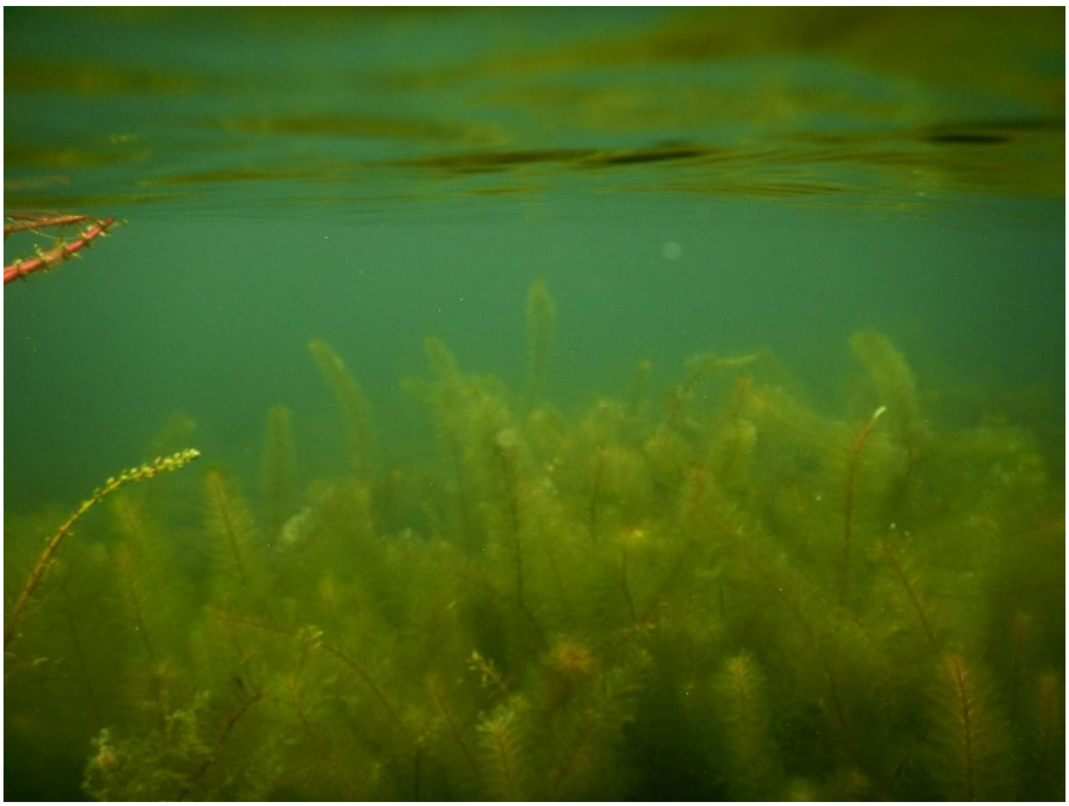
Aquatic Invasive Species Management and Response Plan

Division of Water Supply Protection



Myriophyllum heterophyllum

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Massachusetts Department of Conservation and Recreation
Division of Water Supply Protection
Office of Watershed Management

Abstract

This Aquatic Invasive Species Management and Response Plan for the Division of Water Supply Protection (DWSP) aims to prevent introductions of organisms or conditions that could degrade water quality within the waters of the Ware River, Quabbin, and Wachusett Reservoir Watersheds. The Plan summarizes DWSP's responses to the threat of aquatic invasive species to date and presents a framework for monitoring and making decisions regarding current and new aquatic invasive species threats across the watersheds. Management is framed around three strategies: preventing new and limiting spread of current infestations, monitoring and detection, and response methods.

Acknowledgements

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Abbreviations - The following abbreviations are used in this document.

AIS	Aquatic Invasive Species
CMR	Code of Massachusetts Regulations
DCR	Massachusetts Department of Conservation and Recreation
DWSP	Division of Water Supply Protection
EQ	Environmental Quality Section, DCR-DWSP
MGL	Massachusetts General Law
MA DFW	MA Division of Fisheries and Wildlife
USGS	U.S. Geological Survey
WsPA	Watershed Protection Act

Table 1: Relevant Aquatic Invasive Species Common and Scientific Names

The following species are referenced in this document.

Type	Common Name	Scientific Name
Algae	Didymo	*Didymosphenia geminata*
Algae	Starry stonewort	*Nitellopsis obtusa*
Fish	Common carp	*Cyprinus carpio*
Fish	Giant snakehead	*Channa micropeltes*
Fish	Northern pike	*Esox lucius*
Fish	Northern snakehead	*Channa argus*
Fish	Tilapia	*Oreochromis sp.*
Invertebrate	Asian clam	*Corbicula fluminea*
Invertebrate	Big water crayfish	*Cambarus robustus*
Invertebrate	Chinese mystery snail	*Cipangopaludina chinensis*
Invertebrate	Red Swamp crayfish	*Procambarus clarkii*
Invertebrate	Rusty crayfish	*Faxonius rusticus*
Invertebrate	Virile crayfish	*Faxonius virilis*
Invertebrate	Zebra mussel	*Dreissena polymorpha*
Plant	American lotus	*Nelumbo lutea*
Plant	Asian waterwort	*Elatine ambigua*
Plant	Brazilian waterweed	*Egeria densa*
Plant	Brittle naiad	*Najas minor*
Plant	Common reed	*Phragmites australis*
Plant	Creeping water primrose	*Ludwigia peploides*
Plant	Crested floating heart	*Nymphoides cristata*
Plant	Curly-leaf pondweed	*Potamogeton crispus*
Plant	Eurasian water-milfoil	*Myriophyllum spicatum*
Plant	European frogbit	*Hydrocharis morsus-ranae*
Plant	European water-clover	*Marsilea quadrifolia*
Plant	Fanwort	*Cabomba caroliniana*
Plant	Hydrilla	*Hydrilla verticillata*
Plant	Indian swampweed	*Hygrophila polysperma*
Plant	Mudmat	*Glossostigma cleistanthum*
Plant	One-row yellowcress	*Nasturtium microphyllum*
Plant	Parrot feather	*Myriophyllum aquaticum*
Plant	Pond water-starwort	*Callitriche stagnalis*
Plant	Purple loosestrife	*Lythrum salicaria*
Plant	Sacred lotus	*Nelumbo nucifera*
Plant	Swollen bladderwort	*Utricularia inflata*
Plant	True forget-me-not	*Myosotis scorpioides*
Plant	Variable-leaf milfoil	*Myriophyllum heterophyllum*
Plant	Water chestnut	*Trapa natans*

Type	Common Name	Scientific Name
Plant	Water hyacinth	*Eichhornia crassipes*
Plant	Water lettuce	*Pistia stratiotes*
Plant	Waterwheel	*Aldrovanda vesiculosa*
Plant	Yellow flag iris	*Iris pseudacorus*
Plant	Yellow floating heart	*Nymphoides peltata*
Zooplankton	Fishhook waterflea	*Cercopagis pengoi*
Zooplankton	Spiny waterflea	*Bythotrephes longimanus*

1. Introduction

Introduction of organisms not native to a region can be detrimental to entire ecosystems and the services they provide to humans. Drinking water supply systems, particularly those that are unfiltered, are vulnerable to these impacts. Some introductions may have direct and immediate impacts such as clogging intake works, while effects on the food web and accelerated eutrophication may have more gradual, but lasting impacts on water quality.

The Department of Conservation and Recreation (DCR) – Division of Water Supply Protection (DWSP) is responsible for providing quality raw surface water to the Massachusetts Water Resources Authority (MWRA), which in turn supplies drinking water to approximately 2.7 million people and thousands of industrial users. As an unfiltered system, changes in surface water quality can be more easily carried through the system to end users. It is therefore important to monitor, manage, and prevent introductions of organisms or conditions that would degrade water quality within or being transported to the Reservoirs.

The Environmental Quality (EQ) Sections at Ware River, Quabbin Reservoir, and Wachusett Reservoir Watersheds have been monitoring aquatic invasive species (AIS) in the watersheds and reservoirs for decades. Management activities have differed across the watersheds due to diverse regional needs and concerns, however, the overall goal of the programs is the same: to minimize negative water quality impacts. This document consolidates previous DWSP plans regarding AIS monitoring and response by summarizing historical responses and presenting a framework for monitoring and making decisions regarding current and new AIS threats across the watersheds.

1.1 AIS in the Northeast

States within the northeastern region of the U.S. (all states north of, and including, Pennsylvania and New Jersey) are particularly susceptible to invasions by non-native species. Dense human populations within this region have resulted in multiple pathways of invasive species introduction (Juzwik et al., 2021; Poland et al., 2021). Major international ports provide expedited routes of introduction (Havel et al., 2015; Reynolds et al., 2015) directly to U.S. lands and waters, where an extensively interconnected canal system and human activities (i.e., fish stocking, recreational boating, aquarium and bait industries, etc.) unintentionally facilitate spread (Havel et al., 2015; Poland et al., 2021; Shaker et al., 2017).

Aquatic macrophytes, invertebrates, and microorganisms that spread via fragmentation or reproduce asexually are most likely to establish pioneer infestations (Havel et al., 2015). Once established (i.e., population is sustainable), AIS easily spread to nearby water bodies. As populations grow, the chance for successful dispersal and establishment increases (Havel et al., 2015; Shaker et al., 2017). The northeast's unique land cover composition, heavily forested with 10% of surface area covered by water (Poland et al., 2021) and extensive human-made water control infrastructure, further increases the likelihood of AIS being successfully transported to new areas. Nearby waterbodies and introduction points are more likely to be colonized than those further away, as the potential for AIS to desiccate and become non-viable is lower (Havel et al., 2015; Reynolds et al., 2015).

In addition to these geographical challenges, the northeast's regulations regarding invasive species are inconsistent (Lakoba et al., 2020; Beaury, Fusco, et al., 2021; Bradley et al., 2022), providing gaps in protective efforts through which AIS can spread and become established. Although each state has its own list of regulated species, the methods used to determine potential invasives differs (Bradley et al., 2022), and coordination between states is limited (Lakoba et al., 2020; Beaury, Fusco, et al., 2021). As a result, only about 17% of species have a regulatory overlap between neighboring states (Beaury, Fusco, et al., 2021).

Climate change, as discussed in Section 1.3, also impacts AIS in the northeast, and is considered a major driving force behind AIS spread. The northeastern region is considered the fastest warming region of the U.S. (Karmalkar and Bradley, 2017), where temperatures have continually increased since the 1970s. Future projections for this region (that indicate an increase of 5-9°F by the end of the 21st century) would result in lengthened growing seasons, shorter and milder winters, and more severe weather (Dukes et al., 2009; Barron et al., 2001). In addition, invasive species often expand their ranges along their colder northern boundaries (Dukes et al., 2009) which, according to predictions, will continue to move northward and likely result in increased AIS introductions. Please see Appendix A – AIS of DWSP Concern and Status for a list of AIS that are a concern, either currently or in the future, to DWSP.

1.2 Impacts on Drinking Water

AIS can significantly disrupt aquatic ecosystems by outcompeting native species, altering food webs, and impacting water quality. The cascading effects of AIS can impact drinking water systems by degrading water quality and damaging infrastructure, which in turn can cause substantial economic ramifications.

Some of the key impacts of AIS are:

- **Ecological Impacts**
    - **Decrease in native species and biodiversity.** Invasive species can outcompete native species for food, habitat, and light availability in the case of macrophytes, leading to population declines and potential extinction of native species.
    - **Altered food webs.** Invasive species can disrupt the natural balance of food webs, affecting the entire ecosystem. A diverse community of native plants supports an array of invertebrate prey, which in turn supports higher trophic levels.
    - **Habitat degradation.** Some invasive plants can form dense mats, altering water flow, and overtaking native species. Other invasive plants can alter soil chemistry, reducing available habitat for native plants.
- **Water Quality Impacts**
    - **Water quality degradation.** Invasive species can contribute to decreased water quality by altering nutrient cycles and increasing eutrophication and harmful algal blooms, leading to a less reliable drinking water supply system.

  - **Depletion of oxygen.** Through the alteration of habitats and nutrient cycles, dense mats of senescing invasive plants can deplete oxygen from the water column, creating "dead zones."
  - **Sediment and turbidity settling disruption.** Invasive species can impact the movement, deposition, and composition of sediment, as well as the turbidity of the water column. These alterations can vary depending on the invasive species and their ecological role. For example, *Myriophyllum spicatum* (Eurasian watermilfoil) can form dense mats that trap sediment and increase turbidity while *Dreissena polymorpha* (zebra mussel) can decrease turbidity by filtering large volumes of water and removing suspended particles but alter sediment composition by selectively filtering only particles of a certain size (Lower et al., 2024).
  - **Shifts in pH.** Invasive species can cause shifts in water pH through the alteration of nutrient cycles and dense plant growth. The impact on pH can differ depending on the invasive species present. Shifts in pH can affect drinking water infrastructure and may require additional drinking water treatment.
  - **Restrict or alter water flow.** Some aquatic invasive plants create dense stands or mats which can alter water flow and change sediment accumulation patterns.
- **Economic Impacts**
  - **Cost of management or eradication.** The cost of managing or eradicating invasive species is high.
  - **Fisheries decline.** Invasive species can affect populations of native fish, thus altering the food web, impacting water quality and impacting recreational fisheries.
  - **Infrastructure damage.** Invasive species such as plankton, mussels, and plants can clog pipes and other water infrastructure, leading to costly maintenance and repairs.
  - **Reduced recreational value.** Invasive species can interfere with recreational activity through fouling and clogging gear, and making water bodies unsuitable for activities like fishing, boating, and swimming.

1.3 Influence of Climate Change

Climate change can influence the spread and colonization ability of invasive species and increase their negative effects by exerting more pressure on already stressed native ecosystems. Essentially, climate change can facilitate the spread and establishment of invasive species, making them more prevalent and impactful.

Key ways climate change impacts AIS:

- **Range expansion.** Rising temperatures enable invasive species adapted to warmer waters to move into new regions previously too cold for them and may simultaneously decrease the amount of suitable habitat for native species.

- **Enhanced establishment success.** Warmer temperatures and altered water chemistry can lead to an extended growing season and allow for invasive species to outcompete already stressed native species.
- **Higher growth rate with elevated carbon dioxide (CO_2) levels.** Fast-growing and free floating invasive macrophytes benefit from elevated CO_2 levels and thus outcompete slow-growing and submerged native species (Lind et al., 2022).
- **Increased diseases and outbreaks.** Climate change can also increase the probability of virulent diseases carried by invasive species. As invasive species establish in new regions, they can potentially impact native species that may not have defenses to new viruses. In addition, warm temperatures allow for faster viral reproduction and increased disease severity (Amari et al., 2021).
- **Reduce effectiveness of management controls.** Warmer and wetter conditions can impact prevention and management efforts. For example, preventive measures such as cold weather quarantine (see Section 3.1.1.1) and management efforts like winter drawdowns require a stable cold and dry period to kill invasive species (TRC, 2024).
- **Extended use of water bodies.** Longer growing seasons can increase the period of activity (human and wildlife) in water bodies, thus increasing the amount of time plants are able to grow or become established as well as the probability of invasive species dispersal through human recreation.
- **Increase in chloride in the water column:** An indirect impact of climate change on AIS is the increased use of sodium chloride (NaCl) road salt (due to extreme storms) and its subsequent runoff into water bodies. Increases in chloride may negatively impact native *Potamogeton* (Pondweed) species while facilitating growth of non-native species such as *Phragmites australis* (Common reed) and *Myriophyllum spicatum* (Eurasian milfoil) (June-Wells et al., 2013).

2. AIS History and Status in DWSP Watershed Waterways

The DWSP EQ Sections have been monitoring AIS in the watersheds and reservoirs for decades (Table 2). Management activities are based on local conditions and available resources and have differed across the watersheds due to diverse regional needs and concerns. Invasion history and past responses are summarized herein. These sections are divided into reservoir, watershed, and nearby waters (water bodies that are off-watershed but close to DWSP resources) to describe differences in monitoring and response. Details on these and other efforts are documented elsewhere in DWSP publications including the *Aquatic Invasive Species Assessment and Management Plan* (DCR 2010), *Wachusett Reservoir Aquatic Invasive Species Summary Historical Update and Ongoing Actions* (Trahan-Liptak and Carr 2016), *Aquatic Invasive Species Assessment and Management Summary: 2010-2022 Quabbin and Ware River Watersheds* (DWSP 2022), and annual water quality reports produced by each region.

2.1 Quabbin Reservoir Watershed

2.1.1 Reservoir

Although two invasive species (*Phragmites australis* and *Myriophyllum heterophyllum* (variable-leaf milfoil)) are well-established in the Reservoir and its shoreline, it was not until 2009, with the discovery of *Dreissena polymorpha* in western Massachusetts (in Laurel Lake and downstream reaches of the Housatonic River in Lee and Lenox, MA (MA DCR and MA DFG 2009)), that AIS in the Quabbin Reservoir became a major concern. The discovery of this AIS "poster child" raised awareness of the Quabbin Reservoir's vulnerability to AIS and prompted the establishment of rules governing use of private fishing boats and other outside vessels or equipment, which had not been regulated since they were first allowed on the Reservoir in the 1950s. Although DCR studies (DWSP 2009) concluded that *D. polymorpha* were unlikely to become established at the reservoir, decontamination protocols remain in place to prevent the spread of a variety of AIS threats to the Reservoir (see Section 3.1.1). The primary threat of AIS introduction to the Quabbin Reservoir is at the three Boat Launch Areas (BLAs), where human activities provide a direct pathway to the reservoir. However, shoreline fishing may act as an additional AIS introduction pathway, although to a lesser extent.

In response to this threat, since 2010 the EQ team at Quabbin annually survey portions of the Reservoir to monitor for new and established AIS. Details regarding these efforts can be found in Section 3.2. Fragment barriers are also situated above the horseshoe weirs to prevent any potential AIS introductions into the Reservoir from the holding ponds located at major tributary inflows to the reservoir. In addition, MWRA hires contractors to conduct point-intercept surveys throughout the Reservoir to identify plant species and biomass. These surveys first began in 2006, were conducted again in 2010, and have occurred annually since 2013. More information on the annual surveys in Quabbin and Ware River watersheds can be found in previous annual water quality reports.

Table 2: AIS in the Reservoirs, Watersheds, and Nearby Waters as of 2024

R = Reservoir, W = Watershed, N = Nearby waters, and H = Historic Record (not observed in recent surveys), * indicates some level of management

Type	Scientific Name	Common Name	Quabbin Reservoir Region	Ware River Region	Wachusett Reservoir Region	Sudbury Reservoir Region
Invertebrate	*Cipangopaludina chinensis*	Chinese mystery snail	W	W	R	
Invertebrate	*Faxonius virilis*	Virile crayfish			R	
Invertebrate	*Corbicula fluminea*	Asian clam				R
Plant - Emergent	*Iris pseudacorus*	Yellow flag iris	R/W	W	R	
Plant - Emergent	*Lythrum salicaria*	Purple loosestrife	R/W	W	R/W	
Plant - Emergent	*Myosotis scorpioides*	True forget-me-not	W	W		
Plant - Emergent	*Nasturtium microphyllum*	One-row yellowcress	W	W	R/W	
Plant - Emergent	*Phragmites australis*	Common reed	R/W	W	R*/W	
Plant - Emergent	*Pistia stratiotes*	Water lettuce			W*	
Plant - Floating	*Nymphoides peltata*	Yellow floating heart			W/N	
Plant - Floating	*Trapa natans*	Water chestnut		W*	N	R*
Plant - Submerged	*Cabomba caroliniana*	Fanwort	W/N	W	R*/W	R/W
Plant - Submerged	*Egeria densa*	Brazilian waterweed			N*	
Plant - Submerged	*Elatine ambigua*	Asian waterwort			R	
Plant - Submerged	*Glossostigma cleistanthum*	Mudmat			R	R
Plant - Submerged	*Hydrilla verticillata*	Hydrilla			N*	
Plant - Submerged	*Myriophyllum heterophyllum*	Variable-leaf milfoil	R/W	W	R*/W/N*	R/W
Plant - Submerged	*Myriophyllum spicatum*	Eurasian water-milfoil			R*/W*/N*	R/W
Plant - Submerged	*Najas minor*	Brittle naiad	H		W*/N*	R
Plant - Submerged	*Potamogeton crispus*	Curly-leaf pondweed		W	W/N*	R
Plant - Submerged	*Utricularia inflata*	Swollen bladderwort	R*/W	H	W*	

AIS management within the Quabbin Reservoir has been limited, with single-season removal efforts in 2014 for *Najas minor* (brittle naiad) and in 2017 for *Utricularia inflata* (swollen bladderwort). In 2023, additional management was implemented with the discovery of *U. inflata* in Pottapaug Pond. A full description of *U. inflata* removal efforts can be found within the [2023 Water Quality Report for the Quabbin Reservoir and Ware River watersheds](#).

Phragmites populations are extensive throughout the Quabbin Reservoir, with earliest records dating back to the 1970s (DWSP, 2022). This AIS has formed a dense 60-acre stand north of Mount L Island, which is now often referred to as "*Phragmites* Island." Due to their extensive spread, constant seed source, treatment resiliency, and tolerance of flood and drought conditions, eradication of *Phragmites* at Quabbin is no longer considered feasible with current available methods. If management of *Phragmites* is pursued at Quabbin, efforts should be focused on preventing spread first. Monitoring pioneer infestations is crucial to preventing this species from becoming established in new areas, as management efforts are most effective and feasible at this stage. As new control methods become available, eradication feasibility should be reassessed.

M. heterophyllum is also present throughout the Quabbin Reservoir, and was first observed in Pottapaug Pond in the 1970s, most likely spreading to the Reservoir soon after (DWSP 2022). Like *Phragmites*, this species is well established and may have surpassed the threshold of eradication feasibility. However, management efforts could still be considered to prevent spread and potential structural damage to dams and intakes, and long-term water quality impacts. Such efforts, even at high densities, have been found effective in controlling *M. heterophyllum* populations at Wachusett Reservoir.

2.1.2 Watershed

The Quabbin Reservoir Watershed covers over 95,000 acres of sparsely populated and mostly forested land area, with 77% of the total land area being protected through ownership and land use policies by DWSP, watershed preservation restrictions, other state agencies, municipalities, or non-profit organizations (DWSP 2023). Twelve municipalities are wholly or partially located within the watershed: Athol, Barre, Belchertown, Hardwick, New Salem, Orange, Pelham, Petersham, Phillipston, Shutesbury, Ware, and Wendell.

Within the watershed there are 17 waterbodies (excluding the Reservoir and holding ponds) that have previously been monitored by DWSP since 2010 on either an annual basis or a rotating schedule. Public access to these waterbodies varies, with a higher level of protection in place for the Reservoir (e.g., decontamination requirements, no swimming, and restricted shoreline fishing). DWSP has not conducted AIS management within the watershed (outside of the Reservoir and holding ponds) and is not aware of any private management efforts.

2.1.3 Nearby Off-watershed Waterbodies

Although no management efforts have been conducted by DWSP on waterbodies outside of the watershed, EQ staff periodically monitor several off-watershed ponds near the Quabbin Reservoir. This allows the opportunity for early detection and response actions, when appropriate, to be implemented to prevent or reduce the likelihood of AIS spreading to the Quabbin and other nearby waterbodies.

Ponds currently monitored on an as-able basis include Bassett Pond, Hardwick Pond, Pepper's Mill Pond, and South Spectacle Pond. Of these, only Hardwick Pond contains AIS not already present in the Quabbin Reservoir: *Cabomba caroliniana* (fanwort).

2.2 Ware River Watershed

The Ware River Watershed, located east of the Quabbin Reservoir, encompasses 61,737 acres of mostly undeveloped and heavily forested land area. Of the total land area, 54% is protected either by DWSP, watershed preservation restrictions, other state agencies, municipalities or non-profit organizations (FY24-FY28 Watershed Protection Plan). Eight municipalities are wholly or partially located within the watershed: Barre, Hubbardston, Oakham, Phillipston, Princeton, Rutland, Templeton, and Westminster.

Within the watershed there are 21 waterbodies that have been monitored since 2010 on either an annual basis or a rotating schedule, including areas around the Shaft 8 intake located on the Ware River. Details regarding EQ survey efforts can be found in Section 3.2. Public access to these waterbodies varies and information regarding access can be found in the 2023 Ware River Watershed Public Access Management Plan Update. MWRA hires contractors annually to conduct point-intercept surveys in the river upstream of the Shaft 8 intake and to harvest *M. heterophyllum* in late summer from this area during a water drawdown period, to protect infrastructure and prevent AIS spread through water transfers.

No other AIS management by Quabbin EQ had been conducted within this watershed until the fall of 2024 with the discovery of *Trapa natans* (water chestnut) in Brigham Pond. Due to the limited density, nature of this AIS, and staff availability, initial removal efforts were carried out the same day of discovery. As a result of this detection, Brigham Pond was added to the annual monitoring list to help direct future management efforts. More information on the *T. natans* discovery can be found in the 2024 Water Quality report for the Quabbin Reservoir and Ware River watersheds.

Management by DCR Lakes and Ponds (DCR L&P), Conservation Commissions, and Pond Associations have greatly helped in controlling AIS populations throughout the Ware River Watershed. For example, Whitehall Pond in Rutland is managed by the DCR Lakes and Ponds Program and has been treated with herbicides to control *Potamogeton crispus* (curly-leaf pondweed). Additional ponds managed by entities other than DWSP in this watershed include Asnacomet Pond, Demond Pond, Moulton Pond, and Queen Lake.

2.3 Wachusett Reservoir Watershed

2.3.1 Reservoir

AIS were first documented in Wachusett Reservoir in the 1990s; however, the extent of distribution at that time indicates they were likely present well before the initial documentation. Concerns over water quality and quantity due to increases in density and spatial coverage prompted managers to institute active management of populations upstream of the main reservoir basin in 2002. *M. heterophyllum*, *Myriophyllum spicatum* (Eurasian milfoil), and *C.*

caroliniana (fanwort) were all present in these upper basins; however, density of the former was initially deemed too extensive for management. Control efforts (hand-pulling and installation of benthic barriers) therefore focused on *M. spicatum*, and *C. caroliniana*. Diver Assisted Suction Harvesting (DASH) was implemented in 2012 and has continued as the primary control strategy for dense patches of plant growth. The success of this method also allowed for expansion of management into areas and species (specifically *M. heterophyllum*) where plant growth was denser. This included Stillwater Basin and Quinapoxet Basin, upstream areas that were identified as sources of continued reinfestation to the main basins of the Reservoir. Physical control efforts are carried out by MWRA contractors and are supervised, and at times supplemented, by DWSP aquatic biologists who also manage harvest data acquisition and analysis.

DWSP – Wachusett aquatic biologists have conducted surveys for AIS since the 1990s. With the initiation of management in the early 2000s, survey frequency increased to monitor these efforts and ensure that any expansion or new introduction of AIS were identified and evaluated for management as soon as possible. High priority areas of the Reservoir have been surveyed annually through a combination of meander, rake-toss, and surface inventory; biovolume data is often recorded during surface inventory surveys. Since 1999, the entire 37-mile reservoir shoreline is surveyed every five years via these methods to search for pioneer infestations and observe changes in plant communities (MDC 2002, annual Water Quality reports). Snorkel surveys are also conducted in areas of concern. Through these efforts, several incursions of *M. spicatum* and *M. heterophyllum* into main basin coves have been identified and removed in the same growing season. Most of these pioneer infestations have not seen regrowth and additional management beyond monitoring has not been necessary. Several minute and cryptic AIS, including *Glossostigma cleistanthum* (mudmat) and *Elatine ambigua* (Asian waterwort), have also been documented in the Reservoir and are monitored on a routine basis as part of the overall AIS detection and management program. *Phragmites* is also present in multiple locations along the Reservoir shoreline. Pioneer infestations of this species have been managed with physical means (cutting, covering, hand-pulling) since 2016. With the success of these methods, management expanded to larger patches and now all known stands of *Phragmites* along the shoreline are managed annually.

Public boating is not permitted at Wachusett Reservoir, significantly reducing the risk of AIS introduction. Nevertheless, public access to the shoreline for fishing and other recreational activities as well as in-water access granted to contractors, government agencies, researchers, and emergency response personnel present continued risk along with natural pathways.

2.3.2 Watershed

The Wachusett watershed covers 74,909 acres, with 46% of the land area protected by DWSP, or other organizations, and includes 122 distinct ponds (open water greater than 0.5 acres), which total approximately 5,973 acres of open water. DWSP started routine surveys of a subset of these watershed ponds every five years in 2015 to monitor known AIS infestations and identify new occurrences. Thirty-three of the ponds have been surveyed by DWSP and approximately 17 have at least one AIS present. Most of these AIS are already present in Wachusett Reservoir or widespread regionally. Therefore, DWSP has not extended management efforts to these water bodies. AIS present in the watershed are listed in Table 2.

In addition to the known infestations of AIS within the watershed, DWSP occasionally encounters instances of pioneer AIS and/or non-native organisms. In some of these cases immediate action is taken to remove and dispose of the AIS (e.g., *Pistia stratiotes* (Water lettuce) encountered in Stillwater River in 2020); however, in cases where the AIS is expected not to survive the environmental conditions it was discovered in, response action may be delayed or unnecessary (e.g., Tilapia, see Section 0).

2.3.3 Nearby Off-watershed Waterbodies

The DWSP is also concerned with AIS that are present in waterbodies outside of the watershed, but near the Reservoir. While not hydrologically connected, nearby waterbodies that contain AIS can act as vectors for spread by way of both human anglers and wildlife activities. There are two waterbodies within two miles of the Reservoir which are under management for AIS. These water bodies, South Meadow Pond Complex and Clamshell Pond contain several AIS unique to the area and not already present in Wachusett Reservoir. As with the watershed ponds, the primary goal of the DWSP's management of off-watershed ponds is to minimize the risk of transfer of these invasive species to Wachusett Reservoir.

2.4 Sudbury Reservoir Watershed

2.4.1 Reservoir

AIS have been present in Sudbury Reservoir since at least 2006. To date, seven AIS have been identified in Sudbury Reservoir (Table 2). The MWRA has recruited contractors to both survey for and manage AIS in Sudbury Reservoir since 2007. Survey efforts began in 2007 when MWRA initiated the Source and Emergency Reservoir Macrophyte surveys: baseline macrophyte surveys for the source and emergency reservoirs under MWRA jurisdiction, including Sudbury. Surveys were completed in 2007, 2010, and 2014, and have been completed annually since 2014. Management also began in 2007 with removal of *T. natans* (water chestnut). DASH crews were deployed for the first time in 2017 following the discovery of an infestation of *C. caroliniana* in upstream locations of the reservoir. In 2021, widespread *C. caroliniana* was discovered in additional sections of the reservoir. The management goal was changed to observation and as-needed removal of this species from the area immediately upstream of the Sudbury Reservoir dam to prevent the transportation of *C. caroliniana* to a series of downstream emergency reservoirs.

DWSP has assisted with non-routine survey efforts per MWRA's request; however, most of the AIS survey information comes from contracted Source and Emergency Macrophyte surveys. DWSP will continue to serve as an advisor of MWRA bids for survey and management contracts and will also continue to review Source and Emergency Macrophyte survey results.

2.4.2 Watershed

The Sudbury watershed has not been a focus of DWSP EQ management. The extensive infestations already present within Sudbury Reservoir and other MWRA water supplies in this region make monitoring and active management in the watershed a low priority. Available records, shown in Table 2, may not be accurate for current AIS distribution and conditions throughout the Sudbury watershed.

3. Addressing AIS: Objectives, Strategies, Actions

The goals for AIS management in DWSP watersheds and reservoirs are to protect drinking water quality by preventing new introductions of non-native species and limiting the spread of introductions that have already occurred. In general, the strategies used to meet these goals fall into the following categories: prevention (i.e., exclusion/decontamination, public outreach and education), early detection and rapid response, and ongoing management. These strategies are largely overseen by staff in the Quabbin and Wachusett EQ Sections, at times in collaboration with the MWRA.

Preventing the introduction of non-native species is the most cost-effective approach as success would eliminate the need for future management. However, given the impossibility of covering the numerous species of concern and invasion pathways, early detection followed by a rapid response to new infestations is essential. The implementation of these strategies by DWSP are described in this Section.

3.1 Preventing Infestation and Limiting Spread

3.1.1 Exclusion and Decontamination

AIS may be introduced by many vectors, including anthropogenic, biological, and physical means such as water flow and wind (Kelley et al., 2013). While most biological and physical vectors are uncontrollable, excluding or restricting human activities can be effective protection against the transport of plant fragments, seeds, and other organisms (Johnson et al., 2001). Human activity can be influenced through legal consequences enforced by the Massachusetts State Police and local Police Departments and by regulatory actions enforced by the DWSP. MGL 37B establishes an aquatic nuisance control program making it illegal to knowingly place or cause to be placed an aquatic nuisance in inland waters and CMR 302 18.00 reiterates that no person shall place or cause to be placed an aquatic nuisance species in or upon inland waters without facing civil or criminal penalties. Additionally, as detailed in the Watershed Protection Plan (WPP) (DCR 2023), DWSP has policies to limit or prohibit public access, boating, shoreline fishing and in-water public recreation from specific areas. The implementation of the policies described in the DWSP WPP, as well as each watershed's Public Access Management Plan, are enforced through the Watershed Protection regulations, 313 CMR 11.00. Entry to waterways in both watersheds is permitted to a range of working groups, including but not limited to AIS removal or survey contractors, engineering contractors, emergency responders, researchers, and other cooperating agencies such as the Massachusetts State Police, MassDOT or MassWildlife (MA DFW). In these cases, DWSP requires decontamination of all equipment and boats and the completion of a decontamination inspection prior to entry.

AIS threats are evaluated regularly, and decontamination requirements are determined by the highest procedure level needed to prevent the introduction of potential AIS. There are a range of possible decontamination methods, including treatment with approved chemicals, extended dry times, freezing, and pressure washing with hot water. Regardless of the decontamination method, DWSP or MWRA staff inspect all vessels and equipment prior to use in the Reservoirs and collect Decontamination Certification paperwork. Specific decontamination requirements are outlined in Appendix F – Decontamination Protocols.

Large chest freezers are available at both Quabbin and Wachusett headquarters and offered to contractors and others working on the Reservoirs for the purpose of 24-hour decontamination of equipment, including dive gear. DCR staff also use these freezers for decontamination of survey equipment as needed. DWSP – Wachusett maintains a hot-water pressure washer for decontamination of agency boats. Additional decontamination tools such as self-contained stationery, or mobile boat wash stations should be considered to increase convenience and compliance with regulations to improve AIS prevention measures.

If non-decontaminated equipment is used in the Reservoirs due to an emergency or violation, aquatic biologists are consulted. The last water body where any equipment that touched the water was used is identified and risk to the Reservoirs is assessed accordingly. The location(s) of launch and/or use is also identified, and the surroundings are surveyed for biological matter. Depending on the information gathered, additional surveys in future years may be necessary.

3.1.1.1 Quabbin Reservoir

Recreational shoreline and boat fishing are permitted in designated areas of the Quabbin Reservoir during the designated season and hours. To prevent the introduction of AIS into the reservoir, signage outlining the risks associated with AIS are posted at the boat launch fishing areas, and all anglers are encouraged to thoroughly clean and dry their gear before and after fishing. For boat fishing, private boats with a Quabbin Boat Seal are allowed to launch at the designated boat launch areas (BLAs). These watercrafts are a potential source of AIS and pose a significant risk to the Reservoir as invasive plant fragments and organisms can become lodged in hard-to-clean areas of the boat, trailer, engine compartments, and other small crevices, or they may be transported via residual standing water in components like dry wells. Considering these risks, all private boats are required to participate in the Quabbin Boat Seal (QBS) program. This program was developed in 2009 in response to the potential threat of *D. polymorpha* but has been improved and implemented for over 16 years to reduce the risk of introducing many other AIS.

There are two components of the QBS: Warm Weather Decontamination (WWD) and Cold Weather Quarantine (CWQ). With both programs, certified, decontaminated boats are affixed with a seal, a thin metal cable with a unique identifying numeric Quabbin Boat Tag that connects to the decontaminated trailer, by DWSP EQ staff (Figure 1).

The DWSP's WWD program consists of a visual inspection by trained DWSP staff of the boat and any equipment that could come in contact with water, including the trailer, live wells, bilge, anchor, and trolling motor. These areas are then washed with high-pressure water at a minimum temperature of 140 °F, and the motor is flushed with hot water until the exit temperature of the water reaches 140 °F for a period of 10 seconds. The last step is to seal the boat to its trailer using the Quabbin Boat Tag and cable to ensure it is not launched in any other water bodies before launching at the BLAs. Boaters are charged a fee for the boat decontamination wash (set annually, to cover operational costs of the third-party vendor) but not for the inspection and Quabbin Boat Seal.

Figure 1. Quabbin Boat Seal Program ID Tag and Attachment

Top: the number on the blue tag is recorded in a database and boats with intact seals, as shown at right and bottom, are allowed to enter the Quabbin Reservoir via one of the Boat Launch Areas.

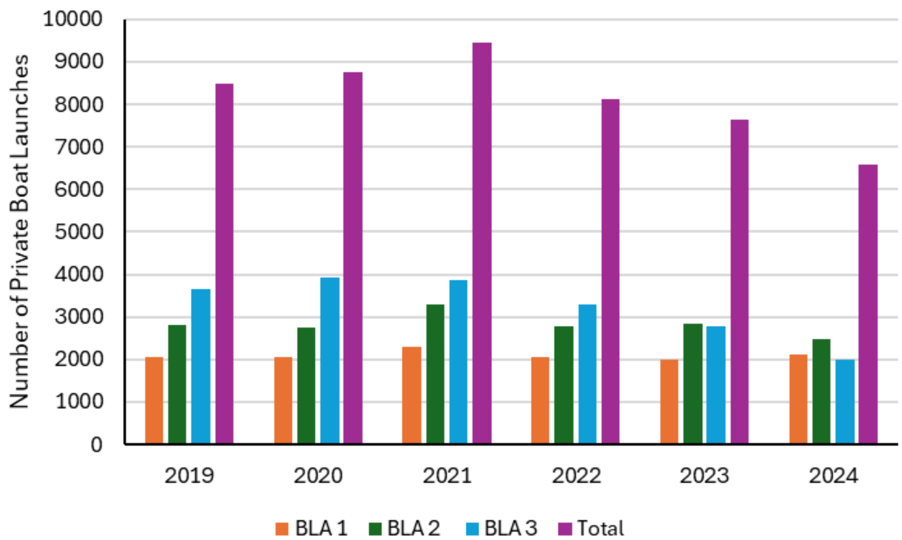
During the initial inspection process, prior to washing, boat owners are asked where and when the boat was last launched so the risk associated with that particular watercraft can be assessed. If the boat was recently in a water body known to harbor AIS, boaters are strongly encouraged to clean all fishing equipment in addition to that included in the decontamination inspection (i.e., downriggers, fishing line, Personal Floatation Devices, etc.). Boaters new to the program are given information on specific AIS of concern and are made aware of the DCR QBS program's purpose. This outreach has been invaluable for establishing compliance and appreciation of efforts to protect the Quabbin Reservoir.

The CWQ program is offered in late fall and early winter and consists of a visual inspection by trained DWSP staff, similar to the first step of WWD, but does not require washing the boat or flushing the motor. After the visual inspection, boats are tagged to ensure that the boat will not be used during the winter months, allowing for desiccation and freezing of any potential AIS on it. Boats with the CWQ tag are then allowed to launch into the Reservoir once the season opens the following April. The CWQ program has no fee.

Before a private boat is launched at one of the BLAs, boat area attendants inspect the seal and, if intact, record the tag number. The seal between the boat and its trailer is then removed, allowing the boat to launch onto the Quabbin Reservoir. DWSP staff prohibit the launching of any boats on the Quabbin Reservoir that do not have an intact Quabbin Boat Seal. When leaving the reservoir, DWSP staff affix a new seal to the boat and that tag number is recorded into the master database. Boats with an intact seal do not have to go through the decontamination or quarantine program again. If the tag has been removed for any reason, that boat must go through either the WWD or CWQ program again before it can be resealed and thereby launched onto the Quabbin Reservoir. DWSP maintains extensive digital records of Quabbin boaters, boat inspections, and boat tag records to aid in water supply protection efforts. In 2024, 6,576 private boats were launched (Figure 2), 4,311 boats were rented, and 965 anglers fished from shore. Overall, approximately 11,300 anglers visited the designated fishing areas at Quabbin Reservoir.

Figure 2. Number of Boats Launched at Quabbin Boat Launch Areas

Numbers of private boats launched in the designated fishing areas of the Quabbin Reservoir. Data collected from records kept by Boat Launch attendants after each launch.



Additional requirements regarding boat and motor specifications for WWD and CWQ can be found on the Quabbin Reservoir Boat Seal website. DWSP staff conducts periodic reviews of decontamination protocols which are updated as needed.

For some ponds within the Quabbin and Ware River watersheds, self-certification of boats (including kayaks and canoes) is required before they can launch into the ponds. Self-certification forms are available at Long Pond and Asnacomet Pond, and boaters are required to complete these forms and display them on their vehicle's windshield. If boats have been in water bodies known to harbor AIS, they must be decontaminated before they can be launched. DWSP Watershed Rangers monitor the boat launches, keep track of self-certification forms, and inform boat owners that did not complete the form about the program.

In addition to the decontamination programs offered to the public, DWSP also requires contractors, law enforcement, and other state agencies to follow established decontamination procedures (Appendix F) before launching their vessels or using diving gear in the Reservoir. DWSP maintains detailed SOPs outlining decontamination program processes.

3.1.1.2 Wachusett Reservoir

Public boating is not allowed on Wachusett Reservoir. Certain situations require that contractors, law enforcement agencies, and staff from other cooperating agencies, including Division of Fisheries and Wildlife and Massachusetts Department of Transportation, use their agency's vessels and equipment on the reservoir. These vessels and any equipment used on or in the Reservoir must comply with the 'Aquatic Invasive Species Decontamination Protocol for MWRA/DCR Reservoirs' (Decontamination Protocol), included in the Appendix. This requirement is included in all RFPs and agreements with other agencies. Compliance with the Decontamination Protocol is also required for DCR-DWSP and MWRA vessels that are moved between reservoirs for any reason. Trained DWSP staff or MWRA personnel are present on site to perform a visual inspection of each vessel and associated equipment before it enters the reservoir. In addition to the inspection, completed decontamination certifications forms are collected and approved/denied at that time. Recognizing that procedures for decontamination may change based on the introduction of new non-native species, this document will be updated as needed.

3.1.2 Public Education and Outreach

Public education and outreach are key to preventing the introduction of new invasive species and limiting the spread of existing ones. To increase awareness of AIS impacts and how they can spread, DWSP provides information via signage, informational kiosks, the DWSP website, and public presentations.

- **Signs and kiosks.** Signs and kiosks are used at boat launches and popular shoreline access points to inform boaters, anglers, and other recreational users of risks associated with the transport of AIS between water bodies. Many ponds with boat launches within DWSP watersheds have Massachusetts Aquatic Invasive Species signage installed. These signs display Massachusetts Law 302 CMR 18.00 regarding transport of any nuisance species within the Commonwealth and may indicate the most worrisome invasive species and list ways to prevent their transport. Information kiosks are present in many boat launch areas and contain pamphlets, posters, and signs with more extensive information on specific species of concern. DWSP staff updates signs and information presented on kiosks as needed.

- **DWSP web page.** To effectively and quickly communicate AIS concerns and requirements to the public, a section on the DWSP web page is maintained with appropriate resources. These include information on current work, new or emerging AIS concerns, listings of closures, centralized information on decontamination procedures, schedule for educational events, and contact information for individuals to report potential sightings of AIS.

- **Public events and presentations.** DWSP staff participate in public events and presentations to inform the public of new developments regarding AIS and associated control programs. Some of these public events include having conversations with and providing educational information to anglers during the QBS program, presenting an AIS lecture at the Les and Terry Campbell Quabbin Visitor Center (QVC) or through the Wachusett Reservoir Watershed Education Program, and attending conventions and relevant public events such as the Springfield Sportsmen's Show. QVC and other staff also field calls from the public and offer informational materials on AIS management and prevention.

Some surveillance and management efforts for AIS may be supplemented by members of the public. Public participation in AIS detection and management can increase awareness and engagement in AIS issues and prevention measures, improve early detection, and provide an opportunity for the public to be active participants in conservation. Opportunities for future public engagement include:

- Weed Watchers training (a program provided by DCR Lakes and Ponds).
- Hand-harvesting training and events for easy-to-identify AIS (e.g., *Trapa natans*).
- Implementation and encouraged use of an existing online reporting tool (e.g., iNaturalist).
- Submission of potential AIS sightings to DCR via an online form.
- Engagement of the boating community to passively gather and share biovolume data.

3.1.3 Internal Education

DWSP staff keep abreast of potential new AIS threats as well as new monitoring and management methods by attending relevant conferences and webinars, staying informed of current publications from the AIS management and monitoring community, and regularly checking online databases such as the U.S. Geological Survey (USGS) Nonindigenous Aquatic Species Database (USGS 2024) and community science sites like iNaturalist. In addition, consultants hired by MWRA provide an annual updated list of AIS of concern for the region, and DWSP works with the DCR Lakes and Ponds Program to coordinate education efforts.

Internal training is provided to BLA attendants and Watershed Rangers yearly or as necessary to ensure all staff are up to date on the latest species of concern and possible introduction pathways.

Aquatic biologists also use water quality data to assess susceptibility of the Reservoirs and tributaries to new invasive species. In addition to the *D. polymorpha* study referenced above, susceptibility to *D. geminata* and *Bythotrephes longimanus* (spiny water flea) have recently been assessed for the Wachusett Watershed and Reservoir.

3.2 Monitoring and Detection Strategies

Searching for new occurrences of non-native species is often a time-consuming task. It is aided by training, knowledge of existing conditions in the focus area, awareness of potential new invasive species, engaging the public and investment in specialized equipment. Detection strategies range from direct observation *in situ,* to laboratory analysis of samples, to remote sensing or use of environmental DNA, among others.

Monitoring the aquatic communities within a water body is an essential component to any program that strives to reduce the risk for establishment of non-native species (Table 3). The primary goal of DWSP's aquatic monitoring program is to detect incursions of AIS to protect water quality. Knowledge of baseline community conditions facilitates early detection of new introductions and provides comparison for future assessments to determine how these introductions, and any possible management strategies, affect the native community over time. Early detection of introductions allows for response measures that maximize the chance for successful eradication or control at a lower cost and effort. Although the focus of the monitoring program is on rapid AIS detection, results of these surveys and site visits can also serve to triage the numerous water bodies in each watershed for future in-depth assessments of water quality conditions (e.g., water quality profiles, nutrients, algae assessments).

Table 3: Methods for Detecting AIS and Potential Use

Method	Use
Meander Survey	To inspect as much littoral zone as possible for AIS or other species of concern.
Surface Inventory (SI)	Visual inspection can be used in waters that are shallow or clear enough to identify plants.
Rake-toss Survey	Rake-tosses are implemented when clarity or other conditions prevent identification from the surface.
Diver Inventory (DI) (including snorkeling)	Inspection by divers can be useful to cover deeper areas, dense plant beds, and shallow locations inaccessible by boats. This method has the added benefit of potential immediate physical removal of AIS detected.
Delineation	For defining the extent of new or existing AIS, quantifying management success, determining level of effort required for management, management areas, etc.
Point-intercept Survey	Best used for research or long-term monitoring. Can be paired with the above surveys and is typically conducted with rake-tosses.
Biovolume Survey	A measure of plants within the water column. Data may be collected visually, but ideally by boat-mounted sonar which is post-processed into heat maps. These data can be collected passively while conducting the survey types above or other work/recreation.
Net Sampling	Large volumes of water can be sampled for zooplankton using net tows (vertical or horizontal). The filtrate or a subset is then analyzed for invasive species.
Remote Sensing	Use of drone or satellite imagery to detect surface cover or identify changes
eDNA	Use of eDNA for AIS detection is an emerging field but could be considered for use, especially for organisms that are difficult to detect at low levels (e.g., *B. longimanus*).

Quabbin and Wachusett Reservoirs, including all directly connected basins, are the first priority for monitoring by DWSP. Extensive knowledge of conditions within the source waters allow biologists to focus on areas of greatest risk and detect changes that may negatively impact water quality more quickly. In the event a new infestation is detected, familiarity with the water body can assist with determining the possible extent of expansion and areas to focus on for additional detections.

Other water bodies within the watersheds or nearby reservoir shorelines are added to monitoring schedules as time allows and prioritized based on several criteria, including connection and proximity to these reservoirs, risk of infestation due to use by the public, proximity to known populations of non-native species, and other factors listed in Table 6. Specific monitoring parameters, timing, and protocols vary depending on the water body. Table 4 presents survey types and target frequency for several water body types and risk categories.

All surveys or site visits are documented and summarized. The level of additional data collection varies depending on the survey type and goals. Likewise, methods and tools involved in surveying vary. Ideally, all water bodies in the watersheds and the reservoirs would be surveyed for macrophytes using a combination of meander, delineation, and point-intercept, along with collection of water quality and plankton community samples. These methods would develop a robust data set with which to track changes in aquatic communities over time; however, these types of surveys are resource intensive and therefore impractical in most cases, given available resources. Therefore, survey types (Table 3) will be selected or used in combination based on priorities for each water body and target species. Table 5 contains a list of equipment and other resources that should be available to staff for AIS monitoring.

As suggested above, some portions of larger water bodies may be prioritized over others, surveyed more frequently, or at a higher resolution. For example, AIS introductions are more likely at public boat launch points, such as those at Quabbin Reservoir, and therefore, these areas are surveyed more frequently than locations where less public access takes place. Likewise, areas around the mouths of tributaries with known upstream infestations are prioritized at Wachusett Reservoir. Factors considered include those listed in Table 6.

3.2.1 Macrophytes

Point-intercept surveys of aquatic macrophytes in Quabbin and Wachusett Reservoir contracted by MWRA have been undertaken annually since 2013. These surveys are useful in identifying changes in aquatic vegetation type and cover at specific locations over the years. However, surveys beyond these points are essential for detection of pioneer infestations. Meander and surface inventory with occasional rake-toss and biovolume mapping methods cover a larger spatial area and are therefore more likely to detect pioneer infestations. These methods are used by DWSP for both reservoir and pond surveys.

A meander and surface inventory of the entire littoral zone of Quabbin and Wachusett Reservoir is conducted every five years[1]. A shallow draft vessel outfitted with a depth finder and side scan sonar is used to navigate the littoral area. Macrophyte observations are documented with GPS points, polygons, and pictures as needed, using ArcGIS Quick Capture and Field Maps. Biovolume data is passively collected during these surveys with the onboard side-scan sonar and surface inventories are supplemented with rake-tosses as needed to identify plant species. To facilitate surveys, each reservoir is broken into zones and a summary of observations in each zone is recorded. The presence of any new AIS or AIS occurring outside of areas where it has previously been documented is immediately addressed, potentially with ongoing management efforts, depending on the species and threat. New infestations are reported according to the procedures outlined in Section 3.3.1. Biovolume survey results are processed and any areas of high biovolume not already documented are re-surveyed.

[1] These surveys have been carried out at Wachusett since 2014 and are anticipated to start at Quabbin in 2026 (or earlier).

Table 4: Target Survey Frequency by Waterway and Risk Type

a) Wachusett and Quabbin Reservoirs

Survey area/category	Survey type(s)	Target frequency
Entire littoral zone	Meander, SI* and/or rake-toss	5 years or more frequent
Priority areas	Meander, SI and/or rake-toss	Annual or more frequent
Main body	Point-intercept (MWRA Contract) Zooplankton tows$^{\beta}$	Annual

b) Ware River

Survey area/category	Survey type(s)	Target frequency
Upstream Shaft 8 Intake	Point-intercept (MWRA Contract)	Annual
Upstream Boat Launch	Meander, SI	Annual

c) Other Waterways

Waterway Type	Management Category	Survey Type(s)	Target Frequency
Watershed waters with known infestations	Under management	Meander, SI and/or rake-toss, point-intercept	Annual or more frequent (to track management progress)
Watershed waters with known infestations	Monitoring only	Meander, SI and/or rake-toss, point-intercept	5 years or more frequent
Nearby waters within 1-2 miles of reservoir	Monitoring only	Meander, SI and/or rake-toss, point-intercept	5 years or more frequent
Watershed/nearby waters with high risk of infestation	Under management	Meander, SI and/or rake-toss, point-intercept	Annual
Watershed/nearby waters with high risk of infestation	Monitoring only	Meander, SI and/or rake-toss, point-intercept	2 years or more frequent
Others as needed	NA	Meander, SI and/or rake-toss, point-intercept	5 years or more frequent

** SI – surface inventory*

$^{\beta}$Quarterly tows followed by scans for AIS

Table 5: Equipment and Other Resources for AIS Monitoring

Equipment	Notes
Medium-size boat with shallow draft available regularly	Essential for reservoir surveys
Canoe and/or kayaks	For near-shore reservoir surveys, smaller waterways
Side scan sonar, depth finder, data processing capabilities	Can be used passively by biologists and other staff navigating through littoral areas. Potential for data gathering by volunteers.
Throw rake	Necessary for low-visibility situations
Zooplankton net(s)	Various sizes based on target species
Snorkel or dive equipment	For Diver Inventory – detailed but time intensive
GPS and/or iPads	Essential for plant surveys of any level
Consumables: write-in the rain paper, sample bags, sample bottles, etc., ethanol preservative	Backups for cases when electronics fail/are unavailable
Water quality meter	Requires separate meter for off-reservoir waterways
Hand-held, pocket microscope	Useful for cryptic plant species, rapid phytoplankton identification

Table 6: Factors Considered for Survey Prioritization

Reservoirs	Other Waterbodies
• Proximity to intakes • Proximity to known infestations • Substrate type • Prevailing wind direction • Proximity to access points • Geography (cove, sandbar, etc.)	• Proximity to Reservoirs • Public access and type • Waterfowl use • Potential changes observed using remote sensing (satellite data)

Many areas of the Reservoirs are surveyed at least once or more on an annual basis. Priority areas identified through extensive littoral surveys and/or previous history of AIS presence are checked for new or reoccurring growth. As above, GPS points and polygons are recorded along with periodic biovolume data. If applicable, data are used to guide contracted removal efforts throughout the season. DCR staff also conduct snorkel surveys and direct removal efforts when conditions warrant.

Examples of Success

Myriophyllum spicatum was encountered in Andrews Harbor of Wachusett Reservoir in 2015 during a snorkel survey. The plants were removed and no further growth in this area has been detected.

A small bed of *Myriophyllum heterophyllum* was detected in Carville Basin during the 2016 full-shoreline and biovolume survey of Wachusett Reservoir. This area is close to the Cosgrove Intake facility and harvesting was initiated immediately. The *M. heterophyllum* bed has since been surveyed and harvested as needed annually with plant density rapidly decreasing to no plants detected in 2022.

Surveys of ponds within the watersheds are a focus of the Wachusett aquatic biology program every five years, although multiple ponds are surveyed annually. Quabbin staff survey some ponds annually and others on a schedule associated with Environmental Quality Assessments in sub-watersheds. Ponds are selected based on factors included in Table 6, especially the risk that presence of AIS in a water body would present to water quality in the Reservoirs. The littoral zones of these water bodies are traversed with a canoe or kayak, and macrophyte observations are documented with a combination of field notes and GPS points/polygons recorded with ArcGIS Quick Capture and Field Maps.

Several off-watershed ponds are surveyed periodically by DWSP due to proximity to the Reservoir shorelines. Detections of AIS in some of these water bodies has resulted in annual surveys as described in the paragraph above.

Detections of AIS in several nearby off-watershed water bodies have also required aquatic biologists to institute active management and ongoing monitoring. In some cases, management with aquatic herbicides has been necessary. These projects and others that require intensive time investments are contracted out while other basic monitoring and physical removal efforts are conducted in-house.

3.2.2 Invertebrates

Invasion by small invertebrates (i.e., *B. longimanus*) is of concern due to recent detection of these organisms in other New England states (NH 2023). DWSP routinely (Wachusett since 2014, Quabbin since 2009) collects and analyzes samples from open water plankton net tows for these organisms. Targeted sampling also takes place at the three Quabbin BLAs.

Studies have shown that detection thresholds for invasive zooplankton can be very high, with populations existing in frequently surveyed water bodies more than ten years before detection (Walsh *et al.,* 2016). Methods such as sediment samples and eDNA analysis are being considered to improve detection in the Reservoirs.

3.2.3 Fish

DWSP collaborates with MA DFW and USGS on several fish monitoring programs. These do not directly monitor for invasive fish species but are establishing baseline fish community data for some tributaries and specific game species in the reservoir. Surveys for specific fish species of concern may be instituted on an incidental or routine basis in the future.

One example of response to a non-native fish introduction is the illegal release of Tilapia into Wachusett Reservoir in 2022. Surveys and removal efforts for approximately 30 fish were conducted in collaboration with MA DFW following an angler-reported observation. Removal efforts were not completely successful, but these fish are not cold-tolerant and are thought to have succumbed to the winter water temperatures (Azaza *et al.,* 2007). Subsequent surveys in 2023 and 2024 did not result in any further Tilapia detections.

3.3 Response

A new discovery of AIS requires a decision for how to react. In some cases, no further action will be taken, while discovery of a species, especially one that is novel and capable of negatively impacting drinking water quality, will require a swift, and likely ongoing, response.

3.3.1 Initial Communication and Evaluation

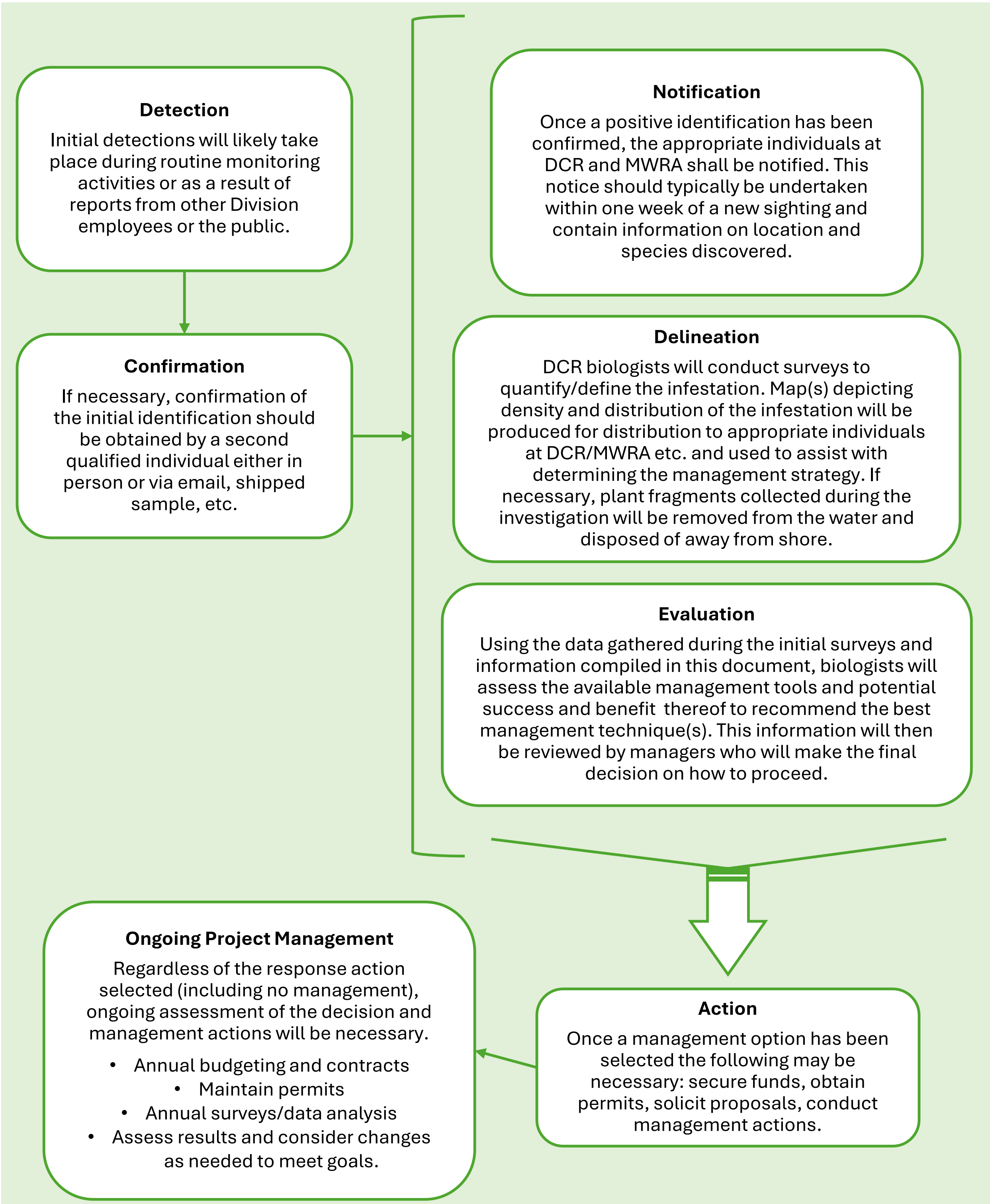
Every new detection of AIS will not necessarily require an extensive response. However, the risk that all new or potential infestations pose to drinking water quality and the wider ecosystem should be evaluated as soon as possible following discovery so that action may be taken, if needed. The procedure depicted in Figure 3 is followed with the understanding that some steps may occur simultaneously or be taken out of order, depending on the situation. Internal communication of potential new detections are made as soon as possible, including between regions.

3.3.2 Management Options

To date, response options for AIS range from no action to implementation of a multi-year integrated response plan. The level of response is determined on a case-by-case basis and is dependent upon the context of each detection or expansion event, which may not be the same for the same species found in one water body versus another. For example, discovery of *M. spicatum* near the Cosgrove Intake at Wachusett Reservoir would necessitate immediate removal, while response to discovery of the same plant in a watershed pond several miles upstream of Wachusett Reservoir would likely be limited to continued monitoring since this species is already present in the Reservoir and nearby waterways.

Figure 3: Flowchart Guiding Response to AIS from Initial Detection to Management

An accessible version of this chart can be found in Appendix D.



Management options fall into three general categories: manual removal, chemical treatment or biological control. The former can include removal by hand or mechanical equipment while chemical removal involves the use of herbicides and algaecides specially formulated for use in aquatic environments. Biological management involves the introduction of organisms that may consume or otherwise negatively impact the target species or creating favorable conditions for existing natural competitors to thrive and outcompete invasive species. Considering the potential long-term and widespread impacts of AIS on the water system, an integrated approach to management of AIS, which often includes both physical management and judicious use of herbicides, is potentially favorable to protect water quality.

A summary of methods is provided in Appendix E. The Massachusetts Guide to Lake Management (MassGLM) should be consulted for additional detail and review specific to Massachusetts regulations (MA DCR 2025). Reports from MWRA contractors have also extensively reviewed future management options and those historically used in the Wachusett and Quabbin systems (TRC 2024).

3.3.2.1 Regulatory Considerations

Many AIS management programs will fall under jurisdiction of the Wetlands Protection Act (M.G.L. c. 131 §40) and require filing of a Notice of Intent with the municipality and DEP. It may be beneficial to communicate intent to conduct manual removal of incidentally encountered pioneer infestations with local Conservation Commissions. If these events do occur, then notification of the activity and determination of further permitting needs may be made. Prior review of permits may be required through DCR's Green Docket process depending on the ownership of the property where management will take place.

Projects involving the management of AIS are likely to fall within jurisdiction of the Watershed Protection Act (WsPA) and may require the filing of an application pursuant to the WsPA Regulations (313 CMR 11.00). Programs undertaken by DWSP are exempt from WsPA as Work of the Division (313 CMR 11.05(6)). DWSP aquatic biologists will continue to assist in review of WsPA applications from others with the goal of working within DCR and with other organizations or private parties to reduce the threat posed by invasive species. DWSP has conditioned previous work to specify management of invasive species rather than 'nuisance' vegetation, require notification of treatment timing and type, and annual reporting. These and other requirements will be considered in review of future WsPA filings.

3.3.2.2 Budget Considerations

Overall costs of management are lower when new discoveries are addressed immediately (Cuthbert et. Al. 2002). Ideally, rapid response funds would be accessible on short notice; this, however, is not always feasible given annual budget restrictions. Therefore, methods to obtain funds on short notice should be established and updated annually ahead of the growing season or during fiscal year planning stages.

Budgeting for existing management programs is typically more straightforward than rapid response. However, it can be difficult to predict budget needs a year in advance to align with fiscal year planning schedules and biological growth patterns. Management programs for AIS are often long-term due to reproductive strategies, and some level of management or time commitment could be required indefinitely once an infestation is detected. At a minimum, the previous year's budget and level of staff effort should be maintained for several years in anticipation of growth rebounding or reinfestation.

3.3.2.3 Management by Other Entities

Management of water bodies within DWSP watersheds may be undertaken by other state, municipal, private, or non-profit organizations. These projects are likely to fall within Watershed Protection Act (WsPA) jurisdiction and may require the filing of an application pursuant to the WsPA Regulations (see above). A WsPA filing may also provide notification to DWSP staff of new AIS concerns within the watershed. It is in the interest of DWSP to work with these groups, when possible, to improve outcomes of management for the benefit of water quality and the wider ecosystem.

The DCR Lakes and Ponds program within the Office of Water Resources oversees management of state-owned water bodies, outside of those owned by DWSP, with a focus on those with DCR access points (i.e., state parks, beaches, etc.). Several water bodies within DWSP watersheds are, or have been, managed by the DCR Lakes and Ponds Program, including Whitehall Pond in Rutland State Park (Ware River Watershed) and Paradise Pond in Leominster State Forest (Wachusett Reservoir Watershed). These programs are exempt from WsPA as Work of the Division (313 CMR 11.05(6)); however, similar conditions to those outlined above are likely.

To date, DWSP does not have public funding available for management of non-DWSP water bodies. Funding sources that may be available for AIS management include the DCR's Partnership Matching Funds Program and Community Preservation Act funds.

3.3.3 Ongoing Response

Regardless of the decision to manage a newly discovered AIS, monitoring of the affected water body, and likely those in the vicinity, will be required for the foreseeable future. Water bodies under management will require visits to conduct management and assess the effects of management actions in the year(s) of management and beyond to ensure long-term success. Even if the response decision is to not conduct management, water bodies with one introduction of AIS have demonstrated vulnerability to additional introductions through the same vector (e.g., aquarium dumping) and should be prioritized for additional early detection surveys. These water bodies should also be monitored periodically to assess the impacts of non-management and to reconsider management if needed.

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Appendix A – AIS of DWSP Concern and Status

R = Reservoir, W = Watershed, N = Nearby, H = Historic Record (not observed in recent surveys).

Type	Species	Common Name	Quabbin Reservoir Region	Ware River Region	Wachusett Region	Northeast Region
Algae	*Didymosphenia geminata*	Didymo				Scattered - **MA**, NY, PA, VT
Algae	*Nitellopsis obtusa*	Starry stonewort				NY, VT
Fish	*Channa argus*	Northern snakehead				CT, **MA**, NY, PA, NJ
Fish	*Channa micropeltes*	Giant snakehead				**MA**, ME, RI
Fish	*Cyprinus carpio*	Common carp				**Entire NE**
Fish	*Esox lucius*	Northern pike				**Entire NE**
Fish	*Oreochromis sp.*	Tilapia			R[1]	**MA**
Invertebrate	*Cambarus robustus*	Big water crayfish				CT, **MA**, NY, VT
Invertebrate	*Cipangopaludina chinensis*	Chinese mystery snail	W	W	R	**Entire NE**
Invertebrate	*Corbicula fluminea*	Asian clam				CT, **MA**, NH, NJ, NY, PA, RI
Invertebrate	*Dreissena polymorpha*	Zebra mussel				CT, **MA**, NY, PA, VT
Invertebrate	*Faxonius rusticus*	Rusty crayfish				**Entire NE** – except RI
Invertebrate	*Faxonius virilis*	Virile crayfish			R	**Entire NE**
Invertebrate	*Procambarus clarkii*	Red Swamp crayfish	N		N	CT, **MA**, NJ, NY, PA,
Plant - Emergent	*Eichhornia crassipes*	Water hyacinth				CT, **MA**, NH, NJ, NY, PA
Plant - Emergent	*Iris pseudacorus*	Yellow flag iris	R/W	W	R	**Entire NE**
Plant - Emergent	*Ludwigia peploides*	Creeping water primrose				NJ, NY, PA
Plant - Emergent	*Lythrum salicaria*	Purple loosestrife	R/W	W	R/W	**Entire NE**
Plant - Emergent	*Myosotis scorpioides*	True forget-me-not	W	W		**Entire NE**
Plant - Emergent	*Nasturtium microphyllum*	One-row yellowcress	W	W	R/W	**Entire NE** – except RI
Plant - Emergent	*Nelumbo lutea*	American lotus				CT, **MA**, NH, NJ*, NY*, PA*, RI
Plant - Emergent	*Nelumbo nucifera*	Sacred lotus				CT, **MA**, NH, NJ, NY, RI

Type	Species	Common Name	Quabbin Reservoir Region	Ware River Region	Wachusett Region	Northeast Region
Plant - Emergent	*Phragmites australis*	Common reed	R/W	W	R/W	**Entire NE**
Plant - Emergent	*Pistia stratiotes*	Water lettuce			W	CT, NJ, NY
Plant - Floating	*Hydrocharis morsus-ranae*	European frogbit				ME, NH, NJ, NY, PA
Plant - Floating	*Nymphoides cristata*	Crested floating heart				nearest state - NC
Plant - Floating	*Nymphoides peltata*	Yellow floating heart			W/N	CT, **MA**, NJ, NY, PA, RI, VT
Plant - Floating	*Trapa natans*	Water chestnut		W	W	CT, **MA**, NH, NJ, NY, PA, RI, VT
Plant - Submerged	*Aldrovanda vesiculosa*	Waterwheel				**MA**, NH, NJ, NY, PA
Plant - Submerged	*Cabomba caroliniana*	Fanwort	W	W	R/W	CT, **MA**, NH, NJ, NY, PA*, RI
Plant - Submerged	*Callitriche stagnalis*	Pond water-starwort				CT, **MA**, NJ, NY, PA
Plant - Submerged	*Egeria densa*	Brazilian waterweed			H	CT, **MA**, NH, NJ, NY, PA, RI, VT
Plant - Submerged	*Elatine ambigua*	Asian waterwort			R	**MA**[2]
Plant - Submerged	*Glossostigma cleistanthum*	Mudmat			R	CT, **MA**, NJ, PA, RI
Plant - Submerged	*Hydrilla verticillata*	Hydrilla			N	CT, **MA**, ME, NJ, NY, PA, RI
Plant - Submerged	*Hygrophila polysperma*	Indian swampweed				nearest state - VA
Plant - Submerged	*Marsilea quadrifolia*	European water-clover				CT, **MA**, ME, NJ, NY, PA
Plant - Submerged	*Myriophyllum aquaticum*	Parrot feather				CT, **MA**, NJ, NY, PA, RI

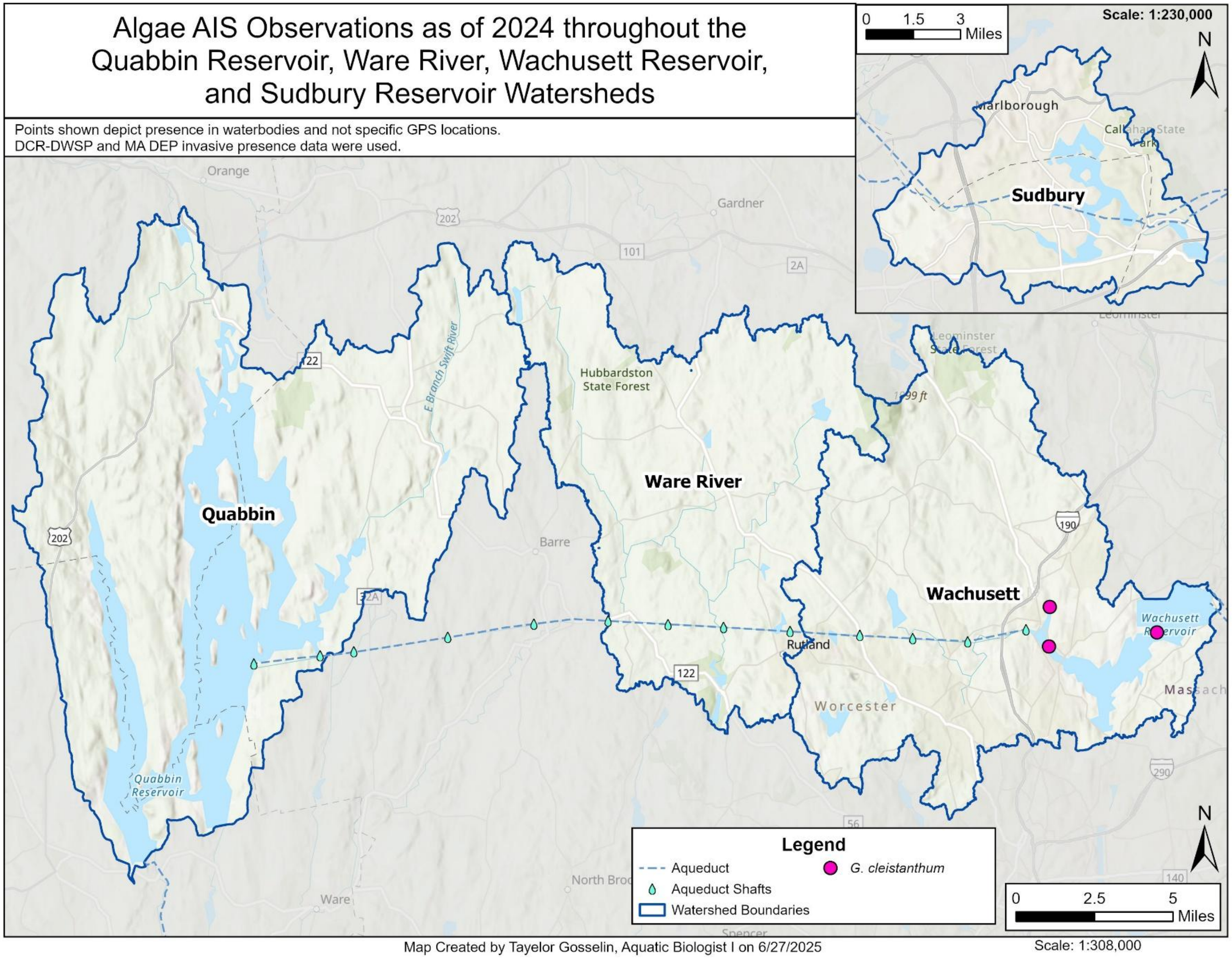
Type	Species	Common Name	Quabbin Reservoir Region	Ware River Region	Wachusett Region	Northeast Region
Plant - Submerged	*Myriophyllum heterophyllum*	Variable-leaf milfoil	R/W	W	R/W	**Entire NE** – NJ*, NY*, PA*
Plant - Submerged	*Myriophyllum spicatum*	Eurasian water-milfoil			R/W	**Entire NE**
Plant - Submerged	*Najas minor*	Brittle naiad	H		W/N	**Entire NE** – except ME & RI
Plant - Submerged	*Potamogeton crispus*	Curly-leaf pondweed		W	W/N	**Entire NE**
Plant - Submerged	*Utricularia inflata*	Swollen bladderwort	R/W	H	W	CT, **MA**, ME, NH, NJ*, NY*, PA*, RI
Zooplankton	*Bythotrephes longimanus*	Spiny waterflea				NH, NY, PA, VT
Zooplankton	*Cercopagis pengoi*	Fishhook waterflea				NY

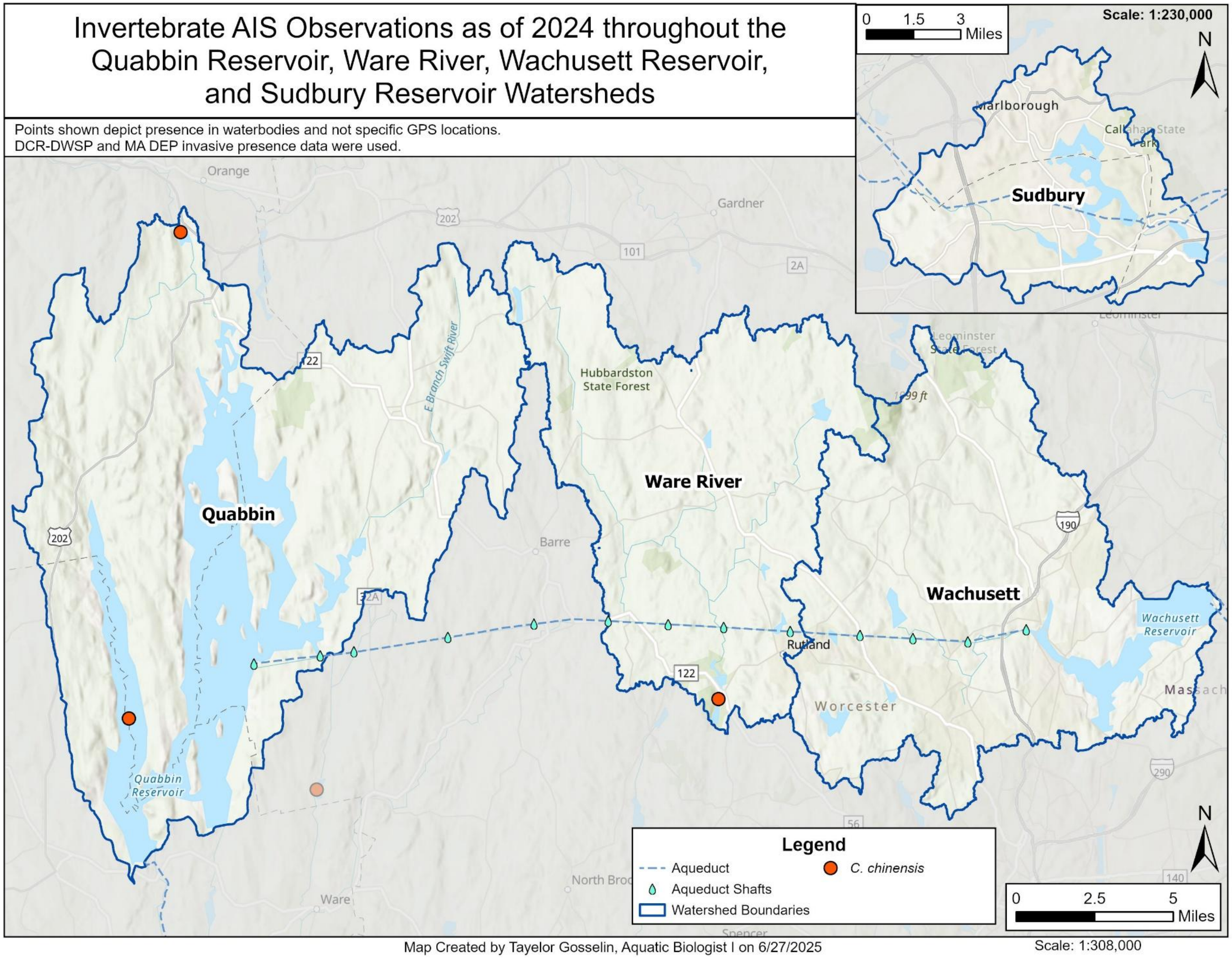
[1] Present in 2022, but not considered viable due to thermal tolerance.

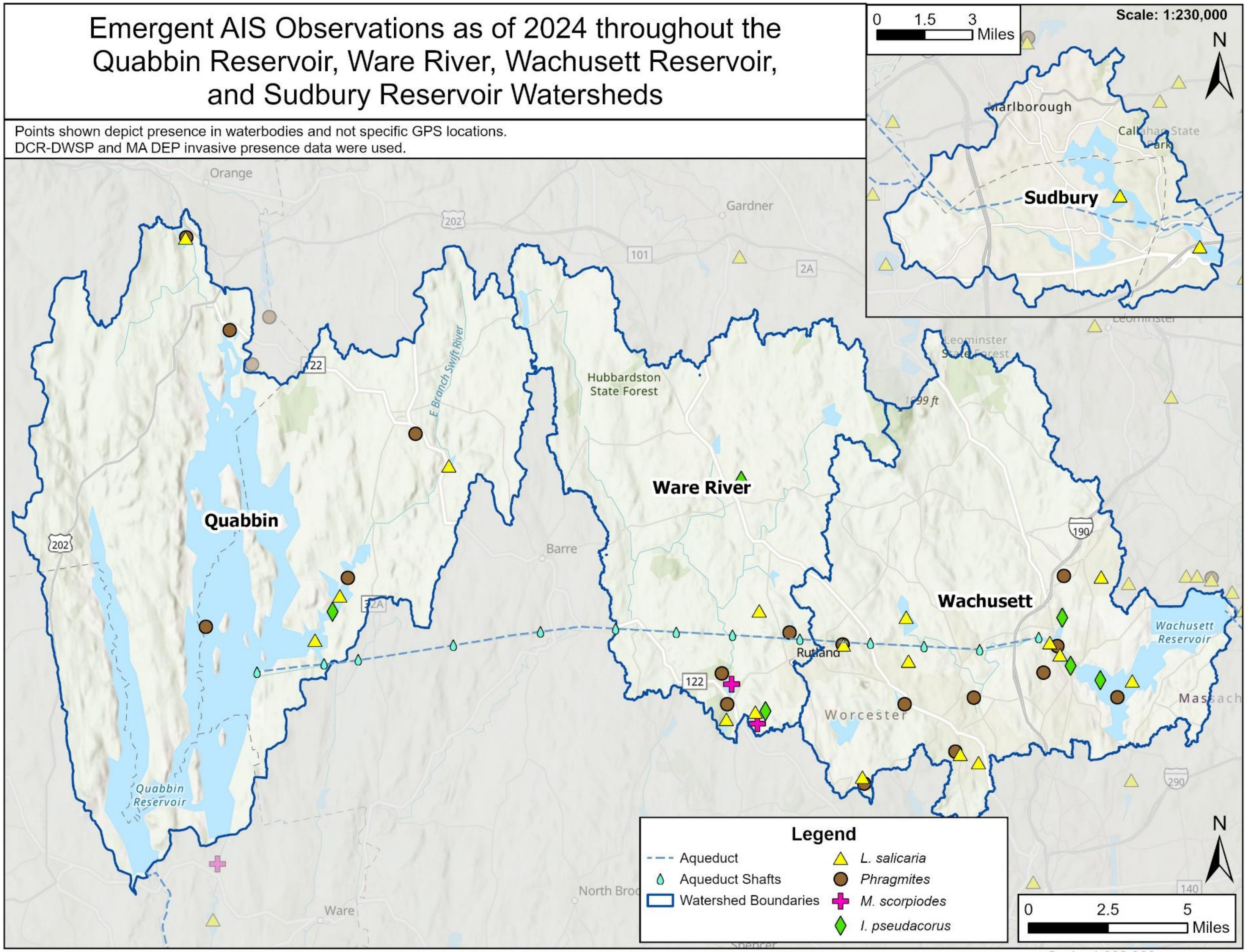
[2] Identification confirmed via DNA analysis in 2014 (Rosman et al., 2016). Distribution indicated this cryptic species was present prior to 2014.

* Native range found within parts of the state.

Appendix B – Reference Maps

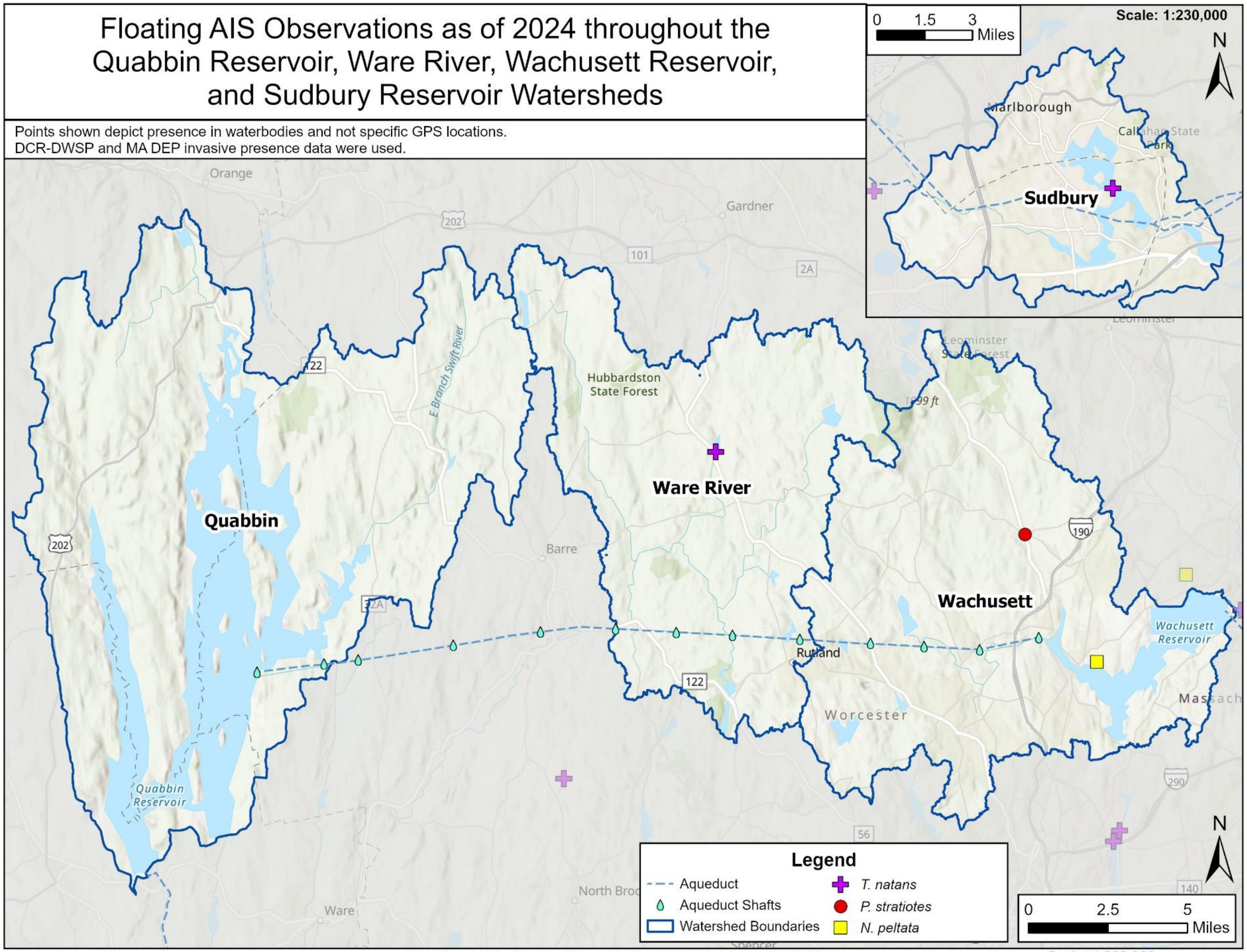



Invertebrate AIS Observations as of 2024 throughout the
Quabbin Reservoir, Ware River, Wachusett Reservoir,
and Sudbury Reservoir Watersheds
Points shown depict presence in waterbodies and not specific GPS locations.
DCR-DWSP and MA DEP invasive presence data were used.
Quabbin
Ware River
Wachusett
Sudbury
Quabbin Reservoir
Wachusett Reservoir
Hubbardston State Forest
Orange
Gardner
Barre
Rutland
Worcester
Ware
Marlborough
Legend
Aqueduct
Aqueduct Shafts
Watershed Boundaries
C. chinensis
Scale: 1:230,000
0 1.5 3 Miles
0 2.5 5 Miles
N
Map Created by Tayelor Gosselin, Aquatic Biologist I on 6/27/2025
Scale: 1:308,000



Map Created by Tayelor Gosselin, Aquatic Biologist I on 6/27/2025

Scale: 1:308,000

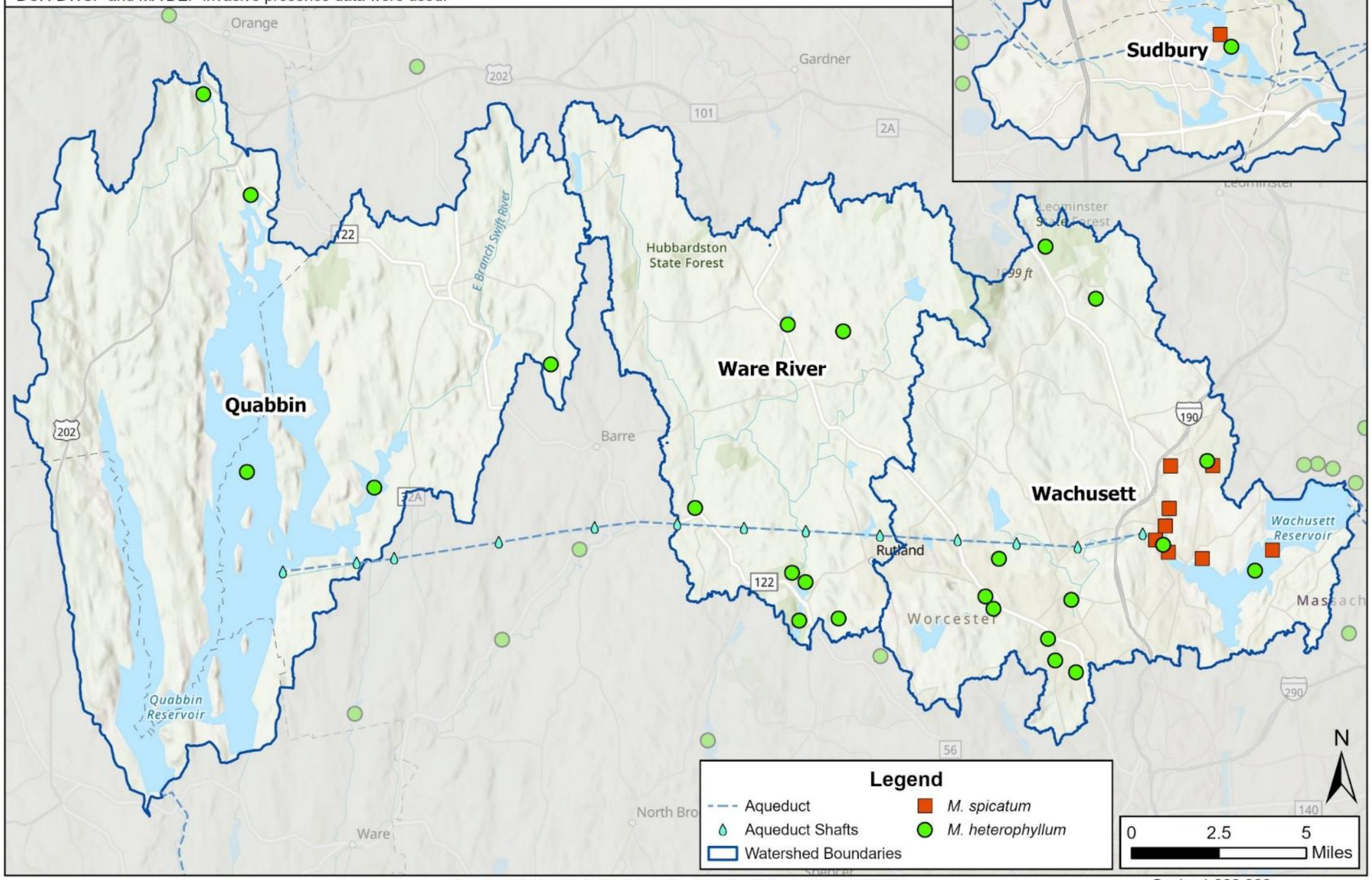


Map Created by Tayelor Gosselin, Aquatic Biologist I on 6/27/2025

Scale: 1:308,000

Myriophyllum Species Observations as of 2024 throughout the Quabbin Reservoir, Ware River, Wachusett Reservoir, and Sudbury Reservoir Watersheds

Points shown depict presence in waterbodies and not specific GPS locations.
DCR-DWSP and MA DEP invasive presence data were used.



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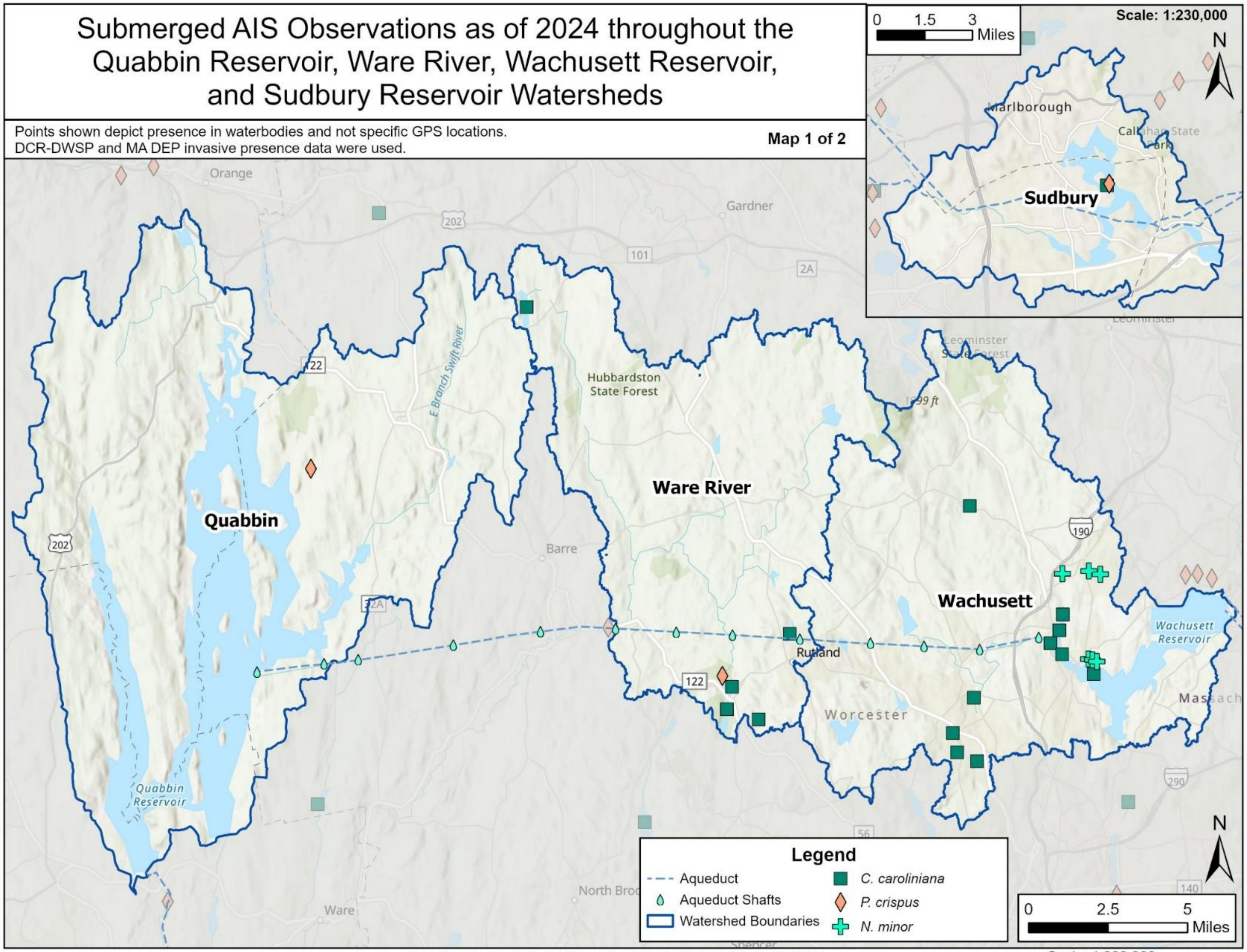

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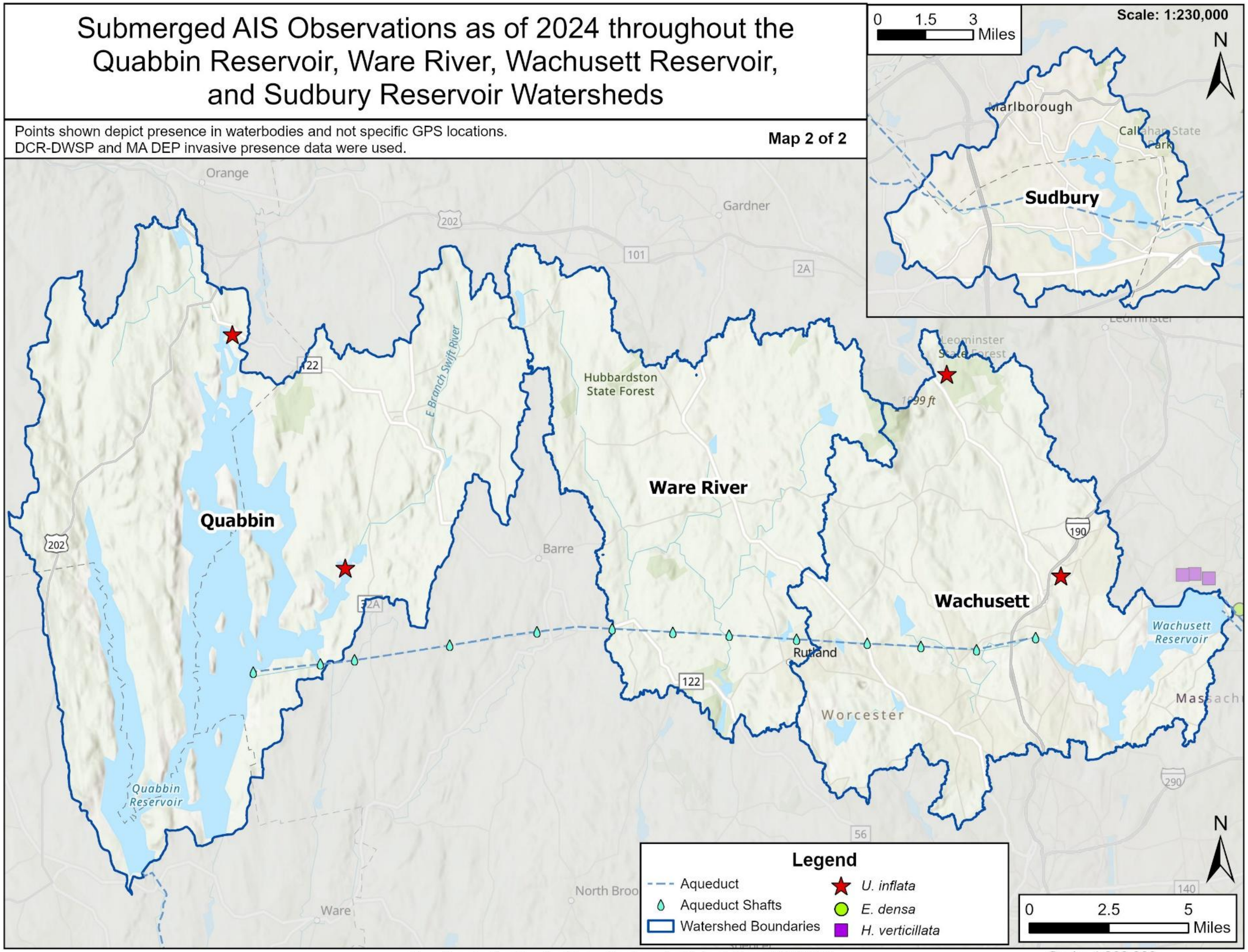


Map Created by Tayelor Gosselin, Aquatic Biologist I on 6/27/2025

Scale: 1:308,000

Appendix C – AIS Occurrences in DWSP Watersheds

Figure A1: Date of First Record for Invertebrate AIS in the Quabbin Watershed and Ware River Watershed

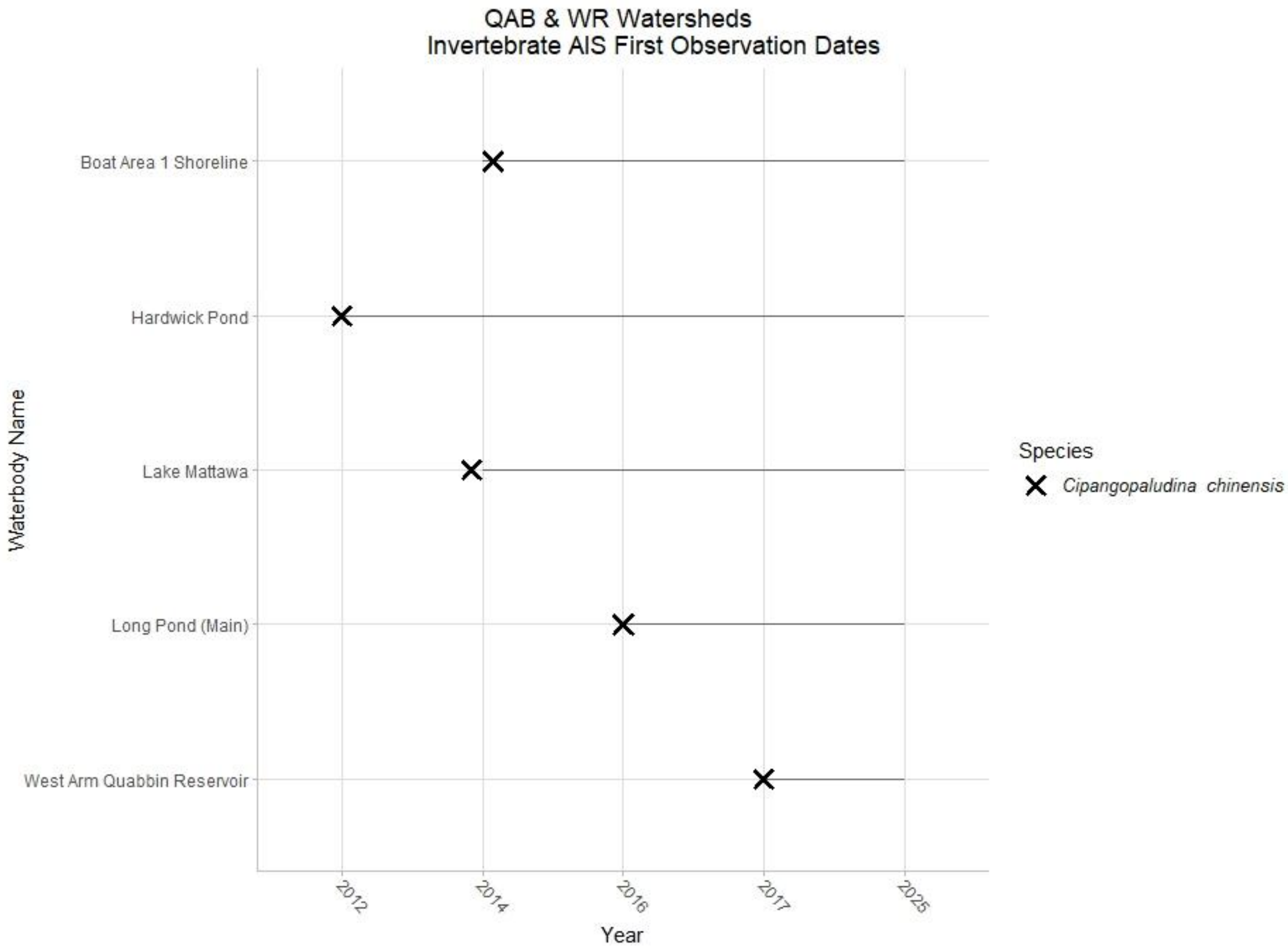


Figure A2: Date of First Record for Submerged & Floating AIS in the Quabbin Watershed and Ware River Watershed

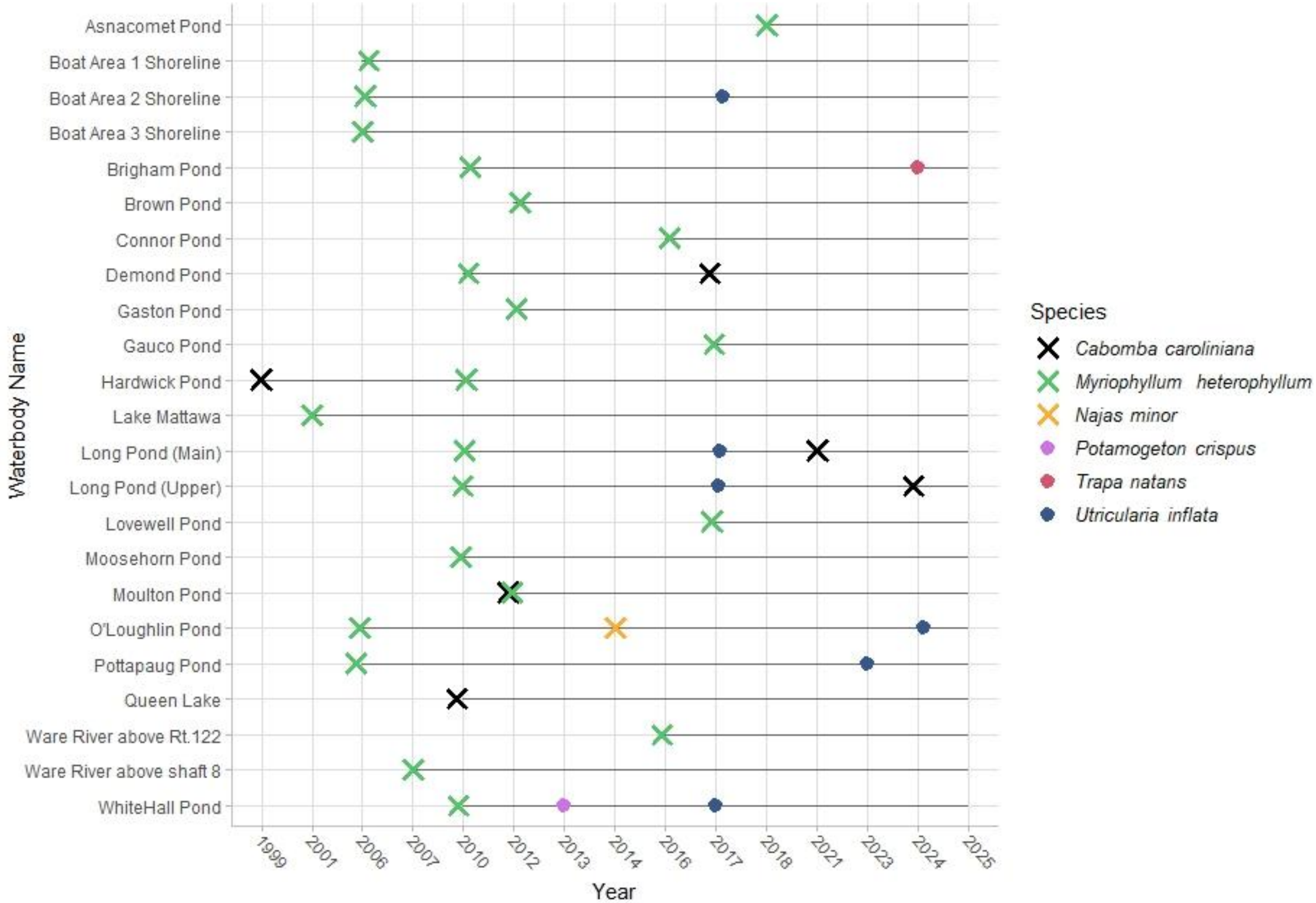


Figure A3: Date of First Record for Emergent AIS in the Quabbin Watershed and Ware River Watershed

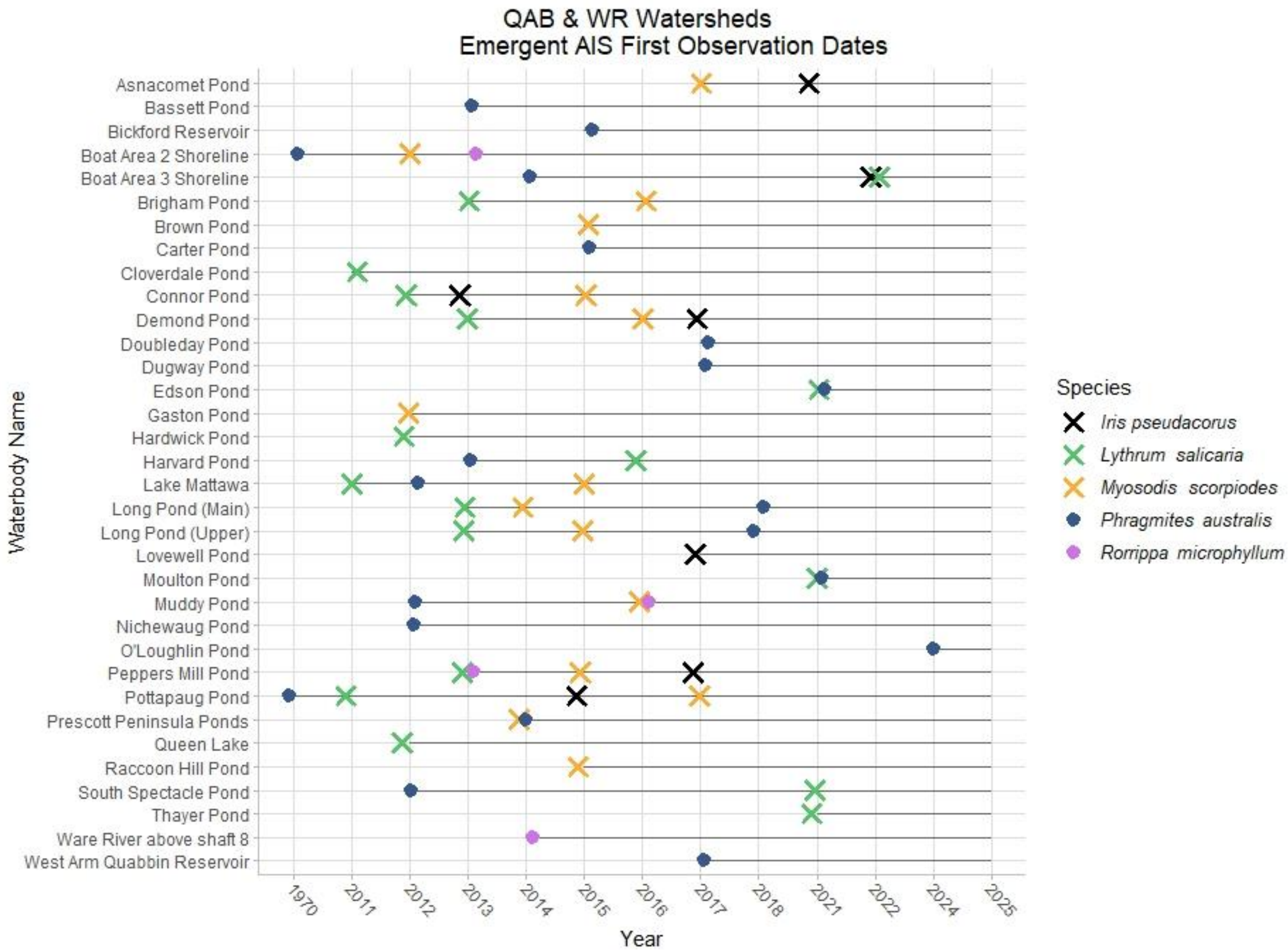


Figure A4: Date of First Record for Submerged AIS in the Wachusett Watershed

*** denotes water bodies that are off-watershed but near Wachusett Reservoir. * denotes sub-basins of Wachusett Reservoir.*

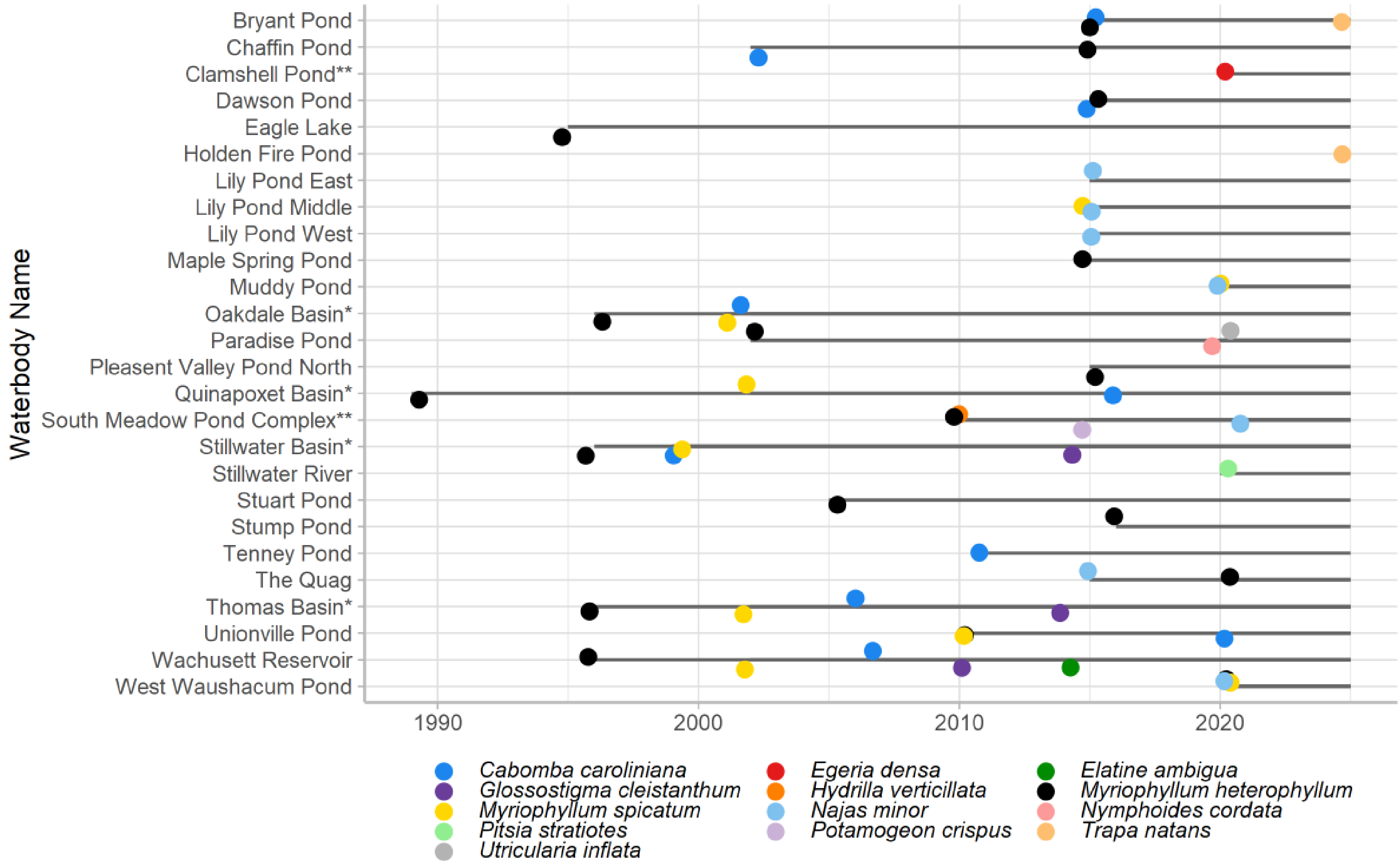
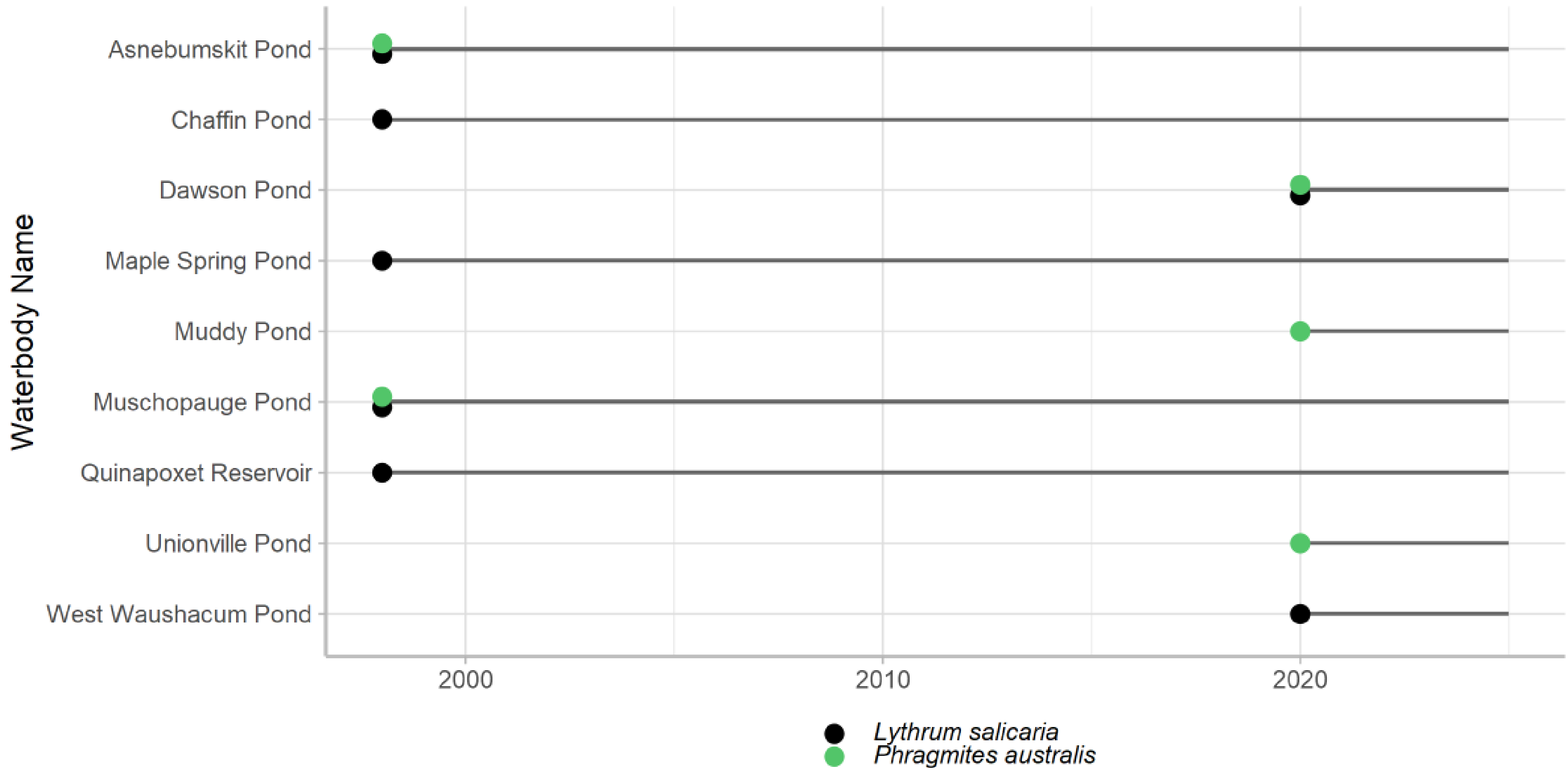


Figure A5: Date of First Record for Emergent AIS in the Wachusett Watershed



Appendix D – Guide for Response to AIS from Initial Detection to Management

This is an accessible version of the flowchart in Figure 3.

1) **Detection**
   Initial detections will likely take place during routine monitoring activities or as a result of reports from other DWSP employees or the public.

2) **Confirmation**
   If necessary, confirmation of the initial identification should be obtained by a second qualified individual either in person or via email, shipped sample, etc.

   a) **Notification**
      Once a positive identification has been confirmed, the appropriate individuals at DCR and MWRA shall be notified. This notice should typically be undertaken within one week of a new sighting and contain information on location and species discovered.

   b) **Delineation**
      DCR biologists will conduct surveys to quantify and define the infestation. Map(s) depicting density and distribution of the infestation will be produced for distribution to appropriate individuals at DCR and MWRA and used to assist with determining the management strategy. If necessary, plant fragments collected during the investigation will be removed from the water and disposed of away from shore.

   c) **Evaluation**
      Using the data gathered during the initial surveys and information compiled in this document, biologists will assess the available management tools and potential success and benefits to recommend the best management techniques(s). This information will then be reviewed by mangers who will make the final decision on how to proceed.

3) **Action**
   Once a management option has been selected, the following may be necessary: secure funds, obtain permits, solicit proposals and hire contractor, conduct management action.

4) **Ongoing Project Management**
   Regardless of the response action selected (including no management), ongoing assessment of the decision and management actions will be necessary.
   - Annual budgeting and contracts
   - Maintain permits
   - Annual surveys and data analysis
   - Assess results and consider changes as needed to meet goals

Appendix E – Management Strategies

The following is a brief overview of common management strategies which may be considered by DWSP for management of AIS. Each of these strategies requires careful planning and monitoring before, during and after implementation. Timing, strategy, active ingredient(s), spatial extent, and duration of the project will all depend on the ultimate goals of the program which in turn dictate permitting and budgeting requirements.

Management Type	Summary
Hand Harvesting	Hand harvesting involves removal of target vegetation by pulling individual plants from the substrate. This work is resource intensive but can be successfully employed, especially in early stages of infestation and on plants that have a substantial stalk. Smaller plants could be removed by hand with the assistance of a suction harvester (Diver Assisted Suction Harvesting).
Diver Assisted Suction Harvesting (DASH)	DASH is hand-harvesting with the addition of a suction hose. Divers remove plants, ideally including root masses, feed them up the suction hose to a barge where they are dewatered and deposited in buckets for subsequent composting on land. This method reduces fragmentation and allows divers to work continuously, especially through dense beds of plants.
Mechanical Harvesting or Hydro-raking	Mechanical harvesting cuts plants below the water surface or rakes them from the substrate. This method is non-selective and can cause sediment disturbance in shallow areas and unavoidably fragments plants. As mechanical harvesting disturbs sediments and releases plant fragments, use of this technique is not recommended for plants that spread via fragmentation or areas that would be sensitive to turbidity.
Fragment Barriers	Fragment barriers can reduce plant spread within or downstream of infested water bodies. Fragment barriers are often used to reduce spread of fragments during physical removal operations. Use of fragment barriers can also be beneficial with new plant introductions by isolating new plant beds within a water body.
Benthic Barriers	Plastic matting can be used to smother plants and is especially useful in areas with pioneer infestations (i.e., very small areas). These mats are typically placed by divers and require maintenance to vent accumulated gases from decaying plant matter, clear sediment, and ensure mats stay in place. Careful monitoring of regrowth following barrier removal is also necessary since bare sediments are more susceptible to colonization by AIS.

Management Type	Summary
Drawdown	Some plants are susceptible to water level drawdowns which allow their roots to freeze or dry out. Refilling water bodies when sediments are frozen disturbs root systems further impacting plants. Success of this method requires proper timing of drawdown for freezing before snow cover and timing to achieve refill for the spring. Drawdown is not an effective technique for annual plants due to the seed's ability to remain dormant out of water.
Herbicides and Algaecides	Specially formulated herbicides and algaecides are available for use in aquatic environments. All aquatic herbicides and algaecides used in Massachusetts must be approved by both EPA and the state and applied by licensed individuals. There are many products on the market, but most are formulated to inhibit plant growth or functions such as photosynthesis. The registration and approval process for herbicides and algaecides involves studies on environmental impacts as well as efficacy on target plants and results in a label that specifies application methods, concentrations, species that are successfully managed, and lists restrictions on water uses during or following application. There are two types of herbicides: contact and systemic. Contact herbicides only affect plants that are actively growing into the water column at the time of treatment while systemic herbicides remain in the water for a longer period, affecting plants as they germinate throughout the season. Impacts on target and non-target species can be adjusted with change in application rate (concentration) and treatment season. As with all management techniques, use of herbicides and algaecides requires careful planning, ongoing monitoring, and likely periodic adjustments to treatment plans to achieve desired results.
No Action	The decision to actively manage a particular AIS within a water body will depend on multiple factors with a focus on immediate and future risk to drinking water quality. If no action is taken, the AIS growth will likely continue to expand, presenting an increased risk of redistribution to the Reservoirs and other local water bodies. This may be an unsatisfactory alternative that would have negative impacts on water quality. Due to risk of transfer and negative impacts to other water bodies, additional survey effort will likely need to be expended in future years.

Appendix F – Decontamination Protocols

DECONTAMINATION CERTIFICATION

Aquatic Invasive Species Decontamination Protocol for MWRA/DCR Reservoirs

Please complete and submit this checklist before deploying a boat/equipment to MWRA/DCR reservoirs (For Quabbin Reservoir, including O'Loughlin Pond and Pottapaug Pond, please comply with the Quabbin Boat Seal Program requirements):

1. ☐ **CLEAN: Carefully inspect boat, trailer, and equipment** for any possible contamination (this includes all interior and exterior boat surfaces, engines, anchors, lines, downriggers, fishing gear, boots, clothing, wetsuits, dive gear, nets, buckets, tools, and any other items exposed to water). **Please note that carpet on any part of the vessel and trailer is not permitted as of 2024.**

   Remove all plant fragments (even those that are native), mud, and debris. Dispose of these materials in an upland area well away from open water and catch basins or watercourses that might discharge into a water body. If a boat or motor were used in a water body that contains zebra mussels, feel the surface for any rough spots. Any rough areas should be thoroughly cleaned until smooth to the touch (see below).

2. ☐ **DRAIN: Drain all water** from boat, bilge, engines, jet drives, live wells, and other equipment, and remove standing water from every nook and cranny that cannot be drained. Water should be released in an area that is "high and dry" just as with disposal of removed plant fragments, mud, and debris.

3. ☐ EACH piece of equipment to be utilized must be subjected to one of the following, depending on the equipment to be used and time available.

DRY *OR* **DECONTAMINATE**

DRY

If time permits, impose downtime for boat, trailer, and all equipment so that they are FULLY DRY for the time periods listed below:

Time of Year	Duration
July and August	1 week
June and September	2 weeks
Before and after these dates	4 weeks
Winter Exposure to freezing temperatures over the winter is considered to be sufficient for decontamination*	

DECONTAMINATE

If drying downtime is not practicable and a visit to another water body is planned, use one, or a combination of the following methods:

Disinfectant	Concentration	Contact Time
Steam/scalding hot water*	>140°F	10 seconds
Chlorine/Bleach Solution	1 oz. per gallon water	10 minutes
Lysol	1% solution	10 minutes
Vinegar	As sold – 100%	20 minutes
Freezing	<32°F	24 hours

* preferred method

4. ☐ Please fill out and submit following checklist for each set of equipment to be utilized for the duration of the project.

Last updated: 1/24/2024 1

DECONTAMINATION CERTIFICATION

Last water body visited: ______________________________
name, town, state

The following pieces of equipment that will be utilized in/on ______________________________
have been decontaminated as follows: *name of MWRA/DCR reservoir*

Please check each decontamination method used. Note 'n/a' if listed equipment will not be used.		Dry __/__/__ to __/__/__	Frozen __/__/__ to __/__/__	Steam/scalding water >140°F*	Chlorine/Bleach Solution	Lysol	Vinegar
Boat	Hull / engine housing						
	Deck						
	Bilge and live well						
	Transom well						
	Rope, anchors						
	Engine cooling system						
	Plant collection equipment						
Trailer	Frame						
	Wheels						
	Bunks/rollers (no carpet)						
Survey Equipment	Throw rake including rope						
	Secchi disk including rope						
	Boots						
	Nets						
	Water samplers						
Dive Gear	Wetsuit						
	Weights						
	BCD						
	Mask, fins, snorkel						
	Air hoses and tanks						
	Plant collection bags/tools						
Other	Please list:						

* preferred method

I hereby certify that the water craft and all other equipment to be utilized on this MWRA/DCR reservoir have been decontaminated as listed above.

______________________ ______________________ ______________________
Print name *Company/Position* *Signature*

5. ☐ MWRA/DCR Personnel

Project/Contract: ______________________________

Inspection: ☐ Pass ☐ Fail Reason:

Staff Name/Signature: ______________________ Date: __________

Last updated: 1/24/2024 2

Appendix G – Species Profiles

The following pages are a quick reference for DWSP staff reacting to potential new AIS occurrences within and around the watersheds. Identification strategies for each species as well as potential impacts to drinking water quality are included along with pictures and links to additional resources. These species profiles may be updated and species added in the future as the region experiences new threats of AIS.

Index of Species Profiled in this Document

Utricularia inflata

Information Category	***Details***
Common Name	Swollen Bladderwort
Similar Species	*U. vulgaris*, *U. pupurea*, *U. radiata*, *U. intermedia*
Native Range	Southern United States, from southern New Jersy to Florida and westward to eastern Texas and southern Oklahoma.
Expansion Pathways	Reproduces by both fragmentation and seeds, can attach to boats, trailers, and fishing gear.
Water Quality Impacts	Carnivorous plant that consumes small prey, such as zooplankton or small insects. Can cause low oxygen conditions when dense mats of swollen bladderwort decay, which can lead to fish kills as well as other aquatic organisms.
Other Impacts	Can result in decreased water quality, displace native species, reduce biodiversity, restrict recreational uses, and diminish aesthetic values.
Control Methods	Herbicides, drawdowns, and mechanical removal.
Present In	O'Loughlin Pond (Q), Pottapaug Pond (Q), Paradise Pond (W), Bryant Pond (W)
Identifying Features	In early spring will produce 3-15 yellow snap-dragon shaped flowers on the emerging stalks. Is a floating plant that is supported by a floating pontoon that contains 4-10 leaves arranged like the spokes of a wheel. There are several species of bladderwort native to Massachusetts. *U. radiata* also produces yellow flowers but has a smaller pontoon and is less bushy. *U. purpurea* does not have a pontoon and has purple flowers. *U. vulgaris* also lacks a floating pontoon and is large and bushy.
References	Utricularia inflata fact sheet from MA DCR

Representative images of Utricularia inflata

U. inflata in bloom.

(Photo credit: Robby Deans [CC BY-NC 4.0](CC BY-NC 4.0))

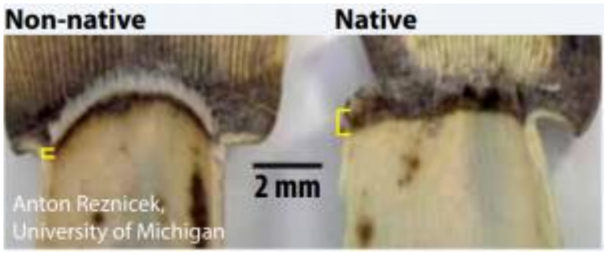
U. inflata flowers.

(Photo credit: Sam Kieschnick [CC BY-NC 4.0](CC BY-NC 4.0))

Phragmites australis

Information Category	***Details***
Common Name	Common Reed
Similar Species	*Phragmites australis* subsp. *Americanus, Calamagrostis canadensis*
Native Range	Europe
Expansion Pathways	Primarily reproduces vegetatively through a system of rhizomes. New plants can generate up to 43 feet away from parent plant. *P. australis* can also spreads through seeds that are dispersed by wind and water. Individual plants can produce hundreds to thousands of seeds each year (germination rates are low in most cases).
Water Quality Impacts	*P. australis* stands can slow the water movement in wetlands and shorelines, lower the oxygen levels in the water, as well as alter the nutrient cycle, which can result in eutrophication.
Other Impacts	Creates dense patches that push out native plants, alters wetland hydrology, increases the potential for fire, can degrade wetland wildlife habitat, and it is allelopathic, meaning it produces a toxic chemical that deter other species from growing/developing in the area.
Control Methods	One effective way to control the spread of *P. australis* is prevention, which can be achieved by planting native species that can compete with *P. australis.* Other ways to remove *P. australis* include controlled burns, chemical treatments, and adjusting the water level around *P. australis.* The best way to eradicate this species is to cut it down before the end of July to maximize the stress on the plant while it is at its weakest point. It is important to remove all fragments, as the fragments can start new plants.
Present In	All watersheds and stands present around Quabbin and Wachusett Reservoir
Identifying Features	In the invasive *P. australis,* leaves are blue green and are darker compared to the native species. The leaf sheaths adhere tightly to the culm as long as it remains standing. In the native *Phragmites*, the leaf sheaths fall off the culm easily once the leaf dies, particularly at the lower nodes. The culms of *P. australis* can reach 15 feet, and golden or purple bushy panicles occur in August and September.
References	Phragmites field guide: distinguishing native and exotic forms of common reed (*Phragmites australis*) in the United States Invasive Plant Factsheet: Common Reed (*Phragmites australis*)

Representative images of Phragmites



Ligule width is much narrower in invasive than in native *Phragmites*.

(Photo credit: Anton Reznicek, University of Michigan)

Stand of *P. australis* at Wachusett Reservoir.

Trapa natans

Information Category	**Details**
Common Name	Water chestnut
Similar Species	*Trapa bispinosa*
Native Range	Europe, Asia, and Africa
Expansion Pathways	*T. natans* primarily spreads through the production of nuts. Each nut can produce 10 to 15 plants, with each plant producing up to 20 seeds. These nuts sink into the sediment, where they can float to other water bodies or be transported by birds or animals. The plant releases the nut in the fall, and the nut can remain viable for up to 12 years.
Water Quality Impacts	*T. natans* can deplete the available oxygen in the water, resulting in low oxygen conditions that can lead to harm of organic organisms.
Other Impacts	Forms large, dense mats at the surface which intercepts the available light for native species, negatively impacts recreational activities such as swimming, boating and fishing, and the sharp barbs can penetrate shoes and feet which pose a risk to swimmers/beach visitors.
Control Methods	Hand pulling water chestnut before the nutlets are released in the fall, drawdowns can be used if it is of adequate depth and time, and herbicides.
Present In	Brigham Pond (WR), Bryant Pond (W), Clamshell Pond (W)
Identifying Features	Green, triangular leaves, with an upper side that is shiny and waxy, and the underside is coated with fine hairs. The submerged leaves are whorled and feathered around the stem and plants have small white flowers with four petals from July to the first frost.
References	MA DCR Water Chestnut Fact Sheet

Representative images of Trapa natans

T. natans rosette floating at the surface

Illustration of *T. natans* (Photo credit: [US Fish & Wildlife Service]())

Underside of the *T. natans* rosette

Bythotrephes longimanus

Information Category	Details
Common Name	Spiny waterflea
Similar Species	*Cercopagis pengoi, Leptodora kindti, Chaoborus punctipennis*
Native Range	Europe and Aisa
Expansion Pathways	Produce tough eggs that are resistant to drying and freezing in the fall. These eggs can attach to boats or equipment and be transported to other waterbodies.
Water Quality Impacts	Harmful algal bloom shifts are potential in waterbodies containing *B. longimanus*, as the species primarily consume native zooplankton, which results in less algae being consumed.
Other Impacts	Alters the food web as *B. longimanus* consume algae and microscopic animals, fouling of fishing gear to anglers, and can result in physical injury of fish as consuming *B. longimanus* can injure the gut track from the spines.
Control Methods	There are currently no control methods for *B. longimanus*. Prevent the spread of *B. longimanus* by cleaning the watercraft and equipment, drain all water from the watercraft, dispose of unwanted bait in the trash, and dry all equipment for at least 5 days.
Present In	Not yet detected in Massachusetts. Closest known occurrence is Lake Winnipesaukee.
Identifying Features	Zooplankton that live in open water. Have a single long tail that contains one to four spines, and have one large, black eyespot. It is commonly seen on fishing line and appears as a gelatinous blob that has a texture of wet cotton.
References	NH DES Spiny Water Flea Fact Sheet MN DNR Fact Sheet: Spiny waterflea (Bythotrephes longimanus)

Representative images of Bythotrephes longimanus

B. longimanus under a microscope (Photo credit: Minnesota Department of Natural Resources)

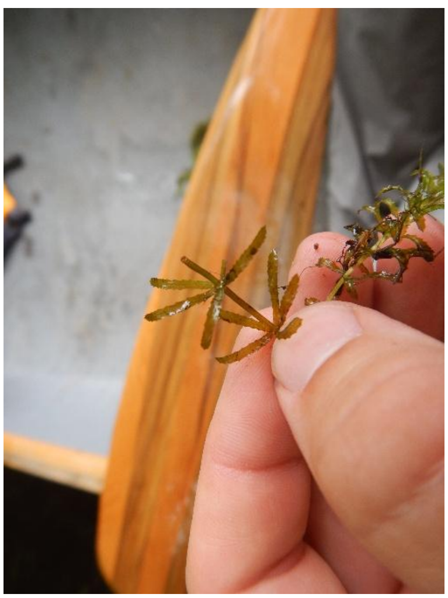
Accumulation of *B. longimanus* on fishing line (Photo credit: Minnesota Sea Grant)

Hydrilla verticillata

Information Category	Details
Common Name	Hydrilla
Similar Species	*Elodea, Egeria densa*
Native Range	Asia
Expansion Pathways	*H. verticillata* has overwintering buds, turions and tubers, that grow at the end of the root. New populations of hydrilla can be created from these turions and tubers, as well as plant fragments. Either of these sections can attach to boats or equipment and be carried to another water body. Can grown an inch per day.
Water Quality Impacts	As the mats of *H. verticillata* decompose, the decomposing process requires a large amount of oxygen from the water, which can lead to reduced oxygen levels in the water.
Other Impacts	*H. verticillata* can create large, dense mats, which result in the displacement of native species, interfere with waterfowl feeding areas and fish spawning sites, slows the water flow of the body of water, and negatively impacts recreational users such as boaters, swimmers, and fisherman.
Control Methods	Mechanical removal, drawdowns, herbicides and the use of biological controls.
Present In	South Meadow Pond complex (W), Clinton (W)
Identifying Features	Leaves are strap shaped, have pointed tips, arranged in whorls of 4-8, and the leaf margins have distinct saw-toothed edges and are rough to the touch. While flowering, the female flowers are single, white, have 6 petals, and float on the surface. The male flowers are greenish and develop close to the leaf axis.
References	MA DCR Fact Sheet on Hydrilla NY DEC Hydrilla Fact Sheet

Representative images of Hydrilla

Dense bed of *H. verticillata* located in South Meadow Pond



Individual plant of *H. verticillata* showing leave whorls of 4 or more, saw-toothed edges, and pointed tip.

Myriophyllum aquaticum

Information Category	**Details**
Common Name	Parrotfeather
Similar Species	*Myriophyllum brasiliense, Myriophyllum proserpinacoides*
Native Range	South America
Expansion Pathways	Reproduces by the fragmentation of either the submerged or emerging plant fragments.
Water Quality Impacts	*M. aquaticum* reduces the dissolved oxygen in the water, which can harm native plants and aquatic life.
Other Impacts	*M. aquaticum* can grow rapidly and overtake parts or the entirety of the waterbody, can impede waterflow which can increase flooding intensity and duration, and push out native aquatic species. There also is a strong correlation between the density of parrotfeather growth and the occurrence of mosquito eggs and larvae.
Control Methods	Chemical and mechanical methods can result in short to medium results.
Present In	Not known from DWSP water bodies
Identifying Features	A heterophyllous plant due to it having both an emergent and submerged leaf form. Emergent leaves are whorled, stiff, appear feather-like, and extend up to 30 cm above the water. The submerged leaves are reddish orange, have whorls of four to six, and are like Eurasian milfoil. White flowers appear on the emerging leaves, being approximately 1/16 inch long.
References	USGS Species profile: Parrot Feather (*Myriophyllum aquaticum*)

Representative images of Myriophyllum aquaticum

M. aquaticum emerging out of the water column (Photo credit: Maurice (epitree/iNaturalist)

M. aquaticum visual up close (Photo credit: André Karwath)

Najas minor

Information Category	Details
Common Name	Brittle Naiad
Similar Species	*Najas flexilis*
Native Range	Europe, western Asia, and northern Africa
Expansion Pathways	Reproduces primarily by seeds but can also reproduce by plant fragmentation.
Water Quality Impacts	*N. minor* reduces the dissolved oxygen in the water, which can harm native plants and aquatic life.
Other Impacts	*N. minor* can form dense mats in the water column. This results in pushing out native aquatic plant species, negatively impacting recreational activities such as boating, fishing, and swimming, and it takes away shelter, food, and nesting habitats for native aquatic organisms.
Control Methods	Herbicide or mechanical controls.
Present In	Lily Ponds (W), Muddy Pond (W), Quag (W), West Washacum (W)
Identifying Features	Has a bushy appearance, leaves are thin and stiff with pointed tips, and the stem color vary from light to dark brown. The leaves are opposite one another but can also appear in whorls.
References	Minnesota DNR: Brittle Naiad (*Najas minor*) See page 102 of the Maine Field Guide to Invasive Aquatic Plants for a Naiad Species Comparisons Chart

Representative images of Najas minor

Dense cluster of *N. minor* located in West Washacum Pond

N. minor visual close up

Myriophyllum spicatum

Information Category	**Details**
Common Name	Eurasian Watermilfoil
Similar Species	*Myriophyllum sibiricum, Ceratophyllum demersum*
Native Range	Europe and Asia
Expansion Pathways	It is most successful at reproducing via fragmentation but can also produce approximately 100 seeds per season.
Water Quality Impacts	*M. spicatum* reduces the dissolved oxygen in the water, which can harm native plants and aquatic life.
Other Impacts	*M. spicatum* can form dense mats in the water column. This results in pushing out native aquatic plant species, negatively impacting recreational activities such as boating, fishing, and swimming, and it takes away shelter, food, and nesting habitats for native animals.
Control Methods	Control methods include mechanical harvesting and herbicide treatment.
Present In	Wachusett Reservoir
Identifying Features	Leaves are feather-like and have four leaves in a whorl. There is a space between each leave of ½ "or greater. The color varies, but the stem is typically light brown, and the tips are red or pink. The leaflets are limp once they are removed from the water. Produces a small pink flower, as well as tiny yellow.
References	Minnesota DNR: Eurasian watermilfoil (*Myriophyllum spicatum*)

Representative images of Myriophyllum spicatum

M. spicatum visual close up, highlighting the space between each feather-like leaf

(Photo credit: Ian Pfingsten/U.S. Geological Survey)

Photo showing the different visual appearances and color on the stem and leaves of *M. spicatum*

(Photo credit: John Hilty)

Nitellopsis obtusa

Information Category	Details
Common Name	Starry Stonewort
Similar Species	Muskgrasses, stoneworts, Narrow-leaf Pondweeds, Stuckenia pectinata
Native Range	Eurasia, from the west coast of Europe to Japan.
Expansion Pathways	Primarily spreads through the movement of water-related equipment. Plant fragments/seeds attach to trailers, watercrafts, scuba gear, and fishing gear and can establish in other water bodies.
Water Quality Impacts	*N. obtusa* reduces the dissolved oxygen in the water, which can harm native plants and aquatic life.
Other Impacts	*N. obtusa* can form dense mats in the water column. This results in pushing out native aquatic plant species, negatively impacting recreational activities such as boating, fishing, and swimming, and it takes away shelter, food, and nesting habitats for native animals.
Control Methods	Mechanical methods such as hand-pulling, diver assisted suction harvesting (DASH), and suction dredging can be used. Herbicide control can also be used.
Present In	Not known from DWSP water bodies
Identifying Features	Bushy, bright green macro-algae. The branchlets are thin, have a branch-like structure, extend in acute angles away from the stem nodes, and the tips may have irregular forks or divisions. White, star shaped bulbils are located on the starry stonewort just below the surface and are the size of a grain of rice.
References	Minnesota DNR: Starry Stonewort (Nitellopsis obtusa)

Representative images of Nitellopsis obtusa

Visual of *N. obtusa* bulbil, which is the size of a grain of rice

(Photo credit: [Paul Skawinski])

Image highlighting the thin branch-like structure of *N. obtusa*

(Photo credit: [Paul Skawinski])

Pistia stratiotes

Information Category	**Details**
Common Name	Water Lettuce
Similar Species	*Eichhornia crassipes*
Native Range	Asia, Africa, and South America
Expansion Pathways	Can reproduce by fragmentation and seeds. Plant fragments/seeds attach to trailers, watercrafts, scuba gear, and fishing gear and can establish in other water bodies.
Water Quality Impacts	*P. stratiotes* reduce the dissolved oxygen in the water, which can harm native plants and aquatic life.
Other Impacts	*P. stratiotes* can create large, floating dense mats that can negatively impact recreational activities like boating, swimming, and fishing. It can impact flood control efforts, as well as clog hydroelectric turbines. It also pushes out native species, which decreases the biodiversity in the water body.
Control Methods	Mechanical, chemical, and biological.
Present In	Introduced in Stillwater River 2020 – physically removed and not observed since 2020
Identifying Features	Floating perennial plant that closely resembles an open head of lettuce. The leaves are thick, soft, green, and covered in short hairs. The roots are feathery and light colored and are submerged in the water.
References	Water Lettuce - Pennsylvania Sea Grant

Representative images of Pistia stratiotes

Multiple *P. stratiotes* floating at the surface of the water.

(Photo credit: [Troy Evans; Great Smoky Mountains National Park])

Image showing the root structure on an individual *P. stratiotes.*

(Photo credit: [Forest and Kim Starr])

Cercopagis pengoi

Information Category	Details
Common Name	Fishhook Waterflea
Similar Species	*Bythotrephes cederstroemii*
Native Range	Black, Caspian, Azov, and Aral seas of Europe and Asia
Expansion Pathways	*C. pengoi* reproduce both sexually and asexually. Reproducing asexually allows the species to quickly establish new populations with limited seed populations. *C. pengoi* start the season by reproducing asexually, where the eggs are delicate. Later in the season they switch to sexual reproduction, where the eggs produced are over-wintering or resting eggs. These eggs are resistant to desiccation, freeze drying, and ingestion by predators. Transferred to other waterbodies primarily by ballast water and boating.
Water Quality Impacts	Harmful algal blooms shifts are potential in waterbodies containing *C. pengoi*, as the species consumes native zooplankton, which results in less algae being consumed.
Other Impacts	The *C. pengoi* consumes other zooplankton, and it competes with other planktivores. The long spine makes the species less palatable to predators, which causes major impact to the food web.
Control Methods	Once in a waterbody, it is almost impossible to eliminate.
Present In	Not known from DWSP water bodies
Identifying Features	The *C. pengoi* ranges from 1 to 3 mm in length without a tail, to 6 to 13 mm with a tail. The tail contains 3 pairs of barbs and a loop at the end.
References	[USGS Fishhook Waterflea Species Profile]

Representative images of Cercopagis pengoi

Individual *C. pengoi* under a microscope, highlighting its long tail which can be up to 13 mm

(Photo credit: [Wisconsin DNR])

Image of a *C. pengoi* under a microscope with a black background, defining the features of the species

(Photo credit: [Igor Grigorovich, University of Windsor])

Cyperinus carpio

Information Category	**Details**
Common Name	Common Carp
Similar Species	*Ictiobus cyprinellus*
Native Range	Europe and Asia
Expansion Pathways	*C. carpio* spawn in spring, but in temperate regions can spawn year-round. Females reach sexual maturity at 3 to 5 years old, and the fecundity (number of offspring produced over the carp's lifetime) can range from 37,490 to 163,000 eggs/kg.
Water Quality Impacts	Increases the turbidity of the water, as well as releases phosphorus which results in an increase in algae.
Other Impacts	*C. carpio* primarily consumes vegetation, and when they eat plants, they become dislodged from the sediment. This results in increased water turbidity, as well deteriorates the environment for native species. The increase in turbidity also reduces the amount of light that penetrates through the water column, reducing the light for photosynthesis. The feeding of *C. carpio* can also disturb spawning and nursery areas of native fish, as well as impact the feeding of sight-oriented species.
Control Methods	Control methods include fish poisons, physical barriers, physical removal, habitat alteration, or the addition of predators, parasites, and pathogens.
Present In	Not known from DWSP water bodies
Identifying Features	A large omnivorous fish that has large scales, a long dorsal fin base, and two long whiskers in its upper jaw. Adults range from light gold to dark brown and have reddish fins. The head is triangular and has a blunt snout.
References	Minnesota DNR fact sheet on Common German and European Carp USGS Common Carp Species Profile USGS: Is it possible to eradicate Invasive carp once they are in an area?

Representative images of Cyperinus carpio

C. carpio on a measuring board

(Photo credit: [M. Rosten/USFWS])

Face of a *C. carpio* showing the whisker along its jaw

(Photo credit: [Kaitlin Kovacs, U.S. Geological Survey])

Nymphoides peltata

Information Category	**Details**
Common Name	Yellow Floating Heart
Similar species	*Nymphoides cordata, Nuphar variegata*
Native Range	Asia
Expansion Pathways	Reproduces primarily by vegetative methods but also can also reproduce sexually. Fragments of the plant that contain leaves and a portion of the stem can develop a new plant. *N. peltata* produces a 2.5 cm long fruit that disperses a range from a few to many seeds.
Water Quality Impacts	*N. peltata* reduces the dissolved oxygen in the water, which can harm native plants and aquatic life. Additionally, *N. peltata* reduces the flow of the waterbody, increasing the chance for algal blooms.
Other Impacts	*N. peltata* can form dense mats at the surface of the water, resulting in the displacement of native species throughout the water column, negatively impact light penetration to algae (can harm the food web of the waterbody), prevent recreational uses such as fishing, swimming, and boating, as well as increase sediment levels.
Control Methods	Mechanical removal and herbicides.
Present In	South Meadow Pond (near Wachusett but off-watershed)
Identifying Features	Shiny green to yellow-green leaves the size of a silver dollar. The leaves are heart-shaped and have slightly wavy margins. The leaves alternate along the stem; on the flower stalks they are opposite. Contain 2 to 5 yellow flowers reaching several inches above the surface of the water. The flowers contain 5 petals, and flower between May and October.
References	MA DCR Fact Sheet on Yellow Floating Heart USGS Yellow Floating-Heart Species Profile

Representative images of Nymphoides peltata

Flowering *N. peltate.*

(Photo credit: Lyn Gettys, [Center for Aquatic and Invasive Plants, University of Florida, IFAS])

The flower, root structure, and the heart-like leaves of *N. peltate.*

(Photo credit: Kareji, [Center for Aquatic and Invasive Plants, University of Florida, IFAS])