MASSACHUSETTS
watershed·based plans

WATERSHED-BASED PLAN

Hamilton Reservoir (MA41019)

April 2021

Prepared By:

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Prepared For:

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection

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Executive Summary

Introduction: The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds and present the information in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows the United States Environmental Protection Agency's (EPA's) recommended format for "nine-element" watershed plans. This WBP was developed by Geosyntec Consultants (Geosyntec) under the direction of the Town of Holland, Massachusetts, with funding, input, and collaboration from the Massachusetts Department of Environmental Protection (MassDEP).

This WBP is for the Hamilton Reservoir watershed. The 413-acre Hamilton Reservoir is almost entirely located in Holland, Massachusetts and approximately 27 acres of the reservoir is located in Union, Connecticut. The reservoir itself is divided into two basins ("north basin" and "south basin") by a causeway (Mashapaug Road). Three major streams flow into the Hamilton Reservoir. The largest stream is Leadmine Brook, on the east side of the reservoir, which flows southward into Connecticut and enters the reservoir via Mashapaug Pond that connects to the reservoir. Browns Brook (MA41-20) discharges into the western side of the south basin. Stevens Brook (MA41-19) discharges into the western side of the north basin.

A dam is located at the northern point of the reservoir, and the Hamilton Reservoir is the headwaters of the Quinebaug River (MA41-01), which begins directly downstream of the dam and flows north through Holland and then south into Connecticut where it flows into the Shetucket River. For this WBP, the Hamilton Reservoir was delineated to the dam at the outlet of the reservoir; the watershed delineation does not include the Connecticut portion of the watershed. Most of the watershed is located within the Town of Holland with small portions also located in the neighboring towns of Wales and Sturbridge, Massachusetts.

Impairments and Pollution Sources: The Hamilton Reservoir (MA41019) is identified as a category 4C water body on the 2016 Massachusetts Integrated List of Waters (303(d) list) due to nonnative aquatic plants (MassDEP 2019). The town has used aquatic herbicides to mitigate this issue with minimal success. Nonpoint source runoff from roadways and residential properties adjacent to the reservoir, which delivers sediment directly to the reservoir, has been identified as the primary pollutant of concern for the reservoir. The high sediment loading has led to shallower and warmer waters making it easier for invasive plants to grow (Phippen and Reynells, 2000; Town of Holland, 2020).

In addition, a 9-foot by 11.5-foot corrugated metal pipe arch is located under the causeway and hydrologically connects the north and south basin. It was concluded in a 2018 Dredging Feasibility Study that the size of this culvert is restricting flow between the north and south basins. This restriction causes the south basin to act as a sediment trap for the north basin and may be contributing to the growth of invasive plants in the south basin (Milone and Macbroom 2018).

Goals, Management Measures, and Funding: The primary goal of this WBP is to improve water quality and ultimately remove the Hamilton Reservoir from the 303(d) list by 2031. The interim goal is to reduce land-use-based sediment loading by 6 tons per year over the next 3 years (by 2024). The Town of Holland has undertaken a methodical approach to improving the health and water quality of Hamilton Reservoir. In recent years, the primary strategy to reduce sediment loading to the reservoir has been to convert private roads (primarily dirt or gravel) into town roads, which are compacted or paved to minimize erosion. Once the roads are town-owned, the Town then implements stormwater Best Management Practices (BMPs) to further minimize the sediment deposited to the reservoir from the roadways and their contributing drainage areas.

The Town of Holland has previously used Section 319 Nonpoint Source Pollution Grant Program (Section 319) and Small Town Road Assistance Program (STRAP) funding to design and install BMPs to help improve the Hamilton Reservoir watershed area. It is expected that funding for future management measures will be obtained from these sources in addition to Town Capital funds, volunteer efforts, and other sources.

Public Education and Outreach: The Town of Holland and stakeholders continually implement a public education and outreach campaign to educate the public about nonpoint source pollution to the Hamilton Reservoir and invasive aquatic plants, with the goal of ensuring continued improvements in water quality and environmental stewardship. Recent efforts include regular Facebook page postings, periodical newsletters, hosting of an annual lake cleanup day, other "lake events," and signs at boat launches and boat ramps to provide a connection between public activities and reservoir water quality. Future efforts will include distributing pamphlets (focusing on residential BMP options) to homeowners around the Hamilton Reservoir.

Implementation Schedule and Evaluation Criteria: The WBP implementation schedule includes milestones for BMP implementation, monitoring, public education and outreach, and periodic updates to the WBP. It is expected that a water quality monitoring program will enable improvements to be directly evaluated over time. The WBP will be reevaluated every three years and adjusted as needed.

Introduction

What is a Watershed-Based Plan?

Purpose & Need

The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds and present the information in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows the United States Environmental Protection Agency's (EPA's) recommended format for "nine-element" watershed plans, as described below.

All states are required to develop WBPs, but not all states have taken the same approach. Most states develop WBPs only for selected watersheds. Massachusetts Department of Environmental Protection's (MassDEP's) approach has been to develop a tool to support statewide development of WBPs so **that good projects in all areas of the state may be eligible for federal watershed implementation grant funds** under Section 319 of the Clean Water Act.

EPA guidelines promote the use of Section 319 funding for developing and implementing WBPs. WBPs are required for all projects implemented with Section 319 funds and are recommended for all watershed projects, whether they are designed to protect unimpaired waters, restore impaired waters, or both.

Watershed-Based Plan Outline

This WBP for the Hamilton Reservoir watershed includes nine elements (a through i) in accordance with EPA Guidelines:

a) An **identification of the causes and sources** or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this WBP and to achieve any other watershed goals identified in the WBP, as discussed in item (b) immediately below.

b) An **estimate of the load reductions** expected for the management measures described under paragraph (c) below, recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time.

c) A **description of the nonpoint source (NPS) management measures** needed to achieve the load reductions estimated under paragraph (b) above as well as to achieve other watershed goals identified in this WBP and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

d) An **estimate of the amounts of technical and financial assistance needed**, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, United States Department of Agriculture's (USDA's) Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant federal, state, local, and private funds that may be available to assist in implementing this plan.

e) An **information/education component** that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

f) A **schedule for implementing the NPS management measures** identified in this plan that is reasonably expeditious.

g) A description of **interim, measurable milestones** for determining whether NPS management measures or other control actions are being implemented.

h) A set of **criteria to determine if loading reductions are being achieved** over time and substantial progress is being made toward attaining water quality standards and, if not, the criteria for determining whether this WBP needs to be revised or, if a NPS total maximum daily load (TMDL) has been established, whether the TMDL needs to be revised.

i) A **monitoring component** to evaluate the effectiveness of the implementation efforts over time measured against the criteria established under item (h) immediately above.

Project Partners and Stakeholder Input

This WBP was developed by Geosyntec under the direction of the Town of Holland, Massachusetts, with funding, input, and collaboration from MassDEP. This WBP was developed using funds from the Section 319 program to assist grantees in developing technically robust WBPs using MassDEP's Watershed-Based Planning Tool (WBP Tool). The Town of Holland was a recipient of Section 319 funding in Fiscal Year 2021 to implement structural best management practices (BMPs) in the Hamilton Reservoir watershed.

The following are core project stakeholders:

- Brian Johnson – Town of Holland Highway Department
- Joanne Higgens – Town of Holland Highway Department
- Stacy Stout – Town of Holland Administrator
- Dawn Kamay – Town of Holland Conservation Commission
- Sam Spratlin – Town of Holland Conservation Commission
- Tom Wilhelm – Friends of Hamilton Reservoir Association, Inc. (FHRA)
- Bob Kamay – FHRA
- Jean Pillo – The Last Green Valley, Inc. (TLGV)
- Mark Stadnicki – SVE Associates
- Matthew Reardon – MassDEP

This WBP was developed as part of an iterative process:

- First, the Geosyntec project team collected and reviewed existing data and reports for the Hamilton Reservoir watershed received from the Town of Holland and other stakeholders.
- Next, a core stakeholder conference call was facilitated on March 17, 2021, to solicit input and gain consensus on elements included in the plan (identifying problem areas, BMP projects, water quality goals, public outreach activities, etc.). The meeting minutes from the stakeholder conference call are included in **Appendix A**.
- Finally, the preliminary WBP was then drafted and reviewed by MassDEP and finalized based on MassDEP input.

Data Sources

This WBP was developed using the framework and data sources provided by MassDEP's WBP Tool and supplemented by information provided in the Section 319 application for "Hamilton Reservoir Watershed Improvement Project" (Town of Holland 2020). Additional data sources were reviewed and are included in subsequent sections of this WBP.

Summary of Completed Work

For over a decade, the Town of Holland has undertaken a methodical approach to improve the health and water quality of the Hamilton Reservoir and to preserve this unique natural, scenic, and recreational resource. In recent years, the primary strategy to reduce sediment loading to the reservoir has been to convert private roads (primarily dirt or gravel) into town roads, which are compacted or paved to minimize erosion. Once the roads are town-owned, the Town then implements stormwater Best Management Practices (BMPs) to further minimize the sediment deposited to the reservoir from the roadways and their contributing drainage areas. The Town of Holland and other stakeholders in the watershed have also been working diligently to increase public awareness and educate the community on the importance of improving the water quality of Hamilton Reservoir. The following project descriptions highlight water quality improvement projects that have been completed within the Hamilton Reservoir watershed (see Element C of this WBP for project locations).

Sturbridge Road Improvements (SVE Associates, 2009)

Stormwater improvements along Sturbridge Road included reconstruction approximately 2,500 linear feet of road between the intersection of East Brimfield Road to the culvert crossing below the reservoir dam and the Quinebaug River, adding a bicycle lane, and installing storm drainage infrastructure; the project also included stormwater improvements at the Holland Elementary School. The project improved positive conveyance of drainage and minimized erosion from these areas.

Over the Top Road Drainage Improvements Project (SVE Associates, 2016)

This project included installing 740 feet of drainage pipe, 590 feet of curbing, installation of seven (7) deep sump catch basins, installation of four (4) drainage manholes, installation of and 250 feet of retaining wall as well as replacing a headwall. The project was administered by the Pioneer Valley Planning Commission (PVPC) and funded by the Massachusetts Department of Housing and Community Development, Fiscal Year 2014 Holland Community Development Block Grant Program. The project improved positive conveyance of drainage and minimized erosion from these areas.

"Improving Water Quality in the Hamilton Reservoir Watershed" Project

The PVPC partnered with the Town of Holland and Horsley Witten Group to assess the Hamilton Reservoir watershed under funding from the Massachusetts DEP's 604(b) Program (PVPC 2007) and recommend priority BMPs to reduce sediment loading to the Hamilton Reservoir. The seven locations that were identified and for which concepts were developed include (in order of assessed priority) (PVPC 2007):

1. Mashapaug Road where it crosses Stevens Brook
2. Mashapaug Road between Brand Street and Fenton Street near the unnamed tributary that discharges to the Hamilton Reservoir
3. May Brook Road approximately 800 feet from the intersection of Union Road and May Brook Road and May Brook Road near the point where May Brook begins to flow parallel to the road

4. Mashapaug Road where it crosses Amber Brook
5. May Brook Road near the mouth of May Brook
6. Private Drive to the south of the unnamed tributary crossing Kimball Hill Road
7. Kimball Hill Road where it crosses an unnamed tributary to the Hamilton Reservoir

The following three locations were selected by the PVPC as high-priority sites for stormwater management and the implementation of BMPs. BMPs were implemented at these sites as part of a fiscal year 2007 Section 319 grant (Project #07-04 319) to reduce NPS pollution to the Hamilton Reservoir. These stormwater improvements, described in more detail below, provided stormwater runoff volume control, promoted infiltration, and reduced the nutrient and sediment loading to Hamilton Reservoir.

- **Mashapaug Road/Fenton Street**: Stormwater improvements along Mashapaug Road at the intersection with Fenton Street included a wetland replacement/improvement area with a sediment forebay, a permanent pool, vegetated planting bench with shrubs and herbaceous wetland species, and a stabilized outlet structure that discharges to a drainage channel that drains into Hamilton Reservoir.
- **Mashapaug Road (Stevens Brook):** Stormwater improvements to Mashapaug Road included installing sediment forebays, vegetated drainage channels, check dams, and a bioretention cell.
- **Kimball Hill Road:** Stormwater improvements to Kimball Hill Road included a wetland replication/improvement area, installing two sediment forebays, and installing natural stone-lined and riprap drainage channels, vegetated swales, and check dams.

Culvert replacements and additional stormwater infrastructure/BMP projects

Numerous culvert replacements have also been completed around the Hamilton Reservoir in the past decade; these replacements may help to decrease erosion and/or upstream deposition of sediment. These locations include the following:

- Mashapaug Road where it crosses Amber Brook
- Mashapaug Road along the small causeway on the eastern side of the Hamilton Reservoir
- Mashapaug/Chandler Road
- Leno Road
- Maybrook Road

Additional stormwater infrastructure/BMP projects that have been completed to help reduce sediment loading to the Hamilton Reservoir include: the following:

- Catch basins on Mashapaug Road in front of “PJ’s Town Crier”
- Sediment ponds at the bottom of Sand Hill Road
- Catch basins and sediment ponds at the bottom of Island Road
- A detention basin at the bottom of Old County Road

Element A: Identify Causes of Impairment & Pollution Sources

Element A: Identify the causes and sources or groups of similar sources that need to be controlled to achieve the necessary pollutant load reductions estimated in the watershed based plan (WBP).

General Watershed Information

Hamilton Reservoir is primarily located in Holland, Massachusetts, which is in southcentral Massachusetts bordering Union, Connecticut. The reservoir encompasses a total of 413 acres, with 386 acres in Holland and 27 acres in Union). The reservoir is divided into two basins ("north basin" and "south basin") by a causeway (Mashapaug Road). Three major streams flow into the Hamilton Reservoir. The largest stream is Leadmine Brook, on the east side of the reservoir, which flows southward into Connecticut and enters the reservoir via Mashapaug Pond that connects to the reservoir. Browns Brook (MA41-20) discharges into the western side of the south basin. Stevens Brook (MA41-19) discharges into the western side of the north basin.

A dam is located at the northern point of the reservoir, and the Hamilton Reservoir is the headwaters of the Quinebaug River (MA41-01), which begins directly downstream of the dam and flows north through Holland and then south into Connecticut where it flows into the Shetucket River. For this WBP, the Hamilton Reservoir was delineated to the dam at the outlet of the reservoir; the watershed delineation does not include the Connecticut portion of the watershed[1]. Most of the watershed is located within the Town of Holland with small portions also located in the neighboring towns of Wales and Sturbridge, Massachusetts.

Table A-1 presents the general watershed information for the Hamilton Reservoir watershed, and **Figure A-1** includes a map of the watershed boundary. A bathymetry map of the Hamilton Reservoir is included in **Appendix B**.

Table A-1: General Watershed Information

Watershed Name (Assessment Unit ID)	Hamilton Reservoir (MA41019)
Major Basin	Quinebaug
Watershed Area (within Massachusetts)	5,858 acres
Water Body Size	413 acres

[1] The watershed delineation was limited to the Massachusetts portion, because the WBP Tool delineations were only developed for the area within Massachusetts and therefore the analyses in this WBP are limited to the watershed area within MA.

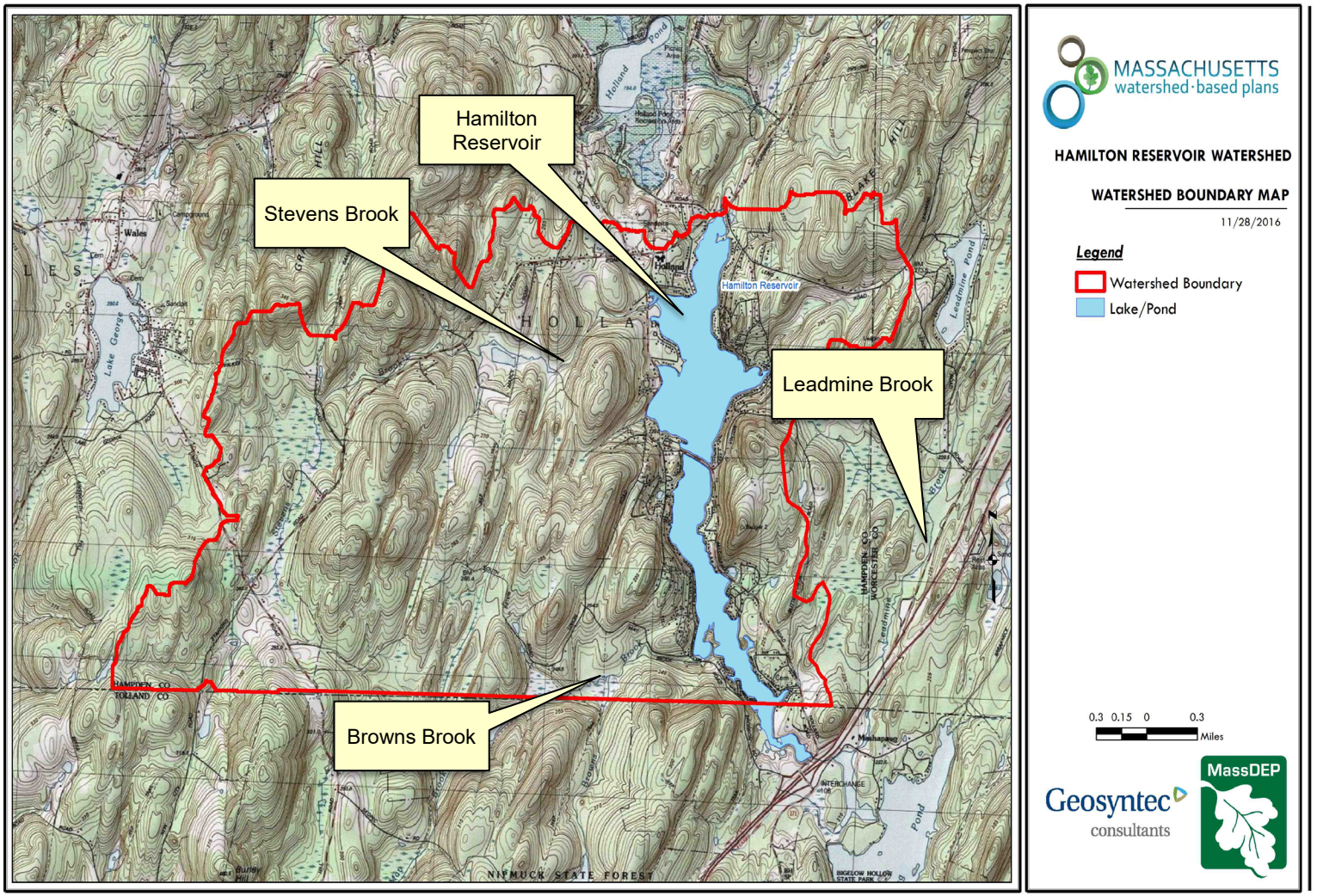


Figure A-1: Watershed Boundary Map

(MassGIS 1999, MassGIS 2001, USGS 2016)

(Ctrl + Click on the map to view a full-sized image in your web browser.)

MassDEP Water Quality Assessment Report and TMDL Review

Appendix C includes select excerpts from the French & Quinebaug River Watersheds 2004-2008 Water Quality Assessment Report (MassDEP 2009) relating to the presence of nonnative macrophyte species and recommendations for Hamilton Reservoir (MA41019). The report recommends continued monitoring for the presence of invasive nonnative aquatic vegetation to help determine the extent of the infestation. Once the extent of the problem is determined and control practices are implemented, the report states that vigilant monitoring must continue. It also recommends posting signs at boat access points to educate lake users of the problem and ways to prevent spreading these nonnative aquatic plant species.

The Hamilton Reservoir does not have a TMDL.

Water Quality Impairments and Pollution Sources

The Hamilton Reservoir (MA41019) is identified as a category 4C water body on the 2016 Massachusetts Integrated List of Waters (303(d) list) due to nonnative aquatic plants. A diagnostic feasibility study was performed in 1983, which originally documented the invasive species challenges in the reservoir (Cox and Popham 1983). The Town of Holland has used aquatic herbicides to mitigate this issue with minimal success. NPS runoff from roadways and adjacent residential properties, which delivers sediment directly to the reservoir, has been identified as the reservoir's primary pollutant of concern. The high sediment loading has led to shallower and warmer waters, making it easier for invasive plants to grow (Phippen and Reynells, 2000; Town of Holland 2020). See Element C for specific roads that were identified as problem areas and priority locations for future stormwater BMP implementation.

In addition, a 9-foot by 11.5-foot corrugated metal pipe arch is located under the causeway and hydrologically connects the north and south basin. It was concluded in a 2018 Dredging Feasibility Study that the size of this culvert is restricting flow between the north and south basins. This restriction causes the south basin to act as a sediment trap for the north basin and may be contributing to the growth of invasive plants in the south basin (Milone and Macbroom 2018).

Impairment categories from the Integrated List are listed in Table A-2. Known water quality impairments for the Hamilton Reservoir, as documented in the MassDEP 2016 Massachusetts Integrated List of Waters, are listed in **Table A-3**.

Table A-2: 2016 Massachusetts Integrated List of Waters Categories

Integrated List Category	Description
1	Unimpaired and not threatened for all designated uses.
2	Unimpaired for some uses and not assessed for others.
3	Insufficient information to make assessments for any uses.
4	Impaired or threatened for one or more uses, but not requiring calculation of a Total Maximum Daily Load (TMDL), including: 4a: TMDL is completed 4b: Impairment controlled by alternative pollution control requirements 4c: Impairment not caused by a pollutant - TMDL not required
5	Impaired or threatened for one or more uses and requiring preparation of a TMDL.

Table A-3: Water Quality Impairments

Assessment Unit ID	Waterbody	Integrated List Category	Designated Use	Impairment Cause	Impairment Source
MA41019	**Hamilton Reservoir**	**4C**	Fish, other Aquatic Life, and Wildlife	Nonnative Aquatic Plants	Introduction of Nonnative Organisms (Accidental or Intentional)

Additional Water Quality Data

Additional water quality data collected from the Hamilton Reservoir from 2016 through 2020 is described below (MassDEP 2021, Solitude Lake Management 2018, Solitude Lake Management 2019, Solitude Lake Management 2020, Town of Holland 2021).

MassDEP collected water quality samples at Hamilton Reservoir on three dates in 2016 at the deep hole site in the southwestern quadrant of the northern lobe, Holland (see Station ID: W2619 in **Figure A-2**), which included sampling for TP. Selected results from the MassDEP deep hole site sampling are shown below in **Table A-4 and Table A-5**. The results for TP were all below the water quality goal for TP, which is discussed in the next section and presented in **Table A-9** below.

MassDEP also collected water quality samples, which included *E. coli*, at Hamilton Reservoir on five dates in 2016 at Station ID: W2602,which is located at the western side of the north basin just southeast of the intersection of Chandler Road and Mashapaug Road (see **Figure A-2** for location). Results from the MassDEP sampling are included in **Table A-6**. The results for *E. coli* were all below the water quality goal for *E. coli*, which is discussed in the next section and presented in **Table A-9** below.

Over the past few years, as part of an aquatic plant management contract between Solitude Lake Management (Solitude) and the Town of Holland Lake Oversight Committee, Solitude has conducted herbicide treatments, vegetation surveys, and some water quality monitoring including sampling for TP (in 2018 and 2019) in Hamilton Reservoir. **Table A-7** provides water quality sampling results excerpted from the 2018 and 2019 Solitude reports. The full reports from 2018 through 2020 are included in **Appendix D**. The results for TP were all below the water quality goal for TP, which is discussed in the next section and presented in **Table A-9** below.

Table A-8 provides *E. coli* data taken by the Town of Holland Board of Health during the summer of 2020 at four different locations in Hamilton Reservoir. In late June/early July, there were three samples (at Massaconnet Shores and Brandon Road) that exceeded the water quality goal for *E. coli*, which is discussed in the next section and presented in **Table A-9** below.

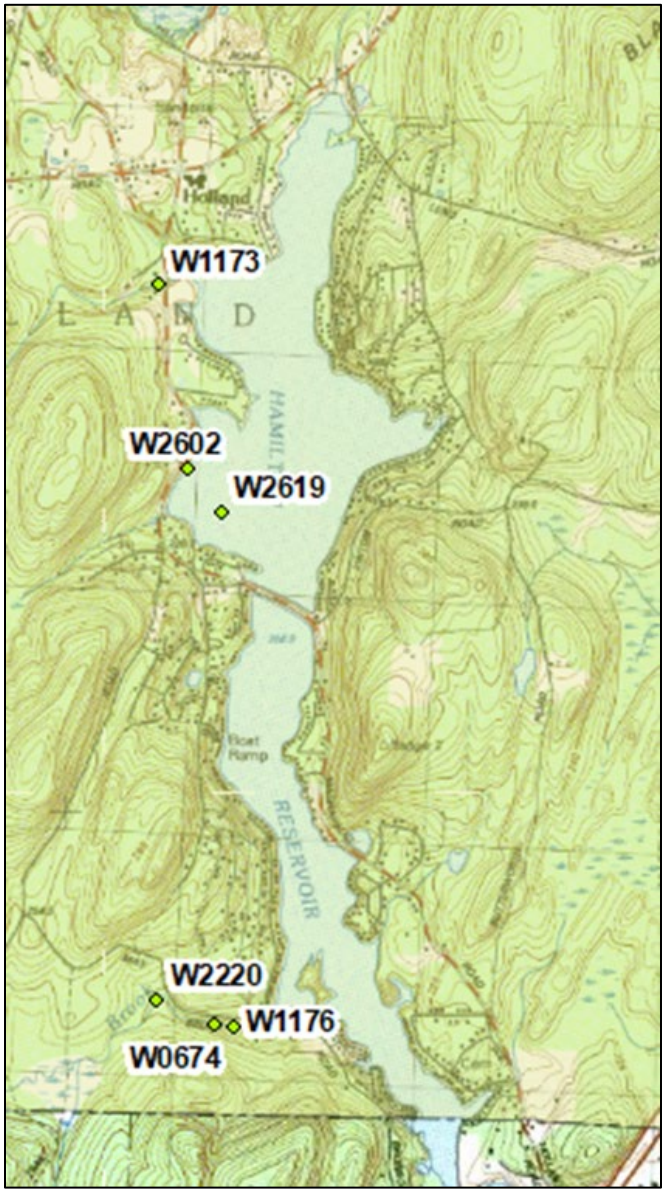


Figure A-2: MassDEP Sampling Locations in Hamilton Reservoir (MassDEP 2021)

Table A-4: Hamilton Reservoir 2016 Laboratory Data (MassDEP 2021)

Date	Station	Station Max Depth (meters)	Sample Depth (meters)	Relative Depth	Secchi Depth (meters)[1]	Parameter	Result
6/7/2016	W2619	4.3	**	Surface	2.7	Alkalinity (mg/L as CaCO3)	8
6/7/2016	W2619	4.3	**	Surface	2.7	Chloride (mg/L)	29
6/7/2016	W2619	4.3	**	Surface	2.7	Dissolved Organic Carbon (mg/L)	2.5
6/7/2016	W2619	4.3	**	Surface	2.7	Hardness (mg/L as CaCO3)	20
6/7/2016	W2619	4.3	**	Surface	2.7	Silicon - Dissolved (mg/L)	0.61 h
6/7/2016	W2619	4.3	**	Surface	2.7	Total Nitrogen (mg/L)	0.16 h
6/7/2016	W2619	4.3	**	Surface	2.7	Total Phosphorus (mg/L)	<0.01
6/7/2016	W2619	4.3	**	Surface	2.7	True Color (PCU)	<15 a
6/7/2016	W2619	4.3	**	Surface	2.7	Turbidity (NTU)	0.9
6/7/2016	W2619	4.3	4.0	Near bottom	2.7	Total Nitrogen (mg/L)	0.22 h
6/7/2016	W2619	4.3	4.0	Near bottom	2.7	Total Phosphorus (mg/L)	0.012
6/7/2016	W2619	4.3	0.0-4.0	--	2.7	Chlorophyll a (mg/m3)	2.8
7/19/2016	W2619	6.2	0.5	Surface	2.4 d	Alkalinity (mg/L as CaCO3)	9
7/19/2016	W2619	6.2	0.5	Surface	2.4 d	Chloride (mg/L)	31
7/19/2016	W2619	6.2	0.5	Surface	2.4 d	Dissolved Organic Carbon (mg/L)	3.2
7/19/2016	W2619	6.2	0.5	Surface	2.4 d	Hardness (mg/L as CaCO3)	20
7/19/2016	W2619	6.2	0.5	Surface	2.4 d	Silicon - Dissolved (mg/L)	0.96
7/19/2016	W2619	6.2	0.5	Surface	2.4 d	Total Nitrogen (mg/L)	0.18
7/19/2016	W2619	6.2	0.5	Surface	2.4 d	Total Phosphorus (mg/L)	<0.01 j
7/19/2016	W2619	6.2	0.5	Surface	2.4 d	True Color (PCU)	<15
7/19/2016	W2619	6.2	0.5	Surface	2.4 d	Turbidity (NTU)	1.2
7/19/2016	W2619	6.2	5.7	Near bottom	2.4 d	Total Nitrogen (mg/L)	0.17
7/19/2016	W2619	6.2	5.7	Near bottom	2.4 d	Total Phosphorus (mg/L)	0.01 j
7/19/2016	W2619	6.2	0.0-5.7	--	2.4 d	Chlorophyll a (mg/m3)	5.2
8/30/2016	W2619	6.3	0.5	Surface	2.3	Alkalinity (mg/L as CaCO3)	7
8/30/2016	W2619	6.3	0.5	Surface	2.3	Chloride (mg/L)	31
8/30/2016	W2619	6.3	0.5	Surface	2.3	Dissolved Organic Carbon (mg/L)	2.8
8/30/2016	W2619	6.3	0.5	Surface	2.3	Hardness (mg/L as CaCO3)	18
8/30/2016	W2619	6.3	0.5	Surface	2.3	Silicon - Dissolved (mg/L)	<0.09 h
8/30/2016	W2619	6.3	0.5	Surface	2.3	Total Nitrogen (mg/L)	0.23
8/30/2016	W2619	6.3	0.5	Surface	2.3	Total Phosphorus (mg/L)	0.01
8/30/2016	W2619	6.3	0.5	Surface	2.3	True Color (PCU)	<15 a
8/30/2016	W2619	6.3	0.5	Surface	2.3	Turbidity (NTU)	1.7
8/30/2016	W2619	6.3	5.7	Near bottom	2.3	Total Nitrogen (mg/L)	0.56
8/30/2016	W2619	6.3	5.7	Near bottom	2.3	Total Phosphorus (mg/L)	0.019
8/30/2016	W2619	6.3	0.0-5.7	--	2.3	Chlorophyll a (mg/m3)	3

1. The Secchi depth is the depth at which a weighted, black-and-white disk, 20 cm in diameter, disappears from view.

mg/L = milligrams/liter
PCU = platinum-cobalt units
NTU = Nephelometric Turbidity Units
" ** " = Missing data (i.e., data that should have been reported, but were not for any reason other than no water).
" a " = accuracy as estimated at William X. Wall Experiment Station (WES) Lab via matrix spikes, PT sample recoveries, internal check standards and lab-fortified blanks did not meet project data quality objectives identified for program or in Quality Assurance Project Plan (QAPP).
" d " = precision of field duplicates (as relative percent difference) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected. "d" may also apply to lab duplicate precision.
" h " = holding time violation (usually indicating possible bias low)
" j " = 'estimated' value; can be used for lab-related issues where certain lab quality control criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the 'reporting' limit or RDL and greater than the method detection limit or MDL (MDL< x <RDL). Also used to note where values have been reported at levels less than the MDL. Also used for estimated ranges based on known metadata.

Table A-5: Hamilton Reservoir 2016 Attended Data (MassDEP 2021)

Date	Station	Sample Depth (meters)	Temperature (degrees C)	pH (Standard Units)	Specific Conductance (uS/cm)	Total Dissolved Solids (mg/L)	Dissolved Oxygen (mg/L)	Saturation Value of Dissolved Oxygen (%)
6/7/2016	W2619	0.5	23.6	6.8	122	78	8.0	97
6/7/2016	W2619	0.9	23.5	6.8	122	78	8.0	97
6/7/2016	W2619	1.5	23.1	6.7	122	78	7.8	94
6/7/2016	W2619	2.0	23	6.7	122	78	7.5	90
6/7/2016	W2619	2.4	22.6	6.6	122	78	7.4 u	88 u
6/7/2016	W2619	3.0	22.1	6.4	122	78	6.5 u	76 u
6/7/2016	W2619	3.6	18.5	6.2	121	77	5.8	64
6/7/2016	W2619	4.0	17.1	6.1	120	76	4.9	53
6/7/2016	W2619	4.4	15.6 u	6	120	77	3.2 u	33 u
7/19/2016	W2619	0.5	26.9	7	127	82	8.1	103
7/19/2016	W2619	1.5	26.9	7	128	82	8.1	103
7/19/2016	W2619	2.5	26.8	7	128	82	8.0	102
7/19/2016	W2619	3.4	24.3	6.4	127	82	5.7	69
7/19/2016	W2619	4.5	22.4 m	6.1 m	129 m	82 m	2.2 m	26 m
7/19/2016	W2619	5.6	18.8	6.3	148	95	<0.2	<2
8/30/2016	W2619	0.5	26.5	6.8	126	81	7.8	98
8/30/2016	W2619	1.0	25.9	6.8	126	81	7.8	98
8/30/2016	W2619	2.0	25.7	6.8	126	81	7.7	96
8/30/2016	W2619	3.0	25.6	6.7	126	80	7.5	94
8/30/2016	W2619	4.0	25.4	6.6	127	81	6.8	84
8/30/2016	W2619	4.9	24	6.2	136	87	0.2	3
8/30/2016	W2619	6.0	20.8	6.9	202	129	<0.2	<2

mg/L = milligrams/liter
uS/cm = microSiemens/centimeter
" ** " = Missing data (i.e., data that should have been reported, but were not for any reason other than no water).
" m " = method not followed; one or more protocols contained in the DWM Multiprobe SOP not followed (e.g., operator error; less than 3 readings per station (rivers) or per depth (lakes); or instrument failure not allowing method to be implemented).
" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly variable water quality conditions, etc.

Table A-6: Hamilton Reservoir 2016 Shoreline Survey Results (MassDEP 2021)

Station	Date	Time	Parameter	Result
W2602	5/18/2016	10:10:00 AM	E. coli (MPN/100mL)	2
W2602	6/22/2016	9:35:00 AM	E. coli (MPN/100mL)	5
W2602	7/13/2016	9:58:00 AM	Anatoxin-a, Total (µg/L)	<0.33 j
W2602	7/13/2016	9:58:00 AM	E. coli (MPN/100mL)	46
W2602	7/13/2016	9:58:00 AM	Microcystins and Nodularins, Total (µg/L)	0.30 j
W2602	8/17/2016	9:45:00 AM	Anatoxin-a, Total (µg/L)	<0.33 j
W2602	8/17/2016	9:45:00 AM	E. coli (MPN/100mL)	16
W2602	8/17/2016	9:45:00 AM	Microcystins and Nodularins, Total (µg/L)	<0.30
W2602	9/21/2016	10:10:00 AM	Anatoxin-a, Total (µg/L)	<0.33
W2602	9/21/2016	10:10:00 AM	E. coli (MPN/100mL)	4
W2602	9/21/2016	10:10:00 AM	Microcystins and Nodularins, Total (µg/L)	<0.30

μg /L = micrograms/liter
MPN/100mL = most probable number/100 milliliters
" j " = 'estimated' value; can be used for lab-related issues where certain lab quality control criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the 'reporting' limit or RDL and greater than the method detection limit or MDL (MDL< x <RDL). Also used to note where values have been reported at levels less than the MDL. Also used for estimated ranges based on known metadata.

Table A-7: Tables excerpted from 2018 and 2019 Aquatic Plan Management Reports (Solitude Lake Management 2018, Solitude Lake Management 2019)

Table 2: July 2018 water quality sampling

Parameter	Units	Detection Levels	Massaconnic Beach	Brandon St. Cove	Aqua Rider's Beach	Boat Ramp
E. Coli	Col/mL	1.0	50	31	67	72
Total Phosphorus	Mg/L	0.010	0.019	0.015	0.021	0.013
Dissolved Phosphorus	Mg/L	0.010	0.013	ND	0.014	ND
True Color	Color Units	5	29	16	40	18
Apparent Color	Color Units	10	50	32	60	29
Ammonia/Nitrogen	Mg/L	0.010	ND	0.080	ND	ND
Total Alkalinity	Mg/L	2.0	14.9	12.3	21.3	11.7
Total Kjeldahl Nitrogen	Mg/L	0.300	0.476	0.533	0.546	0.490
Nitrate/Nitrogen	Mg/L	0.010	ND	ND	ND	ND
Turbidity	NTU	0.20	5.5	2.9	5.2	2.5
pH	pH Units	--	6.8	6.8	6.6	6.8

Table 2: June and July 2019 water quality sampling results

Parameter	Units	Detection Level	North-Primary		North-Secondary		South-Primary		South-Secondary	
			June	July	June	July	June	July	June	July
Total Phosphorus	Mg/L	0.010	0.010	0.014	ND	0.014	ND	0.021	0.015	0.019
Dissolved Phosphorus	Mg/L	0.010	ND	0.011	ND	ND	ND	0.011	ND	0.010
Ammonia/Nitrogen	Mg/L	0.010	0.116	NS	0.080	NS	ND	NS	0.090	NS
Total Alkalinity	Mg/L	2.0	7.3	9.9	NS	9.7	8.8	11.8	NS	11.1
Total Kjeldahl Nitrogen	Mg/L	0.300	0.360	0.339	0.304	0.460	0.455	0.391	0.476	0.634
Nitrate/Nitrogen	Mg/L	0.010	ND	ND	ND	ND	ND	ND	ND	ND
Turbidity	NTU	0.20	3.0	2.4	NS	2.1	2.2	2.7	NS	3.0
Secchi Clarity	Feet		7.0	5.0			6.2	5.0		

*NS=Not sampled; ND=Not-detected

Col/mL = colonies/milliliter
Mg/L = milligrams/liter
NTU = Nephelometric Turbidity Units

Table A-8: Town of Holland Board of Health *E. coli* Data (Town of Holland 2021)

Date	Location	E. coli (MPN/100 ml)
6/22/2020	Brandon Road	8.5
6/29/2020	Brandon Road	**517.2**
7/1/2020	Brandon Road	54.6
7/13/2020	Brandon Road	9.8
7/20/2020	Brandon Road	42.2
7/27/2020	Brandon Road	30.1
8/3/2020	Brandon Road	146.7
8/10/2020	Brandon Road	12.1
8/17/2020	Brandon Road	18.1
8/31/2020	Brandon Road	5.1
6/29/2020	Collette Drive Beach	86.2
7/6/2020	Collette Drive Beach	2
7/13/2020	Collette Drive Beach	21.1
7/20/2020	Collette Drive Beach	7.4
7/27/2020	Collette Drive Beach	<1
8/3/2020	Collette Drive Beach	39.3
8/10/2020	Collette Drive Beach	20.3
8/17/2020	Collette Drive Beach	3.1
8/31/2020	Collette Drive Beach	2
6/29/2020	Craig Road Beach	57.1
7/13/2020	Craig Road Beach	4.1
7/20/2020	Craig Road Beach	2
7/27/2020	Craig Road Beach	66.3
8/3/2020	Craig Road Beach	16.1
8/10/2020	Craig Road Beach	3.1
8/17/2020	Craig Road Beach	3
6/29/2020	Massaconnet Shores	**435.2**
7/1/2020	Massaconnet Shores	**410.6**
7/6/2020	Massaconnet Shores	16
7/13/2020	Massaconnet Shores	38.9
7/20/2020	Massaconnet Shores	1
7/27/2020	Massaconnet Shores	83.9
8/3/2020	Massaconnet Shores	104.3
8/10/2020	Massaconnet Shores	26.5
8/17/2020	Massaconnet Shores	17.3
8/31/2020	Massaconnet Shores	1

MPN/100mL = most probable number/100 milliliters

Water Quality Goals

Water quality goals may be established for a variety of purposes, including the following:

a.) For **water bodies with known impairments**, a Total Maximum Daily Load (TMDL) is established by MassDEP and the EPA as the maximum amount of the target pollutant that the water body can receive and still safely meet water quality standards. If the waterbody has a TMDL for total phosphorus (TP) or total nitrogen (TN) or total suspended solids (TSS), that information is provided below and included as a water quality goal.

b.) For **water bodies without a TMDL for total phosphorus** (TP), a default water quality goal for TP is based on target concentrations established in the Quality Criteria for Water (EPA 1986) (also known as the "Gold Book"). The Gold Book states that TP should not exceed 50 micrograms per liter (µg/L) in any stream at the point where it enters any lake or reservoir, nor should TP exceed 25 µg/L within a lake or

reservoir. For the purposes of developing WBPs, MassDEP has adopted 50 µg/L as the TP target for all streams at their downstream discharge point, regardless of which type of water body the stream discharges to.

c.) Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013) prescribe the minimum water quality criteria required to sustain a water body's designated uses. Hamilton Reservoir is a Class B water body. The water quality goal for fecal coliform bacteria is based on the Massachusetts Surface Water Quality Standards.

d.) **Other water quality goals set by the community** (protection of high-quality waters, in-lake phosphorus concentration goal to reduce recurrence of cyanobacteria blooms, etc.).

Table A-9 lists water quality goals for TP, bacteria (*E. coli*) and nonnative aquatic macrophytes. It is expected that efforts to reduce sediment and nutrient loading will reduce the biomass of nonnative aquatic macrophytes in the Hamilton Reservoir.

Table A-9: Water Quality Goals

Pollutant	Goal	Source
Total Phosphorus (TP)	Total phosphorus should not exceed: --50 µg/L in any stream --25 µg/L within any lake or reservoir	Quality Criteria for Water (USEPA 1986)
Bacteria	**Class B Standards** • Public Bathing Beaches: For *E. coli*, geometric mean of 5 most recent samples shall not exceed 126 colonies/ 100 ml and no single sample during the bathing season shall exceed 235 colonies/100 ml. For enterococci, geometric mean of 5 most recent samples shall not exceed 33 colonies/100 ml and no single sample during bathing season shall exceed 61 colonies/100 ml; • Other Waters and Non-bathing Season at Bathing Beaches: For *E. coli*, geometric mean of samples from most recent 6 months shall not exceed 126 colonies/100 ml (typically based on minimum of 5 samples), and no single sample shall exceed 235 colonies/100 ml. For enterococci, geometric mean of samples from most recent 6 months shall not exceed 33 colonies/100 ml, and no single sample shall exceed 61 colonies/100 ml.	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013)
Nonnative Aquatic Macrophytes	Aquatic vegetation surveys of the Hamilton Reservoir were conducted in 2018, 2019, and 2020 and documented the presence of nonnative aquatic plants, including variable watermilfoil, fanwort, tapegrass, and watershield. This goal is therefore to consistently reduce the assessed biomass of nonnative aquatic macrophytes, eventually leading to delisting of the impairment from the 303(d) list.	Solitude Lake Management 2018, 2019, 2020

Land Use Information

Land use information and impervious cover is presented in the tables and figures below. Land use source data is from 2005 and was obtained from MassGIS (2009b).

Watershed Land Uses

Land use in the Hamilton Reservoir watershed is mostly forested (approximately 81 percent); approximately 9 percent of the watershed is residential (mostly concentrated directly around the Hamilton Reservoir); approximately 7 percent of the watershed is open land or water; approximately 3 percent of the watershed is agricultural; approximately 0.5 percent of the watershed is industrial or commercial; and approximately 0.1 percent of the watershed is designated as highway (**Table A-10** and **Figure A-3**).

Table A-10: Subwatershed Land Uses

Land Use	Area (acres)	% of Watershed
Forest	4,715.86	80.5
Water	400.01	6.8
Low-Density Residential	255.98	4.4
Agricultural	200.8	3.4
Medium-Density Residential	137.49	2.3
High-Density Residential	106.48	1.8
Commercial	20.8	0.4
Open Land	10.52	0.2
Highway	7.21	0.1
Industrial	2.94	0.1
Total:	5,858.09	100

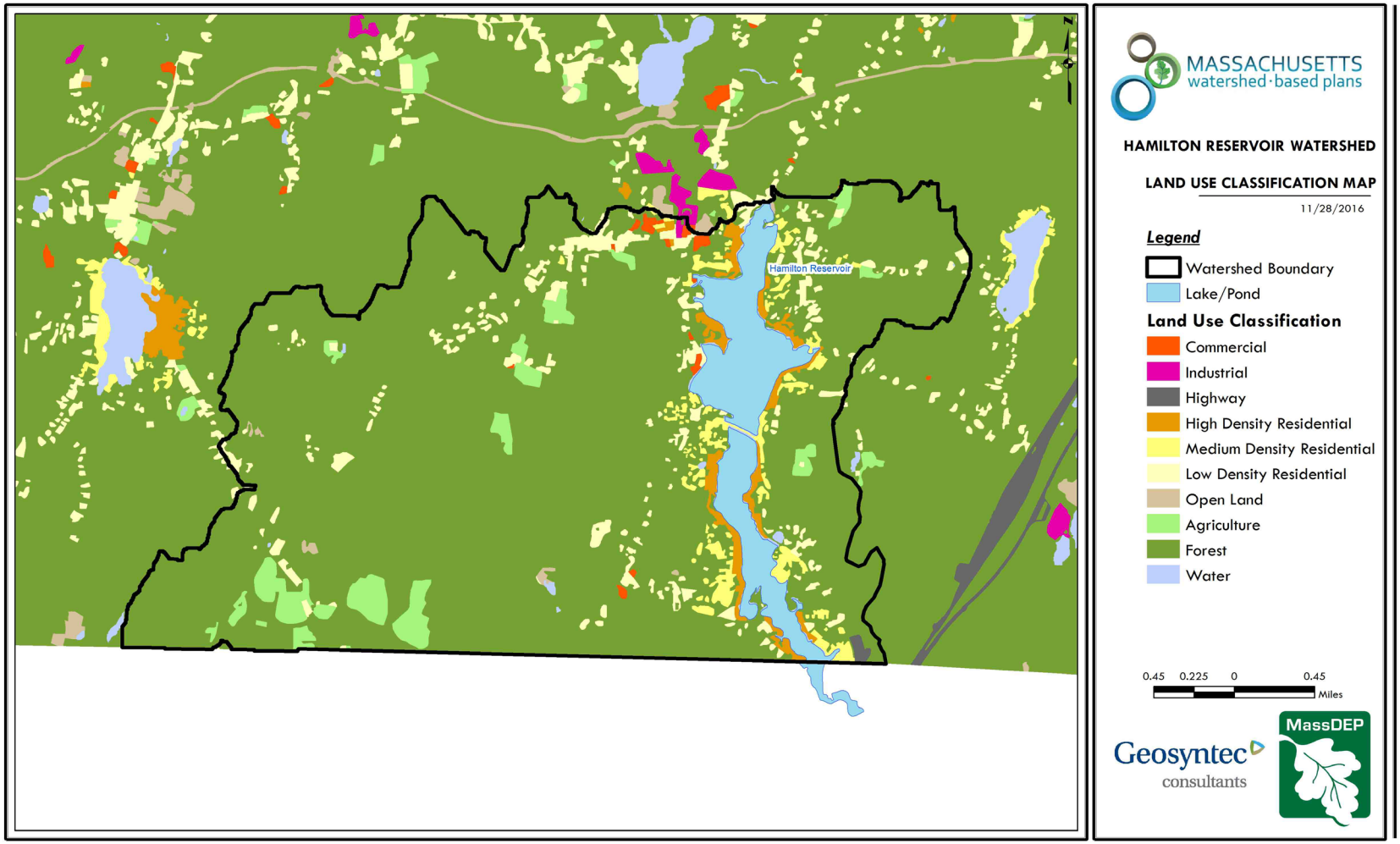


Figure A-3: Subwatershed Land Use Map

(MassGIS 2009b, MassGIS 1999, MassGIS 2001, USGS 2016)

Ctrl + Click on the map to view a full-sized image in your web browser.

Watershed Impervious Cover

There is a strong link between impervious land cover and stream water quality. Impervious cover includes land surfaces that prevent the infiltration of water into the ground, such as paved roads and parking lots, roofs, basketball courts, etc. Impervious area within the watershed is mostly concentrated directly adjacent to the Hamilton Reservoir (**Figure A-4**).

Impervious areas that are directly connected (DCIA) to receiving waters (via storm sewers, gutters, or other impervious drainage pathways) produce higher runoff volumes and transport stormwater pollutants with greater efficiency than disconnected impervious cover areas which are surrounded by vegetated, pervious land. Runoff volumes from disconnected impervious cover areas are reduced as stormwater infiltrates when it flows across adjacent pervious surfaces.

An estimate of DCIA for the watershed was calculated based on the Sutherland equations. EPA provides guidance (EPA 2010) on the use of the Sutherland equations to predict relative levels of connection and disconnection based on the type of stormwater infrastructure within the total impervious area (TIA) of a watershed. The estimated TIA and DCIA for the Hamilton Reservoir watershed is 3.5 percent and 2.3 percent, respectively.

The relationship between TIA and water quality can generally be categorized as listed by **Table A-11** (Schueler et al. 2009). The TIA value for the watershed range is 3.5%; therefore, the river and surrounding tributaries can be expected to show good to excellent water quality; nevertheless, it is likely there is better water quality in the upstream forested parts of the watershed, while more downstream developed areas adjacent to the Hamilton Reservoir have poorer water quality.

Table A-11: Relationship between Total Impervious Area (TIA) and Water Quality (Schueler et al. 2009)

% Watershed Impervious Cover	Stream Water Quality
0% to 10%	Typically high quality, and typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and aquatic insects.
11% to 25%	These streams show clear signs of degradation. Elevated storm flows begin to alter stream geometry, with evident erosion and channel widening. Streams banks become unstable, and physical stream habitat is degraded. Stream water quality shifts into the fair/good category during both storms and dry weather periods. Stream biodiversity declines to fair levels, with most sensitive fish and aquatic insects disappearing from the stream.
26% to 60%	These streams typically no longer support a diverse stream community. The stream channel becomes highly unstable, and many stream reaches experience severe widening, downcutting, and streambank erosion. Pool and riffle structure needed to sustain fish is diminished or eliminated and the substrate can no longer provide habitat for aquatic insects, or spawning areas for fish. Biological quality is typically poor, dominated by pollution tolerant insects and fish. Water quality is consistently rated as fair to poor, and water recreation is often no longer possible due to the presence of high bacteria levels.
>60%	These streams are typical of urban drainage, with most ecological functions greatly impaired or absent, and the stream channel primarily functioning as a conveyance for stormwater flows.

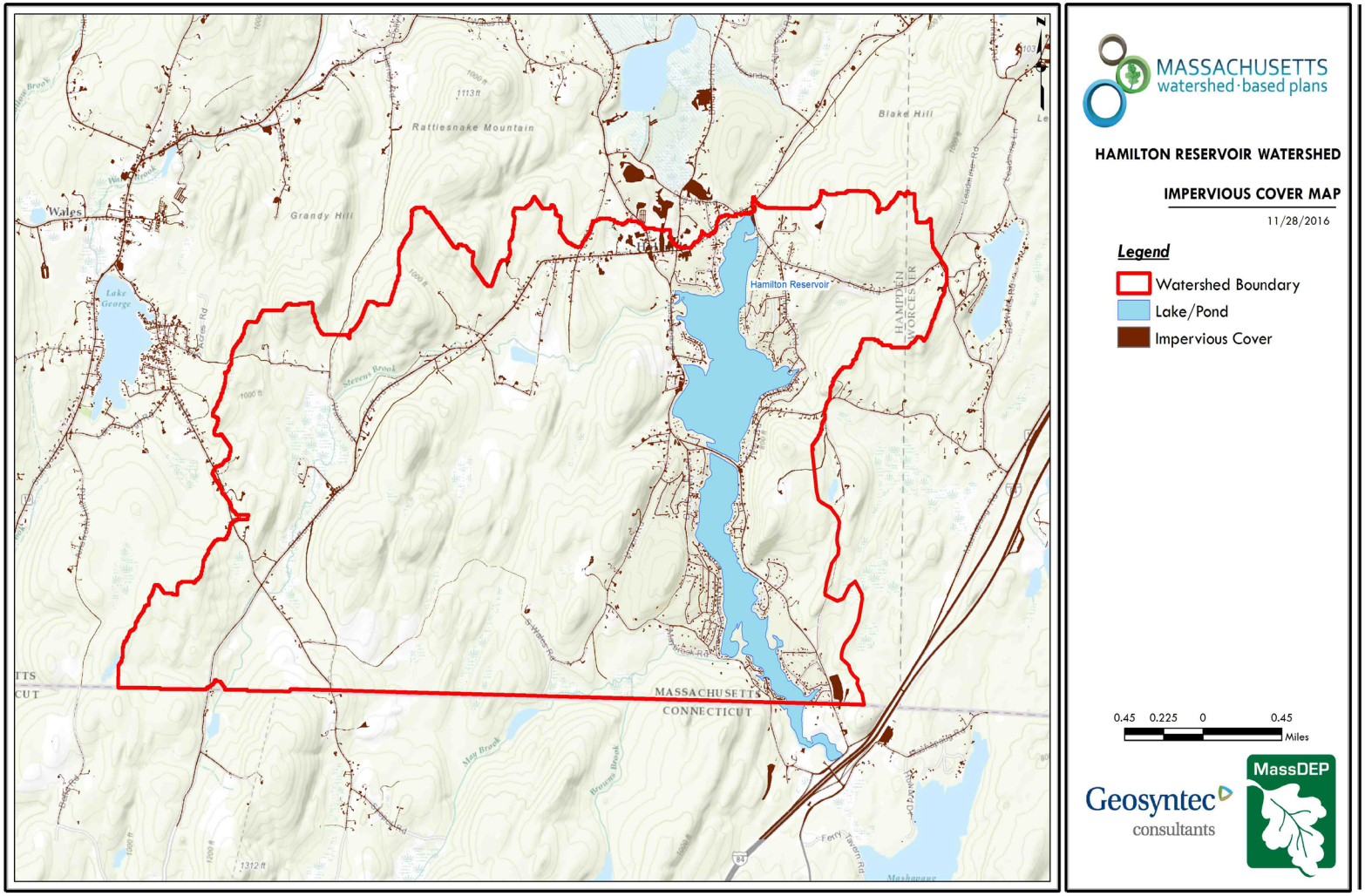


Figure A-4: Subwatershed Impervious Surface Map

(MassGIS 2009b, MassGIS 1999, MassGIS 2001, USGS 2016)

Pollutant Loading

The land use data (MassGIS 2009b) was intersected with impervious cover data (MassGIS 2009a) and USDA Natural Resources Conservation Service (NRCS) soils data (USDA NRCS and MassGIS 2012) to create a combined land use/land cover grid. The grid was used to sum the total area of each unique land use/land cover type.

The amount of DCIA was estimated using the Sutherland equations as described above, and any reduction in impervious area due to disconnection (i.e., the area difference between TIA and DCIA) was assigned to the pervious D soil category for that land use to simulate that some infiltration will likely occur after runoff from disconnected impervious surfaces passes over pervious surfaces.

Pollutant loading for key NPS pollutants in the watershed was estimated by multiplying each land use/cover type area by its pollutant load export rate (PLER). The PLERs are an estimate of the annual total pollutant load exported via stormwater from a given unit area of a particular land cover type. The PLER values for TN, TP, and TSS were obtained from EPA (Voorhees 2016) (see documentation provided in **Appendix E**) as follows:

$$L_n = A_n * P_n$$

Where L_n = Loading of land use/cover type n (lb/yr); A_n = area of land use/cover type n (acres); P_n = pollutant load export rate of land use/cover type n (lb/acre/yr)

Table A-10 presents the estimated land-use-based TP, TN, and TSS within the Hamilton Reservoir watershed. The largest contributor of the land-use-based TP, TN and TSS load originates from areas designated as forested. TP and TN generated from forested areas is generally a result of natural processes such as decomposition of leaf litter and other organic material; therefore, the forested portions of the watershed are unlikely to provide opportunities for nutrient load reductions through BMPs. Residential areas are the second largest contributors of land-use-based TP, TN and TSS load in the watershed. Residential areas provide opportunities for pollutant load reductions through public education and outreach and implementation of residential BMPs. Agricultural areas are the third largest contributors of land-use-based TP, TN, and TSS load in the watershed. Agricultural areas provide opportunities for pollutant load reductions through agricultural BMPs.

It is highly likely that pollutant loading estimates provided by **Table A-13** underrepresent actual conditions for the following reasons.

1) There are multiple dirt and gravel roads adjacent to the Hamilton Reservoir that likely contribute more pollutant loading (TSS, TN, TP) to the reservoir than estimated from the standard PLER from residential areas (**Appendix E**).
2) Pollutant load estimates are solely based on land-use-based runoff and do not consider other sources such as internal loading from bottom sediments, septic systems, and aerial deposition; all of which can be significant sources of pollution to a lake, reservoir, or pond. For example, lake sediment contains phosphorus that is bound to the sediment particles. During periods of anoxia (oxygen concentration ≤ 1 mg/L), phosphorus can be released into the water from lake sediments in soluble form, making it biologically available to fuel increased algal productivity.

Table A-13: Estimated Pollutant Loading for Key Nonpoint Source Pollutants

Land Use Type	Pollutant Loading[1]		
	Total Phosphorus (TP) (lbs/yr)	Total Nitrogen (TN) (lbs/yr)	Total Suspended Solids (TSS) (tons/yr)
Forest	641	3,250	170.14
Agriculture	93	550	6.24
Low-Density Residential	77	768	10.36
High-Density Residential	56	399	5.74
Medium-Density Residential	45	394	5.36
Commercial	16	142	1.77
Highway	6	50	3.37
Open Land	4	34	0.73
Industrial	3	27	0.34
TOTAL	941	5,614	204.04

[1]These estimates do not consider loads from point sources or septic systems.

Element B: Determine Pollutant Load Reductions Needed to Achieve Water Quality Goals

Element B of your WBP should:

Determine the pollutant load reductions needed to achieve the water quality goals established in Element A. The water quality goals should incorporate Total Maximum Daily Load (TMDL) goals, when applicable. For impaired water bodies, a TMDL establishes pollutant loading limits as needed to attain water quality standards.

Estimated Pollutant Loads

Estimated pollutant loads for TP, TN, and TSS were previously presented in **Table A-10** of this WBP. *E. coli* loading has not been estimated for this WBP because there are no known PLERs for *E. coli*. As is explained in Element A, it is highly likely that pollutant loading estimates provided by **Table A-10** underrepresent actual conditions.

Water Quality Goals and Recommended Load Reduction

As discussed in Element A, Hamilton Reservoir is impaired for nonnative aquatic plants. A qualitative water quality goal was established under Element A to consistently reduce the assessed biomass of nonnative aquatic macrophytes, eventually leading to removing the impairment from the 303(d) list. Past studies have suggested that NPS runoff from several areas in the watershed deposit sediment into the reservoir, leading to shallower and warmer waters, and thereby making it easier for plants to grow. Sediment particles also readily transport other pollutants, such as metals, nutrients, and pathogens, which can further degrade water quality.

Management measures will primarily focus on reducing sediment and nutrient loading to the reservoir, which is expected to decrease nonnative aquatic macrophyte biomass. Since limited water quality monitoring has been recently performed and pollutant load estimates likely underrepresent actual conditions, the following adaptive sequence is proposed to establish and track quantitative load reduction goals:

1. Establish an interim goal to reduce land-use-based sediment loading by 6 tons per year over the next 3 years (by 2024).
2. Continue and expand the baseline water quality and vegetation monitoring program in accordance with **Element I** of this document. Use results from the monitoring program to calculate annual sediment and phosphorus budgets and obtain a better understanding of other water quality parameters, such as dissolved oxygen. Annual budgets will provide more fine-tuned predictions of loading, including other potential sources such as internal phosphorus loading from sediment.
3. Based on the annual sediment and phosphorus budgets, establish a realistic, long-term load-reduction goal(s) that, once attained, will result in delisting the Hamilton Reservoir from the 303(d) list for nonnative aquatic macrophytes and approaching or exceeding oligotrophic conditions within the next 10 years (by 2031).

Element C: Describe management measures that will be implemented to achieve water quality goals

Element C: A description of the nonpoint source management measures needed to achieve the pollutant load reductions presented in Element B, and a description of the critical areas where those measures will be needed to implement this plan.

Previous, Current and Ongoing Management Measures

Details on completed management measures in the Hamilton Reservoir watershed are included in the Introduction section of this WBP. The locations of completed, ongoing, and future management measures are identified in Figure C-1.

The Town of Holland was awarded funding through the Fiscal Year 2021 Section 319 NPS Pollution Grant Program to install 10 deep sump catch basins with oil hoods, 6 deep sump drop inlets with oil hoods, and 1,300 feet of pavement and road improvements along Mountain Road and Sandy Beach Road, which are located adjacent to the Hamilton Reservoir. **Appendix F** includes the preliminary design drawings for this project. Currently, there are no catch basins on any sections of these roads where this work will be completed, and sediment-laden storm water flows directly into the south basin of Hamilton Reservoir from these areas. This populated area is steeply sloped, and the highway department has been regularly cleaning and repairing storm water runoff damage for years in this section of town. Because the situation deteriorated so badly in 2019, a temporary repair had to be installed at the bottom of Sandy Beach Road due to the storm water draining to it from Mountain Road and Sandy Beach Road. This temporary repair was needed to make it passable for residents until this project could be completed. It is anticipated that this BMP project will result in a combined load reduction of approximately 5.8 tons per year of TSS, 7.1 pounds per year of TP, and 18.5 pounds per year of TN (Town of Holland 2020). **Table C-1** lists the estimated TSS load reduction from this project as well as the completed Section 319 grant-funded projects.

Table C-1: Estimated TSS Load Reductions from Completed and Ongoing Section 319 grant-funded BMP projects

BMP Location	Status	BMP ID (Figure C-1)	BMP Type	TSS Load Removed (tons/yr)
Mashapaug Road at Stevens Brook	Completed	4	Bioretention Cell	0.48
Kimball Hill Road	Completed	5	Wetland replication/improvement	0.41
Fenton Street and Mashapaug Road	Completed	6	Wetland replication/improvement	0.34
Mountain Road and Sandy Beach Road	Ongoing	16	Drainage infrastructure/road improvements	5.8
TOTAL				7.0

Future Management Measures

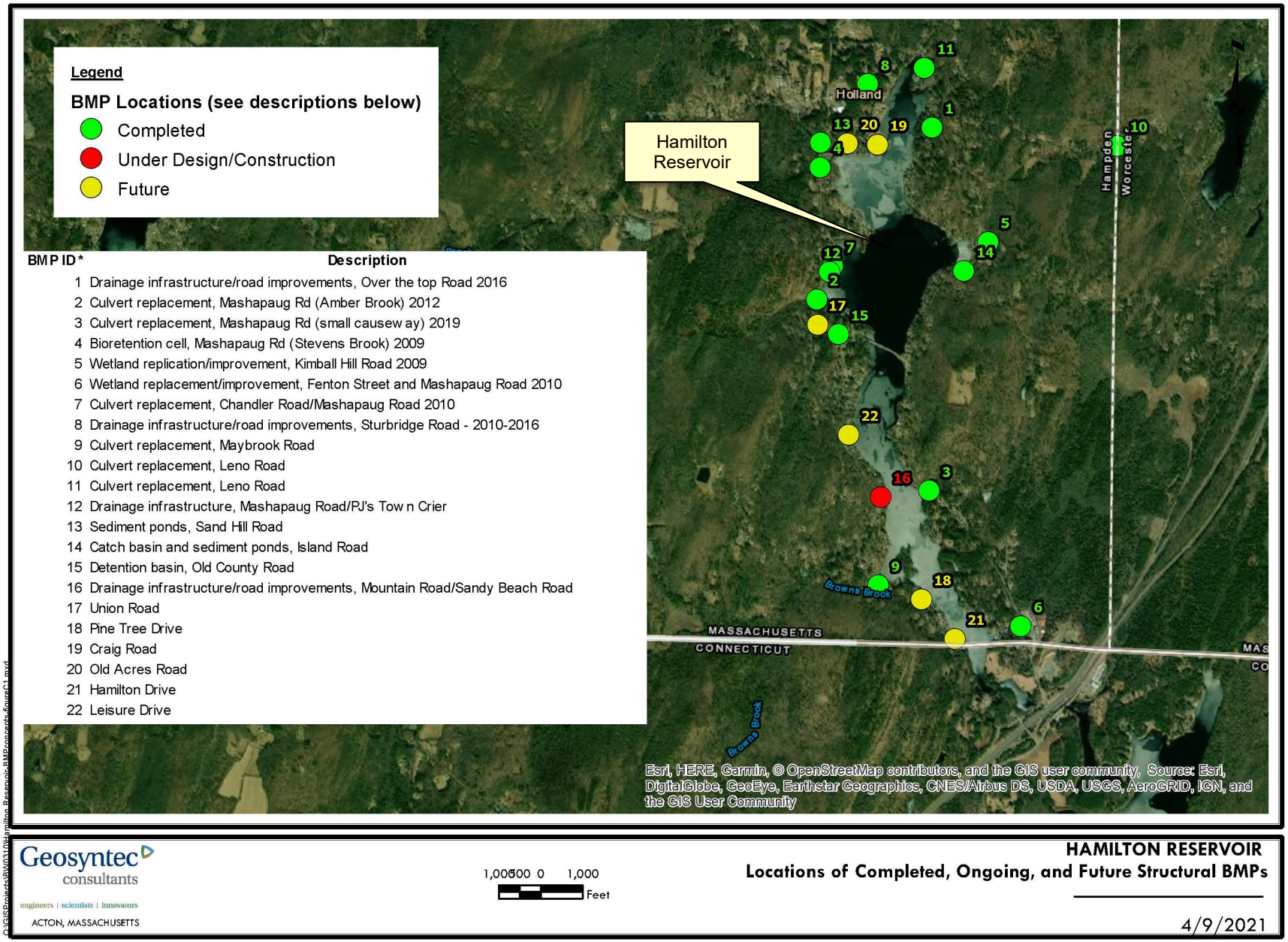
Continuing the strategy of converting dirt and gravel private roads to paved or compacted town-owned roads to minimize erosion, the following roads (see **Figure C-1**) were identified as priority locations for future stormwater BMP implementation during the stakeholder meeting that was held on March 17, 2021 (see **Appendix A** for Meeting Minutes):

- Union Road
- Pine Tree Drive
- Craig Road
- Old Acres Road
- Hamilton Drive
- Leisure Drive

The Town of Holland is considering future road surface and drainage improvements of these roads to reduce sediment loading from these locations.

Nonstructural BMPs

It is recommended that nonstructural BMPs that the Town of Holland currently implements, including street sweeping and catch basin cleaning, be evaluated and potentially optimized. First, it is recommended that potential pollutant load removals from ongoing activities be calculated in accordance with Elements H and I of this document. Next, it is recommended that ongoing activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions, such as increased frequency or improved technology.



BMP ID*	Description
1	Drainage infrastructure/road improvements, Over the top Road 2016
2	Culvert replacement, Mashapaug Rd (Amber Brook) 2012
3	Culvert replacement, Mashapaug Rd (small causew ay) 2019
4	Bioretention cell, Mashapaug Rd (Stevens Brook) 2009
5	Wetland replication/improvement, Kimball Hill Road 2009
6	Wetland replacement/improvement, Fenton Street and Mashapaug Road 2010
7	Culvert replacement, Chandler Road/Mashapaug Road 2010
8	Drainage infrastructure/road improvements, Sturbridge Road - 2010-2016
9	Culvert replacement, Maybrook Road
10	Culvert replacement, Leno Road
11	Culvert replacement, Leno Road
12	Drainage infrastructure, Mashapaug Road/PJ's Tow n Crier
13	Sediment ponds, Sand Hill Road
14	Catch basin and sediment ponds, Island Road
15	Detention basin, Old County Road
16	Drainage infrastructure/road improvements, Mountain Road/Sandy Beach Road
17	Union Road
18	Pine Tree Drive
19	Craig Road
20	Old Acres Road
21	Hamilton Drive
22	Leisure Drive

Figure C-1: Completed, Ongoing, and Future Stormwater Management Projects in Hamilton Reservoir Watershed

Element D: Identify Technical and Financial Assistance Needed to Implement the Plan

Element D: Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

Current Management Measures

The funding needed to implement the current project at Mountain Road and Sandy Beach Road, which is presented in Element C of this WBP, is included in **Table D-1** (Town of Holland 2020). This cost includes the engineering design, construction, and permitting as well as an operation and maintenance plan.

Table D-1: Summary of Current BMP Costs

Existing and Ongoing Management Measures			
BMP	**Total Cost**	**Portion of Total Cost that is grant-funded**	**Grant**
Mountain Road and Sandy Beach Road	$554,371	$256,871	Section 319

Future Management Measures and Monitoring

There are currently no planning-level cost estimates for future BMP projects or for water quality monitoring. Funding for future BMP installations to further reduce pollutant loads within the watershed may be provided by a variety of sources. The Town of Holland has previously used Section 319 and STRAP grant funding to design and install BMPs to help improve the Hamilton Reservoir watershed area. It is expected that funding for future management measures will be obtained from these sources in addition to Town Capital funds, volunteer efforts, and other sources. Additional grant resources may include the Municipal Vulnerability Program (MVP). Any potential monitoring efforts could potentially be eligible for a 604(b) grant or a Water Quality Management Grant. The Town of Holland and stakeholders will use available guidance on potential funding sources for NPS pollution reduction efforts.[2]

[2] Guidance on funding sources to address nonpoint source pollution: http://prj.geosyntec.com/prjMADEPWBP_Files/Guide/Element%20D%20-%20Funds%20and%20Resources%20Guide.pdf

Element E: Public Information and Education

Element E: Information and Education (I/E) component of the watershed plan used to:

1. Enhance public understanding of the project; and
2. Encourage early and continued public participation in selecting, designing, and implementing the NPS management measures that will be implemented.

The components of the watershed public information and education program are described below. Additional outreach products will be determined when future management measures and activities are planned for implementation in the watershed. This section of the WBP will be updated when the plan is reevaluated in 2024 in accordance with Elements F&G of this document.

Step 1: Goals and Objectives

The goals and objectives for the watershed public information and education program.

1. Provide information to promote watershed stewardship.
2. Provide information to homeowners around the Hamilton Reservoir regarding different types of residential BMPs[3] that they could implement.
3. Provide information about septic system maintenance.
4. Provide information about completed and proposed stormwater BMPs and their anticipated water quality benefits.

Step 2: Target Audience

Target audiences that need to be reached to meet the goals and objectives identified above.

1. Watershed residents
2. Businesses, schools, and local government within the watershed
3. Watershed organizations and other user groups

Step 3: Outreach Products and Distribution

The outreach product(s) and distribution form(s) that will be used for each.

1. Pamphlets distributed to homeowners around the reservoir
2. Regular posting on the FHRA Facebook page
3. FHRA newsletters by email and post mail.

[3] Examples of residential BMPs are provided in the "Massachusetts Clean Water Toolkit" (MassDEP, 2016) at https://megamanual.geosyntec.com/NPSManual_2013/HTML/residential.htm

4. Hosting of “lake events” including an annual cleanup day.”
5. Signs at boat launches and boat ramps.

Step 4: Evaluate Information/Education Program

Information and education efforts and how they will be evaluated.

1. Track the number of lake events and attendance at each.
2. Track the number of materials and information distributed, such as pamphlets, newsletters, and emails, and the size of the lists receiving these materials.
3. Track the number of likes or comments on the Facebook page postings.

Elements F & G: Implementation Schedule and Measurable Milestones

Element F: Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

Element G: A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

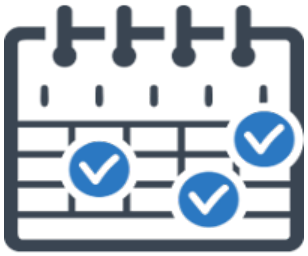


Table FG-1 provides a preliminary schedule for implementing recommendations provided by this WBP. It is expected that the WBP will be reevaluated and updated at least once every three years, or as needed, based on ongoing monitoring results and other ongoing efforts. New projects will be identified through future data analysis and stakeholder engagement and will be included in updates to the implementation schedule.

Table FG-1: Implementation Schedule and Interim Measurable Milestones[4]

Category	Action	Estimated Cost	Year(s)
Monitoring/ Vegetation	Continue performing vegetation surveys and expand annual water quality sampling per Element H&I monitoring guidance.		Annual
Structural BMPs	Implement Mountain Road/Sandy Beach Road project.	$554,371	2021
	Obtain funding, design, prioritize, and implement structural BMP(s) at one of the future project areas identified in Element C.	$550,000	2022
	Obtain funding, design, prioritize, and implement structural BMP(s) at one of the future project areas identified in Element C.	$550,000	2023
Nonstructural BMPs	Document potential pollutant removals from ongoing nonstructural BMPs (i.e., street sweeping, catch basin cleaning).		2020
	Evaluate ongoing nonstructural BMPs and determine if modifications can be made to optimize pollutant removals (e.g., increase frequency).		2021
	Routinely implement optimized nonstructural BMPs.		annual
Public Education and Outreach *(See Element E)*	Continue Facebook postings on NPS pollution and watershed stewardship.		periodical
	Distribute pamphlets to homeowners around the lake, including information on residential BMPs.		annual
	Distribute FHRA newsletters by email and post.		periodical
	Host "lake events" including annual cleanup day.		periodical
Adaptive Management and Plan Updates	Establish a working group that includes stakeholders and other interested parties to implement recommendations and track progress. Meet at least twice per year.		2021
	Reevaluate WBP at least once every three years and adjust, as needed, based on ongoing efforts (e.g., based on monitoring results, 319 funding, etc.). – Next update, December 2024		2024
	Use monitoring results to reevaluate BMP effectiveness at reducing TP, TSS, and/or other indicator parameters in Hamilton Reservoir and establish additional long-term reduction goal(s), if needed.		**2024**
	Delist Hamilton Reservoir from the 303(d) list.		**2031**

[4] Note that goals and milestones of this WBP are intended to be adaptable and flexible. Stakeholders will perform tasks contingent on available resources and funding.

Elements H & I: Progress Evaluation Criteria and Monitoring

Element H: A set of criteria used to determine (1) if loading reductions are being achieved over time and (2) if progress is being made toward attaining water quality goals. Element H asks "**how will you know if you are making progress towards water quality goals?**" The criteria established to track progress can be direct measurements (e.g., E. coli bacteria concentrations) or indirect indicators of load reduction (e.g., number of beach closings related to bacteria).

Element I: A monitoring component to evaluate the effectiveness of implementation efforts over time, as measured against the Element H criteria. Element I asks "**how, when, and where will you conduct monitoring?**"

The water quality goals are presented under Element A and Element B of this WBP. To achieve this target concentration, the annual sediment loading must be reduced to the amount described in Element B. Element C of this plan describes the management measures that will be implemented to achieve this targeted load reduction. The evaluation criteria and monitoring program described will be used to measure the effectiveness of the proposed management measures (described in Element C) in improving the water quality of Hamilton Reservoir

Indirect Indicators of Load Reduction

Vegetation Monitoring: Since 2018, aquatic vegetation is surveyed annually and managed with herbicide treatments on an as-needed basis (see **Appendix D**). Annual vegetation surveys should continue to be conducted using stations and methods consistent with these past assessments (Solitude 2018, Solitude 2019, Solitude 2020). Results from annual monitoring will be used as a metric for measuring changes in biomass and as a metric for understanding water quality trends in response to implementing measures recommended as part of this WBP. It is also recommended that annual vegetation assessments continue to include recommendations as feasible for control measures such as previously implemented treatments.

Vegetation may also be monitored through a volunteer training program, such as the "Last Green Valley" water quality monitoring program, or in accordance with established practices for MassDEP's environmental monitoring for volunteers.

Project-Specific Indicators

Number of BMPs Installed and Pollutant Reduction Estimates:

Anticipated pollutant load reductions from ongoing (i.e., under construction) and future BMPs will be tracked as BMPs are installed. For example, it was estimated that the planned BMPs at Mountain Road and Sandy Beach Road will result in a combined load reduction of approximately 5.8 tons per year of TSS, 7.1 pounds per year of TP, and 18.5 pounds per year of TN (Town of Holland 2020).

Direct Measurements

Direct field measurements are expected to be performed as described below.

Bacteria Sampling: Sampling at will continue to be conducted by the Town of Holland Board of Health. Bacteria counts will be tracked as they relate to water quality standards summarized by Element A and Element B.

BMP Water Quality and Flow Monitoring: As feasible, the effectiveness of structural BMPs will be evaluated by routine inspection during and after storm events to measure amounts of sediment collected (hydrodynamic separators, catch basins, etc.). As feasible, TSS and discharge volume will also be periodically measured at outfalls to Hamilton Reservoir during notable storm events with a goal of capturing up to four events per year. TSS and discharge measurements will later be converted to estimates of annual loading to the reservoir (by extrapolating data according to storm sizes sampled and expected distribution during a typical precipitation year). Results from this monitoring effort will aid in better characterizing base loading to the reservoir and whether additional BMPs are needed to meet interim and long-term water quality goals.

In-Lake Phosphorus and Water Quality Monitoring: Based on a literature review summarized in Element A of this plan, Hamilton Reservoir does not have a monitoring plan. The most recent known water quality samples collected systematically throughout the lake and its receiving waters were collected by Solitude Lake Management (2018, 2019) and MassDEP (2016). In-lake phosphorus measurements will provide the most direct means of evaluating the effectiveness of the measures implemented a part of this plan. It is recommended that sampling be conducted at the locations depicted on **Figure HI-1**. Monitoring stations have been selected to be consistent with past monitoring conducted by Solitude Lake Management. Additional stations could also be included at locations of interest.

Figure HI-1: Proposed Water Quality Monitoring Locations

(Figure Source: Solitude 2018)

Since TP is linked to plant growth, regular monitoring of TP levels at the proposed monitoring locations is recommended to provide data on phosphorus concentration trends in response to implementing the measures described in Element C. Depending on available funding and volunteer resources, the following options for monitoring are recommended:

Option 1: Perform baseline TP sampling three times per year, during spring (late April/early May), mid-summer (early to mid-July), and late summer (early- to mid-September). Collect surface samples at all locations from the middle of the water column and near the bottom (approximately 1.5 feet from bottom) using a Kemmerer sampler or similar type of depth sampling equipment.

Option 2: In addition to the TP monitoring described above, conduct the following during each of the three recommended sampling events:

- Collect chlorophyll-a samples (surface grab sample) at each location. Chlorophyll-a provides an indirect measure of algal productivity.
- Use a Secchi disk to measure water clarity at each location.
- Use an in situ multiparameter water quality probe (e.g., YSI or comparable brand, which can be rented) to collect temperature, dissolved oxygen, specific conductance, and pH at 5-foot intervals at each sampling location

Option 3: As a one-time effort to characterize seasonal internal phosphorus loading, the following could be conducted at the deep hole location Aqua Riders Beach:

- Conduct TP water column sampling and in situ monitoring as described above, once every two weeks from ice-off until fall turnover (typically in mid-October, when the pond surface temperature becomes equal to the bottom temperature). The information gathered from this sampling program can be used to quantify the mass of TP released seasonally from the pond's sediments, which occurs during summer thermal stratification when the hypolimnion becomes nearly depleted of oxygen.

Water quality may be monitored through a volunteer training program or in accordance with established practices for MassDEP's environmental monitoring for volunteers.

Adaptive Management

As discussed by in Element B, the baseline monitoring program (recommended Options 1 and 2) will be used to establish a long-term (10-year) phosphorus load reduction goal (or other parameter[s] depending on results). Long-term goals will be reevaluated at least once every three years and adaptively adjusted based on additional monitoring results and other indirect indicators. If monitoring results and indirect indicators do not show improvement, the management measures and loading reduction analysis (Elements A through D) will be revisited and modified accordingly.

Further, the Town of Holland and stakeholders of the Hamilton Reservoir will implement recommendations from this WBP and track overall progress. It is recommended that public education and outreach products reiterate goals of this WBP; summarize indirect indicators, project-specific indicators, and direct measurements as they relate to established water quality goals; and indicate ongoing outreach efforts and overall next steps.

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Appendices

Appendix A – Hamilton Reservoir Stakeholder Meeting Minutes, March 17, 2021

Meeting Minutes

SORENSEN

Project Name:	Hamilton Reservoir Watershed-Based Plan		
Project #:	SP #1078		
Location:	Hamilton Reservoir Watershed (Holland, MA)		
Meeting Date, #:	2021-3-17	Meeting Time:	2:00 PM - 3:30 PM
Prepared By:	Marie Sorensen, RA	Meeting Location:	Zoom videoconference per Sorensen Partners invitation
Distribution:	All listed below		

Attendees:

Name	Organization
JoAnne Higgens	Town of Holland Highway Department
Brian Johnson	Town of Holland Highway Department
Stacy Stout	Town of Holland Administrator
Mark Stadnicki	SVE Associates
Dawn Kamay	Holland Conservation Commission
Sam Spratlin	Holland Conservation Commission
Tom Wilhelm	Friends of Hamilton Reservoir Association (FHRA)
Bob Kamay	Friends of Hamilton Reservoir Association (FHRA)
Jean Pillo	The Last Green Valley
Matt Reardon	Massachusetts Department of Environmental Protection (MassDEP)
Julia Keay	Geosyntec Consultants, Inc.
Adam Questad	Geosyntec Consultants, Inc.
Marie Sorensen	Sorensen Partners | Architects + Planners, Inc.

"*This project has been financed with Federal Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (the Department) under an s. 319 competitive grant. The contents do not necessarily reflect the views and policies of EPA or of the Department, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.*"

Minutes to be considered final unless comments are received within five (5) business days.

AGENDA

- Greeting – Matt Reardon, MassDEP & Marie Sorensen, Sorensen Partners
- Watershed & Goals Overview (15 min) – Julia Keay & Adam Questad, Geosyntec
- s.319 Grant Project Spotlight (15 min) – Town of Hamilton
- Brief Introductions from All Participants (15 min) – All
- Discussion of Existing BMPs (15 min) – All
- Strategy (30 min) – All

WATERSHED & GOALS OVERVIEW

- Adam Questad, Engineer at Geosyntec, discussed the goals of the meeting. Geosyntec has been working with MassDEP to create Watershed-based Plans, which are required for grantees to be eligible for s.319 grant funding. The goal of the call is to better understand what is happening in the watershed and to identify collaborative project opportunities.
- Julia Keay, Water Resources Engineer at Geosyntec, briefly presented the MassDEP Watershed-based Plans Tool. Link: http://prj.geosyntec.com/prjMADEPWBP/Home. Discussed the nine required elements of a Watershed-based Plan.

- Julia Keay briefly presented background on the Hamilton Reservoir Watershed-based Plan. Geosyntec is preparing the Watershed-based Plan. Along with receiving a s.319 grant, the watershed must have a Watershed-based Plan. Geosyntec understands that sediment is the big issue, mostly concentrated around the lake. Geosyntec is interested in understanding if there are any other sources of pollutants around the lake.

s.319 GRANT PROJECT SPOTLIGHT

"Hamilton Reservoir Watershed Improvement Project"
Timeframe: FY 2021
Budget: $125,000 design; $554,000 build ($256,871 s.319 funds)
Purpose: Reduce sediment & nutrient loading

Members of the Town of Holland (s.319 grantee) described the project and questions were asked:

- JoAnne Higgens. Project location is Mountain Road, Sandy Beach Road, and Sandy Beach Road Extension.
- Mark Stadnicki. Sandy Beach Road Extension is an option. Project consists of re-paving and reclaiming the road, and introducing curbs and deep-sump catch basins to reduce storm and sediment load to the reservoir. The total number of catch basins (10) and drop inlets (6) may be revised higher. There will be approximately 1,300 ft of roadway/pavement improvements.
- Tom Wilhelm. Sandy Beach Road Extension has a lot of wash-out into the lake. Fire Department said they can't get their fire trucks down there anymore. It would be great if it could be included.
- Brian Johnson. Yes the Extension is included.
- Matt Reardon. Is there a possibility of putting a BMP at the end of Sandy Beach Road Extension to treat for phosphorous. Is there real estate available?
- Brian Johnson. Not really.
- Mark Stadnicki. The right-of-way of these roads is already smaller than what is allowed by the Town. Could try to do something but it would be in the right-of-way. Doesn't know if there will be enough room to do something vertically within the road because the ledge is shallow.
- Matt Reardon. Thank you for looking at possibilities. Please try to do what you can.
- Brian Johnson. These roads were private roads. We're turning them into town roads and limiting the sediment problems.
- Tom Wilhelm. A lot of the roads are driveways that people built to access their houses.
- Bob Kamay. Are there any requirements from the State on turning a private road into a Town road?
- Brian Johnson. They are following the Town bylaws. They have to come up with a design, have abutters come to a meeting. Town has to vote for it to become a Town road.
- Mark Stadnicki. There will be some deviations in the road design for which the project will need a waiver through the Planning Board: minimum turning radius, widths and grade.
- Bob Kamay. What is the timing to complete the grant project?
- Matt Reardon. MassDEP's agreement with the grantee extends through June 30, 2022. There is possibility for up to two 1-year extensions.

BRIEF INTRODUCTIONS FROM ALL PARTICIPANTS

Participants were asked to briefly address the following prompts:

⇒ Name?
⇒ Affiliation?
⇒ Connection to Hamilton Reservoir?
⇒ Specific projects, public outreach, and/or monitoring work in the watershed?

JoAnne Higgins, Holland Highway Department, Clerk; and Town of Holland Assessor.

Brian Johnson, Holland Highway Department, Surveyor. Goal for the last few years has been to slow down the sediment going into the reservoir. Sediment has been entering the reservoir at a high speed. Focus has been on picking private roads to convert into Town roads and implement BMPs.

Stacy Stout, Town Administrator. Supporting Highway Department on administration of this project. Supports all Town departments.

Tom Wilhelm, Friends of Hamilton Reservoir Association. Has been a property owner on the lake for 7 years. Eyes and ears for weed issues, sediment issues and other topics. Working with Sam Spratlin of Conservation Commission to develop a mitigation plan. Has seen a big increase in weeds in the last few years. Sent report from weed assessment company to Geosyntec to include in Watershed-based Plan.

Sam Spratlin, Holland Conservation Commission and Lake Oversight Committee.

Dawn Kamay, Holland Conservation Commission and Lake Oversight Committee. Has been living on Hamilton Reservoir for 7 years. Very interested in preserving the lake and its water quality.

Bob Kamay, Friends of Hamilton Reservoir Association. Main focus has been making improvements to south basin boat launch. Next project is to work with Brian Johnson on dam maintenance.

Mark Stadnicki, SVE Associates. Design engineering firm designing the s.319 grant project.

Jean Pillo, The Last Green Valley. Works in the Eastern Connecticut Conservation District. Coordinates the volunteer water quality monitoring program for The Last Green Valley. Has not been any volunteer water quality monitoring yet for the Hamilton Reservoir.

DISCUSSION OF EXISTING BMP PROJECTS

Julia Keay of Geosyntec showed a map of several recent BMP projects and requested information about other recent BMP projects that have been completed in the watershed. JoAnne Higgens and Brian Johnson commented:

- There was a culvert replacement project on Leno Road. Also a culvert replacement project on Leno Road near Sturbridge line;
- A replacement of drainage structures project was done through Ch.90 on May Brook Road close to the CT state line.
- Brian Johnson recommends they review a draft so they can include projects that were not included.
- Julia Keay will send over a draft.

A discussion was held for 20 minutes on the following topics: 1. Pollutant Load Estimates for existing BMP Projects; 2. Current Monitoring Efforts; and 3. Status of Dredging.

1B. Pollutant Load Estimates for existing BMP Projects

- Julia Keay. Geosyntec has pollutant load information for most of the projects. Missing information for Sturbridge Road and Over the Top Road projects.
- JoAnne Higgens. Doesn't know if that information is available.

2. Current Monitoring Efforts

- Julia Keay. Has received 2018, 2019, 2020 Solitude Reports. Also notes that the Town website shows E.Coli monitoring data done by Board of Health for the summer months; was able to access 2020 data.
- Brian Johnson. The only monitoring they do is with the Board of Health.
- Matt Reardon. MassDEP had a deep hole monitoring site in the south basin in 2018, and will share this data [correction, data is from north basin].
- Jean Pillo. (via chat) Does the MA DEP WBP tool have a load reduction BMP calculator for pathogens?
- Julia Keay. (via chat) Currently it just calculates load reductions for TN, TP, and TSS.
- Jean Pillo. (via chat) Are there any known impairments for E. coli in the lake?
- Matt Reardon. (via chat) It has not been assessed in integrated list for recreational uses.

3. Status of Dredging

- Tom Wilhelm. Dredging Study from 2018 showed that it doesn't make any sense to dredge the lake until two causes are taken care of: 1. drainage off of the roads; and 2. at the causeway, making sure culvert sizes are increased between the two sides of the lake.
- Brian Johnson. There were other studies done years ago. Conway Study (18 years ago) talked about fertilizers and people's septics going into the lake. Also talked about the size of the boats and the waves from boats, leading to erosion of the banks. Some of the new boats are trying to create large waves for wakeboarding. Suggested not to have any boats on the lake.
- Matt Reardon. Have you thought about a motor size limit on the lake?
- *General comment that this hasn't been discussed but would be a hard sell with the local waterskiing club being on the lake.*
- Tom Wilhelm. Boats definitely suspend a lot of sediment.
- Brian Johnson. We're not going to dredge the lake fully. That requires an unrealistic amount of funding. But can't we do small dredging where the worst problems are, such as May Brook Cove? or where Stevens Brook comes in?
- Tom Wilhelm. The Dredging Study did have areas of focus.
- Sam Spratlin. Brandon Cove is really silted in.
- Stacy Stout. Is there an opportunity to commission a dredging study for specific areas rather than the whole lake?
- Tom Wilhelm. Can identify 3-4 areas in the south basin that are silted in.
- Sam Spratlin. Undersized culvert on the causeway is a definite cause of sedimentation.

STRATEGY

A strategy discussion was held for 30 minutes on the following topics: 4. Other Areas with High Sediment Loading/Erosion; 5. Public education and outreach; 6. Additional grant funding available.

4. Other Areas with High Sediment Loading/Erosion

- JoAnne Higgens. As Town Assessor, I'm in the neighborhoods quite a bit. Property owners could do something. Lots of property owners are hardscaping, paving entire parking areas and areas around cottages. Does not allow for water to percolate into the soil. Also sees a lot more outdoor showers, which are being built without any way for phosphates from shampoos and body wash to be prevented from washing into the lake. Also lawn fertilization and artificial seeding is coming into the lake.
- Tom Wilhelm. Has been putting recommendations for residents into the FHRA Newsletter.
- Sam Spratlin. We have large houses on very small lots and that's a problem.
- Brian Johnson. Can identify multiple other multiple areas with a lot of sediment problems. Pine Tree Drive. Craig Road. Old Acres Road. Goal is private roads that are at the low end of town, install BMPs to prevent sediment going into lake.
- Tom Wilhelm. Hamilton Drive flows right down the hill into the boat launch.
- Bob Kamay. At the end of Leisure Drive there's a private beach. It's a steep hill and comes to the middle of the beach. There are a few poorly placed basins. Washes out each area constantly. Leisure Drive could use some attention.
- Matt Reardon. Water bars could be used. Has a project in Manchaug Pond, Sutton. Some people are putting them in their driveways as a pilot project. Diverts the water off.
- Adam Questad. (via chat) shared information from the Massachusetts Clean Water Toolkit about water bars. https://megamanual.geosyntec.com/npsmanual/waterbar.aspx
- Jean Pillo. (via chat) I work with the Webster Lake Association. They are having a horrible experience with wake boats and shoreline erosion. They have an active water quality monitoring program. Wake boats are a huge issue. Webster Lake Association is looking for a trend in water clarity. They are using secchi data and a multi-parameter probe, measuring dissolved oxygen, pH, temperature, turbidity, nutrients at surface, along the thermocline, and at lake bottom, 3 times a year. Do you have any secchi depth data to show any trends in water clarity? Are the majority of homes along the lakeshore on unpaved roads? I have seen many runoff issues impacting sedimentation if the roads are not properly maintained.

- Tom Wilhelm. (via chat) Yes. Unpaved or partially paved.
- Jean Pillo. (via chat) Improving the flow under the causeway may improve flow from the south part of the lake to the northern part of the lake, won't it move the problem to more rapid sedimentation to the north pond? The sediment will settle in the north pond due to the dam at the outlet.
- Jean Pillo. South Charlton Reservoir was successful at working with the Town of Charlton at installing a water bar at the boat launch area to divert the water to a settling area to reduce the sediment loading into the pond.
- Julia Keay. What would be the process if Hamilton Reservoir wanted to do volunteer water quality monitoring with the Last Green Valley?
- Jean Pillo. Explained the process and recommended contacting Ziggy Waraszkiewicz (Waraszkiewicz@aol.com)
- Jean Pillo. (via chat) shared information on Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel: Roadshttps://www.fs.fed.us/eng/pubs/pdf/11771802.pdf
- Adam Questad. Going back to the potential BMP opportunity discussion, are there any locations where a larger project could be implemented where it's not in a highly erosive area but potentially runoff could be routed to that location? Low-lying spots that could be targeted that are publicly-owned and closer to the water body that could be targeted for BMPs? Best locations would be low-lying and public spots, but other locations could also be explored.
- Stacy Stout. Conservation Commission does an excellent job making sure everyone's aware of that.
- Dawn Kamay. Trying to improve bank erosion, it's all sand that comes down to the water. If it's not properly managed it keeps coming into the lakebed.
- Stacy Stout. Do we see good compliance with people coming before the Conservation Commission? A lot of new property owners get going on their projects and fortunately get steered to the Conservation Commission by building department and Board of Health.
- Dawn Kamay. Still learning how to protect our banks. Most of the things that hold the banks back now are flat surfaced timbers or flat stone faces that are just bouncing the water back and forth. So banks that are not protected are in bad shape. Trying to get people to think about a less flat surface to their banks so we have more energy absorption.
- Julia Keay. Showed MassDEP Clean Water Toolkit, specifically focusing on how to see examples of residential Best Management Practices (BMPs). Link: https://megamanual.geosyntec.com/NPSManual_2013/HTML/residential.htm

5. Public education and outreach

- Marie Sorensen. Initiated discussion of what is presently being done for public education and outreach and what could be done.
- JoAnne Higgens. It would be possible to look at some of the Clean Water Toolkit strategies that could be produced as a pamphlet to distribute in bulk through FHRA meetings.
- Marie Sorensen. Is there any education being done through the public schools?
- Stacy Stout & JoAnne Higgens. Lots of residents are seasonal.
- Tom Wilhelm. Does regular posts on the Facebook page for FHRA.
- Stacy Stout. On the Town Facebook page, and posts about and holds a lot of lake events at the north and south basins. Seasonal residents don't come to Town Meeting. They do read the FHRA newsletters (distributed by e-mail and snail mail). Lake Association Committee does a great job.
- Jean Pillo. Is FHRA an NPO?
- Tom Wilhelm. Yes.
- Jean Pillo: Then FHRA can receive grants from New England Grassroots Association for public outreach. Are most of the residents on septic or sewer?
- Tom Wilhelm. 100% septic and type tank.
- Jean Pillo. Outreach on septic tank maintenance is important for people who are guests and renters. Recommends using a QR code that people can access on their phones.
- Marie Sorensen. Are there any public cleanup events in town? It can be socially motivating to see others taking care of the reservoir area, might spur people to do something with their own yards or pick up a pamphlet.
- Stacy Stout. One of Holland residents started a cleanup day. Trails committee also cleans up trails.
- Adam Questad. Is there any public signage?
- Julia Keay. Is there any signage about dog waste cleanup?

- Marie Sorensen. Could have signs on curbs near storm drains. Reminder that water flows to the lake.
- *General discussion that most signage is at boat launches and boat ramps, and on trails.*
- Stacy Stout. There is also signage regulating what you bring in and out of the lake, and for weed control.
- Tom Wilhelm. There are no signs for dog waste management.

6. Additional grant funding available

- Marie Sorensen. Initiated discussion about grant opportunities that are available for BMPs and Public Education and Outreach.
- Matt Reardon. For monitoring and design of BMP projects, recommends MA 604B Water Quality Management Planning grants and s.319 grants. Also another big source of grants is MA Municipal Vulnerability Preparedness grants, if you can tie in climate change resiliency; people have used these grants as match for s.319 grants.
- Jean Pillo. Charlton Lakes and Ponds Association convinced their town that their homes assess higher than other similar homes in other parts of town so therefore they could get more tax funds if the ponds were in good health. Recommends contacting Ziggy (Waraszkiewicz@aol.com) and possibly doing fundraisers.
- Jean Pillo. Invites FHRA to become a part of The Last Green Valley (TLGV WAC), they meet quarterly. They will meet May 17 at 9 Am. Contact Jean.pillo@comcast.net.

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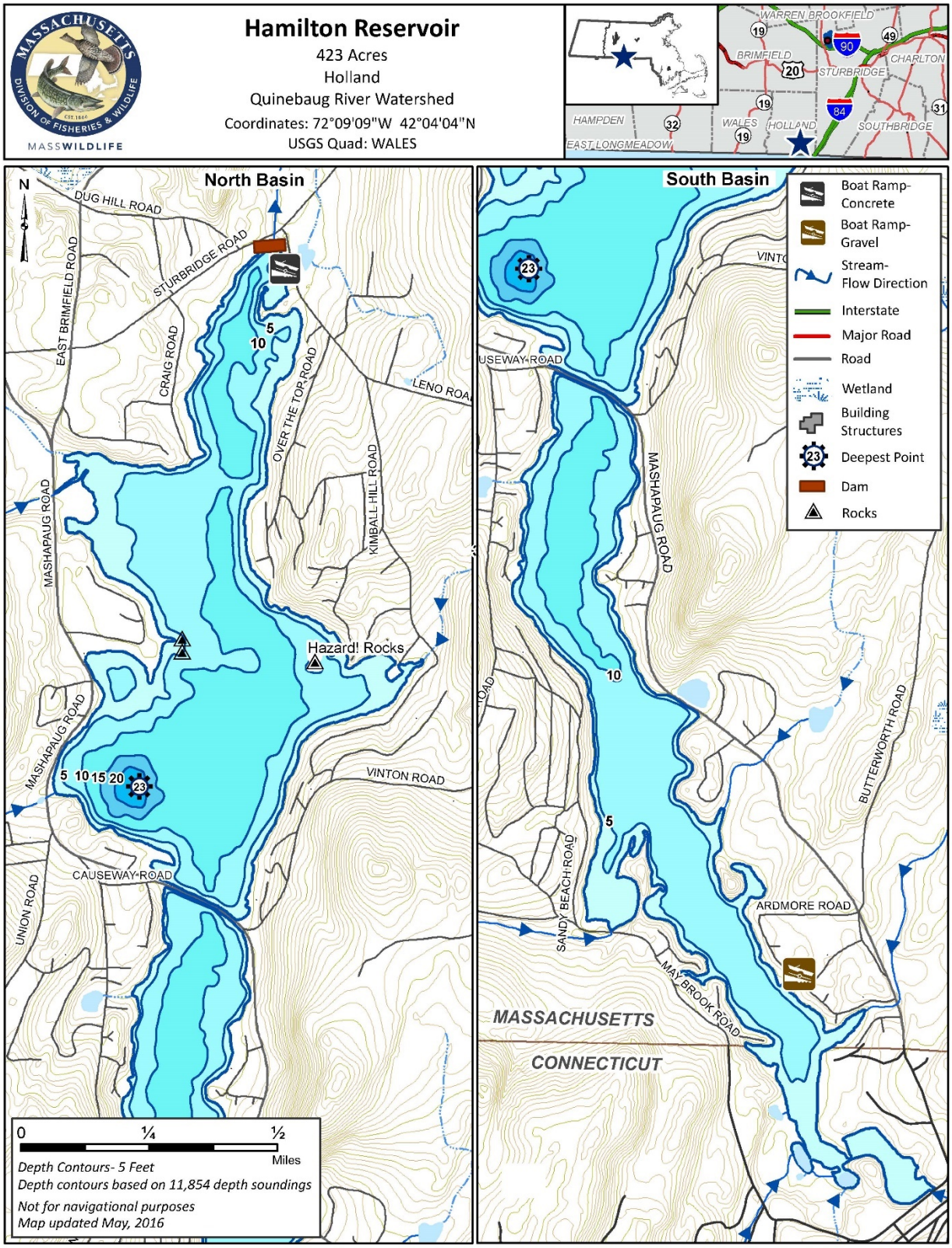
Contact: Julia Keay, JKeay@geosyntec.com
Adam Questad, AQuestad@geosyntec.com
Matt Reardon, Matthew.Reardon@state.ma.us

Appendix B – Massachusetts Division of Fisheries & Wildlife Bathymetry Map



Appendix C – Select Excerpts from French & Quinebaug River Watersheds Water Quality Assessment Report (MassDEP 2009)

French & Quinebaug River Watersheds 2004-2008 Water Quality Assessment Report (MA41019 - Hamilton Reservoir)

AQUATIC LIFE
Biology
The presence of *Myriohyllum heterophyllum* is detailed in the French and Quinebaug 2001 Water Quality Assessment Report (MassDEP 2002b) and has also been detailed in herbicide permit applications (MassDEP 2006b).

The Aquatic Life Use is assessed as impaired due to the presence of a non-native macrophyte species.

PRIMARY AND SECONDARY CONTACT RECREATION AND AESTHETICS
There are two beaches on Hamilton Reservoir one in the north basin and one in the south basin. Currently there is uncertainty associated with the accurate reporting of freshwater beach closure information to the Massachusetts DPH, which is required as part of the Beaches Bill. Therefore, no Primary Contact Recreational Use assessments (either support or impairment) decisions are being made using Beaches Bill data for this waterbody.

Report Recommendations:
Continue to monitor for the presence of invasive non-native aquatic vegetation and determine the extent of the infestation. Prevent spreading of invasive aquatic plants. Once the extent of the problem is determined and control practices are exercised, vigilant monitoring needs to be practiced to guard against infestations in unaffected areas, including downstream from the site, and to ensure that managed areas stay in check. A key portion of the prevention program should be posting of boat access points with signs to educate and alert lake-users to the problem and their responsibility to prevent spreading these species. The Final GEIR for Eutrophication and Aquatic Plant Management in Massachusetts (Mattson et al. 2004) should also be consulted prior to the development of any lake management plan to control non-native aquatic plant species. Plant control options can be selected from several techniques (e.g., bottom barriers, drawdown, herbicides, etc.) each of which has advantages and disadvantages that need to be addressed for the specific site. However, methods that result in fragmentation (such as cutting or raking) should not be used for many species because of the propensity for these invasive species to reproduce and spread vegetatively (from cuttings).
Support improvement of freshwater Beaches Bill data quality and reporting.

Appendix D – 2018, 2019, and 2020 Aquatic Plan Management Reports (Solitude Lake Management 2018, Solitude Lake Management 2019, Solitude Lake Management 2020)

2018 Aquatic Plant Management Report
Hamilton Reservoir
Holland, Massachusetts

Report Prepared by: SŌLitude Lake Management
590 Lake Street
Shrewsbury, MA 01545

Report Prepared for: Lake Oversight Committee
Town of Holland
27 Sturbridge Road
Holland, MA 01521

In accordance with the existing aquatic plant management contract between SŌLitude Lake Management and the Town of Holland - Lake Oversight Committee for Hamilton Reservoir, the following document serves to provide this year's treatment and survey results and the management recommendations for next season.

All management activities were consistent with the Order of Conditions (DEP File #184-129), and the License to Apply Chemicals issued by the MA DEP – Office of Watershed Management (#18035); and with the permit issued by CT DEEP – (AQUA-2017-309).

PRE-MANAGEMENT INSPECTION

On May 29th, a SŌLitude biologist surveyed the Hamilton Reservoir littoral zone. The objective of the survey was to document the density and distribution of variable watermilfoil (*Myriophyllum heterophyllum*) and fanwort (*Cabomba caroliniana*), making note of nuisance and native plant species. As in the past, techniques that were employed to locate and identify the submersed vegetation included the use of a "throw-rake", Aqua-Vu underwater system, and visual surface observations. The areas where watermilfoil was found were mapped and estimates of cover were recorded. Watermilfoil at this time was observed at sparse to moderate abundances. Fanwort remained isolated in the cove west of the boat launch at trace to sparse Densities. Treatment areas were decided upon based off results from the 2017 post-management inspection and the 2018 pre-management inspection (**Figure 1 & 2**).

Watermilfoil density and distribution has seemingly remained constant compared to conditions observed in previous years; in total the overall watermilfoil infestation occupied approximately 65-acres this season as compared to 62-acres in 2017. The native vegetation assemblage was dominated by slender waternymph (*Najas flexilis)*, watershield (*Brasenia schreberi)*, ribbon-leaf pondweed (*Potamogeton epihydrus)*, and common bladderwort (*Utricularia vulgaris)*.

WATERMILFOIL TREATMENT

A single herbicide treatment with Reward (active ingredient: diquat) was applied by Solitude's licensed applicators on June 14th. Approximately 82 gallons of Reward was dispersed in both the northern and southern basins at pre-determined treatment areas. As in the past, notification was given to the Town, the Association and all other required parties prior to each treatment. In addition to this notification, the shorelines of the reservoir were thoroughly posted by the HRA with printed signs, warning of the pending treatment and any use or re-entry restrictions.

MID-SEASON INSPECTION

On July 24th, a SŌLitude biologist performed a mid-season inspection for tapegrass, floating-leaved species, fanwort, and variable watermilfoil. The objectives of this survey were to record the efficacy of the initial watermilfoil treatment conducted on June 14th, and to document the density and distributions of the above-mentioned species in preparation for possible secondary treatment. At this time, it was noted that excellent control of watermilfoil was achieved as result of the first herbicide application. A single patch of milfoil in trace abundance was observed in the northern basin adjacent to the boat launch, and at a single location in the southern basin in the inlet cove (**Figure 3 & 4**). Tapegrass and floating-leaf species were observed in non-nuisance densities and therefore treatments of these species were deemed unnecessary. During this inspection, the fanwort in the cove adjacent to the boat ramp was still present; therefore, a treatment to prevent further spread of this species was recommended.

FANWORT HERBICIDE TREATMENT

On August 23rd a second herbicide treatment was performed to manage the presence of invasive fanwort (*Cabomba caroliniana*). This treatment was performed utilizing Clipper (flumioxazin) herbicide. This was a localized treatment performed in the cove adjacent to the boat ramp in the northern basin. Approximately 2 acres were treated (**Figure 5**) with Clipper and water use restrictions were only implemented for homes adjacent to the treatment areas.

POST-MANAGEMENT INSPECTION

On September 28th, a SŌLitude Biologist performed a post-management inspection of Hamilton Reservoir. The objectives of this survey were to record the efficacy of the 2018 herbicide treatments, as well as evaluate management techniques for the 2019 season and beyond.

The survey displayed decreased watermilfoil growth in both the North & South Basin. The observed plants largely consisted of low-biomass regrowth, which had re-appeared since the June treatment. Reward is a contact herbicide that has minimal impact on the plant's root structure; therefore, regrowth of this species is to be expected. A healthy assemblage of native species remained well represented throughout the entirety of the littoral zone and were seldom present in sufficient quantities. Dominant native species included slender naiad, common bladderwort, yellow and white waterlily, and watershield. In smaller quantities existed several pondweed species (thin-leaf pondweed, Robbin's pondweed, and ribbon-leaf pondweed).

WATER QUALITY

A single water quality sampling round was conducted on July 24th during the mid-season inspection. Samples were collected at four locations for the specific parameters. Please refer to table 1 & 2 for results. Descriptions for the parameters collected are attached (**Water Quality Parameter Explanations**). Please refer to **Figure 6** for water quality sampling locations.

Table 1: 2018 dissolved oxygen and temperature readings

Depth (Meters)	Dissolved Oxygen (mg/L)				Temperature (°C)			
	North		South		North		South	
	May	Sept.	May	Sept.	May	Sept.	May	Sept.
SW	8.56	7.76	8.11	8.01	22.9	26.9	21.2	26.1
1	8.66	7.32	8.13	7.88	22.4	26.6	20.8	26.0
2	8.72	6.45	8.15	7.62	20.5	25.3	20.5	25.7
3	8.30	6.21	8.21	6.97	19.8	23.1	20.2	25.6
4	5.85	5.77	8.21	6.41	16.6	22.8	20.0	24.3
5	3.75	4.19	8.13	6.13	11.6	22.5	19.9	22.9
6	0.91	1.02	7.97	5.66	9.6	22.4	19.8	22.1
7	--	--	7.75	5.30	--	--	19.6	20.6
8	--	--	7.43	4.28	--	--	19.4	20.5
9	--	--	4.53	2.55	--	--	18.8	20.3

Table 2: July 2018 water quality sampling

Parameter	Units	Detection Levels	Massaconnic Beach	Brandon St. Cove	Aqua Rider's Beach	Boat Ramp
E. Coli	Col/mL	1.0	50	31	67	72
Total Phosphorus	Mg/L	0.010	0.019	0.015	0.021	0.013
Dissolved Phosphorus	Mg/L	0.010	0.013	ND	0.014	ND
True Color	Color Units	5	29	16	40	18
Apparent Color	Color Units	10	50	32	60	29
Ammonia/Nitrogen	Mg/L	0.010	ND	0.080	ND	ND
Total Alkalinity	Mg/L	2.0	14.9	12.3	21.3	11.7
Total Kjeldahl Nitrogen	Mg/L	0.300	0.476	0.533	0.546	0.490
Nitrate/Nitrogen	Mg/L	0.010	ND	ND	ND	ND
Turbidity	NTU	0.20	5.5	2.9	5.2	2.5
pH	pH Units	--	6.8	6.8	6.6	6.8

MANAGEMENT RECOMMENDATIONS FOR 2019

We recommend continuing with the monitoring and management program in place at Hamilton Reservoir. The current program has provided effective seasonal control of invasive variable watermilfoil. Desirable open-water conditions can be achieved via area selective herbicide treatments in 2019, while maintaining valuable vegetative diversity within the ecosystem.

It is also recommended that a proper water quality program be implemented for the 2019 season. It is suggested that water samples be collected at three times during the growing season, May, July, and September to gain a broad understanding of water chemistry throughout the summer months. It is also suggested that three algae samples be tested for identification and enumeration three times during the growing season to determine if nuisance algae and/or cyanobacteria exists in Hamilton Reservoir.

It is also recommended to continue to monitor for invasive fanwort in the area of the boat ramp. Since its initial discovery in the lake in 2017, it has seemingly not expanded into other areas of the lake, however annual monitoring of this species should continue to ensure spread of this species is reduced. Spot-treating with the herbicide Clipper,

followed by post-treatment hand-harvesting, would be the best mode of action to stifle regrowth. A new infestation should be dealt with aggressively, as fanwort is a persistent plant that spreads primarily through fragmentation and rhizomes.

If you have any questions or require any additional information please do not hesitate to contact the office. We look forward to working with you in the 2019 season.

Water Quality Parameter Explanations

pH – The pH measurement scale is from 0 to 14, where zero is extremely acidic, 7 is neutral, and 14 is the most basic. pH is related to the concentration of H^+ (hydrogen ions) in solution and can affect many different aspects of water chemistry. Most lakes in the region exhibit pH of between 6 and 8 SU, but certain geology and some biological processes can shift pH outside of this range.
The pH results remained within the desirable range.

Total Alkalinity – Alkalinity is a measure of the buffering capacity of a waterbody against acid additions such as acid rain and pollution, which can be detrimental to wildlife populations. Total alkalinity measures the presence of carbonates, bicarbonates and hydroxides. Values below 20 mg/l are a signal that the pond may be susceptible to fluctuations in pH.
Alkalinity in Hamilton Reservoir is below 20 mg/L, determining that it is susceptible to fluctuations in pH.

Turbidity- Turbidity is a relative measurement of the amount of suspended material in the water. It is measured through a process involving light diffraction of the pond sample as compared to a series of prepared samples. Turbidity values can range from less than one to thousands of units, however, values in most ponds and lakes rarely rises above 5 NTU.
Turbidity levels at Massaconnic Beach and Aqua Rider's Beach were relatively high. Hamilton Reservoir is fairly shallow; therefore, the benthic layer can be impacted by boat traffic and wind, causing increased turbidity.

Nitrate/Nitrogen – Nitrate is another form of nitrogen found in the water column. Nitrate nitrogen is usually the most prevalent form of inorganic nitrogen in the water and results from such things as natural aerobic bacterial activity and fertilizer use. It is also the form that is most readily available for plant and algae growth. Levels lower than 0.3 mg/L can limit plant and algae growth in conjunction with low phosphorus levels.
Nitrogen levels remained below detectable levels (0.010 mg/L).

Ammonia/Nitrogen – Ammonia is a measure of two constituents, NH_3 and NH_4^+, and is a transitional product in the breakdown of organic nitrogen into nitrate. It is typically short-lived in the pond environment except under conditions of low dissolved oxygen. Waterbodies that have a high pH are susceptible to high ammonia concentrations; the higher the pH, the more ammonia will be present within the water column. High levels of ammonia typically indicate a eutrophic pond, and can be toxic to fish at higher levels. Levels <0.05 mg/L are ideal.
For most of the locations, ammonia remained below detectable levels; however, ammonia levels were above "ideal" levels at Brandon St. Cove. This cove is a high residential area that is relatively narrow and close to the road. There are many factors that could influence the ammonia levels within this area, including potential animal, agricultural, or industrial waste effluent.

Total Kjeldahl nitrogen (TKN) is a measure of the nitrogen contained in organic compounds, such as proteins and amino acids, and as ammonia. It is created from biological growth and decomposition. A concentration of 1.0 mg/l or below is considered desirable.
Total Kjedahl nitrogen remained below desirable levels at each sampling station.

Total/Dissolved Phosphorus – Phosphorus is generally considered the limiting nutrient for plant and algae growth, with concentrations of 0.03 mg/l or more being sufficient to stimulate algae blooms. Water column phosphorus (dissolved phosphorus) does not generally relate to rooted plant growth as they obtain most of their nutrients from the pond sediment. In the hypolimnion, low oxygen levels can promote the release of phosphorus from the bottom sediments, which may build up over the summer due lack of transfer to the upper layer of the lake. Under prolonged layering and highly organic substrates, the build-up can be significant (on the order of 0.5-1.0 mg/l or more) and later cause algae blooms when the lake mixes in the fall.
Detectable levels or phosphorus occurred at all sampling stations; however, all results remained below the threshold of 0.030 mg/L where alga growth could occur.

Total & Fecal Coliform Bacteria – Coliform bacteria are naturally occurring in pond systems as well as resultant from human and animal inputs. While total coliform can be partly attributed to naturally occurring bacteria, fecal coliform is an indicator of the presence of human or animal waste inputs. In general, acceptable values in "swimmable waters" for total coliform is less than 1,000 organisms per 100 ml, while for fecal coliform it is 200 organisms per 100 ml.
E. Coli levels at all sampling stations remained below concerning levels.

Apparent Color – The color of the unfiltered pond water, caused by suspended and dissolved matter is the "apparent color". Apparent color values can change drastically depending on weather conditions and commonly increase with storm events and decreases with drought. There are four approximate categories for apparent color: 0-25 is clear, 25-40 is light tea color, 40-80 is tea color, >80 is dark tea color.
If the true color value is subtracted from the apparent color value, then the "true" color of water remains at the "clear" category of 0-25.

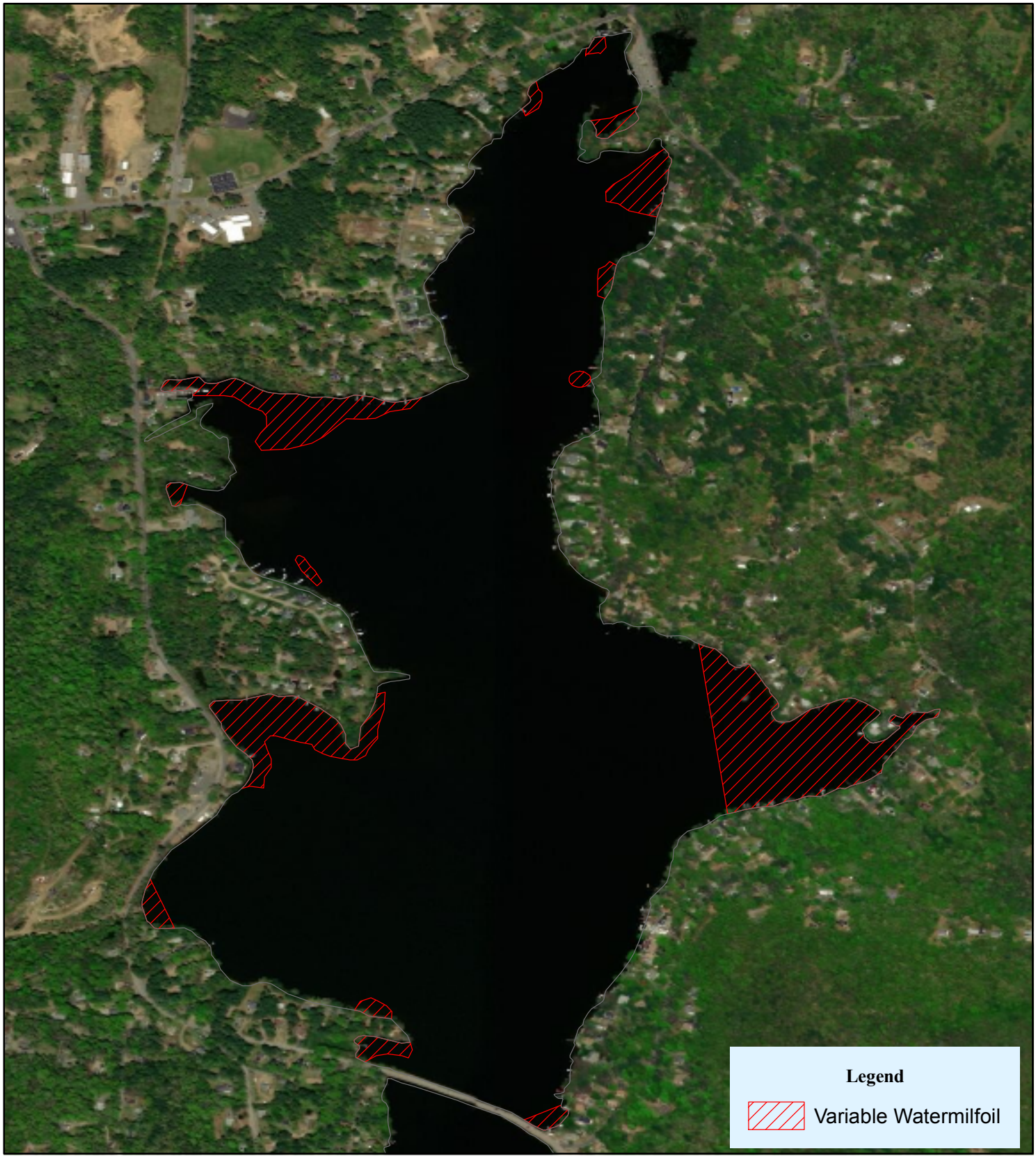
True Color– The color of the filtered pond water, free of particulates represents only dissolved organic matter (DOM) and is the "true color" of the water. This value can be subtracted from the apparent color to determine the quality of water inputs.

Dissolved oxygen (DO) is very important in the pond system. Not only do fish and other aquatic fauna require adequate levels of oxygen, but it also controls many aspects of water chemistry. Values below 5.0 mg/l are undesirable for most aquatic life, however lower values are not uncommon near the sediment layer where oxygen demand is great and oxygen influx is at a minimum. Under extreme anoxic conditions (<1.0 mg/l), phosphorus can be released from the sediment and stimulate algae blooms. Under stratified conditions, which occur in many deeper lakes, oxygen depletion can occur in a significant portion of the water column during summer and winter.
Dissolved oxygen levels remained very good at each station during both the May and September surveys.

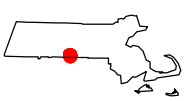
Temperature – is one of the limiting factors for algae and plant growth; as temperature increases, biological activity (photosynthesis, respiration, and decomposition) increases to a point. Temperature is directly related to the amount of available dissolved oxygen, where warmer water holds less oxygen. In deeper waterbodies, temperature stratification occurs; a thermocline occurs at depth where the top layer is warmer and actively exchanges nutrients with the air. The bottom layer is distinctly cooler and isolated from surface impacts.
Temperature measurements were commonly gradual throughout the sampled months.

FIGURE 1: Pre-Treatment Distribution of Variable Watermilfoil

SOLITUDE LAKE MANAGEMENT



Hamilton Reservoir
Holland, MA



Hamilton Reservoir

0 830 1,660

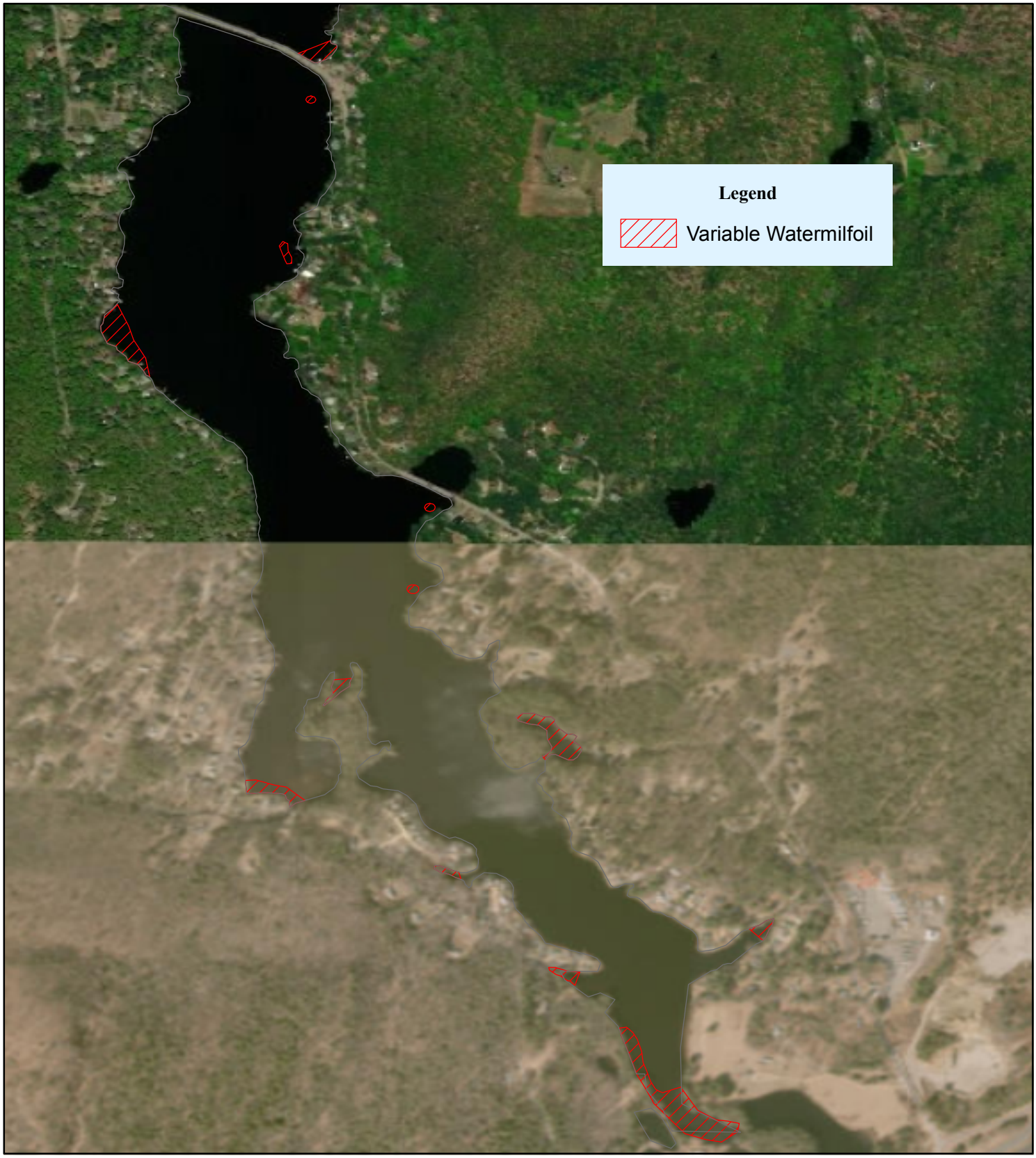
1:10,500 Feet

N

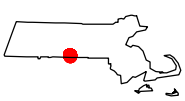
Map Date: 02/21/2019
Prepared by: JMP
Office: SHREWSBURY, MA

FIGURE 2: Distribution of Variable Watermilfoil

SOLITUDE LAKE MANAGEMENT



Hamilton Reservoir
Holland, MA



Lower Hamilton Reservoir

0 960 1,920

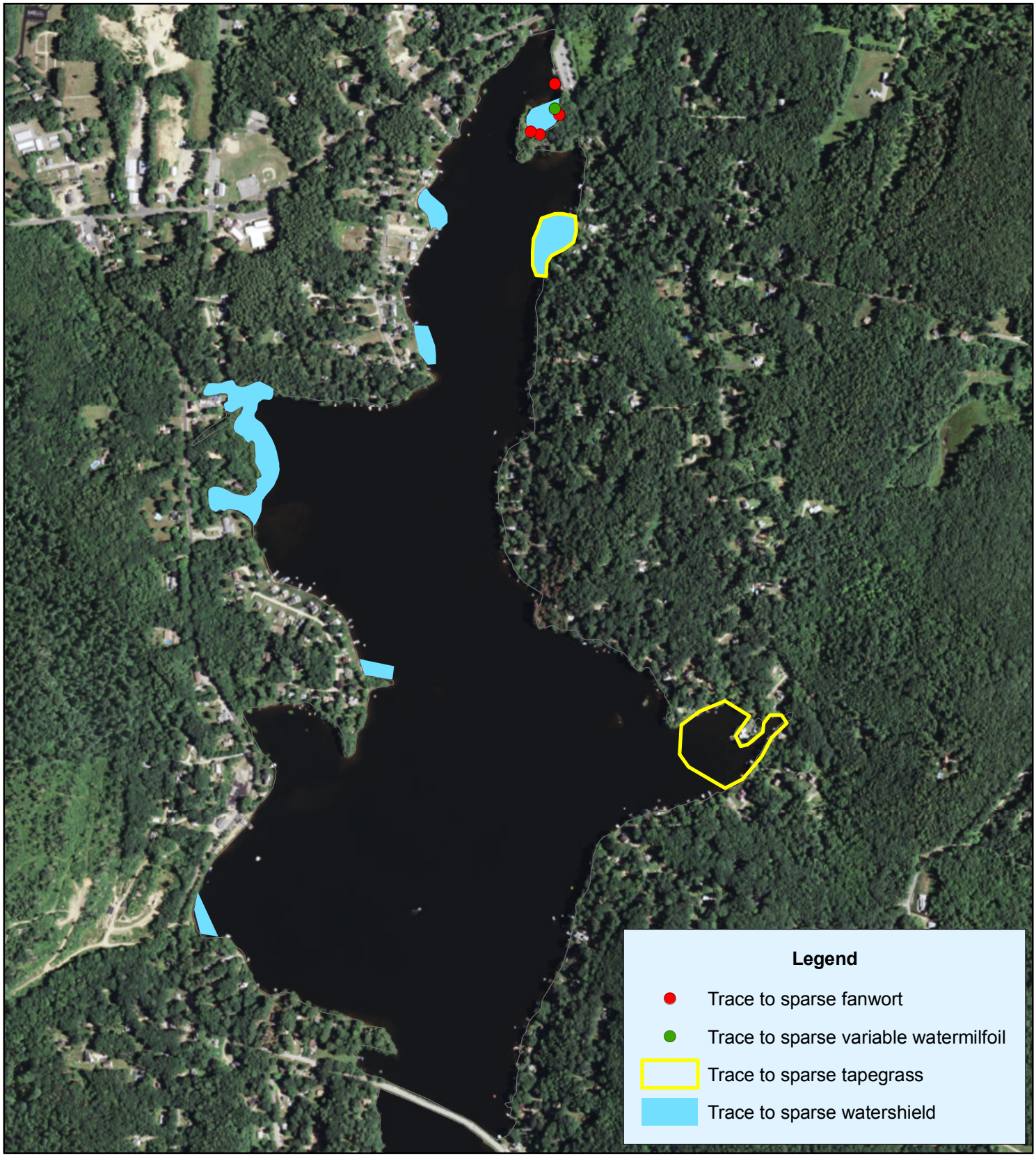
1:12,000 Feet

N

Map Date: 02/21/2019
Prepared by: JMP
Office: SHREWSBURY, MA

Figure 3: Density & Distribution of Target Vegetation

SOLITUDE LAKE MANAGEMENT
888.480.5253
solitudelakemanagement.com



Hamilton Reservoir
Holland, MA

Upper Hamilton Reservoir

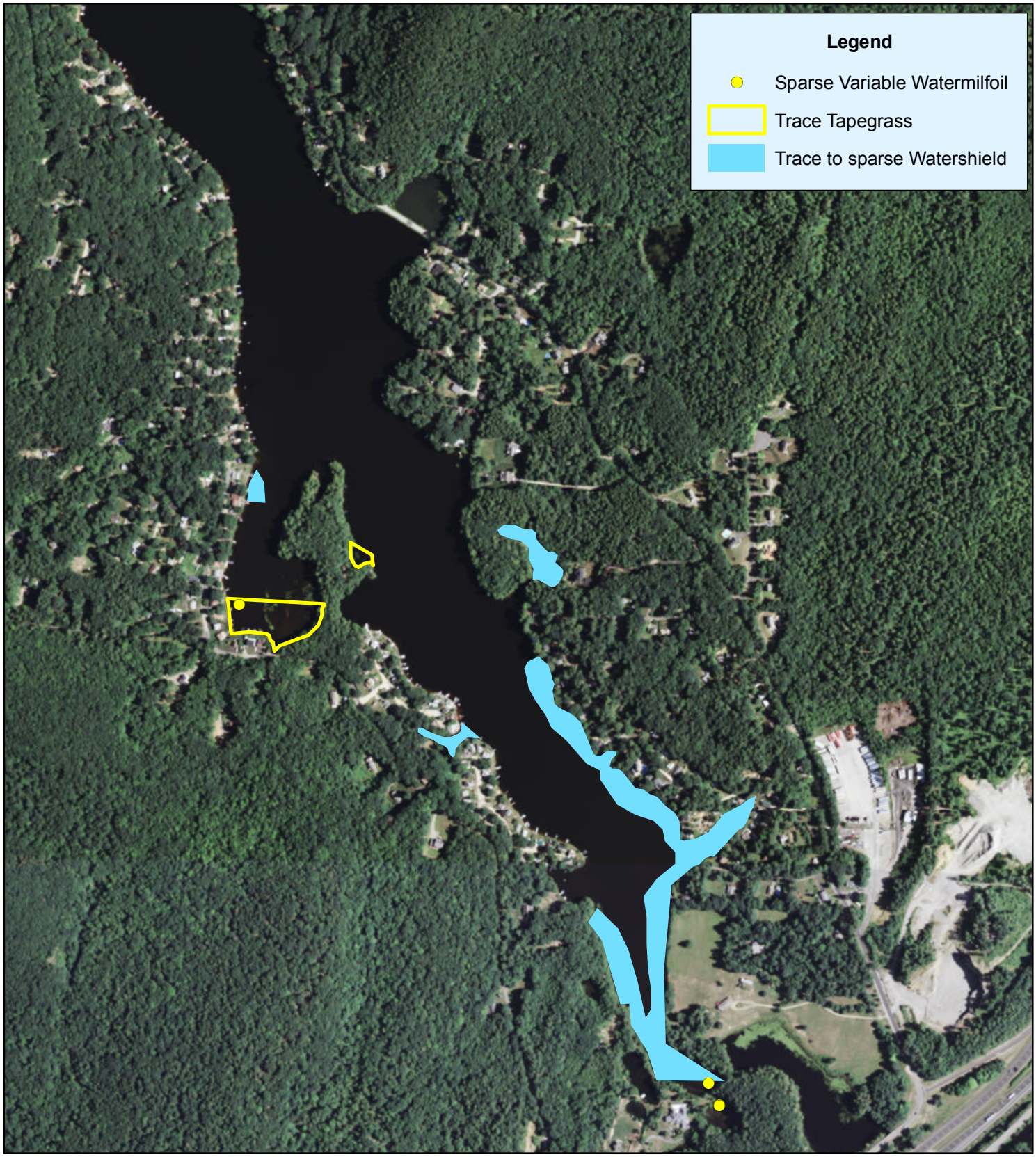
0 950 1,900 N

1:10,381 Feet

Map Date: 07/24/2018
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 4: Distribution of Target Aquatic Vegetation

SOLITUDE
LAKE MANAGEMENT
888.480.5253
solitudelakemanagement.com



Hamilton Reservoir
Holland, MA

Lower Hamilton Reservoir

0 820 1,640

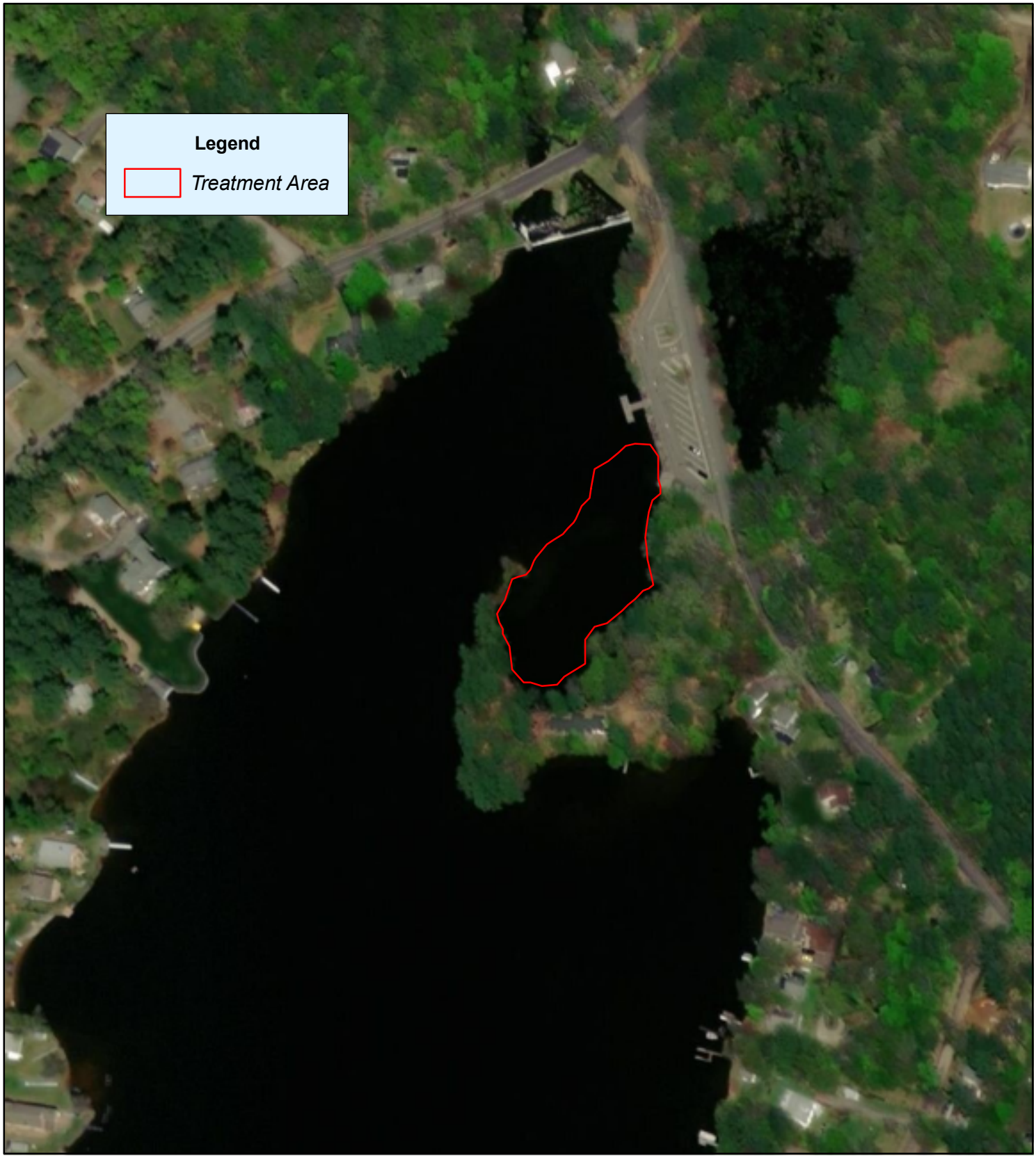
1:9,000 Feet

N

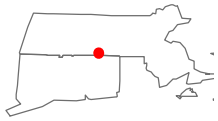
Map Date: 07/24/2018
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 5: Fanwort Treatment Areas

SOLITUDE LAKE MANAGEMENT



Hamilton Reservoir
Holland, MA



Upper Hamilton Reservoir

0 190 380 Feet

1:2,317

N

Map Date: 02/21/2019
Prepared by: JMP
Office: SHREWSBURY, MA

FIGURE 6: Water Quality Stations of North and South Basin

SOLITUDE LAKE MANAGEMENT

Hamilton Reservoir
Holland, MA
[Worcester]

Hamilton Reservoir

0 975 1,950

1:12,517 Feet

N

Map Date: 5/31/2017
Prepared by: ALM
Office: SHREWSBURY, MA

2019 Aquatic Plant Management Report
Hamilton Reservoir
Holland, Massachusetts

Report Prepared by: SŌLitude Lake Management
590 Lake Street
Shrewsbury, MA 01545

Report Prepared for: Lake Oversight Committee
Town of Holland
27 Sturbridge Road
Holland, MA 01521

In accordance with the existing aquatic plant management contract between SŌLitude Lake Management and the Town of Holland - Lake Oversight Committee for Hamilton Reservoir, the following document serves to provide this year's treatment and survey results and the management recommendations for next season.

All management activities were consistent with the Order of Conditions (DEP File #184-129), and the License to Apply Chemicals issued by the MA DEP – Office of Watershed Management (#19011); and with the permit issued by CT DEEP – (AQUA-2019-095).

PRE-MANAGEMENT INSPECTION

On June 5th, a SŌLitude Biologist surveyed the Hamilton Reservoir littoral zone. The objective of the survey was to document the density and distribution of variable watermilfoil (*Myriophyllum heterophyllum*) and fanwort (*Cabomba caroliniana*), making note of nuisance and native plant species. As in the past, techniques that were employed to locate and identify the submersed vegetation included the use of a "throw-rake", Aqua-Vu underwater system, and visual surface observations. The areas where watermilfoil was found were mapped and estimates of cover were recorded (**Figure 1 & 2**).

Watermilfoil at this time in the north basin was observed at sparse to moderate abundances. Fanwort remained isolated in the cove south of the boat launch at trace densities. Treatment areas were determined based off results from the 2018 post-management inspection and the 2019 pre-management inspection.

Watermilfoil density was low for the majority of the season; however, its distribution has remained consistent, being observed in the same historical areas of both the north and south basins. In total, the overall watermilfoil infestation occupied roughly 11-acres this season as compared to 65-acres in 2018. The native vegetation assemblage was dominated by slender naiad (*Najas flexilis)*, watershield (*Brasenia schreberi)*, ribbon-leaf pondweed (*Potamogeton epihydrus)*, common bladderwort (*Utricularia vulgaris)*, tapegrass (*Vallisneria americana*), stonewort (*Nitella spp.*), Robbin's pondweed (*Potamogeton robbinsii*), and snail-seed pondweed (*Potamogeton bicupulatus*).

MID-SEASON INSPECTION

On July 24th, a SŌLitude Biologist performed a mid-season inspection for tapegrass, floating-leaved species, fanwort, and variable watermilfoil. The objectives of this survey were to record the efficacy of the initial watermilfoil treatment conducted on June 20th, and to document the density and distributions of the above-mentioned species in preparation for possible secondary treatment. The variable watermilfoil in the very southern end of the lake did display some minor regrowth and overall, the treatment provided excellent control.

2019 was the first season in several years where nuisance growth of the native species was observed. Tapegrass and thin-leaf pondweed was present in sparse to moderate patches along the shorelines in the northern and southern basin. Fanwort, not observed during the early June survey, was now present in the water column within the cove adjacent to the boat ramp and in a small patch just outside of the cove, displaying obvious movement outside where its original growth was observed. It is within the Lake Oversee Committee's best interest to aggressively manage this species while the growth is still minimal (**Figure 3 & 4**).

HERBICIDE TREATMENTS

Three herbicide treatment events were conducted in 2019. The first treatment conducted on June 20th with Tribune (active ingredient: diquat) targeted areas of variable milfoil growth observed during the early season survey plus several additional areas that were found on the day of treatment. The second treatment was conducted on August 26th with Tribune and Nautique (Chelated copper) herbicides targeting areas of nuisance tapegrass, pondweeds and any re-growth or new areas of milfoil observed in the mid-season survey. Approximately 46-acres were treated during this effort. Finally, on October 8th, areas of floating leaf plants (mostly watershield) were treated in selected areas of both basins using the AquaPro (glyphosate) herbicide. As in the past, notification was given to the Town, the Association and all other required parties prior to each treatment. In addition to this notification, the shorelines of the reservoir were thoroughly posted by the HRA with printed signs, warning of the pending treatment and any use or re-entry restrictions.

POST-MANAGEMENT INSPECTION

On October 29th, a SŌLitude Biologist performed a post-management inspection of Hamilton Reservoir. The objectives of this survey were to record the efficacy of the 2019 herbicide treatments, as well as evaluate management techniques for the 2020 season and beyond.

The survey displayed decreased watermilfoil growth in both the North & South Basin. The observed plants largely consisted of low-biomass regrowth, which had re-appeared since the July treatment. Reward is a contact herbicide that has minimal impact on the plant's root structure; therefore, regrowth of this species is to be expected. A healthy assemblage of native species remained well represented throughout the entirety of the littoral zone and were seldom present in sufficient quantities. Dominant native species included slender naiad, common bladderwort, yellow and white waterlily, and watershield. In smaller quantities existed tapegrass and several pondweed species (thin-leaf pondweed, Robbin's pondweed, and ribbon-leaf pondweed).

WATER QUALITY

Two water quality sampling rounds were conducted on June 5th and July 24th during the early and mid-season inspections. Samples were collected at four locations for the specific parameters. Please refer to table 1, 2, & 3 for results. Descriptions for the parameters collected are attached (Water Quality Parameter Explanations). Please refer to **Figure 7** for water quality sampling locations.

Table 1: June, July, and October dissolved oxygen and temperature profiles

Depth (Meters)	Dissolved Oxygen (mg/L)						Temperature (°C)					
	North			South			North			South		
	06/05	07/24	10/29	06/0	07/24	10/29	06/05	07/24	10/29	06/05	07/24	10/29
SW	9.10	7.15	9.70	8.63	7.02	10.01	20.60	26.12	13.80	20.00	26.26	14.03
2	9.00	7.02	9.65	8.26	6.67	9.74	20.41	26.13	13.44	19.60	26.23	13.81
4	8.98	6.75	9.65	8.03	6.67	9.66	20.21	26.07	12.97	19.59	26.15	13.80
6	8.82	6.83	9.63	8.15	6.81	9.58	19.62	26.04	12.96	19.53	26.02	13.33
8	8.66	6.74	9.64	8.10	6.77	9.14	19.48	25.99	12.85	19.50	25.68	12.97
10	8.48	6.78	9.62		6.14	8.02	19.37	25.96	12.86		24.25	12.82
12	7.93	6.62	9.61				19.07	25.87	12.83			
14	5.82	3.61	9.62				17.08	23.40	12.77			
16	3.75	2.77	9.60				15.10	19.55	12.75			
18		1.63	9.60					16.15	12.74			
20		1.24						14.33				
22		1.02						13.71				

Dissolved oxygen (DO) is very important in the pond system. Not only do fish and other aquatic fauna require adequate levels of oxygen, but it also controls many aspects of water chemistry. Values below 5.0 mg/l are undesirable for most aquatic life, however, lower values are not uncommon near the sediment layer where oxygen demand is great and oxygen influx is at a minimum. Under extreme anoxic conditions (<1.0 mg/l), phosphorus can be released from the sediment and stimulate algae blooms. Under stratified conditions, which occur in many deeper lakes, oxygen depletion can occur in a significant portion of the water column during summer and winter. ***Dissolved oxygen levels remained very good at each station during all three profile sampling events.***

Temperature is one of the limiting factors for algae and plant growth; as temperature increases, biological activity (photosynthesis, respiration, and decomposition) increases to a point. Temperature is directly related to the amount of available dissolved oxygen, where warmer water holds less oxygen. In deeper waterbodies, temperature stratification occurs; a thermocline occurs at depth where the top layer is warmer and actively exchanges nutrients with the air. The bottom layer is distinctly cooler and isolated from surface impacts. ***The north basin has partial stratification at the deep spot by the aqua-riders beach where depths reach 20+ feet. This is evident during the July profile where the thermocline is reached between 14 and 18 feet. The October profile in the North basin displays a consistent temperature gradient where seasonal mixing is occurring. The southern basin is fairly shallow and does not display thermal stratification.***

Table 2: June and July 2019 water quality sampling results

Parameter	Units	Detection Level	North-Primary		North-Secondary		South-Primary		South-Secondary	
			June	July	June	July	June	July	June	July
Total Phosphorus	Mg/L	0.010	0.010	0.014	ND	0.014	ND	0.021	0.015	0.019
Dissolved Phosphorus	Mg/L	0.010	ND	0.011	ND	ND	ND	0.011	ND	0.010
Ammonia/Nitrogen	Mg/L	0.010	0.116	NS	0.080	NS	ND	NS	0.090	NS
Total Alkalinity	Mg/L	2.0	7.3	9.9	NS	9.7	8.8	11.8	NS	11.1
Total Kjeldahl Nitrogen	Mg/L	0.300	0.360	0.339	0.304	0.460	0.455	0.391	0.476	0.634
Nitrate/Nitrogen	Mg/L	0.010	ND	ND	ND	ND	ND	ND	ND	ND
Turbidity	NTU	0.20	3.0	2.4	NS	2.1	2.2	2.7	NS	3.0
Secchi Clarity	Feet	--	7.0	5.0			6.2	5.0		

*NS=Not sampled; ND=Not-detected

Please refer to the Water Quality Parameter page for water quality & algae analysis for **Tables 2 & 3**.

Table 3: June and July Algal sample enumeration & identification

Organism Type	North				South			
	Most Common Species & Total Count		Most Common Species & Total Count		Most Common Species & Total Count		Most Common Species & Total Count	
	June		July		June		July	
Diatomaceae	Synedra	525	Not Present	0	Cyclotella	80	Cyclotella	920
Protozoa	Dinobryon	280	Not Present	0	Dinobryon	370	Not Present	0
Rotifera	Not Present	0	Not Present	0	Not Present	0	Not Present	0
Chlorophyceae	Ulothrix	30	Ulothrix	1880	Ulothrix	28	Ulothrix	1100
Cyanophyceae	Spirulina	0	Psuedanabaena	330	Anabaena	20	Not Present	0
Miscellaneous	Not Present	0	Not Present	0	Not Present	0	Not Present	0

MANAGEMENT RECOMMENDATIONS FOR 2020

We recommend continuing with the monitoring and management program at Hamilton Reservoir. Over the last year or so, we have discussed moving to use of a new systemic herbicide for the milfoil, ProcellaCOR, which will provide multiple seasons of milfoil control versus the diquat herbicide that's been used in the past. While the cost is significantly higher, we understand that this new treatment approach may be funded in 2020. Desirable open-water conditions can be achieved via area selective herbicide treatments in 2020, while maintaining valuable vegetative diversity within the ecosystem.

It is also recommended that the suggested water quality program be re-instituted for the 2020 season. Two sample rounds were performed during the 2019 season, but was interrupted mid-season due to funding. If funding is an issue, we can further discuss the monitoring program to slim it down to meet funding needs.

It is also recommended to continue to monitor for invasive fanwort in the area of the boat ramp. Since its initial discovery in the lake in 2017, it has seemingly not expanded into other areas of the lake, however annual monitoring of this species should continue to ensure spread of this species is reduced. Spot-treating with the herbicide Clipper, followed by post-treatment hand-harvesting, would be the best mode of action to stifle regrowth. A new infestation should be dealt with aggressively, as fanwort is a persistent plant that spreads primarily through fragmentation and rhizomes.

If you have any questions or require any additional information please do not hesitate to contact the office. We look forward to working with you in the 2020 season.

Water Quality Parameter Explanations

Table 2: June and July 2019 water quality sampling results

Parameter	Units	Detection Level	North-Primary		North-Secondary		South-Primary		South-Secondary	
			June	July	June	July	June	July	June	July
Total Phosphorus	Mg/L	0.010	0.010	0.014	ND	0.014	ND	0.021	0.015	0.019
Dissolved Phosphorus	Mg/L	0.010	ND	0.011	ND	ND	ND	0.011	ND	0.010
Ammonia/Nitrogen	Mg/L	0.010	0.116	NS	0.080	NS	ND	NS	0.090	NS
Total Alkalinity	Mg/L	2.0	7.3	9.9	NS	9.7	8.8	11.8	NS	11.1
Total Kjeldahl Nitrogen	Mg/L	0.300	0.360	0.339	0.304	0.460	0.455	0.391	0.476	0.634
Nitrate/Nitrogen	Mg/L	0.010	ND	ND	ND	ND	ND	ND	ND	ND
Turbidity	NTU	0.20	3.0	2.4	NS	2.1	2.2	2.7	NS	3.0
Secchi Clarity	Feet		7.0	5.0			6.2	5.0		

*NS=Not sampled; ND=Not-detected

Total/Dissolved Phosphorus is generally considered the limiting nutrient for plants and algae growth, with concentrations of 0.03 mg/l or more being sufficient to stimulate algae blooms. Water column phosphorus (dissolved phosphorus) does not generally relate to rooted plant growth as they obtain most of their nutrients from the pond sediment. In the hypolimnion, low oxygen levels can promote the release of phosphorus from the bottom sediments, which may build up over the summer due lack of transfer to the upper layer of the lake. Under prolonged layering and highly organic substrates, the build-up can be significant (on the order of 0.5-1.0 mg/l or more) and later cause algae blooms when the lake mixes in the fall. ***Detectable levels or phosphorus occurred at all sampling stations; however, all results remained below the threshold of 0.030 mg/L where alga growth could occur.***

Ammonia/Nitrogen is a measure of two constituents, NH_3 and NH_4^+, and is a transitional product in the breakdown of organic nitrogen into nitrate. It is typically short-lived in the pond environment except under conditions of low dissolved oxygen. Waterbodies that have a high pH are susceptible to high ammonia concentrations; the higher the pH, the more ammonia will be present within the water column. High levels of ammonia typically indicate a eutrophic pond, and can be toxic to fish at higher levels. Levels <0.05 mg/L are ideal. **The June sample indicated an elevated level of Ammonia in both locations in the Northern basin, and the secondary location in the Southern basin. All levels were above the "ideal" threshold of 0.05 mg/L. Unfortunately, ammonia samples were not collected during the July sample round.**

Total Alkalinity is a measure of the buffering capacity of a waterbody against acid additions such as acid rain and pollution, which can be detrimental to wildlife populations. Total alkalinity measures the presence of carbonates, bicarbonates and hydroxides. Values below 20 mg/l are a signal that the pond may be susceptible to fluctuations in pH. ***Alkalinity in Hamilton Reservoir is below 20 mg/L, determining that, as similar to most other lakes in New England, is susceptible to fluctuations in pH.***

Total Kjeldahl nitrogen (TKN) is a measure of the nitrogen contained in organic compounds, such as proteins and amino acids, and as ammonia. It is created from biological growth and decomposition. A concentration of 1.0 mg/l or below is considered desirable. ***Total Kjedahl nitrogen remained below desirable levels at each sampling station.***

Nitrate/Nitrogen is another form of nitrogen found in the water column. Nitrate nitrogen is usually the most prevalent form of inorganic nitrogen in the water and results from such things as natural aerobic bacterial activity and fertilizer use. It is also the form that is most readily available for plant and algae growth. Levels lower than 0.3 mg/L can limit plant and algae growth in conjunction with low phosphorus levels. ***Nitrogen levels remained below detectable levels (0.010 mg/L).***

Turbidity is a relative measurement of the amount of suspended material in the water. It is measured through a process involving light diffraction of the pond sample as compared to a series of prepared samples. Turbidity values can range from less than one to thousands of units, however, values in most ponds and lakes rarely rises above 5 NTU. ***Turbidity levels were observed below 5NTU's at each sampling station during both June and July sampling events.***

Table 3: June and July Algal sample enumeration & identification

Organism Type	North				South			
	Most Common Species & Total Count		Most Common Species & Total Count		Most Common Species & Total Count		Most Common Species & Total Count	
	June		July		June		July	
Diatomaceae	Synedra	525	Not Present	0	Cyclotella	80	Cyclotella	920
Protozoa	Dinobryon	280	Not Present	0	Dinobryon	370	Not Present	0
Rotifera	Not Present	0	Not Present	0	Not Present	0	Not Present	0
Chlorophyceae	Ulothrix	30	Ulothrix	1880	Ulothrix	28	Ulothrix	1100
Cyanophyceae	Spirulina	0	Psuedanabaena	330	Anabaena	20	Not Present	0
Miscellaneous	Not Present	0	Not Present	0	Not Present	0	Not Present	0

Algae cell counts in both June and July were relatively stable and low. Ulothrix, a common type of filamentous green algae, was observed throughout the season in both the North and South basin. Green algae is naturally occurring and where nutrient levels are sufficient for growth. No species of green algae is toxic. Three cyanobacteria species were collected, but all cell counts were low. The World Health Organization (WHO) determined that 70,000 cells/mL is where human health is at risk. At no point during each sampling event did the cyanobacteria species reach this threshold.

Figure 1: June Density and Distribution of Variable Watermilfoil

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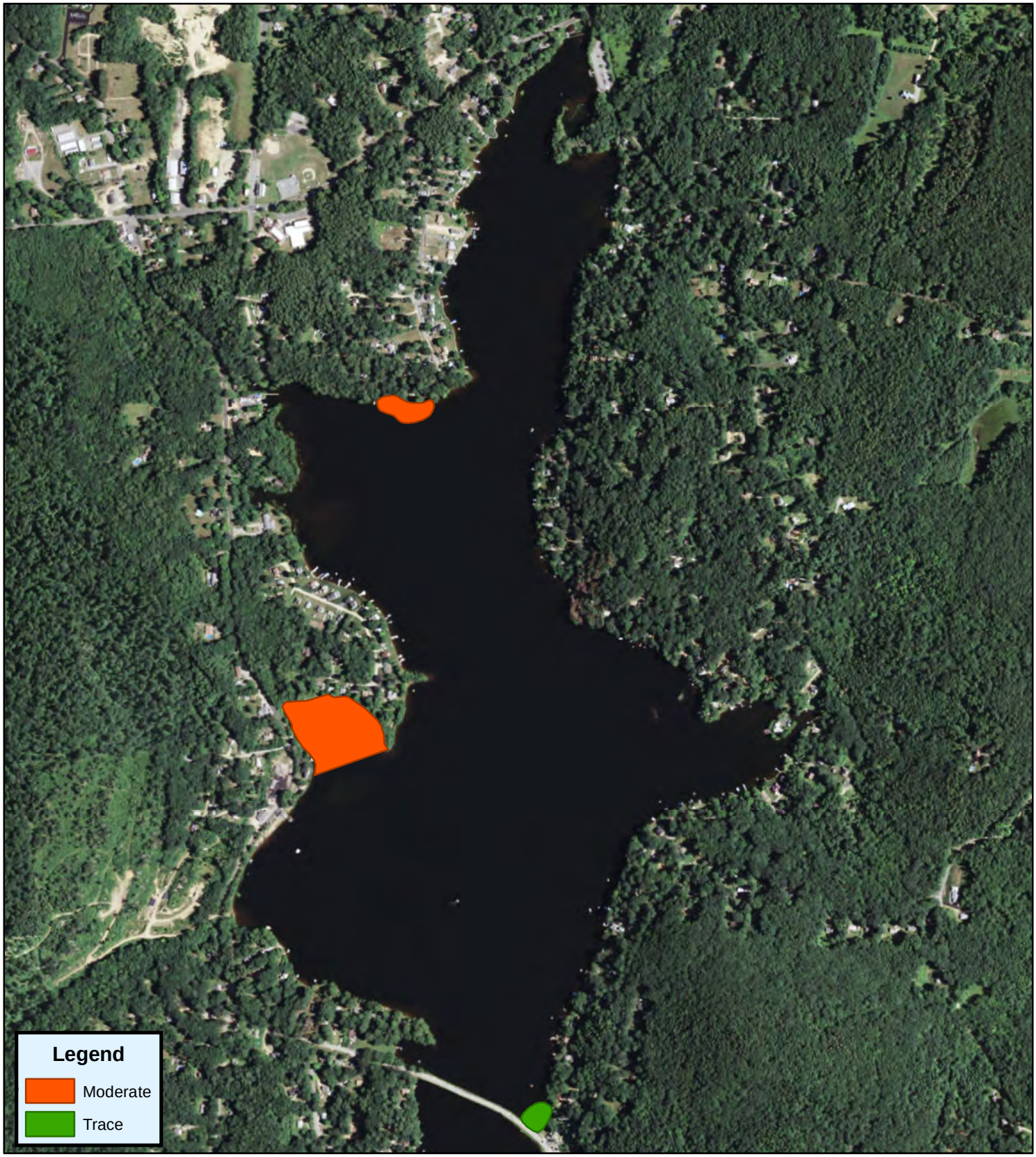
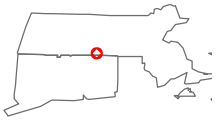


Hamilton Reservoir
Holland, MA



Upper Hamilton Reservoir

0 550 1,100 2,200

1:10,500 Feet

N

Map Date: 02/19/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 2: June Density and Distribution of Variable Watermilfoil

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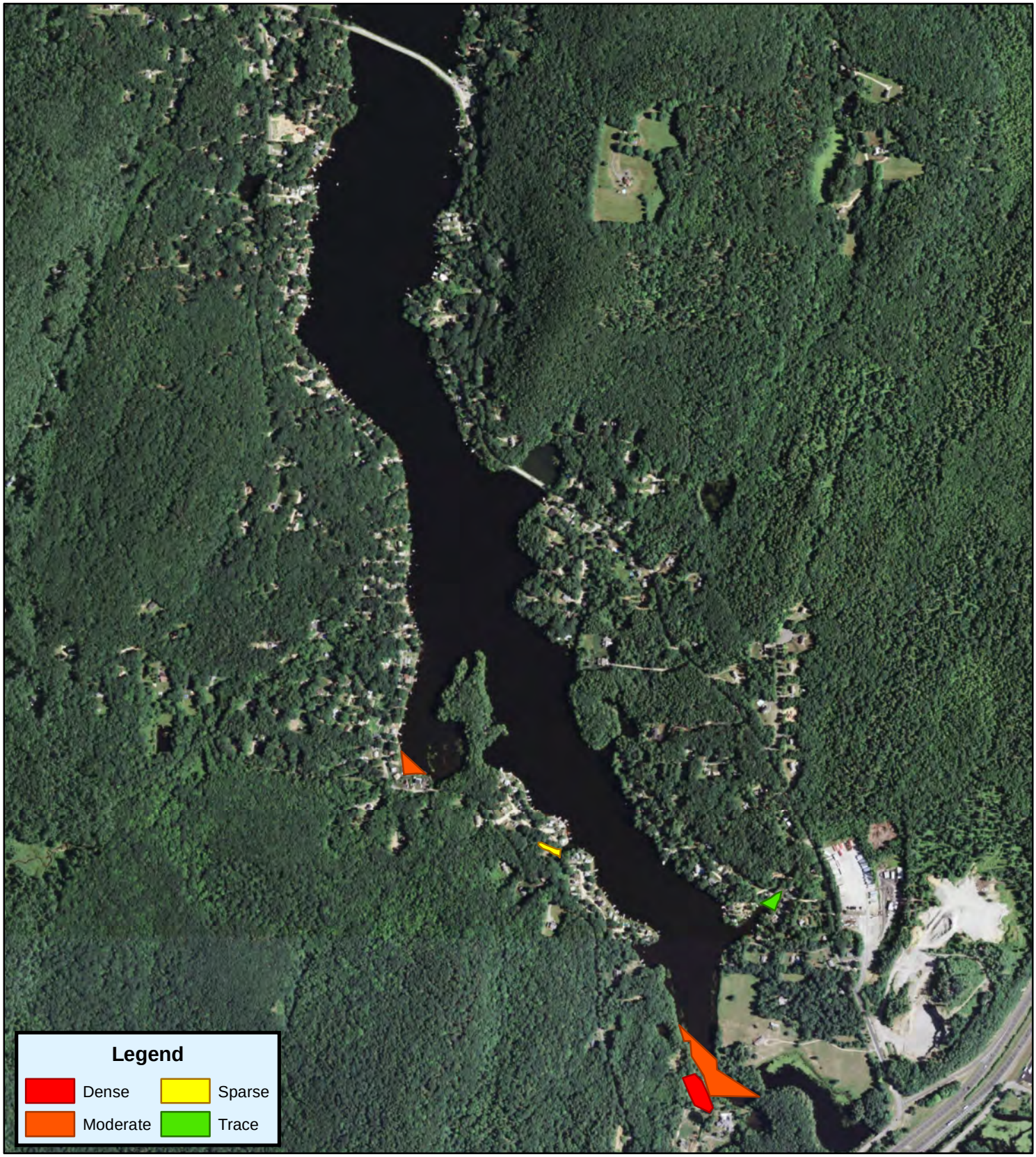
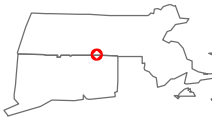


Hamilton Reservoir
Holland, MA



Lower Hamilton Reservoir

0 700 1,400 2,800

1:12,500 Feet

N

Map Date: 02/19/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 3: July Density and Distribution of Submersed and Floating Aquatic Vegetation

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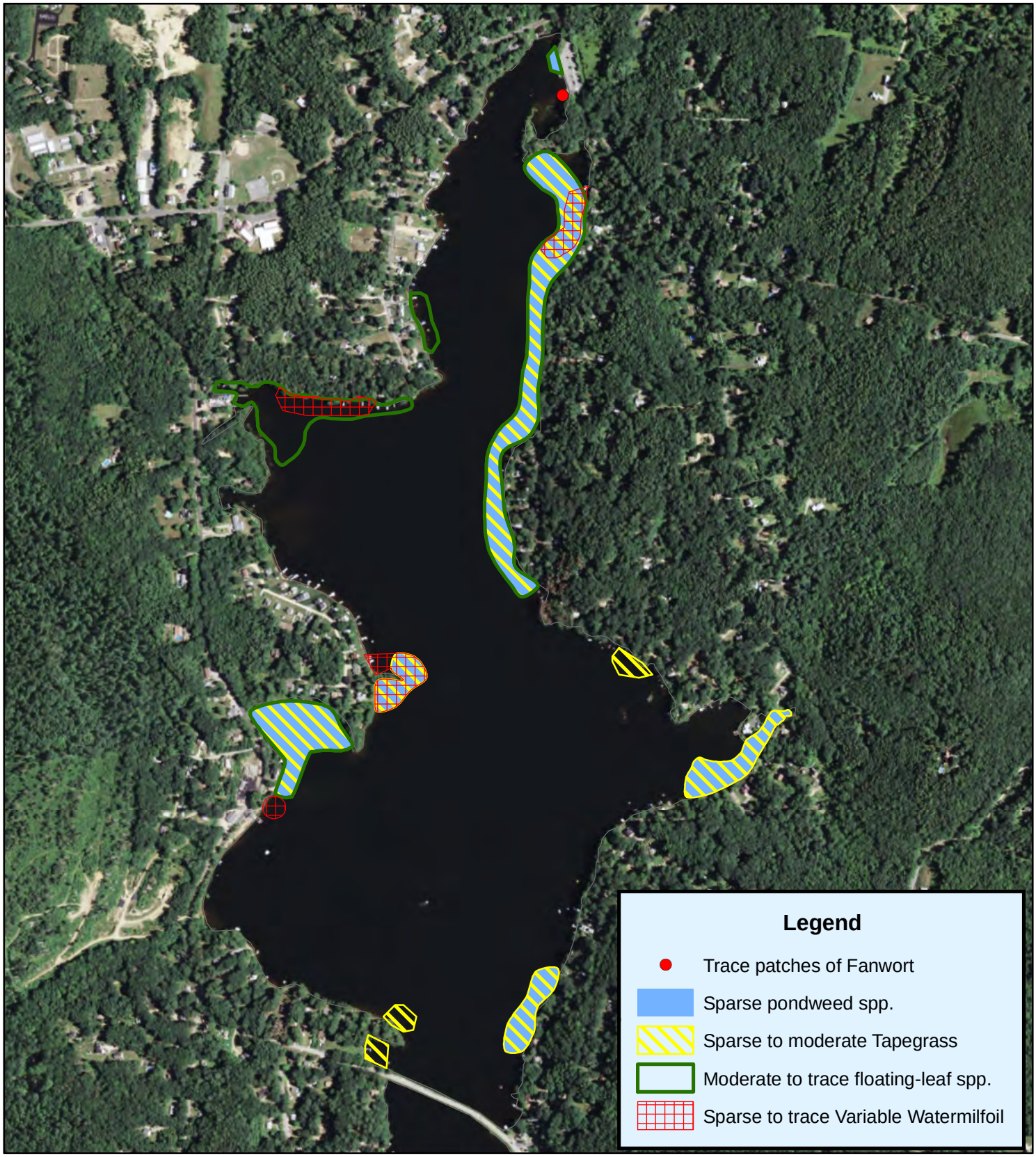
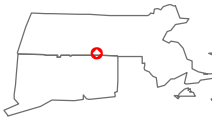


Hamilton Reservoir
Holland, MA



Upper Hamilton Reservoir

0 550 1,100 2,200

1:10,500 Feet

N

Map Date: 02/19/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 4: July Density and Distribution of Submersed and Floating Aquatic Vegetation

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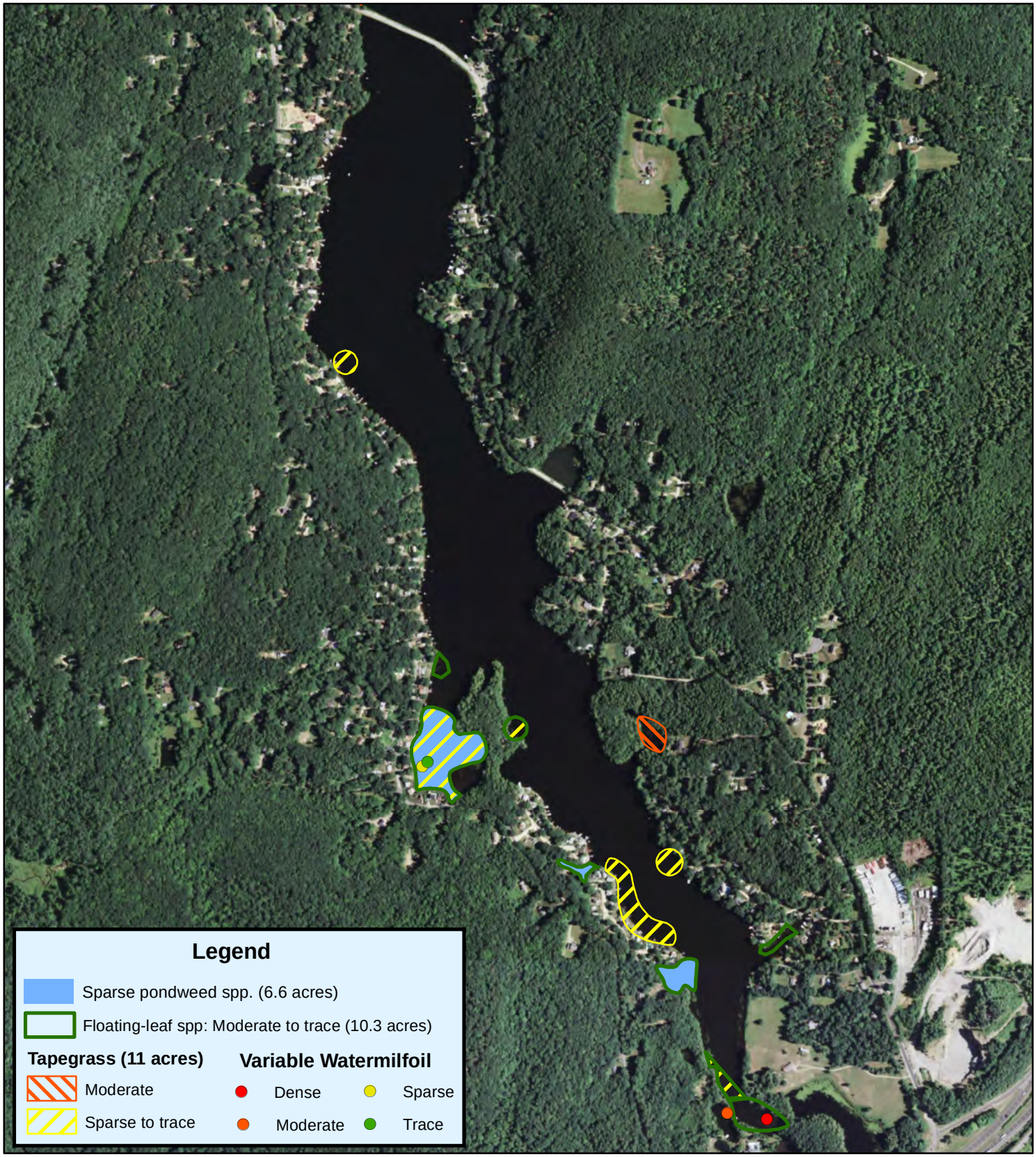
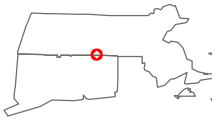


Hamilton Reservoir
Holland, MA



Lower Hamilton Reservoir

0 625 1,250 2,500

1:12,000 Feet

N

Map Date: 02/19/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 5: October Density and Distribution of Invasive Aquatic Vegetation

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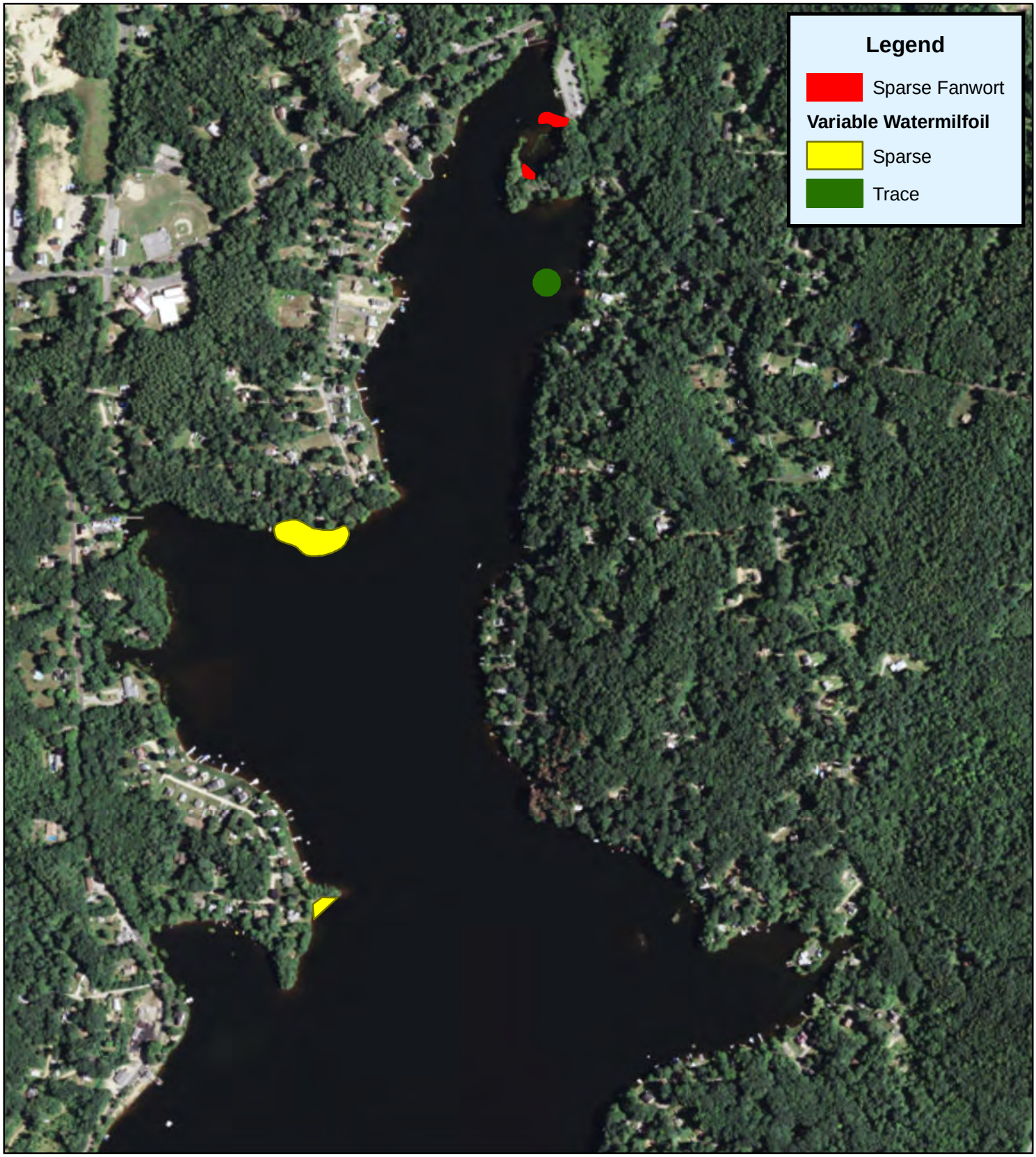
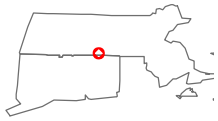


Hamilton Reservoir
Holland, MA



Upper Hamilton Reservoir

0 425 850 1,700

1:7,933 Feet

N

Map Date: 02/19/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 6: October Density and Distribution of Invasive Aquatic Vegetation

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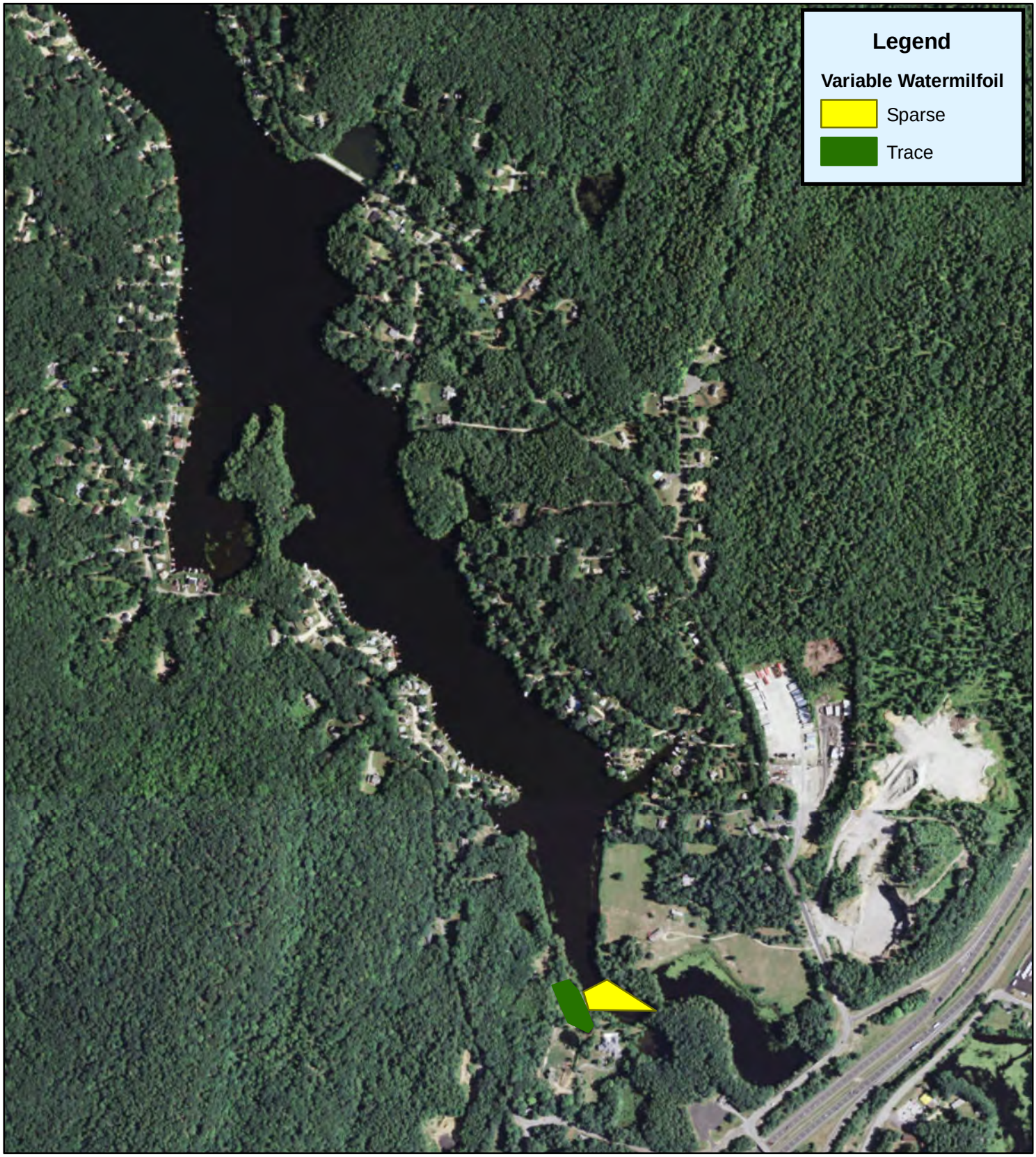
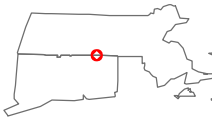


Hamilton Reservoir
Holland, MA



Lower Hamilton Reservoir

0 500 1,000 2,000

1:9,200 Feet

N

Map Date: 02/19/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 7: Water Quality Sampling Locations

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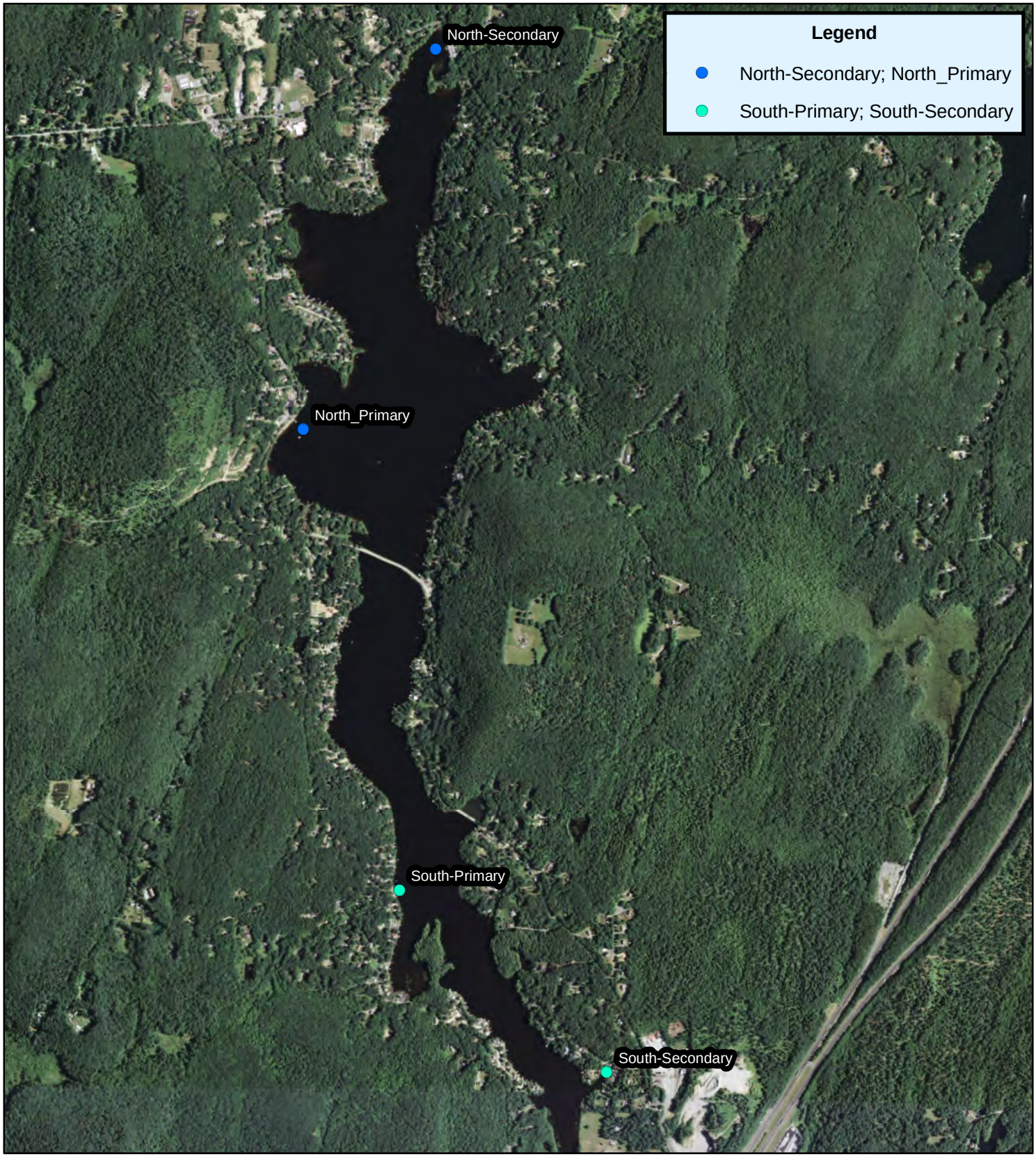
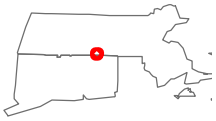


Hamilton Reservoir
Holland, MA



Hamilton Reservoir

0 1,700 3,400 Feet

1:21,000

N

Map Date: 02/20/20
Prepared by: ALM
Office: SHREWSBURY, MA

2020 Aquatic Plant Management Report
Hamilton Reservoir
Holland, Massachusetts

Report Prepared by: SŌLitude Lake Management
590 Lake Street
Shrewsbury, MA 01545

Report Prepared for: Lake Oversight Committee
Town of Holland
27 Sturbridge Road
Holland, MA 01521

In accordance with the existing aquatic plant management contract between SŌLitude Lake Management and the Town of Holland - Lake Oversight Committee for Hamilton Reservoir, the following document serves to provide this year's treatment and survey results and the management recommendations for next season.

All management activities were consistent with the Order of Conditions (DEP File #184-0335), and the License to Apply Chemicals issued by the MA DEP – Office of Watershed Management (#WM04-0000025); and with the permit issued by CT DEEP – (AQUA-2019-095).

PRE-MANAGEMENT INSPECTION

On May 21st, a SŌLitude Biologist surveyed the Hamilton Reservoir littoral zone. The objective of the survey was to document the density and distribution of variable watermilfoil (*Myriophyllum heterophyllum*) and fanwort (*Cabomba caroliniana*), making note of nuisance and native plant species. As in the past, techniques that were employed to locate and identify the submersed vegetation included the use of a "throw-rake", Aqua-Vu underwater system, and visual surface observations. The areas where watermilfoil was found were mapped and estimates of cover were recorded (**Figure 1 & 2**).

Watermilfoil at this time in the north basin was observed at trace to sparse abundances. Fanwort remained isolated in the northern most cove next to the boat launch in trace densities. Treatment areas were determined based off results from the 2019 post-management inspection and the 2020 pre-management inspection.

Watermilfoil density was moderate for the majority of the 2020 season; however, its distribution has remained consistent, being observed in the same historical areas of both the north and south basins. In total, the overall watermilfoil infestation occupied roughly 30-35 acres this season. The native vegetation assemblage was dominated by slender naiad (*Najas flexilis)*, watershield (*Brasenia schreberi)*, ribbon-leaf pondweed (*Potamogeton epihydrus)*, common bladderwort (*Utricularia vulgaris)*, tapegrass (*Vallisneria americana*), stonewort (*Nitella spp.*), Robbin's pondweed (*Potamogeton robbinsii*), and snail-seed pondweed (*Potamogeton bicupulatus*).

MID-SEASON INSPECTION

On July 14th, a SŌLitude Biologist performed a mid-season inspection for tapegrass, floating-leaved species, fanwort, and variable watermilfoil. The objectives of this survey were to record the efficacy of the initial watermilfoil treatment conducted on June 17th, and to document the density and distributions of the above-mentioned species in preparation for possible secondary treatment. The variable watermilfoil in the very southern end of the lake did display some minor regrowth but overall, the treatment provided excellent control (**Figure 3 & 4**).

Tapegrass and Water shield were present in trace to moderate patches along the shorelines in the northern and southern basin. Fanwort, observed in trace patches during the late May survey, was now present in the water column within the cove adjacent to the boat ramp and in a moderate patch just outside of the cove, displaying obvious movement from where its original growth was observed. It is within the Lake Oversee Committee's best interest to aggressively manage this species while the growth is still minimal.

HERBICIDE TREATMENTS

Three herbicide treatment events were conducted in 2020. The first treatment conducted on June 17th with Tribune (active ingredient: diquat) targeted areas of variable milfoil growth observed during the early season survey plus several additional areas that were found on the day of treatment. A total of 35 acres were treated. The second treatment was conducted on August 17th with Tribune and Nautique (Chelated copper) herbicides targeting areas of nuisance tapegrass, pondweeds and any re-growth or new areas of milfoil observed in the mid-season survey. At this time, the boat ramp cove was also treated with diquat and Red Eagle (flumioxazin) for control of fanwort. Approximately 20-acres were treated during this effort. Finally, on September 14th, areas of floating leaf plants (mostly watershield) were treated in selected areas of both basins using the AquaPro (glyphosate) herbicide. As in the past, notification was given to the Town, the Association and all other required parties prior to each treatment. In addition to this notification, the shorelines of the reservoir were thoroughly posted by the HRA with printed signs, warning of the pending treatment and any use or re-entry restrictions.

POST-MANAGEMENT INSPECTION

On October 5th, a SŌLitude Biologist performed a post-management inspection of Hamilton Reservoir. The objectives of this survey were to record the efficacy of the 2020 herbicide treatments, as well as evaluate management techniques for the 2021 season and beyond.

The survey displayed decreased watermilfoil growth in both the North & South Basin. The observed plants largely consisted of low-biomass regrowth, which had re-appeared since the July treatment. Diquat is a contact herbicide that has minimal impact on the plant's root structure; therefore, regrowth of this species is to be expected. A healthy assemblage of native species remained well represented throughout the entirety of the littoral zone and were seldom present in sufficient quantities. Dominant native species included slender naiad, common bladderwort, yellow and white waterlily, and watershield. In smaller quantities existed tapegrass and several pondweed species (thin-leaf pondweed, Robbin's pondweed, and ribbon-leaf pondweed) (**Figure 5 & 6**).

Although the fanwort infestation near the boat ramp was treated in July, unfortunately, additional growth was identified to have traveled to a south-eastern location in the northern basin.

MANAGEMENT RECOMMENDATIONS FOR 2021

We recommend continuing with the monitoring and management program at Hamilton Reservoir. Over the last couple of years or so, we have discussed moving to use of a new systemic herbicide for the milfoil, ProcellaCOR, which will provide multiple seasons of milfoil control versus the diquat herbicide that has been used in the past. While the cost is significantly higher, we understand that this new treatment approach may be funded in 2021. Desirable open-water conditions can be achieved via area selective herbicide treatments in 2020, while maintaining valuable vegetative diversity within the ecosystem.

It is also recommended that the past water quality program be re-instituted for the 2021 season. Two sample rounds were performed during the 2019 season but was interrupted mid-season due to funding. If funding is an issue, we can further discuss the monitoring program to slim it down to meet funding needs.

It is also recommended to continue to monitor for invasive fanwort throughout the lake and conduct herbicide treatment as needed. Since its initial discovery in the lake in 2017, management has consisted of diver handpulling and herbicide treatment which has limited its spread until this year. Annual monitoring of this species should continue to ensure spread of this species is minmized. Spot-treating with the flumioxazin herbicide, followed by post-treatment hand-harvesting, would be the best mode of action to stifle regrowth. Any new infestation should be dealt with aggressively, as fanwort is a persistent plant that spreads primarily through fragmentation and rhizomes.

If you have any questions or require any additional information please do not hesitate to contact the office. We look forward to working with you in the 2021 season.

Figure 1: Upper Hamilton May Density and Distribution of Variable Watermilfoil

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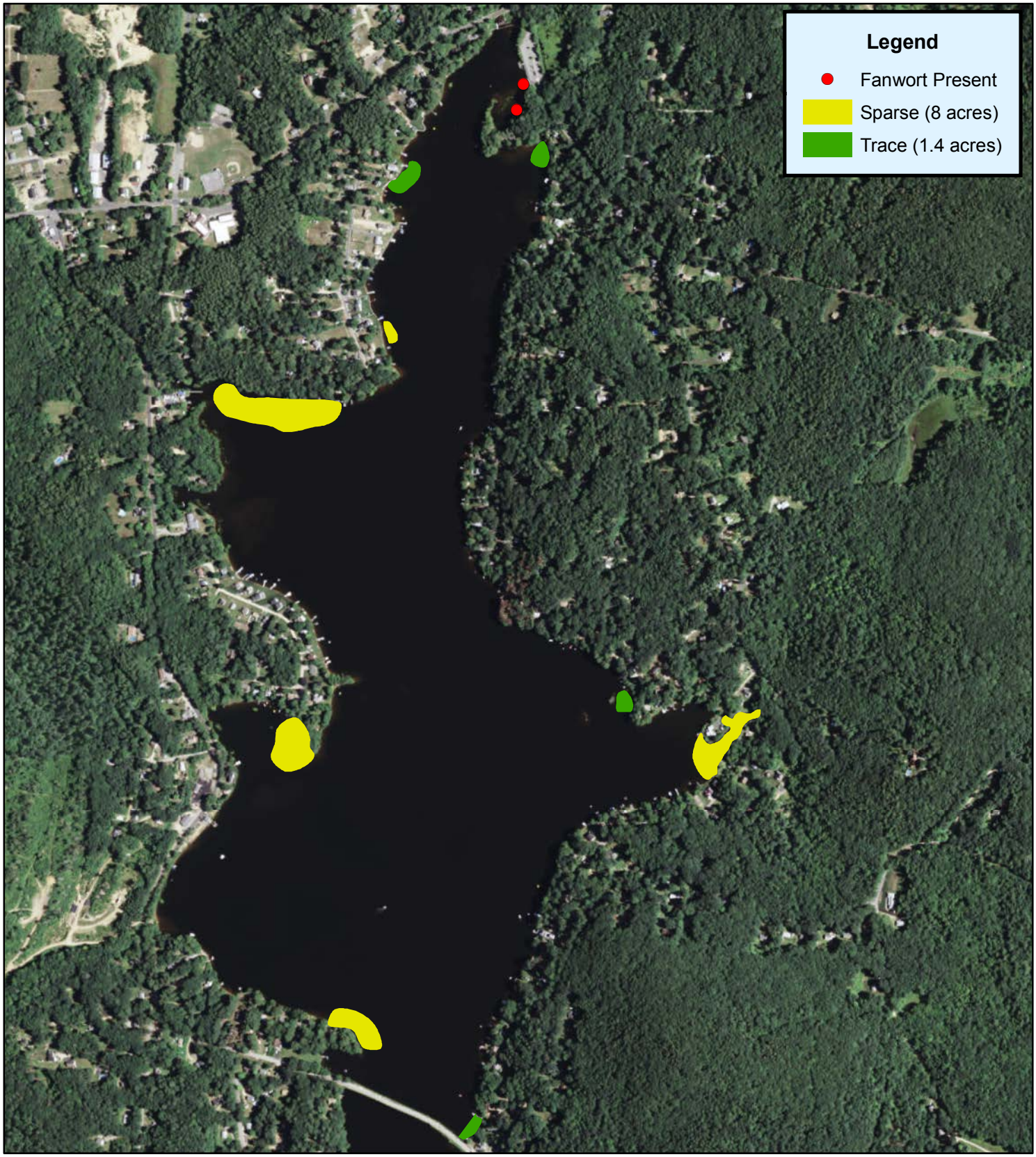
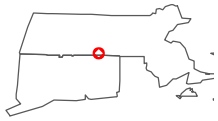


Hamilton Reservoir
Holland, MA



Upper Hamilton Reservoir

0 550 1,100 2,200

1:10,326 Feet

N

Map Date: 05/21/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 2: Lower Hamilton May Density and Distribution of Variable Watermilfoil

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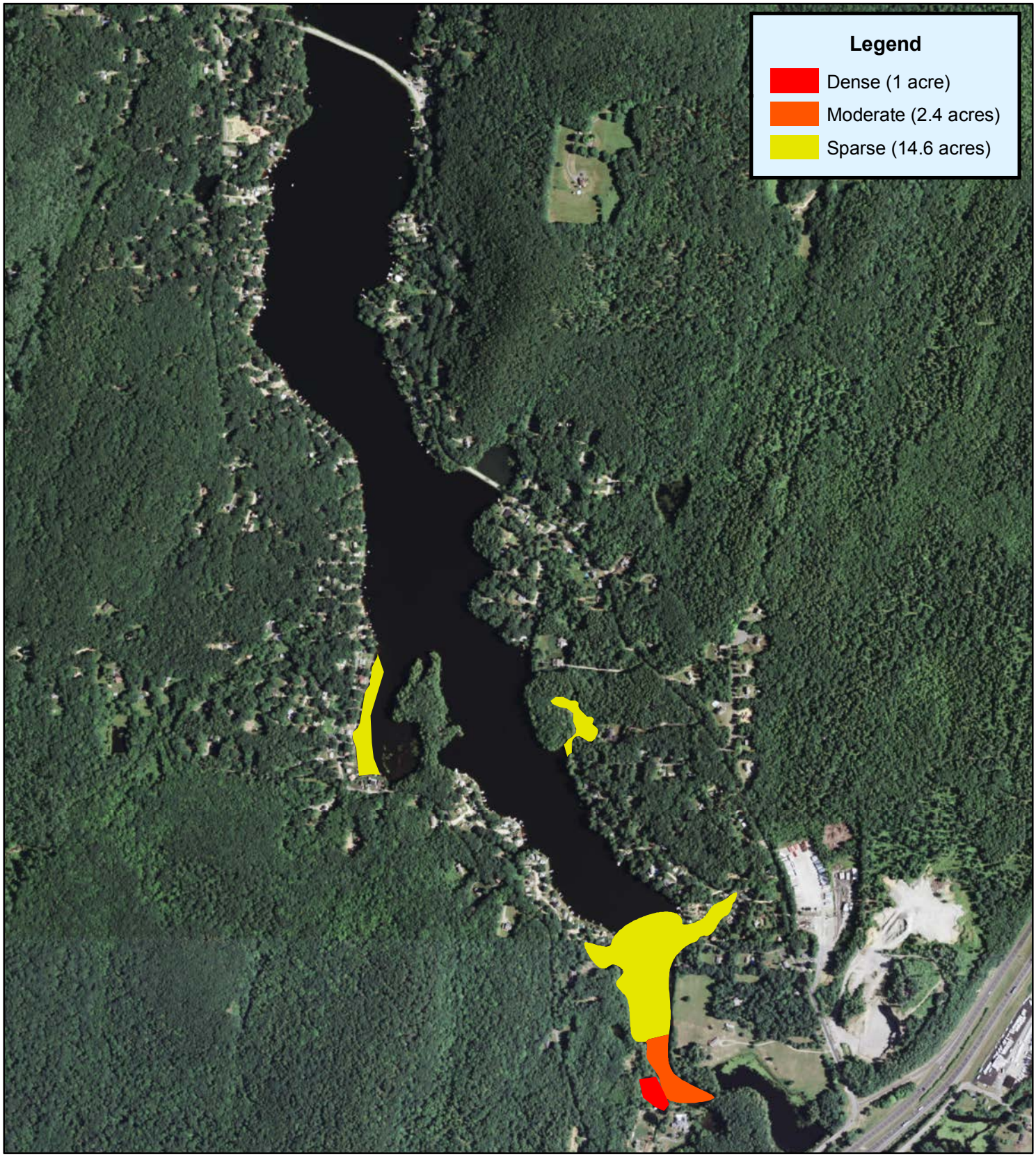
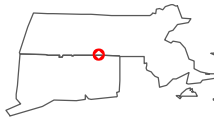


Hamilton Reservoir
Holland, MA



Lower Hamilton Reservoir

0 625 1,250 2,500

1:12,500 Feet

N

Map Date: 05/21/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 3: Upper Hamilton July Density and Distribution of Target Vegetation

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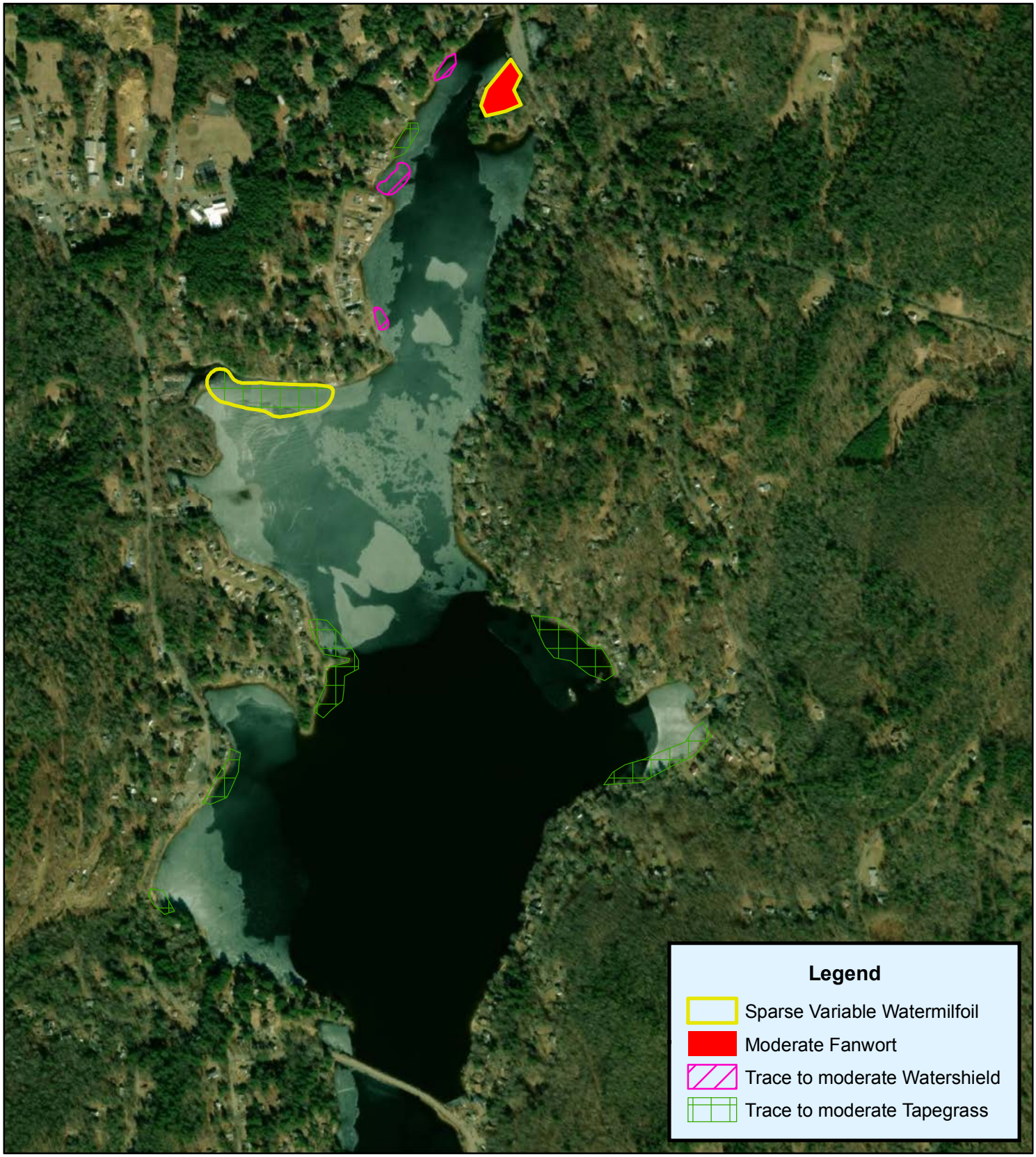
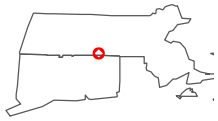


Hamilton Reservoir
Holland, MA



Lower Hamilton Reservoir

0 495 990 1,980

1:10,500 Feet

N

Map Date: 07/14/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 4: Lower Hamilton May Density and Distribution of Target Vegetation

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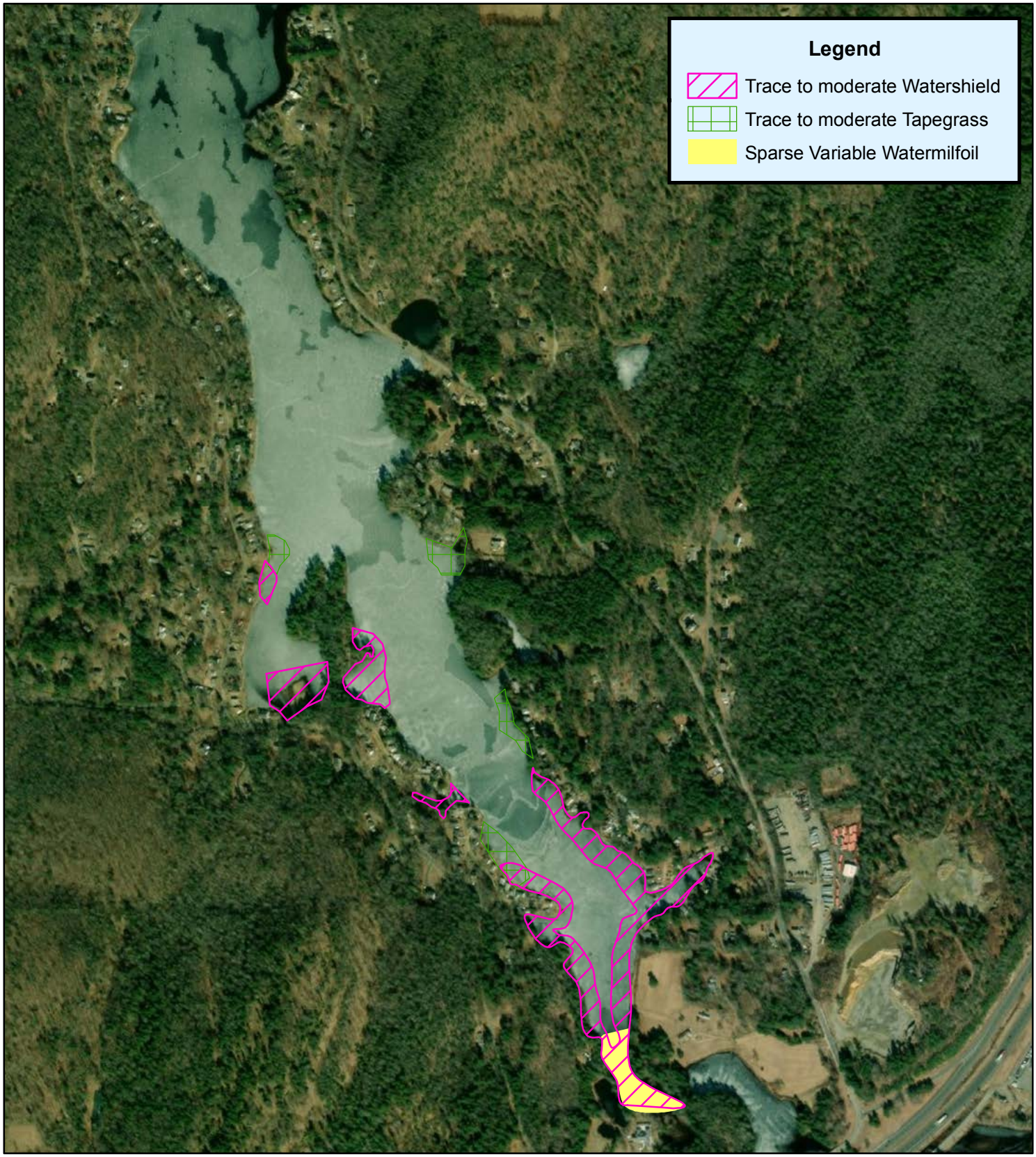
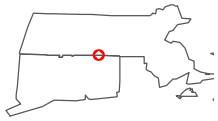
solitudelakemanagement.com



Hamilton Reservoir
Holland, MA



Lower Hamilton Reservoir

0 480 960 1,920

1:10,137 Feet

N

Map Date: 07/14/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 5: Upper Hamilton Post-Management Density and Distribution of Target Vegetation

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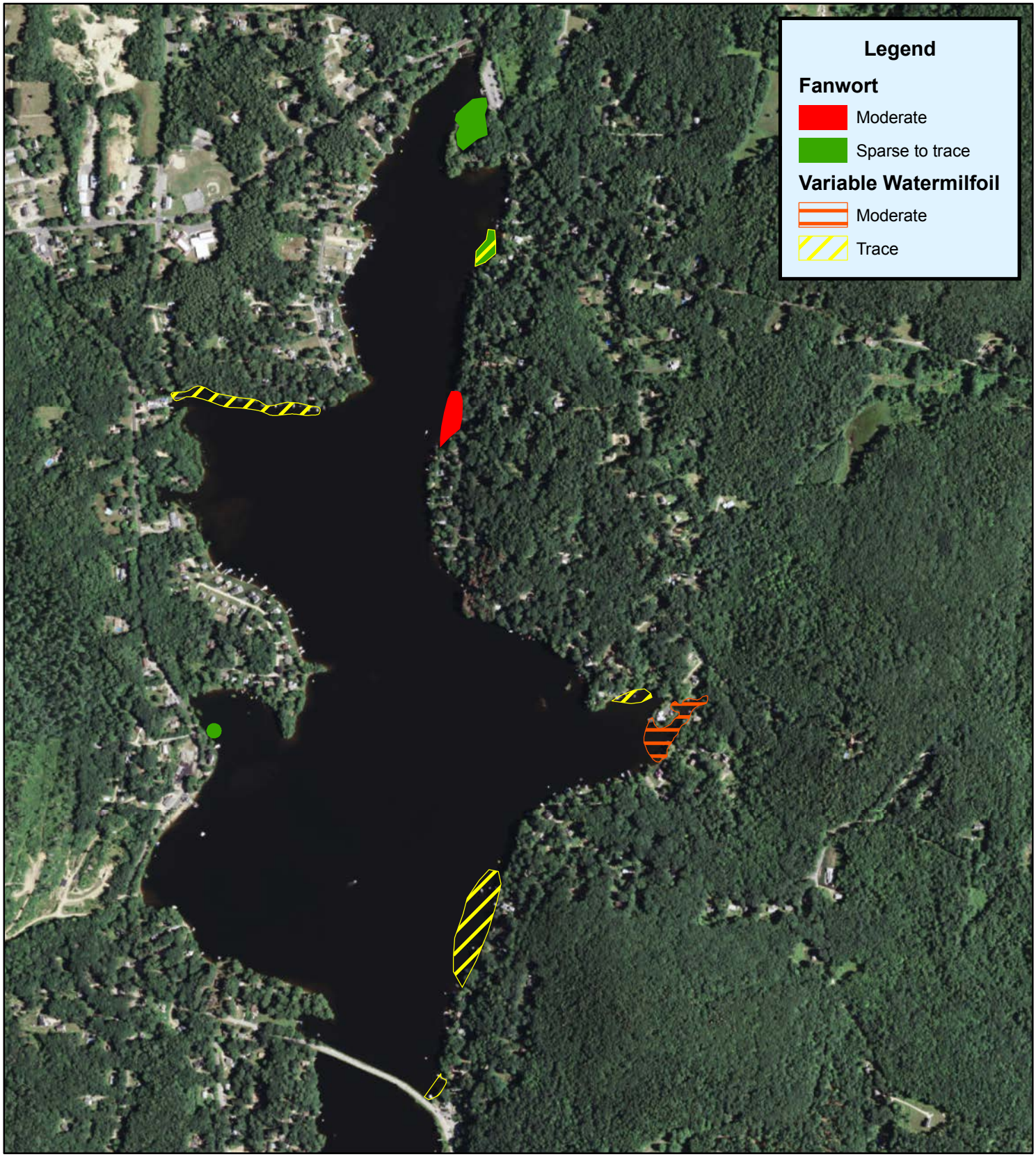
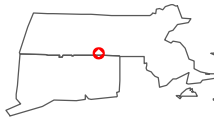


Hamilton Reservoir
Holland, MA



Upper Hamilton Reservoir

0 500 1,000 2,000

1:11,000 Feet

N

Map Date: 11/20/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 6: Lower Hamilton Post-Management Density and Distribution of Target Vegetation

SOLITUDE LAKE MANAGEMENT
888.480.5253
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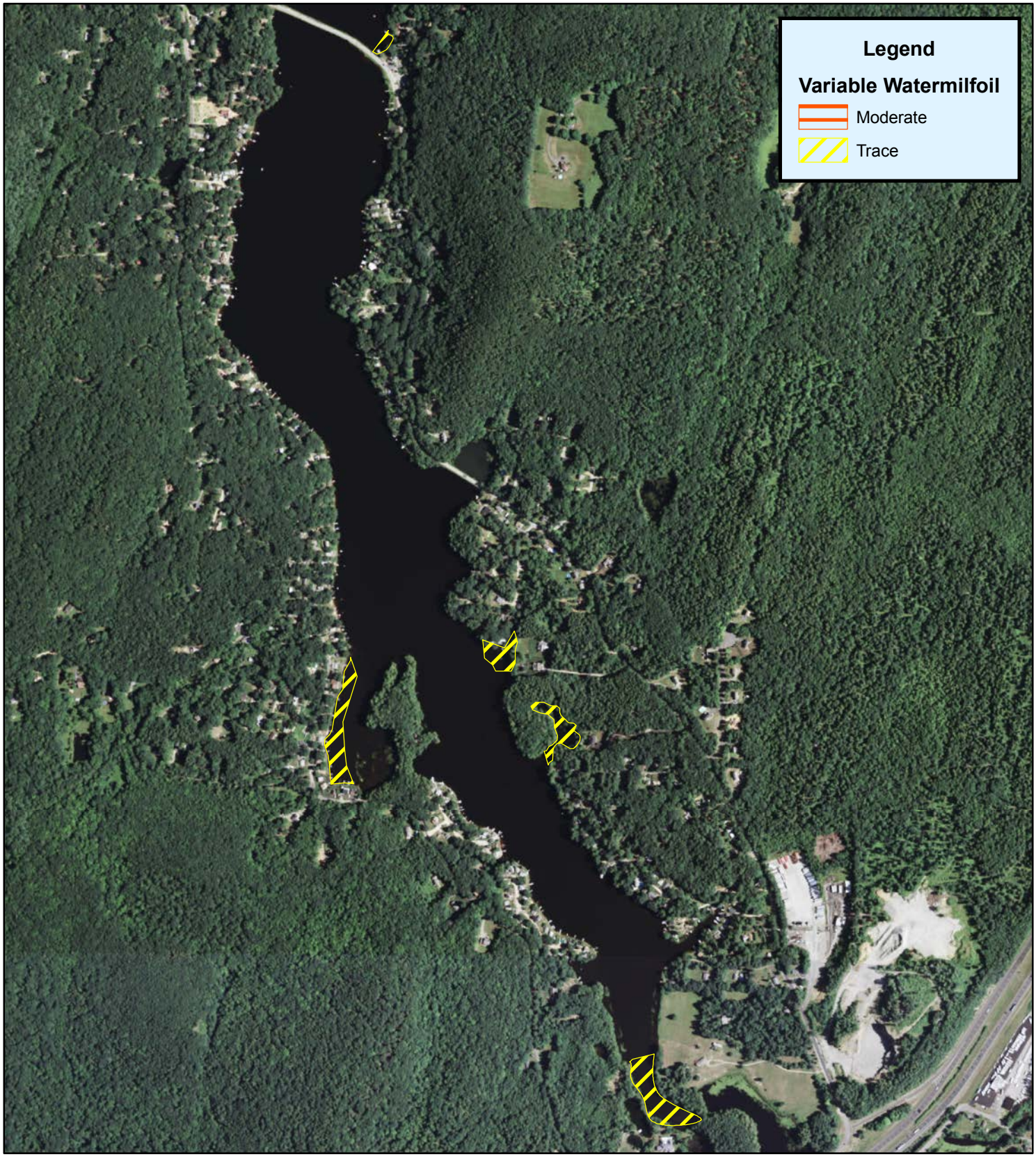
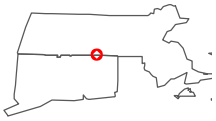


Hamilton Reservoir
Holland, MA



Lower Hamilton Reservoir

0 500 1,000 2,000

1:12,000 Feet

N

Map Date: 11/20/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Appendix E – Pollutant Load Export Rates (PLERs)

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
AGRICULTURE, HSG A	0.45	7.14	2.59
AGRICULTURE, HSG B	0.45	29.4	2.59
AGRICULTURE, HSG C	0.45	59.8	2.59
AGRICULTURE, HSG D	0.45	91.0	2.59
AGRICULTURE, IMPERVIOUS	1.52	650	11.3
COMMERCIAL, HSG A	0.03	7.14	0.27
COMMERCIAL, HSG B	0.12	29.4	1.16
COMMERCIAL, HSG C	0.21	59.8	2.41
COMMERCIAL, HSG D	0.37	91.0	3.66
COMMERCIAL, IMPERVIOUS	1.78	377	15.1
FOREST, HSG A	0.12	7.14	0.54
FOREST, HSG B	0.12	29.4	0.54
FOREST, HSG C	0.12	59.8	0.54
FOREST, HSG D	0.12	91.0	0.54
FOREST, HSG IMPERVIOUS	1.52	650	11.3
HIGH-DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
HIGH-DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
HIGH-DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
HIGH-DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
HIGH-DENSITY RESIDENTIAL, IMPERVIOUS	2.32	439	14.1
HIGHWAY, HSG A	0.03	7.14	0.27
HIGHWAY, HSG B	0.12	29.4	1.16
HIGHWAY, HSG C	0.21	59.8	2.41
HIGHWAY, HSG D	0.37	91.0	3.66
HIGHWAY, IMPERVIOUS	1.34	1,480	10.2
INDUSTRIAL, HSG A	0.03	7.14	0.27
INDUSTRIAL, HSG B	0.12	29.4	1.16
INDUSTRIAL, HSG C	0.21	59.8	2.41
INDUSTRIAL, HSG D	0.37	91.0	3.66

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
INDUSTRIAL, IMPERVIOUS	1.78	377	15.1
LOW-DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
LOW-DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
LOW-DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
LOW-DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
LOW-DENSITY RESIDENTIAL, IMPERVIOUS	1.52	439	14.1
MEDIUM-DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
MEDIUM-DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
MEDIUM-DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
MEDIUM-DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
MEDIUM-DENSITY RESIDENTIAL, IMPERVIOUS	1.96	439	14.1
OPEN LAND, HSG A	0.12	7.14	0.27
OPEN LAND, HSG B	0.12	29.4	1.16
OPEN LAND, HSG C	0.12	59.8	2.41
OPEN LAND, HSG D	0.12	91.0	3.66
OPEN LAND, IMPERVIOUS	1.52	650	11.3
[1]HSG = Hydrologic Soil Group			

Appendix F – Preliminary Design Drawings for Sandy Beach Road & Mountain Road Improvements

PRELIMINARY

SANDY BEACH RD & MOUNTAIN RD IMPROVEMENTS PHASE 1

PREPARED FOR:

TOWN OF HOLLAND

27 STURBRIDGE RD
HOLLAND, MA 01521
413.245.7108

PREPARED BY:

SVE

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COMMONWEALTH OF MASSACHUSETTS
ANTHONY WONSESKI JR.
CIVIL
No. 46615
REGISTERED PROFESSIONAL ENGINEER

VOID - NO SIGNATURE

ANTHONY WONSESKI, JR. DATE
R.C.E. NUMBER: 46615

G1998
28 - MAY - 20
SANDY BEACH RD &
MOUNTAIN RD IMPROVEMENTS
PRELIMINARY SET

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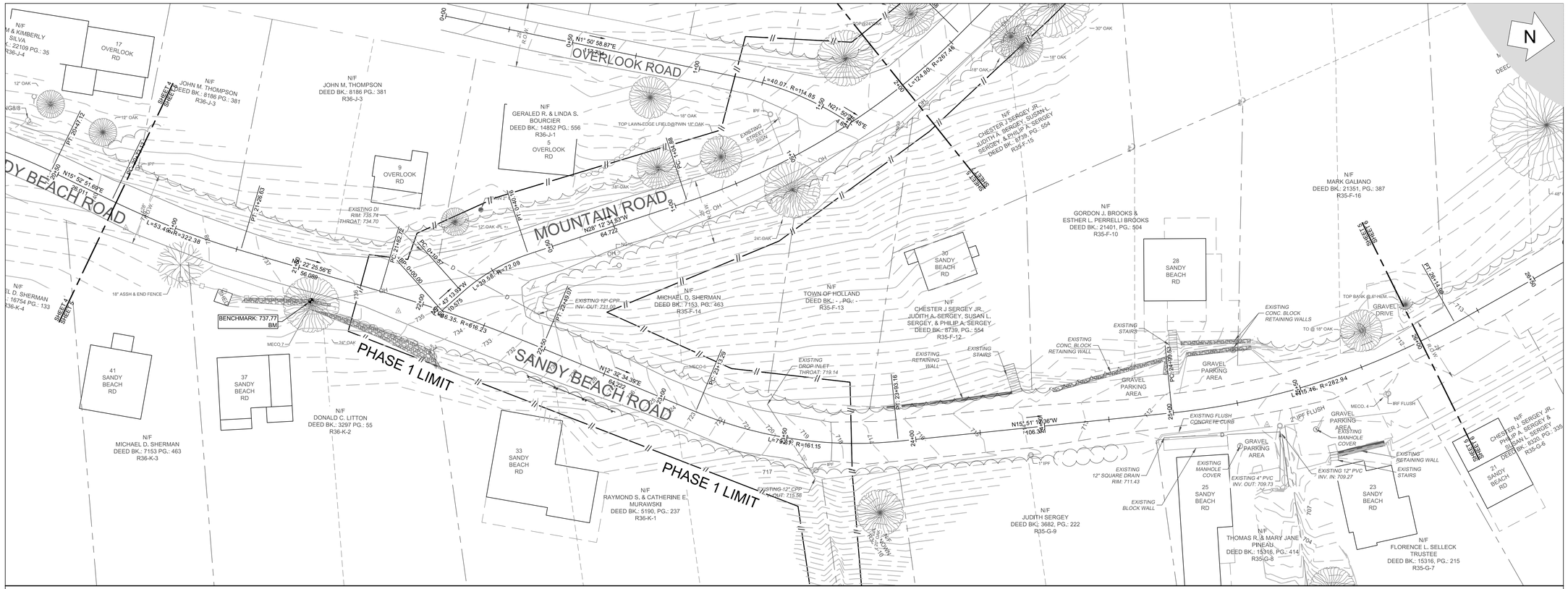
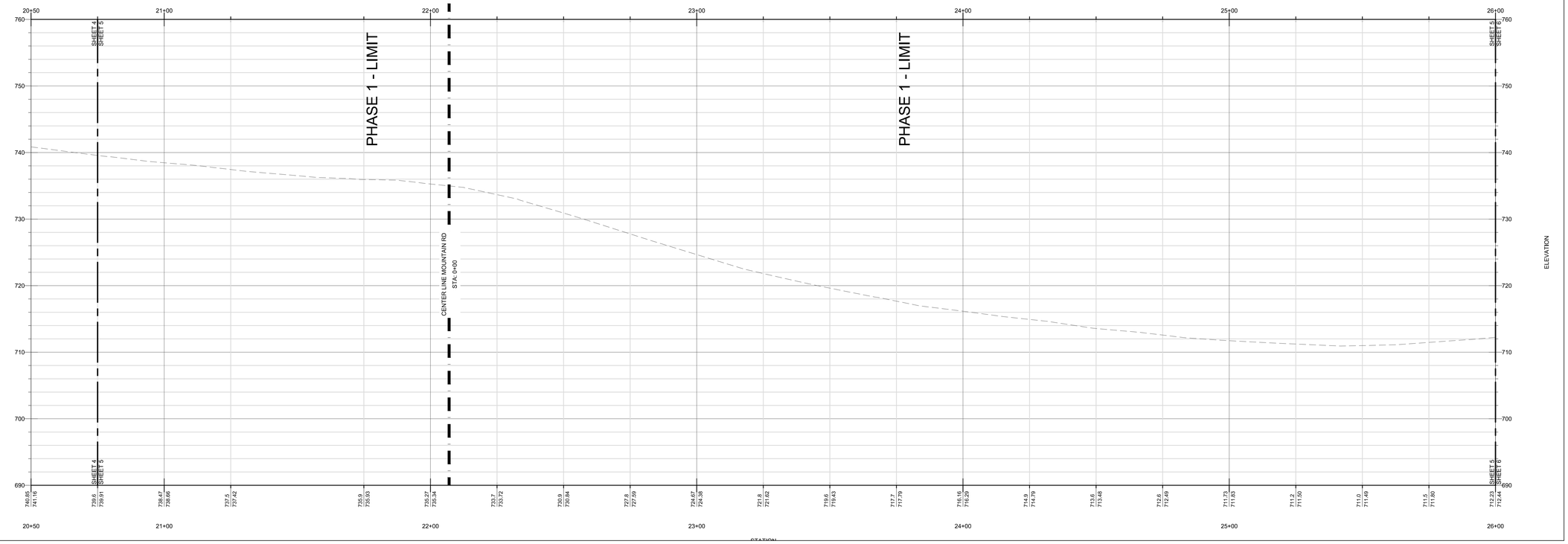


Profile View of Alignment - (PROP SANDY BEACH) (1)



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SITE PLAN

SANDY BEACH RD & MOUNTAIN ROAD IMPROVEMENTS

TOWN OF HOLLAND
27 STURBRIDGE RD
HOLLAND, MASSACHUSETTS

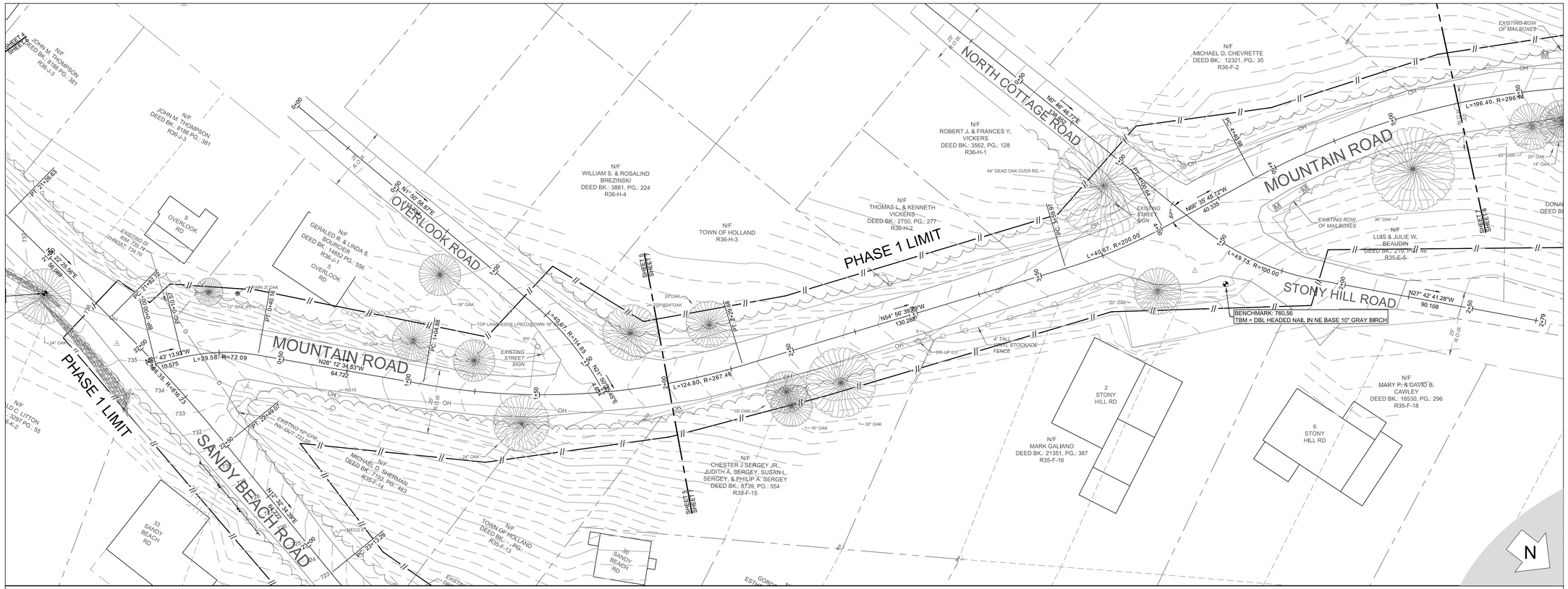
0 10 20 40
GRAPHIC SCALE 1" = 20'

PROJ. #: G1998

DATE: 28 - MAY - 20

DESIGN: MJS
DRAWN: MJS
CHECKED: AW

SHEET 5/18



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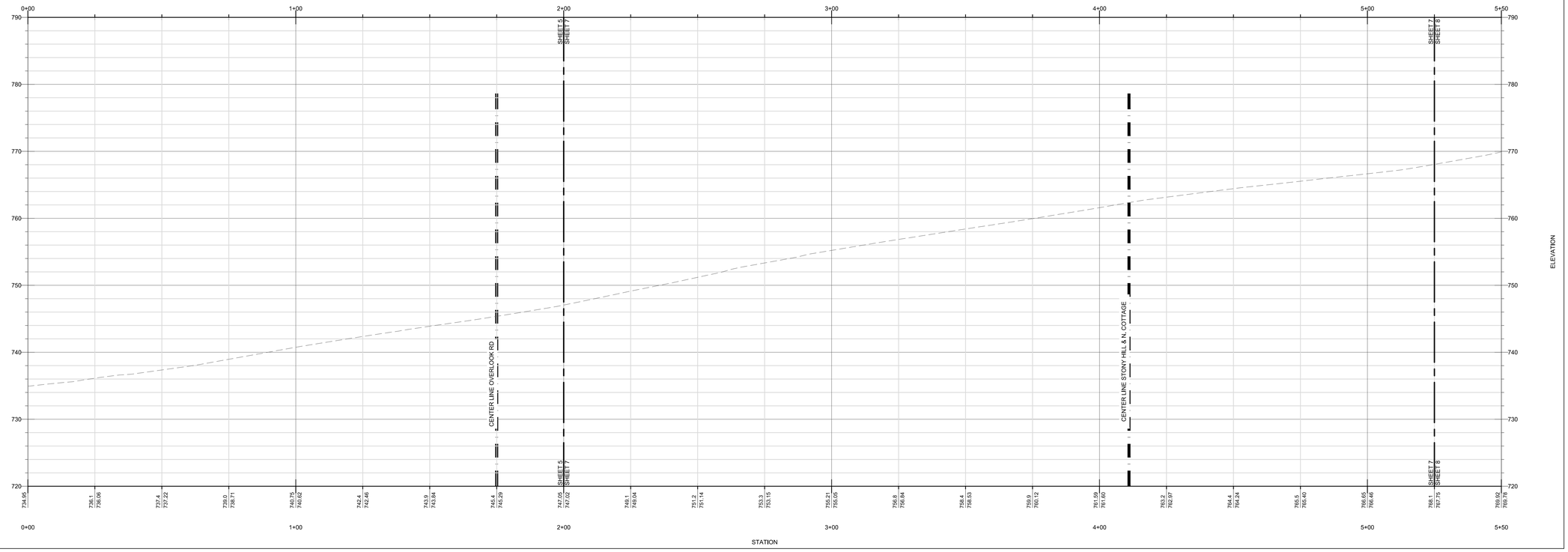

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TOWN OF HOLLAND
27 STURBRIDGE RD
HOLLAND, MASSACHUSETTS

0 10 20 40
GRAPHIC SCALE 1" = 20'

PROJ. #: G1998

DATE: 28 - MAY - 20

DESIGN: MJS
DRAWN: MJS
CHECKED: AW

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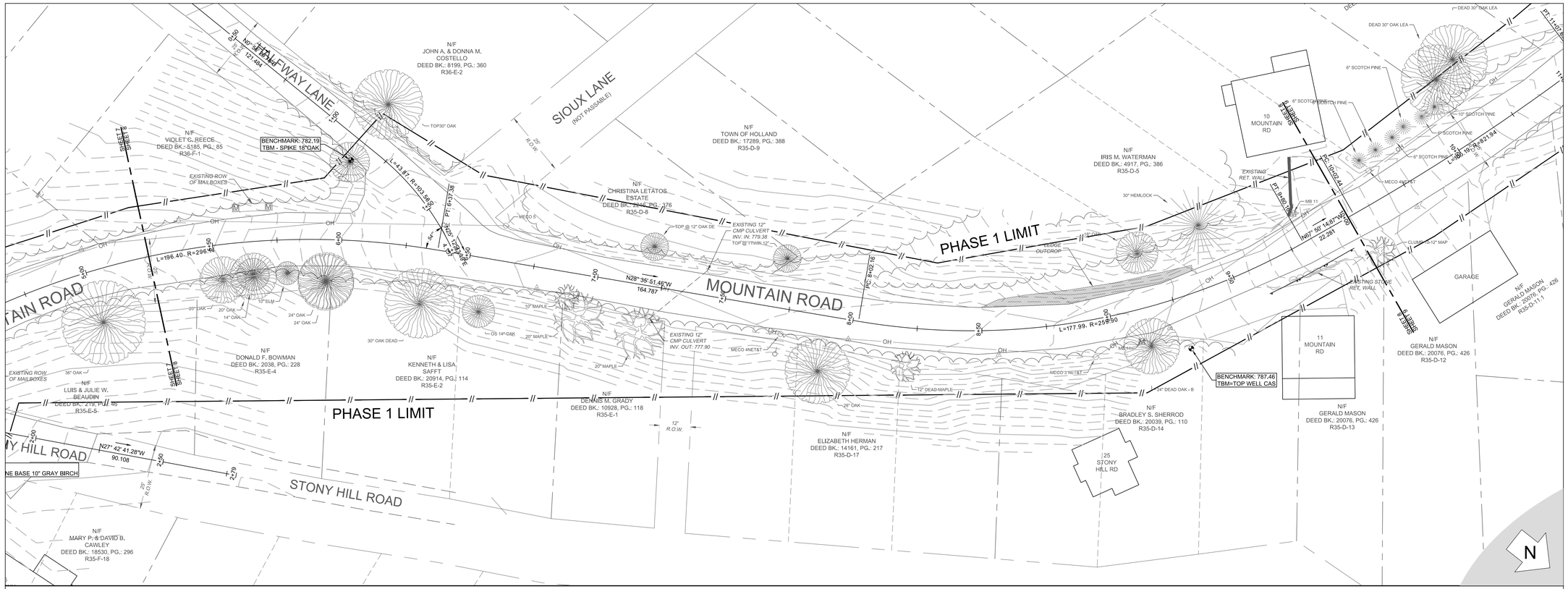

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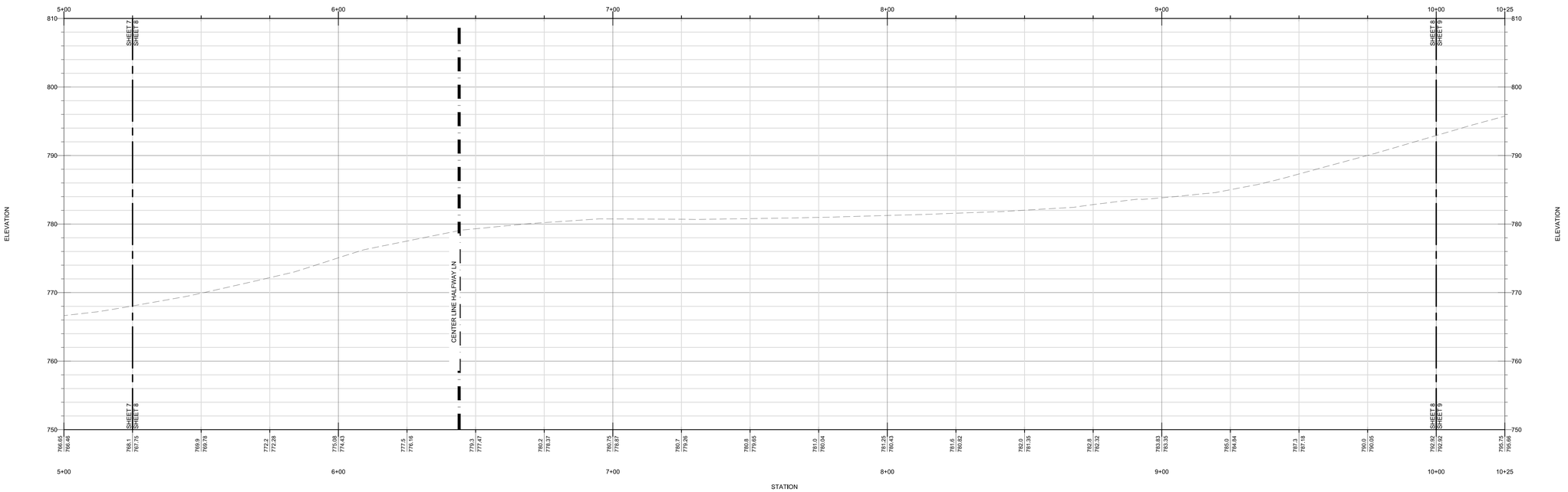

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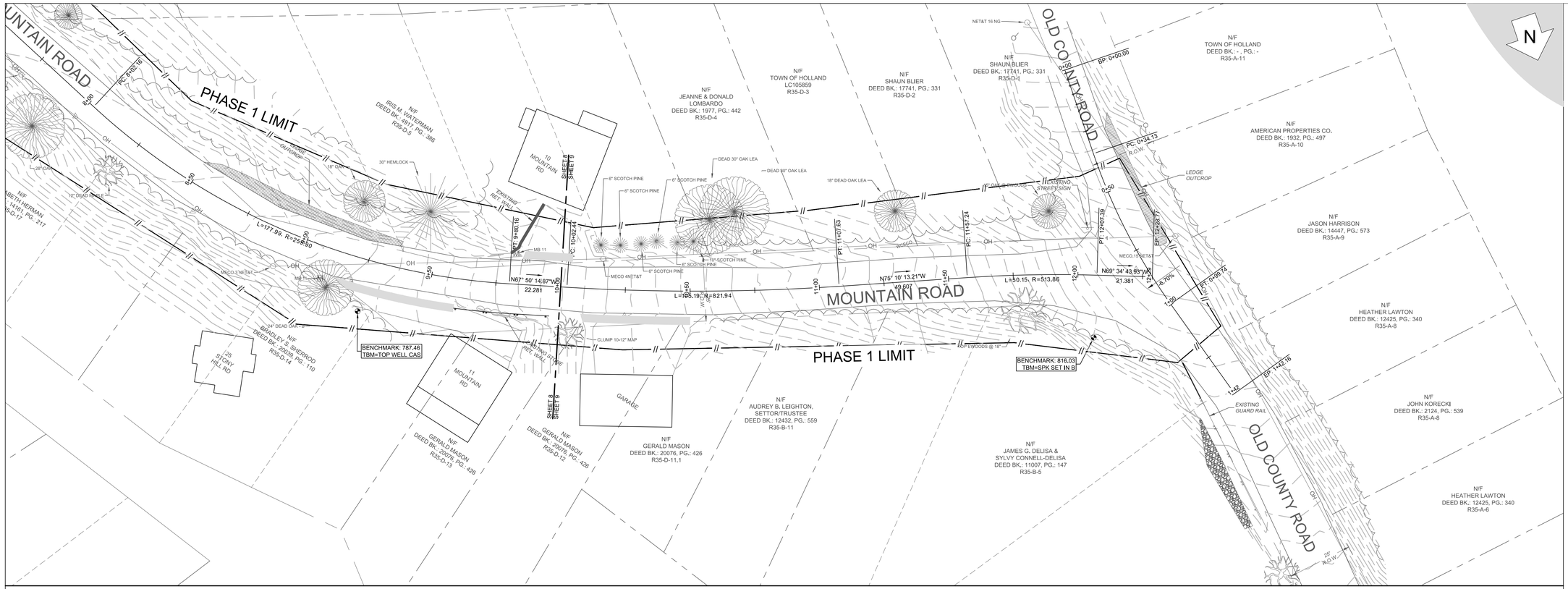

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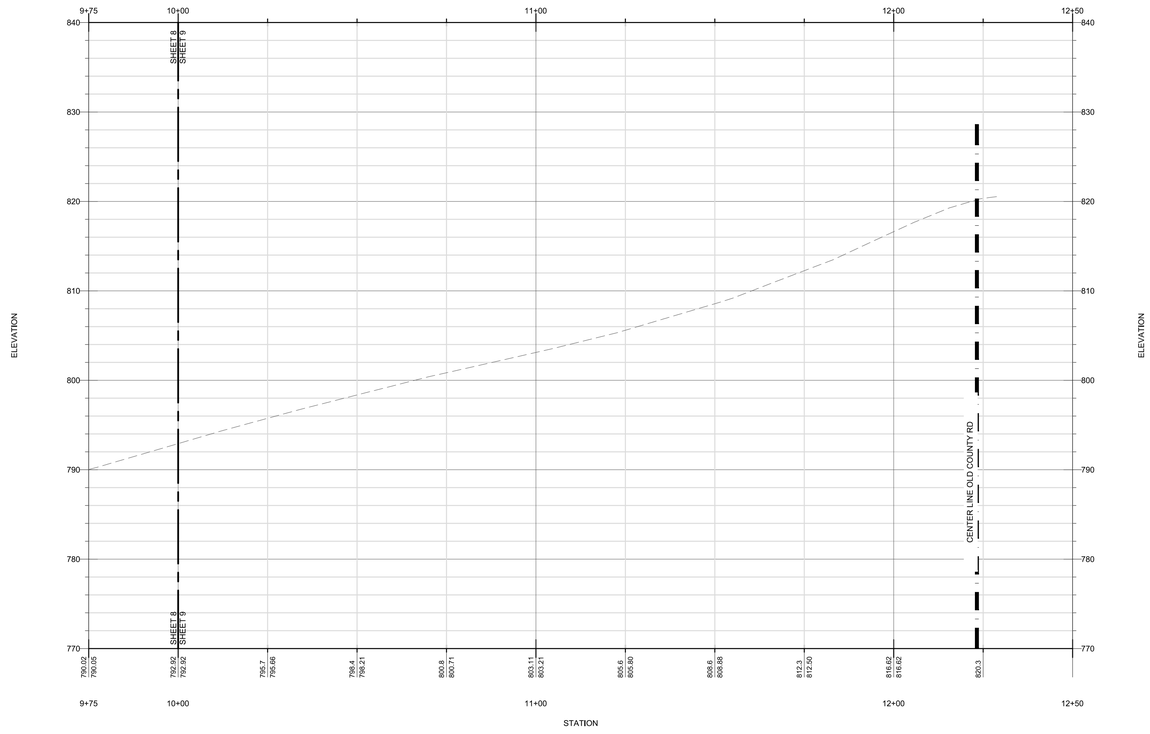

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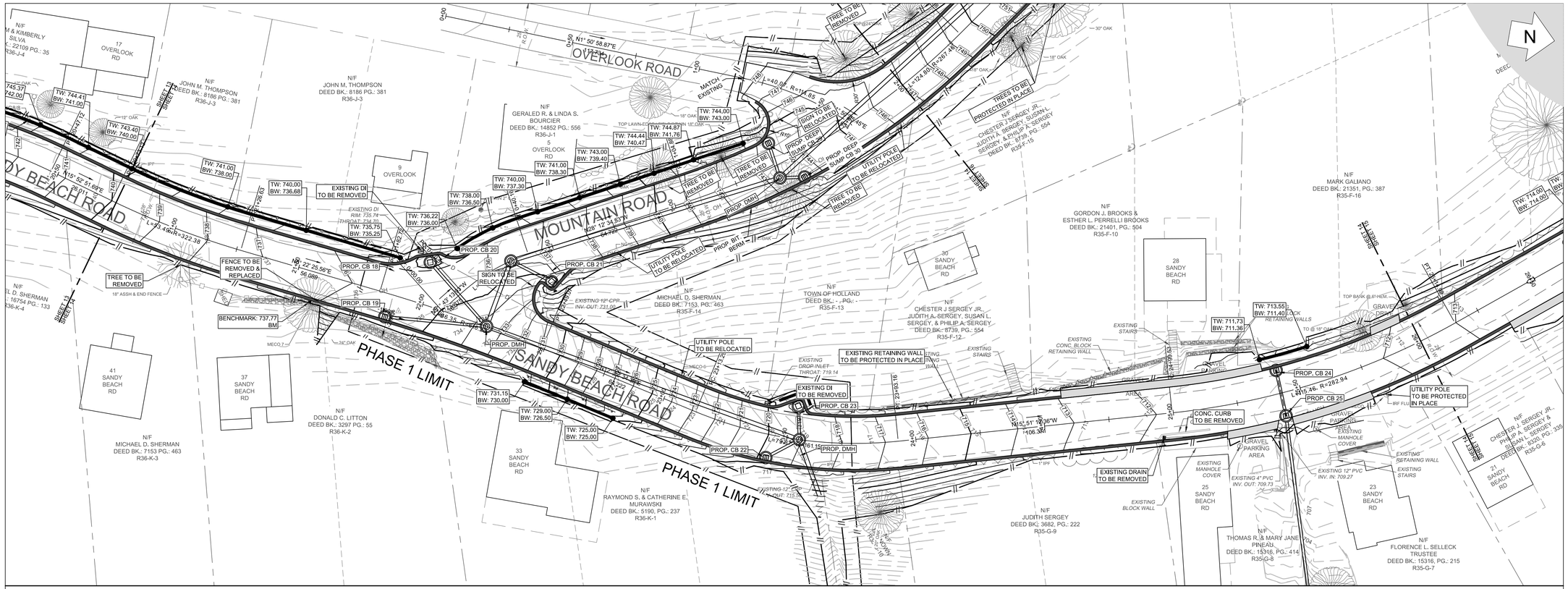

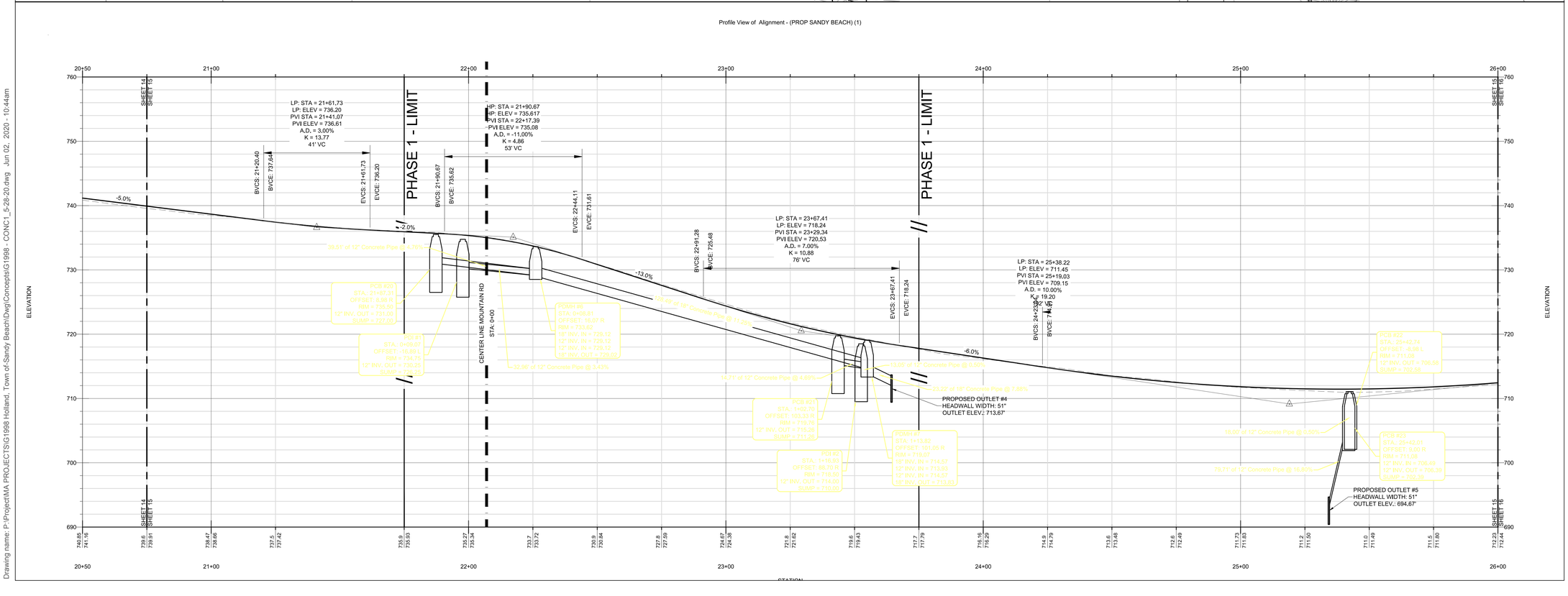

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TOWN OF HOLLAND
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HOLLAND, MASSACHUSETTS

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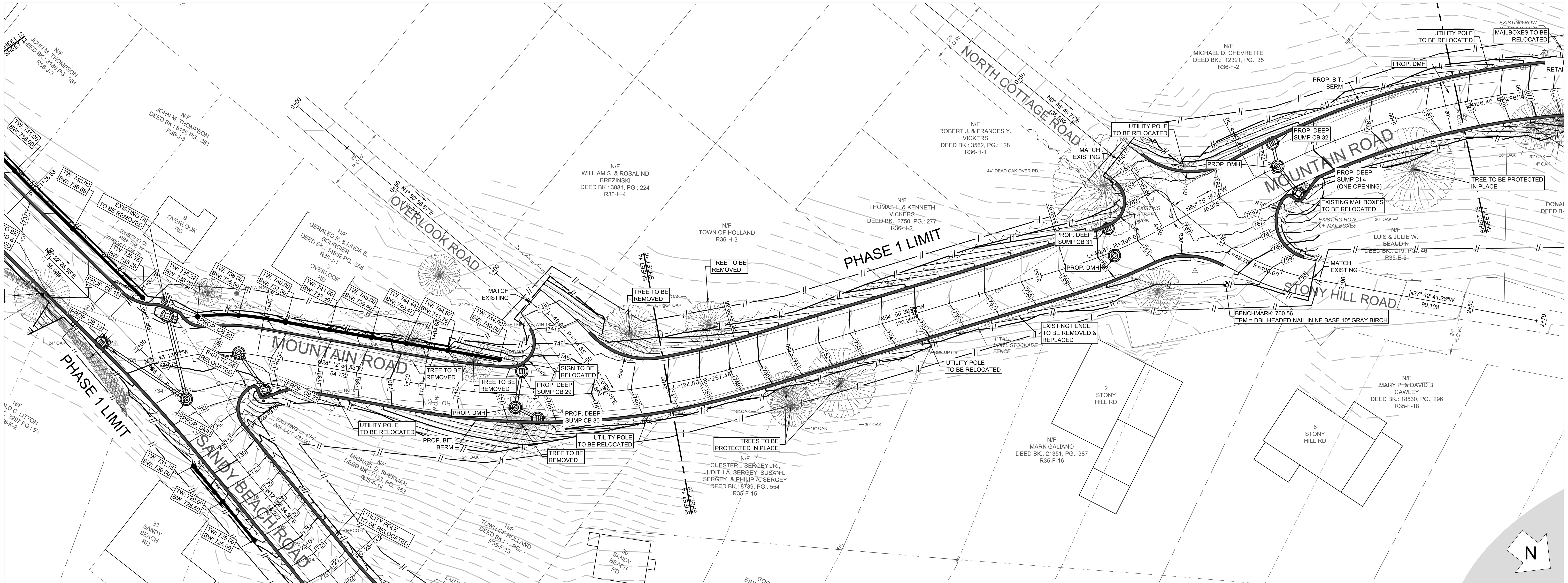

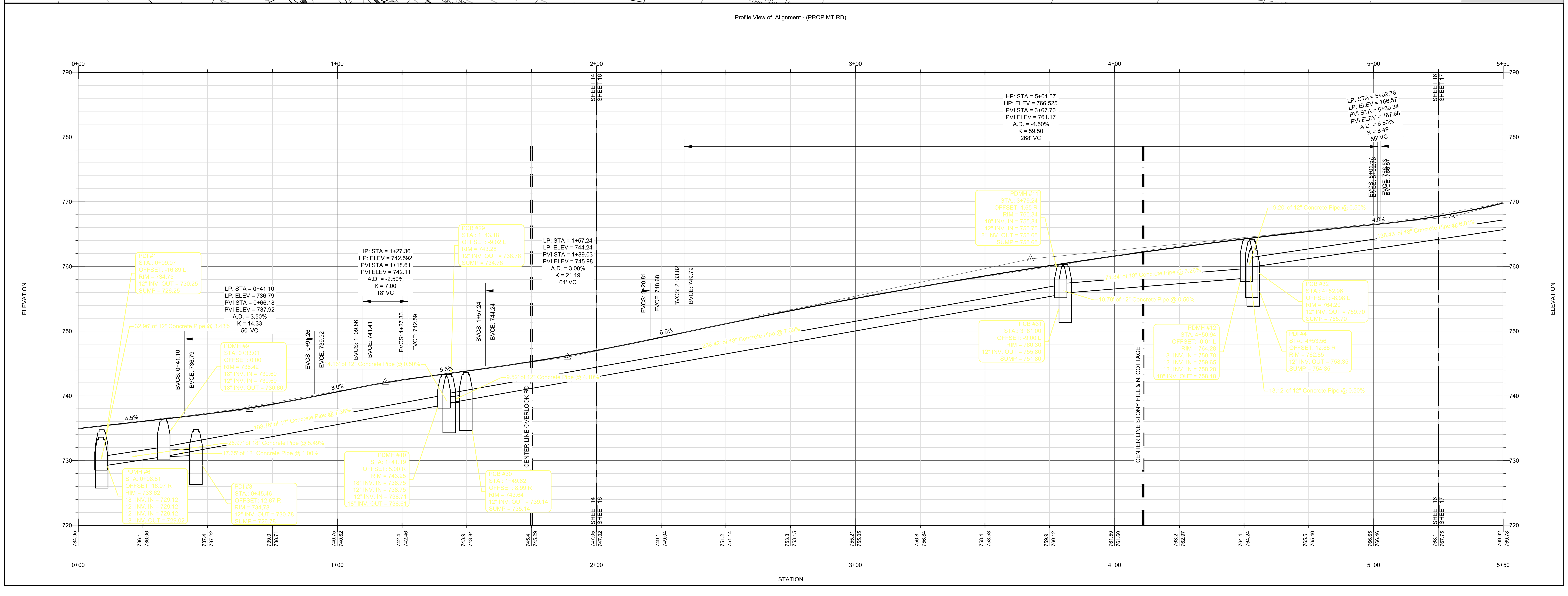

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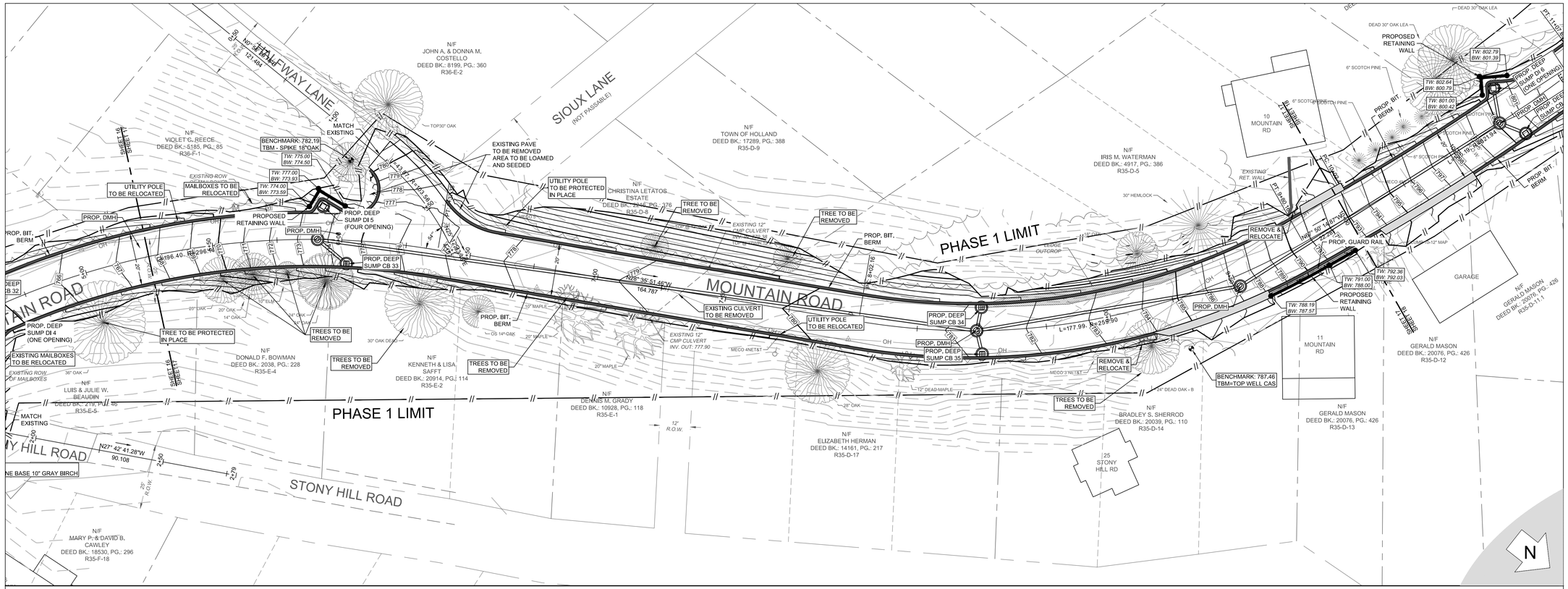

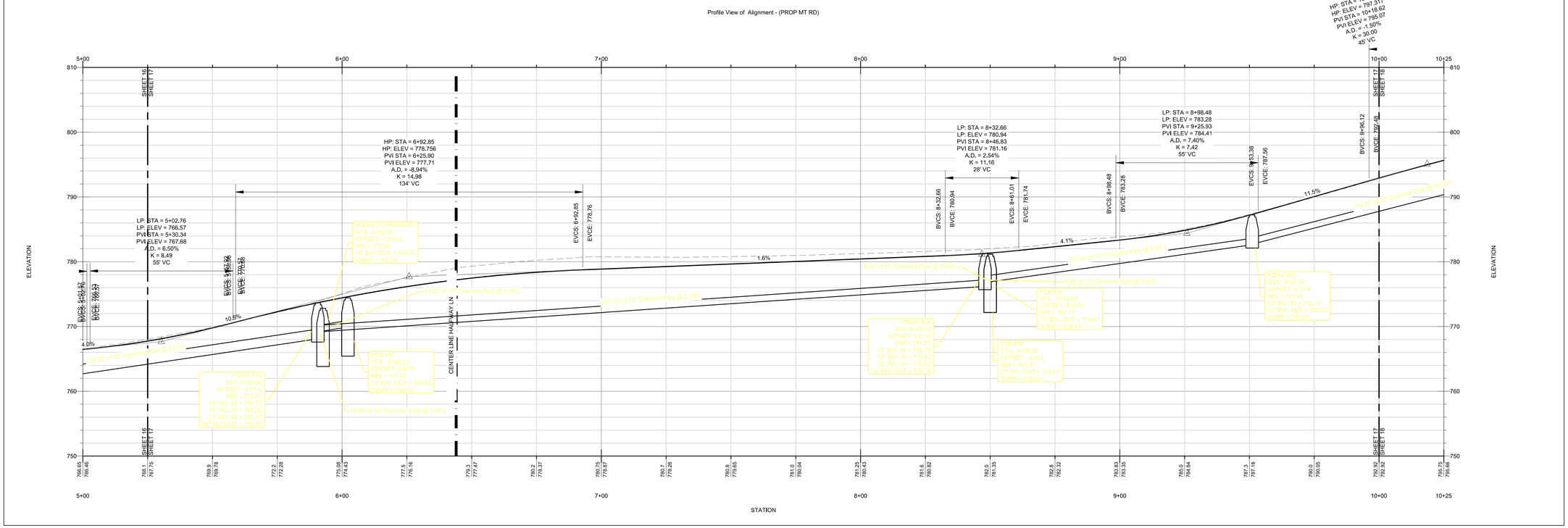

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HOLLAND, MASSACHUSETTS

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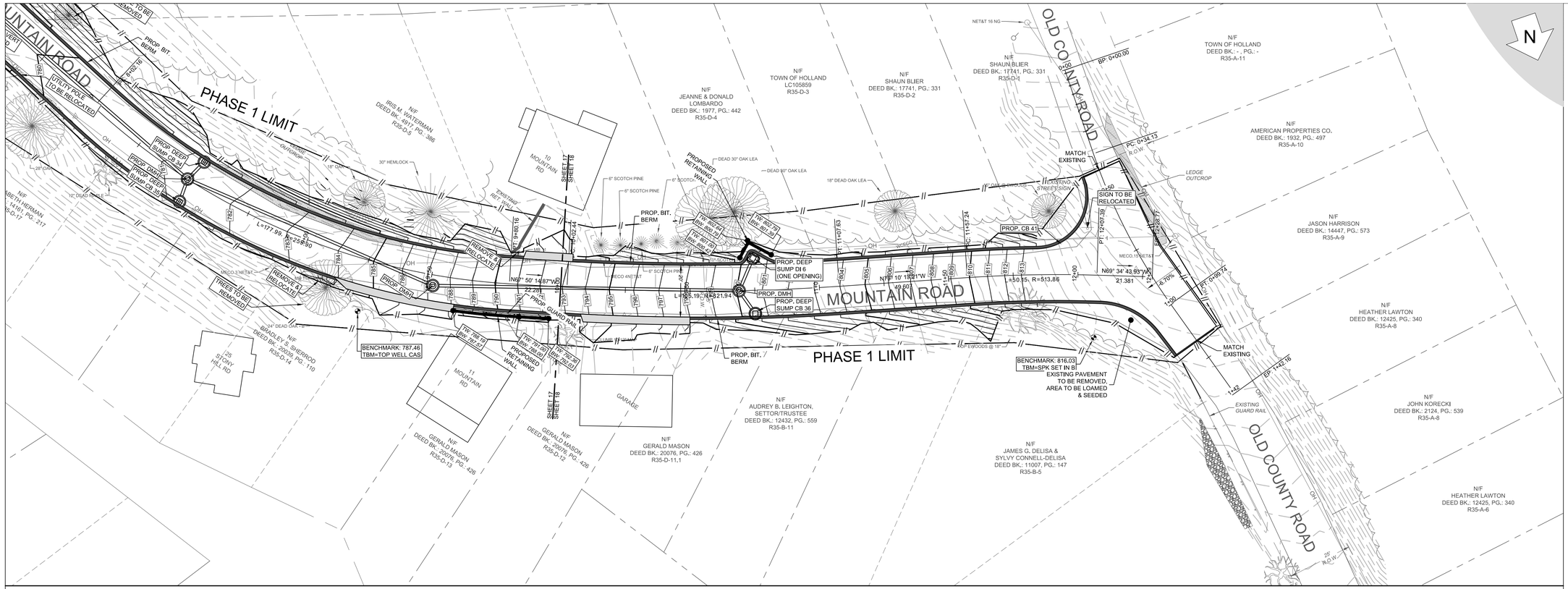

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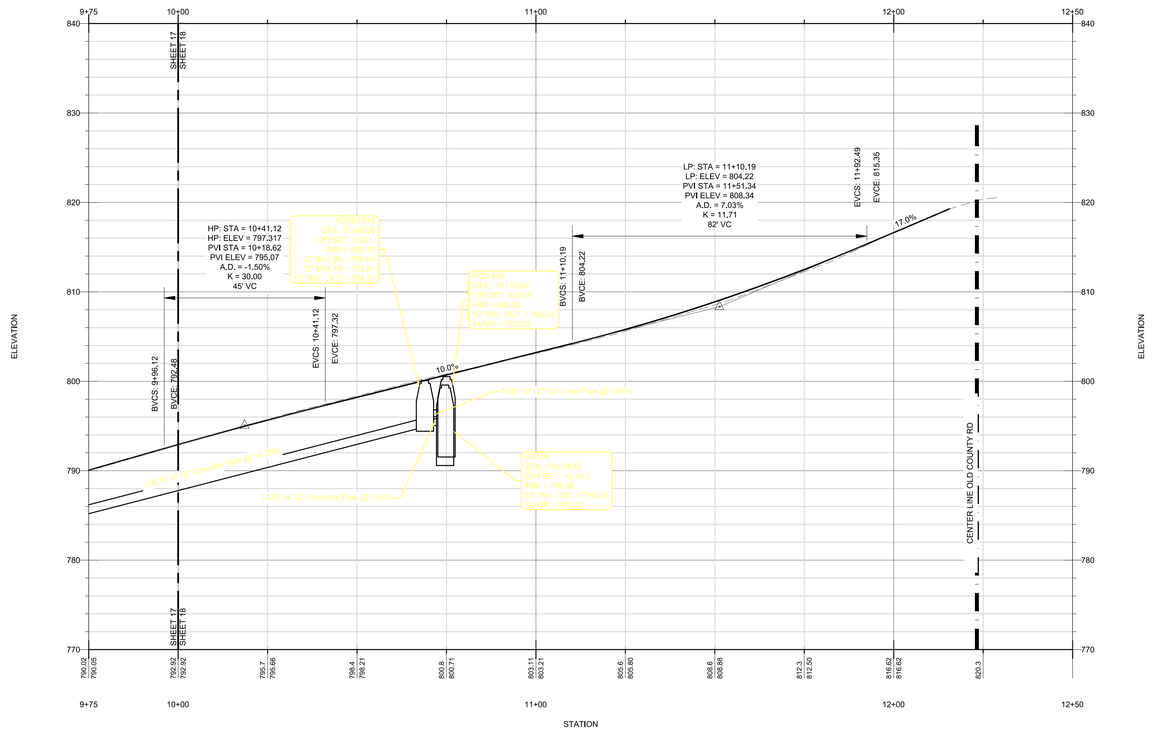

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TOWN OF HOLLAND
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HOLLAND, MASSACHUSETTS

0 10 20 40
GRAPHIC SCALE 1" = 20'

PROJ. #: G1998

DATE: 28 - MAY - 20

DESIGN: MJS
DRAWN: MJS
CHECKED: AW

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