SPY POND

Management Plan

July 2019

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INTRODUCTION AND BACKGROUND

Spy Pond is a 102-acre, waterbody located in Arlington, Massachusetts and is considered to be a Great Pond by the Massachusetts Department of Environmental Protection (DEP). As Spy Pond is a glaciated "kettle hole" pond, there is no regularly flowing inlet, but instead a number of storm drains that discharge directly to the pond. The outlet is located at the southern end, leading directly to Little Pond and the Alewife River. The shoreline of Spy Pond supports moderate to extensive residential development and the pond is widely used for fishing, boating, swimming and passive wildlife viewing.

In 2019, SŌLitude was contracted by the Town of Arlington to manage Spy Pond in addition to create the following management plan. There is often a desire to understand the causes of excessive plant growth. In the case of Spy Pond, there are aquatic infestations of invasive or non-indigenous aquatic plants: curlyleaf pondweed (*Potamogeton crispus*), Eurasian watermilfoil (*Myriophyllum spicatum*), and water chestnut (*Trapa natans*). "Invasive aquatic plants are generally defined as non-native (from another geographic region, usually another continent) plant species that cause ecological and/or economic harm to a natural or managed ecosystem. Invasive aquatic plants often cause both economic and ecological harm."[1] These plants were likely introduced to the lake by human use (boats and boat trailers, aquarium dumps), from an upstream source or through wildlife vectors. These introduced plants are opportunistic by nature and will often out compete native species, which is why they are considered invasive. They can become established in all types of freshwater systems from deep natural lakes to created stormwater detention ponds. Once introduced they are often difficult to control and usually nearly impossible to truly eradicate. One of the axioms for control of rooted plants in lakes is that:

"No amount of watershed management will control an existing infestation

- Rooted aquatic plant growths are not controlled by clean water
- Increased water clarity may extend plant growth
- Watershed management complements in-lake management"[2]

Effectively managing the invasive aquatic plants in Spy Pond will require an ongoing commitment to monitoring and in-lake management utilizing a suite of the most effective strategies available. Any management plans that are developed for the pond will need to remain fluid, as waterbodies are not static systems and just as conditions may change, management techniques also change and are continually refined.

ONGOING AQUATIC VEGETATION MANAGEMENT

Managing invasive aquatic plants in a public waterbody like Spy Pond will require a commitment to ongoing monitoring and maintenance efforts. Unfortunately, there are no proven strategies that can effectively eradicate most invasive aquatic plants, but they can be effectively managed. An integrated management plan is typically required that incorporates prevention and education, comprehensive monitoring and multiple in-lake control strategies. Once plants like milfoil have become established in a lake, management is usually focused on achieving selective control of the invasive species, while preserving and promoting the growth of beneficial native species. This is the recommended approach used at Spy Pond, although it is

[1] Biology and Control of Aquatic Plants, A Best Management Practices Handbook, AERF 2014, p. 7
[2] Practical Guide to Lake Management in Massachusetts, Commonwealth of Massachusetts, Executive Office of Environmental Affairs, 2004, p. 22.

understood that some native species present frequently reach nuisance densities during the growing season.

MANAGEMENT OBJECTIVES

Deciding what management technique or combination of management techniques to use for control of milfoil and other invasive aquatic plant species in a given lake system can be a difficult decision to make and is dependent on number of factors including lake morphology, size of area to be managed, non-target plant species present, management objectives and cost. Formulating realistic and attainable management objectives is a critical first step when developing an integrated, long-term aquatic vegetation management program. Since eradication is generally not attainable, efforts should be focused on developing a sustainable management program. The following management objectives or principals should be incorporated into a long-term aquatic vegetation management program for Spy Pond. The goal will be to develop a program that adequately addresses all of these stated needs.

1. Target control of known invasive species, namely curlyleaf pondweed, Eurasian watermilfoil, and water chestnut
2. Target control of known nuisance native species, namely snailseed pondweed (*Potamogeton bicupulatus*)
3. Prevent the establishment of other non-native and potentially invasive species
4. Preserve a diverse native plant assemblage for fish and wildlife habitat
5. Avoid any adverse impacts on water quality
6. Manage excessive algae growth that may be impairing water quality and/or human health
7. Improve recreation for the multiple user groups, including: fishing, rowing, and sailing, power boating and swimming

EVALUATION OF MANAGEMENT OPTIONS

The following section discusses several aquatic plant management options. Each strategy is evaluated in reference to the current conditions found at Spy Pond, discussing both advantages and disadvantages of the particular technique. Non-chemical controls are discussed first, followed by an evaluation of mechanical harvesting and chemical treatment options.

Hand-Pulling, Suction Harvesting and Benthic Barriers

Hand-pulling, suction harvesting (or DASH - diver assisted suction harvesting) and benthic barrier installations are generally used to control small localized patches of dense plant growth or widely scattered aquatic growth. The efficiency and high per-acre unit cost of these control strategies often limits their application to newly discovered, "pioneer" infestations or as follow-up to a larger scale management strategy such as chemical treatment or drawdown. It is usually ineffective, expensive and sometimes counter-productive to utilize these strategies on large-scale control efforts.

All three of these approaches have been utilized as primary Eurasian watermilfoil management strategies at other lakes in the Northeast with varied success, and while they can be effective they are often best utilized as part of an integrated management plan that incorporates chemical and physical controls.

Table 4: Comparison of Manual Variable Watermilfoil Control Techniques[3]

Approach	Typical Application	Advantages	Limitations
Hand-Pulling	Widely scattered plants <500 stems per acre	• Highly selective • Can utilize trained volunteers in some cases	• Impractical for large areas with milfoil coverage greater than ~1-5%. • Reduced visibility from poor water clarity or suspended sediments from a mucky bottom
Suction Harvesting / DASH	Small scattered to moderate infestations (< 1 acre in size)	• More efficient than hand pulling for higher plant densities	• Equipment difficult to relocate • Additional staff required • Increased turbidity • Very high cost
Benthic Barriers	Small dense patches (< 0.25 acres)	• Quick control for small areas • Prevents re-infestation • Barriers can be reused	• Non-selective, kills all plants and may impact macroinvertebrates and other non-target organisms • Barriers require routine maintenance • High cost per acre

Mechanical Removal

Several different approaches have been used to mechanically remove aquatic vegetation. The most commonly employed strategies in the northeast include dredging, harvesting and hydro-raking. Other mechanical techniques like rotovating/rototilling have been used on a limited basis elsewhere across the country with anecdotal, if any, demonstrated project experience in New England.

Mechanical control of milfoil species is generally not recommended in water bodies like Spy Pond where the species are not already distributed throughout a majority of the littoral area. Unavoidable plant fragmentation resulting from mechanical harvesting or hydro-raking will likely lead to increased milfoil distribution. There is also considerable qualitative evidence that suggests repetitive mechanical harvesting stimulates increases in milfoil abundance. Major limitations of mechanical approaches at Spy Pond are presented below.

- *Dredging* - Dredging involves the removal of bottom sediment to add water depth. It controls aquatic vegetation through physical removal of the plant and root structures and nutrient-rich sediments, leaving nutrient-poor sediments less suitable for plant growth. There can also be the added benefit of increasing water depth below the photic zone or the depth that light can penetrate to support plant growth.

  Dredging can be accomplished by various means. Dry-dredging involves draining the lake and using conventional excavation equipment. Wet-dredging, performed without lowering the water levels, uses drag-line equipment from shore or excavation equipment on floating barges. Hydraulic or suction dredging involves the use of a floating barge equipped with an auger cutting head that pumps a slurry of sediment and water to nearby containment basins for dewatering. Dredging projects carry a high cost relative to other management techniques, and seldom are they a cost-effective means of controlling rooted aquatic plants. Detailed planning and complicated, local, state and federal permits will also be required for most dredging projects. The permitting, data collection and planning process prior to implementation can take several years and may cost $50,000-$100,000 or more on large lakes.

[3] Commonwealth of Massachusetts Executive Office of Environmental Affairs. *Practical Guide to Lake Management Massachusetts* (2004): 102-103.

Dredging is not a recommended strategy for aquatic vegetation control at Spy Pond.

- *Harvesting* - Cutting and collecting aquatic vegetation with specialized equipment is termed mechanical harvesting. Mechanical harvesters are barges propelled by paddle wheels and equipped with depth-adjustable cutting heads and conveyor-mesh storage areas. Plants are typically cut near the sediment and water interface, usually to a maximum depth of 7 feet. Once a full load is collected, the harvester travels to shore to off-load. Complimentary shore-conveyors and trailer conveyors are available to transfer the harvested material directly into dump trucks, or it can be stockpiled on shore to dewater before being loaded and hauled to a permanent disposal location.

  With the exception of true annual plants that only propagate from seed, harvesting typically provides temporary control of aquatic plants. However, many aquatic plants re-grow rapidly after being cut (much like cutting a lawn), necessitating two or more cuttings per summer to maintain open-water conditions. Milfoil growth rates have been documented at more than one inch per day and re-growth is usually fairly rapid following harvesting programs. Harvesting also poses a significant risk of spreading highly invasive species like variable watermilfoil and fanwort which propagate through vegetative fragmentation. As a result, harvesting is not a recommended technique to control small or partial lake infestations of these plants and it is not recommended for Spy Pond.

- *Hydro-Raking* - Mechanical hydro-raking involves the removal of aquatic plants and their attached root structures. Hydro-rakes are best described as floating backhoes. The barge is powered by paddle wheels similar to a harvester, and it is equipped with a hydraulic arm that is fitted with a York rake attachment. The rake tines dig through the bottom sediments, dislodging the plants in water depths up to approximately 12 ft. Most hydro-rakes do not have on-board storage, so each rake full needs to be deposited directly on-shore or else onto a separate transport barge. Plants with large, well-defined root structures like waterlilies and emergent species are most efficiently removed through hydro-raking. In some cases, control of these and similar species can be attained for 2-3 years or longer. This approach is also sometimes favored for annual weed maintenance of beach and swim areas but is not a recommended approach for Spy Pond.

  Hydro-raking is not well suited for control of milfoil growth presently found in Spy Pond. Removing the plant root structures may provide slightly longer-term control of the submersed milfoil growth, but there is probably an even greater risk of creating and spreading plant fragments that could worsen the infestation. Disturbance of the bottom sediments may also stimulate re-vegetation by opportunistic plants like these.

  However, hydro-raking may be a viable management option to recover depth in the area south of Elizabeth Island in Spy Pond as aquatic plant species growing there are primarily seed bearing. Utilizing hydro-raking would allow for plant removal as well as removal of accumulated organic debris.

Drawdown

Lowering water levels during the winter months to expose aquatic plants to freezing and desiccation (drying) is a commonly used management approach in northern climates. It can be a relatively low or no-cost management strategy, provided that several key conditions are met. First and foremost, the target species must be susceptible to drawdown conditions. Eurasian watermilfoil and fanwort are positively controlled by drawdown. Second, the lake must have a suitable low-level outlet structure to facilitate gravity lowering. There are often other complicating issues associated with winter drawdown. Some of the more common issues raised include:

- Inability to sufficiently lower the water level due to limitations of outlet control structure and insufficient capacity and gradient of outlet stream
- Inability to expose enough of the littoral zone while still maintaining sufficient water volume to allow overwintering of fish and wildlife populations
- Impacts to the recharge rate of the adjacent wells
- Exposure of adjacent wetlands to freezing and drying conditions during winter months which could alter hydrology and the plant community
- Interference with recreational use of the lake during the winter months

Biological Controls

The introduction of herbivorous insects and fish is often considered to be a natural and potentially long-term management strategy to control excessive aquatic vegetation. Sterile or triploid grass carp (*Ctenopharyngidon idella*) that consume aquatic plants are regularly used as a management strategy in southern tier states. In the Northeast, they can only be used in New York and Connecticut waterbodies under site specific permits and provided that certain conditions are met. They reportedly do not show a feeding preference for variable watermilfoil and are therefore not recommended for use in a productive lake with a diverse native plant and fish community like Spy Pond. Non-selective vegetation removal on a large scale may have serious impacts on fish habitat and the overall lake ecology. Stocking of triploid grass carp is not currently permitted in Massachusetts.

The milfoil weevil (*Euhrychiopsis lecontei*) has shown promise as a potential long-term time watermilfoil management strategy but the results of weevil stockings have been mixed and maintaining suitable weevil densities for sustained control has proven difficult. The weevil is a small native insect that was discovered in Vermont to have a feeding preference for Eurasian watermilfoil over its native host species northern watermilfoil (*Myriophyllum sibiricum*). Weevil stocking as a potential watermilfoil management strategy has generated a considerable amount of interest and study over the past two decades.

The weevil does not eradicate watermilfoil, but instead destroys apical meristems (or growth tips) on the plant and reduces the buoyancy of the stems, causing the plants to collapse towards the bottom. Adult weevils live submersed and lay eggs on milfoil meristems. The larvae eat the meristem and bore down through the stem and pupate (metamorphose) lower on the stem. The consumption of meristem and stem mining by larvae are the two main effects of weevils on the plant and this damage can suppress plant growth, reduce root biomass and carbohydrate stores and cause the plant to sink from the water column.[4]

Stocking and maintaining appropriate weevil densities would likely be difficult and costly in Spy Pond. Research suggests that weevil populations ranging from 0.5-2.0 weevils per stem of milfoil are necessary to obtain reductions of watermilfoil.[5] Based on available pricing, a stocking of

[4] University of Minnesota, Department of Fisheries, Wildlife and Conservation Biology, 12/9/10 <http://fwcb.cfans.umn.edu/research/milfoil/milfoilbc.html>

[5] State of Washington Department of Ecology, *Aquatic Plant Management - Milfoil Weevil, The Milfoil Weevil in Washington* 12/9/10. < http://www.ecy.wa.gov/programs/wq/plants/management/weevil.html>.

100,000 weevils would cost upwards $120,000 for the weevils alone. If an initial stocking of this magnitude were performed, based on the fish population in the lake and the lack of undeveloped shoreline, it is likely that a large percentage of weevils would not overwinter successfully, requiring subsequent stockings to maintain appropriate weevil densities.

Weevil survival following stockings has been widely varied and the heath and proliferation of weevils has been linked to a number of factors including: sediment types, flow rates, water chemistry, fish predation, location of milfoil growth and availability of overwintering habitat.

Failure of most weevil stocking programs has been attributed to fish predation and lack of appropriate overwintering habitat.[6] To successfully overwinter weevils need "natural" undeveloped shoreline where they can spend the winter in loose soil, plants or leaf litter; lawns and managed shoreline are inappropriate and limit the potential for overwintering survival.[7] Weevil populations are also prone to fish predation and large populations of predatory fish (particularly sunfish) can severely diminish weevil populations. Loss of weevils to predation reportedly increases with the distance of the milfoil growth from shore so smaller lakes with milfoil beds near shore are more suitable for weevil stocking.[8]

Robert Johnson of the Cornell University Research Ponds has concluded after years of ongoing study that that while stocking *E. lecontei* at high densities can, in some cases, cause reductions of Eurasian watermilfoil, the process has not been perfected enough to be considered a dependable control strategy. "Although the milfoil weevil shows potential as a biological control for Eurasian watermilfoil more work is needed to determine which factors limit weevil densities and what lakes are suitable candidates for weevil treatments in order to implement a cost and control effective program."[9]

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[6] State of Washington Department of Ecology, *Aquatic Plant Management - Milfoil Weevil, The Milfoil Weevil in Washington*
12/9/10. < http://www.ecy.wa.gov/programs/wq/plants/management/weevil.html>.

[7] Cornell University Research Ponds Facility, Department of Ecology and Evolutionary Biology.
12/8/10. <http:www.eeb.cornell.edu/ponds/index.html>

[8] Cornell University Research Ponds Facility, Department of Ecology and Evolutionary Biology.
12/8/10. <http:www.eeb.cornell.edu/ponds/index.html>

[9] State of Washington Department of Ecology, *Aquatic Plant Management - Milfoil Weevil, The Milfoil Weevil in Washington*
12/9/10. < http://www.ecy.wa.gov/programs/wq/plants/management/weevil.html>.

Herbicide Treatment

The use of chemicals to control nuisance aquatic plant and algae growth is probably the most widely used management strategy for lakes with submersed aquatic plant infestations that are beyond effective control with non-chemical techniques like hand-pulling, suction harvesting or bottom barriers. Herbicides that are registered for aquatic use must meet strict federal guidelines and demonstrate that there is not an "unreasonable risk" to humans and the environment when applied in accordance with their product label. According to Madsen (Madsen 2000), "currently no product can be labeled for aquatic use if it poses more than a one in a million chance of causing significant damage to human health, the environment, or wildlife resources. In addition, it may not show evidence of biomagnification, bioavailability or persistence in the environment."

Performing chemical treatments in lakes and ponds is a highly regulated activity. Aquatic herbicides and algaecides are subject to periodic re-registration with the U.S. Environmental Protection Agency (EPA) where the latest technology and scientific studies are used to evaluate the potential impacts of these products. Most of the commonly used products have recently completed EPA's more stringent re-registration process. Aquatic herbicides and algaecides must also be registered for use in Massachusetts. Aquatic treatments in Massachusetts must obtain a site-specific License to Apply Chemicals from the Department of Environmental Protection, Division of Watershed Management and must be approved by the local Conservation Commission(s). Applications must be performed under the direct supervision of an Aquatic Applicator that is Commercially Certified and licensed in Massachusetts. Additionally, coverage under the federal National Pollutant Discharge Elimination System (NPDES) general permit has been required since 2011.

When properly used, aquatic herbicides are capable of providing area and, to some extent, species selective plant control, often with less temporary disturbance than comparable mechanical or non-chemical techniques. Herbicides are generally described as having either "contact action", meaning that only the actively growing portions of the plants that the chemical comes into contact with are controlled; or "systemic action", where the herbicide is internally translocated throughout the plant effectively killing the stem, foliage and root structures. Systemic herbicides are usually preferred for control of perennial nuisance weeds like variable watermilfoil and fanwort, since multiple-year plant control can be achieved. This often helps in reducing the frequency of amount of chemicals that must be applied to achieve the desired level of control.

Species-selective control is usually desired when targeting non-native and invasive species like milfoil. Treatment programs can be tailored to limit impacts to non-target native species through treatment timing, treatment location, use of different herbicide formulations, and manipulation of the herbicide concentration or dose rate. Achieving species-selectivity is often challenging considering the limitations of the available herbicide formulations and the variability of response seen from lake to lake. Water chemistry, lake morphology, bottom sediment type and plant composition all potentially influence herbicidal activity and the results are often not completely predictable.

Summaries of aquatic herbicides commonly used to control invasive aquatic plants found in Spy Pond are described in more detail below. Only chemicals that are currently registered for aquatic use in Massachusetts were discussed in detail. These products are already registered for aquatic use in Massachusetts in the Final GEIR.

Contact Herbicides

Currently available contact-acting herbicides target and disrupt different pathways, but are similar in that they only control portions of the plant that are directly contacted (above the sediment). Contact herbicides are relatively fast acting, with most plant uptake usually occurring over a 1-3 day period. Susceptible plants generally die-back within 1-2 weeks of exposure. Contact-acting herbicides will usually provide summer-long control of target species. Since the root structures are not controlled, re-growth usually occurs from the same root and vegetative structures the following year. Reduced re-growth of variable watermilfoil has been reported following successive years of treatment with contact herbicides.

Contact aquatic herbicides currently registered in Massachusetts include the active ingredients: diquat, endothall, copper and flumioxazin. Of these products, only diquat provides effective and feasible control of the milfoil found within Spy Pond.

- Endothall does provide effective control of Eurasian watermilfoil but is more effective when used in combination with other products.
- Copper based herbicides do not provide much control of Eurasian watermilfoil; if any, it generally lasts for only a matter of weeks, so they are not usually recommended for use; additionally, there are concerns over copper accumulation in the sediment.
- Flumioxazin does provide very good control of Eurasian watermilfoil, but it does have a significantly higher cost and there are state restrictions that limit the amount that can be applied annually.

Diquat – Diquat (trade name Reward, Tribune) is a fast-acting contact herbicide that would be applied to the lake when the plants are vigorously growing, but not at full maturity. Treatment at this time allows for maximum herbicide uptake by the plants, which promotes effective summer long control, and reduces the amount of vegetative biomass decomposition post-treatment. Unfortunately, since diquat is a contact herbicide annual maintenance treatments will likely be required. Although, successive annual treatments generally cause a reduction in plant distribution and density over time; therefore, reducing treatment requirements.

Diquat is a widely used herbicide and is applied to thousands of lakes and ponds throughout North America to control nuisance submersed aquatic plants. Diquat is registered for use in Zone II, Wellhead Protection Areas in Massachusetts. Diquat is translocated to some extent within the plant. Its rapid action tends to disrupt the leaf cuticle of plants and acts by interfering with photosynthesis. Upon contact with the soil, it is absorbed immediately and thereby biologically inactivated. The concentration of diquat in treated water after an application at the 2 gallon/surface acre use rate is approximately 0.37 ppm ion immediately after application. However, diquat residues in water rapidly decline to typically between 0.064 and 0.144 ppm ion eight hours after application and to below 0.01 ppm ion during the next five days. Diquat not adsorbed by the plants is rapidly and strongly bound to soil and rendered biologically unavailable. Diquat is slowly degraded by microbial activity and sunlight exposure. "Though this degradation is slow, long-term field studies have shown that diquat does not accumulate in the soil or sediments."[10]

Endothall – Endothall (trade name Aquathol K) is a contact herbicide that inhibits the use of oxygen for respiration. Similar to diquat from an application standpoint, endothall is best applied when plants are growing but not at full maturity yet. Utilizing

[10] Aikens, Jonathan, Ph.D., Syngenta, Letter regarding Lake Cochituate, MA, 2004

endothall typically requires annual maintenance treatments, but over successive years can cause a reduction in target plant distribution and density. Recently, endothall has shown to have systemic activity in lab studies and has recently been relabeled to reflect that information.

Endothall is typically applied at a rate of 2-3 parts per million and allows for selective control of target vegetation. Endothall compounds break down readibly and are not persistent in the aquatic environment.

Flumioxazin – Flumioxazin (trade name Clipper) is classified as a Protoporphyrinogen oxidase (PPO) inhibitor that initiates cell membrane disruption, providing control of a broad range of susceptible plants. Clipper is a true contact herbicide that provides quick and effective control of target plant species. Although Clipper is not shown to have systemic activity, one or more years of reasonable fanwort control have been observed at other fanwort control projects in New England where Clipper has been applied. Flumioxazin is extremely fast-acting and has a very short half-life, so it is perfect for spot/site-specific treatments.

Flumioxazin is a relatively newly registered herbicide in Massachusetts, and subsequently its use carries a number of restrictions which limit its use potential. Until flumioxazin is more widely used in the State, and more data is collected, it is unlikely that these restrictions will change. The current MA DEP policy restricts use of Clipper in any single area of a lake or pond to once every four years, except for treatments conducted within the immediate vicinity of shoreline structures (e.g., boat launches, docks, swimming beaches, dams, water intake pipes), drainage ditches, and ponds entirely internal to golf courses, etc. Based on the mode of action and use patterns of Clipper, this restriction undermines successful management of many non-native, invasive species, including fanwort.

Systemic Herbicides

Systemic herbicides translocate throughout the plant and target control of all of the plant tissue including the root structures. Systemic herbicides currently registered in Massachusetts include fluridone (Sonar), triclopyr (Renovate), 2,4-D (Navigate), and florpyrauxifen-benzyl (ProcellaCOR). These products are generally preferred for Eurasian watermilfoil control because they are often capable of controlling the entire plant and providing multiple-years of nuisance-level control. This does not mean that there will not be regrowth the year after treatment, but it will often require several years for the milfoil infestation to recover to pre-treatment levels. Aggressive milfoil management programs that are attempting to achieve milfoil "eradication" are relying on consecutive treatments with systemic herbicides until milfoil densities are reduced to the point where non-chemical controls can be cost-effectively utilized.

Fluridone – Fluridone (trade name Sonar) is often the herbicide of choice for managing lake-wide infestations of watermilfoil. It has demonstrated the ability to provide fairly selective control of Eurasian watermilfoil at low doses and its systemic action typically yields multiple years of effective control. Fluridone works by inhibiting the synthesis of carotenoids (yellow pigments) in plants, which in turn protect chlorophyll. Without carotenoids, the chlorophyll is broken down by sunlight and susceptible plants in effect starve to death.

Fluridone has a favorable toxicology profile. It is labeled for use directly in potable (drinking) water reservoirs at low concentrations (<20 ppb) with no restrictions on using the treated lake water for drinking or domestic purposes. The only water use restriction associated with fluridone is a precaution on using treated water for irrigation purposes until in-lake concentrations drop to safe reuse levels.

Eurasian watermilfoil is susceptible to low dose (10-20 ppb) concentrations of fluridone, provided that adequate contact time can be maintained for 90 days or longer. It also offers fairly good species selectivity with low dose (<10 ppb) applications. It also has a favorable toxicology profile. The major disadvantage of fluridone is that its high solubility and long contact time requirements makes it difficult to achieve effective control in "spot" or shoreline applications, even when using the slow-release pellet formulations (PR, Q, SRP and ONE).

2,4-D – Having been used for well over four decades 2,4-D is the oldest and most extensively researched systemic herbicide in the aquatics industry. Granular formulations of 2,4-D BEE ester (presently called Navigate) were exclusively used in the northeast until granular formulations of 2,4-D amine (Sculpin) were introduced in 2010. The granules sink to the bottom where the active ingredient is released over a period of hours to a few days. Plant uptake occurs at the leaves, shoots and root structures. It mimics plant auxins, promoting cell growth; essentially plants grow themselves to death. Epinasty or the bending and twisting of leaves and stems are the visible signs associated with 2,4-D exposure. 2,4-D is highly selective since it is most effective on dicot, or broad-leafed, species. Commonly managed aquatic dicots include watermilfoils, water chestnut and occasionally water lilies. Most monocot or narrow-leafed aquatic species, are only marginally impacted or tolerant of 2,4-D applications, rending it a highly selective herbicide. Treatment typically occurs when the plants are in their most active phase of growth, but before peak biomass is reached. This usually falls between late May and early July. Plants die-back completely within 2-4 weeks of treatment. The systemic action of 2,4-D can sometimes provide 2-3 years of nuisance-level Eurasian watermilfoil control from a single application. The current product label for 2,4-D granular restricts the use of treated lake water for drinking and irrigation until in-lake concentrations drop below 70 ppb and 100 ppb, respectively. This typically takes anywhere from 2-4 weeks depending on the portion of the lake being treated and the total amount of product being applied. Additionally, 2,4-D is not effective when managing fanwort growth.

In Massachusetts, 2,4-D is not approved for use in Zone II, wellhead protection areas due to concerns over the potential for well contamination. Well inventories must be performed and setbacks for wells are established depending on soil type. Because of these State concerns and the extended water use restriction periods, there is a negative public perception on the toxicity of 2,4-D, which limits its use here in Massachusetts.

Triclopyr – Triclopyr (trade name Renovate) is another auxin mimic systemic herbicide that targets dicot or broad-leafed plants, with a mode of action similar to 2,4-D. It is translocated throughout the entire plant killing the stem, foliage and roots. It only requires a relative short contact time (days as opposed to months with fluridone) with targeted plants, and is effective for partial lake treatments. Renovate is available in both liquid (Renovate 3) and granular (Renovate OTF) formulations and can be used in a variety of morphological settings to achieve optimal milfoil control. Treatments with Renovate in the Northeast have proven very effective providing selective, multi-year control of milfoil in a single application. Additionally, triclopyr is not effective when managing fanwort growth.

Because of its different chemistry and associated water use restrictions, triclopyr may be permitted for use at some locations where 2,4-D cannot be used. But in Massachusetts use of triclopyr within Zone II areas is reviewed on a case-by-case basis.

Florpyrauxifen-benzyl – Trade name ProcellaCOR is a newly registered systemic herbicide used for milfoil control. ProcellaCOR is quickly absorbed by the target vegetation and translocated within the plant. The mode of action of the herbicide causes impacted vegetation to lose structural integrity at the growth nodes. Residual levels of the herbicide remaining the water decline rapidly and reduction is due to the uptake by the targeted vegetation and overall degradation. The chemistry of ProcellaCOR has been designed to seek out target plants and be uptaken by those within a matter of hours. Additionally, ProcellaCOR has earned a Reduced Risk Classification by the US EPA due to its low use rates (ounces to the acre vs gallons/pounds of other products), no anticipated impact on human health or non-target organisms, and has very minimal water-use restrictions.

All of the products discussed above are currently registered by the EPA for aquatic applications and are registered for use in Massachusetts. Several manufacturers have recently introduced new products for control of invasive aquatic plants, many of which already have EPA registration for aquatics. Massachusetts has its own state registration process, which often takes several years to complete following EPA registration.

RECOMMENDED MANAGEMENT PROGRAM

Given the scope of the current invasive and nuisance aquatic plant infestations at Spy Pond, we recommend continuing with an integrated management program that utilizes aquatic herbicides and potential future use of diver hand-pulling and/or hydro-raking. When used properly the combination of these techniques can effectively control milfoil and other nuisance species and can significantly reduce their distribution and density over time. Ongoing maintenance treatments will likely be required for the foreseeable future, however the program should seek to reduce the scope and frequency of treatments over time. Even when systemic herbicides can be used, complete control of all the targeted plant growth rarely occurs in heavily infested areas, so follow-up removal of "stubborn" plants by hand-pulling can improve the duration of milfoil control following treatment. Recommended ideal management timeline is as follows:

Ideal Management Program Timing

Timing	Category	Task
Spring	Monitoring	Conduct aquatic plant survey to finalize management activities for 2019 season
Spring-Summer	Herbicide Treatment	Curlyleaf pondweed control – diquat herbicide treatment; tentatively early to mid-May
Summer	Monitoring	Continue monitoring to identify milfoil and nuisance pondweed growth
Mid-late summer	Herbicide Treatment	Milfoil/spiny naiad/nuisance pondweed control – diquat herbicide treatment; tentatively mid-July
Fall	Monitoring	Conduct aquatic plant survey to document current conditions, evaluate effectiveness of management techniques performed, and guide future efforts

2019 Management Program Timing

Timing	Category	Task
May	Monitoring	Conduct aquatic plant survey to finalize management activities for 2019 season
July	Herbicide Treatment	Diquat herbicide treatment for nuisance pondweed and naiad control
Late July / Early August	Monitoring	Post-treatment survey and continue monitoring to identify milfoil, spiny naiad and nuisance pondweed growth, if any
August	Herbicide Treatment	Milfoil/spiny naiad/nuisance pondweed control – diquat herbicide treatment; if necessary
September	Monitoring	Conduct aquatic plant survey to document current conditions, evaluate effectiveness of management techniques performed, and guide future efforts

Permitting

In-lake aquatic vegetation or algae management activities that may be performed at Spy Pond as part of this management plan will need to secure the appropriate State and local permit approvals. There is an existing Orders of Condition that covers the herbicide treatments.

Herbicide treatments also require a License to Apply Chemicals (BRP WM04) which is issued by DEP on an annual basis.

Monitoring

Routine monitoring is a critical component of all effective management programs. A combination of professional and volunteer monitoring efforts should be utilized at Spy Pond.

Professional monitoring of the following items should be considered:

- Aquatic vegetation surveys, biannually to support management efforts

Volunteer monitoring should be utilized for:

- Ongoing, routine water quality monitoring and water clarity (Secchi disk) monitoring
- Weed watchers or organized program for invasive species monitoring
- Weed watchers to monitoring for water chestnut plants and future hand-pulling efforts (if necessary)

Herbicide Treatments

Management activities will include the following tasks: filing of an annual License to Apply Chemicals, a pre-management survey, herbicide treatment(s) (if warranted by the pre-management survey results), diver hand-pulling (if plant growth does not warrant a treatment or for late summer regrowth following treatment), and associated post-management survey.

The preparation and filing of the annual License to Apply Chemicals is with Massachusetts Department of Environmental Protection, Watershed Management Division, which will be done prior to any treatment events. The pre-management survey is to be completed likely in the spring to determine the presence of target species (i.e. curlyleaf pondweed, Eurasian watermilfoil) and determine the areas requiring treatment or harvesting efforts.

- Any curlyleaf pondweed abundance and distribution should be treated utilizing diquat herbicide
- If milfoil abundance and distribution remain low, divers would be utilized to conduct hand-pulling to target the growth
- If milfoil abundance and distribution are greater than feasible to hand-pull, herbicide treatment utilizing diquat will be conducted to those areas of growth

A mid-summer survey will also be conducted to assess the abundance and distribution of any nuisance, thin-leaf pondweed growth as well as invasive spiny naiad growth. Based on historical conditions, treatment of some degree is anticipated to be conducted to manage the dense growth using diquat.

If treatment is warranted, a map of the tentative treatment areas will be provided to representatives from the Town. Upon finalization of treatment areas, the treatment date will be established by mutual agreement with the Town and public notification will be completed as required. Depending on the plant growth stage observed during the pre-treatment survey, the treatment will be scheduled accordingly as to impact the plants while biomass is still low.

Based on the findings of the interim treatment survey, diver hand-pulling may be arranged following the survey. This effort would be conducted in the event that there is milfoil growth outside of an area that was treated, to minimize the potential for future spread of the species. Later in the season, another comprehensive post-treatment survey will be performed; all composition, abundance and distribution data will again be included in the final report to the Town.