protection of habitat for fish, plants, or wildlife…"

24. Notification of Interested Parties

The Water Board has notified the permittee and other interested agencies and persons of its intent to issue a Waste Discharge Requirement permit for the discharge, and has provided them an opportunity to attend a public meeting and to submit written comments and recommendations regarding this matter.

25. Consideration of Public Comment

The Water Board, in a public meeting, heard and considered all comments pertaining to the Facility and the discharge.

IT IS HEREBY ORDERED, that TKPOA, to meet the provisions contained in Division 7 of the California Water Code, and regulations adopted thereunder, and the provisions of the Federal Clean Water Act of 1977, as amended, and regulations and guidelines adopted thereunder, shall comply with the following:

I. DISCHARGE SPECIFICATIONS: This WDR addresses waste discharges related to operating the circulation system and require implementation of a new non-point source pollution reduction strategy.

A. General Requirements and Prohibitions

1. The discharge of any toxic chemical as defined in USEPA's National Toxics Rule (40 CFR Part 131, and section 303(c)(2)(B) of the Clean Water Act (CWA)) or hazardous waste as defined in Section 311(b)(2) of the Federal Water Pollution Control Act (33 U.S.C. Sec. 1251 et seq.) is prohibited.

2. Discharges from the Facility shall not cause a pollution or nuisance, as defined in Section 13050 of the California Water Code.

3. The operation of the Lagoon Water Treatment Plant (LWTP) for chemical treatment is prohibited under this WDR. No chemicals or amendments shall be added to the circulation system; and the discharge of chemicals or amendments are prohibited from the circulation system when it is in operation. If TKPOA determines that it will test or utilize the LWTP, the Discharger must obtain approval from the Water Board under a separate Order.

B. Prohibited Non-Stormwater Discharges

Illicit discharges. such as paint or waste oil and the following categories of non-storm water discharges are prohibited from being discharged to surface waters from the storm drain/culvert at the parking lot located at Cove 3C, 439 Ala Wai Blvd, South Lake Tahoe, CA. This storm drain discharges directly into surface waters of the Marina Lagoon.

1. Discharges from residential car washing containing detergents are prohibited because they have the potential to contain nutrients, such as phosphorus and other additives.

2. Discharges of chlorinated or de-chlorinated swimming pool and spa discharges are prohibited because this water contains constituents that are prohibited from being discharged into Lake Tahoe and these waters also are usually of a higher temperature than the cold waters of Lake Tahoe and discharging warm water to cold waters of Lake Tahoe is prohibited in the Basin Plan.

TKPOA is to promote compliance with the Municipal stormwater permit (Order No. R6T-2011-0101) for stormwater draining into CLST storm drains, and to promote compliance with the NPS Plan for stormwater discharges directing entering surface waters or percolating among private homeowners within the Facility by means of education and outreach activities, which will be detailed in the NPS Plan.

C. Shared Stormwater Treatment Facilities

For the shared stormwater treatment facilities, TKPOA must either meet the surface water numeric effluent limits, as specified below, or document coordination with the CSLT to demonstrate that shared stormwater treatment facilities treating private property discharges and public right-of-way stormwater are sufficient to meet the CSLT's average annual fine sediment and nutrient load reduction requirements. Should any private or shared stormwater facility be identified within the TKPOA facility, it is responsibility of CSLT under its Municipal Stormwater permit and it is the responsibility of TKPOA to coordinate with CLST as above.

To document coordination with the CSLT, TKPOA is to provide to the Water Board a Shared Stormwater Treatment Facility report documenting evidence of cooperation with CSLT. This report shall be submitted by **October 1, 2014**, and must include but not be limited to:

- Notes from meeting and phone conversations concerning maintenance activities and management of stormwater from the shared stormwater facilities;
- Plans for water quality improvement projects or management actions, including management of snow storage and parking lot runoff.

If TKPOA does not submit the Shared Stormwater Treatment Facility report by the due date, then TKPOA must meet the surface water numeric effluent limits for stormwater runoff that cannot be infiltrated to a facility capable of infiltrating the runoff from a 20-year, one hour storm. The numeric effluent limits are as follows:

Constituent	Maximum Concentration
Total Nitrogen as N	0.5 mg/l
Total Phosphorus as P	0.1 mg/l
Total Iron	0.5 mg/l
Turbidity	20 NTU
Grease and Oil	2.0 mg/l

D. Notification Requirements

TKPOA shall notify the Water Board Executive Officer by telephone as soon as the TKPOA or the TKPOA's agents have knowledge of any unauthorized discharge or discharge in violation of this permit and shall confirm this notification in writing within one week of the telephone notification. The written notification shall contain pertinent information explaining reasons for the discharge, and indicate steps taken or planned, and dates thereof, to correct the problem and prevent it from reoccurring. An estimate of the amount of flow discharged shall be included.

E. Other Prohibitions

1. Unless specifically granted, authorization pursuant to this Permit does not constitute an exemption to applicable discharge prohibitions prescribed in the Basin Plan.

2. Discharges from the TKPOA stormwater collection, conveyance, and stormwater treatment facilities that cause or contribute to a violation of narrative or numeric water quality standards or objectives are prohibited.

3. Discharges from the TKPOA stormwater collection, conveyance, and stormwater treatment facilities shall not cause or contribute to a condition of "nuisance," which is defined in the Lahontan Basin Plan as:

   "Anything which meets all of the following requirements:

   - *Is injurious to health, or is indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property.*
   - *Affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal.*
   - *Occurs during or as a result of the treatment or disposal of wastes."*

4. Stormwater discharges regulated by this Permit shall not contain a hazardous substance equal to or in excess of a reportable quantity listed in 40 CFR Part 117 and/or 40 CFR Part 302.

5. For grading or construction projects on TKPOA common land areas, the removal of vegetation or disturbance of ground surface conditions between October 15 of any year and May 1 of the following year is prohibited. Where it can be shown that granting a variance would not cause or contribute to the degradation of water quality, a variance to the dates stated above may be granted in writing by the Executive Officer.

6. The discharge attributable to human activities of any waste or deleterious material to surface waters of the Lake Tahoe HU is prohibited.

   An exemption to this prohibition may be granted whenever the Water Board finds all of the following:

   a. The discharge of waste will not, individually or collectively, directly or indirectly, unreasonably affect the water for its beneficial uses, and

   b. There is no reasonable alternative to the waste discharge, and

   c. All applicable and practicable control and mitigation measures have been incorporated to minimize potential adverse impacts to water quality and beneficial uses.

7. The discharge attributable to human activities of any waste or deleterious material to land below the highwater rim of Lake Tahoe or within the 100-year floodplain of any tributary to Lake Tahoe is prohibited.

8. The discharge attributable to human activities of any waste or deleterious material to Stream Environment Zones (SEZs) in the Lake Tahoe HU is prohibited.

9. The discharge of garbage or other solid waste to lands within the Lake Tahoe Basin is prohibited.

10. The discharge of industrial waste within the Lake Tahoe Basin is prohibited. Industrial waste is defined as any waste resulting from any process or activity of manufacturing or construction. Stormwater discharges from industrial facilities are not prohibited when wastes in the discharge are controlled through the application of management practices or other means and the discharge does not cause a violation of water quality objectives.

11. Use of aquatic herbicides is prohibited in the current Lahontan Basin Plan. Once the Basin Plan Amendment is in effect, a separate NDPES permit is still required for application of aquatic herbicides directly to the water, and is subject to the requirements of the Basin Plan Amendment.

12. Each batch of harvested aquatic weeds shall not be stored in excess of 90 days.

II. PROVISIONS

A. Explanatory Provisions

1. Surface waters, as used in this WDR, include, but are not limited to, live streams, either perennial or ephemeral, which flow in natural or artificial watercourses, natural lakes, and artificial impoundments of waters within the State of California. The Tahoe Keys lagoons are considered surface waters of the State of California.

2. The requirements prescribed herein do not authorize the commission of any act causing injury to the property of another, nor protect TKPOA from liability under federal, state, or local laws, nor guarantee TKPOA a capacity right for waste load assimilation, flow, or storage in the receiving waters.

B. <u>NPS Plan Requirements</u>

1. This WDR requires TKPOA to develop a NPS Plan to control and prevent impacts to the receiving waters from sources of pollution within the TKPOA jurisdiction. TKPOA is required to submit the NPS Plan to the Water Board for Executive Officer review and acceptance **by January 31, 2016, and annually thereafter**. The NPS Plan may be part of the Integrated Management Plan for Aquatic Weeds or may be developed separately. This approach provides TKPOA the flexibility necessary to establish appropriate management practices for the different types of operations, activities, and pollutant sources that may impact the surface waters at the Facility. The NPS Plan must include site-specific management practices for minimizing and preventing pollution from stormwater and other nonpoint sources.

2. The NPS Plan is a written document that must contain drawings, maps, and copies or references to parts of other relevant plans and at a minimum, address the following elements:

   a. A schedule for regular monitoring of activities and management actions, including inspections.
   b. A description of existing and planned management and education/outreach activities to reduce potential source loading of nutrients, including irrigation and fertilizer practices. This is to include a plan to track the number of households reached and success of outreach efforts annually.
   c. Map drainage of stormwater path(s) which enters the Facility from outside the Facility boundaries; map “sensitive areas” that drain directly to waterways from both common and private areas. This mapping shall identify these areas that may be potential nutrient (nitrogen and phosphorus), sediment and other pollutant sources and locations (including snow storage areas), and these areas may be suitable for application of localized management practices to reduce or prevent discharge of pollutants.
   d. An adaptive management process that assesses the effectiveness of the management activities that were undertaken during the last season, and

identifies management activities that are planned to be undertaken the next season to further address water quality impairments.

e. An annual tally of the cumulative number of properties which have received a Tahoe Basin Best Management Practices Certificate of Completion for installing and maintaining best management practices (BMPs). This section must include a short narrative describing the types of BMPs installed and a rough estimate of the total acres retrofitted compared to the acres needing a BMP retrofit.
f. An evaluation of TKPOA irrigation and fertilizer practices and existing rules relating to TKPOA property owners maintenance of private properties. The written evaluation must explain rationale for choosing to implement certain elements and not all elements that are listed in Attachment D, including drought-related water conservation measures to prevent overwatering and runoff).
g. TKPOA's pursuit of institutional changes (such as modification of Covenants, Conditions & Restrictions (CCRs)) to provide more options for landscape practices or turf alternatives that may reduce residential NPS N and P sources.

3. The NPS Plan must be readily available for review by TKPOA employees or Water Board inspectors. A copy of any requirements incorporated by reference into the NPS Plan must be kept at the Facility. Through this plan TKPOA shall assure that discharges would neither cause, nor contribute to, an exceedance of water quality standards and objectives, nor create conditions of nuisance in the receiving water.

C. Integrated Management Plan for Aquatic Invasive Weeds

TKPOA is to prepare an Integrated Management Plan for Aquatic Invasive Weeds in cooperation with Water Board, TRPA, Tahoe Resource Conservation District, and other appropriate regulatory agencies and submit it to Water Board staff by **January 31, 2016** and begin implementation of the plan after acceptance by Water Board Executive Officer. The Aquatic Plant Monitoring Plan, required in the Monitoring and Reporting Program, may be part of the IMP or may be developed separately. The IMP must include best management practice control measures to limit the spread of viable plant fragments during aquatic weed harvest operations. This permit does not authorize or cover the use of aquatic herbicides.

The IMP document is to include, at a minimum:

1. The purpose of the Integrated Management Plan.

2. A description of the aquatic invasive weed problem, including detailed maps of infestations and problem areas.

3. TKPOA is to certify that any bottom barriers installed under this permit meet the conditions given in Attachment E. A report of bottom barrier implementation is to be prepared annually, and is to include the location, and dimensions of all installed bottom barriers and a summary of acres of bottom barrier installed to date.

4. A discussion of the problems associated with management of aquatic plants in the Keys including the beneficial role of aquatic plants compared to negative impacts of uncontrolled growth of aquatic weeds, and the effect of aquatic plants on beneficial uses in the Tahoe Keys (e.g. impairment of navigation and recreational use of the waters), including non-native Eurasian watermilfoil and curly leaf pondweed.

5. A discussion of other problematic aquatic invasive species in the Tahoe Basin such as warm-water fishes, Asian clam, signal crayfish as well as species that could invade Lake Tahoe such as quagga mussels.

6. A history of non-chemical aquatic weed control efforts to date, including mechanical harvesters, Solar Bees, and bottom barriers.

7. Proposed integrated weed management and control methods. These control methods should include an evaluation of current mechanical harvesters, design improvements to the mechanical equipment, and an assessment of other mechanical methods such as rototilling. The proposed methods should consider best management practices for weed fragment control, boat inspections; and public involvement and education. Biological control methods such as weevils or grass carp, should be evaluated.

D. <u>Annual Reports and Updates</u>

1. Pursuant to Section 13267(b) of the California Water Code, TKPOA shall comply with Monitoring and Reporting Program requirements of Order No. R6T-2014-0059 and with the "General Monitoring and Reporting Provisions."

2 An adaptive management approach shall be implemented by use of annual updates of the NPS plan and the IMP. TKPOA shall submit an annual updated NPS Plan, IMP, and updated Aquatic Plant Monitoring Plan, including a summary of the success of bottom barrier implementation, by no later than January 31 of each year covering the previous 12 months from October 1 through September 30 (except the first period will be from January 31 through September 30, 2016), beginning in January 31, 2016, and based on these observations, revise the NPS plan for the upcoming season as appropriate. The NPS Plan shall including these minimum updates:

   a. <u>Management Practices Planned</u> – Include a schedule listing specific management practices planned to address the identified problems and describe the details of each BMP and explain how the BMP implementation will adequately address the problem. Show the anticipated BMP implementation date on the schedule. For education and outreach activities, this is to include a list of planned outreach activities or events sponsored. Education and outreach activities considered should include, at a minimum those issues identified in Attachment D concerning irrigation and fertilization, and BMP retrofitting of homes with a goal of 100% compliance. For issues involving modifying institutional constraints to allow a larger suite of effective BMPs for NPS nutrient control, report planned actions such as proposed amendments to CCRs. Actions to remove institutional constraints should include, at a minimum, water conservation and turf removal.

b. Management Practices Implemented – Describe the management practices that were implemented for the reporting period. Discuss constraints, obstacles, and other problems noted during the reporting period. For education and outreach activities, this is to include a list of outreach activities or events sponsored, the number of individuals or households reached, and how many homeowners who attended workshops or received outreach information implemented the BMPs. For BMP retrofits, this is to include an annual tally of the cumulative number of properties which have received a Tahoe basin BMP Retrofit Certificate of Completion and an estimate of the total acres covered by those BMP retrofits. For issues involving modifying institutional constraints to allow a larger suite of effective BMPs for NPS nutrient control, results of actions (such as member votes) and the implications of adopted modifications shall be reported.

c. TKPOA is to develop the Aquatic Plant Monitoring Plan by January 31, 2016 and implement it beginning **January 31, 2016** and annually thereafter, as updated. This may be part of the IMP, or a separate monitoring plan.

d. Water Quality Certification Status – TKPOA is to report no later than **January 31, 2015** and annually thereafter, the following concerning the status of the WQC project:

- Total square feet or acres treated,
- Locations of treatment
- Success of bottom barrier installation project - document improvements in beneficial uses (navigation and recreation) such as critical areas clear of weeds, reductions in invasive aquatic species.

3. In the event TKPOA is unable to comply with any of the conditions of this WDR due to:

a. Breakdown or serious malfunction of lagoon water circulation equipment;
b. Accidents caused by human error or negligence;
c. Other causes such as acts of nature;

TKPOA shall notify the Executive Officer by telephone as soon as TKPOA or TKPOA's agents have knowledge of the incident or noncompliance and confirm this notification in writing within one week of the telephone notification. The written notification, pursuant to Section 13267(b) of the California Water Code, shall contain pertinent information explaining reasons for the incident or noncompliance, and indicating steps taken or planned, and dates and times thereof, to correct the problem and prevent it from reoccurring.

4. TKPOA shall file a Report of Waste Discharge with the Water Board at least 180 days before making any material change or proposed change in the character, location, or volume of the discharge.

E. <u>Administrative Provisions</u>

1. Board Order No. R6-2004-0024(NPDES Permit No. CA0103021) expired on June 9, 2009, and is hereby rescinded.

2. TKPOA shall comply with "Standard Provisions for WDR Permits," as shown on Attachment "C", which is made a part of this WDR.

3. The California Regional Water Quality Control Board, Lahontan Region, hereby reserves the right to change all or any portion of this WDR upon legal notice to all concerned parties, and after an opportunity to be heard is given to all concerned parties.

III. <u>WATER QUALITY CERTIFICATION</u>

THE REGIONAL WATER BOARD HEREBY CERTIFIES that projects in compliance with the conditions given below will comply with the applicable provisions of Clean Water Act sections 301 (Effluent Limitations), 302 (Water Quality Related Effluent Limitations), 303 (Water Quality Standards and Implementation Plans), 306 (National Standards of Performance), and 307 (Toxic and Pretreatment Effluent Standards), and Section 10 of the Rivers and Harbors Act (33 U.S.C. 401 et seq.). TKPOA will develop rules, applications, and permits to control the number and quality of installation of bottom barriers. This Certification Order authorizes TKPOA to administer a project for bottom barrier installation for control of aquatic invasive species and aquatic weeds within TKPOA common areas and within TKPOA member properties given the following conditions apply:

A. <u>Water Quality Certification Requirements</u>

1. Project Description – The project consists of not more than five acres at one time of non-chemical aquatic weed control, using bottom barriers. Installation is allowed in TKPOA common areas or on TKPOA member properties as

administered by TKPOA covered under this water quality certification.

2. BMP Implementation – TKPOA must comply with the conditions of Attachment E “Best Management Practices for Bottom Barrier Installation for Invasive Weed Control.”

3. Project Size- The project size shall not exceed a total of five acres at one time covered by bottom barriers.

4. Compensatory Mitigation is neither required nor applicable for this project because it is a small habitat restoration project.

5. Primary Project Purpose - This Order authorizes activities whose primary purpose is habitat restoration. The project shall not be for restoration and enhancement conducted as part of a larger project whose primary purpose is not habitat restoration. e.g., land development or flood management.

6. Individual Project Plans with Monitoring Plan – TKPOA must develop rules, application processes, permits, and an inspection and monitoring program to regulate and oversee individual homeowner’s installation of bottom barriers. However, TKPOA will retain ultimate responsibility of all bottom barrier installation and removal under this Water Quality Certification. Bottom barrier installation and removal must conform to the BMP specified in Attachment E. The purpose of the required inspection and monitoring program is to evaluate the success or failure of the bottom barrier projects and minimum elements must include an inspection of the efficacy of the anchors, bottom barrier integrity, buildup of gas beneath the barrier, and any other relevant observations. The level of detail required of the individual project plans and permits, the inspection and monitoring program, and the associated reporting shall be commensurate with the scope and size of the restoration project.

   Annually, at the start of the aquatic plant growing season, or not less than 7 calendar days prior to bottom barrier placement, TKPOA shall provide the Executive Officer of the Lahontan Regional Water Board a copy of TKPOA’s rules, application processes, inspection and monitoring program, and, individual permits. Each individual permit must contain, at a minimum, the following items:

   a. Location of the individual project (map, GPS coordinates, or property street address).
   b. Bottom barrier construction and installation details including material type (narrative and illustration) and installation method(s).
   c. Footprint of bottom barrier in square feet or acres.
   d. Planned duration of in-place bottom barrier (planned installation and removal dates)

7. Monitoring Report - See Monitoring and Reporting Program, Section 1.D.

8. Standard Conditions – This Certification is subject to modification or revocation upon administrative or judicial review, including review and amendment pursuant to section 13330 of the Water Code and article 6 (commencing with section 3867) of chapter 28, title 23 of the California Code of Regulations.

   This Certification action is not intended and shall not be construed to apply to any activity involving a hydroelectric facility requiring a Federal Energy Regulatory Commission (FERC) license or an amendment to a FERC license unless the pertinent certification application was filed pursuant to subsection 3855(b) of chapter 28, title 23 of the California Code of Regulations, and the application specifically identified that a FERC license or amendment to a FERC license for a hydroelectric facility was being sought.

   This Certification is conditioned upon total payment of any fee required under chapter 28, title 23 of the California Code of Regulations and owed by the applicant.

9. Special Conditions:

   a. Other Permits - This Order does not relieve the project applicant from the responsibility to obtain other necessary local, state, and federal permits, nor does this Order prevent the imposition of additional standards, requirements, or conditions by any other regulatory agency.

   b. Liability - This Order does not convey any property rights or exclusive privileges. The requirements prescribed herein do not authorize the commission of any act causing injury to persons or property, do not protect the permittee from liability under federal, state, or local laws, and do not create a vested right to continue to discharge waste. To maximize treatment effectiveness, bottom barriers must be installed at the beginning of the grow season, no later than May 31. Barriers are recommended to remain in place for at least eight weeks. Bottom barriers must be removed at the end of each growing season, no later than October 15 of each year.

   c. Cumulative Impact- The project will not result in impacts that are significant when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects.

d. Endangered, Threatened, Candidate, Rare, Sensitive, or Special Status Species -The project will not result in a taking, either directly or through habitat modification, of any plants or animals identified as endangered, threatened, candidate, rare, sensitive, or special status species in local or regional plans, policies, or regulations of the California Department of Fish and Wildlife, the U.S. Fish and Wildlife Service, or the National Marine Fisheries Service, unless the take is authorized by those agencies.

e. Toxic Substances- The project will not discharge substances in concentrations toxic to human, plant, animal, or aquatic life or that produce detrimental physiological responses.

f. Hazardous Substances - The project will not discharge waste classified as "hazardous" as defined California Code of Regulations title 22, section 66261 and Water Code section 13173.

g. Water Diversion and Use - This Order does not authorize any new or modified diversion or impoundment of water, unless such diversion or impoundment is solely for the purpose of temporary dewatering for construction of the restoration project. Any permanent diversion or impoundment for beneficial use of water must have a State Water Board water rights permit.

h. Historical Sites - This Order does not authorize any activity adversely impacting a significant historical or archeological resource; directly or indirectly destroying a unique paleontological resource or site or unique geologic feature; disturbing any human remains; or eliminating important examples of the major periods of California history or prehistory, unless the activity is authorized by the appropriate historical resources agencies.

i. California Ocean Plan - The project shall not cause a violation of any applicable water quality objectives, including impairment of designated beneficial uses of receiving waters of the state, as adopted in the State Water Board California Ocean Plan.

j. Water Quality Control Plan (Basin Plan) -The project shall not cause a violation of any applicable water quality objectives, including impairment of designated beneficial uses of receiving waters of the state, as adopted in the appropriate Regional Water Board water quality control plan(s)

k. Porter-Cologne Water Quality Control Act - The project shall comply with all requirements of the Porter-Cologne Water Quality Control Act (Water Code, § 13000 et. seq.)

l. Enforcement- In the event of any violation or threatened violation of the conditions of this Order, the violation or threatened violation shall be subject to any remedies, penalties, process, or sanctions as provided for under state law. For purposes of Clean Water Act (CWA) section 401(d), the applicability of any state law authorizing remedies, penalties, process, or sanctions for the violation or threatened violation constitutes a limitation necessary to ensure compliance with the water quality standards and other pertinent requirements incorporated into this Order.

i. If the applicant fails or refuses to furnish technical or monitoring reports, as required under this Order, or falsifies any information provided in the monitoring reports, the applicant is subject to civil liability for each day in which the violation occurs. All reports, notices, or other documents required by this Order or requested by the State or Regional Water Boards shall be signed by the applicant or a duly authorized representative of the project.

ii. In response to a suspected violation of any condition of this Order, the State or Regional Water Boards may require the applicant to furnish, under penalty of perjury, any technical or monitoring reports the State or Regional Water Boards deem appropriate, provided that the burden, including cost of the reports, shall be in reasonable relationship to the need for the reports and the benefits to be obtained from the reports.

iii. The applicant shall allow the staff(s) of the State or Regional Water Boards, or an authorized representative(s), upon the presentation of credentials and other documents, as may be required by law, to enter the project premises for inspection, including taking photographs and securing copies of project-related records, for the purpose of assuring compliance with this Order and determining the ecological success of the project.

B. Granting of Prohibition Exemption

The Water Board hereby grants an exemption to Basin Plan Chapter 5 prohibition of discharge or threatened discharge below the high water rim of Lake Tahoe, for bottom barrier installation meeting all applicable criteria listed therein for an exemption to the prohibition (see Finding 16):

a. The project is necessary for environmental protection;
b. There is no reasonable alternative, including relocation which avoids or reduces the extent of encroachment in the below the highwater rim of Lake Tahoe; and

c. Impacts are fully mitigated.

Summary Schedule of Items Required(Deliverables) for Water Board Review

Finding	Order	Description	Due Date(s)
16	II.E.2.d	Water Quality Certification Status	January 31. 2015 and annually thereafter
7	I.C.	Shared Stormwater Treatment Facilities	October 1. 2014
18	II.B.1	Nonpoint Source (NPS) Plan	January 31. 2016 and annually thereafter
17	II.C.1	Integrated Management Plan (IMP) , including Bottom Barrier Project Summary	January 31. 2016 and annually thereafter
17	II.E.2.	Aquatic Plant Monitoring Plan	January 31. 2016 and annually thereafter
15	III.A.6	Bottom Barrier permitting processes and Inspection Monitoring Plan and Schedule	Annually, at the start of the aquatic plant growing season or at least 7 days before project installation
15	III.A.6	Individual Bottom Barrier Project Plans and Permits	at least 7 days before project installation

Certification:

I, Patty Z. Kouyoumdjian, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of an Order adopted by the California Regional Water Quality Control Board, Lahontan Region, on July 17, 2014.

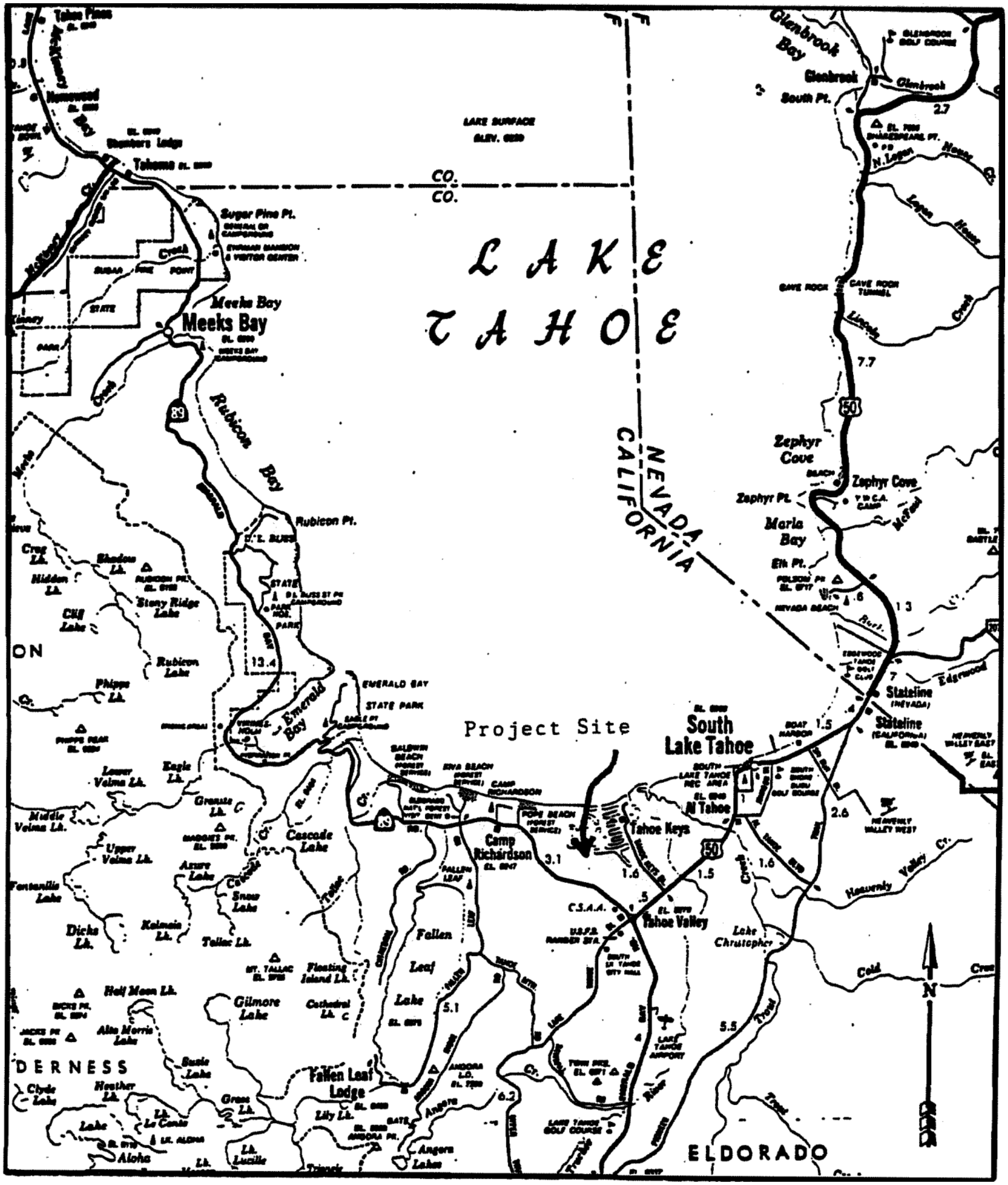
Patty Z. Kouyoumdjian

PATTY Z. KOUYOUMDJIAN
EXECUTIVE OFFICER

Attachments:
A. General Location Map
B. Facility Map; Monitoring Locations
C. Standard Provisions for WDR Permits
D. Guidelines for Development of the Non-Point Source Management Plan for Fertilizer and Irrigation of Landscaped Areas
E. Best Management Practices for Bottom Barrier Installation for Invasive Weed Control

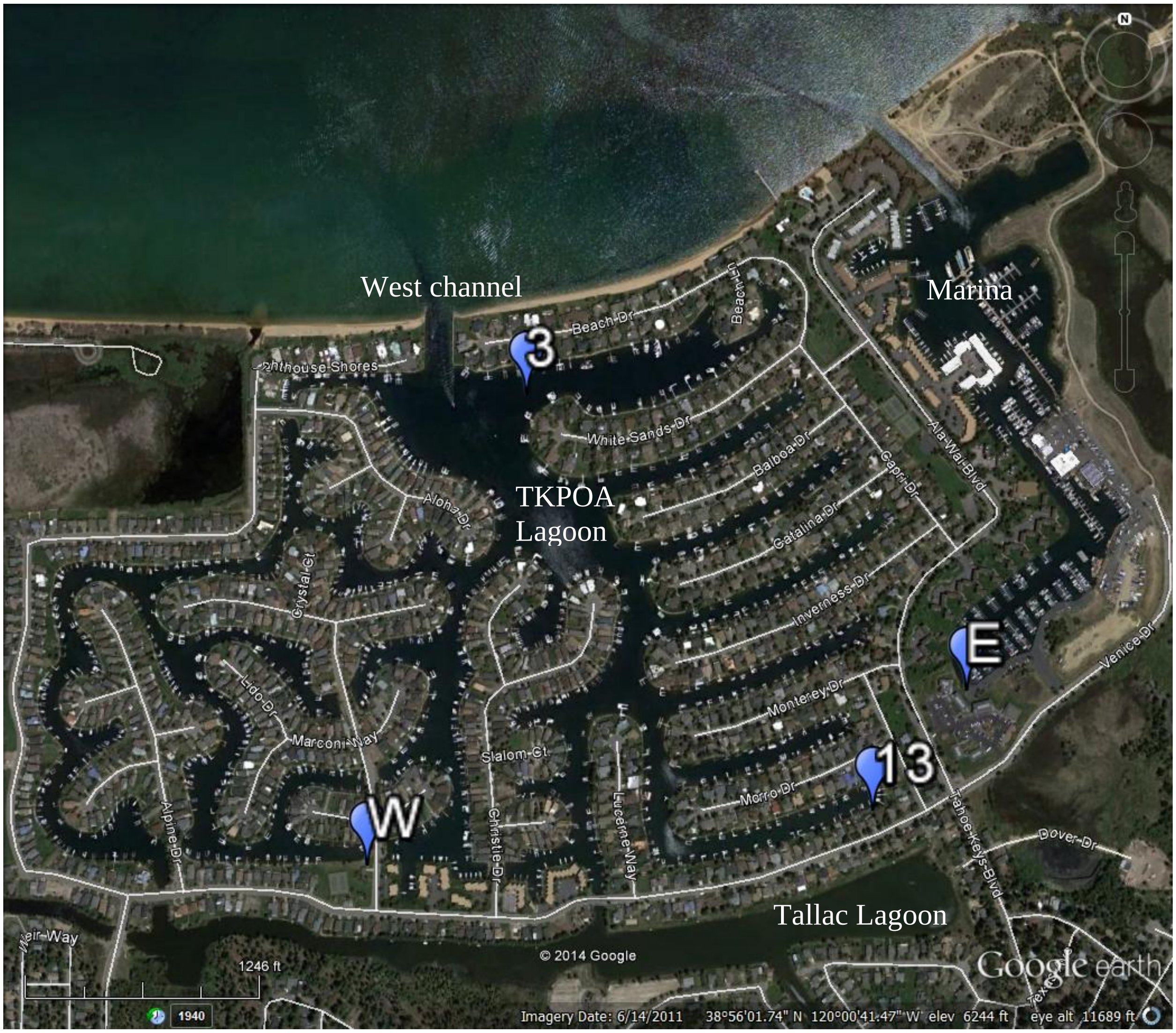
ATTACHMENT "A"

Project Location Tahoe Keys Lagoon and Marina



ATTTACHMENT “B”

TKPOA sampling locations when circulation system is operating.



Legend:

W - West side TKPOA Lagoon pump station intake

E - East side Marina pump station intake

3 - Discharge point nearest the west channel ingress/egress

13 - Discharge point in the TKPOA Lagoon cove furthest from west channel

ATTACHMENT C

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION

STANDARD PROVISIONS
FOR WASTE DISCHARGE REQUIREMENTS

1. Inspection and Entry

   The Discharger shall permit Regional Board staff:

   a. to enter upon premises in which an effluent source is located or in which any required records are kept;

   b. to copy any records relating to the discharge or relating to compliance with the Waste Discharge Requirements (WDRs);

   c. to inspect monitoring equipment or records; and

   d. to sample any discharge.

2. Reporting Requirements

   a. Pursuant to California Water Code 13267(b), the Discharger shall immediately notify the Regional Board by telephone whenever an adverse condition occurred as a result of this discharge; written confirmation shall follow within two weeks. An adverse condition includes, but is not limited to, spills of petroleum products or toxic chemicals, or damage to control facilities that could affect compliance.

   b. Pursuant to California Water Code Section 13260 (c), any proposed material change in the character of the waste, manner or method of treatment or disposal, increase of discharge, or location of discharge, shall be reported to the Regional Board. Any such proposal shall be reported to the Regional Board at least 120 days in advance of implementation. This shall include, but not be limited to, all significant soil disturbances.

   c. The Owners/Discharger of property subject to WDRs shall be considered to have a continuing responsibility for ensuring compliance with applicable WDRs in the operations or use of the owned property. Any change in the ownership and/or operation of property subject to the WDRs shall be reported to the Regional Board. Notification of applicable WDRs shall be furnished in writing to the new owners and/or operators and a copy of such notification shall be sent to the Regional Board.

   d. If a Discharger becomes aware that any information submitted to the Regional Board is incorrect, the Discharger shall immediately notify the Regional Board, in writing, and correct that information.

e. Reports required by the WDRs, and other information requested by the Regional Board, must be signed by a duly authorized representative of the Discharger. Under Section 13268 of the California Water Code, any person failing or refusing to furnish technical or monitoring reports, or falsifying any information provided therein, is guilty of a misdemeanor and may be liable civilly in an amount of up to one thousand dollars ($1,000) for each day of violation.

f. If the Discharger becomes aware that their WDRs (or permit) are no longer needed (because the project will not be built or the discharge will cease) the Discharger shall notify the Regional Board in writing and request that their WDRs (or permit) be rescinded.

3. Right to Revise WDRs

The Regional Board reserves the privilege of changing all or any portion of the WDRs upon legal notice to and after opportunity to be heard is given to all concerned parties.

4. Duty to Comply

Failure to comply with the WDRs may constitute a violation of the California Water Code and is grounds for enforcement action or for permit termination, revocation and re-issuance, or modification.

5. Duty to Mitigate

The Discharger shall take all reasonable steps to minimize or prevent any discharge in violation of the WDRs which has a reasonable likelihood of adversely affecting human health or the environment.

6. Proper Operation and Maintenance

The Discharger shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) that are installed or used by the Discharger to achieve compliance with the WDRs. Proper operation and maintenance includes adequate laboratory control, where appropriate, and appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities or similar systems that are installed by the Discharger, when necessary to achieve compliance with the conditions of the WDRs.

7. Waste Discharge Requirement Actions

The WDRs may be modified, revoked and reissued, or terminated for cause. The filing of a request by the Discharger for waste discharge requirement modification, revocation and re-issuance, termination, or a notification of planned changes or anticipated noncompliance, does not stay any of the WDRs conditions.

8. Property Rights

The WDRs do not convey any property rights of any sort, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of federal, state or local laws or regulations.

9. Enforcement

The California Water Code provides for civil liability and criminal penalties for violations or threatened violations of the WDRs including imposition of civil liability or referral to the Attorney General.

10. Availability

A copy of the WDRs shall be kept and maintained by the Discharger and be available at all times to operating personnel.

11. Severability

Provisions of the WDRs are severable. If any provision of the requirements is found invalid, the remainder of the requirements shall not be affected.

12. Public Access

General public access shall be effectively excluded from treatment and disposal facilities.

13. Transfers

Providing there is no material change in the operation of the facility, this Order may be transferred to a new owner or operation. The owner/operator must request the transfer in writing and receive written approval from the Regional Board’s Executive Officer.

14. Definitions

a. "Surface waters" as used in this Order, include, but are not limited to, live streams, either perennial or ephemeral, which flow in natural or artificial water courses and natural lakes and artificial impoundments of waters. "Surface waters" does not include artificial water courses or impoundments used exclusively for wastewater disposal.

b. "Ground waters" as used in this Order, include, but are not limited to, all subsurface waters being above atmospheric pressure and the capillary fringe of these waters.

15. Storm Protection

All facilities used for collection, transport, treatment, storage, or disposal of waste shall be adequately protected against overflow, washout, inundation, structural damage or a significant reduction in efficiency resulting from a storm or flood having a recurrence interval of once in 100 years.

ATTACHMENT “D”

GUIDELINES FOR DEVELOPMENT OF THE NON-POINT SOURCE MANAGEMENT PLAN FOR FERTILIZER USE AND IRRIGATION OF LANDSCAPED AREAS

A Nonpoint Source Water Quality Management Plan (NPS Plan) must be developed as part of this WDR to minimize the potential for Nonpoint Source pollution. The goal of the plan is to provide a management approach that maximizes good turf characteristics, with high nutrient absorbing capacity, while minimizing potential for transport of contaminants to surface waters and ground waters.

This plan should consider the following items:

(1) Irrigation Efficiency: Describe for each irrigation station, how a reasonably efficient irrigation system distribution uniformity (DU) is to be achieved and maintained, with a goal of an average system DU of 0.70 or higher.

(2) Minimize Irrigation Water Leaching: Describe how leaching of percolating waters passing beyond the root zone will be minimized and how that will be evaluated (e.g. Soil moisture measurements, leaching fraction approach or applied water versus evapotranspiration approach, etc.) Goal is less than 10% percolation of applied water through proper irrigation scheduling.

(3) Chemical storage locations

(4) List of chemicals used at the Facility (fertilizers, herbicides).

(5) Copy of the Material Safety Data Sheet (MSDS) or Global Harmonization Sheet (GHS) for each chemical listed.

The NPS plan must consider, at a minimum, the following topics:

FERTILIZER USE

- Timing of application
- Method of application, including setbacks adjacent to surface waters (for example Lake Tahoe golf courses do not broadcast fertilize within 25-50 feet of water).
- Form of fertilizer, including slow release or low- or no-phosphorus (“lake friendly”) products
- Frequency of application
- Amount applied per unit area (pounds or kilograms per 1000 square feet or per acre).
- Residual soil nitrate and phosphate (P)[1, 2]
- Soil nutrient testing to determine appropriate fertilizer application rates[2]
- Plant tissue testing to give feedback concerning adequacy of fertilizer program

IRRIGATION

- Scheduling (amount and timing, including drought-related water conservation measures to prevent overwatering and runoff)
- Soil moisture measurement and root zone water holding capacity
- Evapotranspiration rates
- Concentration of water soluble Total Kjeldahl Nitrogen (TKN), nitrate, and water soluble total phosphate in shallow groundwater (<= 10 feet below ground surface).
- Soil compaction / restrictive layers that impede percolation, and proposed amendments to allow greater permeability.

MONITORING PROGRAM

- **Groundwater**

Consider construction and development of shallow, relatively inexpensive monitoring wells in common areas adjacent to surface water such as at Cove 3C (at least one upgradient and one downgradient monitoring well.) Goal is to assess effectiveness of improved landscape management practices on groundwater quality.

- **Surface Water**

See Monitoring and Reporting Program for requirements.

- **Training**

Type of training that will be given to the people involved in the monitoring program.

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1 Residual soil nitrate is typically determined to a 60 centimeter soil depth using a minimum of 10 subsamples per sample within a given area of interest, though the appropriate field methodology is best determined by a soil scientist based on local conditions—soil series, soil texture, root depth, etc. Total phosphorus may be determined at a minimum of two soil depths to assess potential phosphate breakthrough, particularly important on coarse, sandy soils, such as those commonly found in the Lake Tahoe basin.

2 Inorganic soil nitrogen (ammonium and nitrate) is typically determined from a 2 molar potassium chloride soil extract; extractable phosphate is typically determined as bicarbonate-extractable P on representative soil samples. Harsher extractants for P may be used for more acidic soils. References include the current editions of *Methods of Soil Analysis* and *Soil Testing and Plant Analysis* published by the American Society of Agronomy/Soil Science Society of America/Crop Science Society of America; and the current edition of *Soil Sampling and Methods of Analysis* published by the Canadian Society of Soil Science.

ATTACHMENT E

Best Management Practices for Bottom Barrier Installation for Invasive Weed Control

The following best management practices are required when installing bottom barriers for purposes of controlling invasive weeds (e.g., Eurasian watermilfoil).

Prior to Installation.

1. If the bottom barrier will be anchored by the driving of material (e.g., rebar), prior to installing the bottom barrier, the project proponent must affirmatively document whether there are any subsurface utilities in the area of construction and submit such documentation to the Tahoe Keys Property Owners Association (TKPOA). This can be accomplished by: (1) contacting all utilities (both public and private) that provide service in the area, documenting these contacts and submitting such documentation to the TKPOA; (2) contacting Underground Service Alert, documenting this contact and submitting such documentation to the TKPOA; or, (3) some other equivalent affirmative action to determine whether or not there are any subsurface utilities in the area of construction (i.e., bottom barrier placement) and submitting the results of such action to the TKPOA. The area of construction is defined as any area within the project boundaries where bottom barriers will be placed and anchored by the driving of material (e.g., rebar). If subsurface utilities are located in the project area, the project proponent must implement protective measures during construction to avoid utilities.

Installation.

1. The barrier should be secured to the lake bottom with inert material such as rebar or heavy chain. The use of sand bags to secure the barrier should be avoided to prevent the potential of inadvertently discharging sediment and its associated nutrients to the water column.

2. Placement of the bottom barrier should not impede safe harbor and navigation.

3. If a motorized boat or other equipment is used for transporting, deploying, and/or retrieving the bottom barrier, the project proponent must monitor for chemical leaks, and have an emergency spill kit on hand to use if a leak is detected.

Removal.

When removing the barrier, the project proponent must take measures to prevent the introduction or spread of noxious/invasive weeds and animals. After removal from the lake, the barrier should be relocated to an area where the barrier can be washed down over a vegetated area that will capture and contain any runoff.

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

LAHONTAN REGION

WDID NO. 6A090089000

MONITORING AND REPORTING PROGRAM NO. 2014-0059

FOR

TAHOE KEYS PROPERTY OWNERS ASSOCIATION

El Dorado County

I. MONITORING

The following monitoring program must be implemented.

A. General Information

1. General Provisions: This Monitoring and Reporting Program (MRP) includes requirements for monitoring and reporting management actions and water quality data as required under Board Order No R6T-2014-0059. The Discharger shall comply with *General Provisions for Monitoring and Reporting*, dated September 1, 1994, which is included as Attachment “1” and made part of this Monitoring and Reporting Program.
2. Monitoring: The purpose of water quality monitoring is to detect changes in the physical and chemical conditions in the waters as a result of Facility operations, and to monitor compliance with waste discharge requirements. Because the numerous Facility components may readily be taken in and out of operation, it is the intent of this sampling program to provide comprehensive monitoring while minimizing duplicative sampling requirements as a result of overlap and lapses in the operation of Facility equipment. For the purposes of this monitoring program, “monthly” means a monitoring frequency of thirty (30) days.
3. Analytical Reporting Limits: Because of the unique nature of waters in the Lake Tahoe Basin, exceptional analytical testing capabilities for nutrients and other contaminants are generally required to assure compliance with water quality standards and non-degradation objectives specified in the *Water Quality Control Plan for the Lahontan Region* and the WDR Permit for the Facility. Reporting Limits, or RLs, for chemical analyses are therefore specified herein. Values for RLs (which are analytical reporting limits) are typically 4 to 5 times higher than minimum detection limits, or MDLs. RLs shall be, at a minimum, as sensitive as the more restrictive of those required for analysis of pollutants (40 Code of Federal Regulations, Part 136), or analysis of drinking water (California Code of Regulations, Title 22, Division 4, Chapter 15; or 40 Code of Federal Regulations, Part 141).

B. **Water Quality Monitoring for Circulation System**

The purpose of this monitoring is to ensure operation of the circulation system does not adversely affecting water quality.

1. Sampling Locations – Lagoon and Marina Water Quality Monitoring: The following surface water quality sampling stations have been consistently monitored under previous permits, and shall continue to be monitored for consistency under this WDR permit: the West Side Pump Station intake (W); the East Side Pump Station intake (E); a discharge point near the West Channel ingress/egress (3); and a discharge point in a cove furthest from West Channel (13). Water quality sampling locations are specified in Attachment "B" of the WDR permit. Samples shall be collected within 10 feet of the referenced sampling location.
2. Sampling Frequency: Samples shall be taken at a minimum of monthly frequency, with at least one sample taken before circulation, at least once during circulation, and one sample within a week of cessation of circulation.
3. Sample Type: Representative grab samples of waters to be analyzed shall be considered sufficient for the purposes of this monitoring program.
4. Analysis of Samples: All analyses shall be performed in accordance with Attachment 1, General Provisions for Monitoring and Reporting.
5. Samples in Sections B.1 need not be collected when the circulation system is not operated or if substantial ice cover in the sampling location is documented. . When samples cannot be collected due to weather or other conditions the Discharger shall submit a report stating the reason for why sample data is not collected during that month.
6. Monitoring Parameters

   Water quality samples shall be collected and analyzed for each of the parameters in Table 1.

Table 1: Monitoring Parameters

Parameter	Units	Reporting Limit (RL)
Dissolved Oxygen	mg/L	0.05 mg/L
Temperature	°F or °C	0.2 °F or 0.1 °C
Nitrate and Nitrite Nitrogen	mg/l as N	0.01 mg/l as N
Ammonia Nitrogen	mg/l as N	0.01 mg/l as N
Total Kjeldahl Nitrogen	mg/l as N	0.08 mg/l as N
Total Phosphorus	μg/l as P	8 μg/l as P
Dissolved Reactive (Ortho) Phosphorus	μg/l as P	8 μg/l as P

C. **Aquatic Plant Monitoring Plan**

The Discharger is to prepare a monitoring plan for aquatic plants in cooperation with Water Board, TRPA, and other Agency staff as appropriate by **January 31, 2016**. TKPOA is to survey Tahoe Keys Lagoon and Tahoe Keys Marina initially and thereafter annually for aquatic plant types and their respective percent cover, plant height and estimated biomass, and create accurate weed location maps and summarize findings initially and thereafter in annual reports. TKPOA is to follow monitoring protocol similar to that of Sierra Ecosystem Associates, 2013[1] given in "Method" Sections 2.1-2.3 of that report, summarized below:

- Survey work is to be timed to capture non-native plants Curly-leaf pondweed and Eurasian watermilfoil at maturity and at the end or peak of their growing period. This typically occurs mid-to-late August.
- A Hazard Analysis and Critical Control Plan (HACCP) to prevent the spread of plant propagules (including aquatic invasive plant species fragments and curly-leaf pondweed turions) by survey activities is to be prepared and followed.
- Survey data for larger infestations of non-natives is to include transects with data points were taken every 20 feet along 100-foot sections, and for smaller infestations, square footage as well as plant composition, and plant height information are to be taken.

[1] Sierra Ecosystem Associates (SEA), 2013. Lake Tahoe Aquatic Plant Survey Project: 2012 Results. Prepared for Tahoe Regional Planning Agency.

The monitoring plan may be part of the IMP or may be developed separately (WDR Order Section II.C). The monitoring plan will be implemented upon submission of the plan to Water Board staff. Annually, beginning in January 31, 2017, submit aquatic plant monitoring reports.

D. **Bottom Barrier Monitoring Report**

1. Monitoring Report - TKPOA shall implement the monitoring program documented in the Bottom Barrier Monitoring Plan from Finding 15 and Section III.A. of the Order and shall provide Monitoring Reports at least annually to the Water Board. The Monitoring Report shall document status of performance standards and project goals. Each Monitoring Report shall include:
    a. A summary of findings - inspection results including anchor and bottom barrier integrity and other observations.
    b. Identification and discussion of problems with achieving performance standards.
    c. Proposed corrective measures, to be approved by the Regional Water Board.
    d. Monitoring data, if any.

E. **Flow Monitoring**

If the circulation system is operated, TKPOA shall keep a log or permanent record of the following:

1. Average daily flow rate at monitoring location D during operation of the East Side Pump Station and/or West Side Pump Station, in millions of gallons per day.
2. Total volume of water discharged at monitoring location D during operation of the East Side Pump Station and/or West Side Pump Station in millions of gallons.
3. Estimated volume of water, in millions of gallons, discharged on a daily and monthly basis from each of the following locations: 6, 7, C1, C2, C3, C4, C5, and C6.

F. **Operations and Maintenance of Water Circulation System**

The Discharger shall keep a log or permanent record of the following:

1. For any Facility pump, the dates and hours of operation, the pump number or name, and the rated or estimated flow rate(s) during operation.
2. The calibration of any flow measuring devices.

II. REPORTING

A. Report Format

1. The Discharger shall arrange the monitoring data in a concise form to clearly show compliance or non-compliance with each discharge specification to facilitate review by Regional Board staff. All violations of requirements shall be clearly described. TKPOA shall note and explain any occurrence of noncompliance with any waste discharge requirement. If there are no violations to report, the Discharger shall certify that fact in writing. This report shall include a summary of operational problems and maintenance activities as described in Section I.D., above.
2. For every item where the requirements are not met, TKPOA shall submit a statement of the actions taken or proposed which will bring the discharge into full compliance with requirements at the earliest time and submit a timetable for completion. **Any omission of data shall be accompanied by an explanation and plan to obtain the omitted data.**
3. All reports shall be signed by a responsible officer or duly authorized representative of TKPOA, shall include the name and contact information for a person knowledgeable about the contents of the report, and shall be submitted under penalty of perjury.

B. Submittal Periods

1. Monthly monitoring reports shall be submitted not later than the 15th day of the month following the sampling event and shall include a summary of water quality monitoring data in the format described in Section II.A above. Water quality data submitted by the Discharger shall be designated as Water Quality Data for the Circulation System

C. Operations and Maintenance Reporting Requirements

A brief summary of maintenance activities and any operational problems shall be submitted to the Regional Board with each monitoring report. The summary shall discuss:

1. Any modification or additions to the water circulation system
2. Any major maintenance conducted on the water circulation system.
3. Any major problems occurring in the water circulation system.
4. The calibration of any measuring devices.
5. Aquatic plant removal operations conducted by the Discharger during the monitoring period. The estimated quantity of aquatic plants mechanically removed from the lagoon and/or marina during the monitoring period shall be reported with a map indicating the general locations of any aquatic plant removal activities. Quantities shall be indicated by the estimated volume (in cubic yards or cubic meters) of freshly harvested plant matter.

Ordered by: Patty Z. Kouyoumdjian Dated: July 17, 2014

PATTY Z. KOUYOUMDJIAN
EXECUTIVE OFFICER

Attachments: 1. General Provisions for Monitoring and Reporting (September 1, 1994)

ATTACHMENT 1

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

LAHONTAN REGION

GENERAL PROVISIONS

FOR MONITORING AND REPORTING

1. SAMPLING AND ANALYSIS

   a. All analyses shall be performed in accordance with the current edition(s) of the following documents:

      i. Standard Methods for the Examination of Water and Wastewater

      ii. Methods for Chemical Analysis of Water and Wastes, EPA

   b. All analyses shall be performed in a laboratory certified to perform such analyses by the California State Department of Health Services or a laboratory approved by the Regional Board Executive Officer. Specific methods of analysis must be identified on each laboratory report.

   c. Any modifications to the above methods to eliminate known interferences shall be reported with the sample results. The methods used shall also be reported. If methods other than EPA-approved methods or Standard Methods are used, the exact methodology must be submitted for review and must be approved by the Regional Board Executive Officer prior to use.

   d. The discharger shall establish chain-of-custody procedures to insure that specific individuals are responsible for sample integrity from commencement of sample collection through delivery to an approved laboratory. Sample collection, storage, and analysis shall be conducted in accordance with an approved Sampling and Analysis Plan (SAP). The most recent version of the approved SAP shall be kept at the facility.

   e. The discharger shall calibrate and perform maintenance procedures on all monitoring instruments and equipment to ensure accuracy of measurements, or shall insure that both activities will be conducted. The calibration of any wastewater flow measuring device shall be recorded and maintained in the permanent log book described in 2.b, below.

   f. A grab sample is defined as an individual sample collected in fewer than 15 minutes.

   g. A composite sample is defined as a combination of no fewer than eight individual samples obtained over the specified sampling period at equal intervals. The volume of each individual sample shall be proportional to the discharge flow rate at the time of sampling. The sampling period shall equal the discharge period, or 24 hours, whichever period is shorter.

2. <u>OPERATIONAL REQUIREMENTS</u>

h. Sample Results

Pursuant to California Water Code Section 13267(b), the discharger shall maintain all sampling and analytical results including: strip charts; date, exact place, and time of sampling; date analyses were performed; sample collector's name; analyst's name; analytical techniques used; and results of all analyses. Such records shall be retained for a minimum of three years. This period of retention shall be extended during the course of any unresolved litigation regarding this discharge, or when requested by the Regional Board.

i. Operational Log

Pursuant to California Water Code Section 13267(b), an operation and maintenance log shall be maintained at the facility. All monitoring and reporting data shall be recorded in a permanent log book.

3. <u>REPORTING</u>

j. For every item where the requirements are not met, the discharger shall submit a statement of the actions undertaken or proposed which will bring the discharge into full compliance with requirements at the earliest time, and shall submit a timetable for correction.

k. Pursuant to California Water Code Section 13267(b), all sampling and analytical results shall be made available to the Regional Board upon request. Results shall be retained for a minimum of three years. This period of retention shall be extended during the course of any unresolved litigation regarding this discharge, or when requested by the Regional Board.

l. The discharger shall provide a brief summary of any operational problems and maintenance activities to the Board with each monitoring report. Any modifications or additions to, or any major maintenance conducted on, or any major problems occurring to the wastewater conveyance system, treatment facilities, or disposal facilities shall be included in this summary.

m. Monitoring reports shall be signed by:

iii. In the case of a corporation, by a principal executive officer at least of the level of vice-president or his duly authorized representative, if such representative is responsible for the overall operation of the facility from which the discharge originates;

iv. In the case of a partnership, by a general partner;

v. In the case of a sole proprietorship, by the proprietor; or

vi. In the case of a municipal, state or other public facility, by either a principal executive officer, ranking elected official or other duly authorized employee.

n. Monitoring reports are to include the following:

i. Name and telephone number of individual who can answer questions about the report.

ii. The Monitoring and Reporting Program Number.

iii. WDID Number 6A265300900.

o. Modifications

This Monitoring and Reporting Program may be modified at the discretion of the Regional Board Executive Officer.

4. NONCOMPLIANCE

Under Section 13268 of the Water Code, any person failing or refusing to furnish technical or monitoring reports, or falsifying any information provided therein, is guilty of a misdemeanor and may be liable civilly in an amount of up to one thousand dollars ($1,000) for each day of violation.

Appendix D
Aquatic Plant Monitoring Plan
and
Hazard Analysis and Critical Control Plan

Monitoring and Reporting Program No. 2014-0059
Aquatic Plant Monitoring Plan for the Tahoe Keys Lagoon and Tahoe Keys Marina

Pursuant to WDID No. 6A09008900, issued to the Tahoe Keys Property Owners Association by the Lahontan Regional Water Quality Control Board on July 18, 2014.

This Aquatic Plant Monitoring Plan (APMP) for the Tahoe Keys Lagoon and Keys Marina is a requirement of the Waste Discharge Requirements issued to the Tahoe Keys Property Owners Association. In compliance with Section 1.C, this plan describes the protocol to be followed, the timing of the survey, the reporting requirements, and includes the Hazard Analysis and Critical Control Plan (HACCP) necessary to prevent the spread of unwanted aquatic invasive species.

The objectives of the APMP are to:

- Conduct annual surveys of the Tahoe Keys Lagoon and the Tahoe Keys Marina for aquatic plants for percent cover, plant height, and estimated biomass.
- Create accurate maps depicting the location and relative species abundance of aquatic plants.
- Assess progress toward achieving objective of increasing the freeboard distance or navigational clearance in the waterways of the Tahoe Keys lagoons and Tahoe Keys Marina as stated in the Integrated Weed Management Plan (Plan).

<u>Methods</u>

This protocol utilizes two sampling methods:
1. A georeferenced, point-intercept protocol to determine presence or absence of aquatic plant species, the variety of aquatic plant species present, and to estimate biomass.
2. A geo-referenced, hydroacoustic imaging protocol to determine canopy height and quantify volume of aquatic plants present.

Both sampling methods will be conducted from the topside of a survey boat. Aquatic plant canopies in the Tahoe Keys lagoons are typically too dense to safely and effectively sample with a dive team. Safety concerns include reduced visibility and a high probability that divers could become entangled in the weeds.

1. Timing of Survey
Monitoring should be timed to capture the peak of the growing period and biomass for the target plants. Curlyleaf pondweed typically starts to dieback in midsummer while Eurasian watermilfoil grows rapidly in early summer and continues to produce high biomass through mid-late summer. Both species produce flowers in early summer; however, flower production in Eurasian watermilfoil is typically very sparse in the Tahoe Keys lagoons. For typical growing seasons, the surveys should be conducted in the

last week in July to the first week of August to capture maximum biomass produced by both plants before senescence.

If aquatic herbicides are implemented under the Plan, additional surveys will conducted at appropriate post-treatment times based on the mode of action of the herbicide.

2. Hazard Analysis and Critical Control Point Plan (HACCP)

Prior to the start of the survey, the survey teams must be instructed in the requirements of the Hazard Analysis and Critical Control Plan (HACCP) to prevent the spread of plant propagules during and after the survey. Requirements of the HACCP include proper disposal of plant fragments brought to the surface, cleaning equipment before leaving a survey area, and capturing any fragments created by boat operation. The complete HACCP is attached to this protocol.

3. Establish Transects

The Tahoe Keys Main Lagoon and Tahoe Keys Marina have large areas of aquatic plant infestation. Determining presence or absence, species composition and relative abundance at points along a transect line is the most effective survey technique. Establishing transects allows survey teams to use the point-intercept methods to sample in the same location in future years so that aquatic weed growth can be compared from year to year.

Transects or tracks will also be established for hydroacoustic sampling to ensure consistent year-to-year sampling. These tracks will be co-incident with the point-intercept transects to ensure that estimates of bio-volume and canopy height associated with the dominant species observed from the hydroacoustic sampling correlates with the information from the point-intercept surveys.

In the first year of the surveys, five to 10 transect lines will be established in each cove and lagoon in the Tahoe Keys lagoons and Tahoe Keys Marina. The number will be dependent on the size of each cove or lagoon so that a consistent number of samples are taken per square foot area. The transect lines will cross each cove or lagoon in order to capture the gradient change of species composition in relation to the depth of water. The ends of the transect lines will be recorded using both GPS and landmarks such as docks or piers. Photo points of the termini of each transect will be taken. Transect lines may need to be adjusted due to the irregular shape of some coves or to avoid obstructions such as docks.

4. Sampling

Sampling will occur every 20 feet along each transect and at the termini. If an obstruction such as a dock interferes with sampling, that point will be dropped from the survey. At every observation point, the following data will be collected:

- Date and time
- Location (GPS)
- Presence/absence of aquatic plants
- Species composition

- Estimates of biomass using a suspension digital scale.
- Estimates of biomass from the hydroacoustic scans.
- Water depth and water temperature at mid-depth.
- Plant height as determined by hydroacoustic sampling.

The location along the transect line will be recorded for each observation point using a GPS unit using satellite-based augmentation system (SBAS). Measurements will be within 1-meter horizontal accuracy. GPS coordinate data will be reported in northing/easting and projected in Universal Transverse Mercator (UTM) Zone 10 using North American Datum of 1983 (NAD83). Post-processing of data will include differential correction and analyzed using Arc GIS version 10.2 with Spatial Analyst, or similar. Post-processed GIS files will be provided as a shapefile or geodatabase with metadata included.

Presence or absence of plants will be recorded at each location on the transect line using standard point-intercept methods. If plants are present, samples will be taken by plunging a double-tined, pole-mounted thatch rake into the water until the rake touches bottom. Depth will be noted using reference marks on the pole.

The pole will be twisted 360 degrees to capture plants and the rake will be carefully retrieved. Based on visual estimates, the percent species composition will be determined and presence of native vs. non-native species noted. Plants will be keyed using one of several sources including, “Aquatic and Riparian Weeds of the West”, “An Aquatic Plant Identification Manual for Washington’s Freshwater Plants”, or “The Jepson Manual, Higher Plants of California.”

Areas where the water clarity allows will be observed using an Aquascope viewing tube or similar device to estimate species composition and relative plant density. A viewing tube is particularly useful for areas of curlyleaf pondweed which is not effectively sampled using a sampling rake and may be otherwise underrepresented in the sample.

The biomass of the sample retrieved on the rake will be recorded as the net fresh weight (gross weight minus the sampling rake and pole) after a 30-second drip time.

All data will be noted on Field Data forms and later will be compiled with GPS information.

5. Data Analysis

Spatial (GPS) data will be analyzed using ArcGIS with Spatial Analyst or equivalent software. Maps will be created showing the distribution of species, biomass density, and water depth.
Maps of hydroacoustic sampling may be generated by contract with specialized services.

Correlation analyses will be performed on the relationship between species composition and water depth.

6. Reporting

The raw data and analysis results will be reported the LRWQCB by January 31st each year starting in 2016. The report will include description of the plant removal operations conducted by the TKPOA in the previous year. For mechanical harvesting operations, the report will include a volume estimate of the quantity of plant material removed

7. Adapting Protocols

After the first year of sampling and reporting, protocols will be reviewed with LRWQB and may be adjusted to optimize sampling for more precise reporting of conditions in the Tahoe Keys lagoons and Tahoe Keys Marina.

Step 1 – Activity Description

<table>
<tr><th colspan="2">Management Objective & Contact Information</th></tr>
<tr><td colspan="2">HACCP Plan Title: Tahoe Keys and Keys Marina Aquatic Plant Survey Project</td></tr>
<tr><td rowspan="3">Management Objective:
Survey extent of aquatic plants and develop a spatial database of occurrences of aquatic plants in Tahoe Keys and Keys Marina</td><td>Contact Person:</td></tr>
<tr><td>Phone:</td></tr>
<tr><td>Email:</td></tr>
</table>

Activity Description i.e. Who; What; Where; When; How; Why
Who: Survey Team What: Aquatic plant sampling Where: In the lagoons of the Tahoe Keys and the Keys Marina When: Mid-summer survey season How: Load boat with sampling and GPS equipment and conduct vegetation surveys. Travel to next survey site by boat or return to dock/point of entry. The Survey Team will travel to established transect sites in the lagoons to conduct surveys for aquatic plants. Samples of aquatic plants will be taken for verification purposes as necessary. Samples will be collected with a tined rake from the boat deck. The sample will be weighed and the species composition will be determined. The samples will be disposed of by transferring them to the TKPOA weed harvesting staff. Work will be conducted during the mid-summer survey season during the identifiable period for the represented species. More than one area may be sampled in a single day. Areas infested with non-native aquatic species will be mapped using GPS.

HACCP Step 2 – Activity Flow Chart

Outline Sequential Tasks of Activity

Task 1	Title: Boat Launch and Travel to Survey Site Load boat with clean equipment at marina/dock and travel to survey site.
Task 2	Title: Survey for Aquatic Plants Inspect area for aquatic plants; if present sample by using rake along transect. Dispose of plant samples on boat. Collect GPS and attribute data as needed.
Task 3	Title: Travel to Next Survey Site or Return to Dock Traveling to additional survey sites will be time-dependent. Plant fragments that become entrapped in the boat propeller will be gathered and disposed with the plant samples.
Task 4	Title: Unload Boat. Equipment will be unloaded; Plant samples will be unloaded and disposed of; boat may or may not be removed from water at this time.

HACCP Step 3 – Identify Potential Non-Targets

Non-Targets That May Potentially Be Moved/Introduced
Vertebrates: Warm water fishes. Bullfrogs
Invertebrates: Zebra mussel, quagga mussel, Asian clam, spiny waterflea, New Zealand mud snail,
Plants: Eurasian water-milfoil, Curly Leaf pondweed
Other Organisms (pathogens, parasites, etc.): None

HACCP Step 4 – Non-Target Analysis Worksheet

1 **Tasks** **(From Step 2)**	2 **Potential Non-targets** **(From Step 3)**	3 **Risk Assessment** **Are any non-targets significant?** **Yes or No**	4 **Justification** **Justify your answer in Column 3**	5 **Control** **What control measures can be applied during this task to reduce the risk of non-targets?**	6 **CCP?** **Is this task a CCP? Yes or No**	7 **Justification** **Justify your answer in Column 6**
Task # 1 Title: Boat Launch and Travel to Survey Site	<u>Vertebrates</u> Warm water fishes. Bullfrog	No	No contact with invasive species; boat and equipment are clean.	Ensure boat and equipment are free of unwanted species.	No	Boat cleanliness is a condition of its being launched in the Tahoe Keys.
	<u>Invertebrates</u> Zebra mussel, quagga mussel, Asian clam, spiny waterflea, New Zealand mud snail,	No	No contact with invasive species; boat and equipment are clean.	Ensure boat and equipment are free of unwanted species.	No	
	<u>Plants</u> Eurasian water-milfoil Curly Leaf pondweed	No	No contact with invasive species; boat and equipment are clean.	Ensure boat and equipment are free of unwanted species.	No	
	<u>Other</u> (None)	No	No contact with Invasive species; boat and equipment are clean.	Ensure boat and equipment are free of unwanted species.	No	
Task # 2 Title: Survey for Aquatic Plants	<u>Vertebrates</u> Warm water fishes. Bullfrog	No	Low probability of contact with non-target species.	Avoid incidental collection of non-target organisms.	No	
	<u>Invertebrates</u> Zebra mussel, quagga mussel, Asian clam, spiny waterflea, New Zealand mud snail,	No	Low probability of contact with non-target species.	Avoid incidental collection of non-target organisms.	No	
	<u>Plants</u> Eurasian water-milfoil Curly Leaf pondweed	Yes	Plants will be sampled at survey sites. Potential to spread plant propagules.	Inspect all equipment used in plant sampling and clean as necessary. Dispose of plant samples onboard boat. Do not return samples to open water.	Yes	Moving contaminated equipment risks introducing non-native plants to new site in nearshore area.
	<u>Other</u> (None)	No	Low probability of contact with non-target		No	

			species.			

Task # 3 Travel to Next Survey Site or Return to Dock	Vertebrates Warm water fishes. Bullfrog	No	Low probability of contact with non-target species.	Avoid incidental collection of non-target organisms.	No	
	Invertebrates Zebra mussel, quagga mussel, Asian clam, spiny waterflea, New Zealand mud snail,	No	Low probability of contact with non-target species.	Avoid incidental collection of non-target organisms.	No	
	Plants Eurasian water-milfoil Curly Leaf pondweed	No	Equipment will be cleaned before commencing travel.	Inspect all equipment used in plant sampling and clean as necessary. Dispose of plant samples onboard boat. Do not return samples to open water.	Yes	Equipment must be inspected before moving to new area to prevent spread of plant propagules
	Other (None)	No	Low probability of contact with non-target species.		No	

Task # 4 Unload Boat	Vertebrates Warm water fishes. Bullfrog	No	Inspect all equipment to ensure cleanliness.		No	
	Invertebrates Zebra mussel, quagga mussel, Asian clam, spiny waterflea, New Zealand mud snail,	No	Inspect all equipment to ensure cleanliness.		No	
	Plants Eurasian water-milfoil Curly Leaf pondweed	No	Inspect all equipment to ensure cleanliness.	Dispose of plant fragments in established disposal sites in the Keys and Keys Marina areas.	Yes	Prevent introduction of invasive aquatic weeds to non-infested areas.
	Other (None)	No	Low probability of contact with non-target species.		No	

HACCP Step 5 – Non-Target Risk Action Plan (NTRAP)

Mangement Objective **From Step 1**	Survey extent and density of aquatic plants and develop a spatial database of known aquatic plants in Tahoe Keys and Keys Marina.		
Critical Control Point: **Task #**	**2**	**Title:**	Survey for Aquatic Plants
Significant Non-Target(s) **(Step 4, Column 3)**	**Non-native plant propagules could be disseminated.**		
Control Measure(s) **(Step 4, Column 5)**	**Inspect all equipment used in plant sampling and clean as necessary.**		
Precribed ranges, limits, or citeria for control measure(s): **(PRLC)**	**Inspect, remove plant parts using towels, place debris in trash containers. Dispose of trash containers away from water.**		
Monitoring the Control Measure(s) **Who?**	**Survey Team.**		
How?	**Visual Inspection.**		
Where?	**At survey site.**		
How often?	**At completion of any plant survey.**		
Corrective Action(s) **if Control Measures Fail** **(or PRLC cannot be met)**	**Evaluate control methods to determine that controls are in place and are effective. Implement additional control methods if new invasive species are detected during survey.**		
Supporting Documents **(*For example, Management Plan, Checklist, Decontamination Techniques, SOPs, Scientific Journal Articles, etc.*)** **Tahoe Regional Management Plan, HACCP for Stream Bioassessment in the Tahoe Basin Washington State HACCP filed for Sampling Aquatic Species, HACCP filed by Boone Research Center**			
Development Team Members	**Kris Kiehne, Jeremy Waites of Sierra Ecosytem Associates**		
Date Developed:	**01/28/2015**	**Date(s) Reviewed:**	

Appendix E
Information on Aquatic Herbicides

Aquatic Herbicides

Chemical control of aquatic plants consists of herbicide control. When properly applied, registered aquatic herbicides can control aquatic vegetation without harming fish or wildlife. Herbicides that have been approved for use in aquatic systems have been extensively studied for both efficacy and potential impacts to the aquatic ecosystem to the extent that there have been many more studies conducted for this method of control than for any other of the commonly used methods.

This section describes the types of herbicides available to control aquatic plant growth and their efficacy, summarizes research that has been conducted on aquatic herbicides, and discusses concerns of herbicide use, the regulation of herbicides in the United States and California, and monitoring requirements for herbicide applications.

Regulatory Authorities and Definitions

Herbicides are a subgroup of general pesticides. The distribution, sale, and use of all pesticides are regulated by the US Environmental Protection Agency (EPA) through the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and by the California Environmental Protection Agency (CalEPA) through the Department of Pesticide Regulation (DPR).

Regulation of aquatic herbicides falls under the authority of the Federal Clean Water Act and is delegated in California to the State Water Resources Control Board. In the Lake Tahoe Basin, the Lahontan Regional Board has authority to regulate uses of aquatic herbicides. In California, the regional water quality control boards may approve aquatic herbicide use by issuing a National Pollutant Discharge Elimination System (NPDES) permit. This represents a third level of environmental protection and regulation and applies to any proposed use of aquatic herbicides in “Waters of the United States” which includes Lake Tahoe.

Formulation

Herbicide product formulation has a direct effect on the efficacy of an herbicide product and on its approved uses. The US EPA and DPR register and approve the use of individual herbicide products. There may be several products with the same active herbicidal ingredient which have been registered for use, but which differ in formulation. Therefore, the environmental conditions, the location, and season all impact whether an herbicide is both approved for use and is useful in controlling a particular nuisance plant.

For example, herbicide products with the same active ingredient may be formulated as either a liquid or a dry granule. Additionally, certain formulations can result in different release rates of the active ingredient. Each formulation is given separate review and registration by EPA and DPR.

Environmental Fate

There are many physical and biological variables that can affect how an herbicide moves in the environment. These variables include chemical volatilization, absorption to other compounds, diffusion, movement due to wind or water currents, and degradation by ultraviolet light or by microbes. These variables impact the environmental fate of an herbicide and how well it works on the target plant. These variables, as well as the time and distance scale of each. are summarized in Table 1 below.

Table 1. Aquatic Herbicide Environmental Fate

Effect	**Scale: Distance**	**Scale: Time**
Diffusion	Feet	Minutes to hours
Volatilization	Inches-Feet	Minutes to hours
Horizontal currents	Feet to Miles	Minutes to days
Vertical currents (density driven or convection)	Feet	Diurnally
Uptake by target and non-target organisms	Less than 1 inch	Minutes to hours
Physical, chemical and microbial degradation	Less than 1 inch	Minutes to days
Adsorption to particles	Less than 1 inch	Minutes to hours
Combination with other chemicals	Less than 1 inch	Minutes to hours

For optimal efficacy of aquatic herbicides, the characteristics of the product, physical and biological conditions of the treatment site and susceptibility of the target plant must be understood. Other critical components are the herbicide concentration and contact time required for efficacy. This concept is summarized in Figure 1.

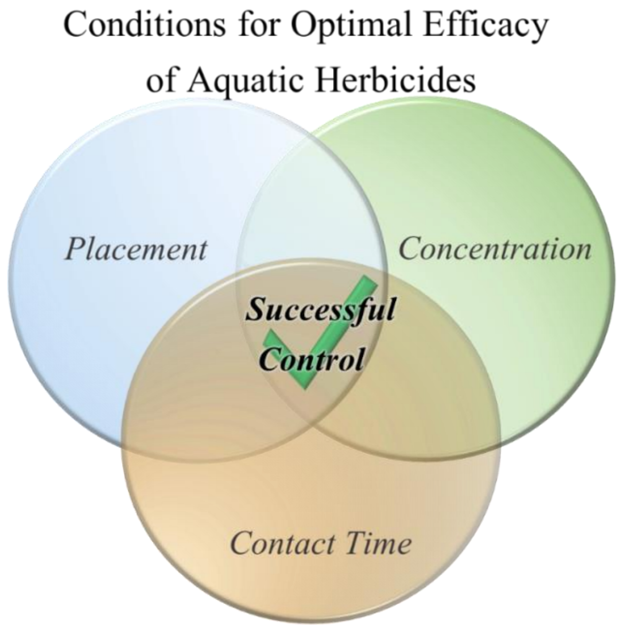

Figure 1. Herbicide Efficacy (Source: K. Getsinger, L. Anderson)

Types of Herbicides

Herbicides are categorized in two major groups based on their ability to enter the target plant and move through the plant, from shoots to the roots, roots to shoots, or both and are known as contact or systemic herbicides.

Contact Herbicides

These affect the plant tissues that are directly exposed to the herbicide. Typically contact herbicides act very rapidly, within minutes to a few hours, depending on concentration and target plant susceptibility. Contact herbicides do not provide long-term control of aquatic plants because the active ingredient does not move from the affected tissues to the roots or rhizomes, a process known as translocation, and unaffected plant structures can re-grow.

Systemic Herbicides

These enter the plants through shoots, leaves, rhizomes and roots and are then are translocated to other parts of the plant where they have deleterious effects such as disrupting normal plant cell functions such as protein synthesis or disrupting growth regulation. Typically systemic herbicides require longer contact time (days or weeks) and more time to completely kill the target plant. The advantage of systemic type herbicides is that they usually provide longer lasting control because they affect the plants' ability to re-grow and can often inhibit the plants' ability to produce flowers and vegetative propagules.

Types of Aquatic Herbicides

Aquatic herbicides fall into the same categories as terrestrial herbicides, contact or systemic, and are regulated for use in the same ways. Aquatic herbicides have been developed to control specific aquatic plant species and contain different active ingredients that provide more or less selective control of aquatic plants with minimized injury to non-target aquatic plants. Aquatic herbicides approved for use in California are summarized in Table 2. Herbicides are routinely used to control aquatic plant growth in aquatic sites worldwide. In California, they have been used at numerous sites including Big Bear Lake, Clear Lake, and in the Sacramento-San Joaquin Delta.

Table 2. Summary of Approved Aquatic Herbicides for California

Active Ingredient	Type	
	Contact	Systemic
2,4-D		√
Bispyribacsodium		√
Diquat	√	
Endothall	√	
Fluridone		√
Glyphosate		√
Imazamox		√
Imazapyr		√
Penoxsulam		√
Triclopyr		√

Herbicide Application Methods

Regardless of the mode of action, aquatic herbicides are delivered either to the water column around the shoots and leaves of the plants or to the sediment near the roots and rhizomes. If delivered via the water column, the herbicide typically is applied at mid-depth or just above the sediment. Granular formulations can release the active ingredient into the water column or just above the sediment layer. If delivered via the sediment, the herbicide must be at or just below the sediment surface so that it can be taken up by the roots and rhizomes. For sediment delivery to the plants, a granular form of an herbicide can be applied to or incorporated into the sediment during a period when the area is dewatered. Routes of entry are summarized in Figure 2.

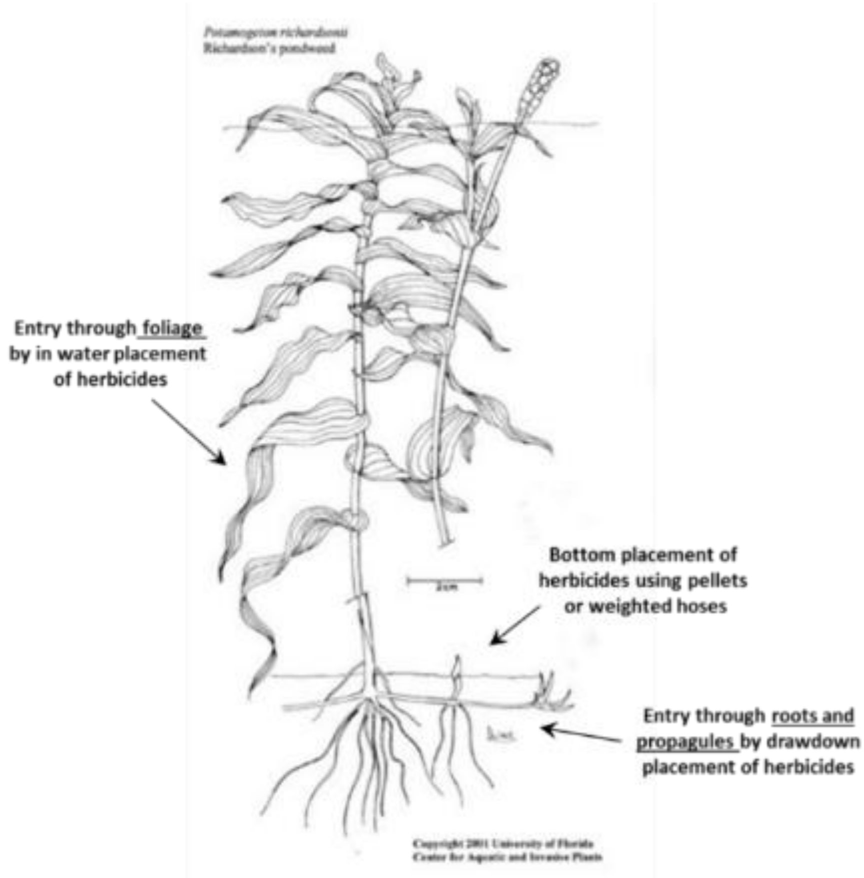

Figure 2. Routes of Aquatic Herbicide Entry

Consideration for herbicide use in the Tahoe Keys lagoons includes:

- Site of application. This could be a single cove, a series of adjacent coves, or an open area that connects one or more coves.
- Rate or amount of herbicide used. The amount of active ingredient used is based on the total volume of water in the treatment site. In the case of a dewatered site, the rate could be based on surface area.
- Containment structures. The site of application could be physically separated from adjacent, non-target areas by installing temporary floating-boom curtains or more permanent containment structure such as sheet pilings driven into the sediment. Impermeable sheets could be used to cover the bottom of the site of application, either before or after the herbicide is applied. Use of containment structures requires additional permits and must be placed by trained divers. However, they can restrict the herbicide exposure to the target site beneath the sheet and provide adequate contact times in the treated area.
- Methods of placement. The herbicide could be applied by surface application of granular formulation, by sub-surface injection to achieve specific concentration at

the application site, by precision-placement injection using GPS, or by incorporating the herbicide into the sediment layer after dewatering the site of application.

- Combined Herbicides. Combinations of herbicides may give better control of aquatic plants by providing a broader range of modes of actions and active ingredients.

Concerns of Herbicide Use

Non-target Impacts

As discussed above, physical variables can cause an herbicide to move from the site of application. Prior to application, weather conditions such as wind and temperature, must be monitored to ensure that the herbicide does not physically move outside of the treatment area and affect non-target organisms.

Aquatic herbicides are stringently tested for toxicity to humans, animals, and fish as part of the registration process required by the US EPA and California EPA. Despite the low toxicity and lack of carcinogenicity of these compounds, skepticism persists among the general public as to the safety of aquatic herbicides. To educate the public and help dispel unwarranted concerns about aquatic herbicides, links to information for the five aquatic herbicides that are proposed for use in the Integrated Weed Management Plan for the Tahoe Keys Lagoons are included at the end of this appendix. The interested reader will find details on the chemistry and the toxicology studies that have been completed for these aquatic herbicides and information on how the active ingredient is intended to be used. Manufacturers provide additional information on the labels which are required as part of the packaging of the product.

In must be emphasized that to protect human health and the aquatic habitat, all chemicals must be used properly. All aquatic herbicides must be used according to label directions and must be handled only by individuals trained in the proper handling and disposal of such products.

Herbicide Resistance

Another important consideration in using any herbicide is the risk of inducing resistance in the target plant population. Herbicide resistance has been well-documented in terrestrial plants and has also been demonstrated in aquatic plant species. It is a result of continued exposure to the same active ingredient and the same mode of action which does not completely eradicate the target plant population. The surviving plant population then becomes a source of plants that resist the active ingredient. The potential to develop herbicide resistance can be reduced by using herbicides with different active ingredients and modes of action over time.

Monitoring Herbicidal Control Methods

Monitoring methods used to assess efficacy, non-target effects and environmental fate of aquatic herbicides must be tailored to the application method, the specific product used, and the use of the site and the water at which the product will be applied.

For the aquatic herbicides that are suitable for the aquatic plants found in the Tahoe Keys lagoons, extensive information is available for characteristics such as half-life, ability to bind with sediment and organic material, modes of degradation and rates, contact time, and concentration needed for optimal efficacy on the target plants.

The following section explains the rationale and approach to be taken for the specific herbicide monitoring methods to be developed for the Tahoe Keys lagoons.

- Analysis for residues of herbicide active ingredients. Analysis of residual active ingredients at the treatment site must be determined in a timely manner following application. Analysis can be completed within 24 to 48 hours after a sample has been received by a certified laboratory to ensure that threshold levels for efficacy and regulatory compliance are met.

- Location of sampling stations. Stations used for sampling must be located based on all relevant information, including likely water movement and potential for off-site transport of the active ingredient. Properly positioned sampling stations will reveal information on the movements and dissipation of the herbicide and provide quality control to verify that the proper concentration and contact time have been achieved. Fixed stations should be established within and adjacent to the site of application. Permits typically require documentation of active ingredient residues outside the treatment zone, sampling stations should be established at increasing distances from the zone to satisfy permit reporting requirements. The placement and number of sampling stations will be determined in consultation with the staff of the Lahontan Board and in compliance with all permits.

- Water sampling methods. Depending on the type of product and application methods, herbicide residues may be dispersed throughout the entire water column or primarily localized near the bottom. The depth of water sampling as well as testing parameters will be determined based on type of herbicide applied and in consultation with the Lahontan Board. Testing would include the following:

  (1) Dissolved oxygen (surface and bottom)
  (2) pH (surface and bottom)
  (3) Temperature (surface and bottom)
  (4) Turbidity (surface and bottom)
  (5) Nutrients (Nitrates and phosphorous, surface and bottom)

In addition to the tests listed above, testing for photosynthetically active radiation (PAR) at the water surface, mid-depth and at the bottom would measure for impacts to the plant canopy and habitat as a result of aquatic plant management.

- Quality Assurance/ Quality Control (QA/QC)
  The integrity of sampling, sample storage and sample transport is critical to validation of data derived from residue sampling. Sampling crews will be trained in proper methods to ensure that contamination does not occur and that the samples are properly handled. Sampling crews and boats will be separate from and independent of application crews and boats. The processes of sample handling, storage, transport and shipping must be documented with a Chain of Custody (COC) form approved by Lahontan Board. Sample labels will be properly coded and a sufficient number of control samples will be submitted to ensure unbiased reporting.

- Sampling for potential ground water movement
  It is unlikely that herbicide residues will contact groundwater sources in the area due in part to their adsorption to soil particles which limits movement away from the application site. As a precaution, pre- and post-application water samples will be taken at one or more potable water pump stations within the Tahoe Keys. The duration of sampling will be determined in consultation with the South Tahoe Public Utility District, local water purveyors, and the Lahontan Board.

Links to Additional Information

The links listed below represent just a few of the sites where the reader can obtain unbiased information about registered aquatic herbicides. The US EPA makes available technical information on all registered herbicides through the Office of Pesticide Programs. The Wisconsin Department of Natural Resources has produced a series of summary fact sheets about aquatic herbicides which are easily understood by the layperson.

Environmental Protection Agency Office of Pesticide Programs
http://www.epa.gov/pesticides

Triclopyr:
http://dnr.wi.gov/lakes/plants/factsheets/TriclopyrFactsheet.pdf

http://npic.orst.edu/factsheets/triclogen.pdf

Imazamox:
http://dnr.wi.gov/lakes/plants/factsheets/imazamoxfactsheet.pdf

http://www.mass.gov/eea/docs/agr/pesticides/aquatic/imazamox.pdf

Fluridone:
http://dnr.wi.gov/lakes/plants/factsheets/FluridoneFactsheet.pdf

http://www.co.thurston.wa.us/health/ehipm/pdf_aqua/aquatic%20actives/Fluridone.pdf

Endothall:
http://dnr.wi.gov/lakes/plants/factsheets/EndothallFactsheet.pdf

http://extoxnet.orst.edu/pips/endothal.htm

Penoxsulam:
http://dnr.wi.gov/lakes/plants/factsheets/PenoxsulamFactsheet.pdf

http://www.epa.gov/pesticides/chem_search/reg_actions/registration/fs_PC-119031_27-Sep-04.pdf