Lake Maspenock Aquatic Vegetation Control and Management Plan

Final Report

June 2021

Prepared for:

Town of Hopkinton Board of Selectmen

Prepared by:

Lake Maspenock Citizen Input Group and
Hopkinton Department of Public Works

EXECUTIVE SUMMARY

This document contains the revised Lake Maspenock Aquatic Vegetation Control and Watershed Management Plan (the "Plan") prepared for the Hopkinton Board of Selectmen (BOS). The Plan provides an updated, comprehensive long-term vegetation control management approach for Lake Maspenock (the "Lake"). The Plan summarizes previous diagnostic reports, currently available water quality data and aquatic vegetation maps, watershed evaluation and analysis, and reviews available aquatic vegetation and lake management options. Finally, it recommends options and actions for protecting and enhancing the recreational, ecological, and aesthetic features of the Lake. This document updates and replaces the prior Plan completed in November 2016.

The initial 2016 Plan was developed through the efforts of the volunteer Lake Maspenock Aquatic Vegetation Control Management Advisory Group ("Advisory Group"), the Director of the Hopkinton Department of Public Works (DPW), with technical assistance by Dr. David Mitchell, Certified Lake Manager (CLM). The Plan emerged through the course of approximately 15 meetings, extensive research into and screening of available vegetation control options, research with other lake associations regarding their vegetation control experiences, and field monitoring of vegetation status on the Lake. The revised Plan provides updated water quality data, integrates the results of five years of aquatic vegetation surveys (2016-2020), considers new management options, and presents revised management policies.

Advisory Group

The Advisory Group was created and charged by the Hopkinton BOS in May 2015 to develop a long-term plan to control and manage the aquatic weeds in the Lake and otherwise protect the valued attributes of the Lake. The Advisory Group is composed of five residents of Hopkinton appointed by the BOS and represents the following interests:

- One resident of the area in the vicinity of Lake Maspenock who has a background in weed management and control;
- One designee from the Conservation Commission;
- One designee from the Parks & Recreation Department; and
- Two at-large members.

Starting in October 2015, the Advisory Group met regularly in public meetings to investigate potential aquatic vegetation control options and to develop a comprehensive, long-term plan to preserve and protect the beneficial uses of the Lake. The initial Advisory Group has evolved into a standing committee and continues to meet regularly and provide direction and staffing for aquatic vegetation surveys.

Public Education and Involvement

As per the BOS's charge, public input and comment were invited at every stage during the public meetings. Minutes of the meetings were scrupulously kept and regularly posted on the Town website. In addition, the Group actively sought out stakeholder interests and concerns through a Resident Survey.

The Hopkinton Resident Survey (the "Survey") was conducted in winter 2016. The survey was conducted by both electronic (Kwik Survey) and traditional (paper) methods. The purpose of this survey was to collect information regarding resident attitudes towards the Lake, their uses and preferences for recreation, and their

thoughts regarding its present condition. At the same time, the Survey provided an opportunity to educate Town residents not familiar with the Lake and its available recreational uses as well as to promote public awareness of the work of the Advisory Group in development of the Plan.

To further involve the Town residents, two public forums were conducted by the Advisory Group in February 2016 to inform Lake stakeholders and describe progress to date. Preliminary results of the Resident Survey were presented at these meetings. A third public form was conducted in October 2016 to describe the draft final plan and to inform the public of the benefits, costs, and challenges of various vegetation control options. The revised Plan is likewise intended to be communicated to the Hopkinton BOS and the public.

Natural and Recreational Features of Lake Maspenock

The Plan describes historical and current sources of information, lake basin natural characteristics, watershed features including land use, review of current water quality data and aquatic vegetation reports, and designates priority areas and protected uses.

Lake Maspenock is a central and extremely important recreational resource for the Town and its residents. The Lake provides a large spectrum of active and passive recreational pursuits and is accessible to residents all year-round. Some of the more important recreational features and uses of the Lake include:

- Sandy Beach, a public beach, operated by the Hopkinton Parks and Recreation Department (P&RD), which also provides lifeguards, swimming lessons and other activities along with adjacent playground facilities;
- Resident Boat Ramp, a developed boat launch facility with trailer parking (residents apply for boat launch permits);
- Undeveloped public access, consisting of a public easement off West Main Street allowing non-motorized boats access to the Lake for canoeing, kayaking, bird watching, and passive enjoyment;
- Public events, such as the Long-Distance Lake Swim, fishing tournaments, ice fishing derbies, the Fourth of July Boat Parade, the Lake Clean Up, and other events; and
- Scenic views from the abutting Peppercorn Hill and Hopkinton Area Land Trust hiking trails.

At the same time, the Lake is an important ecological resource, containing protected wetland areas and ecological habitat to abundant and diverse fish and aquatic wildlife (amphibians, and reptiles). In addition, it provides avian habitats for waterfowl and fishing grounds for bald eagles and osprey, as well as other animal species.

The surface area of the Lake is estimated at 234 acres with shoreline in Hopkinton, Milford and Upton. It is the source of the downstream Mill River. The maximum depth is reported at slightly over 20 ft. with an average depth of about 8 ft. The depth contours clearly indicate the outline of the original natural pond. The northern basin (“North Basin”) is comparatively shallow averaging about 5-6 ft. in water depth.

The Lake has no large named tributaries but receives flow through a conduit from an approximate 15-acre wetland situated above West Main Street at the northern end. Other sources of water include precipitation, flow from several unnamed small streams, groundwater inputs, as well as storm water and overland flow from the eastern and western shorelines. Water losses from the Lake include evaporation and outflow exiting via the dam surface spillway or through the lower drainage ports during drawdown. A prior diagnostic study (M&E 1987) measured an average outflow of approximately 3.7 cubic feet per second (cfs). This corresponds to an average flushing rate in the Lake on the order of 1.4 times per year, which corresponds to a residence time of approximately 260 days. The flushing rate varies throughout the year, being slower in summer and early fall during low flow periods and more rapidly during winter and spring.

The Lake Maspenock Dam, constructed in 1901, is an 800 ft. long stone masonry and earthen embankment dam with a hydraulic height of approximately 16 ft. and a maximum structural height of approximately 18 ft. The dam has a lower level discharge gate (port), consisting of a 3 ft. square stone masonry culvert, which is located at elevation 331.7 feet and controlled by machinery located at the top of the dam. This lower outlet allows the Town to conduct controlled water level drawdowns to a maximum of approximately 8 feet below crest elevation (PARE 2013).

The watershed drainage area for the Lake is estimated at approximately 1,813 acres (2.83 sq. mi) and is contained within the larger Blackstone River watershed. The watershed extends approximately three miles north of the dam to near an interchange for Interstate 495. Watershed land use is varied and includes forested, residential, commercial and industrial uses; mineral extraction (sand and gravel), and wetlands. A portion of the western watershed is undeveloped and protected as part of the Peppercorn Hill Conservation Area in Upton. There is also a large undeveloped section on the eastern side of the watershed that is owned by the Dell Corporation (formerly EMC).

Recent water quality data reported (2011-2020) shows low levels of phosphorus, often near or below detection values (10 ppb). Comparison of these levels with historic values from the 1970s and 1980s indicate improved water quality. Current nitrogen levels are not available but would also be expected to have been reduced due to the elimination of septic tank contributions by sewering of shoreline residences and better storm water treatment. Low-to-moderate nutrient levels are consistent with observations of good water clarity (as measured by a Secchi disk), detection of adequate dissolved oxygen throughout the water column, and relatively rare reports of major algal blooms or bacterial contamination.

Aquatic vegetation surveys have been conducted in the Lake over the last 40 years. Two non-indigenous invasive species, fanwort and variable milfoil, have been present in the Lake since the 1970s and were consistently co-dominants in all surveys prior to 2015. Following drawdowns in 2010-2013, there was a marked reduction of fanwort and milfoil but native largeleaf pondweed expanded its range and density to dominate the plant community. Since 2016, vegetation growth trends have been variable (see below).

Current Water Quality and Aquatic Vegetation Conditions in the Lake

The current status of Lake Maspenock is a low to moderately-fertile lake which supports all of its designated water uses, both recreational and ecological. The water quality is very good considering the level of development in the watershed, with a high number of shoreline residential units and the considerable impervious surface on sloping areas. Evidence of good water quality includes low total phosphorus, availability of dissolved oxygen sufficient for a healthy fish community, and good water clarity (often 8-12 ft.) during much of the year.

The Lake's shallow depth and rich sediments naturally sponsors plant growth in the North Basin, in coves and along shorelines. The aquatic plant community had been dominated by fanwort and variable milfoil for many years, but both have decreased since 2012 due to winter drawdowns. The decline of these invasive species has released native, seed-bearing plants such as largeleaf pondweed, naiad, and tape grass to spread to newly-opened bottom areas.

Identification and Screening of Vegetation Control Methods.

The Advisory Group was tasked with finding a workable, long-term solution for treatment of the Lake's nuisance weeds and protection of lake qualtiy. The Group conducted this search with an open-minded approach and considered many potential physical, chemical, and biological options. This approach also included keeping the public well-informed by transparent decision-making, educational public meetings, and soliciting resident feedback.

Information regarding potential aquatic vegetation control and management is widely available and easily accessed. The Advisory Group researched a wide spectrum of vegetation control options, drawing upon information and guidelines developed by the Massachusetts Department of Environmental Protection (MA DEP) as well as those available from a rich literature of scientific articles, lake studies, and regulatory guidance from regulators and extension agencies from other states. Based on this information, a preliminary screening was conducted to weed out and eliminate those options that were clearly not feasible, not effective, or too costly for use on the Lake. The results of the initial screening process were presented to Town residents in two public forums conducted in February 2016.

The Advisory Group further considered the results of the initial screening to refine the list to those options which are best suited to the Lake and the nature of the lake management zone. The following options were eliminated at the second round of investigation: dredging, several herbicides, and biological controls. The options were presented at the October 2016 public forum. In its five-year review, the Advisory Group revisited these screening steps again in 2021 and came to similar conclusions.

Selection of Recommended Vegetation Control Options

Based on the review of potential vegetation options, the Advisory Group selected the following methods for application: drawdown, benthic barriers, hand-pulling, mechanical harvesting, and herbicides. Each of these selected control methods is fully described and discussed in the Plan.

One of these control methods - drawdown - is already in place and has been shown to be highly effective at times. Lake winter drawdowns have been shown to be an effective means of controlling many non-native macrophyte species including fanwort and milfoil species. For Lake Maspenock, these drawdowns include both the normal five-foot and a more extensive ("deep") eight-foot drawdown for invasive weed control. The deep drawdown is conducted on a three-year schedule using the procedures described in the Lake Maspenock Dam Operations & Maintenance Manual (PARE 2009).

To fine-tune the Plan, the Advisory Group found it useful to initially divide the Lake into sub-areas or lake management zones (LMZs), to facilitate identification of more tailored, cost-effective management options. Each lake management zone was delineated based on several factors including the depth of water, the ecological habitat of each zone, the active or passive recreational uses, and the intensity of those uses. During the 2021 review, it was decided that it would be advantageous to combine the original 10 LMZs into a smaller set of management zones to combine areas of similar characteristics and usage. The Advisory Group reclassified each zone with relative priority for management ranging from high to low. The Group examined the nature and recreational use for each zone and gave a higher priority to those areas with the most intense public and private use or which have had specific weed problems in the past.

The Advisory Group then matched the selected vegetation control options to the individual LMZs. The need for any sort of treatment will be assessed on a LMZ-specific, year-to-year basis. This involves tracking of conditions during the early growing season to help predict whether treatable conditions exist or could exist in the near future (i.e., later in the summer, next growing season). This need for annual assessment requires that a lake monitoring program be regularly conducted to provide the observation and data on which to make an informed decision.

The Plan recommends monitoring of water quality, aquatic vegetation, the drawdown depth and duration as well as other surveys, as needed. A lake monitoring program allows stakeholders to follow water quality trends, update plant community trends, and document vegetation control results and successes. It provides the information to better manage the lake and, as needed, to make adjustments in the overall lake management plan.

Watershed management is the most cost-effective means to reduce or eliminate future watershed inputs of sediments and nutrients to Lake Maspenock. Even if in-lake vegetation management options are applied, watershed management is still important to further advance the investment made to control plants. Primary objectives under the watershed management goals for the Lake would be: (1) communication and public education for watershed stakeholders; (2) watershed inspection for current or developing erosion or nutrient sources; and (3) advocacy and coordination with other watershed stakeholders and local agencies for identifying potential opportunities for extension or preservation of open space.

The revised five-year plan is based on the annual winter drawdown cycle (supplemented by a deep drawdown every third year), the potential for active treatment, lake monitoring, and watershed management options. If the deep drawdown is particularly effective (e.g., winter 2015-16), the need for active treatment is likely to be minimal for the first and possibly the second summer following drawdown. The nature of any future potential treatment would depend on the location, density and species composition of nuisance weeds as matched with selected treatment options. Lake monitoring should be conducted every year to provide updated water quality and vegetation status data and to provide information for treatment decision-making.

As described above, effective lake management will need to draw upon considerable technical expertise and practical experience to make responsible annual treatment decisions. This requires both continuity of purpose and long-term commitment by interested parties. Therefore, the Advisory Group was transformed into a permanent standing committee responsible to DPW Director. Qualified members are appointed by the Board for three-year terms. The Group provides regular reports to the Director regarding the current or anticipated status of aquatic vegetation in the Lake and assess the performance and cost-effectiveness of any options used to control the weeds.

The cost of implementing the Lake Management Plan on an annual basis will be subject to the amount and nature of treatment that would be required which will vary as a function of aquatic weed growth. Very little cost may be incurred in a season with little plant growth while significant monies may be required if weed populations are widespread and impact recreation. A good analogy is that of the need for road salting and sanding which will vary widely depending on winter storms and labor and equipment needs and is impossible to predict prior to the critical season.

The Advisory Group suggests that the current allocation of $60,000 be continued as the base budget item for the next few years. Monies that are not spent during a low activity year would be returned to the Town. As part of the long-term approach, the Lake Management Plan would be revisited in Year 3 (2024) for any minor adjustments and given a thorough review and evaluation for major changes or revisions in Year 5 (2026). These scheduled reviews will provide a good opportunity to check on what monies have been used and whether the base budget needs to be adjusted.

Contents

1. INTRODUCTION

1.1. Lake Maspenock

Lake Maspenock (the "Lake"), also known as North Pond, is a large waterbody situated mainly within the Town of Hopkinton in Middlesex County, MA but which shares shoreline with the towns of Upton and Milford (Worcester County) (Figure 1). The name comes from the Nipmuc dialect of Eastern Algonquin translated as "The Waters at The Base of The Great Hill" (LMPA undated). The present shape of the Lake was formed from a small natural waterbody (estimated at 30-40 acres) whose size was greatly increased by impoundment of water by the dam located at its southern end. Lake Maspenock is listed as a Great Pond[1] by the State of Massachusetts (MA EOEEA 2014) and classified as a Class B waterbody, suitable for primary contact recreation[2]. Primary uses of the Lake are recreation including boating (developed and undeveloped boat launches), fishing, swimming (public beach), providing aquatic life support (ecological habitats) and aesthetic appreciation.

1.2. Impairment of Lake Maspenock by Excess Aquatic Vegetation

Due to the shallow nature of northern end of the Lake and its rich sediments, rooted aquatic plants (macrophytes) have probably flourished since the construction of the Lake Maspenock Dam in 1901.Two non-indigenous (non-native) invasive species, fanwort (*Cabomba caroliniana*) and variable milfoil (*Myriophyllum heterophyllum*), appear to have become well established at high levels by the 1970's (JCA 1979). Appendix A provides a short history and timeline of vegetation control efforts in the Lake.

Invasive species succeed because the species' growth habit and lack of natural control agents (insects, diseases, or herbivores) enable it to produce and maintain large, dense populations very rapidly. The density and location of these beds may substantially interfere with or eliminate activities such as boating, swimming, fishing and waterskiing, or other recreational uses of the water. It can also influence shoreline property values, degrade ecological habits, and reduce the overall enjoyment of the aesthetic features of the Lake.

In recent years, the Town has practiced water level drawdown for aquatic vegetation control of these two invasive species. While drawdown appears to have been initially successful in controlling fanwort and milfoil, it also led to rapid colonization of the shallow areas by native species, including largeleaf pondweed (*Potamogeton amplifolius*) and tape grass (*Valisneria americana*). Largeleaf pondweed is not typically considered an invasive species, but it has opportunistically expanded its coverage in the Lake in response to the drawdown and reached nuisance levels in 2013-2015. The deep drawdown of winter 2016 was highly successful in controlling macrophyte densities of all nuisance densities in the North Basin for two growing seasons. However, this technique is not always reliable for control and has not eliminated the potential for recolonization and impairment due to dense growth.

[1] A great pond is defined by the Commonwealth of Massachusetts as any pond or lake that contains more than 10 acres in its natural state.

[2] Classified under 14 CMR 4.00: Massachusetts Surface Water Quality Standards.

1.3. Formation and Responsibilities of the Advisory Group

The Lake Maspenock Aquatic Vegetation Control Management (LMAVCM) Advisory Group was a direct result of the 2015 Hopkinton Town Meeting (May 4, 2015). At that meeting, voters rejected a proposed plan to use herbicides to control weeds in Lake Maspenock, but approved funding of $60,000 to explore other management options. Subsequently, at its next meeting (June 23, 2015), the Hopkinton Board of Selectmen (BOS), pursuant to Section 32 of the Town Charter, approved the formation and charge of the Lake Maspenock Weed Control Management Advisory Group (i.e., the Advisory Group) to work with the Director of Public Works on long-term control and management of the aquatic weeds in Lake Maspenock. This volunteer board was later renamed the Citizen Input Group ("CIG") but for convenience will be referred to as the Advisory Group in this document.

The composition of the Advisory Group is composed of five Town residents appointed by the BOS. The membership of the Advisory Group reflects the following required categories:

- One resident of the area in the vicinity of Lake Maspenock who has a background in weed management and control;
- One designee from the Conservation Commission;
- One designee from the Parks & Recreation Commission; and
- Two at-large members.

The BOS further stipulated that the Advisory Group make recommendations to the Director of Public Works regarding measures to facilitate effective public education and participation in the formulation of a comprehensive weed management and control plan (i.e., Lake Management Plan) for Lake Maspenock. The Advisory Group was charged with the following tasks:

- Ensuring that factual information regarding treatment options is communicated;
- Coordinating, consulting and providing methods and means for seeking public input; ensuring effective public participation at the meetings and that public input is fully considered; and
- Formulating methods and means of increasing public awareness about the benefits, cost and potential for health or ecological risks of the Lake Management Plan.

Based on the BOS charge and objectives, the Advisory Group developed the following Vision Statement in 2016 (see Appendix D) that summarizes the Group's perceived mission:

The Lake Maspenock Weed Management and Advisory Group will engage Hopkinton residents in preserving both the recreational value and environmental significance of the Lake and surrounding watershed. To accomplish this goal, the Advisory Group will submit a comprehensive, long term plan to the Board of Selectmen. Public participation is key to the development and implementation of the plan.

1.4. Development and Update of Lake Management Plan

Starting in October 2015, the Advisory Group met regularly in public meetings to investigate potential aquatic vegetation control options and to develop and craft a comprehensive, long-term Lake Management Plan to preserve and protect the beneficial uses of the Lake. To further involve the Town residents, two forums were conducted by the Advisory Group in February 2016 to inform the public and describe progress to date. At these meetings, preliminary results of the Resident Survey (see Section 3) were also presented. A third public form was conducted in October 2016 to describe the draft final plan and to keep the public aware of the benefits, costs, and potential risks of various vegetation control options. Presentation slides of the public forums and comments received during them as included as Appendix F.

It was recognized early in the process that the Plan should also include watershed management. Watershed management works to reduce or eliminate the input of the nutrients and sediments that are responsible for impaired water quality and aquatic weed growth. Watershed management looks to address direct and non-point source (NPS) inputs through a combination of technical options (e.g., storm water treatment) and behavioral changes (e.g., better environmental practices of shoreline and lake area residents).

The need for a long-term Lake Management Plan is required because lakes are highly interactive systems with variable feedback to environmental change (e.g., development of largeleaf pondweed after control of invasive species). It is difficult to alter one characteristic, such as aquatic plant growth, without affecting some other part of the ecosystem such as fish production. Some of these indirect effects may respond at different time scales. Therefore, the Plan was designed with explicit short-term objectives but possesses a long-term perspective for judging overall lake quality and preference conditions.

The Advisory Group recognized that different areas of the lake require different treatment. Accordingly, management strategies should involve a mix of methods. A hypothetical example of this type of layered management program could include mechanical harvesting or cutting to reduce plant biomass, treatment with herbicides, and follow-up "spot" treatments that may include a combination of methods, including hand pulling, diver-assisted suction harvesting (DASH), or targeted application of aquatic herbicides.

Finally, the Advisory Group believes that it is very important to evaluate success of a lake treatment. This is accomplished by setting specific target objectives and having post-implementation monitoring to track any changes in the following year(s) after a particular treatment to identify its effectiveness and longevity. Through this evaluation, the Lake Management Plan can identify those options that best fit the Lake and eliminate those which are ineffective or too costly and thus, improve the efficiency of the Plan.

As part of the long-term approach, the Plan was to be reviewed and updated by the Advisory Group each five years. This allows incorporation of more current monitoring data (both water quality and aquatic vegetation surveys), recent advances in vegetation control options, and changes in Advisory Group or Town policy to be considered in refining the Plan. The Plan was reviewed by the Advisory Group in spring 2021 and a updated, revised final report approved and finalized in June 2021.

1.5. Organization of the Lake Management Plan

This document describes the data, tasks and activities involved in the development and refinement of the treatment strategy as well as the recommended provisions of Lake Management Plan. This information is presented in seven sections, as follows:

- Section 1 - Introduction: provides general overview of Lake Maspenock features, its history of impairment by aquatic vegetation, the formation and function of the Advisory Group, and their approach to development of a Lake Management Plan;
- Section 2 – Lake Maspenock Characteristics: describes the historical and current sources of information, lake basin characteristics, watershed features including land use, and a review of

existing water quality data and aquatic vegetation reports, and designation of priority areas and protected uses;

- Section 3 – Current Lake and Resident Use: identifies the common uses and recreational features of the Lake, provides a summary of the 2016 Hopkinton Resident Survey and presents the lake management zone identification and priority determinations.
- Section 4 – Aquatic Vegetation Management Options: outlines the Advisory Group's evaluation of physical, chemical and biological aquatic vegetation control methods, including results of the preliminary screening, secondary site-specific evaluations; preliminary costing and permitting information, and draft list of potential options;
- Section 5 – Watershed Management Options: identifies potential watershed-based management options; public education; watershed management, and enhancing protected land with the watershed;
- Section 6 – Comprehensive, Long-Term Plan: summarizes the selected aquatic vegetation options, discusses public input process and provides recommendations for consideration by BOS; and;
- Section 7 – References.

Additional information including field notes, laboratory analytical reports, water chemistry data, vegetation survey datasheets, etc. are provided in a series of Appendices. A glossary of aquatic terms is included to provide definitions of specialized terms and expressions which may be unfamiliar to the public.

2. LAKE MASPENOCK AND WATERSHED CHARACTERISTICS

2.1. Prior Studies and Sources of Information on Lake Maspenock

Table 1 documents sources of information used in the preparation of the Plan. Information regarding the physical, chemical, and biological characteristics of Lake Maspenock were collected from several studies and data sources including: Jason Cortell and Associates (JCA) 1979; Metcalf and Eddy (M&E) 1987; Aquatic Control Technology (ACT) 2009, 2012, and SOLitude Lake Management (2016). In addition, water quality monitoring data from the LMPA and results from the Advisory Group's aquatic vegetation surveys are available. Additional information was gathered from State sources (MA DEQWE 1980; MA DFW 1993) and from internet websites, particularly the LMPA (www.lmpa.org). This information included lake basin shape, hydrology, water quality, aquatic vegetation, and watershed features.

Table 1. Previous studies and sources of information on Lake Maspenock, Hopkinton, MA.

Year	Report	Source	Description	Period	Data Type
1979	A Bioengineering Study of Lake Maspenock, Hopkinton, MA	Jason Cortell & Associates	Diagnostic/Feasibility Study	1977-1978	Physical (temp, DO), water quality, bacteria, aq. vegetation, watershed data
1980	Water Quality Monitoring Datasheet (partial)	MA Department of Environmental Quality and Wastewater Engineering (DEQWE)	Periodic water quality monitoring datasheet	One sample on 6/4/80	Water Quality Sampling
1987	Final report to the Town of Hopkinton on Diagnostic Feasibility Study of North Pond, Hopkinton, MA.	Metcalf and Eddy	Diagnostic/Feasibility Study	1984-1987	Physical (temp, DO), water quality, bacteria, aq. vegetation, watershed data
1993	Bathymetric Map of North Pond and General Information	MA Division of Fish and Wildlife	Bathymetric map, access, and general fisheries information	1979- 1980	Physical (depth contours), fishery data
2008	2007 Biological Survey of Lake Maspenock (North Pond), Hopkinton, MA.	Aquatic Control Technology (ACT)	Letter report with survey and aquatic vegetation control options	Field survey: 11/29/07	Aquatic vegetation survey
2013	2012 Biological Survey of Lake Maspenock, Hopkinton, MA.	Aquatic Control Technology (ACT)	Narrative and aquatic vegetation mapping in support of WPA NOI	Field Survey: 8/12/2012	Aquatic vegetation survey
2016	2015 Biological Survey of Lake Maspenock, Hopkinton, MA.	SOLitude Lake Management ((SML)	Letter report with survey details and aquatic vegetation map	Field survey: 8/31/15	Aquatic vegetation survey

2011-2021	Water Quality Monitoring	Lake Maspenock Preservation Association	Yearly (2-3X) WQ monitoring of three in-lake sampling locations	2011-2021	Physical (temp, DO), phosphorus and bacteria
2016-2020	2012 Aquatic Vegetation Surveys	Lake Maspenock Citizen Input Group	Spring and late summer in-lake aquatic vegetation surveys	Field Surveys	Aquatic vegetation ID and density

2.2. Lake and Watershed Description

The physical dimensions (morphology) of a lake are important determinants since they often dictate the nature and quality of the types of water uses (e.g., ecological, recreational, water supply, etc.). Morphology is also important when considering the applicability or cost-effectiveness of various potential vegetation control or watershed management options

The surface area of the Lake is estimated at 234 acres and it drains a watershed area of approximately 1,813 acres (MADEP 2013). The outflow exiting over the dam is the source of the Mill River downstream within the larger Blackstone River basin. Table 2 provides a summary of the morphometric parameters associated with Lake Maspenock. The maximum depth is reported at just over 20 ft. with an average depth of about 8 ft. It has a high shoreline development index (DL) indicative of its elongated north-south axis and the large shoreline length. The watershed to lake surface area ratio is approximately 7.7 to 1. This low ratio suggests a low-to-moderate potential influence of watershed land use on lake water quality.

Table 2. Morphometric Characteristics of Lake Maspenock and its Watershed.

Parameter	Symbol	Value	units
Lake Surface Area	SA	234	acres
Maximum Length	L_{max}	11,000	ft
Maximum Width	W_{max}	2,640	ft
Volume	V	9.27E+07	ft3
Mean Depth	Z_{avg}	8	ft
Maximum Depth	Z_{max}	20	ft
Mean to Maximum Depth Ratio	Z_{avg}:Z_{max}	0.34	unitless
Shoreline Length (main basin)	C	9,800	ft
Shoreline Development index	DL	2.95	unitless
Watershed Area	WA	1813	acres
Watershed to Pond Area Ratio	WA:SA	7.7:1	unitless

Sources: M&E (1974); ACT (2012); and MASS GIS

The general shape and north-south orientation of the Lake are shown in Figure 1 (ACT 2012). Overall water flow movement goes from north to south with hydrological inputs entering the northern half and exiting the basin via the spillway of the dam located at the southern terminus. There are several peninsulas and islands which provide backwater areas that often are potential areas of accumulation for sediment and/or nutrient inputs. The long shoreline length has allowed considerable residential development, particularly on the northern half of the eastern shoreline (Hopkinton).

The bottom depth contours of Lake Maspenock are depicted on the bathymetric map (Figure 2) prepared by MA DFW (1993). The depth contours clearly indicate the outline of the former natural pond which has a maximum depth of about 20 feet. The North Basin is wider on an east-west axis and is comparatively shallow averaging about 5-6 ft. in water depth. The southern basin ("South Basin) stretches about 1.25 miles south from Woody Island to the dam at the southern end of the Lake.

2.2 Hydrologic Characteristics

Hydrologic inputs to Lake Maspenock are varied and often diffuse. The Lake has no large named tributaries but receives flow through a conduit from an approximate 15-acre wetland situated above West Main Street (M&E 1987). Other hydrologic inputs include precipitation, and flow from several small unnamed streams, groundwater, as well as storm water and overland flow from the eastern and western shorelines. Hydrologic outputs from the lake include evaporation and water exiting via the dam crest spillway or lower drainage port.

The Lake Maspenock Dam was constructed in 1901 on land located in Milford. It is an 800 ft. long stone masonry and earthen embankment dam with a hydraulic height of approximately 16 ft. and a maximum structural height of approximately 18 ft. (PARE 2013). The dam was originally constructed for water supply purposes, but was purchased by the Town of Hopkinton in 2007. It is currently operated and maintained by the Town Department of Public Works (DPW) to support recreation, flood protection, and other water uses.

The dam is classified as a large size, high (Class I) hazard[3] potential dam (PARE 2013). The dam outlet spillway is elevation 348 (NGVD[4]) or two feet below the dam crest. The dam has a discharge gate (port), consisting of a 3 x 3 ft. square stone masonry culvert located at elevation 331.7 feet and controlled by machinery at the top of the dam (PARE 2013). This allows the Town to conduct controlled drawdowns to approximately 8 feet below crest elevation. During annual winter drawdowns, Hopkinton DPW personnel routinely monitor the Lake elevation level and adjust the lower outlet gate to maintain the pool elevation. Reference water level measurements are taken from the top of a pin installed on the upstream wall and relevant observations about flow control, daily precipitation, and dam repair status are noted.

The M&E (1987) diagnostic study measured an average outflow of approximately 3.7 cubic feet per second (cfs). The average flushing rate in the Lake during this period was on the order of 1.4 times per year, which corresponds to a residence time of approximately 260 days. The flushing rate varies through the year, being slower in summer and early fall during low flow periods and more rapid during winter and spring.

[3] Both size and hazard classifications are according to the Commonwealth of Massachusetts dam safety rules and regulations located at 302 CMR 10.0.

[4] National Geodetic Vertical Datum (NGVD) of 1929

Figure 1. Lake Maspenock Locus Map (from ACT 2012)

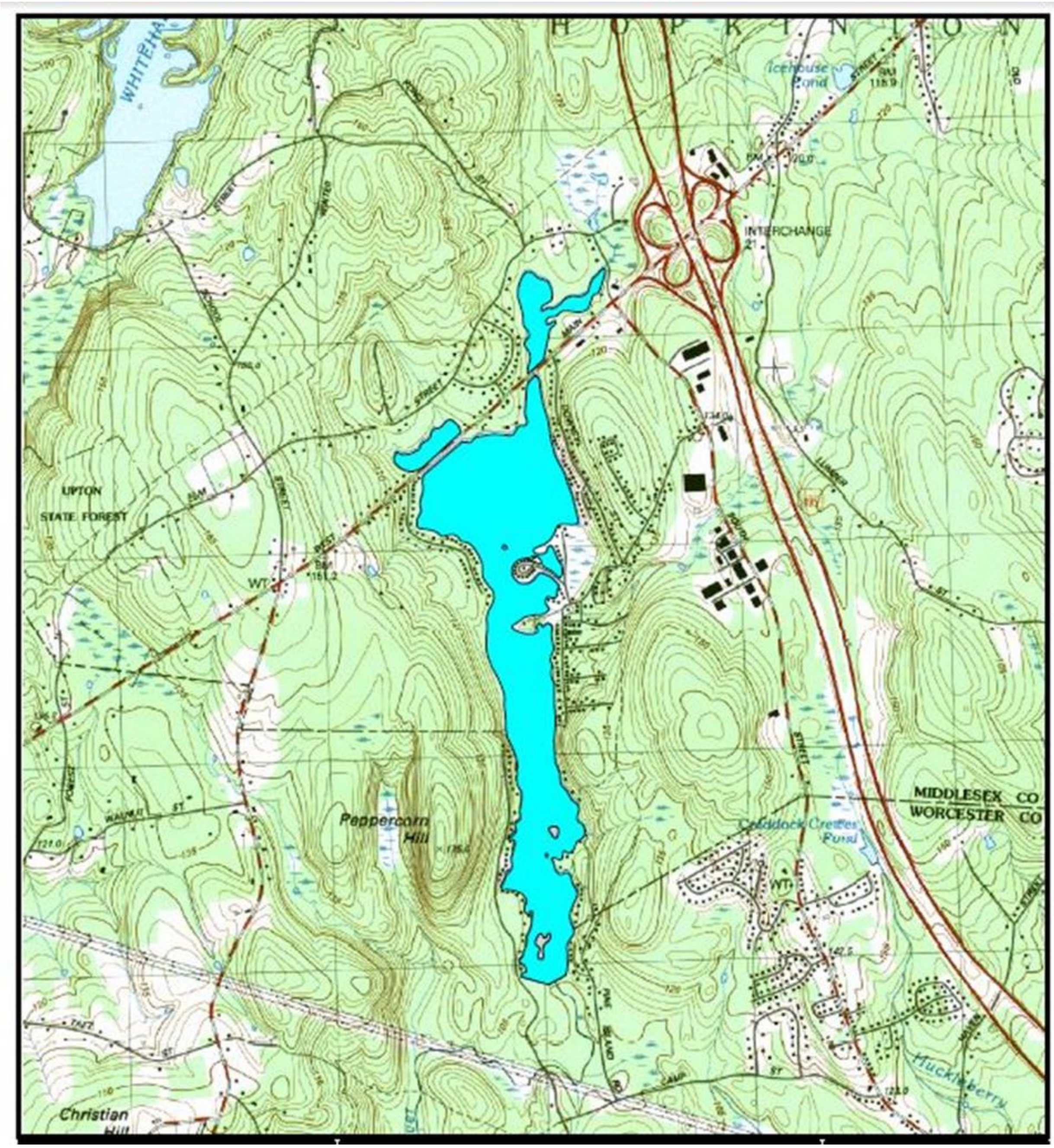
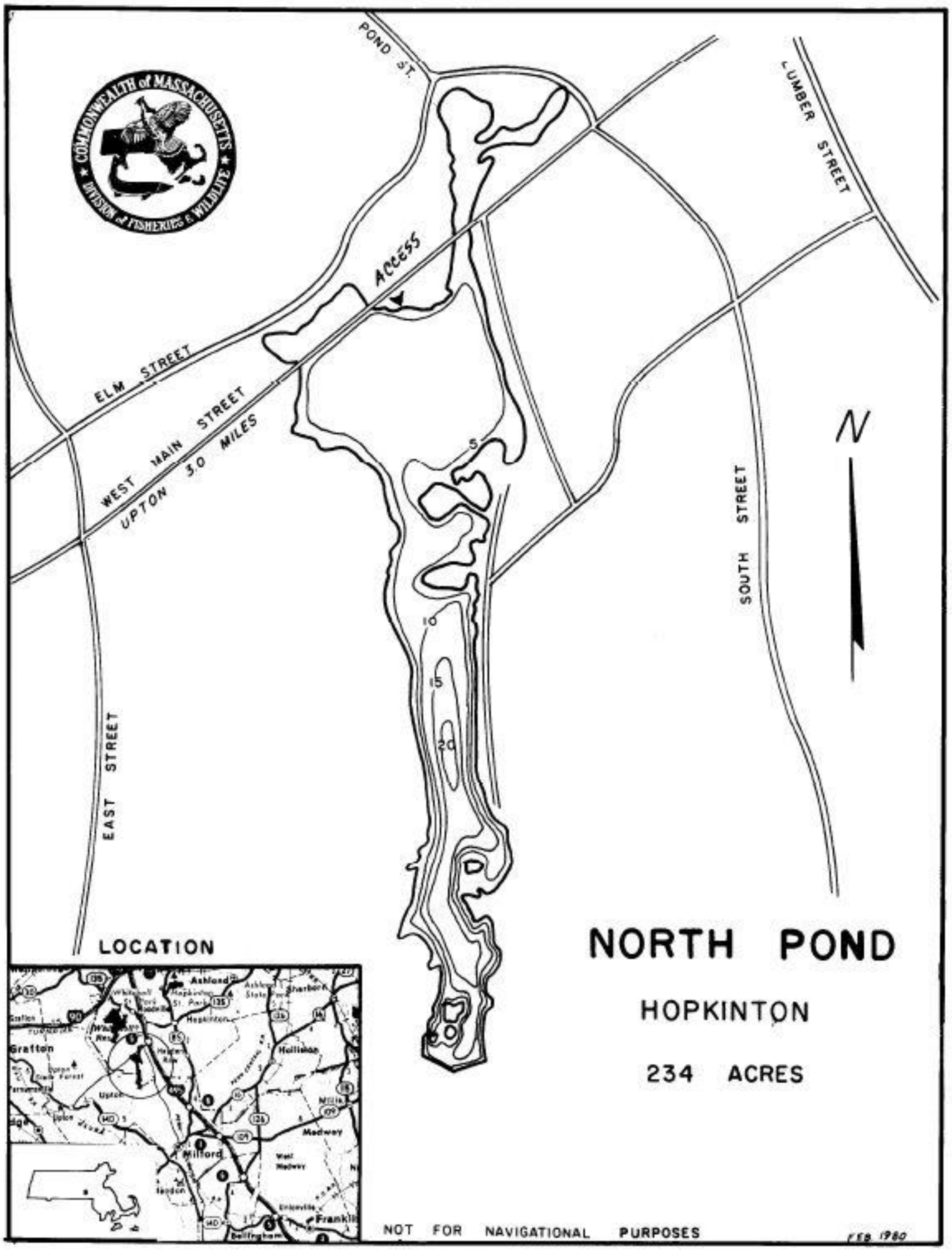


Figure 2. Bathymetric Map of Lake Maspenock (source MA DFW 1993).



2.3. Watershed Mapping and Land Use

The watershed drainage area for Lake Maspenock was reported as approximately 1,813 acres (2.83 sq. mi)[5], based on MassGIS digital terrain model and delineation software from USGS (PARE 2013). A watershed map (Figure 3) was constructed by importing data layers through Massachusetts Geographic Information System (GIS) data viewer (MA DEP 2014).

The watershed (Figure 3) extends approximately three miles north of the dam to near an interchange for Interstate 495.The watershed area has an average slope of 4.6% with isolated areas of steeper terrains, generally limited to the hillsides surrounding the impoundment (PARE 2013).

The watershed land use is varied and includes forested undeveloped land, residential, commercial and industrial uses; mineral extraction (sand and gravel), and wetlands. There is a Massachusetts Department of Transportation salt storage and handling facility near the northern end of the Lake. This land use includes a number of commercial and industrial facilities located along South Street to the east. Residential development continues in the watershed including new structures and conversions of summer cottages to year-round residences. A portion of the western watershed is undeveloped and protected as part of the Peppercorn Hill Conservation Area in Upton. There is also a large undeveloped section on the eastern side of the watershed that is owned by the Dell Corporation (formerly EMC).

According to Natural Heritage maps provided by MAGIS (2019 database), Lake Maspenock is not located within the boundaries of any designated habitat areas as determined by the Massachusetts Natural Heritage and Endangered Species Program (NHESP) nor are there NHESP designated habitats in the watershed or immediately downstream in Milford. Any non-exempt work activities within Priority and/or Estimated Habitat require review under the Massachusetts Endangered Species Act (MESA, M.G.L. c.131A) and its implementing Regulations (321 CMR 10.00).

2.4. Water Quality Data

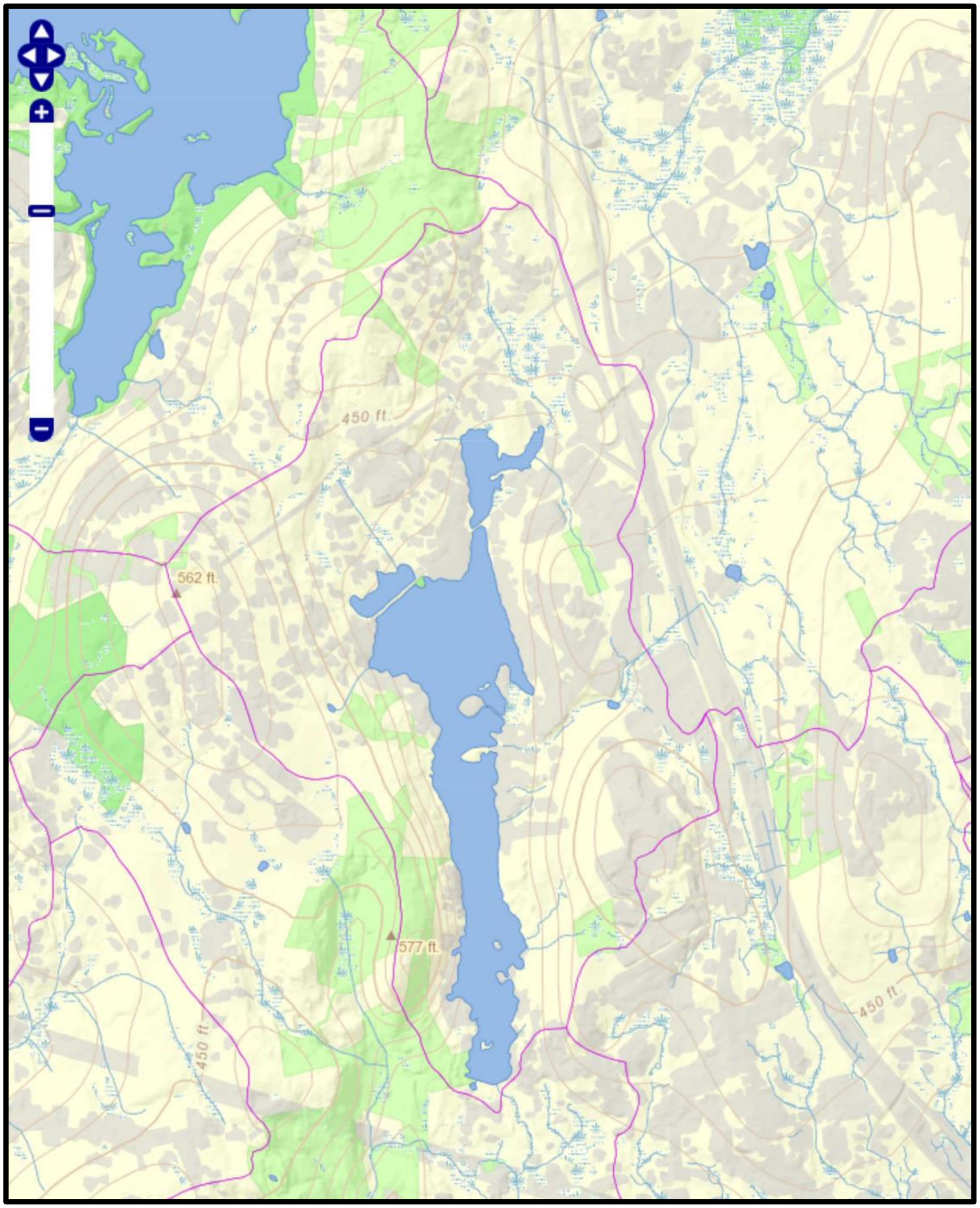
Sources of identified water quality data and the parameters monitored are presented in Table 3. Water quality data from most of these sources are provided in Appendix B.

Although water quality has been recently monitored since 2009 by the Lake Maspenock Protection Association (LMPA), comprehensive water quality sampling data sets are also available from the periods 1977-79 (JCA 1979) and 1984-1987 (M&E 1987). These sampling programs were associated with multi-year Diagnostic/Feasibility (D/F) studies and included sampling of surface water tributaries, in-lake stations, and the outlet (dam spillway). The water quality parameters monitored included measures of lake structure (temperature, dissolved oxygen, specific conductivity, and pH) at both surface and bottom water depths. Nutrients were measured throughout including a suite of nitrogen (nitrate (NO_3), ammonia (NH_3), and Kjeldahl nitrogen TKN) and phosphorus (total (TP) and dissolved (DP)) fractions. Other conventional water quality parameters (alkalinity, turbidity, total suspended and total dissolved solids) were measured as was chlorophyll-a, an indicator of phytoplankton levels. Storm water flow and quality was sampled during two rainfall events (M&E 1987).

[5] Reported in PARE (2013) as indicated by USGS Massachusetts Stream Stats (http://water.usgs.gov/osw/streamstats/massachusetts.html.

Figure 3. Lake Maspenock Watershed Map

(red outline indicates watershed boundary limits)



Due to their importance and influence on overall lake function (Wetzel 2001), both D/F studies assessed the levels of nutrients in the water column (phosphorus and nitrogen). Phosphorus is the element usually "limiting" primary productivity in temperate zone lakes, as it is most often the element in shortest supply relative to the needs of plant. It is also more easily controlled than most other essential plant nutrients. The level of total phosphorus in a lake is a good indicator of the degree of fertilization (or eutrophication) that the lake is receiving from its tributaries and watershed. Under certain conditions (anoxic bottom water) there is the possibility of internal recycling of phosphorus from the bottom sediments.

Nitrogen is another important plant nutrient and occurs in three major forms in aquatic systems: ammonia, nitrate, and organic compounds. Ammonia and nitrate are readily available for uptake by plants. Nitrogen inputs to aquatic systems are more difficult to control as a consequence of high nitrogen levels in the atmosphere, the application of fertilizers in the watershed, and the high mobility of nitrate in the soil.

Both phosphorus and nutrient levels in the Lake were considered elevated by both the JCA (1979) and M&E (1987) reports. In-lake total phosphorus concentrations reported by JCA ranged between 10-20 parts per billion (ppb), while the M&E reported tributary concentrations ranging between 28-29 ppb, with in-lake concentrations ranging from 16-19 ppb and decreasing from north to south. These concentrations compare with a threshold of 25 ppb, which is widely considered to be a threshold from moderately to well-fertilized lakes (Wetzel 2001). Nitrogen levels were also elevated, consistent with anthropogenic (man-made) inputs.

Elevated nutrient levels are likely to have been influenced by storm water inputs, originating in commercial/industrial parks along South Street and elsewhere, and groundwater flow from septic systems around the Lake. Since the time of the D/F studies, nutrient inputs appear to have been significantly reduced due to the installation of sanitary sewers in the Hopkinton watershed and the installation of storm water treatment systems (including a large detention pond by EMC / Dell) in the upper eastern watershed.

Water quality monitoring data reported by the LMPA (2011-2020) shows decreased levels of phosphorus, often near or below detection values (10 ppb). The long-term average from 2011-2020 was 10 ppb with a geometric mean[6] of 8 ppb. Nitrogen levels are not reported but would also be expected to have been reduced due to the elimination of septic tank contributions and better storm water treatment. Reduced nutrient levels are consistent with observations of good water clarity (as estimated by a Secchi disk), detection of adequate dissolved oxygen throughout the water column, and few reports of major algal blooms.

It is also likely that another factor responsible for the low in-lake nutrient values is the uptake of nutrients or sequestering of sediments by the rooted aquatic vegetation. This beneficial function should be kept in mind when considering significant reduction in the coverage of macrophytes in the Lake as this could potentially lead to higher in-lake nutrient levels. Long-term monitoring would be useful in detecting such trends.

Monitoring for bacterial contamination (via *E. coli* bacteria counts) is conducted weekly by the Town during summer recreation season (mid-June – late August) at the Sandy Beach public swimming area. Review of the testing data for the last two years (2019-2020) indicated that only one sample of a total of 57 taken exceeded the acceptable threshold level.

[6] Geometric mean is often used with environmental data sets to reduce the influence of a few very large or low values.

Table 3. Sources of water quality data for Lake Maspenock, Hopkinton, MA.

Author/Firm	Study Period	# Sample Locations	Sampling Frequency	In Situ observations	Nutrient Fractions	Other WQ Parameters	Bacterial Counts
Jason Cortell & Associates	1977-1978	4 in-lake (1 deep); outlet, 2 outfalls; 8 tributaries	Weekly ice-free period; monthly during winter	Temp. pH, DO, specific conductivity	Phosphorus (TP); Nitrogen (NH_3-N, NO_3-N, TKN)	Alkalinity, CO2, Fe, turbidity, Chl a	*T. Coliform, F. Coliform, F. Strepto.*
MA Department of Environmental Quality and Wastewater Engineering (MA DEQ&WE)	1980	Unknown (partial report), looks to be 4 in-lake (1 deep)	Single Sample	Temp. pH, DO, specific conductivity	Phosphorus (TP); Nitrogen (NH3-N, NO3-N, TKN)	Alkalinity, hardness, Cl, Fe, Mn, TSS, TS	*T. Coliform, F. Coliform*
Metcalf and Eddy	1984-1987	5 locations: inlet, outlet, 4 in-lake (2 deep), and eastern tributary	Weekly ice-free period; monthly during winter	Temp. pH, DO, specific conductivity, SDT	Phosphorus (TP); Nitrogen (NH3-N, NO3-N, TKN)	Alkalinity, Cl, turbidity, TSS, TDS, Chl a, phytoplankton	*T. Coliform, F. Coliform*
Lake Maspenock Preservation Association	2011-2021	3 in-lake locations: north, middle, south basins	Yearly (2-3X) WQ monitoring of in-lake sampling locations.	Temp. pH, DO (>2015)	Total phosphorus	-	*E. coli;* did not include beach testing data

Nutrient, chl-a, and Secchi disk transparency (SDT) data can also be used to determine whether the water quality of Lake Maspenock is currently supporting all designated water uses, as indicated by its overall trophic status[7]. The concept of trophic status is based on the fact that changes in nutrient levels (measured by TP and TN) cause changes in algal biomass (measured by chlorophyll-a) which in turn causes changes in pond clarity (measured by SDT). A trophic state index (TSI) is a convenient way to quantify this relationship. This consists of comparison of ambient values of key indicators (i.e., phosphorus and/or nitrogen fractions, chlorophyll-a, and SDT) to previously established criteria or thresholds. For these calculations, surface phosphorus values were used and, where values were below method detection limits, an assumption of one-half the detection limit was used[8].

For this comparison, we used the Trophic State Index (TSI) developed by Carlson (1977). This method uses a log transformation of SDT values as a measure of algal biomass on a scale from 0 - 100. Each increase of ten units on the scale represents a doubling of algal biomass. Since chl-a and TP are usually closely correlated to SDT measurements, these parameters can also be assigned trophic state index values (EPA, 2011). Thus, the available trophic state indicators are input into a set of empirical equations:

$$TSI_{sdt} = 60 - 14.41 \ln SDT\ (m)$$

$$TSI_{chla} = 9.81 \ln \text{chlorophyll a}\ (ug/L) + 30.6$$

$$TSI_{tp} = 14.42 \ln TP\ (ug/L) + 4.15$$

where: TSI_x is Carlson trophic state index and ln is the natural logarithm.

Table 4 presents the TSI values calculated for Lake Maspenock using concentrations and values measured in the South Basin from summer 1984 (M&E 1987). For comparison with current conditions, we also calculated the TSI using the long-term geometric mean (9 ppb) from LPMA monitoring (i.e., 2011-2021) and the average Secchi disk transparency depth (i.e., 8.3 ft.) observed at two deep South Basin sampling locations measured during aquatic vegetation surveys from 2016-2020.

The scores are interpreted as indicated in the exhibit below the calculations. Accordingly, the 1984 TSI values classify Lake Maspenock as a mesotrophic waterbody (i.e., TSI from 40 to 50), while those from recent data suggest it is much closer to an oligotrophic pond category (i.e., TSI ranges 30-40). However, it is important to note that this comparison is based only on limited seasonal water quality data and field observations and does not take into account the abundance of any aquatic vegetation.

[7] Trophic state refers to the general nutrient concentrations and productivity of a lake or pond. The three common trophic states are oligotrophic ("poorly fertilized'); mesotrophic ("moderately fertilized') and eutrophic ("well fertilized'). For further description of trophic state see Wetzel (2001).

[8] The use of one-half the method detection limit as an estimate of a non-detected value is commonly used when a non-zero number is required. Thus, there is some uncertainty regarding what the exact value is.

Table 4. Lake Maspenock TSI Calculations (1984 vs. 2011-21)		South basin July-Aug 1984 data	TSI scores	South basin 2011-2021 data	TSI scores
Secchi Disk:	**TSI(SD) = 60 - 14.41 ln(SD)** SDT expressed as meters	3.66	41	2.44	47
Chlorophyll a:	**TSI(CHL) = 9.81 ln(CHL) + 30.6** Chlorophyll a expressed as ug/L	5.23	47	-	-
Total Phosphorus:	**TSI(TP) = 14.42 ln(TP) + 4.15** TP expressed as ug/L	22	45	9	32
	where ln = natural log Avg. score:		44		39

TSI score	Description of lake conditions and eutrophic indicators
< 30	Oligotrophic; clear water; high DO throughout the year in the entire hypolimnion
30-40	Oligotrophic; clear water; possible periods of limited hypolimnetic anoxia (i.e., when bottom DO = 0-2 mg/L)
40-50	Moderately clear water; increasing chance of hypolimnetic anoxia in summer; fully supportive of all swimmable/aesthetic uses
50-60	Mildly eutrophic; decreased transparency; anoxic hypolimnion; macrophyte problems; warm-water fisheries only; supportive of all swimmable/aesthetic uses but "threatened"
60-70	Blue-green algae dominance; scums possible; extensive macrophyte problems
70-80	Heavy algal blooms possible throughout summer; dense macrophyte beds; hypereutrophic
> 80	Algal scums; summer fish kills; few macrophytes due to algal shading; rough fish dominance

2.5. Aquatic Vegetation Data

Detailed aquatic vegetation surveys have been conducted in Lake Maspenock over the last 50 years including 1974, 1984, 2003, 2007, 2012 and 2015 (JAC 1979; M&E 1987; ACT 2008 and 2013; SOLitude 2016) as well as the more recent Advisory Group surveys from 2016-2020. The survey data include both qualitative (observational) and semi-quantitative (e.g., lake rake tosses) data taken from approximately 12 stations during late spring and late summer (Figure 4). However, not all surveys were conducted in every year nor all stations visited during each survey due to poor weather or volunteer staffing limitations. For example, no survey was conducted in spring 2017 and the June 2019 survey only visited five stations. While the vegetation surveys listed above have been conducted by a wide variety of organizations, using different methods, and visiting different stations at varying times of the year, there is sufficient data to allow for evaluation of long-term trends in macrophyte community composition and growth patterns.

Table 5 lists the aquatic macrophyte species and other aquatic taxa (microalgae and filamentous algae) reported by the historic surveys, with the relatively dominant plant species indicated by the bold "X" and sub-dominants by "*". Fanwort and variable milfoil have been present in the Lake since the 1970s and are consistently co-dominants in all surveys prior to 2015. [Note: the 1984 survey apparently misidentified *M. heterophyllum* as northern milfoil, *M. sibericum* and this has been corrected in Table 5]. Following drawdowns in 2010-2013, there was a reduction of fanwort and milfoil as largeleaf pondweed expanded its range and density to dominate the plant community. Naiad (*Najas*) and bladderwort (*Utricularia*) species were important as understory plants in much of the lake. Comparison of species lists indicates that there appears to be some uncertainty regarding the presence of the similar appearing pondweed (*Elodea)* and Brazilian elodea (*Egeria*) that can be resolved with further sampling. Other macrophyte species appear to be present in trace amounts or mostly reported from the isolated upstream wetland area (JCA 1979).

Results from the 2016-2020 aquatic vegetation surveys are shown in Table 6. The data indicate the continuing numerical dominance of four species – fanwort, variable milfoil, largeleaf pondweed and naiad over the years. Fanwort and variable milfoil were relatively more reduced in the years following the winter 2016 drawdown. Tape grass has been increasing during the last two years and there is some reduction in bladderwort. Other species are found in lesser numbers and are often restricted to a few stations (see below).

For a more quantitative analysis, Table 7 compiles all the data from the Advisory Group surveys and represents data gathered from 105 field observations over the five years grouped by station location. The percentages are the frequency each species was observed at a particular station with percentages $\geq$ 50% indicated in bold. The lake-wide category at the bottom refers to frequency each species was found at all stations in all years. The top five most observed species include naiad (57%), variable milfoil (49%), bladderwort (41%), largeleaf pondweed (39%), and fanwort (30%). Other species were found at less than 20% frequency.

Figure 4. Aquatic Vegetation Survey Locations (2016-2020)

Table 5. Aquatic Macrophytes and Taxa Reported in Vegetation Surveys of Lake Maspenock (1974-2016)									
Plant Name	Species Name	Status	Invasive?	1974	1984	2007	2012	2015	2016
Fanwort	*Cabomba caroliniana*	Non-native	Yes	X	X	X	X	X	*
Variable watermilfoil	*Myriophyllum heterophyllum*	Non-native	Yes	X	X	X	X	X	*
Largeleaf Pondweed	*Potamogeton amplifolius*	Native	Possible	-	-	*	*	X	*
Naiad species	*Najas* spp.	Non-native	Possible	-	-	*	X	X	*
Ribbon-leaf Pondweed	*Potamogeton epihydrus*	Native	No	-	-	-	*	-	*
Thinleaf Pondweed	*Potamogeton pusillus*	Native	No	*	-	-	*	-	-
Curlyleaf Pondweed	*Potamogeton crispus*	Non-native	Yes	-	-	*	-	-	-
Brazilian elodea	*Egeria densa*	Non-native	Possible	-	-	*	*	-	-
Waterweed	*Elodea canadensis*	Native	Possible	*	-	-	-	-	*
Tape Grass	*Vallisneria americana*	Native	No	-	-	-	*	*	*
Bladderwort	*Utricularia* spp.	Native	No	*	*	*	*	*	*
Stonewort	*Nitella* spp.	Native	No	*	-	-	*	-	*
Watershield	*Brasenia schreberi*	Native	No	*	-	-	-	-	-
White Waterlily	*Nymphaea odorata*	Native	No	*	-	-	*	*	-
Spatterdock	*Nuphar advena*	Native	No	*	-	-	-	-	-
Filamentous Algae	Various species	Native	No	*	-	-	*	*	-

Key: **X** = dominant species; * = non-dominant species reported by survey; - = not reported in survey.

Table 6. Aquatic Macrophytes and Taxa Reported in CIG Vegetation Surveys of Lake Maspenock (2016-2020)

Plant Name	Species Name	Status	Invasive?	2016	2017	2018	2019	2020
Fanwort	*Cabomba caroliniana*	Non-native	Yes	*	*	X	X	X
Variable watermilfoil	*Myriophyllum heterophyllum*	Non-native	Yes	*	X	X	X	X
Largeleaf Pondweed	*Potamogeton amplifolius*	Native	Possible	X	X	X	X	X
Naiad species	*Najas* spp.	Non-native	Possible	X	X	X	X	X
Waterweed	*Elodea canadensis*	Native	Possible	*	*	*	*	*
Tape Grass	*Vallisneria americana*	Native	No	*	*	*	X	X
Bladderwort	*Utricularia* spp.	Native	No	X	X	X	*	*
Stonewort	*Nitella* spp.	Native	No	*	*	*	-	*
Ribbon-leaf Pondweed	*Potamogeton epihydrus*	Native	No	*	-	*	*	-

Key: **X** = relatively dominant species; * = non-dominant species reported by survey; - = not reported in survey.

Table 7. Lake Maspenock Aquatic Vegetation Survey Results (2016-2020): Aquatic Species Observed

Code	n	BW	EN	FW	LLP	Nit	RLP	TG	VMf	WW
NB/EC	9	22%	**67%**	-	-	-	-	44%	11%	-
NB/CL	9	44%	**56%**	11%	44%	-	-	11%	44%	-
NB/C	2	**50%**	**100%**	-	**100%**	-	-	**100%**	**50%**	-
NB/WB	8	**50%**	**75%**	-	13%	-	-	-	**75%**	-
NB/NWI	8	38%	**63%**	-	13%	-	-	25%	13%	-
B/WI	8	38%	**88%**	38%	13%	13%	13%	**88%**	**75%**	-
NSI	7	14%	**57%**	14%	14%	-	-	29%	29%	-
SB/SB	9	44%	**56%**	**89%**	**89%**	-	-	-	**89%**	11%
SB/WB	8	**50%**	**50%**	**50%**	25%	13%	-	-	**50%**	-
SB/EC.n	8	25%	38%	**50%**	38%	-	25%	-	25%	-
SB/EC.s	8	38%	**63%**	**100%**	**100%**	13%	-	-	**100%**	**100%**
SB/WC	8	**63%**	25%	25%	13%	25%	-	-	13%	-
SB/SPI	5	**60%**	20%	20%	40%	20%	-	-	**60%**	44%
SB/Dam	8	**50%**	**63%**	-	**88%**	-	13%	13%	**50%**	25%
Lake-wide	105	**41%**	**57%**	**30%**	**39%**	**6%**	**4%**	**18%**	**49%**	**13%**

Code	Common Name	Scientific Name	Indigenous?	Invasive?
BW	Bladderwort spp.	*Utricularia spp.*	Yes	No
EN	European naiad	*Najas spp.*	No	Yes
FW	Fanwort	*Cabomba carolinia*	No	Yes
LLP	Largeleaf Pondweed	*Potamogeton amplifolius*	Yes	Opportunistic
Nit	Nitella (macroalgae)	*Nitella spp.*	Yes	No
RLP	Ribbonleaf Pondweed	*Potamogeton epihydrus*	Yes	No
TG	Tape grass	*Valisnaria americana*	Yes	Opportunistic
VMf	Variable milfoil	*Myriophyllum heterophyllum*	No	Yes
WW	Waterweed	*Elodea canadensis*	Yes	No

Table 7 indicates that the plant species fall into three generally groupings: (1) those species found ubiquitously throughout the lake (naiad, bladderwort, variable milfoil, and largeleaf pondweed); (2) species found mostly in the North Basin (tape grass); and (3) species largely confined to the South Basin (fanwort, stonewort (*Nitella*), waterweed, and ribbonleaf pondweed). These spatial patterns of species presence are mostly likely due to the influence of the winter drawdown separating species according to their ability withstand desiccation and freezing of the rooting substrate and, to a lesser degree, on the substrate type and exposure to wave action. For example, two stations (SB/SB and SB/EC.s) are particularly good habitats for macrophyte growth due to their deep depth (leading to relative immunity from drawdown impacts), soft organic substrate, and physically sheltered locations.

The aquatic vegetation surveys also include a qualitative classification of density or biomass ranging from trace, sparse, moderate and dense for the station or individual species. This additional information was also considered in characterizing the importance of the various macrophyte species in Lake Maspenock and recent trends. In general, biomass density increased from late spring to late summer, as would be expected.

European naiad is the most widely-distributed species in the Lake and forms dense, low mats in many locations, often in association with bladderwort. Bladderwort is widely found but is a small, fragile plant with relatively little biomass. Because of their low growth habit (i.e., not extending into the water column) neither of these two species significantly impairs recreational usage.

Largeleaf pondweed and variable milfoil are found in most survey locations in both North and South Basins, sometimes in very dense patches (e.g., central area of North Basin). Variable milfoil seems to have a slight edge in prevalence and biomass in the 2016-2020 survey records. Both species can pose significant impairment to boating and swimming if too dense and should be considered as potential target species of aquatic vegetation control.

Non-indigenous fanwort invaded Lake Maspenock in the 1970s and has persisted ever since. However, recent surveys demonstrate that this species is definitely negatively impacted by the winter drawdowns (e.g., deep drawdown on winter 2016). Accordingly, it is largely confined to locations in the South Basin which retain water cover throughout the year. Further, most survey observations of this plant indicate either “trace” or “sparse” density (i.e., one or two individual plants) with few large patches, suggesting that the winter drawdowns are successful in largely keeping this species in check.

Tape grass has rapidly increased in coverage in the North Basin in recent years. In locations, this plant is found in dense patches with prominent curling fruiting structures which reach to the surface are particularly prone to fouling boat propellers. The coverage and density of this species should be tracked in future surveys to better characterize the extent of expansion. As noted earlier, other species (stonewort, waterweed) are found at low levels in areas where water depth is little affected by the drawdown. These species pose negligible concern for recreational usage.

2.6. Summary of Current Status of Lake Maspenock

The current status of Lake Maspenock is that of a good quality lake which supports all of its designated uses, both recreational and ecological. The water quality is very good considering the level of development in the watershed with a high number of residential units, significant shoreline development, and the amount of impervious surface. Evidence of good water quality includes low total phosphorus, availability of dissolved oxygen sufficient for a healthy fish community, and good water clarity (often 8-12 ft.) during much of the year. Still, there is some potential for an occasional algal bloom or isolated growths of filamentous algae but these are naturally occurring and do not constitute evidence of increasing cultural eutrophication. Based on data from the 1970s and 80s, water quality is trending to better conditions, probably due to reduction of phosphorus sources in the watershed and more effective storm water management and extension of sewers over much of the watershed.

The shallow depth and rich sediments of Lake Maspenock will continue to sponsor plant growth in the North Basin, in sheltered coves, and in the shallows along shorelines. The aquatic plant community has been dominated by fanwort and variable milfoil for many years, but both have decreased markedly since 2012 due to winter drawdowns. The decline of these invasive species has released seed-bearing plants such as largeleaf pondweed, naiad, and tapegrass to spread to newly-opened bottom areas.

Aquatic vegetation surveys (2016-2020) indicate that the deep winter drawdowns can significantly reduce macrophyte biomass in shallower areas during subsequent years while still allowing growth of sufficient plant cover elsewhere for good ecological balance. However, rebound of increased macrophyte numbers and density may occur if effective drawdown levels are not reached. Even with drawdowns, certain species are expanding so that alternative control options should be considered. The Lake provides many benefits to Hopkinton residents but long-term strategic and sustainable management and protection is needed to ensure these benefits will endure for future generations.

3. CURRENT LAKE USE AND RESIDENT SURVEY

3.1 Current Lake Recreational Use

Lake Maspenock is a central and extremely important recreational resource for the Town and its residents. The Lake provides a large spectrum of active and passive recreational pursuits and is accessible to residents all year-round. Some of the more important recreational features and uses of the Lake include:

- Sandy Beach, a public beach, operated by the Hopkinton Parks and Recreation Department (P&RD), which also provides lifeguards, swimming lessons and other activities along with adjacent playground facilities;
- Resident Boat Ramp, a developed boat launch facility with trailer parking (residents apply for boat launch permits);
- Undeveloped public access, a public easement off West Main Street that allows non-motorized boats to access the Lake for canoeing, kayaking, bird watching, and passive enjoyment;
- Public events, such as the Long Distance Lake Swim, fishing tournaments, ice fishing derbies, the Fourth of July Boat Parade, the Lake Clean Up, and other events; and
- Scenic views from the abutting Peppercorn Hill and Hopkinton Area Land Trust hiking trails.

At the same time, the Lake furnishes protected wetland areas, home to abundant and diverse aquatic wildlife (fish, amphibians, and reptiles). In addition, it provides avian habitats for waterfowl and fishing grounds for bald eagles and osprey, as well as other bird species.

3.2 Hopkinton Resident Survey

The Advisory Group conducted a Hopkinton Resident Survey (the "Survey") in winter 2016. The purpose of this survey was to collect information regarding resident attitudes towards Lake Maspenock, their uses and preferences for recreation, and their thoughts regarding its present condition. At the same time, the Survey provided an opportunity to educate Town residents not familiar with the Lake and its recreational and ecological uses as well as to promote public awareness of the work of the Advisory Group in development of the Lake Management Plan.

The survey was conducted by both electronic (Kwik Survey) and traditional (paper) methods. Survey questions included general questions as to whether Town residents are aware of where the lake is, that the Advisory Group has convened, of ongoing issues regarding excessive weed growth, how residents use the lake and whether they have noticed changes over time.

Notice of the Survey (as well as the public meetings) were distributed by a various media including inserts to local newspaper *(Hopkinton Independent*), posting to the local internet HopNews, postings on Town websites for the DPW, P&RD, and the Hopkinton Conservation Commission, as well as by word-of-mouth. The promotion and distribution of the survey was timed to allow for preliminary results to be available for the two public forums, held, respectively, on February 9 and 27, 2016.

The survey proved quite successful, getting responses from approximately 140 residents and lake users. It provided a good mechanism for getting feedback from the citizens regarding their feelings and aspirations for the Lake. A summary of the Survey results is presented in Table 8. For the Plan revision in 2021, these results were assumed to still be representative of Town residents' current attitudes about Lake Maspenock.

Table 8. Resident Lake Use Survey

1) Do you know where Lake Maspenock is located?	
Yes	138
No	1

2) Do you know where Hopkinton's public Sandy Beach is located?	
Yes	137
No	2

3) Do you know where the Hopkinton public boat ramp is?	
Yes	136
No	5

4) Do you use Lake Maspenock for recreational activities?	
Yes	128
No	12

5) How often do you use the lake for recreation?	
Frequently	89
Occasionally	40
Never	11

6) How do you use the lake for recreational activities?	
Swimming	116
Motor boating	60
Canoeing or kayaking	91
Water skiing or jet skiing	33
Fishing	72
Passive enjoyment such as picnicking	65
Sandy Beach playground	59
Winter sports, such as ice fishing, snow shoeing, cross country skiing	60
Snowmobiles or ATVs	25
Other	

7) Do you know Hopkinton residents can purchase seasonal beach tags and boat trailer stickers at the Parks & Rec. Dept. in Hopkinton Town Hall?	
Yes	128
No	11

8) Do you participate in Hopkinton Parks & Rec. activities at Lake Maspenock?	
Yes	53
No	11

9) Have you noticed a change in your enjoyment of the lake over time?	
Yes	91
No	47

10) If so, do you attribute this to?	
Water quality change	19
Weed density change	73
Personal lifestyle change	2

11) Are you aware of the Hopkinton Town appointed Lake Maspenock Weed Management and Control Advisory Group?	
Yes	119
No	22

12) Are you aware of ongoing issues related to managing weed growth in the lake?	
Yes	133
No	7

13) Are you interested in volunteering to help the current effort to educate Hopkinton residents about lake quality issues?	
Yes	23
No	67
Maybe	43
14) Please enter your name and email address to learn more about volunteering and ongoing public education efforts.	
[Note: a list of potential volunteers was contacted by the Advisory Group by email in April 2016].	

15) Please add your questions and comments here.

3.3 Identification and Prioritization of Lake Management Zones

There is a wide spectrum of physical characteristics, sediment conditions, wave exposure, and macrophyte communities found within the Lake. The Plan took into account these different natural attributes, along with the type and distribution of current recreational usage found in these areas. Accordingly, the Advisory Group found it useful to divide the Lake into lake management zones (LMZs), to facilitate identification of more tailored, cost-effective management options. In addition, the Group classified the areas as to their priority for active management. The original LMZs were reconsidered and refined in the 2021 Plan revision.

3.4 Defining of Lake Management Zones

The LMZs were developed based on several factors including the depth of water, the ecological habitat characteristics of each zone, the area-specific active or passive recreational uses of each area and the intensity of those uses. Initial consideration of these areas in 2016 identified 10 sub-areas. Table 9 provides a general description of the location and boundaries, relevant water uses and characteristics of these sub-areas, and their size (in acres).

The shoreline areas zones were generally differentiated by general basin location (North or South) and the type of shoreline land use (private developed, undeveloped, public use). After the initial identification session, it was decided to identify an additional zone (Zone 10 - The Swamp) due to its unique ecological and protected wetland habitat. The locations of the original 10 sub-areas are shown on Figure 5.

While useful for describing various sub-areas of the Lake In 2016, upon review in 2021, this system was deemed overcomplicated for purposes of lake management; particularly when it was recognized that active aquatic vegetation treatment would likely be restricted to a smaller number of selected areas. Accordingly, the original areas were regrouped into five LMZs (designated A – E). These redefined LMZs zones, boundaries, and the rationale for their inclusion are described below.

- **LMZ A: North Basin Shoreline** – consists of sub-area (#1) which includes the bordering shoreline surrounding the North Basin and the undeveloped public access point located off West Main Street. The boundaries of this LMZ extends to approximately 50 ft. offshore of the land and include numerous private docks and anchorages.

- **LMZ B: North Basin Central Area** - consists of a single sub-area (#2) representing the majority of the Lake within the North Basin. This LMZ extends approximately to the edge of the constricted channel located west of Woody Island. This area is host to many popular recreational uses including boating, fishing, and waterskiing. It has shallow depth and is scattered with many near-surface or submerged rocks that may pose a potential hazard to unwary boaters.

- **LMZ C: Recreation Area** – consists of sub-areas #3 and #4 and extends lake-wide from south of Woody Island to south of Sandy Island. This LMZ contains important recreational features including the Public Beach and Boat Ramp. It is the area of greatest public access to the Lake including boats and craft brought in from outside Hopkinton. This latter feature makes it a particularly important area to monitor and treat as necessary to prevent introduction of non-indigenous nuisance species.

- **LMZ D: South Basin Shoreline** – consists of sub-areas #6 and #8 and constitutes the shoreline residence areas located in the South Basin. These include two stretches in Hopkinton and Milford along the east side of the Lake (separated by private non-developed land) and the shoreline residences south of Peppercorn Hill land preserve in Upton. Similar to LMZ A, the boundary extends to approximately 50 ft. offshore.

- **LMZ E: South Basin and Undeveloped Areas -** this LMZ was created by combining sub-areas #5, #7, and #9 which constitute most of the waters in the South Basin as well as a special habitat (sub-area #10), This LMZ includes the deep central portion of the South Basin, the undeveloped shoreline areas in Hopkinton and Upton, and the large wetland area located to the east of Twin Island Road. This LMZ is characterized as either open space shoreline or wetland areas with limited recreational use or central lake areas where water depth (i.e., >10 ft.) is sufficient to make impairment by aquatic vegetation unlikely.

3.5 Priorities for Weed Management:

The Advisory Group reviewed each of the five management zones with regard to their relative priority and probability for active aquatic vegetation management and categorized them as High, Medium, and Low Priority. For example, the Group examined the natural characteristics and recreational use for each zone and gave a higher priority to those areas with greater public use, tangible recreational benefits, or had specific weed problems in the past. Based on this approach, the North Central Basin Area (LMZ B) and Recreation Area (LMZ C) were given a High Priority classification. These two zones are relatively shallow, contain diverse active and passive recreational uses, are easily accessed and heavily used by Town residents and general public, and have a history of nuisance weed problems.

The North Basin Shoreline (LMZ A) and South Basin Shorelines (LMZ D) include most of the privately-owned shoreline and abutting docks. While these waters are prized by their adjacent private owners, they are less likely to host heavy public use with the exception of an occasional fisherman. These areas were given a Medium Priority. Some lake management activities may occur in these LMZs but it is more likely to be conducted on a residence-specific basis by private homeowners to improve local off-shore conditions. It is important to note that any management activity conducted within the Lake is subject to the Wetland Protection Act and will require a permit application as well as review and approval by the Hopkinton Conservation Commission.

Finally, LMZ E represents those areas of the lake where aquatic vegetation control is very unlikely and thus was categorized as Low Priority. This LMZ includes a variety of different areas in the South Basin where deep water levels making it difficult for aquatic weed growth to extend to the surface, shorelines that are public open space or lack residences, or areas where protected wetland status would preclude vegetation control activities.

Table 9. Sub-Areas and Lake Management Zones within Lake Maspenock.

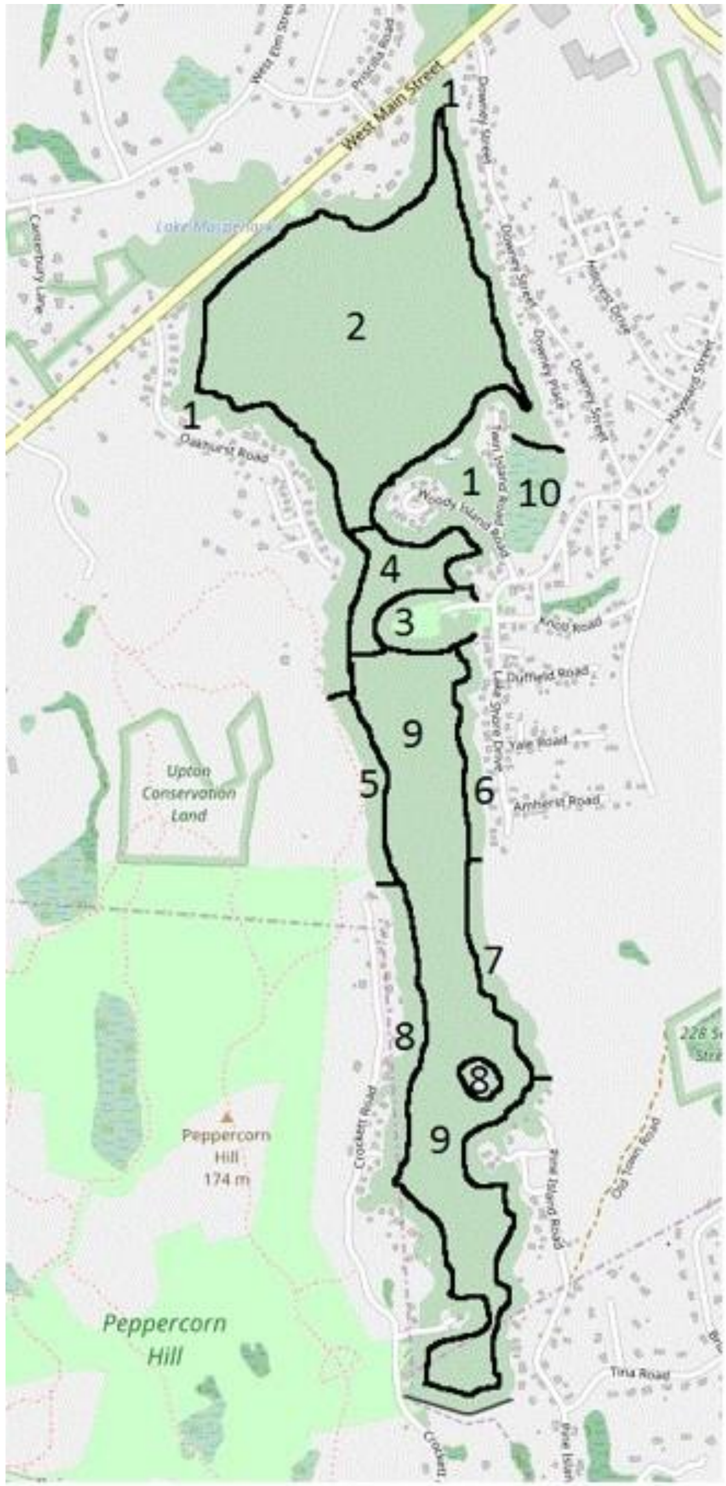
Zone#	Sub-Area Identifier	Description and Boundaries	Water Uses and Characteristics	Acreage	New LMZ
1	**North & Middle Basin Shoreline**	This area includes the area within 50 feet of the shoreline from the boat ramp, all the shoreline along Woody Island and Twin Island (excluding the shallow wetland "swamp" between Downy Place and Twin Island), the shoreline along Downey Place & Street to West Main Street, and all of Oakhurst Road. This also includes the "rock pile".	This shoreline zone has a large number of residences that actively use the shore for recreation including swimming, kayaking, boating, etc. The area is generally shallow with the deepest points being 5 to 8 feet. Many of the residences have docks for their boats as well as provide access for swimming. The bottom varies from rocks to mud with some large boulders. Weeds are often seen on the surface in the summer months and tend to build up along the shore	**17**	**A**
2	**North Basin Center**	This area encompasses the center of the basin to "the pass" on the southern end of the basin. The area is generally 5' to 8' deep with muddy bottom.	This zone is generally used for active recreation including, general boating, water skiing, fishing, kayaking, etc. Weeds are routinely seen on the surface. Motor boats cut the weed tops which tend to float along the edges and into Zone 1.	**94**	**B**
3	**Sandy Beach Shoreline**	This area encompasses the area within 50' of the shoreline from the boat ramp, along Sandy Beach, to the first residence on Lakeshore Drive. A stream heavily influenced by storm water runoff enters the lake next to the boat ramp sometimes creating turbid water conditions.	The boat ramp provides access to the lake. The area is used to access the lake by the public for active recreation (boating) and for passive recreation (kayaking, fishing, and swimming). The bottom varies from mud, gravelly rocks, sand, and occasional boulders.	**2**	**C**
4	**Central Basin Center**	Zone 4 is a transitional basin for boaters to access the northern and southern basins through "the pass". The zone extends from "the pass" to the end of the No Wake Zone fronting Sandy Beach. The basin depth is from 4' to 8'.	The bottom is generally muddy to rocky in nature. Active (boating and fishing) and passive recreation (kayaking) are common. Some weed growth is seen due to the shallow nature of the zone.	**12**	**C**

Table 9. Sub-Areas and Lake Management Zones within Lake Maspenock.

Zone#	Sub-Area Identifier	Description and Boundaries	Water Uses and Characteristics	Acreage	New LMZ
5	**Southern Basin Undeveloped Shoreline WEST**	This area encompasses the area within 50' of the shoreline from the last shore front residence on Oakhurst Road to the first shore front residence on Crockett Road.	This area is characterized by a tree-lined shore with many rocks, boulders and occasional downed trees. Blueberry bushes grow along the edges. The area is extensively used for passive recreation (swimming, kayaking, berry gathering, etc.). The southern portion of this zone experiences frequent waves from boat wakes coming from the Southern Basin Center.	**2**	**E**
6	**Southern Basin Developed Shoreline EAST**	This area encompasses the area within 50' of the shoreline along the shore front residences on Lakeshore Dr. The northern portion has a shallower depth profile transitioning to a steeper slope to the south. Maximum water depth ranges from shallow at the northern end 6' to 10' plus at the southern end.	Many of the residences have docks for their boats as well as provide access for swimming. The bottom varies from sand to mud with occasional rocks and boulders toward the southern portion of this zone.	**2**	**D**
7	**Southern Basin Undeveloped Shoreline EAST**	This area encompasses within 50' of the shoreline from the last residence on Lakeshore Dr. to the first residence on Pine Island Road. This area has a very steep bottom profile with large rocks and boulders. Maximum depth is 15+ feet. This area can experience strong wave action due to boat wakes.	Activities include both active (boating and fishing) and passive (kayaking and swimming) recreation. The area includes a small bay (southern portion) where boaters like to anchor and swim. The bottom is generally rocky with some mud in the southern bay area. Weeds grow actively on the bottom but do not tend to be seen on the surface with the exception of the small bay area.	**2**	**E**
8	**Southern Basin Developed Shoreline WEST**	This area encompasses the area within 50' of the shoreline from the northernmost residence on Pine Island Road, to the dam, and up to the northernmost residence on Crockett Road. This area also includes the shoreline around all the islands in the southern basin. The water depth varies from shallow to deep.	Many residences have docks to access the water for boating as well as swimming. The bottom also varies in nature with areas of rocks, mud, and boulders. Weeds have been a problem in some of the shallow areas especially around and near the southern islands.	**8**	**D**

Table 9. Sub-Areas and Lake Management Zones within Lake Maspenock.					
Zone#	**Sub-Area Identifier**	**Description and Boundaries**	**Water Uses and Characteristics**	**Acreage**	**New LMZ**
9	**Southern Basin Center**	This area encompasses the center of the southern basin from the end of the No Wake Zone in front of Sandy Beach to the dam. The water depth ranges from 8' at the northern end of the zone to 20' at the middle and southern end of the zone.	The zone is extensively used for active recreation (boating, occasional fishing) with some passive recreation (kayaking). Weeds are generally not seen or disturbed by boats due to the depth of the water.	**94**	**E**
10	**The Swamp**	The swamp extends from 16 Downey Place across to 26 Twin Island Road and south to Hayward Street. Much of the zone is either wetlands or narrow shallow channels.	The area is exclusively used for passive recreation (canoeing/kayaking/fishing). The zone sports an abundance of wildlife and vegetation. Some invasive species have been seen growing in this zone.	**1**	**E**

Figure 4. Lake Management Zones of Lake Maspenock



4. AQUATIC VEGETATION CONTROL MANAGEMENT OPTIONS

This section describes the beneficial functions of aquatic plants, identify previous weed management efforts at Lake Maspenock and describes the history and results of the current winter drawdown (see also Appendix A). This section also documents the Advisory Group's review and selection of potential vegetation control options and matching control options to the lake management zones introduced in the previous section. Finally, it provides some specific options for lake management zones, both short-term and long-term vegetation management and discusses a monitoring program to ensure that control options are restorative and cost-effective.

4.1. Introduction

Aquatic macrophytes are an important part of a healthy, diverse lake ecosystem. Aquatic plants provide many of the same functions as terrestrial plants. Not all aquatic plants are nuisances which require removal. Some of the beneficial functions that aquatic macrophytes provide include:

- Habitat and food for fish, invertebrates, amphibians, and waterfowl;
- Food for other wildlife and mammals;
- Spawning medium for many fish, invertebrates, and amphibians;
- Dissolved oxygen production;
- Attenuation of wave energy and protection of lake bottom and shorelines;
- Stabilization of temperature, light, and ecosystem function;
- Nutrient recycling and slowing of sediment transport; and
- Emergent vegetation provides a habitat for certain songbirds or wading birds who may nest at these sites or use them as feeding areas.

However, the balance between the aquatic plant community and other aquatic organisms may be disrupted when invasive, non-native plants are introduced to lakes and become nuisance aquatic weeds[9]. Problems occur because the invasive species growth habit and lack of native predators enable it to produce and maintain large, dense populations very rapidly. Weedy aquatic plant species can increase dramatically, out-compete diverse natural vegetation, and alter fish and wildlife habitat and activities. This excessive growth can be responsible for:

- Deterioration of fish and wildlife habitat;
- Potential loss of habitat for threatened and endangered fish, wildlife, or other aquatic species;
- Deterioration of wetlands and water quality;

[9] A weed is any plant growing out of control and at the expense of other plants or animals, or one that is unwanted in an area or ecosystem.

- Diminished water surface area for recreational activities such as fishing and boating;
- Reduction of property value adjacent to the deteriorated aquatic habitat;
- Impeding commercial navigation;
- Blocking pumps, sluices, and industrial, agricultural, and domestic water supply intakes; and
- Flooding, increased silting, and reduced reservoir capacity.

Aquatic vegetation management and control is often required to restore balance when non-indigenous, plants invade and dominate the ecosystem. As evidence by recent events in the Lake, even native vegetation (e.g., largeleaf pondweed) can grow to nuisance levels in some circumstances, requiring control and management.

4.2. Previous Weed Management and Lake Drawdown

Excessive aquatic vegetation, dominated by invasive species, has been a long-standing issue in Lake Maspenock for at least 40 years. The 1974 aquatic vegetation map indicated dense stands of fanwort and variable milfoil (JCA 1979). A MA DFW description of the lake (circa 1980) reported aquatic vegetation to be "common to abundant" and "appears to be increasing steadily."

No definitive information was available regarding aquatic vegetation control practices prior to the 1970s although there is some suggestion that sodium arsenate was used (JCA 1979). M&E (1987) reported that Silvex and 2,4-D were used to control the weeds in the 1970s. [Note: the use of Silvex for aquatic applications was rescinded by the US EPA in 1983]. Both D/F studies conducted macrophyte surveys and provided species inventories (see Table 5). Lake vegetation was surveyed again in comprehensive biological surveys conducted in 2003 and 2007 by Aquatic Control Technology (ACT) of Sutton, MA. The scope and nature of the invasive weed infestation is well recognized and various means to control were discussed and considered (LMPA 2015). A proposed use of chemical herbicide treatment to reduce aquatic vegetation in Summer 2015 was approved by the Hopkinton Conservation Commission but was ruled out by the town meeting process.

The purchase of the Lake Maspenock dam by Hopkinton in 2007 led to investigation of modification of the annual water elevation drawdown to provide greater nuisance weed control. Lake winter drawdowns are an effective means of controlling many non-native macrophyte species including fanwort and milfoil species (Cooke et al. 1993). For example, Lonergan et al. (2014) found that exposure of dewatered milfoil plants for two consecutive days at -5ºC (23ºF) was sufficient to kill both roots and shoots.

Table 10 presents the response to winter drawdown of many of the macrophyte species reported for Lake Maspenock. As shown in Table 10, some species decrease in abundance following drawdown, while other species increase, and some plants and algal taxa show little or no response.

In 2009, the Hopkinton Conservation Commission approved and conditioned the notice of intent (NOI) under the Wetlands Protection Act to include both the normal and a more extensive ("deep") drawdown for invasive weed control. The deep drawdown was to be conducted on a three-year schedule using the procedures described in the Lake Maspenock Dam Operations & Maintenance Manual (PA 2003) which stipulated that the impoundment should be drawdown at the end of October to El. 345.5 and returned to normal pool El. 348.0 in April, using low level outlet to lower the level of the impoundment to the drawdown elevation. In order to maintain this elevation, the low-level gate may be regularly adjusted to regulate the level of the impoundment. Further, all orders of conditions for implementing drawdowns should be reviewed periodically to ensure compliance and renewed as required.

The first extensive drawdown was conducted in late 2011 through early 2012, resulting in a water level reduction of approximately 7 feet (LMPA 2015). In the Summer 2012 growing season, the aquatic vegetation was "markedly improved" with a drastic reduction of the fanwort and milfoil biomass in the lake, with no apparent negative effects on other life forms in the lake (ACT 2012). However, in the summers that followed (2013 and 2014), the native largeleaf pondweed (*Potamogeton amplifolius*) population exploded, becoming widespread and dense enough to impact recreation (LPMA 2015).

A second more extensive drawdown was attempted during Winter 2013-14. Weather conditions prevented the drawdown from being fully implemented with the lake level brought down by about 5 feet. This second "deep" drawdown was much less effective in reducing biomass, such that largeleaf pondweed coverage and density increased and greatly impacted recreational use in shallow parts of the lake.

Table 10. Selected Macrophyte Species: Response to Winter Drawdown.

Plant Name	Species Name	Decreased Abundance	No change or trend	Increase in Abundance
Fanwort	*Cabomba caroliniana*	**X**		
Variable watermilfoil	*Myriophyllum heterophyllum*	**X**		
Largeleaf Pondweed	*Potamogeton amplifolius*			**X**
Naiad species	*Najas flexilis*			**X**
Ribbon-leaf Pondweed	*Potamogeton epihydrus*			**X**
Brazilian elodea	*Egeria densa*	**X**		
Waterweed	*Elodea canadensis*			**X**
Tape Grass	*Vallisneria americana*		**X**	
Bladderwort	*Utricularia* spp.		**X**	
Stonewort	*Nitella* spp.		**X**	
Watershield	*Brasenia schreberi*	**X**		
White Waterlily	*Nymphaea odorata*	**X**		
Spatterdock	*Nuphar advena*	**X**		
Filamentous Algae	Various species		**X**	

Response information adapted from Cooke et al. 1993.

Due to the poor results achieved by the second “deep” drawdown, the Hopkinton Conservation Commission allowed another, earlier (one year ahead of schedule) deep drawdown in Fall 2015-Winter 2016. The third deep drawdown was able to reach and maintain the target elevation of 8 ft. below normal pool elevation for an extended period including cold spells in February 2016. Figure 5 is an aerial photographic overflight conducted in January 2016 which indicates the extensive area of lake bottom that was exposed by this deep drawdown; particularly in the North Basin and along shoreline areas including.

Figure 5. Lake Maspenock Winter 2015-2016 Drawdown Condition

Sandy Island public beach. Note the general lack of snow cover in the dewatered lake basin which, when present, may protect dewatered plants and prevent lethal soil temperatures.

Qualitative surveys of the macrophyte community conducted by the Advisory Group in June and September 2016 (see Appendix C), indicated that the drawdown had achieved considerable success in knocking back both the coverage and the density of the nuisance species (fanwort, variable milfoil, and largeleaf pondweed).

Subsequently, the CIG conducted late spring and late summer aquatic vegetation surveys during 2017-2020, over that period, macrophyte density increased to nuisance levels in several areas of the North Basin by summer 2019. The deep winter drawdown in 2020 was prevented due to issues regarding a private water well potentially affected by a drop in lake elevation. In spring 2020, the DPW submitted a NOI application to the Hopkinton Conservation Commission for an aquatic vegetation control treatment plan using herbicides but this NOI permit application was denied by the Commission in May 2020.

The effectiveness and impact of the winter drawdowns over the last 11 years was analyzed in more detail using information recorded by the Hopkinton DPW. Table 11 summarizes the record of the various winter drawdowns conducted between 2010 and 2021 based on the water level elevations at the Hopkinton Dam (pers. comm. Eric Carty, Hopkinton DPW, 2021). These data records also include incidental information on gate valve position, major precipitation events, and other relevant factors influencing drawdown operation (e.g., gate repair work, downstream considerations). Table 11 presents the maximum drawdown depth achieved (equates to minimum water level), the winter date it was achieved, and the number of days of relative low water (as approximated by the number of consecutive days water elevations stayed within 10 percent of maximum drawdown depth[10]). For deep drawdown years (i.e., drawdown target elevation of 8 ft. lowered), the number of days the water level stayed below 6 ft. was noted as was the average daily temperature (as approximated by daily temperatures recorded in Auburn, MA[11]). Table 11 also indicates the date of complete Lake refill to the dam spillway crest elevation and the number of days it took to achieve refill from the date of the target drawdown depth.

Table 11 is instructive in that it demonstrates how much variability exists between drawdown years. The DPW records indicate that drawdown is usually started between mid-September and mid-October and continued until the target depth is reached (or as close as feasible). The Lake is then allowed to refill by closing the gate and letting natural precipitation and runoff fill the basin. However, differences in the weather and precipitation from year to year dictated how quickly the target depth was reached (if at all), as well as the timing and duration of low water. For some years, the drawdown and refill period were rapid (e.g., 2016-17) while in other years, maximum drawdown was not reached until late winter and water levels fluctuated considerably before refill (e.g., 2018-19).

[10] It should be noted that due to fluctuations in the maximum drawdown depth, the elevation associated with the 10% reduction "low water" conditions varied from year to year. This variability is the reason that the low water period could be lesser or greater than the number of days when absolute water depth ≥ 6 ft.

[11] Daily average air temperatures were downloaded from https://www.auburnweatherlive.com/wxhistory.php.

Table 11. Lake Maspenock Winter Water Level Drawdowns (2010-2021).								
Year	Type	Max. depth[1] (ft)	Date of Max Depth	Days Low Water[2]	Days depth > 6 ft[3]	Avg. Temp (F^{o})[4]	Date of Complete Refill	Days until Refill[5]
2010-2011	Regular	4.2	1/3	63	-		4/21	108
2011-2012	Deep	6.2	1/4	17	11	30.5°	5/23	139
2012-2013	Regular	3.8	1/13	80	-		4/23	100
2013-2104	Regular	5.0	12/23	26	-		4/20	118
2014-2015	Regular	4.2	1/23	46	-		5/8	105
2015-2016	Deep	8.2	12/14	50	65	34.2°	4/22	129
2016-2017	Regular	4.7	1/1	15	-		4/10	100
2017-2018	Regular	4.6	2/8	23	-		4/27	78
2018-2019	Regular	4.7	2/4	52	-		5/23	86
2019-2020	Regular	5.2	12/9	50	-		4/15	127
2020-2021	Deep	7.3	2/1	23	33	24.1°	6/14	133

1 = maximum depth of drawdown measured at Hopkinton Dam outlet (DPW records)

2 = number of consecutive days that water stayed within approximately 10% of maximum drawdown depth

3 = number of consecutive days that water drawdown depth was equal to or greater than 6 ft.

4 = average daily temp recorded at Auburn, MA during period when drawdown depth equal to or greater then 6 ft.

5 = number of days between matching target depth and water spilling at gateway.

As expected, the hydrologic fluctuations are greater for those of a deep (i.e., 8 ft.) drawdown. Deep drawdowns can be highly effective in reducing plant growth in the North Basin if target drawdown depths are achieved and severe winter conditions occur during periods of low water. As noted above, the winter 2015-16 drawdown was highly effective in suppressing aquatic vegetation growth in subsequent growing seasons. This was attributable to a combination of a deep maximum drawdown depth, a long low water period, a lengthy period when water level was below 6 ft., and low air temperatures. In contrast, the 2011-12 drawdown lacked sufficient depth and duration to desiccate and freeze target vegetative propagules in the dewatered sediments despite low temperatures.

By looking at such factors it may be possible to make some preliminary predictions at the growth potential for the coming growing season. For the most recent deep drawdown (winter 2020-21), the depth and duration of low water, coupled with very low average temperatures (i.e., 24.1ºC) during period of sediment exposure, may bode well for better than average control of aquatic vegetation in the 2021 growing season. The strength of this prediction will be evaluated by the late spring 2021 aquatic vegetation survey results.

4.3. Identification of Potential Vegetation Management Options

4.3.1. Overview

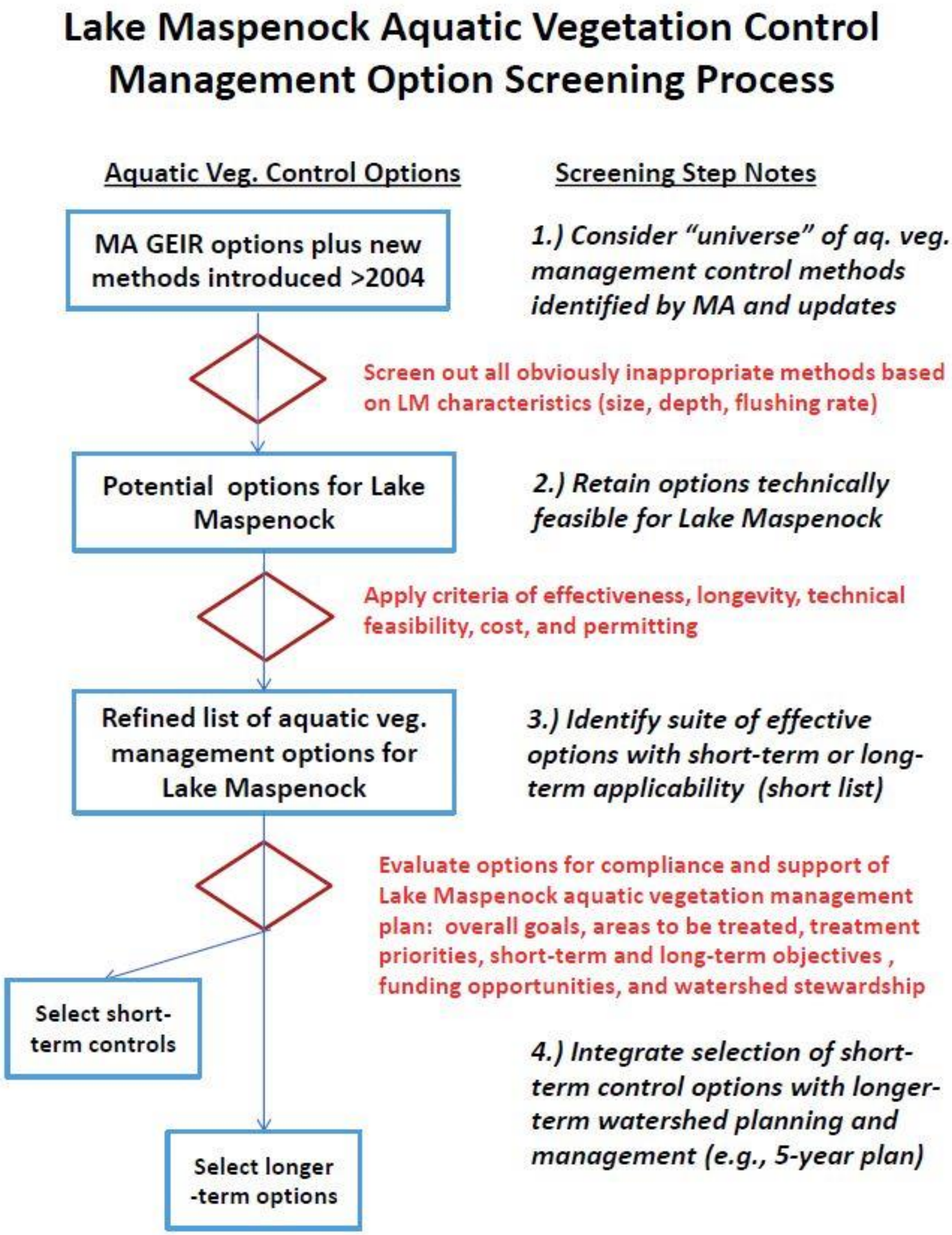
As noted earlier, the Advisory Group was tasked with finding a workable, long-term solution for treatment of the Lake's nuisance weeds and protection of lake conditions. The Group conducted this search with an open-minded approach and considered a wide variety of potential physical, chemical, and biological options. This approach also included keeping the public well-informed by transparent decision-making, educational public meetings, and soliciting resident feedback (see Section 3.2).

A preliminary screening was conducted to weed out and eliminate those options that were clearly not feasible, not effective, or too costly for use on Lake Maspenock. The results of the initial screening process were presented to Town residents in two public forums conducted in February 2016 (see Appendix F). The management options which passed the preliminary screening were further reviewed and investigated by the Advisory to select those best suited for Lake Maspenock. This selection focused on several key factors:

- Feasibility – is this option possible to conduct on Lake Maspenock?
- Effectiveness – how well does the option work in other lakes?
- Human health and ecological effects – does the option pose human and environmental risk?
- Cost – what is the estimate cost of the option (total or $/per acre)?
- Longevity of treatment – how long would the beneficial effects of the option last?
- Compatibility with other options – does it complement the beneficial effect of other options?

The Advisory Group also recognized that there was no "one-size-fits-all" option for all of the zones of interest and that a suite of options dealing with various degrees of control is appropriate. Final options will include both short-term and long-term management as well as monitoring of the Lake plant community. The Group expects the lake management plan to adapt and evolve over the long-term as various options are tested and evaluated. A schematic flow chart illustrating the Group's general approach to selected aquatic vegetation management options is provided in Figure 6.

Figure 6. Lake Maspenock Aquatic Vegetation Control Management Options Screening Process.



4.3.2. Sources of Information on Management Options

Information regarding potential aquatic vegetation control and management is widely available and easily accessed. An excellent, but now somewhat dated, general compendium of techniques, project experiences, advantages and disadvantages, and permitting requirements specific to Massachusetts is presented in the *Eutrophication and Aquatic Plant Management in Massachusetts. Final Generic Environmental Impact Report* (GEIR) (EOEA 2004). Aquatic vegetation management options are also summarized in *The Practical Guide to Lake Management in Massachusetts* (Wagner, 2004), a companion guide to the GEIR. Further, MA DEP (2004) provided *Guidance for Aquatic Plant Management in Lakes and Ponds: As it relates to the Wetlands Protection Ac*t. (MA DEP Policy/SOP/Guideline #BRP/DWM/WW/G04-1).

With regard to information regarding the registration and use of aquatic herbicides in Massachusetts, we consulted the Department of Agricultural Resources website (MA DAR 2021) for information on aquatic vegetation control at: https://www.mass.gov/herbicides-for-aquatic-vegetation-management. This site provides updated information and resources regarding herbicide active ingredients and products that have been approved for use in lakes and ponds in Massachusetts with detailed toxicity and environmental fate profiles for each of the registered pesticides.

In addition, aquatic vegetation control management guidance is widely available from the scientific literature, on websites of state regulatory agencies, non-profit lake associations, and commercial lake management companies. Some of the more informative and useful references included:

- Cooke, et al. 1993. Restoration and management of lakes and reservoirs 2nd edition;
- Gibbons et al. 1999. Guide for Developing Integrated Aquatic Vegetation Management Plans in Oregon;
- Masser, M., Murphy, T. and J. Shelton. 2013. Aquatic Weed Management: Herbicides. Southern Regional Agricultural Center (SRAC) Publication No. 361;
- McComas, S. 2011. Literature Review on Controlling Aquatic Invasive Vegetation with Aquatic Herbicides Compared to Other Control Methods: Effectiveness, Impacts, and Costs. Blue Water Science;
- Osgood, D. 2015. Do You Want Something that Works? LakeLine 35(1): 8-15;
- Washington Department of Ecology (WA DOE). General Permits: About Pesticides Currently Allowed for Use Under Permit in Washington Waters. (website); and
- Wisconsin Department of Natural Resources Aquatic Plant Management Fact Sheets located at: https://dnr.wi.gov/lakes/plants/factsheets/.

Additional references and documents are listed in the Section 7.0 References.

The potential aquatic vegetation management and control methods provided in the Massachusetts GEIR (EOEA 2004) are divided up into into three broad categories – physical, chemical and biological treatments. Table 12a presents the physical options, with a brief description of the mode of action, along with alternative approaches. Table 12b presents similar information chemical and biological options. The numeric listing used for the tables approximates that used by the Massachusetts (2004) GEIR.

Table 12a. Types of Physical methods for aquatic vegetation control and management.

MA GEIR Designation	Alternative Approaches	Basis mode of action
1. Benthic Barriers		Mat of variable composition laid on bottom of target area, preventing growth; can cover area for as little as several months or permanently; usually applied around docks, in boating lanes, and in swimming areas.
1.a	Porous Materials	
1.b	Non-Porous Materials	
1.c	Sediment Barrier	
2. Dredging		Sediment is physically removed by wet or dry excavation, with deposition in a containment area for dewatering/disposal. Plants and seed beds are removed and regrowth limited by light and/or substrate limitation. Due to high costs and significant permitting requirements, dredging is used only on severely impacted lakes.
2.a	"Dry" excavation	
2.b	"Wet" dredging	
2.c	Hydraulic dredging	
3. Dyes and surface covers		Water soluble dye is mixed with lake water, thereby limiting light penetration and inhibiting plant growth. Dyes remain in system until diluted or photodegraded.
4. Mechanical harvesting		Plants cut or removed by mechanical means, usually with some disturbance of the sediments. Collected plants transported to shore for dessication, composting, or other disposal. Range of techniques includes manual, diver assisted, and mechanized.
4.a	Hand-pulling	
4.b	Cutting (no collection)	
4.c	Cutting (w/ collection)	
4.d	Rototilling	
4.e	Hydroraking	
5. Water Level Control		Lowering or raising the water level to create an inhospitable environment for aquatic plants. Disrupts plant life by dessication, freezing, or light limitation.
5.a	Drawdown	
5.b	Flooding	

Table 12b. Types of Chemical and Biological methods for aquatic vegetation control.		
MA GEIR Designation	**MA Registered Herbicides**	**Target Species**
CHEMICAL CONTROLS		
6. Herbicides		
6.a	Copper-based	Targeted for algal control
6.b	Diquat	Broad-spectrum (MF, PW, Na, FW) - spot
6.c	Endothall	Broad-spectrum; (MF, PW, Na) - spot
6.d	Florpyrauxifen-benzyl	Selective (MF)
6.e	Flumioxazin	Broad-spectrum herbicide; (FW,MF,PW)
6.f	Fluoridone	Broad-spectrum (MF, PW, Na, FW) lake trtmt
6.g	Glyphosate	Only for floating-leaved and emergents
6.h	Imazamox	Selective (PW)
6.i	Imazapyr	Only for floating-leaved and emergents
6.j	Penoxsulfam	Not registered in MA
6.k	Peroxide-based	Targeted for algal control
6.l	Triclopyr	Selective (MF)
6.m	2,4-D	Broad-spectrum herbicide (MF)
	(spp. code: FW = fanwort; MF = milfoils; Na = naiads; PW = pondweeds)	
BIOLOGICAL CONTROLS		
7. Biological Introductions		
7.a	Herbivorous fish	Not legal in Massachusetts
7.b	Herbivorous insects	
7.c	Bacterial/viral pathogens	Not tested as a plant control option
7.4	Selective plantings	Not feasible as a control option

4.3.3. Initial Screening of Management Options

The Advisory Group conducted an initial screening of vegetation control options to remove those that were obviously not appropriate for Lake Maspenock. The results of this screening are presented in Table 13a (physical controls) and Table 13b (chemical and biological controls).

Vegetation management options that were screened out are identified and the reason for their elimination given. The reasons for eliminations were varied and included consideration of lake size or volume, the ability to permit the action, ineffective treatment of target macrophytes or other clearly apparent factors. The methods that passed this initial screening were considered further.

Table 13a. Preliminary Screening of Physical Methods

PHYSICAL CONTROLS			
GEIR Designation	Method Description	Passed 1st Screen	Rationale for Screened Out Option
1. Benthic Barriers			
1.a	Porous Materials	**Yes**	
1.b	Non-Porous Materials	**No**	Sheets often pull up due to gas build-up
1.c	Sediment Barrier	**No**	Filling in lake basin not permitable
2. Dredging			
2.a	"Dry" excavation	**No**	Lake can't be completely drained, permits
2.b	"Wet" dredging	**Yes**	
2.c	Hydraulic dredging	**Yes**	
3. Dyes and surface covers		**No**	Surface area of lake is too large
4. Mechanical harvesting			
4.a	Hand-pulling	**Yes**	
4.b	Cutting (no collection)	**No**	Biomass can decay, reduce DO
4.c	Cutting (w/ collection)	**Yes**	
4.d	Rototilling	**No**	Not used for nuisance plant control
4.e	Hydroraking	**No**	Used for deep rooted plants (e.g., waterlily)
5. Water Level Control			
5.a	Drawdown	**Yes**	
5.b	Flooding	**No**	Flooding affects shoreline residences

Table 13b. Preliminary Screening of Chemical and Biological Methods.			
GEIR Designation	Method Description	Passed 1st Screen	Rationale for Screening Out Option
6. Herbicides			
6.a	Copper-based	**No**	Targeted for algal control
6.b	Diquat	**Yes**	Broad-spectrum (MF, PW, Na, FW) - spot
6.c	Endothall	**Yes**	Broad-spectrum; (MF, PW, Na) - spot
6.d	Florpyrauxifen-benzyl	**Yes**	Selective (MF)
6.d	Flumioxazin	**Yes**	Broad-spectrum herbicide; (PW PW, Ca)
6.e	Fluoridone	**Yes**	Broad-spectrum (MF, PW, Na, FW) lake tr
6.f	Glyphosate	**No**	Only for floating-leaved and emergents
6.g	Imazamox	**Yes**	Selective (PW)
6.h	Imazapyr	**No**	Only for floating-leaved and emergents
6.i	Penoxsulfam	**No**	Not registered in MA
6.j	Peroxide-based	**No**	Targeted for algal control
6.k	Triclopyr	**Yes**	Selective (MF)
6.l	2,4-D	**Yes**	Broad-spectrum herbicide (MF)
7. Biological Introductions			
7.a	Herbivorous fish	**No**	Not legal in Massachusetts
7.b	Herbivorous insects	**Yes**	
7.c	Bacterial/viral pathogens	**No**	Not tested as a plant control option
7.4	Selective plantings	**No**	Not feasible as a control option

4.3.4. Further Screening of Management Methods

The Advisory Group further considered the results of the initial screening to refine the list to those options which are best suited to Lake Maspenock and the nature of the lake management zone. The following options were eliminated at the second round of investigation: dredging, several herbicides, and biological controls. The reasons for rejection are briefly summarized below.

Dredging

The removal of sediment from Lake Maspenock was one of the recommendations of the M&E (1987) study. They proposed removal of the top 4 ft. of sediment from 95 acres (primarily in North Basin) for a total removal estimate of 610,600 cubic yards (CY) that would be hydraulically dredged over a period of several years. The 1987 cost estimate of $4.6 million (M) was based on overall removal cost of $4.0 /CY and assumed construction of large containment basins for dewatering and treating the return flow of the dredge sludge. This approach was rejected for a variety of reasons:

- The cost to perform dredging in Massachusetts was conservatively estimated in 2016 at $15-$20 /CY. These increases have come about due to inflation, increased cost of disposal, and much stricter environmental permitting. This would put the present costs on the order of at least $9.2 M to $12.2 M. It was assumed that costs would likely be significantly greater in 2021;

- Dredging of the top 4 ft. of sediment does not remove all of the organic material that plants like to root in (i.e., does not get down to a hard sand or gravel layer) and increasing water depths to 9 to 12 ft. would not place the plants out of the photic zone which receives sunlight. In other words, favorable conditions for plant growth would still exist;
- More sediment boring and depth measurements and testing would be required. For example, USEPA New England can require testing of sediment at a frequency at one sample per 1,000 CY at about $250/sample just for permitting processes;
- Due to the steep shoreline and existing land use, it would be difficult to site the 12-acre detention basin proposed by M&E in close proximity to the lake. The site proposed by M&E (land near the MA Department of Transportation salt storage unit) is probably not feasible due to current activity and potential impacts to downstream wetlands;
- The concept that "volunteers" would be capable and willing to dig out and take away the silt from the detention basin is unrealistic; and
- Comparing the results from the limited sediment testing by M&E (1987) indicated that two of the four samples exceeded the MA DEP Beneficial Use Determination (BUD) Soil 1 Category /GW 1 for mercury, lead and zinc). While this is the most stringent category, it suggests that sediment chemistry may reduce the potential reuses of the dewatered material (EOEEA 2016b).

Herbicides

The Advisory Group considered further the wide array of aquatic herbicides that passed the initial screening, namely aquatic herbicides with active ingredients including Diquat, Endothall, Florpurauxifen-benzyl, Flumioxazin, Fluoridone, Imazamox, Triclopyr, and 2,4-D. The Group made a detailed study of these pesticides based on the MA fact sheets as well as federal and state reviews of the pesticides. The Group focused on the specific properties of these herbicides, including effectiveness against target species, potential human and ecological risks, mode of application, and other considerations. From this review, the following herbicides were eliminated from current planning:

- Flumioxazin – this broad-spectrum herbicide was rejected since it mostly effective against Eurasian water milfoil and less effective against variable milfoil, pondweeds *(Potamogeton* spp.), or fanwort;
- Fluoridone - this broad-spectrum herbicide can successfully treat all the nuisance species (fanwort, milfoil, largeleaf pondweed), but requires a whole lake treatment requiring several days' retention of water (no spilling over dam) and restricted recreation activities during that period. The Group considered that any use of herbicide will be on an area-specific basis and a whole lake treatment is not appropriate;
- Imazamox – this systemic herbicide was rejected since it mostly effective against Eurasian water milfoil and less effective against variable milfoil, pondweeds (Potamogeton spp.), or fanwort;

- Triclopyr - this systemic herbicide was rejected since it is effective against milfoil but not against pondweeds or fanwort; and
- 2,4-D - this broad-spectrum herbicide was rejected since it is effective against milfoil but not against fanwort or water milfoil. This active ingredient also has a certain notoriety with the public due to historic use in defoliants.

Based on this review, endothall, florpyrauxifen-benzyl, and diquat were retained, based on their effectiveness against target species and ability to treat smaller areas and not the whole lake. Both endothall and diquat can successfully treat all the nuisance species including largeleaf pondweed and fanwort. They are also sometimes combined as a blended treatment. Registered in Massachusetts in 2019, florpyrauxifen-benzyl has been shown to be very effective in targeting milfoil species.

Biological control

The biological control of using herbivorous insects was also reviewed and rejected by the Advisory Group. There has been some limited success with the introduction of large numbers of weevil insects to reduce nuisance aquatic weeds. For example, the milfoil weevil, *Euhrychiopsis lecontei*, has been associated with declines of Eurasian watermilfoil (*Myriophyllum spicatum*) in certain lakes in the U.S., including Vermont and the Midwest. However, this approach was rejected for the following reasons:

- The approach is costly since large numbers of weevils have to be cultured in controlled laboratory settings and released into the lake. These populations are generally not self-sustaining in New England so that new introductions are likely to be needed in successive years;
- Reliability is uncertain as some treatments have had little or no effect of plant density possibly due to adverse effects of climate and/or predators (fish). The consensus of treatment results indicates that, at best, most treatments provide low to moderate gains;
- The density of variable milfoil in Lake Maspenock has been reportedly high during certain years in selected but separate areas but other nuisance weeds are also present. The weevils work best when there is a dense monoculture of Eurasian watermilfoil in a confined area since the weevils have limited dispersal capabilities; and
- This approach would be very difficult to sustain on a lake the size of Lake Maspenock, would not address other target species, and there are more direct and cost-effective ways to control the plants.

4.3.5. Potential Aquatic Vegetation Control Options

Based on the review of potential vegetation control options, the Advisory Group selected the following methods for application: benthic barriers, hand-pulling (including diver-assisted suction harvesting), mechanical harvesting, drawdown, and herbicides. Where costs are provided, they should be considered very approximate and preliminary. Actual costs will be developed by lake treatment firms on a size, season, and area-specific basis. The cost of the treatment products and labor do not reflect the cost of application for and approval of a permit by the Hopkinton Conservation Commission. Descriptions and detailed information on these methods are provided below and in Appendix E.

Benthic barriers

Manufactured benthic barriers are negatively buoyant materials, usually in sheet form, including polyethylene, polypropylene, fiberglass, and nylon, which can be applied on top of plants to limit light, physically disrupt growth, and allow unfavorable chemical reactions to interfere with further development of plants (Perkins et al., 1980). Benthic barriers can be an effective treatment for the control macrophytes in small, localized areas of a lake like a dock, boat launch, or a swimming beach, but are generally not practical for use in large areas (greater than several acres) as a consequence of cost and maintenance requirements (EOEA, 2004). This method is usually considered a low impact treatment and is easily permitted under the Massachusetts Wetland Protection Act (WPA).

Barriers are an effective and fairly rapid method to achieve a plant free water column in localized areas. The barriers need to be weighted down and affixed to the bottom with stakes or similar anchors. They are more effective if applied early in the season and maintained by removal and cleaning on a regularly basis. If no maintenance is performed, sediment accumulates on top of the barriers, allowing rooting of aquatic macrophytes. Regular visual surveys can be conducted of the benthic barriers to determine if weed growth is occurring on or through the barrier(s).

Current cost estimates for benthic barriers were established in 2021 by contacting a local lake management company (SOLitude) and reviewing prices on vendor websites. Benthic barriers come in large rolls of variable dimensions (e.g., 7-10 ft. wide; 30-100 ft. long) with prices per square foot ranging from $0.75 to $1.50/sq. ft., with the higher priced product including rebar weights sewn into material. For purposes of costing, the Advisory Group estimated an average cost of $1.10/sq. ft. or $48,000/acre. However, this treatment is usually only installed on much smaller areas (e.g., 1/10th to ½ acre). The cost covers the initial application but does not include recommended maintenance and annual removal after the summer season. If simply installed and left in the lake, benthic barriers can be silted over and plants may develop on top of or grow through the barrier within 3-5 years.

Hand-pulling

Hand-pulling or hand-harvesting is the selective removal of unwanted plants on an individual basis (EOEA 2004). It is very labor-intensive and may be conducted in shallow water by waders and in deeper waters by divers. This latter method is referred to as diver assisted suction harvesting or DASH.

Hand pulling of localized populations can be extremely effective in removing small populations of nuisance plants provided the plant fragments are removed from the water (EOEA 2004). Hand pulling can also effectively address non-dominant growths of undesirable species in mixed assemblages, or small patches of plants targeted for removal. This technique is not suited to large-scale efforts, especially when the target species or assemblage occurs in dense or expansive beds.

In areas where just a few plants are established, pulling those plants by hand can be an effective approach with minimal impact to any non-target organisms. Repetition of this approach is likely to be needed, as not all targeted plants may be found during the initial effort, or if there is a need to harvest plants growing from seed deposits. Macrophytes can be surveyed following the same protocols as or as part of the monitoring described below.

Costs of hand-harvesting are very variable ranging from little to no cost for volunteer efforts in shallow waters to over $2,000/day for two DASH divers and boat crew. A proposal for treatment of Lake Maspenock from AB Aquatics (9/15/15) provided cost estimates for two divers to cover 3.15 acres in 6-9 days ($13,800-$18,000); 15 acres in 30-40 days ($63,600- $84,800); and 150 acres in 300 days over two growing seasons ($636,000). It is likely that these costs have only increased in the intervening five years. Due to the high costs of DASH, the Advisory Group would consider this approach only for very limited areas of the Lake or in response to introduction of a new invasive species to the Lake.

Mechanical harvesting

Mechanical plant removal operations are successful in producing at least temporary relief from nuisance plants and in removing organic matter and nutrients without the addition of a potentially deleterious substance (EOEA 2004). Harvesting can be an effective short-term treatment to control the growth of aquatic plants. With repeated application at appropriate intervals, it can produce long-term shifts in the plant community, but it is unlikely to reduce long-term plant density substantially. Harvesting is generally used seasonally to remove vegetation that limits lake uses such as boating and swimming.

Mechanical harvesting has variable success depending on the nature of the dominant species and its means of reproduction. It is usually timed to control early summer growth and is conducted at a moderate depth (e.g., 3-7 ft.). If properly conducted and timed, it can be effective in reducing biomass and seeds for next year’s growth. It can provide a predictable if somewhat ineffective means to reduce biomass in areas of the Lake heavily used for recreation. However, mechanical harvesting has a poor record with invasive species such as fanwort or milfoils due to the rapid plant biomass regrowth (days or weeks) and the potential for spreading of the plants to new areas through re-rooting of plant fragments.

Given the historic prevalence of fanwort and milfoil, harvesting should not be considered the primary means of aquatic plant control in Lake Maspenock. In addition, particular care will be required in operating a harvester in the North Basin due to the numerous boulders and rock piles at or near the surface. However, it can be integrated with other measures (e.g., hand-harvesting, drawdown, herbicide) to control plant biomass and increase recreational usage. The most effective use of this method may be to create boating lanes or clear areas of heavy recreational usage. It is also an alternative to be considered in the event that the recommended herbicide spot treatments are not able to be conducted. The success of harvesting would be evaluated as part of the regular monitoring of aquatic vegetation.

Costs for mechanical harvesting were established by contacting a local lake management company (SOLitude) in 2021. Costs will vary with the area, depth, and size of harvester employed. Typical cutting rates would be 1-2 acres/day for a mid-sized harvester (plus labor) costing $1,800/day with a one-time mobilization ($2,500) cost. A second harvester/transporter can be used to increase efficiency of cutting by reducing travel time to offload cut material. It is also important to note that removal and disposal of cut vegetation from the Lake would be required for any harvesting program but specific unloading and disposal areas were not identified by the Group and would need further investigation.

Drawdown

Drawdown is a multipurpose lake management tool that can be used for aquatic plant control (EOEA 2004; Wagner 2004). The water level is lowered by pumping, siphoning, or opening a pipe or gate in the dam. Lake drawdown can provide an inexpensive and effective control of certain macrophytes. Lake drawdown decreases abundance of some of the chief nuisance species, particularly those which rely on vegetative propagules for overwintering and expansion (see Table 10), and is known to be effective against fanwort and milfoil species While this technique is not effective on all submerged species, it does decrease the abundance of some of the chief nuisance species, particularly those that rely on vegetative propagules for overwintering and expansion, and allows for repopulation by native species (Cooke et al., 1993). Additional benefits may include opportunities for shoreline maintenance, consolidation of flocculent bottom materials, and oxidation or removal of nutrient-rich sediments.

The effectiveness and impact of the winter drawdowns in Lake Maspenock over the last 11 years was analyzed in Section 4.2. The deep drawdown of winter 2015-2016 was clearly very effective in suppressing summer 2016 growth of all major nuisance species (fanwort, milfoil and largeleaf pondweed). However, Table 11 indicates that each deep drawdown may not reach its target depth or have sufficient duration to significantly suppress vegetation growth in the following growing season, the drawdown has been shown to be an effective means to reduce invasive species on a regular basis. Even the regular 5-ft drawdowns are likely to be an important factor in reducing shoreline growth.

The Advisory Group strongly recommends continuation of this practice of deep drawdowns on a 3-year cycle. The cost of conducting the annual drawdown is already established as part of the Town budget so that no additional expenses are required. It will be useful to continue to monitor drawdown depths, duration of dewatering precipitation patterns, and average temperatures to establish some correlation between the conditions and the density of vegetation in the following season. This information is being collected by the DPW or is otherwise publicly available.

Herbicides

Treatment of aquatic vegetation by chemicals (herbicides) is a commonly used method in many parts of the United States for reducing large expanses of nuisance aquatic vegetation. They are an effective means to rapidly reduce unwanted biomass and promote recreational use. However, it can be costly and there may be significant concerns with direct and indirect effects on non-target organisms of poorly planned or inappropriate applications. Therefore, any treatment must be carefully thought out and monitored. An herbicide treatment can often be an effective short-term management procedure to produce a rapid reduction in algae or vascular plants for periods of weeks to months (EOEA 2004). However, the Advisory Group felt it is not necessarily the management tool of first choice and this approach should be integrated with other forms of vegetation control for the long-term management of Lake Maspenock. As discussed in Section 4.3.4, the Advisory Group's review of potential herbicides retained use of endothall, diquat, and florpyrauxifen-benzyl as potential vegetation management options.

Endothall (7-oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid) is a selective contact herbicide that has been used to manage submerged aquatic vegetation for over 50 years (CCE 2012). Endothall acid works by interfering with plant respiration, affecting protein and lipid biosynthesis, and disrupting plant cell membranes (CCE 2012). The herbicide damages the cells of susceptible plants at the point of contact but does not affect areas untouched by the herbicide, such as roots or tubers (underground storage structures). It is a selective herbicide that effectively controls milfoil, pondweeds, and naiad species.

Endothall is applied in solid form, as either a dipotassium salt or an amine salt, which then breaks down after application into endothall acid, the form that acts as an herbicide. It causes cellular breakdown of plants within 2-5 days. Symptoms of plant damage, including defoliation and browning, will become apparent within a week of application and plants will fall out of the water column within 3-4 weeks after application (CCE 2012).

Potential costs of endothall application were established by contacting a local lake management company (SOLitude) in 2021. The price per acre treated is approximately $540/acre, so costs will vary with the amount of lake area treated. One-time mobilization costs are approximately $2,000.

Diquat, or diquat dibromide (6,7-dihydrodipyrido (1,2- a:2',1'-c) pyrazinediium dibromide) is a fast-acting herbicide that works by disrupting cell membranes and interfering with photosynthesis (WDNR 2012). It is a broad (non-selective) herbicide and will kill a wide variety of plants on contact. Following treatment, plants usually die within a week. It does not move throughout the plants, so it will only kill the exposed parts of the plant. Accordingly, Diquat may not be effective in lakes or ponds with muddy water or where plants are covered with silt because it is strongly attracted to silt and clay particles in the water.

Diquat aquatic formulations are applied as liquids. Only partial treatments of ponds or bays should be conducted (1/2 to 1/3 of the water body) to avoid mass plant decomposition and resulting low dissolved oxygen levels (WNDR 2012). Untreated areas can be treated 10-14 days after the first treatment.

Potential costs of diquat application were established by contacting a local lake management company (SOLitude) in 2021. The price is less than for endothall so that chemical costs are approximately $275/acre with mobilization costs approximately $2,500. It may be possible to use a diquat-endothall mixture that is often more effective than application of the individual herbicides.

Florpyurauxifen-benzyl (available as ProcellaCOR®) is a systemic herbicide that can control various submerged, floating and emerged weed species. The active ingredient is 2-pyridinecarboxylic acid, 4-amino, 3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)-5-fluoro-, phenyl methyl ester. It is applied as a liquid and is effective against several aquatic problem species such as Eurasian and variable watermilfoil, hydrilla, and other pond weeds (SEPRO 2019)

The herbicide is a member of a new class of synthetic auxins, the arylpicolinates. The herbicide mimics the plant growth hormone auxin that causes excessive elongation of plant cells (e.g., larger, twisted leaves, stem elongation) and fragility of leaf and shoot tissue. The herbicide is Initial symptoms will be displayed within hours to a few days after treatment with plant death and decomposition occurring over 2 – 3 weeks. One advantage of florpyrauxifen-benzyl is that it has relatively short contact exposure time (CET) requirements (12 – 24 hours typically).

Potential costs of florpyrauxifen-benzyl application were established by contacting a local lake management company (SOLitude) in 2021. The price per acre treated is approximately $1200/acre, so costs will vary with the amount of lake area treated. One-time mobilization costs are approximately $2,500.

4.3.6. Summary of Selected Vegetation Control Options

Table 14 provides a summary of the aquatic vegetation control methods selected by the Advisory Group for use in Lake Maspenock. The table shows a range of control options ranging from no active control (we assumed that the current drawdown procedure would continue) to low intensity treatment (hand-harvesting, benthic barriers) to more aggressive management options (harvesting, herbicides). The table also indicated what kinds of lake conditions would be the present indicating a need for vegetation control based on the relative abundance, distribution and density of plants within a specific LMZ. The plant thresholds indicate the kind of observations that lake users would likely encounter, with the intensity of management dependent on the prevalence and nuisance level of aquatic weeds. Sample data sheets used for aquatic vegetation monitoring are contained in Appendix C. Due to the different natures of the LMZ, the thresholds for action can vary, usually as a function of potential or actual recreational impacts.

Table 14. Summary of Selected Aquatic Vegetation Control and Management Options

Management Intensity	**Activity**	**Estimated Costs***	**Conditions for Action**	**Plant Thresholds**
Current	Drawdown and Monitoring	$0	Follows a successful deep draw down	Plants in check
Low	Benthic Barriers; Hand-Harvesting	$2 - $24K	Isolated patches in areas with high public use	Spotty patches, mostly preventative actions
Moderate	Small-scale Herbicide Treatment;	$20 - $30K	Heavy plant growth but confined to isolated coves or shoreline areas	Plants clearly present but height or density does not significantly impact lake functions. in management zone
High	Large-Scale Harvesting or Herbicide	$80 - $120K	Lake-wide, heavy plant growth impeding ecological and recreational functions	Plants impinging surface over many areas, boating and swimming impacted over most zones

*Costs are only approximate and would need to be refined by applicator/vendor based on factors of size, depth and season. Permitting costs are not included.

4.3.7. Aquatic Vegetation Control Methods by LMZ

Table 14 above includes a range of relative cost estimates based on the vegetation control option and the size of the LMZs for which it would likely be employed. Again, not all methods are expected to be used across LMZs with little or no treatment likely for some LMZs. The Advisory Group matched the selected vegetation control options to the individual LMZs. These matches are summarized in Table 15.

Table 15. Lake Management Specific Vegetation Control Options

Management Options	A	B	C	D	E
Drawdown	X	X	X	X	X
Hand-harvesting	X	-	X	X	-
Benthic Barriers	-	-	X	-	-
DASH	-	-	X	-	-
Harvesting	-	X	-	-	-
Spot-treatment herbicide	X	-	X	X	-
Large area herbicide	-	X	-	-	-

As can be seen in Table 15, the size and characteristics of the LMZs (refer to Table 9) dictate which vegetation treatment options are likely to be appropriate and effective. Some options are exclusive to a LMZ (e.g., benthic barriers for Zone C, the public beach). Harvesting and/or herbicide treatment are likely to be applicable only to LMZ B, which constitutes the largest portion of the North Basin. LMZ C has the greatest number of potential options (5), while LMZ D is likely to host only modest shoreline vegetation control, principally through individual homeowners. LMZ E receives no active treatment except for the lake-wide effects of winter drawdown since this area includes the deeper areas of the Lake where deep drawdown will have reduced effect.

It is important to note that Table 15 does not necessarily dictate what treatment will happen to the LMZ on an annual basis. The need for any vegetation treatment will be assessed on a LMZ-specific, year-to-year basis. This involves tracking of conditions during the growing season to help predict whether treatable vegetation nuisance conditions exist or could exist in the near future (i.e., later in the summer, next growing season). This need for annual assessment requires that an aquatic vegetation survey be regularly conducted to provide the observation and data on which to make an informed decision.

4.4. Lake Monitoring Program

As noted above, a regular lake monitoring program allows stakeholders to follow water quality trends, update plant community trends, and document vegetation control results and successes. It provides the information to better manage the lake and, as needed, to make adjustments in the overall lake management plan. This monitoring program already exist, thanks to the efforts of the LMPA and the efforts of the Advisory Group. The monitoring program is briefly outlined below and an example vegetation monitoring data sheet contained in Appendix C.

4.4.1. Water Quality Monitoring

Currently, water quality is monitored three times per year (spring, summer and fall) by the LMPA. Surface water samples are collected at three locations corresponding roughly to the north, central and southern basins. The suite of parameters monitored includes: total phosphorus, surface dissolved oxygen (DO), temperature, pH, and fecal coliform (*E. coli*) and Secchi disk transparency (SDT) depth. Water quality data from this program for 2011-2021 are provided in Appendix B.

The present sampling program provides useful information, but it only partially addresses the suite of parameters that are typically used to monitor lakes' water quality. While total phosphorus is sampled, some other important nutrient forms are not, notably dissolved phosphorus, and the nitrogen fractions – ammonia (NH_3), nitrate (NO_3), and total Kjeldahl nitrogen (TKN). These should be monitored because nitrogen is next in importance to phosphorus in promoting growth in freshwater primary producers (algae and plants) and may be the limiting factor during some periods of the year. These additional parameters provide important diagnostic information (e.g., tracing the source of the nutrient, its availability for uptake by algae, and indications of DO status). It is recommended that these additional parameters be added to the monitoring parameters.

In addition, other water quality parameters may be useful to monitor in Lake Maspenock such as specific conductance (estimated total dissolved solids), alkalinity (indicated buffering capacity), iron (redox indicator), and chloride (correlates with watershed salt runoff). Chlorophyll a (primary pigment responsible for algal photosynthesis) should be monitored but this could be limited to the two summer samples due to cost.

Besides water quality collections, it is recommended that a temperature and DO profile (i.e., observations made from surface to just above bottom at several depths) be conducted at the central basin. This is the deepest location and would indicate to what extent the lake is thermal stratified (if at all) and if there is a significant oxygen demand (consumption) from the sediments. This information can assess the likelihood of internal recycling (released from the sediments) of phosphorus, which can occur under low DO conditions.

Sampling and observations should be conducted at approximately the same periods per year. The timing of the sampling has been somewhat variable making year-to-year comparisons less easy. Sampling for spring conditions, when nutrient levels are highest, is best conducted between late March and early May.

Mid-summer samples should be collected from early June to mid-July and late summer samples should be collected between mid-August until mid-September.

Additional monitoring is conducted by Town in the form of regular testing for bacteria at the swimming beach during the summer recreation season. From time to time, unacceptably high bacteria counts may temporarily close the beach until retesting indicates safe bacterial levels. However, records from 2019-2020 show a very low frequency (i.e., < 2%) of exceedance of acceptable thresholds suggesting this is not a chronic concern. Keeping track of the date, duration and frequency of the events can provide useful information. In addition, any detections of blue-green algal toxins should also be noted.

Finally, it is recommended that a formal set of sampling and analysis protocols be established so that lake sampling is conducted using the same procedures each year. These protocols are typically organized as a QAPP (quality assurance project plan). A QAPP provides guidance regarding the technical details of sampling methods, the sample locations (fixed GPS locations), making sure field observations are uniformly recorded and documented, reporting limits for chemical analyses, inclusion of laboratory quality assurance duplicates and blanks, and other important information and/or standardized forms.

4.4.2. Aquatic Vegetation Monitoring

Aquatic vegetation monitoring should continue to be regularly conducted in Lake Maspenock. These data allow updated tracking of the aquatic plant community, early detection of new invasive or unwanted species, and provide information critical to decision-making regarding the need, timing, and implementation of management options. Finally, it permits long-term evaluation and comparison of the vegetation control options as to their ability to reduce/manage weeds, the longevity of beneficial effects, and overall cost-effectiveness. These assessments will provide information to allow to adapt or fine-tune the management plan over time.

As conducted by the Advisory, aquatic vegetation surveys are conducted twice a year (during late spring and late summer) using observation points selected from among approximately 12 locations as indicated in Figure 4 and GPS locations listed in Appendix C. The survey data includes both qualitative (observational) and semi-quantitative (e.g., lake rake tosses) methods as quantified using standard methods of scoring and information sheets (see Appendix C for method details)

The first observations should be conducted in late spring (e.g., May) with the second monitoring occurring in late summer (e.g., late July to mid-August). The first observation helps assess indicators of early vegetation growth following the winter drawdown and provide an initial prediction as to the potential need for treatment later in the season. The second observation assesses conditions during a period of relatively full aquatic plant development. Again, this can be used to evaluate the effectiveness of the annual winter drawdown and any additional vegetation controls made during the summer. As available, the aquatic vegetation database may be supplemented with other surveys results (e.g., by lake management company, as part of their WPA permit requirements).

4.4.3. Drawdown Monitoring

The annual drawdown is regularly monitored by the DPW with regard to the depth and duration of the water elevation change. Variation in the effectiveness in plant control has been noted in the analysis in

Section 4.2 when target drawdown depths are not achieved or the climatic conditions are less favorable. Analysis of this data and support observation of precipitation and air temperatures may allow the Group to anticipate or correlate the effectiveness of the degree of plant control in the following growing season.

4.4.4. Other Monitoring

Other types of monitoring may be conducted on Lake Maspenock as needed including: biological surveys (e.g., waterfowl counts, mussel surveys); recreational use surveys (e.g., numbers/types of lake users, boat counts), or watershed monitoring (e.g., stormwater surveys, turbidity monitoring). Currently, however, no other monitoring efforts except water quality, aquatic plant community, and drawdown are planned.

5. REVIEW OF WATERSHED MANAGEMENT OPTIONS

A *watershed* is the surface drainage area that contributes water to a lake, river, or other body of water. Activities occurring in a lake watershed affect the health of the water body. The watershed is the ultimate source of nutrient and sediments to the lake, and controlling or reducing watershed loads help preserve and protect the lake and its benefits for future generations. Accordingly, it is important for the residents on the shoreline, adjacent to, and/or uphill of Lake Maspenock to be aware of activities occurring in the watershed that could potentially adversely affect the Lake.

Watershed management is the most cost-effective means to reduce or eliminate future watershed inputs of sediments and nutrients to Lake Maspenock. Even if in-lake vegetation management options are applied, watershed management is still important to further advance the investment made to control plants. Primary objectives under the watershed management goals for Lake Maspenock would be: (1) communication and public education for watershed stakeholders[12]; (2) watershed inspection for current or developing erosion or nutrient sources; and (3) advocacy and coordination with other watershed stakeholders and local agencies for identifying potential opportunities for extension or preservation of open space.

5.1. Watershed Stakeholder Education

Education involves creating public awareness of the problem and the potential for resolution. Education facilitates involvement of volunteer labor and other resources to accomplish the management program (e.g., volunteer hand harvesting). Many activities can be used for education, including workshops, public meetings, press conferences, news releases, posters and flyers, popular articles, postings at boat ramps, videos for interest groups, development of publicized web sites, and involvement of regulators, sports person associations, fish and wildlife groups, and concerned citizens and businesses.

Behavioral modifications involve changing the actions of watershed residents and shoreline owners to improve water quality. Such changes may include conversion to non-phosphate fertilizer, installation of a riparian buffer zone, and adopting measures consistent with good environmental stewardship of the lake. Behavioral modifications can be brought about in two principal ways, through education and/or the implementation of local bylaws (much less preferred). Education is a critical first step and should precede any attempt at regulation.

Resident environmental practices involve changing small-scale but important activities of watershed residents to improve water quality. Such changes may include conversion to non-phosphate detergents (already the case in MA), elimination of garbage grinders, and eliminating illegal dumping in roadways and watercourses. Most residences in close proximity to the Lake (at least in Hopkinton) are connected to a public sewer system, so conversion to non-phosphorus detergents and elimination of garbage grinders will probably contribute a very small improvement in watershed loadings to the Lake, but should be a consistent practice across the watershed.

[12] Stakeholders means the collective body of shoreline residents, watershed residents, lake association, beach users, and interested parties that have an active interest in the protection and enhancement of Lake Maspenock.

Buffer strips (or vegetated filter strips or grassed buffers) are areas of grass or other dense vegetation that separate a waterway from an intensive land use. These vegetated strips allow overland flow to pass through vegetation that filters out some percentage of the particulates and decreases the velocity of the storm water. Particulate settling and infiltration of water often occurs as the storm water passes through the vegetation. Buffer strips need to be at least 25 ft. wide before any appreciable benefit is derived, and superior removal requires a width >100 ft. This can create land use conflicts, but creative planting and use of buffer strips can be a low cost, low impact means to minimize inputs to the aquatic environment. This management technique is recommended for the Lake Maspenock watershed.

As shown in Figure 3, the watershed of the Lake is not extensive and is contained mostly within Hopkinton. These features make it easier to identify and educate watershed residents and users. Public education can be accomplished by mailing informative brochures addressing watershed management topics to all residents in the watershed, establishment of a Town community website (or reference to the LMPA website), posting of this plan and other documents on the Town website, through the use of video programs on local access television, by placing informative signs in high access areas, or by holding public meetings for watershed residents. Public education relies heavily upon cooperation from residents, the LMPA, and other lake users, and is not likely to result in major improvements in plant control.

However, some level of improvement has been noted in other studies and the education process sets the stage for community involvement and cooperation. Examples of educational fact sheets, brochures, and pamphlets that could be adopted for use in the Lake Maspenock watershed are provided in Appendix G.

5.2. Watershed Inspection and Review

Since nutrient enrichment is highly correlated with erosion of soil particles into the lake, most of the activities under this area are related to erosion prevention from a watershed sources such as shorelines, roadways (stormwater), minor tributaries, land development, and other land uses. In addition to reducing the substrate and nutrients supporting macrophyte growth, such sources also contribute to decreased water quality and the development of algal blooms. Reductions in external watershed loading will help preserve long-term water quality and discourage expansion of aquatic plants.

Developed areas are normally the primary target of watershed management. Development of a watershed increases the amount of impervious surface that changes the hydrology of the area and tends to increase loading of pollutants to waterways. Pollutants falling from the sky as atmospheric deposition are not incorporated into soils as in forests or meadows, but rather are transported into the aquatic environment. Source reduction controls are methods used to reduce the amounts of pollutants generated in the watershed, or to prevent their release to the environment. Additional pollutants from human activities in developed areas include solids from exposed soils, nutrients from fertilizers and waste disposal, bacteria from waste disposal and pets, hydrocarbons from automotive and other machine use, and metals from a variety of sources. These are also carried into the aquatic environment and can cause water quality degradation and use impairment.

Transport mitigation refers to a variety of means by which pollutants generated in the watershed can be prevented from entering Lake Maspenock due to upgradient detention and treatment. These measures are often used when an undesirable land use or pollutant source, for whatever reason, cannot be directly reduced or eliminated. These measures include a number of watershed best management practices (BMPs) which can be used to reduce transport of nutrients and sediments from entering the Lake. Such mitigation can encompass a large suite of options, ranging from those done on an individual house lot (e.g., rain barrels to detain roof runoff, small areas ("raingardens") to direct local runoff for detention and recharge), to more extensive treatment options that treat larger volumes of stormwater (e.g., wetland detention).

Potential watershed management is particularly targeted at impervious surfaces and roadways close to the Lake due to the proximity as well as the industrial areas located along South Street due to their impervious areas (rooftops and parking lots) and potential runoff. Recent stormwater treatment improvements, including the detention basin located at the north end of the former EMC property appear to be in good condition.

At this time, there does not seem to be any existing significant untreated runoff entering the Lake, However, regular review of watershed stormwater treatment devices and/or detection of potential new sources is called for. This watershed surveillance should involve both watershed residents (and/or LMPA) and the DPW. Watershed residents should report any new, on-going or deteriorating sources of soil erosion or runoff directly or indirectly entering the Lake and contact the Conservation Commission with their concerns. The DPW regularly reviews and conducts BMPs such as street sweeping and catch basin cleaning in the watershed to ensure that these practices and structures are operating correctly and being maintained. It is recommended that the Hopkinton Conservation Commission regularly conducts an inspection of privately maintained BMPs in the watershed (i.e., EMC / Dell and MADOT facilities).

5.3. Additional Protection and Conservation of Watershed

Protection of lake water quality by increased protection of land uses involves (a) purchasing properties (or portion that become available on the market) that could contribute excessive amounts of pollutants if developed and converting these properties to less deleterious land uses or (b) increasing the amount of conservation land or similar protected status to additional lands.

As an illustration of the first method, the Town might decide to purchase developable property and convert the land to open space, thus reducing potential pollutant generation from this parcel of land. This can be an expensive proposition, but it may be practical for targeting specific properties that by their proximity to Lake or tributary or by the nature of their potential future use are more likely to generate pollutants which would eventually discharge into Lake Maspenock. For the second option, agreements could be made with existing property owners to place all or a portion of their land under conservation or protected status. Such an arrangement is currently in place for a length of the eastern shoreline of the Lake near the central basin and other opportunities may come up.

For either of these options, planning and coordination with the Hopkinton Community Preservation Committee, the Hopkinton Planning Board, the Hopkinton Area Land Trust and similar organizations would be critical. A key parcel identified by the Advisory Group is the 111-acre undeveloped parcel of land owned by Dell / EMC on the eastern side of Lake Maspenock which abuts the shoreline. The development of this area would likely have a detrimental effect on water quality and wildlife habitat. The protection of Lake Maspenock watershed areas as a key objective in the Town Open Space is strongly advised.

6. COMPREHENSIVE LONG-TERM PLAN

The following sections outline the details of the Comprehensive Long-Term Vegetation Control and Management Plan including the major elements, schedule and cost.

6.1. Comprehensive Long-Term Vegetation Control and Management Plan

The Advisory Group is recommending to the Hopkinton BOS a comprehensive, long-term vegetation control and management plan for Lake Maspenock. This plan was originally conceived in 2016 through the course of numerous meetings (approximately 15), extensive research and screening of available vegetation control options, research with other lake associations regarding their vegetation control experiences, and field monitoring of vegetation status on the Lake (June and September). As required, a five-year review was conducted and a revised Plan was developed and approved by the Advisory Group in June 2021 .

6.2. Public Participation and Input

As per the Advisory Group's charge, public input and comment were invited at every stage during the public meetings, and minutes of the meetings were scrupulously kept and regularly posted on the Town website. The Group actively sought out stakeholder interests and concerns through the Resident Survey (Section 3.2) and kept the public aware of the benefits, costs, and potential risks of various vegetation control options.

The Group presented detailed information regarding the development of the plan at three well-attended public forums held in 2016 describing, respectively, the preliminary screening results (February 9th and 27th) and the selected management options and long-term plan (October 8th). In all, the Advisory Group has worked diligently and effectively to provide and justify the thoughtful selection of control options that would be most effective and acceptable for vegetation control on the Lake. The Plan includes both short-term and long-term options and involves both in-lake vegetation control and watershed management options, lake monitoring and regular review of the Plan. These features are presented in Table 16 which provides the revised five-year cycle of the proposed plan (i.e., from 2021-2025).

6.3. Details of the Long-Term Plan

Table 16 provides details of the long-term plan, including the schedule for the drawdown over the next five years, the potential for active treatment, lake monitoring, and watershed management options. The annual winter drawdown, supplemented by a deep drawdown every third year, is a critical determinant of vegetation control in the Lake. If the deep drawdown is particularly effective (as was the case for winter 2015-2016), the need for active treatment is likely to be minimal for the first and possibly the second summer following drawdown. Since ideal conditions for the deep drawdown are unlikely to be present for each event, it is more conservative to assume the active treatment may be necessary in the second year and likely in the third year. As described in Section 4.3, the nature of the treatment would depend on the location, density and species composition of nuisance weeds with treatment options outlined in Table 15.

Table 16. Five Year Cycle for Lake Maspenock Management Plan: 2021-2025.					
	YEAR 1 **2021**	**YEAR 3** **2022**	**YEAR 3** **2023**	**YEAR 4** **2024**	**YEAR 5** **2025**
In-Lake Activities					
Winter Drawdown	Normal	Normal	Deep	Normal	Normal
Active Treatment	Treatment needs likely to be minor	Treatment needs likely to increase	Treatment needs likely to be minor	Treatment needs will vary based on deep draw success	Treatment needs may or may not be minor
Lake Monitoring	Seasonal	Seasonal	Seasonal	Seasonal	Seasonal
Watershed Activities					
Public Education	Identify Public Education Needs	Supply relevant information to watershed residents	Distribute to new stakeholders, as needed	Distribute to new stakeholders, as needed	Evaluate Information and update, as needed
Watershed Inspection	Monitor and identify any emerging issues		Monitor and identify any emerging issues		Monitor and identify any emerging issues
Land Protection	Identify Any 0pportunities		Coordinate with CPA committee		Re-evaluate Opportunities
Lake Management Plan	Initiate plan and continue active monitoring		Make any "mid-stream" adjustments		Assess methods and results; review and modify Plan as needed

Lake monitoring (Section 4.4) would be conducted every year to provide updated water quality and vegetation status data and to provide information for treatment decision-making.

As described above, effective lake management will need to draw upon considerable technical expertise and practical experience to make responsible annual treatment decisions. This requires both continuity of purpose and long-term commitment by interested parties. Therefore, it was commendable that the Advisory Group was made a permanent standing committee responsible to the DPW Director with qualified members appointed by the BOS for three-year terms. The Advisory Group should continue to provide regular reports to the Director regarding the current or anticipated status of aquatic vegetation in the Lake and assess the performance and cost-effectiveness of any options used to control the weeds.

The watershed management options are listed with a more variable schedule of implementation. Public education is the first priority, as discussions with shoreline residents indicate that they want information and guidance on how to manage their property in an "environmentally and lake-friendly" fashion. Although information is available from many sources, some degree of customization would be required to make the information relevant and specific to Lake Maspenock.

At the present time, there are no obvious sources of sediment or pollution entering the Lake as the DPW has done an excellent job in mitigating or eliminating them. However, the watershed erosion and BMP inspection program should be periodically revisited to identify any developing concerns. The responsible parties are likely to be the Conservation Commission and DPW. The former for responding to watershed stakeholder complaints or tips regarding active erosion areas and the latter for regular inspection of existing stormwater treatment devices in the Town and their knowledge of the current stormwater infrastructure.

Opportunities for land acquisitions are hard to predict and are often the subject of private negotiations between land owner and Town representative (e.g., CPC, town counsel), so no specific schedule was given. The 111-acre undeveloped parcel own by Dell / EMC which abuts the eastern shoreline of the Lake is identified as a high-priority land acquisition candidate for the Town due to its size, the uncertainty of Dell / EMCs intentions with regard to future use and the disposition of the property, and the detrimental effect the development of this parcel would have on Lake Maspenock water quality and wildlife habitat.

6.4. Costs of Plan

The cost of implementing the Lake Management Plan on an annual basis will be subject to the amount of treatment that would be required which will vary as a function of aquatic weed growth. Very little cost may be incurred in a season with little plant growth while significant monies may be required if weed populations are widespread and impact recreation. A good analogy is that of the need for road salting and sanding which will vary widely depending on winter storms and labor and equipment needs and is impossible to predict prior to the critical season.

Representative cost information is provided in Table 14 with treatment cost ranging from less than $2,000 to over $100,000. The major fixed annual cost would be those associated with lake monitoring which includes water quality, aquatic vegetation, and drawdown monitoring. Water quality is collected by the

LMPA with the cost of monitoring equipment and laboratory analysis costs covered by the DPW. The Advisory Group and select volunteers conduct the spring and late summer aquatic vegetation surveys. At the option of the Director, professional technical support may be used to summarize the information. An estimated range of $2,500 - $6,000 is reasonable with the cost depending on how much of the work is conducted by volunteers versus a lake management professional. It is assumed that any treatment activity would be conducted under an Order of Conditions issued through a Notice of Intent (NOI) filing with the Conservation Commission by the DPW.

The Advisory Group suggests that the current allocation of $60,000 be continued as the base budget item for the next few years. Monies that are not spent during a low activity year would be returned to the Town. As indicated in Table 16, the Lake Management Plan should be revisited in Year 3 (2023) for any minor adjustments and given a thorough review and evaluation for major changes or revisions in Year 5 (2025). These scheduled reviews will provide a good opportunity to check on what monies have been used and whether the base budget needs to be adjusted.

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GENERAL AQUATIC GLOSSARY

Abiotic - Pertaining to any non-biological factor or influence, such as geological or meteorological characteristics.

Acid precipitation - Atmospheric deposition (rain, snow, dryfall) consisting of free or combined acidic ions, especially nitrates, sulfates and oxides of nitrogen and sulfur from industrial and transportation sources.

Algae - Aquatic single-celled, colonial, or multi-celled plants, containing chlorophyll and lacking roots, stems, and leaves.

Algal bloom — Heavy growth of algae in and on a body of water as a result of high nutrient concentrations.

Alkalinity — The acid combining capacity (of carbonate) solution, also describes its buffering capacity.

Ammonia Nitrogen (NH_3) - A form of nitrogen present in sewage and is also generated from the decomposition of organic nitrogen. It can also be formed when nitrites and nitrates are reduced. Ammonia is particularly important since it has high oxygen and chemical demands, is toxic to fish in un-ionized form and is an important aquatic plant nutrient because it is readily available.

Anoxic - Without oxygen

Aphotic Zone - Dark zone, below the depth to which light penetrates. Generally equated with the zone in which most photosynthetic algae cannot survive, due to light deficiency.

Aquatic plant survey —A systematic mapping of types and location of aquatic plants in a waterbody, usually conducted by means of a boat. Survey information is presented on an aquatic plant map.

Attenuation - The process whereby light is reduced as it passes down into the water column due to a combination of absorption and back reflectance. Attenuation is greater in productive lakes.

Bathymetry - The measurement of depths of water in oceans, seas, or lakes or the information derived from such measurements.

Bathymetric map —A map showing depth contours in a waterbody. Bottom contours are usually presented as lines of equal depth, in meters or feet.

Benthos - Bottom-dwelling organisms living on, within or attached to the sediment. The phytobenthos includes the aquatic macrophytes and bottom-dwelling algae. The zoobenthos (benthic fauna) includes variety of invertebrate animals, particularly larval forms and molluscs.

Bioavailable - Able to be taken up by living organisms, usually refers to plant uptake of nutrients.

Biocontrol — Management using biological organisms, such as fish, insects or micro-organisms like fungus.

Biological Oxygen Demand (BOD) - The BOD is an indirect measure of the organic content of water. Water high in organic content will consume more oxygen due to the decomposition activity of bacteria in the water than water low in organic content. It is routinely measured for wastewater effluents. Oxygen consumption is proportional to the organic matter in the sample.

Biotic - Pertaining to biological factors or influences, concerning biological activity.

BMPs (Best Management Practices) — Practices or methods used to prevent or reduce amounts of nutrients, sediments, chemicals or other pollutants from entering water bodies from human activities. BMPs have been developed for agricultural, silvacultural, construction, and urban activities (e.g. stormwater treatment).

Bottom barriers — Synthetic or natural fiber sheets of material used to cover and kill plants growing on the bottom of a waterbody; also, called sediment covers.

C**FS -** Cubic feet per second, a measure of flow.

Chlorophyll (chl-*a*) - Major light gathering pigment of all photosynthetic organisms imparting the characteristic color of green plants. Its relative measurement in natural waters is indicative of the concentration of algae in the water.

Color - Color is determined by visual comparison of a sample with known concentrations of colored solutions and is expressed in standard units of color. Color in lake waters is related to solids, including algal cell concentration and dissolved substances.

Concentration - The quantity of a given constituent in a unit of volume or weight of water.

Conductivity - The measure of the total ionic concentration of water. Water with high total dissolved solids (TDS) level would have a high conductance. A conductivity meter tests the flow of electrons through the water which is heightened in the presence of electrolytes.

Contact herbicide -— An herbicide that causes localized injury or death to plant tissues with which it contacts. Contact herbicides do not kill the entire plant. Aquathol® and diquat are contact type herbicides.

Control intensity map -— A map of a waterbody showing areas requiring no, low or high levels of aquatic plant control; for Lake Maspenock this is based on lake management zones.

Decomposition - The metabolic breakdown of organic matter, releasing energy and simple organic and inorganic compounds which may be utilized by the decomposers themselves (e.g., bacteria and fungi).

Detritus — Settleable material suspended in the water: organic detritus, from the decomposition of the broken down remains of organisms; inorganic detritus, and settleable mineral materials.

Diquat — The active chemical ingredient of the aquatic contact herbicide Ortho Diquat®.

Dissolved oxygen —A measure of the amount of oxygen gas dissolved in water and available for use by aquatic life. Water temperature significantly and conversely affects the amount of oxygen which water can contain. Biological activity also affects local DO levels.

Dissolved Phosphorus (DP) – the soluble or filterable fraction of phosphorus in a waterbody

Drainage basin — The area drained by, or contributing to, a stream, lake, or another waterbody (see watershed

Drawdown — Decreasing the level of standing water in a waterbody to expose bottom sediments and rooted plants. Water level drawdown can be accomplished by physically releasing a volume of water through a controlled outlet structure or by preventing recharge of a system from a primary external source.

Dredging — Physical methods of digging into the bottom of a waterbody to remove sediment, plants or other material. Dredging can be performed using mechanical or hydraulic equipment.

Ecology — Scientific study of relationships between organisms and their surroundings (environment)

Ecosystem - A dynamic association or interaction between communities of living organisms and their physical environment. Boundaries are arbitrary and must be stated or implied.

Emergent plants —Aquatic plants that are rooted or anchored in the sediment around shorelines, but have stems and leaves extending well above the water surface (e.g. cattails and bulrushes).

Endothall — The active chemical ingredient of the aquatic contact herbicide Aquathol®.

Eradication — Complete removal of a specific organism from a specified location, usually refers to a noxious, invasive species. Under most circumstances, eradication of a population from a site is very difficult to achieve.

Erosion - The removal of soil from the land surface, typically by runoff water.

Eutrophic - High nutrient, high productivity trophic state generally associated with unbalanced ecological conditions and poor water quality.

Eutrophication - Process by which a body of water ages, most often passing from a low nutrient concentration, low productivity state to a high nutrient concentration, high productivity stage. Eutrophication is a long-term natural process, but it can be greatly accelerated by man's activities. Eutrophication as a result of man's activities is termed cultural eutrophication.

Exotic (also referred to as non-indigenous) — Refers to species of plants or animals that are not native to a particular region into which they have moved or invaded (e.g., fanwort, Eurasian watermilfoil, Brazilian elodea).

Fecal Coliform Bacteria - Bacteria of the coli group that are present in the intestines or feces of warm-blooded animals. They are often used as indicators of the sanitary quality of the water. Their concentrations are expressed as number of colonies per 100 ml of sample.

Floating-leafed plant — Plants with oval or circular leaves floating on the water surface, but are rooted or attached to sediments by long, flexible stems. Waterlilies are examples of rooted floating-leafed plants.

Food Chain - A linear characterization of energy and chemical flow through organisms such that the biota can be separated into functional units with nutritional interdependence. Can be expanded to a more detailed characterization with multiple linkages, called a food or trophic web.

Fluoridone — The active chemical ingredient of the systemic aquatic herbicide SONAR®.

Flushing rate — Term describing rate of water volume replacement of a waterbody, usually expressed as basin volume per unit time needed to replace the waterbody volume with inflowing water. The inverse of the flushing rate is the (hydraulic) detention time. A lake with a flushing rate of 1 lake volume per year has a detention time of 1 year.

Free-floating plants — Plants that float on or under the water surface, unattached by roots to the bottom. Some have small root systems that simply hang beneath the plant. Water hyacinth and tiny duckweed are examples of free-floating plants.

Glyphosate —The active chemical ingredient of the systemic herbicide RODEO®.

Grass carp —Also known as white amur, grass carp (*Ctenopharyngodon idella*) is a large, vegetation-eating member of the minnow family. Introduction of grass carp is against the law in Massachusetts.

Groundwater - Water in the soil or underlying strata, subsurface water.

Hardness - A physical-chemical characteristic of water that is commonly recognized by the increased quantity of soap required to produce lather. It is attributable to the presence of alkaline earths (principally calcium and magnesium) and is expressed as equivalent calcium carbonate (CaCO3).

Herbicide —A chemical used to suppress the growth of or kill plants.

Habitat — The physical place where an organism lives.

Humus - Humic substances form much of the organic matter of sediments and water. They consist of amorphous brown or black colored organic complexes.

Hydraulic retention time (HRT) — The period of detention of water in a basin. The inverse of detention time is flushing rate. A lake with a detention time of one year has a flushing rate of 1 lake volume per year.

Hydrologic Cycle - The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

Impervious - Not permitting penetration or percolation of water.

Integrated aquatic plant management — Management using the best combination of plant control methods that optimizes target weed species control, maximizes beneficial uses, minimizes environmental impacts and optimizes overall costs.

Intermittent – Discontinuous flow, usually generally referring to the seasonal flow of a stream or swale through a channel drainage path.

Kettle hole lake - A kettle hole lake is a waterbody formed by a topographic depression produced by the melting of a stagnant block of ice and the subsequent downward and inward collapse of deposited material.

Lake Management Zones (LMZs) —A map of a waterbody showing division of lake for management based on physical characteristics and important human use areas or zones (such as swimming, boating, fishing) and habitat areas for fish, wildlife and waterfowl.

Leaching - Process whereby nutrients and other substances are removed from matter (usually soil or vegetation) by water. Most often this is a chemical replacement action, prompted by the quality of the water.

Limiting nutrient — Essential nutrient needed for growth of plant organism which is the scarcest in the environment. Oftentimes, in freshwater systems, either phosphorus or nitrogen may be the limiting nutrient for plant growth. The chemical form in which the nutrient occurs and the nutritional requirements of the plants involved often determine whether a chemical is limiting or not.

Limnology - The comprehensive study of lakes, encompassing physical, chemical and biological lake conditions.

Littoral — The region of a body of water extending from shoreline outward to the greatest depth occupied by rooted aquatic plants.

Littoral Zone - Shallow zone occurring at the land-water interface of aquatic ecosystems. It extends from the shoreline outward to a point where rooted aquatic plants are no longer found due to light limitation.

Loading - Inputs into a receiving water that may exert a detrimental effect on some subsequent use of that water.

Macro-algae — Large, easily seen (macroscopic) algae. The macro-algae *Nitella* sp. Sometimes forms dense plant beds and can be a conspicuous member of the aquatic plant community.

Macrofauna - A general term which refers to animals which can be seen with the naked eye or without the aid of a microscope.

Macrophyte — Higher plant, macroscopic plant, plant of higher taxonomic position than algae, usually a vascular plant that may bear flowers and seeds. Aquatic macrophytes are those macrophytes that live completely or partially in water. May also include algal mats under some definitions.

Mesotrophic - An intermediate trophic state, with variable but moderate nutrient concentrations and productivity.

Micrograms per Liter (ug/1) - A unit expressing the concentration of chemical constituents in solution as mass (micrograms) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter.

Million gallons per day (MGD) - Million gallons per day, a measure of flow.

Mitigation —Actions taken to replace or restore animals or plants that may have been damaged or removed by certain prior activities.

Morphology — Study of shape, configuration or form.

Nitrate (NO_3) - A form of nitrogen that is important since it is the end product in the aerobic decomposition of nitrogenous matter. Nitrogen in this form is stable and readily available to plants.

Nitrite (NO_2) – A form of nitrogen that is the oxidation product of ammonia. It has a fairly low oxygen demand and is rapidly converted to nitrate. The presence of nitrite-nitrogen usually indicates that active decomposition is taking place (i.e., fresh contamination).

Nitrogen - A macronutrient which occurs in the forms of organic nitrogen, ammonia nitrogen, nitrite nitrogen and nitrate nitrogen. Form of nitrogen is related to a successive decomposition reaction, each dependent on the preceding one, and the progress of decomposition can be determined in terms of the relative amounts of these four forms of nitrogen.

NOI – Notice of Intent under the Massachusetts Wetlands Protection Act

Non-point (pollutant) source (NPS) —A diffuse source of water pollution that does not discharge through a pipe or other readily identifiable structure. Non-point pollution typically originates from activities on land and the water. Examples of non-point sources are agricultural, forest, and construction sites, marinas, urban streets and properties.

Non-target species —A species not intentionally targeted for control by a pesticide or herbicide.

Noxious weed — Non-native plant species that, because of aggressive growth habits, can threaten native plant communities, wetlands or agricultural lands.

Nutrients - Are compounds which act as fertilizers for aquatic organisms. Small amounts are necessary to the ecological balance of a waterbody, but excessive amounts can upset the balance by causing excessive growths of algae and other aquatic plants. Sewage discharged to a waterbody usually contains large amounts of carbon, nitrogen, and phosphorus. Storm water runoff often contributes substantial nutrient loadings to receiving waters.

Oligotrophic - Low nutrient concentration, low productivity trophic state, often associated with very good water quality, but not necessarily the most desirable stage, since often only minimal aquatic life can be supported.

OoCs – Orders of Conditions associated with an approved Notice of Intent (NOI)

Organic - Containing a substantial percentage of carbon derived from living organisms; of a living organism.

Overturn - The vertical mixing of major layers of water caused by seasonal changes in temperature. In temperate climate zones overturn typically occurs in spring and fall.

Oxidation —A chemical process that can occur in the uptake of oxygen.

Oxygen Deficit - A situation in lakes where respiratory demands for oxygen exceeds its production via photosynthesis or its input from the drainage basin, leading to a decline in oxygen content.

pH —The negative logarithm of the hydrogen ion activity. A hydrogen concentration scale from 0 (acidic) to 14 (basic) used to characterize water solutions. Pure water is neutral at pH 7.0.

Phosphorus - A macronutrient which appears in waterbodies in combined forms known as ortho- and poly-phosphates and organic phosphorus. Phosphorus may enter a waterbody in runoff where fertilizers are used. Stormwater runoff from highly urbanized areas, septic system leachate, and lake bottom sediments also contribute phosphorus. A critical plant nutrient which is often targeted for control in eutrophication prevention plans.

Photic Zone - illuminated zone, surface to depth beyond which light no longer penetrates. Generally equated with the zone in which photosynthetic algae can survive and grow, due to adequate light supply.

Photosynthesis - Process by which primary producers make organic molecules (generally glucose) from inorganic ingredients, using light as an energy source. Oxygen is evolved by the process as a byproduct.

Phytoplankton - Algae which are suspended, floating or moving only slightly under their own power in the water column. Often this is the dominant algal form in standing waters.

Plankton - The community of suspended, floating, or weakly swimming organisms that live in the open water of lakes and rivers.

Point (pollutant) source (PS) — A source of pollutants or contaminants that discharges through a pipe or culvert. Point sources, such as an industrial or sewage outfall, are usually readily identified.

Pollution - Undesirable alteration of the physical, chemical or biological properties of water, addition of any substance into water by human activity that adversely affects its quality. Prevalent examples are thermal, heavy metal and nutrient pollution.

Pollutant —A contaminant, a substance that is not naturally present in water or occurs in unnatural amounts that can degrade the physical, chemical, or biological properties of the water. Pollutants can be chemicals, disease-producing organisms, silt, toxic metals, oxygen-demanding materials, to name a few.

Potable – Water usable for drinking purposes, fit for human consumption.

Primary production — Conversion of inorganic matter to organic matter by photosynthesizing organisms, typically it is the creation of biomass by plants (macrophytes and algae). It involves the formation of organic matter or sugars in plant cells from light, water and carbon dioxide.

Problem statement —A written description of important uses of a waterbody that are being affected by the presence of problem aquatic plants.

Public Awareness/Outreach — Programs designed to share technical information and data on a particular topic, usually associated with activities (such as management) on or around a waterbody.

Riparian - Of, or related to, or bordering a watercourse.

Runoff - Water and its various dissolved substances or particulates that flow at or near the surface of land in an unchanneled path toward channeled and usually recognized waterways (such as a stream or river).

Secchi disc — Typically a 20-cm (8-inch) diameter disc painted white and black in alternating quadrants. It is used to measure light transparency in lakes. The Secchi disk transparency (SDT) depth is the average of (1) the depth at which the disk lowered into the water is no longer visible and (2) the depth at which it is visible again.

Secondary Productivity - The growth and reproduction (creation of biomass) by herbivorous (plant-eating) organisms. The second level of the food web or trophic system.

Sediment — Solid material deposited in the bottom of a basin.

Sedimentation - The process of settling and deposition of suspended matter carried by water, sewage, or other liquids, by gravity. It is usually accomplished by reducing the velocity of the liquid below the point at which it can transport the suspended material.

Sensitive areas — Critical areas in the landscape, such as wetlands, aquifer recharge areas, and fish and wildlife habitat conservation areas. In Massachusetts, the Natural Heritage Endangered Species Program (NHESP) identifies priority habitats for threatened or endangered species.

Sewage (Wastewater) - The waterborne, human and animal wastes from residences, industrial/commercial establishments or other places, together with such ground or surface water as may be present.

Specific Conductance - The measure of a water sample's capacity to convey an electric current providing a generalized measure of the inorganic dissolved load of the water. It is dependent on temperature and the concentration of ionized substances in the water. Distilled water exhibits specific conductance of 0.5 to 2.0 microSiemens per centimeter (uS/cm), while natural waters show values - from 50 to 500 (uS/cm). In typical New England lakes, specific conductance usually ranges from 100-300 (uS/cm).

Stakeholders —The collective group of individuals, businesses, agencies and organizations who have an interest in the condition and/or management of a particular waterbody.

Storm Sewer - A pipe or ditch which carries storm water and surface water, street wash and other wash waters or drainage, but excludes sewage and industrial wastes.

Stratification - Process whereby a lake becomes separated into two relatively distinct layers as the result of temperature and density differences. Further differentiation of the layers usually occurs as the result of chemical and biological processes. In most lakes, seasonal changes in temperature will reverse this process after some time, resulting in the mixing of the two layers.

Submersed plant —An aquatic plant that grows with all or most of its stems and leaves below the water surface. Submersed plants usually grow rooted in the bottom and have thin, flexible stems supported by the water. Common submersed plants are milfoils and pondweeds.

Substrate - The base of material on which an organism lives, such as cobble, gravel, sand, muck, etc.

Surface Water - Refers to lakes, bays, sounds, ponds, reservoirs, springs, rivers, streams, creeks, estuaries, marshes, inlets, canals, oceans and all other natural or artificial, inland or coastal, fresh or salt, public or private waters at ground level.

Susceptibility — The sensitivity or level of injury demonstrated by a plant to effects of an herbicide.

Suspended Solids - Those which can be removed by passing the water through a filter. The remaining solids are called dissolved solids. Suspended solids loadings are generally high in stream systems which are actively eroding a watershed. Excessive storm water runoff often results in high suspended solids loads to lakes. Many other pollutants such as phosphorus are often associated with suspended solids loadings.

Systemic herbicide —An herbicide in which the active chemicals are absorbed and translocated within the entire plant system, including roots. Depending on the active ingredient, systemic herbicides affect certain biochemical reactions in the plant that can cause plant death. SONAR®, RODEO® and Aqua-Kleen® are systemic herbicides.

Taxon (Taxa) **-** Any hierarchical division of a recognized classification system, such as a genus or species.

Thermal stratification — Horizontal layering of water in a lake caused by temperature-related differences in density. A thermally stratified lake is generally divided into the epilimnion (uppermost, warm, mixed layer), metalimnion (middle layer of rapid change in temperature and density) and hypolimnion (lowest, cool, least mixed layer).

Thermocline - Boundary level between the epilimnion and hypolimnion of a stratified lake, variable in thickness, and generally approximating the maximum depth of light penetration and mixing by wind.

Topographic map —A map showing elevation of the landscape in contours of equal height (elevation) above sea level. This can be used to identify boundaries of a watershed.

Total Phosphorus (TP) – all fractions (organic + inorganic) of phosphorus in a waterbody

Tributaries — Rivers, streams or other channels that flow into a waterbody.

Triclopyr— The active ingredient of a systemic herbicide used for aquatic plant control.

Trophic state — The stage or condition of an aquatic system, characterized by biological, chemical and physical parameters. Overall term used to describe the productivity of the lake ecosystem and classify it as oligotrophic (low productivity, "good" water quality), mesotrophic (moderate productivity), or eutrophic (high productivity; "poor" water quality).

Trophic Level - The position in the food chain determined by the number of energy transfer steps to that level; 1 = producer; 2 = herbivore; 3, 4, 5 = carnivore.

Trophic State - Trophic State Index (TSI) - a convenient way to classify lakes' trophic state through of comparison of ambient values of key indicators (i.e., phosphorus and/or nitrogen fractions, chl-*a*, and SDT) to previously established criteria or thresholds.

Turbidity - The measure of the clarity of a water sample. It is expressed in Nephelometric Turbidity Units which are related to the scattering and absorption of light by the water sample.

Vascular plant—A vascular plant possesses specialized cells that conduct fluids and nutrients throughout the plant. The xylem conducts water and the phloem transports food.

Water Quality - A term used to describe the chemical, physical, and biological characteristics of water, usually with respect to its suitability for a particular purpose or use.

Watershed (or drainage basin) - A geographical area or region which is so sloped and contoured that surface runoff from streams and other natural watercourses is carried away by a single drainage system by gravity to a common outlet; also, commonly referred to as a watershed or drainage area. The definition can also be applied to subsurface flow in groundwater.

Watershed management —The management of the natural resources of a drainage basin for the production and protection of water supplies and water-based resources.

Wetland —A generalized term for a broad group of wet habitats. Wetlands are areas of vegetation that are transitional between land and water bodies and range from being permanently wet to intermittently water covered.

WPA –Wetland Protection Act (Massachusetts).

Zooplankton - Microscopic animals suspended in the water; protozoa, rotifers, cladocera, copepods and other small invertebrates.

Monitoring Site No.: NB/EC   Sampler Name: C Esthimer   Survey Date: 9-10-2021

GPS Location N ______   Total Depth (ft): 2' 7"   SDT Depth (ft): 2'

W ______

Plant Name	Aquatic Vegetation Coverage OBS. #1	OBS. #2	OBS. #3	OBS. #4	Aquatic Vegetation Density OBS. #1	OBS. #2	OBS. #3	OBS. #4
Variable milfoil								
Fanwort								
Naiad	1	1						
Egeria								
Large leaf pondweed	1	1						
Ribbon-leaf Pondweed								
Pondweed A								
Pondweed B								
Elodea								
Wild Celery (tapegrass)								
Bladderwort								
Nitella								
Najas spp.								
White waterlily								
Yellow waterlily								
Watershield								
Unknown 1								
Unknown 2								
Filamentous Algae								
Attached Algae	1	1						
Tape Grass	1	1						

Observations: water murky, tannic colored

Coverage code: 1 = 5-25% 2 = 26-50% 3 = 51-75% 4 = 76-100%

Density code: T = trace S = sparse M = medium D = dense

2

Monitoring Site No.: NB/CL Sampler Name: C Esthimer Survey Date: 9-10-2021

GPS Location N NB Total Depth (ft): 7.2" SDT Depth (ft): 5'

W

Plant Name	Aquatic Vegetation Coverage OBS. #1	OBS. #2	OBS. #3	OBS. #4	Aquatic Vegetation Density OBS. #1	OBS. #2	OBS. #3	OBS. #4
Variable milfoil	2	2						
Fanwort	2	2						
Naiad	2	2						
Egeria								
Large leaf pondweed	2	3						
Ribbon-leaf Pondweed								
Pondweed A								
Pondweed B								
Elodea								
Wild Celery (tapegrass)								
Bladderwort								
Nitella								
Najas spp.								
White waterlily								
Yellow waterlily								
Watershield								
Unknown 1								
Unknown 2								
Filamentous Algae	2*	2*						
Attached Algae	1*	1*						

Observations: * seen using scope

Coverage code: 1 = 5-25% 2 = 26-50% 3 = 51-75% 4 = 76-100%

Density code: T = trace S = sparse M = medium D = dense

Sheet Number of

3

Monitoring Site No. NB/C Sampler Name: C Esthimer Survey Date: 9-10-2021

GPS Location N Center Slalom Total Depth (ft): 7'4" SDT Depth (ft): 7'4"

W ____________

Plant Name	Aquatic Vegetation Coverage OBS. #1	OBS. #2	OBS. #3	OBS. #4	Aquatic Vegetation Density OBS. #1	OBS. #2	OBS. #3	OBS. #4
Variable milfoil								
Fanwort								
Naiad	2	3						
Egeria								
Large leaf pondweed	2	1						
Ribbon-leaf Pondweed								
Pondweed A								
Pondweed B								
Elodea								
Wild Celery (tapegrass)								
Bladderwort								
Nitella								
Najas spp.								
White waterlily								
Yellow waterlily								
Watershield								
Unknown 1								
Unknown 2								
Filamentous Algae								
Attached Algae	0	1						
Tape Grass	2	3						

Observations:

Coverage code: 1 = 5-25% 2 = 26-50% 3 = 51-75% 4 = 76-100%

Density code: T = trace S = sparse M = medium D = dense

Sheet Number ____ of ____

4

Monitoring Site No.: NB/WB   Sampler Name: C Esthimer   Survey Date: 9-10-2021

GPS Location N ______ W ______   Total Depth (ft): 6'   SDT Depth (ft): 6'

Plant Name	Aquatic Vegetation Coverage OBS. #1	OBS. #2	OBS. #3	OBS. #4	Aquatic Vegetation Density OBS. #1	OBS. #2	OBS. #3	OBS. #4
Variable milfoil								
Fanwort								
Naiad								
Egeria								
Large leaf pondweed	all clear - no vegetation							
Ribbon-leaf Pondweed								
Pondweed A								
Pondweed B								
Elodea								
Wild Celery (tapegrass)								
Bladderwort								
Nitella								
Najas spp.								
White waterlily								
Yellow waterlily								
Watershield								
Unknown 1								
Unknown 2								
Filamentous Algae								
Attached Algae								

Observations:

Coverage code: 1 = 5-25% 2 = 26-50% 3 = 51-75% 4 = 76-100%

Density code: T = trace S = sparse M = medium D = dense

Sheet Number ____ of ____

5 Monitoring Site No. NB/NWI Sampler Name: C Esthimer Survey Date: 9-10-2021

GPS Location N ______ W ______

Total Depth (ft): 5' SDT Depth (ft): 4'

Plant Name	Aquatic Vegetation Coverage OBS. #1	OBS. #2	OBS. #3	OBS. #4	Aquatic Vegetation Density OBS. #1	OBS. #2	OBS. #3	OBS. #4
Variable milfoil								
Fanwort								
Naiad	3	3						
Egeria								
Large leaf pondweed								
Ribbon-leaf Pondweed								
Pondweed A								
Pondweed B								
Elodea								
Wild Celery (tapegrass)								
Bladderwort								
Nitella								
Najas spp.								
White waterlily								
Yellow waterlily								
Watershield								
Unknown 1								
Unknown 2								
Filamentous Algae								
Attached Algae								
Tape Grass	3	3						

Observations: The water depth in September is usually 2-2.5! Water level high. Weeds moderate.

Coverage code: 1 = 5-25% 2 = 26-50% 3 = 51-75% 4 = 76-100%

Density code: T = trace S = sparse M = medium D = dense

Sheet Number ____ of ____

6 Monitoring Site No.: B/WI   Sampler Name: C Esthimer   Survey Date: 9-10-2021

GPS Location N ____________ W ____________   Total Depth (ft): 7.2"   SDT Depth (ft): 7.2"

Plant Name	Aquatic Vegetation Coverage OBS. #1	OBS. #2	OBS. #3	OBS. #4	Aquatic Vegetation Density OBS. #1	OBS. #2	OBS. #3	OBS. #4
Variable milfoil								
Fanwort								
Naiad								
Egeria								
Large leaf pondweed	1	0						
Ribbon-leaf Pondweed								
Pondweed A								
Pondweed B								
Elodea								
Wild Celery (tapegrass)								
Bladderwort								
Nitella								
Najas spp.								
White waterlily								
Yellow waterlily								
Watershield								
Unknown 1								
Unknown 2								
Filamentous Algae								
Attached Algae								
Tape grass	2	3						

Observations:

Coverage code: 1 = 5-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-100%

Density code: T = trace, S = sparse, M = medium, D = dense

Sheet Number ____ of ____

7

Monitoring Site No.: NSI   Sampler Name: C Esthimer   Survey Date: 9-10-2021

GPS Location N Boat Ramp   Total Depth (ft): 3'6"   SDT Depth (ft): 4'4"

W

Plant Name	Aquatic Vegetation Coverage OBS. #1	OBS. #2	OBS. #3	OBS. #4	Aquatic Vegetation Density OBS. #1	OBS. #2	OBS. #3	OBS. #4
Variable milfoil								
Fanwort	1	1						
Naiad								
Egeria								
Large leaf pondweed								
Ribbon-leaf Pondweed								
Pondweed A								
Pondweed B								
Elodea								
Wild Celery (tapegrass)								
Bladderwort								
Nitella								
Najas spp.								
White waterlily								
Yellow waterlily								
Watershield								
Unknown 1								
Unknown 2								
Filamentous Algae								
Attached Algae								
Tape grass	3	3						

Observations: Depth measurements incorrect due to boat movement

Coverage code: 1 = 5-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-100%

Density code: T = trace, S = sparse, M = medium, D = dense

Sheet Number   of

8 Monitoring Site No.: SB/SB Sampler Name: C Esthimer Survey Date: 9-10-2021

GPS Location N ____ W Sandy Beach Total Depth (ft): 4.2' SDT Depth (ft): 5'

Plant Name	Aquatic Vegetation Coverage OBS. #1	OBS. #2	OBS. #3	OBS. #4	Aquatic Vegetation Density OBS. #1	OBS. #2	OBS. #3	OBS. #4
Variable milfoil	1	1						
Fanwort								
Naiad								
Egeria								
Large leaf pondweed								
Ribbon-leaf Pondweed								
Pondweed A								
Pondweed B								
Elodea								
Wild Celery (tapegrass)								
Bladderwort								
Nitella								
Najas spp.								
White waterlily								
Yellow waterlily								
Watershield								
Unknown 1								
Unknown 2								
Filamentous Algae								
Attached Algae								

overall clear

Observations: water murky, tannic colored. Depths may be off due to boat movement

Coverage code: 1 = 5-25% 2 = 26-50% 3 = 51-75% 4 = 76-100%

Density code: T = trace S = sparse M = medium D = dense

9 Monitoring Site No.: SB/WB   Sampler Name: C Esthimer   Survey Date: 9-10-2021

GPS Location N ______ W ______   Total Depth (ft): 6'2"   SDT Depth (ft): 11"

Plant Name	Aquatic Vegetation Coverage OBS. #1	OBS. #2	OBS. #3	OBS. #4	Aquatic Vegetation Density OBS. #1	OBS. #2	OBS. #3	OBS. #4
Variable milfoil	1	1						
Fanwort								
Naiad	1	0						
Egeria								
Large leaf pondweed								
Ribbon-leaf Pondweed								
Pondweed A								
Pondweed B								
Elodea								
Wild Celery (tapegrass)								
Bladderwort								
Nitella								
Najas spp.								
White waterlily								
Yellow waterlily								
Watershield								
Unknown 1								
Unknown 2								
Filamentous Algae								
Attached Algae								

Observations: depths off due to boat movement

Coverage code: 1 = 5-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-100%

Density code: T = trace, S = sparse, M = medium, D = dense

10 Monitoring Site No.: SB/Dam   Sampler Name: C Esthimer   Survey Date: 9-10-2021

GPS Location N ______ W Dam   Total Depth (ft): 10'   SDT Depth (ft): 5'

Plant Name	Aquatic Vegetation Coverage				Aquatic Vegetation Density			
	OBS. #1	OBS. #2	OBS. #3	OBS. #4	OBS. #1	OBS. #2	OBS. #3	OBS. #4
Variable milfoil	1	1						
Fanwort								
Naiad								
Egeria	3	3						
Large leaf pondweed								
Ribbon-leaf Pondweed								
Pondweed A								
Pondweed B								
Elodea								
Wild Celery (tapegrass)								
Bladderwort								
Nitella								
Najas spp.								
White waterlily								
Yellow waterlily								
Watershield								
Unknown 1								
Unknown 2								
Filamentous Algae								
Attached Algae								

Observations: murky water. debris moving toward dam

Coverage code: 1 = 5-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-100%

Density code: T = trace, S = sparse, M = medium, D = dense

Sheet Number of

11

Monitoring Site No.: SB/EC.n   Sampler Name: C Esthimer   Survey Date: 9-10-2021

GPS Location N South Basin
W North of Rock pile   Total Depth (ft): 10.2   SDT Depth (ft): 8.4'

Plant Name	Aquatic Vegetation Coverage OBS. #1	OBS. #2	OBS. #3	OBS. #4	Aquatic Vegetation Density OBS. #1	OBS. #2	OBS. #3	OBS. #4
Variable milfoil	2	2						
Fanwort	2	2						
Naiad								
Egeria								
Large leaf pondweed	3	3						
Ribbon-leaf Pondweed								
Pondweed A								
Pondweed B								
Elodea	1	1						
Wild Celery (tapegrass)								
Bladderwort								
Nitella								
Najas spp.								
White waterlily								
Yellow waterlily								
Watershield								
Unknown 1								
Unknown 2								
Filamentous Algae								
Attached Algae								

Observations:

Coverage code: 1 = 5-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-100%

Density code: T = trace, S = sparse, M = medium, D = dense

Sheet Number of