



WATERSHED-BASED PLAN

Lake Massapoag (MA73030)

2026-2050

Sharon, Massachusetts

WBP# 1870/1955



Prepared By:

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TRC

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Funders:



Authors:



Contents

Contents	2
Acronym List	7
Table and Figure List	8
Executive Summary	11
Goals	11
Phosphorus Budget for the Lake and Target Reduction Level	11
Sources of Excess Phosphorus	12
Key Actions Needed	12
Integral Relationship with other Town of Sharon Plans	12
Background on Sharon's Water Resources	14
Sharon Watersheds and Wetlands	14
Lake Massapoag	14
Lake Area, Depth and Volume	16
Lake Massapoag Bathymetry: Deep Hole and Varying Depths	16
Lake Massapoag Coves and Lagoon	16
Lake Level Variation	18
Lake Tributaries and Drainage Sub-Basins	20
Lake Massapoag Open Space and Recreational Use	21
Recreational Usage of Lake Massapoag by Local and Area Residents	22
Youth Recreational, Educational, and Economic Impacts of Lake Massapoag	22
Summary of Lake and Beach Benefits	23
Sharon's Groundwater, Aquifers, Recharge and Discharge	23
Aquifer Protection	24
Drinking Water Supply and Water Conservation Efforts	25
Underground Springs and Currents	27
Wastewater Systems	28
Introduction: What is a Watershed-Based Plan?	29
Purpose & Need	29
Watershed-Based Plan Outline	29
Project Partners, Funding, and Stakeholder Input	30
Data Sources	31

Summary of Completed Work (BMPs)	33
Element A: Identify Causes of Impairment & Pollution Sources	35
General Watershed Information	35
Sources of Excess Phosphorus.....	35
Lake Massapoag History and LMAC work	38
Lake Committee Work 1960s to 2020	38
Septic and Nutrient Control:	38
LMAC Dashboards	39
MassDEP Water Quality Assessment Report and TMDL Review.....	42
Literature review information:.....	43
TRC: Water Quality Reports Summary	43
In-Lake Water Quality Testing	43
External Loading: Direct Shoreline Runoff, Stormwater Outfalls, and Groundwater Seepage	45
LMAC Phycocyanin, Secchi Disk, and Aluminum Testing	54
Neponset River Annual Water Quality Reports.....	56
LMAC External Phosphorus Monitoring	56
NepRWA and LMAC Sucker Brook <i>E. coli</i> Testing.....	58
NepRWA CWMN Sites in Sharon Phosphorus and <i>E. coli</i> Trends.....	58
Town of Sharon Swim Beach <i>E. coli</i> Testing	61
Invasive and Native Aquatic Weeds	62
Present Aquatic Plant Assemblage	62
Plant Management	63
Invasive Plant Growth Patterns	66
Water Quality Impairments.....	73
Water Quality Goals	74
Land Use and Impervious Cover Information.....	76
Watershed Land Uses	76
Watershed Impervious Cover	78
Pollutant Loading.....	79
Pollutant loading information:	82
Pollutant Loading Analysis.....	82
Lake Loading Response Model (LLRM)	82

Element B: Determine Pollutant Load Reductions Needed to Achieve Water Quality Goals.....	84
Estimated Pollutant Loads.....	84
Water Quality Goals	84
Phosphorus Load Estimates by Watershed Delineation	86
Pollutant Load Criteria.....	86
Pollutant load reduction information:.....	86
Septic Load Contribution: Human Wastewater Phosphorus Load to Watershed.....	86
Element C: Describe management measures that will be implemented to achieve water quality goals.....	90
BMP Suitability Index:.....	90
Site Surveys for Potential Stormwater Control Measures (SCMs)	94
Proposed Management Measures:	96
Element D: Technical and Financial Assistance Needed to Implement Plan	101
Element E: Public Information and Education.....	105
Lake-Friendly Landscaping and Gardening:.....	105
Septic Education and Upgrading:	106
Previous Public Engagement Efforts and Other Information	106
Additional Resident Concerns at LMAC’s Public Hearing on the Draft WBP and at Town Meeting	107
Elements F & G: Implementation Schedule and Measurable Milestones.....	108
Interconnections with Other Town of Sharon Plans	108
Relevant Excerpts from Other Sharon Plans	108
Imagine Sharon Master Plan (2019).....	108
Sharon Water Management Plan (2010).....	108
Sharon Stormwater Management Plan (2019, updated 2022)	109
Sharon Municipal Vulnerability Preparedness (MVP) Plan (2021).....	111
Sharon Hazard Mitigation Plan.....	111
Sharon Open Space and Recreation Plan (2025).....	112
Scheduling and milestone information:	115
LMAC Recommendations	115
Proposed Additional Testing	115
Elements H & I: Progress Evaluation Criteria and Monitoring	116
Phosphorus and Cyanobacteria.....	116
<i>E. coli</i>	116

Interim Success Measures:.....	116
A related strategy is Geese Reduction and Deterrence	116
Invasive Weeds.....	117
Indirect Indicators of Load Reduction	117
Project-Specific Indicators	117
Direct Measurements.....	117
Aquatic Plant Mapping	117
In-Lake Sampling.....	118
Groundwater Seepage Survey.....	118
Shoreline Run-Off	118
Stormwater Outfalls	119
CWMN Testing Schedule	119
Additional Research on Wastewater Phosphorus Contributions.....	120
Adaptive Management.....	120
Element J: Recommendations	120
Recommendations For Discussion and Feedback from Town Boards:	121
Proposed Non-Structural Management Measures: LMAC Activities, Operations, Funding,	121
LMAC Relationship to the Town	121
Plan for Staff Capacity and Staffed Operational Management of Lake Management Actions.....	121
Rationale: Operational Management, Financial Management, Fundraising	121
Need for Additional Public and Private Resources.....	122
Need for Increased Annual Maintenance Funding for Invasive Weed Management and Other Activities..	123
Potential Additional Revenue Sources to Consider.....	123
Recommendations for Departments, Board, and Committee Actions and Initiatives.....	123
Recreation Department (for pathogen mitigation).....	124
Department of Public Works (for external phosphorus loading)	124
Conservation Department (for nutrient reduction, erosion control, lake level management)	125
LMAC (for external phosphorus loading and pathogen mitigation)	125
Camps (for pathogens mitigation and external phosphorus loading).....	126
Review of Administrative and Regulatory Changes	126
Board of Health (for pathogen mitigation).....	126
Planning Board (for external phosphorus loading and pathogen mitigation)	127

Zoning Board of Appeals (for external phosphorus loading and pathogen mitigation)	127
Potential Bylaw Amendments (E coli and phosphorus control).....	127
Recommendations for Updates in State Laws and Programs	128
LIST OF APPENDICES (see separate pdf documents)	129
A. WBP Projects: 1 and 2 VMB West and East 3 Lake Ave, 4 Capen Hill, 5 Massapoag Ave, with Project Addenda (HydroCAD Reports for 1, 2 and 3)	129
B. WBP Master Budget Sheet	129
C. NepRWA, Combined Catchment Delineation and Pollutant Loading Estimate	129
E. Storm Drain Outfalls Survey, Josh Philibert.....	129
F. Analysis of Septic Systems Within the Lake Massapoag Surface Water Protection District, Susan Peck	129
G. TRC, External Phosphorus Sampling Memos.....	129
H. TRC, Nutrient Budget and Sediment Core Study.....	129
External References.....	130
Internal References	132

Acronym List

BMPs	Best Management Practices
CCB	Community Center Beach
CPC	Community Preservation Commission
CWMN	Community Water Monitoring Network
DASH	Diver Assisted Suction Harvesting
DPW	Department of Public Works
EPA	Environmental Protection Agency
I/A	Innovative and Alternative Treatment Systems
LLRM	Lake Loading Response Model
LMSC	Lake Massapoag Study Committee
LMAC	Lake Massapoag Advisory Committee
LOL	Love Our Lake
MassDEP	Massachusetts Department of Environmental Protection
MVP	Municipal Vulnerability Preparedness
MYC	Massapoag Yacht Club
NepRWA	Neponset River Watershed Association
NPS	Non-Point Source
PLER	Pollutant Load Export Rate
SCM	Stormwater Control Measures
SHS	Sharon High School
TMDL	Total Maximum Daily Load
TM	Technical Memoranda
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
VMB	Veterans Memorial Beach
WBP	Watershed Based Plan

Table and Figure List

LMAC Figure BG-1: Lake Massapoag and Wetlands in Lake Watershed.....	15
LMAC Table BG-1: Amount of Area at Various Depths in Lake Massapoag.....	16
LMAC Table BG-2: Lake Massapoag Cove Acreage	16
LMAC Figure BG-2: Bathymetric Map of Lake Massapoag.....	16
LMAC Figure BG-3: Lake Massapoag Coves and Lagoon.....	17
LMAC Figure BG-4: Lake Massapoag Lake Level Comparisons 1998-2021	18
LMAC Figure BG-5: Lake Massapoag Lake Level 2023 and 2024-2025	19
LMAC Figure BG-6: Blue Hills Observatory 2023, 2024 and 2025 Precipitation	20
LMAC Figure BG-7: Map of Major Lake Massapoag USGS-Delineated Sub-Basins	21
LMAC Table BG-3: Major Lake Massapoag USGS-Delineated Sub-Basins Contribution Breakdown	21
LMAC Table BG-4: Town of Sharon Beach, Boat Ramp Parking, and Kayak Storage Passes 2022-2025	22
LMAC Figure BG-8: Ground and Surface Water Protection Districts, Wells, Monitoring Wells in Sharon	24
LMAC Figure BG-9: Town of Sharon Aquifers.....	25
LMAC Figure BG-10: Town Drinking Water Wells and Tanks in Sharon.....	26
LMAC Figure BG-11: Lake Massapoag Ice Holes from Pilot Drone Survey and Airplane	27
LMAC Table I-1. Existing Resources Related to Lake Massapoag.....	31
LMAC Table I-2. Existing BMPs in Lake Massapoag Watershed (added during the planning process).....	33
LMAC Figure I-1. BMPs and Shoreline Maintenance and Repairs During Watershed-Based Plan Period	34
Table A-1: General Watershed Information	35
Figure A-1: Watershed Boundary Map, defined by Town of Sharon Surface Water Protection District.....	36
LMAC Figure A-2: Sharon High School Elevation Contour and Drainage Map.....	37
LMAC Figure A-3: Town of Sharon Planning Board Surface Water Protection District.....	37
LMAC Figure A-4: Lake Massapoag Dashboard 2022	40
LMAC Figure A-5: Lake Massapoag Dashboard Report 2023	40
TRC Table A-1: Total Phosphorus Levels at Lake Massapoag 2022-2025.....	44
TRC Table A-2: Dissolved Phosphorus Levels at Lake Massapoag 2022-2025	44
LMAC Table A-3a: Historical Total Phosphorus Levels at Lake Massapoag 1981 and 2016.....	44
LMAC Table A-3b: Historical Phosphate Levels at Lake Massapoag 1989-1991	45
TRC Table A-4: Total Phosphorus and Total Nitrogen Levels from Stormwater Runoff	45
TRC Figure A-5: Summary of Total Phosphorus and Total Nitrogen Results from Stormwater Runoff	46
TRC Table A-5: Total Phosphorus and Total Nitrogen Levels from Stormwater Outfalls.....	47

TRC Figure A-6: Summary of Total Phosphorus and Total Nitrogen Results at Storm Drain Outfalls.....	48
TRC Table A-6: Dissolved Phosphorus and Total Nitrogen Levels from Shallow Groundwater	49
TRC Figure A-7: Daily Dissolved Phosphorus and Total Nitrogen Loads at Seepage Sampling Locations.....	50
TRC Table A-7: <i>E. coli</i> Levels along Sucker Brook	51
TRC Table A-8: Total Phosphorus Levels of Lagoon Tributaries	51
TRC Table A-9: Total Phosphorus Levels in Lagoon Outlet into South Cove	51
TRC Figure A-8: Hot Spot Survey Locations along Sucker Brook, the Lagoon and its Tributaries	52
TRC Figure A-9: Concentrations of Iron-Bound Phosphorus at Core Depth.....	53
TRC Table A-10: Deep Hole Water Quality Parameters Pre- and Post-Alum Treatment	54
LMAC Figure A-10: Cyanobacteria Levels at Veteran’s Memorial Beach 2023-2025.....	55
LMAC Figure A-11: Water Clarity in the Deep Hole 2024-2025	55
LMAC Table A-11: Total Aluminum Levels Post-Alum Treatment 2025.....	55
NepRWA Table A-12: Sucker Brook Sampling Results May – October 2022-2025	56
LMAC Table A-13: Phosphorus Levels at Inflows 2023.....	57
LMAC Table A-14: Phosphorus Levels at Inflows 2022.....	57
NepRWA Table A-15: Sucker Brook <i>E. coli</i> (MPN/100 mL).....	58
NepRWA Figure A-12: Total Phosphorus at Sucker Brook, Massapoag Brook, Beaver Brook 2022-2025.....	59
NepRWA Figure A-13: <i>E. coli</i> at Sucker Brook, Massapoag Brook, Beaver Brook 2022-2025.....	60
LMAC Figure A-14: Community Center Beach <i>E. coli</i> levels June - September 2017-2025.....	61
LMAC Table A-16: Closures of Community Center Beach due to High <i>E. coli</i> Levels 2017-2025.....	61
TRC Table A-17: Aquatic Plant Species Observed at Lake Massapoag, July 2023	63
LMAC Table A-18: Summary of DASH Efforts 2017-2025.....	66
SOLitude Figure A-15: Weed Maps/Vegetation Assemblage in Lake Massapoag 2018	67
SOLitude Figure A-16: Weed Maps/Vegetation Assemblage in Lake Massapoag 2019	68
SOLitude Figure A-17: Weed Maps/Vegetation Assemblage in Lake Massapoag 2020	69
SOLitude Figure A-18: Weed Maps/Vegetation Assemblage in Lake Massapoag 2021	70
TRC Figure A-19: Fanwort Coverage in Lake Massapoag 2022	71
TRC Figure A-20: Fanwort (Left) and Variable-Leaf (Right) Coverage in Lake Massapoag 2022.....	72
Table A-19: 2022 MA Integrated List of Waters Categories.....	73
Table A-20: Water Quality Impairments (MassDEP 2023a)	73
Table A-21: Surface Water Quality Classification by Assessment Unit	75
Table A-22: Water Quality Goals	75

Table A-23: Watershed Land Uses.....	76
Figure A-22: Comparative Watershed Land Use Map.....	77
Table A-24: Total Impervious Area (TIA) Values for the Watershed	78
Table A-25: Relationship between Total Impervious Area and water quality (Schueler et al. 2009)	78
Figure A-23: Watershed Impervious Surface Map	79
Table A-26: Pollutant Loading for Key Nonpoint Source Pollutants.....	80
Table A-27: Pollutant Loading Export Rates	81
Table A-27: Estimated Pollutant Loading Summary by Source	83
Table B-1: Pollutant Load Estimate (PLE) Reductions Needed	85
LMAC Septic Figure B-1: Total Wastewater Systems in Surface Water Protection District by Year	87
LMAC Septic TABLE B-2: Potential Phosphorus Load to Lake Watershed from Septic Systems	89
Table C-1: Matrix for BMP Suitability Index GIS-based Analysis	90
Figure C-1: BMP Suitability Index Map	91
LMAC Figure C-2: Storm Drain Details around Lake Massapoag.....	92
LMAC Figure C-3: Map of Catchments and Drainage Infrastructure in Lake Watershed.....	93
NepRWA Figure C-4: Sites Surveyed for Potential SCM/BMPs, based on NepRWA Desktop Analysis	95
Table C-2: Proposed Management Measures, Estimated Pollutant Load Reductions and Costs	96
1. VMB Memorial Beach West End Parking Lot & Drainage Improvement Project FY27	96
LMAC Figure C-5: Veterans’ Memorial Park Beach Stormwater and Shoreline Improvement Project	97
Table C-2 (cont): Proposed Management Measures, Estimated Pollutant Load Reductions and Costs.....	98
2. VMB Memorial Beach East End Parking Lot and Drainage Improvement Project: FY28	98
Table C-3: Proposed Management Measures, Estimated Pollutant Load Reductions and Costs	98
3. Lake Ave/Beach Street Stormwater Runoff Mitigation Project: FY29.....	98
Table C-4: Proposed Additional BMPs.....	100
Table D-1: Summary of Funding Needed to Implement the Watershed Plan	101
LMAC Table F&G-1: Stormwater Maintenance Checklist (simplified version).....	110
Table FG-2: Implementation Schedule and Interim Measurable Milestones	113
LMAC Table FG-3: Actions Summary and Timeline	114
TABLE HI-1: Monitoring and Evaluation Summary.....	119
Internal References with Links: Existing Resources Related to Lake Massapoag	132

Executive Summary

The purpose of a Massachusetts nine-element Watershed-Based Plan (9-E WBP) is to organize information about Massachusetts' watersheds and present it in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. This WBP was prepared for Lake Massapoag, a 392-acre predominantly spring-fed lake located in the Town of Sharon, Massachusetts. Lake Massapoag is an important recreational waterbody, and its continued vitality as a resource is challenged by the water quality impacts of suburban development, and increasingly those impacts are being exacerbated by complex physical, chemical, and biological changes over time.

Lake Massapoag is heavily used by an estimated 10,000-20,000 people per season from Sharon and surrounding towns, including 2,500 seasonal and day pass holders for its two public beaches, campers at Everwood Day Camp, Salvation Army's Camp Wonderland, Town STAR camp and Sports camp, SHS Sailing Team, Massapoag Yacht Club, lake abutters, and many people for fishing, walking, picnicking, and active and passive recreation. The lake supports about 400 summer jobs staffing two town public beaches, two large summer camps, town day camp and youth recreation sailing instruction, and new Boston Boat Rental concession.

Lake Massapoag's 3.62 square mile watershed includes about 930 homes, a high school, middle school and private preschool, the town community center and some town offices, two summer camps, a small conference center/resort, an event venue, a small yacht club, a synagogue, and a capped municipal landfill.

Goals

The Overall Goal of the plan is to maintain and enhance its safe use for swimming, boating, fishing, wildlife protection, and passive enjoyment.

- The primary targeted pollutant for this effort is phosphorus. High levels of phosphorus contribute to cyanobacteria populations and harmful algal blooms, rendering the lake unsafe for recreation. This 9-E WBP quantifies the phosphorus budget for the lake and outlines projects and efforts to reduce external phosphorus loading, which also helps reduce shoreline erosion. The Plan includes future nutrient inactivation in 5-10 years following the initial one-third dose alum treatment in June 2025.
- Another target is elevated *E. coli* levels at Community Center Beach and Sucker Brook after heavy rains. Testing has helped identify problem areas; DNA testing is needed to determine human vs. animal sources, and guide remediation and mitigation to keep Community Center Beach open for swimming.
- Additionally, the plan will seek to mitigate growth of invasive weeds, such as fanwort and milfoil, in the South Cove, Fletcher's Cove and the Lagoon, through Diver-Assisted Suction Harvesting to limit its expansion in the coves and along the lake shoreline.

Phosphorus Budget for the Lake and Target Reduction Level

LMAC set a goal to reduce the annual phosphorus load in the lake from 1,365 lbs/year to 915 lbs/year: the amount needed to maintain the lake's phosphorus level below the recommended 0.025 mg/L. This requires a 495 lbs/year reduction – one-quarter of a ton – a significant amount. See **Element B** for information from consultants TRC and NepRWA on water quality sampling and modeling to determine the phosphorus budget.

Sources of Excess Phosphorus

The sources of excess phosphorus in the watershed include stormwater runoff from streets and land, the capped and closed municipal landfill, pet and wildlife waste, atmospheric deposition, and seepage of domestic wastewater from residences, institutions and small businesses. **Element A** presents water quality findings.

The Lake Massapoag Watershed lacks sewers (except those that transport waste from Sharon Middle School and Veterans Memorial Beach to Sharon High School). All wastewater generated in the watershed is discharged to leaching fields and from there to the groundwater. The only wastewater treatment plants are at Sharon High School and the 47-bedroom Salvation Army Conference Center which also serves Camp Wonderland. About 40 of the residential onsite and small commercial systems have Innovative and Alternative (I/A) treatment. However, none of these systems provide advanced phosphorus removal.

Therefore, to complement the Watershed-Based Plan, the Town of Sharon will need to further quantify wastewater inputs, develop a companion Wastewater Mitigation Plan, and a Wastewater Advisory Committee.

Key Actions Needed

To accomplish Plan goals, the Town must:

- Invest significant time, attention, and capital resources for the projects for Plan implementation, and prioritize them within the Town Finance Committee, Capital Outlay, Priorities, Select Board, Community Preservation Commission, Planning Board, Zoning Board of Appeals, and other committees.
- Invest significant time, attention, and program resources in considering and implementing the Plan's recommendations to reboot and strengthen policies, programs, and innovative technologies to limit excess nutrients and protect the watershed. Work with other communities, state officials and legislators to update regulations, programs, and resources so they enable local control and provide incentives and resources to limit and reduce excess nutrients.
- To implement the 9-E WBP, the Town must institutionalize LMAC's operational functions in its departmental structure, so resource development, operations, and administration are performed on an ongoing basis by town staff, with LMAC guiding planning, evaluation, and oversight.

With the completion of this planning effort and the significant actions implemented during the planning period, LMAC has grown beyond an oversight committee to become a de facto operational unit of town government. Institutionalizing operational functions and administration and securing staff within the town's departmental structure is key to sustained resource development, project implementation, and continued lake improvement.

Integral Relationship with other Town of Sharon Plans

To be successful, the Watershed-Based Plan must be integrally connected with other Town plans, objectives, functions, and resources. These include:

- [Sharon Water Department Master Plan](#) (2010)
- Sharon's Comprehensive Plan, *Imagine Sharon: Preserve our Past/Forge our Future* (2019)
- [Sharon Stormwater Management Plan](#) (2019, updated 2022)
- [Sharon Municipal Vulnerability Preparedness Plan](#) (2021)
- [Sharon Hazard Mitigation Plan 2025 Update](#) (2025)
- [Sharon Open Space and Recreation Plan](#) (2025)

Key excerpts from these plans are noted in **Elements F & G: Implementation Schedule and Measurable Milestones**. In addition, Sharon has a five-year Capital Outlay Plan. Planning for the lake's healthy future must be embedded in all comprehensive and targeted planning efforts as the entire watershed impacts the lake.

Funding and Support

The *Watershed-Based Plan for Lake Massapoag 2026-2050* was prepared with funding support from the Massachusetts Department of Environmental Protection (MassDEP) 604(b) Water Quality Management Planning Grant Program (Project #22-03/604) and Massachusetts Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Action Grant (Sharon FY24). This MassDEP grant has been financed with Federal Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (the Department) under a Section 604(b) 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. Local matching funds for water quality testing and analysis were provided by the Town of Sharon Community Preservation Commission and the Town of Sharon annual budget for the Lake Massapoag Advisory Committee.

We thank the members of the LMAC's Steering Committee for this effort, which included representatives from partners including Everwood Day Camp, Camp Wonderland, Sharon High School, Sustainable Sharon Coalition, Sharon Friends of Conservation, and Massapoag Yacht Club. Several additional organizations and individuals have participated in Education and Science Advisory Groups. In addition, we have had regular participation of representatives of Sharon's other boards, committees, and departments, including the Town Conservation Administrator, Health Department Administrator, engineering staff from the DPW, and a representative from the Select Board.

Background on Sharon's Water Resources

To prepare this plan, LMAC collected and reviewed a wide variety of historical documents, including the plans above, to place the lake and watershed in the context of the Town's water resources. This section summarizes key information that is relevant to the lake, watershed, aquifers, and Town, making it easier to find in the future.

Sharon Watersheds and Wetlands

- The Town of Sharon contains the headwaters of two watersheds: the Neponset River watershed to the north, and the Taunton River watershed to the south, see LMAC **Figure BG-1** below.
- There are numerous wetlands in the Neponset River and Lake Massapoag watersheds, providing areas to absorb and release phosphorus seasonally, and additional wetlands in the Taunton River watershed.
- The Surface Water Protection District protects the lake watershed, the Groundwater Protection District protects the public water supply, and there is some overlap between the two.

Lake Massapoag

- The lake has three shallow coves: South Cove, Fletcher's Cove, and Horton's Cove (Beach Rd/Beach St), and a lagoon behind the Community Center with an inlet into the South Cove via a control structure.
- Massapoag Brook exits the Flume House via a control structure, indicated by the dam in the map below.
- Downstream ponds include Hammer Shop, Mann's, and Trowel Shop Pond, feeding the Neponset River.
- Pictures below illustrate the lake's two public beaches, Salvation Army's Camp Wonderland in operation 101 years, Everwood Day Camp, local yacht club, and LMAC's Love our Lake educational campaign.



Veterans Memorial Beach

Community Center Beach

Community Center Beach Closed

Camp Wonderland



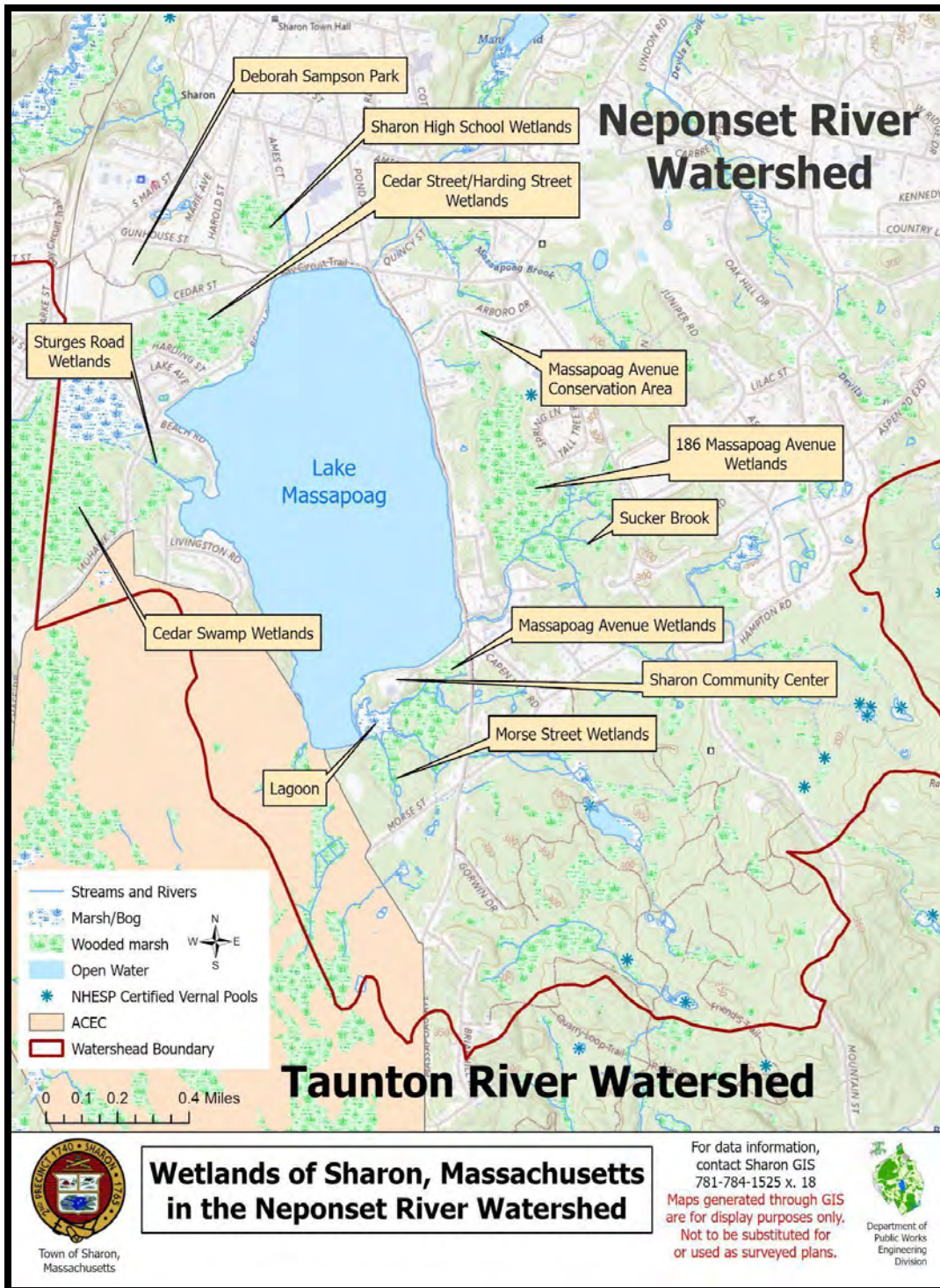
Everwood Day Camp

Massapoag Yacht Club

Love our Lake Banner

Love our Lake Sign

LMAC Figure BG-1: Lake Massapoag and Wetlands in Lake Watershed



Source: DPW and Sharon Conservation Department

Lake Area, Depth and Volume

The lake is about 392 acres, 1.3 miles long by 0.8 miles wide, has a deep hole of 45 feet, and an average depth of 14.6 feet, see LMAC Table BG-1 and LMAC Figure BG-2 below. Water in the lake is estimated to turn over about once a year.

Here are basic statistics from IEP's 1984 *Diagnostic and Feasibility Study of Lake Massapoag*:

Drainage Area = 2,239.4 acres (3.4998 mi²)

Max width = 4,068 ft (0.77 mi)

Lake Area = 392 acres (0.62 mi²)

Lake Volume = 252.34 x 10⁶ ft³

Max depth = 45 ft

Lake perimeter (shoreline) = 20,700 ft (3.92 mi)

Mean depth = 14.59 ft

Retention Time (turnover) = 0.864 years

Max length = 6,831 ft (1.29 mi)

Depth to Hypolimnion = 27.9 ft

Note: With warming temperatures, the depth to hypolimnion is estimated to be somewhere between 15 and 25 feet based on TRC's water quality monitoring in June and July 2025.

Lake Massapoag Bathymetry: Deep Hole and Varying Depths

LMAC **Table BG-1** shows the amount of acreage at various depths. There is a 45-foot-deep hole west of the center with recharge springs from Great Cedar Swamp to the west (major source of drinking water supply).

LMAC Table BG-1: Amount of Area at Various Depths in Lake Massapoag

Depth	0-5 Ft	5-10 Ft	10-15 Ft	15-20 Ft	20-25 Ft	25-30 Ft	30-35 Ft	35-40 Ft	40-45 Ft	45 Ft
Acres	52.86	60.04	50.41	101.72	69.83	20.49	13.37	10.52	9.34	3.18
Cum	391.77	338.91	278.87	228.45	126.73	56.90	36.41	23.04	12.52	3.18
% Tot	13%	15%	13%	26%	18%	5%	3%	3%	2%	1%
Cum %	100%	87%	71%	58%	32%	15%	9%	6%	3%	1%

Source: Sharon Department of Public Works

See LMAC **Figure BG-2** below for a bathymetric map of the lake.

Lake Massapoag Coves and Lagoon

LMAC **Table BG-2** gives the acreage of Fletcher's Cove, South Cove, and the Lagoon. LMAC **Figure BG-3** depicts maps. Invasive weed growth is primarily in these coves and the Lagoon. Native plants are also increasing in density and area of coverage in the coves, the lagoon, and the lake shoreline.

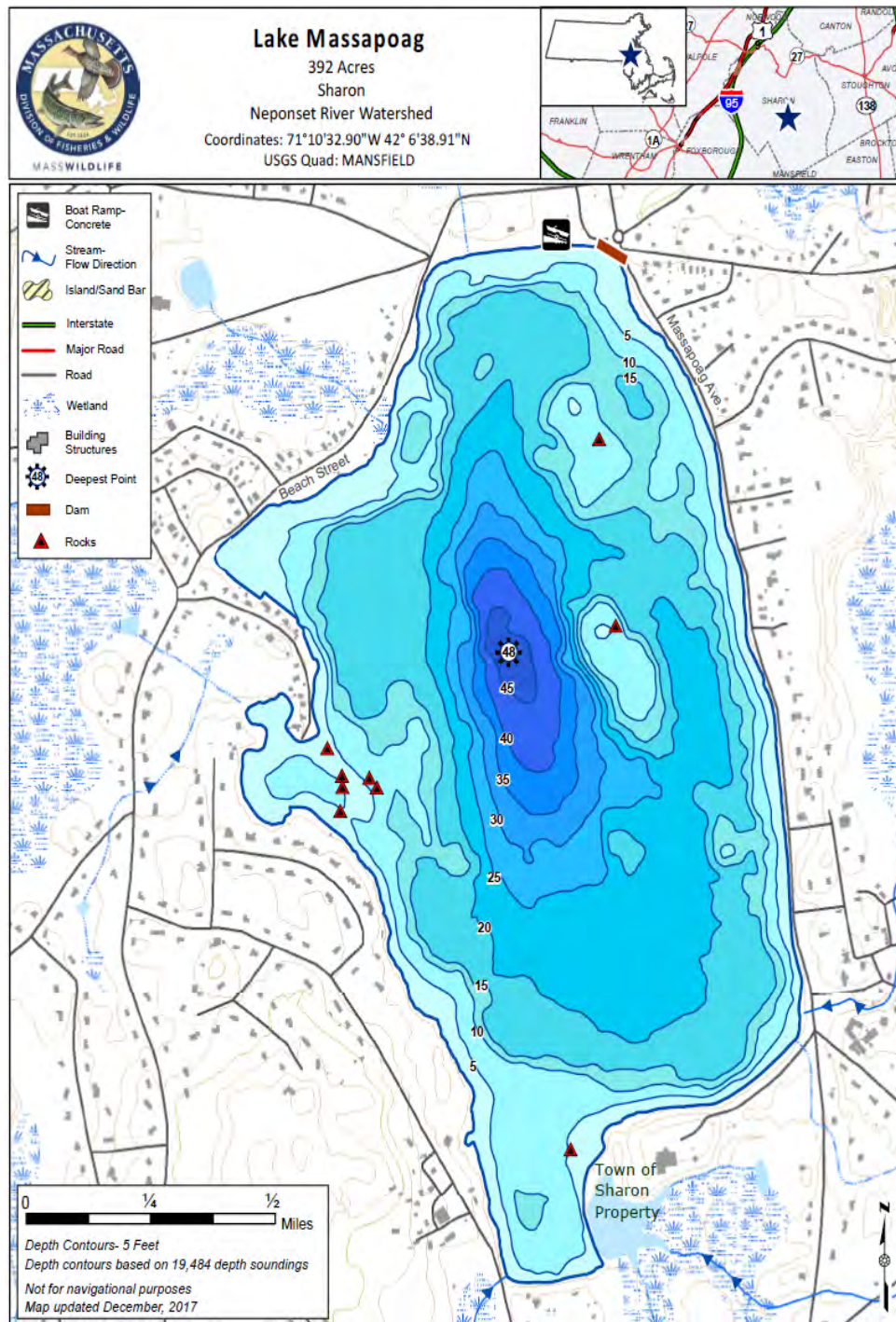
LMAC Table BG-2: Lake Massapoag Cove Acreage

Cove	Acreage
South Cove	10.2 – 16.6
Fletcher's Cove	5 – 6.6
Lagoon	5

Source: Town of Sharon DPW and Conservation Department

The acreage depends on the endpoint selected between the cove and the lake; it also varies with lake level.

LMAC Figure BG-2: Bathymetric Map of Lake Massapoag



Source: Mass Wildlife, 2017

LMAC Figure BG-3: Lake Massapoag Coves and Lagoon



Fletcher's Cove



Lagoon

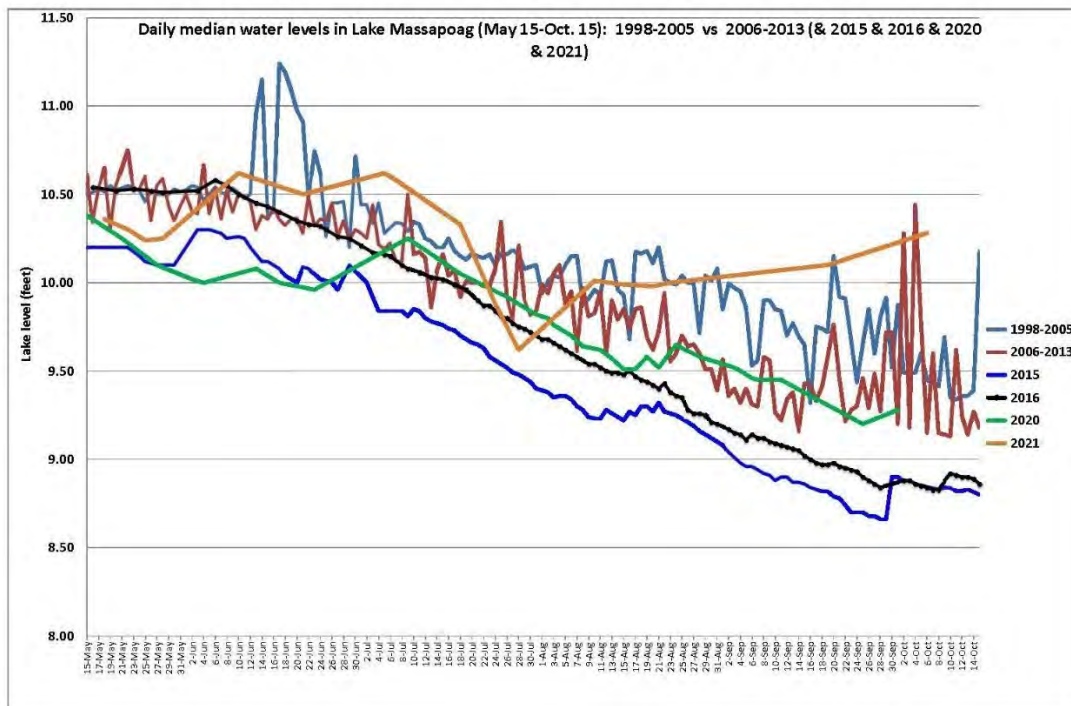


*Top Left: Fletcher's Cove, Top Right: Lagoon, Bottom: South Cove
Horton's Cove is off the intersection of Beach St. and Beach Rd.
Source: Town of Sharon DPW and Conservation Department*

Lake Level Variation

The lake level varies with precipitation, and with management of the control structures at the flume house outflow, the lagoon inflow, and the SHS/Wetlands inflow to the lake. The guidelines for managing the lake level are set forth in, [Procedures and Schedules for Controlling the Water Level in Lake Massapoag](#), which was last amended and approved by MassDEP in April 2000. LMAC **Figure BG-4** shows a historical graph of lake levels maintained by a series of volunteers over the years.

LMAC Figure BG-4: Lake Massapoag Lake Level Comparisons 1998-2021
1998-2005 (light blue) vs 2006-2013 (red) averages;
2015, 2016, 2020 and 2021 (2014 and 2018 lake lowered for fluridone treatment)



Source: LMSC volunteers

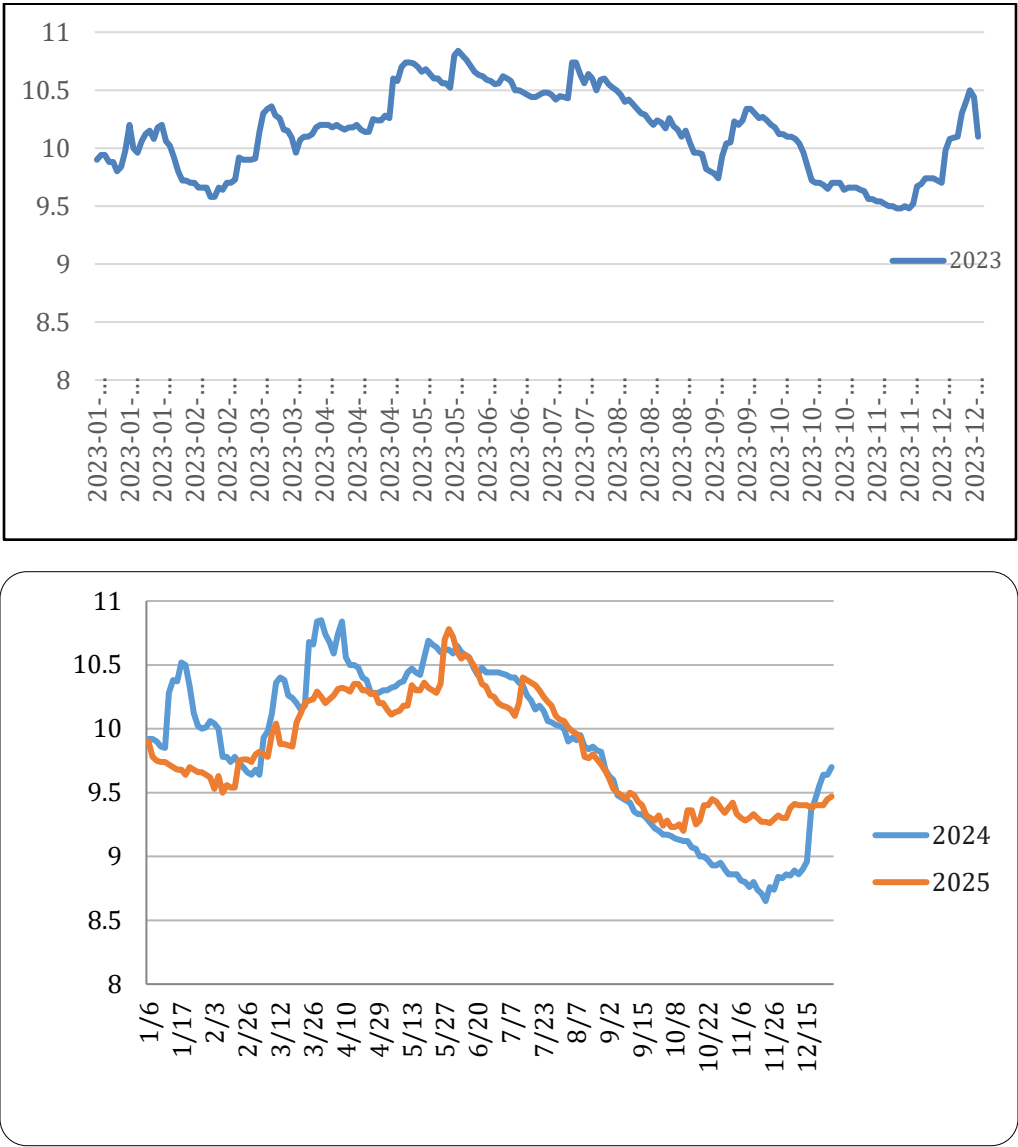
Note the impacts of both lake level management and precipitation on lake levels. In the past, LMSC used to keep the lake level high in the summer based on thinking it would keep the water temperature cooler and reduce algal growth. Adoption of the [Procedures and Schedules for Controlling the Water Level in Lake Massapoag](#) as amended in 2000, incorporated the need to maintain healthy but not excessive downstream flow to the Neponset River Watershed and the value of release and of the lake to maintain cleaner water. In general, the maximum level is 10.5 feet in the summer (251 feet above sea level), and 9.5 feet in winter (250 feet above sea level), with a downstream required flow.

The lake was lowered in 2014 and again in 2018 as required by NHESP to protect endangered shoreline plants when fluridone herbicidal invasive weed treatments were done in Fletcher's and South Cove, and in the Lagoon, respectively; there were subsequent drought years resulting in lower lake levels. Turnover in Conservation staff appears to have impacted the frequency of lake level management in 2020 and 2021 (COVID years).

Heavy July 2021 rainfall (11.6 inches for the month) triggered a lakewide cyanobacteria bloom, closing the entire lake for over two weeks. The lake level was then lowered markedly to help flush and clear the bloom.

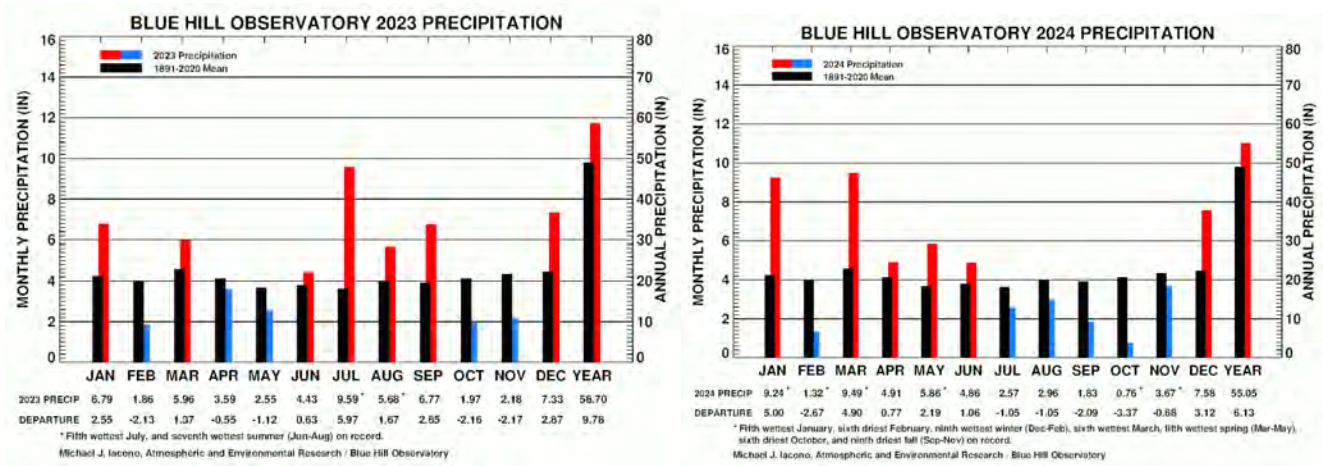
Since 2022, the Conservation Administrator closely monitors and adjusts the lake level via the outflow at the flume house and at the control structures at the lagoon and pipe from the SHS/Wetland area. LMAC monitors the lake level and compares it with precipitation records from Blue Hill Observatory and a local Ambient weather station obtained in 2025. See **Figure BG-5** for Lake Levels in 2023 and 2024-2025, and **Figure BG-6** for monthly precipitation records 2023-2025.

LMAC Figure BG-5: Lake Massapoag Lake Level 2023 and 2024-2025



Source: Charts by LMAC members, data from Conservation Administrator.

LMAC Figure BG-6: Blue Hills Observatory 2023, 2024 and 2025 Precipitation



Source: Blue Hills Observatory, <https://bluehill.org/2023-precipitation/>, <https://bluehill.org/2024-precipitation/>.

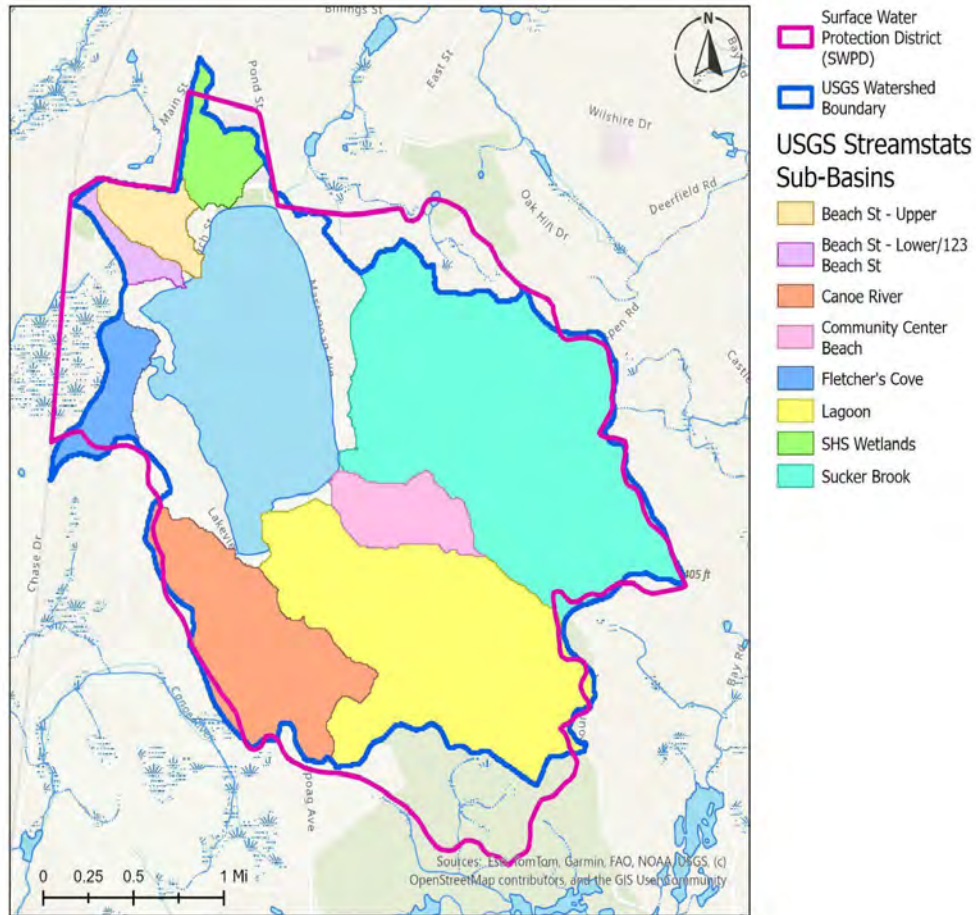
Source: Blue Hills Observatory, <https://bluehill.org/2025-precipitation/>.

As noted, the lake level is heavily influenced by precipitation. 2023 had a very wet summer and almost 10 inches above average for the year. The first half of 2024 had more average rainfall, while the first half of 2025 was on target with the historical mean. Both then turned into droughts, with rainfall and lake levels staying low until the end of 2024 and starting to recover in October 2025. The low water level in fall 2024 allowed for good inspection of outfall pipes, clearing of weeds and debris, and reclamation of beach sand that had eroded into the exposed shallow bottom of the lake. With the more typical lake level in fall 2025, LMAC had a successful Rake the Lake shorefront volunteer event in mid-November.

Lake Tributaries and Drainage Sub-Basins

Lake Massapoag has a handful of tributaries and seven drainage sub-basins, as indicated in the StreamStats map below (LMAC **Figure BG-7**). The largest sub-basin contributions are from Sucker Brook and the Lagoon, both at the southern end of the lake (LMAC **Table BG-3**).

LMAC Figure BG-7: Map of Major Lake Massapoag USGS-Delineated Sub-Basins



Source: NepRWA

LMAC Table BG-3: Major Lake Massapoag USGS-Delineated Sub-Basins Contribution Breakdown

Sub-Basin Name	Area (square miles)	Percent of Lake Watershed (as delineated by USGS StreamStats Boundary, shown in blue above)
Sucker Brook	1.05	29%
Lagoon	0.79	22%
Canoe River	0.39	11%
Community Center Dr	0.13	4%
Fletcher's Cove	0.10	3%
SHS Wetlands	0.10	3%
Beach St - Upper	0.09	2%
Beach St - Lower	0.05	1%

Lake Massapoag Open Space and Recreational Use

The Town has made efforts to acquire additional land around the lake to help protect it, including the purchase of a large property to become the Sharon Community Center which also includes extensive shoreline and the lagoon, and the land formerly occupied by Horizons for Youth Camp, which is now Town-owned and leased to Everwood Day Camp and Sharon Bilingual Montessori School.

Recreational Usage of Lake Massapoag by Local and Area Residents

An estimated 10,000-20,000 people use Lake Massapoag each year, and summer camps and public beaches create 350- 400 summer jobs for young people. Lake Massapoag is heavily used by residents of Sharon and surrounding communities for swimming, sailing, boating, paddling, fishing, and picnicking. The recreational beach season for Veterans Memorial Park Beach and Community Center Beach is late June - late August. The lake is also heavily used before and after hours, and early and late season. See LMAC **Table BG-4** below for a summary of the passes issued from 2022 through 2025.

- In 2025, a total of 2,507 beach passes (an estimated 5,000-7,500 people), 115 boat launch parking passes, and 132 kayak storage spaces were issued.
- 45% of seasonal passholders qualify for reduced rates for senior citizens, veterans, or the disabled, and 27% of all passholders qualify for reduced rates.
- Nonresidents (NR) hold 55% of daily and 9% of seasonal passes; they come from Avon, Brockton, Canton, Chestnut Hill, Dedham, Easton, East Bridgewater, Foxborough, Mansfield, Medfield, Needham, Norton, Norwood, Roslindale, Stoughton, Walpole, West Roxbury, Westwood, and Providence.

LMAC Table BG-4: Town of Sharon Beach, Boat Ramp Parking, and Kayak Storage Passes 2022-2025

Daily Passes						
	2022	2023	2024	2025	+/-	Percent
One Day Boat	16	14	2	22	20	2%
NR Daily Individual	45	49	63	198	135	19%
NR Daily Car	39	342	379	392	13	37%
Resident Daily Car	90	256	154	186	32	17%
Resident Daily Individual	111	237	72	267	195	25%
Total Daily	301	898	670	1065	395	100%
Season Passes						
	2022	2023	2024	2025	+/-	Percent
Boat Ramp	115	104	100	93	-7	6%
NR Adult Car	25	42	60	52	-8	3%
NR Reduced Car	23	47	56	66	10	4%
Resident Season Car	493	525	533	513	-20	33%
Resident Season Car Reduced	334	345	366	375	9	24%
New! Resident Companion		8	13	7	-6	0%
Resident Season Adult Walk In	254	221	244	172	-72	11%
NR Adult Walk In	29	10	13	13	0	1%
Resident Season Reduced Walk In	240	255	273	247	-26	16%
NR Reduced Walk In	22	9	17	11	-6	1%
Purple Heart		3	6	8	2	1%
Total Season	1535	1569	1681	1557	-124	100%
Total Passes	1836	2467	2351	2622	271	
Kayak Storage Rack	132	132	132	132		

Source: LMAC from Recreation Department data

Youth Recreational, Educational, and Economic Impacts of Lake Massapoag

The lake hosts large summer camps which together serve over 2,250 youth. The town has a 100+ -year history of serving as a site for Fresh Air camping for disadvantaged youth.

- Salvation Army's residential Camp Wonderland, founded in 1924, serves 850 economically disadvantaged children (200-220 per week) with 80 employees.
- Everwood Day Camp serves 1,298 children (440-700 per week), including 47 from Elizabeth Peabody House serving low-income families in Boston and Somerville, with 235 employees. Its site includes the former Camp Gannett (former Fresh Air camp) and Kiddie Camp, which became Horizons for Youth.
- The Town's STAR day camp has 100 children which use Veterans Memorial Beach.
- The Town hires 40 lifeguards, gate guards, and staff for lake beaches.
- Boston Boat Rental opened a concession for public canoe, kayak, and paddleboard rentals in 2025.

Sharon High School's Sailing Team hosts league races, Massapoag Yacht Club offers public sailing instruction, races, and sailing for 80 member families from Sharon and many surrounding area towns, and the Sharon Triathlon is a popular annual lake event. Many people swim, boat, fish, walk, and picnic; children swim and play in the sand. A residential day program brings young adults to walk at the lake. The Town offers a youth fishing derby and lakeside concerts. Many abutting property owners heavily use the lake.

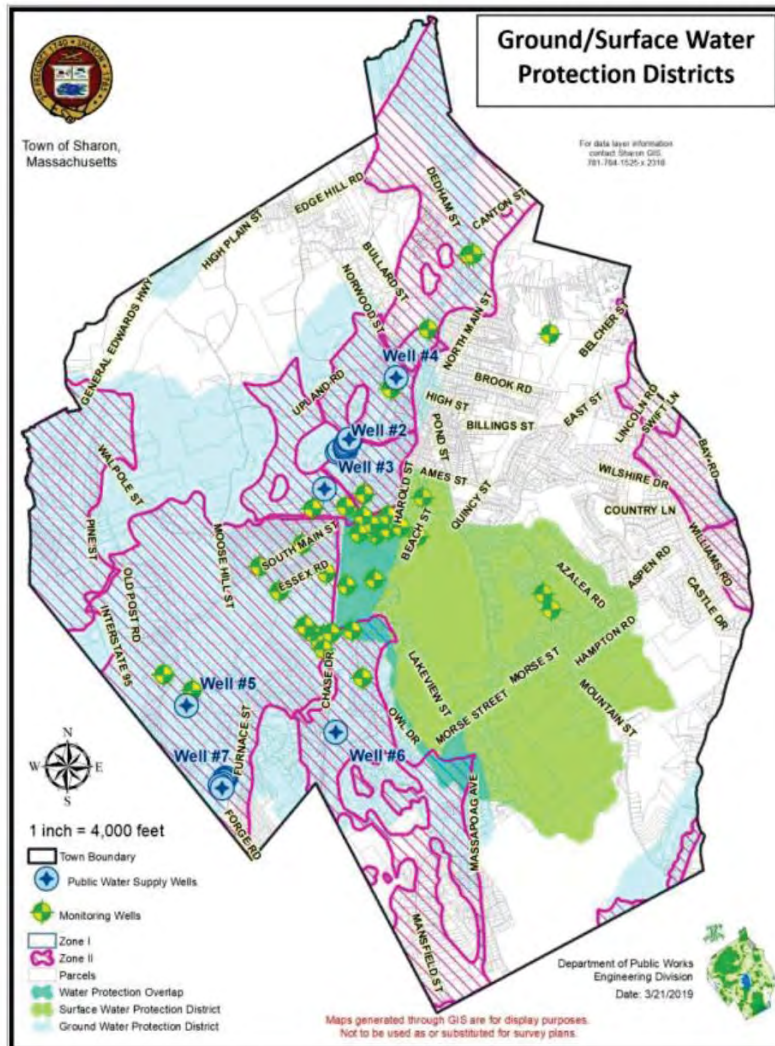
Summary of Lake and Beach Benefits

- An estimated 10,000-20,000 people and 350-400 summer jobs will be heavily impacted without strong action to restore and safeguard Lake Massapoag's health.
- For children at area camps, losing the opportunity to swim and gain water safety skills can impact them for life: especially disadvantaged campers, who enjoy lake access for a couple weeks each summer.
- For town and area residents, valuable recreational and outdoor exercise opportunities will be lost.
- The health of Lake Massapoag impacts many cities and towns downstream to Boston Harbor.

Sharon's Groundwater, Aquifers, Recharge and Discharge

- The lake empties into Massapoag Brook and is one of the headwaters of the Neponset River Watershed.
- In Sharon, as elsewhere in Massachusetts, groundwater of sufficient quality, quantity and yield is usually found in stratified drift deposits. Groundwater in the stratified-drift aquifers in the Town of Sharon is unconfined (not isolated from potential contamination from surface spills and other land uses).
- Groundwater and surface water protection districts for Sharon have been established and are shown in LMAC **Figure BG-8** below.
- Recharge to the aquifer is by infiltration from precipitation, by lateral leakage from adjacent till and bedrock, from septic system discharge. This includes recharge from the Atlantic White Cedar Swamp and from underground springs.
- Discharge from the aquifer is by leakage to the small streams and ponds in the town, by evaporation in areas where groundwater is near land surface, and by non-returned pumpage.
- For comparison purposes, minimum allowable summertime discharge from the lake alone on an annual basis is roughly equal to total annual town well pumping.

LMAC Figure BG-8: Ground and Surface Water Protection Districts, Wells, Monitoring Wells in Sharon

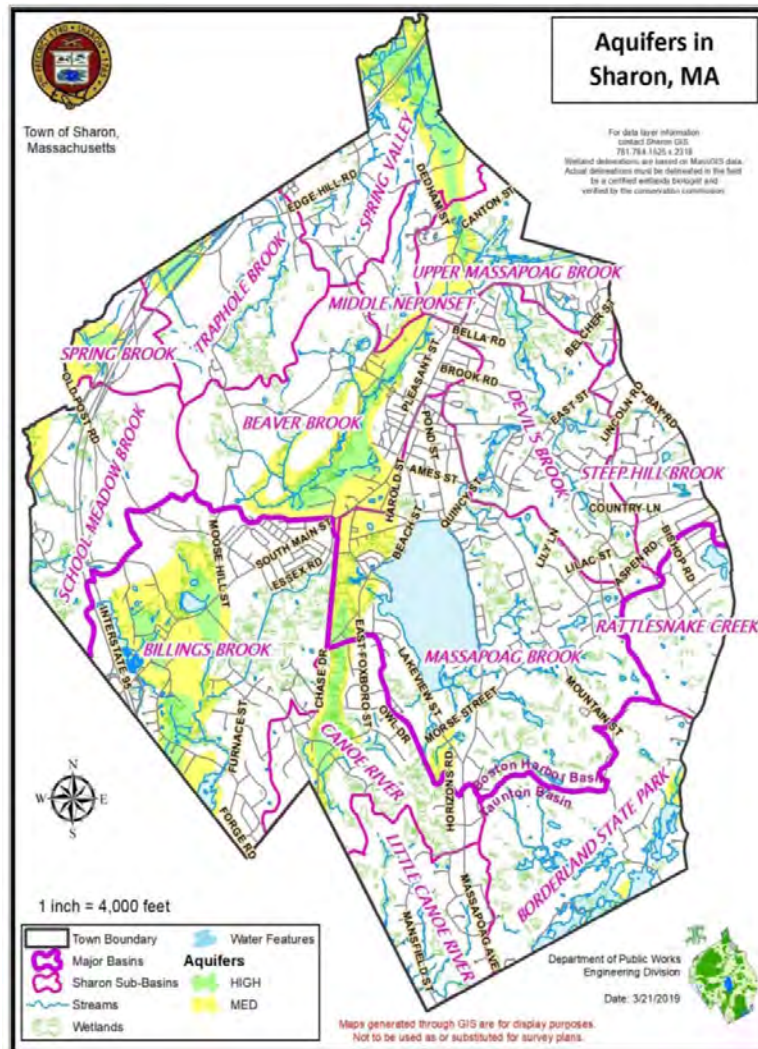


Source: DPW

Aquifer Protection

- To better protect the town's aquifers and lake, modeling studies were done to determine whether the water level could be raised in Sharon's 300-acre Atlantic white cedar swamp, which is located between South Main St. and East Foxboro St and a major recharge area for Lake Massapoag. It was found that even a small increase in water levels would be problematic for homes in Sharon Heights.
- The town has implemented an aquifer protection plan that is incorporated in its current zoning by-laws (LMAC **Figure BG-9** Below). Increased levels of protection may be necessary as the town may face water quality issues as well as the need for new sources.
- The aquifers beneath Sharon are higher in elevation than those in adjacent towns and therefore provide water to the water supplies of adjoining towns as follows: Billings Brook Aquifer to Foxboro, Canoe River Aquifer to Mansfield, and Beaver Brook Aquifer to Canton.

LMAC Figure BG-9: Town of Sharon Aquifers

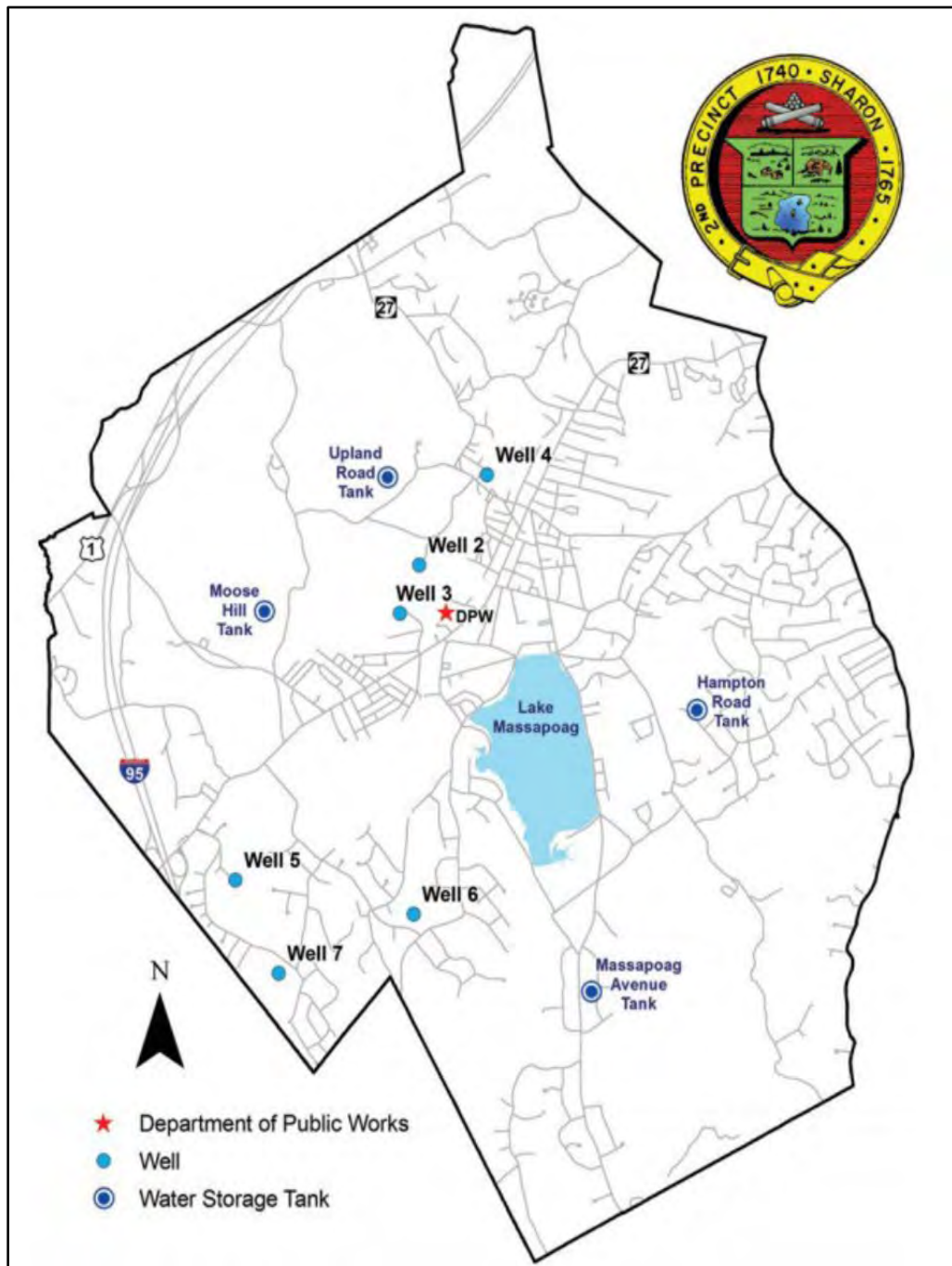


Source: DPW

Drinking Water Supply and Water Conservation Efforts

- The Town of Sharon's public water supply is drawn from six wells (active wells No. 2 through No. 7 shown in LMAC **Figure BG-10** below), drawing on aquifers in three separate watersheds: the Beaver Brook Watershed in the Neponset River Basin, and Billings Brook and Canoe River Watersheds in the Taunton River Basin.
- A new facility is being built to treat wells 2, 3 and 4 for PFAs; and 2 and 3 for iron and magnesium.
- There are four water tanks, each at approximately the same height, transferring water as needed.
- In 2024, annual pumpage was 415 million gallons, meter usage 390 million gallons, flushing 6.5 million gallons, municipal meters 1 million gallons, and annual leakage about 4.2 percent.
- Average usage is 57 gallons per day; under MA recommended average of 65 gallons per person per day.
- Sharon's successful water conservation efforts include a graduated rate structure, rebates for water saving appliances, water saving devices, and the Eye on Water app used by 22 percent of residents.
- Similar programs and incentives could be developed for phosphorus conservation and mitigation.

LMAC Figure BG-10: Town Drinking Water Wells and Tanks in Sharon



Source: DPW

Underground Springs and Currents

LMAC is interested in more information on Lake Massapoag's underground springs, which are noted in older historical documents and briefly referenced in more recent ones. We requested the DPW GIS Specialist take drone photographs when there is partial icing with some open water holes in the lake and correlate it with bathymetric (depth) information to assess which areas may be fed by underground springs. A pilot survey was done in mid-December and focused on the eastern side of the lake, see **Figure BG-11** below. The red outlined areas note holes in the ice cover. This survey will be repeated when conditions are favorable and footage from the western shoreline will be added. The second photo is taken from an airplane by a resident in early February.

LMAC Figure BG-11: Lake Massapoag Ice Holes from Pilot Drone Survey and Airplane



Source: DPW, December 2025

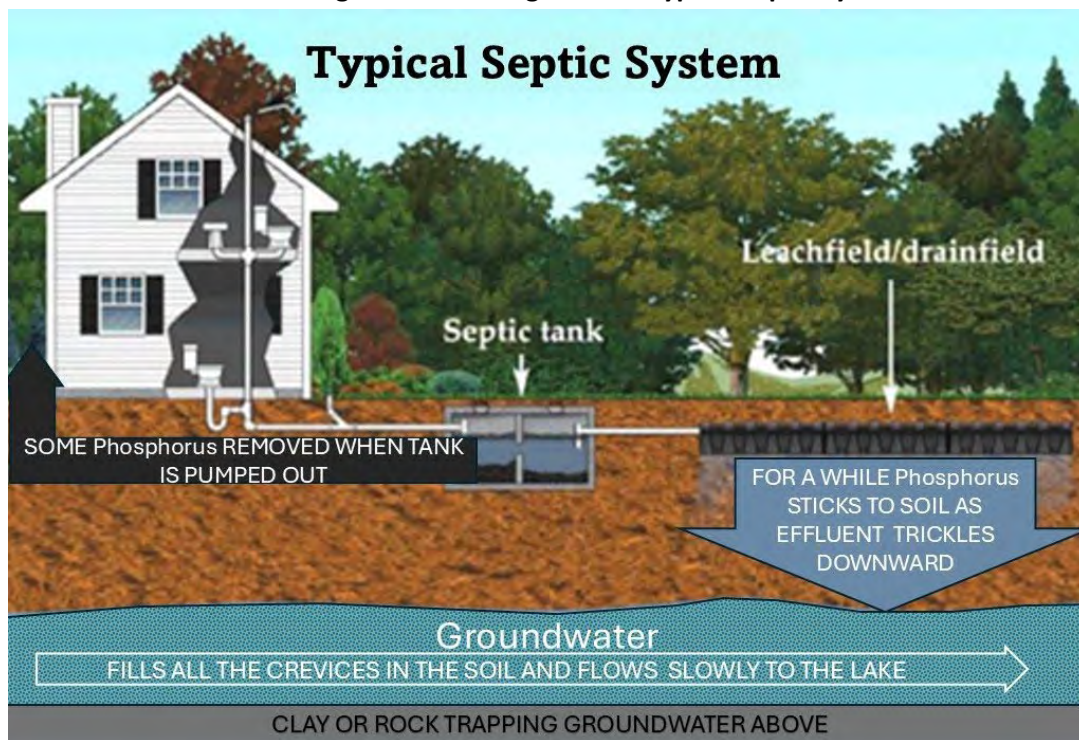


Source: Abby Phillips, February 3, 2026

Wastewater Systems

- The majority of wastewater in town is treated by on-lot septic systems. The town has very limited areas of private sewers, no public sewers, some operating package wastewater treatment systems, and more in the planning stages.
- Sharon Woods, a large development in the south of town, the area of Sharon Galleries, and Avalon Sharon, an apartment/condo complex on the opposite end of town are connected to out-of-town sewers in Mansfield and Norwood, respectively.
- LMAC is concerned about septic system leachate making its way to Lake Massapoag via groundwater flow from the soil absorption systems located in the watershed. These systems contribute phosphorus to the groundwater which eventually reaches the lake. Depending upon the extent to which the phosphorus is adsorbed to the soil, this phosphorus will add to the phosphorus loading, leading to increased potential for eutrophication.
- LMAC notes that even septic systems that meet the 1995 Title 5 Standards and the 40 Innovative/Alternative (I/A) systems do not remove more than about 20% of phosphorus from human waste.¹ See **Figure BG-12** below. We face a growing, long-term excess phosphorus loading challenge.

LMAC Figure BG-12: Diagram of a Typical Septic System



Source: Susan Peck

¹ Lombardo P. 2006. [Phosphorus Geochemistry in Septic Tanks, Soil Absorption Systems, and Groundwater](#). Prepared by Lombardo Associates, Inc., Newton, MA. (quotes 20% -30%); George Heufelder, M.S., R.S. and Keith Mroczka [Evaluation of Methods to Control Phosphorus in Areas Served by Onsite Septic Systems - The State of the Art](#) (2004). Massachusetts Alternative Septic System Test Center (MASSTC) a unit of Barnstable County Department of Health and Environment (2004) MASSTC tests showed average long term removal <10%.

Introduction: What is a Watershed-Based Plan?

Purpose & Need

The purpose of a Massachusetts Watershed-Based Plan (9-E 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 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 9-E WBP 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 where 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 the early and continued participation of residents 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, Funding, and Stakeholder Input

This 9-E WBP was developed by the Town of Sharon's Lake Massapoag Advisory Committee (LMAC), with grants from the Massachusetts Department of Environmental Protection (MassDEP) 604(b) Water Quality Management Planning Grant Program (Project #22-03/604) and Massachusetts Executive Office of Energy and Environment (EEA) Municipal Vulnerability Preparedness (MVP) Action Grant (Sharon FY24). The MassDEP grant was financed with Federal Funds from the Environmental Protection Agency (EPA) to MassDEP under a Section 604(b) competitive grant. The contents do not necessarily reflect the views and policies of EPA or of MassDEP, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

Lake Massapoag Advisory Committee (LMAC)

The Lake Management Study Committee (LMSC) was created by the Town of Sharon, MA in 1969. It was subsequently renamed the Lake Massapoag Advisory Committee (LMAC) at the 2022 Town Meeting, which also expanded its membership and scope, and began to increase its budget to address the challenges facing Lake Massapoag. Lake Massapoag is a Great Pond, by state definition, and thus overseen by the Select Board. It is managed under the orders of conditions set by the Town of Sharon Conservation Commission, whose Administrator participates in LMAC meetings without a vote. LMAC has seven representatives, with two each appointed by the Select Board, Planning Board, and Conservation Commission, and one member appointed by the Recreation Advisory Committee, with staggered three-year terms.

TRC

TRC is an environmental consulting firm that offers field studies, planning, design, permitting, and program management services related to lake and watershed management. TRC has worked closely with the Town of Sharon LMAC for the past three years on a variety of tasks including sediment sampling to implement a high-dose alum treatment in June 2025, water quality sampling, plant mapping, and wet-weather sampling to develop recommendations for best lake management practices.

Neponset River Watershed Association (NepRWA)

NepRWA is a member-supported nonprofit organization dedicated to the improvement and protection of the Neponset River and its watershed. NepRWA's mission is to protect and restore the natural resources of the Neponset River, its tributaries, and surrounding watershed lands for the benefit of present and future generations. Included in that mission is a commitment to supporting resilience efforts throughout the region. NepRWA works to support the LMAC's efforts to protect Lake Massapoag through multiple channels, including working with the Town of Sharon as part of the Neponset Stormwater Partnership, leading the Love our Lake education campaign, and supporting the LMAC's work on BMP implementation for a resilient Lake Massapoag.

Project Partners

LMAC's Steering Committee for this effort includes representatives from partners including Everwood Day Camp, Camp Wonderland, Sharon High School, Sustainable Sharon Coalition, Sharon Friends of Conservation, and Massapoag Yacht Club. Additional organizations and individuals have participated in Education and Science Advisory Groups. In addition, we have had regular participation of representatives of Sharon's other boards, committees, and departments, including the Town Conservation Administrator, Health Department Administrator, engineering staff from the DPW, and a representative from the Select Board.

Data Sources

This WBP was developed using the framework and data sources provided by MassDEP's [WBP Tool](#). Additional resources related to water supply quality and watershed management are listed in LMAC **Table I-1** below.

LMAC Table I-1. Existing Resources Related to Lake Massapoag

Report/Resource Name	Location/Link
Historical Reports (1984-2021)	
Diagnostic and Feasibility Study of Lake Massapoag (IEP 1984)	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/lake-consultant-reports
Update of Aquatic Vegetation Survey, Phytoplankton & Water Quality Analyses at Lake Massapoag (IEP 1987)	same
Saran Twombly, Final Evaluation of the Management Policy for Lake Massapoag (August 20, 1997)	same
Restoration and Revitalization of the Sharon Great Cedar Swamp, DEC, (2012)	same
Lake Massapoag Year-End Report (Lycott 2014)	same
Lake Massapoag Annual Reports (SOLitude 2016-2021)	same
TRC In-Lake Water Quality Reports (2022-2025)	
Water Quality & Aquatic Plant Mapping 2022 (TRC 2023)	same
Lake Massapoag Annual Report 2023 (TRC 2024)	same
TRC, Lake Massapoag Alum Monitoring Report 2025	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/lake-dashboard-and-water-quality
TRC Wet Weather, Seepage, Hot Spot Results (2024-25)	
TRC Water Quality Sampling Memos (2023-2025): Storm Drain Survey Results Wet Weather Shoreline Results Groundwater Seepage Survey Results Hot Spot Sampling at Sucker Brook and Lagoon August and September 2024 Water Quality Results	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/building-blocks-of-the-watershed-based-plan See also Appendix G
Alum Feasibility & Treatment Reports (2023-2025)	

Lake Massapoag Sediment Sampling Report (TRC 2023)	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/lake-consultant-reports
Lake Massapoag Sediment Coring and Nutrient Inactivation Dosing Study (TRC 2024)	Same See also Appendix H
High Dose Alum Treatment Monitoring Report Dec 2025	same
Alum Treatment Report (SOLitude, 2025)	same
Pollutant Loading Estimates (NepRWA)	
Lake Massapoag Catchment Delineation Update and Pollutant Load Estimate Full Report (2024) – NepRWA	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/building-blocks-of-the-watershed-based-plan
Site Selection Considerations for Stormwater Control Measures (NepRWA)	same See also Appendix D
Lake Loading Response Model (TRC)	
Lake Massapoag Nutrient Budget Memo on the Lake Loading Response Model (TRC 2025)	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/building-blocks-of-the-watershed-based-plan See also Appendix H
BMPs, SCMs, and Outfall/Storm Drain Surveys	
BMP Site Visit Surveys (2024) – NepRWA	same. See also Appendix D
Josh Philibert, Outfalls Smoke Tested and Monitored (2024)	same See also Appendix E
Endangered Species Survey (2023)	
Rare & Endangered Species Vegetation Survey (2023) - Pondweed Pursuits	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/plant-surveys-and-botanist-reports
Invasive Weed Treatment Reports 2014-2018	
Lake Massapoag Invasive Aquatic Plant Control Project Summary (2014) - Oxbow Associates	same
Lake Massapoag Invasive Aquatic Plant Control Project Summary (2018) - Oxbow Associates	same
Wastewater System Analyses	
Analysis Of Septic Systems Within The Lake Massapoag Surface Water Protection District (Susan Peck 2025)	https://www.sharonma.gov/2035/Wastewater-System-Analyses See also Appendix F
Weston & Sampson Executive Summary of Preliminary Design Report for Wastewater Collection and Treatment (Weston & Sampson 1989)	same
Other Historical Reports	
Lake Massapoag Study Committee Timeline 1970-2021	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/lake-dashboard-and-water-quality
Lake Massapoag Study Committee 1990 Monitoring Report	same

Summary of Completed Work (BMPs)

LMAC has been active during the planning process, conducting annual Diver-Assisted Suction Harvesting (DASH) in South Cove and Fletcher's Cove, invasive plant mapping, a Love our Lake educational campaign, annual spring goose egg addling, adding an Aquatic Barrier and Filtergrass to the Lagoon outlet to the lake in June 2024, and conducting a June 2025 high-dose alum treatment. The Town redesigned its public boat launch with drainage improvements, and Recreation Department paid for erosion control measures along the east end of Veterans Memorial Beach walking path. Sharon's Department of Public Works (DPW) filled in and re-graded gulleys that had opened from the west parking lot, and during the extended fall drought, reclaimed exposed sand that had migrated downslope.

Several Sharon residences have lake-friendly yards and shorelines, with some challenged by erosion, runoff, and salt spreading during winter storms; the Town is purchasing its first piece of brine spray equipment in FY27. Sharon's Conservation Administrator advises lakeshore owners on erosion and runoff control measures as they file permits for shoreline improvements, such as the model project underway at Sapphire Estate. Another example is a Massapoag Ave homeowner who installed two sets of cultec chambers in the front yard in 2022 to hold 30,000 gallons of stormwater runoff. A new resident building a home will add a rain garden in front.

LMAC Table I-2. Existing BMPs in Lake Massapoag Watershed (added during the planning process)

	Location/Type + Year	Plans/Documentation
Non-Structural BMPs	High-Dose Alum Treatment of Deep Lake Sediment for Internal Phosphorus Inactivation, June 2025	67K gal alum + 31K gal sodium aluminate applied in 21-foot contour, funded by \$525K CPC grant, of which \$450K for treatment, rest for monitoring, soft costs.
	Diver-Assisted Suction Harvesting (DASH), annual 2023-2025	20 days in South Cove and Fletcher's Cove, split between late June and late August/early Sept, funded \$25K by LMAC/CPC and \$25K by Everwood Day Camp
	Invasive Plant Mapping, 2022 and 2023	See TRC Annual Reports 2022 and 2023 in table above
	Love our Lake Educational Campaign, 2023-2025, Rake the Lake event November 2025.	Community Presentations, Tables at Events, Lake Info Walks, Newsletter mailed to all residents with water bills, Lawn Signs, etc. focused on lake-friendly landscaping and yards, outdoor cleaning, septic maintenance, etc. Logo, signs by NepRWA
	Goose Egg Addling, 2023-2025	LMAC contracts with a company to limit growth of the resident goose population, \$1,200/year; Recreation hires seasonal border collie service
Maintenance	Veterans Memorial Park Beach: East Lot	DPW and Recreation Dept Erosion Control 2024
	Veterans Memorial Park Beach: West Lot	DPW Erosion Control Project Fall 2024
	Veterans Memorial Park Beach: West Lot	DPW Temporary Paving Spring 2025
	Veterans Memorial Park Beach: Beach	DPW Sand Reclamation during Fall 2024 Drought
Structural BMPs	Public Boat Ramp Parking Lot Drainage Improvements, 2024	Drainage Design Boat Ramp Design Plan 5/13/2024, installed September 2024, funded \$80K state earmark, balance by Town of Sharon

	Nutrient-Reducing Aquatic barrier and Filtergrass in South Cove at Lagoon inlet, 2024	Installed July 2024 by EverBlue Lakes \$7,350 + \$3,962 funded by LMAC, maintenance by Everwood Day Camp
	Saphire Estate shoreline erosion control project 2025-2026 (included as a model of a private BMP). Hardscaping was completed 2025, landscaping begun, to be completed in 2026. Two cultec chambers were added by a homebuyer to a front yard along Massapoag Ave in 2022 which holds 30,000 gallons of runoff. Resident building a new house across from the lake plans an extensive rain garden in the front yard.	Saphire Estate: Owner created a channel parallel to the road and filled it with large gravel. In the gravel is a drainpipe with holes only on the top side. If the road runoff is great enough to fill the channel, the water will not back up onto the street, but rather, will enter the pipe and be discharged to some rip rap down by the water. Small storm events will infiltrate in the ditch, and during larger storms, some sediment will still be trapped in the ditch. Water reaching the lake will have less sediment than before. The slope that was eroding has been stabilized with hardscaping and vegetation. Some of the infiltrated water will reach the vegetation which may absorb some of the nutrients before they reach the lake.

LMAC Figure I-1. BMPs and Shoreline Maintenance and Repairs During Watershed-Based Plan Period

BMPs During Planning Period

Shoreline Maintenance and Repairs at VMB (Before and After)



Boat Launch Redesign
2024



VMB West Lot Flooding
2023



VMB West Lot Erosion
2023



VMB East Lot Erosion
2024



Aquatic Barrier at Lagoon



West Lot Flooding Repair
2024



West Lot Erosion Repair
2024



East Lot Repair 2024

Element A: Identify Causes of Impairment & Pollution Sources

General Watershed Information

Lake Massapoag is a 392-acre, natural, stream and spring-fed lake, located in Sharon, MA. It is one of the Town's most valuable natural resources. Lake Massapoag is a headwater of the Neponset River Watershed. Note the size of the lake varies with precipitation, weather conditions, and lake level.

Table A-1: General Watershed Information

Watershed Name (Assessment Unit ID):	Massapoag Lake (MA73030)
Major Basin:	BOSTON HARBOR: Neponset, Neponset River Note: Southern Sharon is in the Taunton River Watershed
Watershed Area (within MA):	2,316.4 (ac)
Water Body Size:	389 (ac)

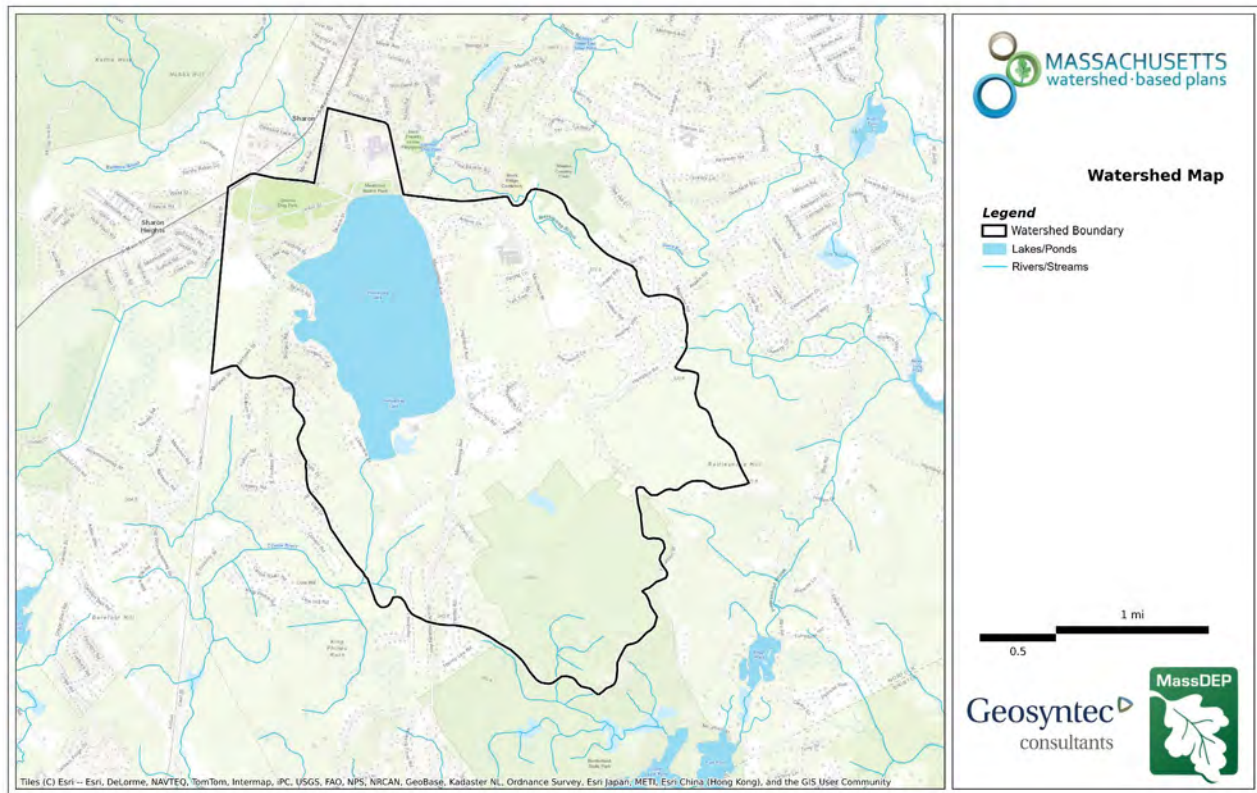
Sources of Excess Phosphorus

The sources of excess phosphorus in the watershed include stormwater runoff from streets and land, the capped and closed municipal landfill, pet and wildlife waste, atmospheric deposition, and seepage of domestic wastewater from the residences, institutions and small businesses described above.

The Lake Massapoag Watershed lacks sewers (except those that transport waste from Sharon Middle School and Veterans Memorial Beach to Sharon High School). All wastewater generated in the watershed is discharged to leaching fields and from there to the groundwater. The only wastewater treatment plants are at Sharon High School and the 47-bedroom Salvation Army Conference Center which also serves Camp Wonderland. About 40 of the residential onsite and small commercial systems have Innovative and Alternative (I/A) treatment. However, none of these systems provide advanced phosphorus removal.

Therefore, to complement the Watershed-Based Plan, the Town of Sharon will need to further quantify wastewater inputs, develop a companion Wastewater Mitigation Plan, and a Wastewater Advisory Committee.

Figure A-1: Watershed Boundary Map, defined by Town of Sharon Surface Water Protection District

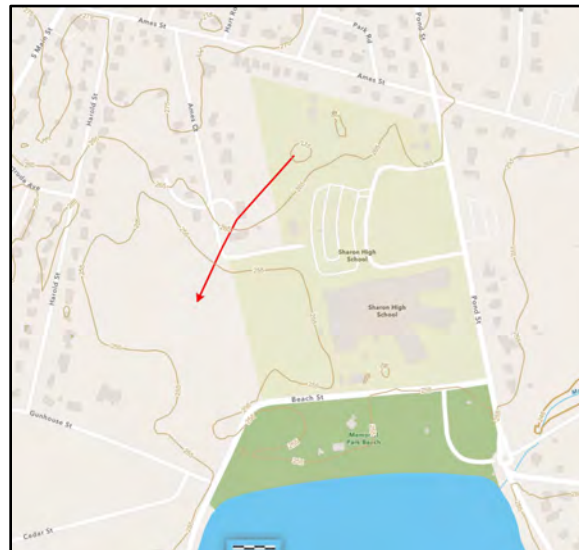


Sources: Watershed Boundary Map (MassGIS, 2007; MassGIS, 1999; MassGIS, 2001; USGS, 2016), based on Town of Sharon Surface Water Protection District (SWPD), found at https://www.townofsharon.net/sites/g/files/vyhlf3801/f/uploads/zoning_map_2022.pdf

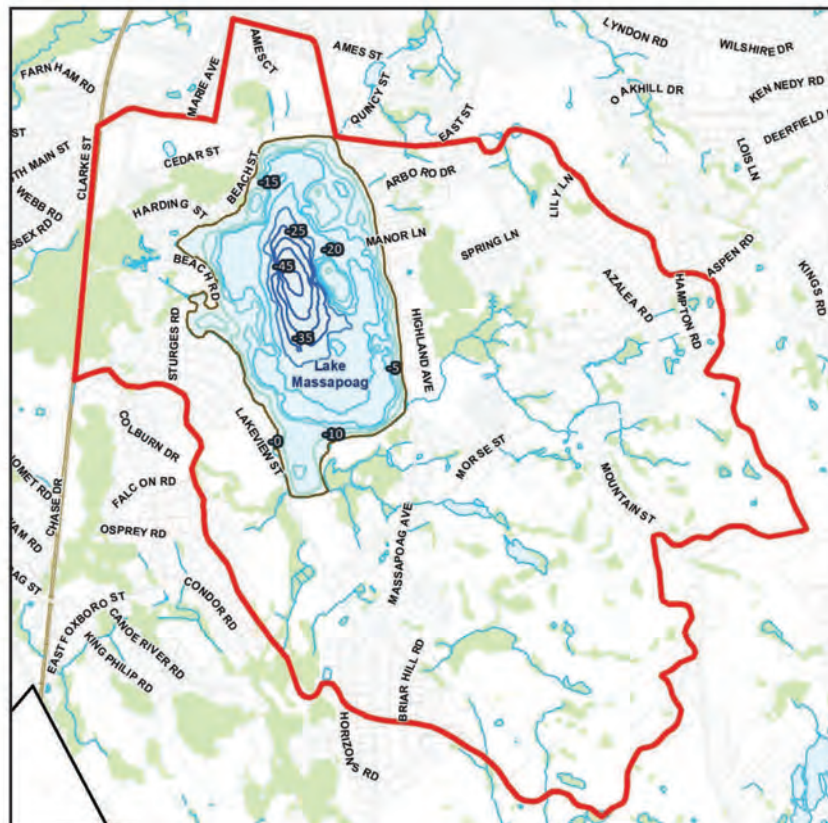
After further data analysis, including the septic information and Sharon High School Elevation Contour and Drainage Map shown in LMAC Figure A-2, the LMAC decided to define the boundary of the watershed as the Surface Water Protection District (SWPD) as shown in red in Figure A-3 below. This is the boundary which the town has adopted for planning and zoning purposes. This decision was made after the phosphorus estimates were done by NepRWA and TRC, and accounts for some of the variance in phosphorus estimates between the WBP online tool, NepRWA's PLE, and TRC's LLRM.

Based on Town GIS data, the Town of Sharon has updated its watershed map to add the area north of Sharon High School, which is situated at the northern end of the lake. Based on the elevation contours on the town GIS, the ground surface slopes downhill from this area to the wetland next to the SHS athletic track, as indicated by the red arrow in LMAC Figure A-2 below. That wetland then drains to the lake.

LMAC Figure A-2: Sharon High School Elevation Contour and Drainage Map



LMAC Figure A-3: Town of Sharon Planning Board Surface Water Protection District



This map corresponds to the Sharon Planning Board's Surface Water Protection District on its 2022 [zoning map](#).

Lake Massapoag History and LMAC work

Many years ago, Massapoag was a working lake, providing a source of bog iron for manufacturing revolutionary war cannons and cannonballs, power for downstream mills, and ice for the ice houses serving the greater Boston area. Later it became a resort community, with large hotels, and a growing collection of small beach cottages and then larger homes along its shores. It also housed three large summer camps which are now combined into two, Salvation Army's Camp Wonderland and Everwood Day Camp.

Lake Committee Work 1960s to 2020

For a comprehensive history of the lake in the 1970s and early 1980s, see the *Diagnostic and Feasibility Study - Lake Massapoag* conducted by IEP in 1984. It was commissioned due to frequent *E. coli* problems, especially at the northern end which houses the heavily used Veterans Memorial Park Beach, and occasional algal blooms, raising further concerns about lake safety and public health. Additionally, see the LMSC Timeline 1970-2021.

Septic and Nutrient Control:

The 1984 IEP report found the watershed surface was the primary source of phosphorus from runoff and tributary streams. Septic systems within 300 feet of the shoreline were a significant source of phosphorus loading, as they control *E. coli* and nitrogen but not phosphorus. The report predicted that without action and with continued development, the lake would become eutrophic by the year 2000 due to increased runoff, increased septic flow in the watershed, and the gradual reduction in the ability of the soils to attenuate groundwater; and outlined many recommendations for improvement.

Several of the recommended improvements were implemented in the following years, including closing and capping the Town landfill, installing more stormwater control best management practices (BMPs), installation of extensive stormwater management along the full length of Beach Street and along the mile-long segment of Massapoag Ave where it abuts the lake, redirecting drainage at Arboro Drive through underground pipes into Massapoag Brook, onsite erosion control (addressed through a subsequent Memorial Beach redesign project), biannual street sweeping, and a volunteer program for inspection and clearing of storm drains. In addition, the town upgraded its septic regulations and began actively purchasing swamps surrounding the lake in the 1970s, and in 1979 required 2-acre zoning in the Lake Massapoag watershed. A subsequent redesign of Massapoag Ave to add a bicycle lane and meet state roadway standards for Chapter 90 funding removed some stormwater controls, such as the Cape Cod berm, which has led to an increase in shoreline erosion and nutrient runoff.

Sewer system options were proposed for the lake in 1989 based on a Weston Sampson Feasibility Study, which were unfortunately voted down due to cost. A new wastewater treatment system was installed at Sharon High School in 1998, which also became the treatment site for Sharon Middle School and Veterans Memorial Beach in the early 2000s. Since 1995, 374 of 873 pre-1995 septic systems, including 103 cesspools, were upgraded to comply with new more stringent 1995 Title 5 regulations through its mandatory inspection requirements. All except 195 have been repaired or shown to be in compliance through Title 5 inspections. The systems at the Sharon Community Center, the Salvation Army Conference Center, Camp Wonderland and Everwood Day Camp, the Sapphire events venue, and the Montessori School were also all upgraded. *E. coli* levels fell significantly at Memorial Beach as a result but have continued to be elevated at Sucker Brook and nearby Community Center Beach, despite Camp Wonderland replacing its old cesspools with a new wastewater treatment system.

The report also made recommendations for land use regulation, zoning and subdivision control, and wetlands protection. The Town purchased one of the large camp properties when it came up for sale to prevent more intensive development. It is now leased by Everwood Day Camp, which also leases an adjacent parcel from its Elizabeth Peabody House owner for use.

State law changes were enacted: Title 5 in 1995, a ban on phosphates in laundry detergents in 1993 which previous lake committee members worked to help gain passage, and a ban on phosphates in dish detergents in 2007. Title 5 set up a system of inspection, replacement and maintenance of septic systems that accelerated replacement. However, new septic and treatment systems, including Innovative/Alternative (I/A) ones, reduce nitrogen but not phosphorus, which is more difficult and costly to control.

As a result of these actions, the Town gained nearly 40 years of lake health. The Lake Committee actively worked to monitor water quality, advocate for town improvements, and worked to help pass and implement the state's phosphorus ban on detergents. Lake water quality significantly improved. However, not all actions were taken, some were changed, maintenance in the face of heavy rains began to fall short, and septic phosphorus continued into the lake despite Title 5 upgrading the majority of systems.

Four decades later, we again faced cyanobacteria blooms from external phosphorus loading, intensified by heavy rainfall and heat, along with high levels of internal loading from accumulated legacy phosphorus. Other challenges include invasive weed growth in two coves and high *E. coli* levels at Sucker Brook and Community Center Beach, especially after heavy rain. During COVID, Lake Committee activity was minimal and lost ground. A lakewide cyanobacteria bloom closed the entire lake for over two weeks in July 2021 and catalyzed action.

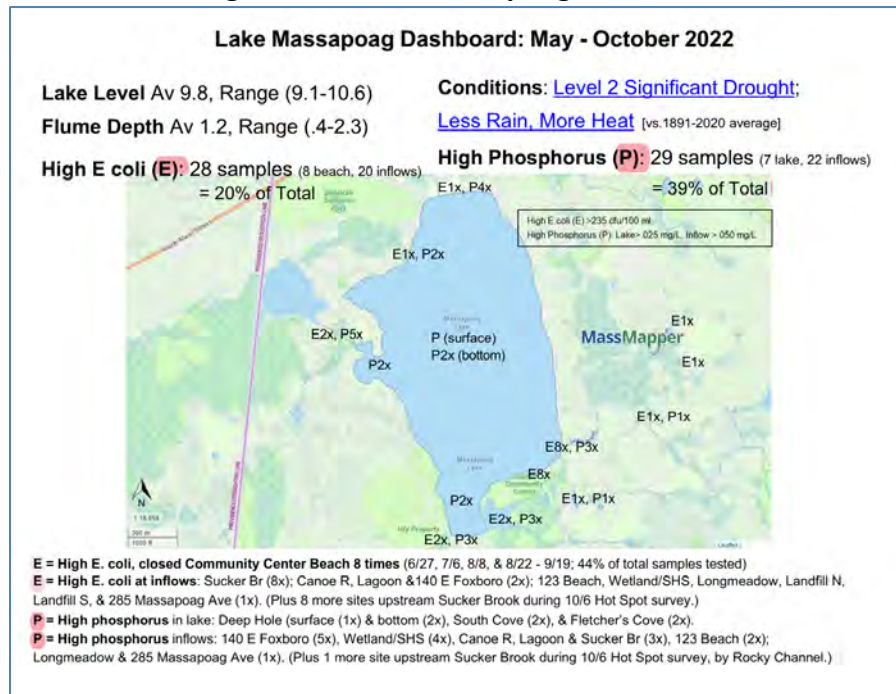
Weed and Algae Control:

Invasive weeds began to grow in Lake Massapoag in the 1960s, leading to the formation of the Town's Lake Management Study Committee in 1969, and chemical treatment that year to control milfoil in the South Cove. Diver Assisted Suction Harvesting (DASH) was planned in 1974. Winter drawdowns were approved by the Conservation Commission in 1975 and conducted from 1977 into the 1980s. To allow for winter drawdowns, the DPW cleared out blockages in Massapoag Brook and reinforced its banks between Lake Massapoag and North Main Street and rebuilt the culvert under North Main Street. Before 1991, the lake level was kept as high as possible in the summer to limit algae and weed growth by reducing light penetration. After extensive study, the town changed the policy to limit weed and algae growth by increasing the outflow of the top layer of hot water to keep the lake cooler. The herbicide fluridone was used to control fanwort and milfoil in the South Cove and Fletcher's Cove in 2014, and in the Lagoon in 2018.

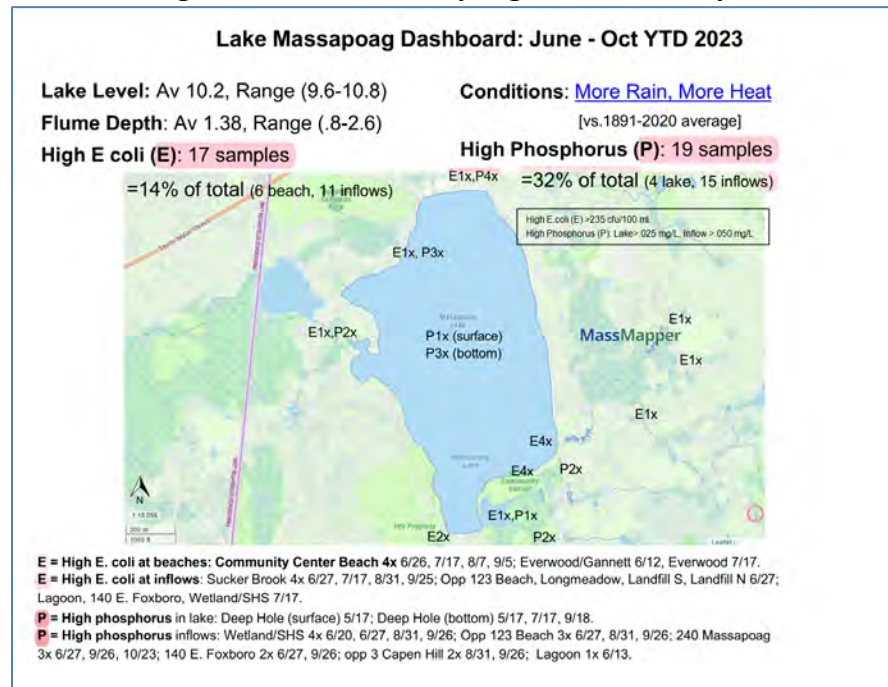
LMAC Dashboards

In 2022 and 2023, LMAC conducted monthly phosphorus and *E. coli* testing at lake tributaries and stormwater outfalls and mapped these data with Board of Health weekly *E. coli* swim beach test results from the town's public beaches, summer camps, and MYC, and compiled dashboards to identify problem areas at the lake. These helped make the case for action and support from town public officials and departments, area residents, and the many stakeholders who use the lake to prepare this comprehensive, long-term 9-E Watershed-Based Plan for Lake Massapoag 2026-2050. These data were summarized in the Dashboards in the LMAC Figures A-4 and A-5.

LMAC Figure A-4: Lake Massapoag Dashboard 2022



LMAC Figure A-5: Lake Massapoag Dashboard Report 2023



It was clear that concerted action was needed. LMAC secured funds for the Watershed-Based Plan from DEP and MVP, hired consultants, expanded testing, launched educational and outreach efforts, piloted nutrient reduction efforts in the South Cove, and conducted research to prepare for a high-dose alum treatment in June 2025.

Outreach includes a spirited Love our Lake (LOL) Campaign to highlight the need for concerted town and resident actions. Highlights of the campaign, a partnership between LMAC and NepRWA, include:

- Updating LMAC's website for the lake, lakemassapoag.net, and installing posters in beach path kiosks
- A series of educational "Lake Walks" for residents, typically along Memorial Beach, plus an "Inside the Lake Walk" during the fall 2024 drought
- Printing and distribution of a Love our Lake newsletter mailed with Town water bills
- Printing and distribution of 250 Love our Lake lawn signs, and an online survey of actions people were taking to help the lake
- Tables at Town events such as Sharon Day, Sustainable Sharon, Sharon Garden Club, and Cottage Elementary School's STEAM night where we had pH testing kits for use, and LOL stickers for kids
- Working with Sharon High School biology and environmental studies faculty to integrate laboratory phosphorus sampling and testing into their spring field unit at Memorial Beach, and materials for assignments
- Supporting Everwood Day Camp in its "Nature/Water" walk for all campers in 2024
- Presentations to Sustainable Sharon Coalition, Sharon Garden Club, Sharon Historical Society, Sharon Men's Club, Sharon Adult Center, Massapoag Yacht Club, and more

Phosphorus has been identified as a leading pollutant for Lake Massapoag. The lake has experienced more frequent bacterial blooms which limit the recreational use of the lake or certain beaches for extended periods of time, especially in mid-summer to early fall when the lake's value as a recreational water resource is highest.

Management actions and BMPs during the planning process included the following:

- DPW designed and installed reconstruction and drainage improvements at the town's public boat launch in fall 2024 with support from a state earmark grant
- DPW did interim erosion control measures at Memorial Beach west and east in fall 2024
- LMAC conducted DASH treatments of fanwort and milfoil in South Cove and Fletcher's Cove in 2022-2025 with support from the Town of Sharon, a Community Preservation Commission grant, and Everwood Day Camp
- LMAC piloted a low-dose alum treatment in South Cove in 2023 with support from Everwood Day Camp
- LMAC piloted installation of an aquatic barrier and filtergrass units at the Lagoon inlet into South Cove to reduce invasive weed transfer and nutrient loading in 2024
- LMAC conducted a high-dose alum treatment to inactivate deep lake sediment phosphorus in June 2025

To restore a resilient Lake Massapoag 2025-2050, the LMAC will work to:

- implement this plan to reduce external loading via siting and construction of new stormwater control measures and non-structural BMPs and monitor progress,
- conduct an updated septic-phosphorus contribution study and examine alternatives to present to the town,
- conduct DNA testing of elevated *E. coli* in Sucker Brook and Community Center Beach to determine human and animal sources to guide remediation and mitigation strategies,

- implement expanded invasive weed reduction efforts in the South Cove and Fletcher’s Cove to address fanwort and milfoil and reduce risk of spread to other shoreline areas,
- make recommendations for updates in the town’s administrative and regulatory systems to better protect the lake and watershed from septic, stormwater, and lawn nutrient contributions, and
- work aggressively on education and outreach for adoption of lake-friendly yard, shoreline, and outdoor cleaning practices, control stormwater erosion and runoff, and upgrade and maintain septic systems.

MassDEP Water Quality Assessment Report and TMDL Review

The following reports are available:

- [DIAGNOSTIC FEASIBILITY STUDY LAKE MASSAPOAG SHARON, MASS.](#) (1984)
- [UPDATE OF AQUATIC VEGETATION SURVEY, PHYTOPLANKTON AND WATER QUALITY ANALYSES at LAKE MASSAPOAG](#) (1987)
- [LANDFILL DIAGNOSTIC/FEASIBILITY STUDY: REPORT TO THE TOWN OF SHARON, MASS.](#) (1987)
- [Neponset River Watershed 2004 Water Quality Assessment Report](#) (2010)
- [Northeast Regional Mercury Total Maximum Daily Load](#) (2007)
- For these and additional reports, see <https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/lake-consultant-reports>

The section below summarizes the findings of any available Water Quality Assessment Report and/or TMDL that relate to water quality and water quality impairments. Select excerpts from these documents relating to the water quality in the watershed are included below (note: relevant information is included directly from these documents for informational purposes and has not been modified).

Neponset River Watershed 2004 Water Quality Assessment Report (MA73030 - Massapoag Lake)
Aquatic Life Non-native species (<i>Myriophyllum heterophyllum</i>, <i>Cabomba caroliniana</i>) have been observed in Massapoag Lake. Fish Consumption MA DPH has issued a fish consumption advisory for Massapoag Lake due to mercury contamination. Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not eat any Largemouth Bass fish from this water body. The general public should limit consumption of Largemouth Bass fish to two meals per month (See Special Note 1 and 2 and 2). Primary Contact Insufficient data were available to assess the Primary Contact Use. Secondary Contact Insufficient data were available to assess the Secondary Contact Use. Aesthetics Insufficient data were available to assess the Aesthetic Use. Report Recommendations: NA

Historical and current Technical Memoranda (TM) produced by the MassDEP Watershed Planning Program are available here: [Water Quality Technical Memoranda | Mass.gov](#) and are organized by major watersheds in Massachusetts. Most of these TMs present the water chemistry and biological sampling results of WPP monitoring surveys. The TMs pertaining primarily to biological information (e.g., benthic macroinvertebrates, periphyton, fish populations) contain biological data and metrics that are currently not reported elsewhere. The data contained in the water quality TMs are also provided on the “Data” page ([Water Quality Monitoring Program Data | Mass.gov](#)). Many of these TMs have helped inform Clean Water Act 305(b) assessment and 303(d) listing decisions.

Literature review information:

TRC: Water Quality Reports Summary

TRC has assessed several aspects of Lake Massapoag through a field-based sampling program. The following sections below represent a summary of the sampling performed to date in relation to external and internal phosphorus loading to the lake. For a full description of the sampling completed to date, please refer to TRC’s reports in their entirety, which can be found here: [Building Blocks of the Watershed-Based Plan | Town of Sharon MA](#) and [Lake Consultant Reports | Town of Sharon MA](#).

In-Lake Water Quality Testing

TRC sampled in-lake water quality from 2022 to 2025. Water quality sampling included assessment of the vertical temperature-dissolved oxygen profile in the deep hole and assessing nutrient level from the surface and bottom of the water column in the deep hole and South Cove. Profiles of the deep hole indicate that the lake thermally stratifies over the summer from approximately June through September, where warm water overlays cold water and inhibits vertical mixing. This, combined with oxygen demand, ultimately creates an anoxic environment below 20-25 ft, making it difficult for aquatic life to survive there.

Grab samples collected from the surface and bottom of the deep hole and at the surface of the South Cove were analyzed for nutrients, including total and dissolved phosphorus. Although there is no statewide phosphorus standard established, concentrations greater than 0.025 mg/L are typically considered excessive. TRC Tables 1 and 2 show the total and dissolved phosphorus results from the lake over the 2022 to 2025 sampling period. Phosphorus exceedances, particularly at the bottom of the deep hole, were observed from 2022 through 2024 (except for August 2024).

In June 2025, a high-dose alum treatment was conducted at the lake. As a requirement of the alum monitoring, additional monthly sampling at the deep hole for total phosphorus was conducted from July to November, as shown below in TRC Table 10. Post-alum treatment tests show no phosphorus levels over 0.025 mg/L in the samples collected from July to November (TRC Table 10). For additional information on the in-lake water quality sampling, please refer to TRC’s reports located here: [Lake Consultant Reports | Town of Sharon MA](#) (2022 and 2023) and [Building Blocks of the Watershed-Based Plan | Town of Sharon MA](#) (2024).

TRC Table A-1: Total Phosphorus Levels at Lake Massapoag 2022-2025

Location	Units	10/3/22	5/17/23	7/17/23	9/19/23	8/22/24	9/18/24	8/18/25*	9/29/25*
Deep Hole- S	mg/L	0.018	0.029	0.016	0.024	0.019	0.015	0.016	0.006
Deep Hole- B	mg/L	0.031	0.025	0.03	0.129	0.016	0.038	0.024	<0.003
South Cove	mg/L	0.087	NS	NS	0.023	0.013	0.015	0.018	0.009

Bold values exceed 0.025 mg/L; NS = Not Sampled

* Sample events occurred post 2025 alum treatment. See TRC Table 10 below for additional monthly monitoring results at the deep hole.

TRC Table A-2: Dissolved Phosphorus Levels at Lake Massapoag 2022-2025

Location	Units	10/3/22	7/17/23	9/19/23	8/22/24	9/18/24	8/18/25*	9/29/25*
Deep Hole- S	mg/L	0.017	0.008	0.013	0.011	0.011	0.01	<0.003
Deep Hole- B	mg/L	0.013	0.022	0.107	0.014	0.042	0.018	<0.003
South Cove	mg/L	0.012	NS	0.012	0.008	0.011	0.008	0.006

Bold values exceed 0.025 mg/L; NS= Not Sampled

* Sample events occurred post 2025 alum treatment

Earlier phosphorus testing conducted by other consultants also indicated high total phosphorus levels in the lake. IEP, Inc. (1984) tested total phosphorus levels in 1981 and demonstrated exceedances of 0.025 mg/L (LMAC Table A-3a). The Lake Management Study Committee (LMSC) did in-house sampling from 1989 to 1991 (LMAC Table A-3B). LMSC sampled phosphate levels, a form of phosphorus, and results showed excessive levels of phosphate at the bottom of the deep hole. Additional sampling was conducted by SOLitude in 2016 for total phosphorus and indicated total phosphorus was detected below the reporting limit of 0.010 mg/L at the surface of the deep hole and South Cove, although the bottom of the deep hole was not sampled at that time.

LMAC Table A-3a: Historical Total Phosphorus Levels at Lake Massapoag 1981 and 2016

Location	Units	June 1981	July 1981	Aug 1981	Sept 2016
Deep Hole- S	mg/L	.05	.06	.02	<.010
Deep Hole- B	mg/L	.03	.04	.29	NS
South Cove	mg/L	NS	NS	NS	<.010

Bold values exceed 0.025 mg/L; NS = Not Sampled

Deep Hole- S & B: Surface and Bottom

Sources: 1981 data from IEP (1984), 2016 data from SOLitude (2016)

LMAC Table A-3b: Historical Phosphate Levels at Lake Massapoag 1989-1991

Location	Units	Aug 1989	Sept 1989	Aug 1990	July 1991	Aug 1991	Sept 1991
Deep Hole- S	mg/L	.01	<.010	.01	NS	NS	NS
Deep Hole- B	mg/L	.01	.15	.01	.50	.90	1.0

Bold values exceed 0.025 mg/L; NS = Not Sampled

Deep Hole- S & B: Surface and Bottom

Sources: 1989-1991 data from LMSC records.

External Loading: Direct Shoreline Runoff, Stormwater Outfalls, and Groundwater Seepage

Direct Shoreline Runoff

In June 2024, TRC analyzed external nutrient loading from direct stormwater runoff into the lake using unattended wet weather samplers (photo to the right). Direct runoff into the lake contained high concentrations of total phosphorus, ranging from 0.444 mg/L to 4.47 mg/L, with the highest concentrations at the **east and west ends of Memorial Beach** (2.84 mg/L and 4.47 mg/L, respectively; TRC Figure 5) (TRC Table 4).



Although not a pollutant of concern for this report, samples were also collected for total nitrogen. Total nitrogen values were elevated (greater than 1.0 mg/L) at all locations, with the west end of Memorial Beach near the dock having an extremely high concentration of total nitrogen (66.8 mg/L). This sampling indicated that significant nitrogen and **phosphorus can be mobilized directly into the lake during intense precipitation events.**

For additional information on the wet-weather runoff sampling methodology, please refer to TRC's memo located here: [TRC, Lake Massapoag Wet Weather Shoreline Sampling Run-off Results](#).

TRC Table A-4: Total Phosphorus and Total Nitrogen Levels from Stormwater Runoff

Sample ID	Location Description	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
SW-4	Memorial Beach (West Side)	4.47	66.8
SW-5	Memorial Beach (East Side)	2.84	8.00
SW-6	Community Center Beach	0.895	6.24
SW-1	Everwood/Gannett	0.724	2.44
SW-2	189 Massapoag Ave	0.465	4.58
SW-3	Massapoag Yacht Club	0.444	1.76

Note: Samples organized from highest to lowest total phosphorus concentration

TRC Figure A-5: Summary of Total Phosphorus and Total Nitrogen Results from Stormwater Runoff



Stormwater Outfalls

In 2024, TRC analyzed external nutrient loading into the lake from stormwater outfalls (photo to the right) and from flowing tributaries. Samples were collected during rain events to capture wet-weather conditions. Sample locations are shown in TRC Figure 6. Stormwater outfalls (sites where storm drains in the street empty into the lake) had elevated phosphorus concentrations, with **total phosphorus values ranging from 0.067 mg/L to 0.489 mg/L. The most elevated phosphorus concentrations were at outfalls located at 19-21 Livingston Road and 31 Livingston Road (TRC Table 5).**



Total nitrogen values were also elevated at some locations and ranged from 0.89 mg/L to 2.84 mg/L (TRC Table 5). Samples were also collected from the outfall at Sucker Brook (Outfall-7) over two wet-weather events to analyze external nutrient loading from tributaries during a rain event. Sucker Brook showed elevated total phosphorus and total nitrogen concentrations. Excessive nutrient loads from stormwater outfalls may be attributed to several factors including but not limited to fertilizer use, pet/geese waste, decomposing organic matter, and/or erosion of soils. For additional information on the wet-weather storm drain outfall sampling, please refer to TRC's memo located here: [TRC, Lake Massapoag Storm Drain Survey Results](#).

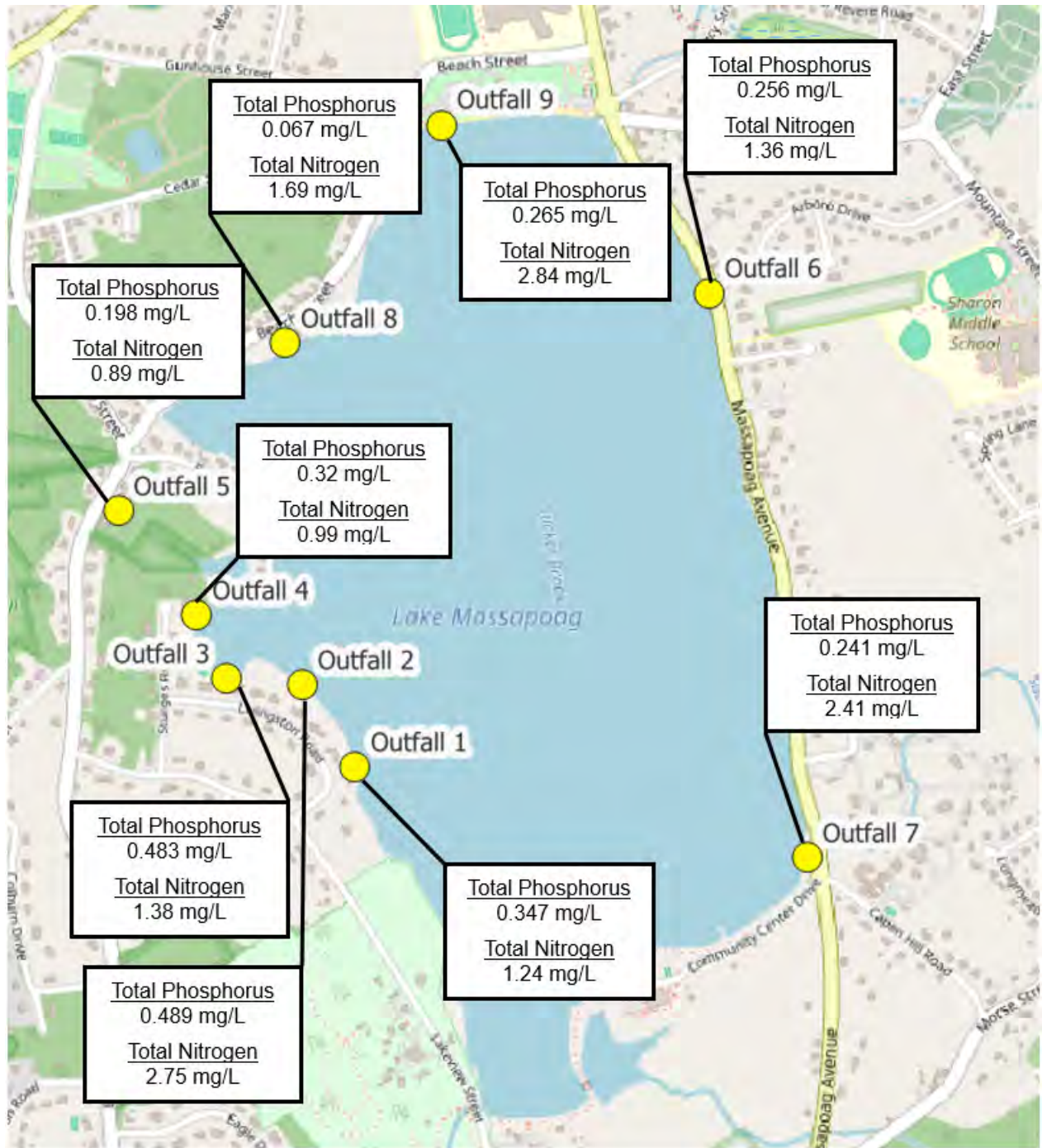
TRC Table A-5: Total Phosphorus and Total Nitrogen Levels from Stormwater Outfalls

Sample ID	Location Description	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
Outfall-2	19-21 Livingston Road	0.489	2.75
Outfall-3	31 Livingston Road	0.483	1.38
Outfall-1	7-11 Livingston Road	0.347	1.24
Outfall-4	25 Sturges Road	0.32	0.99
Outfall-9 *	VMB Outfall	0.265	2.84
Outfall-6	Massapoag Ave at Arboro Drive	0.256	1.36
Outfall-7	Sucker Brook	0.241	2.41
Outfall-5	140 E. Foxboro Street	0.198	0.89
Outfall-8 *	123 Beach Street	0.067	1.69
Outfall-7 ^	Sucker Brook	0.032	NS

Notes: ^ Sucker Brook sampled again on May 31, 2025 for just total phosphorus; (NS= not sampled).

* Outfall-8 and 9 not flowing during initial visit on November 21, 2024. Outfalls resampled on May 31, 2025. Samples organized from highest to lowest phosphorus concentration.

TRC Figure A-6: Summary of Total Phosphorus and Total Nitrogen Results at Storm Drain Outfalls



Groundwater Seepage

In September 2024, TRC measured groundwater seepage rates and groundwater quality in shallow areas (up to 10 feet deep) of Lake Massapoag along the shoreline (photo to the right). Sample locations are shown in TRC Figure 7. On the day of the survey, seepage of groundwater was predominantly positive, suggesting net in-seepage of groundwater to the lake. Measured groundwater quality showed dissolved phosphorus concentrations in shallow groundwater were above 0.025 mg/L and total nitrogen were above 1.0 mg/L at all locations.



Daily loads of dissolved phosphorus and total nitrogen into the lake were then calculated by multiplying the seepage rate with the associated concentration (Table 6).

Based on these results, it is **likely that phosphorus and nitrogen concentrations in groundwater seepage are being influenced by human activity (e.g. septic systems and/or fertilization)** from the surrounding land. This analysis does not account for groundwater seepage in deeper areas of the lake. Given that Lake Massapoag is also fed by underwater springs, it is important for future testing to analyze the potential phosphorus loading from groundwater springs.

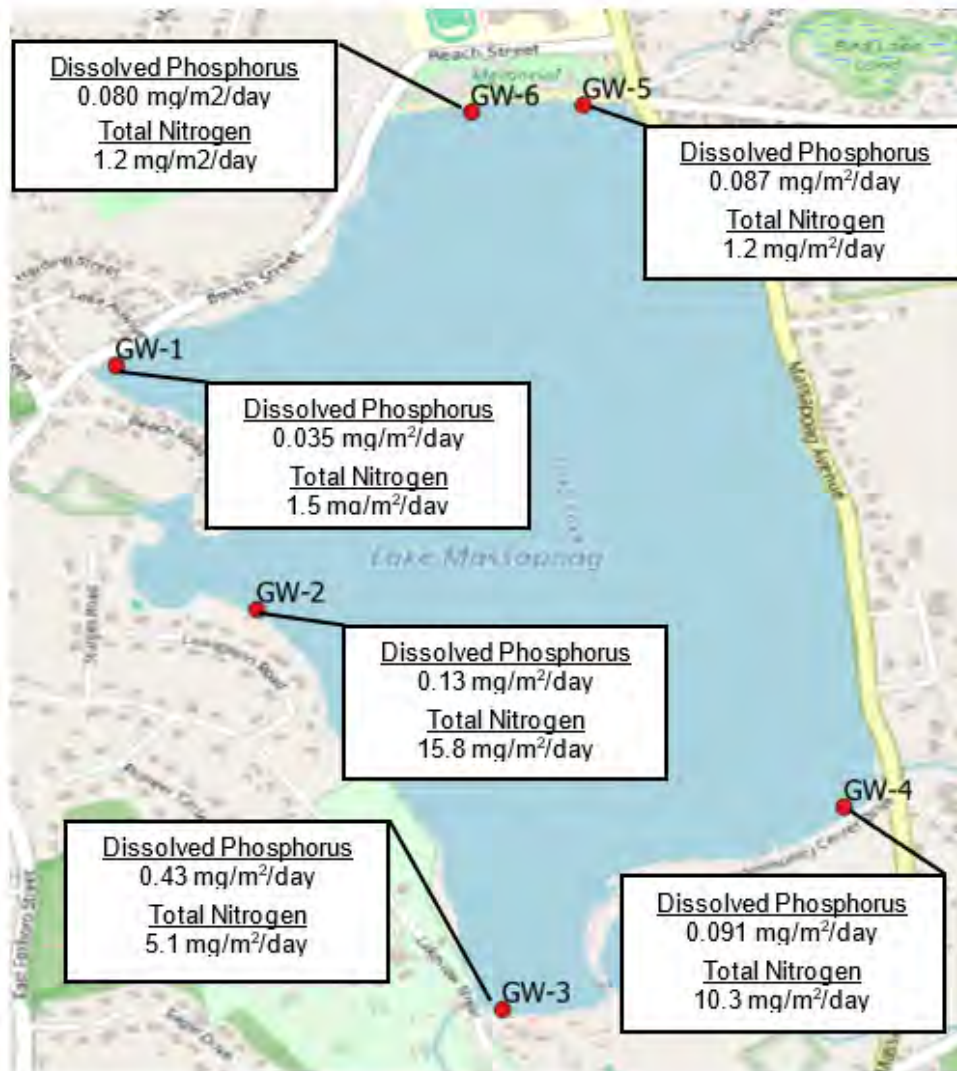
For additional information on the groundwater seepage survey and groundwater quality sampling, please refer to TRC's memo located here: [TRC, Lake Massapoag Groundwater Seepage Survey Results](#).

TRC Table A-6: Dissolved Phosphorus and Total Nitrogen Levels from Shallow Groundwater

Sample ID	Location Description	Average Seepage Rate (L/m ² /day)	Dissolved Phosphorus (mg/L)	Dissolved Phosphorus Daily Load (mg/m ² /day)	Total Nitrogen (mg/L)	Total Nitrogen Daily Load (mg/m ² /day)
GW-3	By the Everwood Gannett Campus, southern side of lake	2.9	0.148	0.43	1.74	5.1
GW-2	Along Livingston Road, on western side of lake	3.6	0.035	0.13	4.38	15.8
GW-4	By Community Center Beach, southeastern side of lake	2	0.045	0.091	5.09	10.3
GW-5	By eastern end of Memorial Beach, northern side of lake	0.3	0.252	0.087	3.59	1.2
GW-6	By western end of Memorial Beach, northern side of lake	0.9	0.085	0.08	1.32	1.2
GW-1	By Beach St and Beach Rd intersection, western side of lake	0.5	0.07	0.035	2.96	1.5

Note: Samples organized from highest to lowest dissolved phosphorus daily load concentration

TRC Figure A-7: Daily Dissolved Phosphorus and Total Nitrogen Loads at Seepage Sampling Locations



Hot Spot Survey

In 2024 and 2025, TRC conducted a hot spot survey by collecting water samples along eight **Sucker Brook** sites over the course of two wet weather events (TRC Figure 8). The results showed **excessive *E. coli* levels ranging from 866 MPN/100 mL to 4,600 MPN/100 mL (TRC Table 7)**. TRC also collected water samples during a wet-weather event from the tributaries leading into the lagoon that feeds the South Cove (TRC Figure 8).

Phosphorus levels in the lagoon tributaries were excessive (>0.05 mg/L), ranging from 0.119 mg/L to 0.16 mg/L (TRC Table 8). TRC collected several total phosphorus samples (including duplicate samples indicated as BMP-1D and BMP-2D) at the outlet of the lagoon entering the South Cove (TRC Figure 8).

Samples were collected upstream and downstream of the filtergrass to test the phosphorus removal capabilities of the recently installed BMP. The average phosphorus concentrations downstream were slightly lower than the concentrations upstream, indicating the potential for some amount of phosphorus removal, although more

sampling is needed to prove a statistical difference. Additionally, the average of all the samples collected at the lagoon outlet was 0.024 mg/L (TRC Table 9).

When compared to the phosphorus inputs from the tributaries into the lagoon, this indicates that **the lagoon and surrounding wetlands attenuate some amount of phosphorus preventing its entry into the lake**. For additional information on the hot spot surveys, please refer to TRC's memo located here: [Hot Spot Survey Results at Sucker Brook and the Lagoon](#).

TRC Table A-7: *E. coli* Levels along Sucker Brook

Sample ID	<i>E. Coli</i> (MPN/100ml)
SB-7	4600
SB-8	>2420
SB-2	1986
SB-3	1417
SB-5	1300
SB-4	1203
SB-6	1000
SB-1	866

Note: Samples organized from highest to lowest *E. coli* concentration. Values have been rounded (see lab report for detailed results).

> = Reported as a greater than value because the undiluted result was above lab calibration range.

TRC Table A-8: Total Phosphorus Levels of Lagoon Tributaries

Sample ID	Total Phosphorus (mg/L)
LT-1	0.16
LT-4	0.136
LT-2	0.119
LT-3	NS

Note: Samples organized from highest to lowest concentration.

NS= Not Sampled (LT-3 observed to be not flowing during sample visit).

TRC Table A-9: Total Phosphorus Levels in Lagoon Outlet into South Cove

Sample ID	Sample Location	Total Phosphorus (mg/L)
BMP-1	Upstream Filtergrass	0.032
BMP-2	Downstream Filtergrass	0.024
BMP-2D	Downstream Filtergrass- Duplicate	0.021
BMP-1D	Upstream Filtergrass- Duplicate	0.02
Outlet Average		0.024

Note: Samples organized from highest to lowest concentration.

TRC Figure A-8: Hot Spot Survey Locations along Sucker Brook, the Lagoon and its Tributaries



Note: Sucker Brook locations are shown in orange; lagoon and tributary sampling locations are in blue.

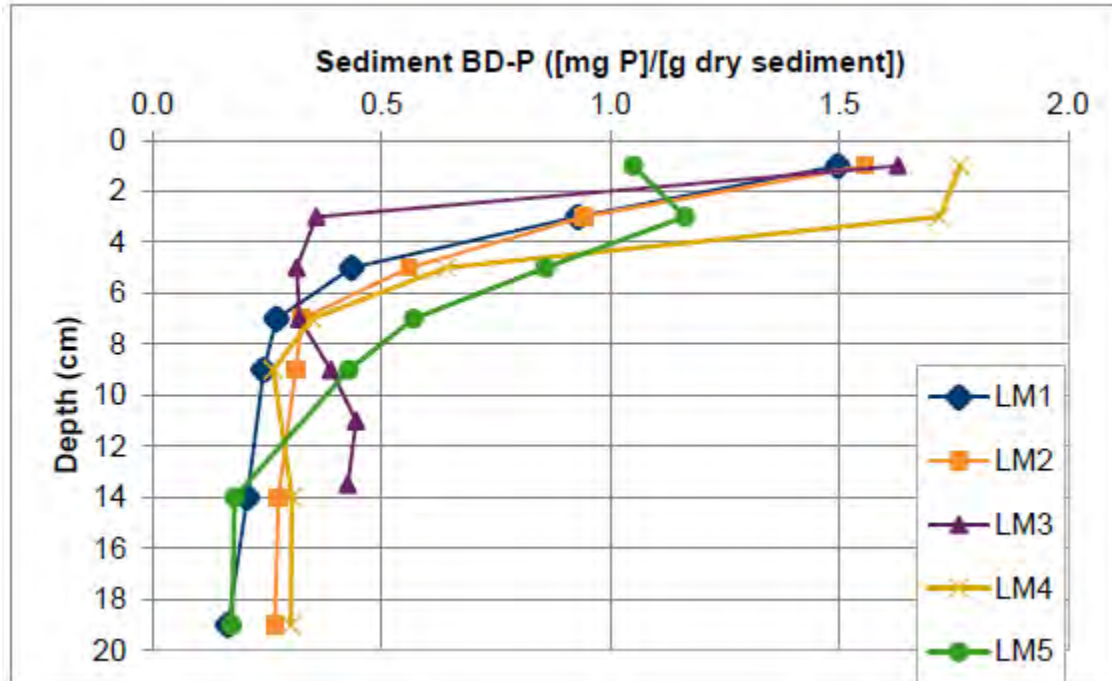
Internal Load Phosphorus Contribution

As part of a [2024 nutrient inactivation dosing study](#), TRC analyzed lake sediments to estimate the level of internal phosphorus loading in the lake. Past sediment sampling in 2022 and 2023 identified iron-bound and loosely sorbed (mobile) phosphorus in deep lake sediments that experienced prolonged seasonal depletion of dissolved oxygen, as shown in the temperature-dissolved oxygen profiles of the lake.

In 2023, TRC conducted an in-depth study to delineate the phosphorus-sediment conditions and provide recommendations for nutrient inactivation as a possible action to reduce internal loading of phosphorus. Sediment cores retrieved from the deep areas of the lake which experience anoxia were analyzed for different forms of phosphorus. Results from the study showed that iron-bound and loosely sorbed phosphorus were the primary phosphorus fractions in lake sediments.

TRC Figure 9 below shows the concentrations of iron-bound phosphorus (per dry weight of sediment) at core depth. The results show that the top four cm of the sediment core is where the majority of the iron-bound phosphorus resides, with concentrations decreasing at depth. These results indicate that the surficial sediments are the most prone to releasing phosphorus under anoxic conditions. When sediments become anoxic over much of the summer and early autumn, this iron-bound phosphorus will release from the sediments and likely become the primary source of internal phosphorus loading in the lake. The average daily internal phosphorus release rate was calculated to be approximately 19.93 mg/m².

TRC Figure A-9: Concentrations of Iron-Bound Phosphorus at Core Depth



Source: TRC

2025 High-Dose Alum Treatment

Based on the nutrient inactivation study, a high-dose alum treatment plan was designed for the lake. The treatment area encompassed most of the area within the 21-foot contour resulting in a total area of 108 acres. In early June 2025, the lake was treated with approximately 67,531 gallons of alum (containing 14,857 kg Al) and 30,671 gallons of sodium aluminate (containing 17,482 kg Al) at a ratio of approximately 2.2:1 (vol: vol) alum to sodium aluminate. The treatment contractor was SOLitude Lake Management (SOLitude).

TRC monitored the lake throughout the treatment to test for any swings in the pH as well as observe any stress on aquatic life. Overall, no measurable negative impacts to water quality or biological resources were observed over the course of the alum treatment program. TRC also conducted pre- and post-treatment monitoring which included analyzing total phosphorus at the bottom of the deep hole of the lake and near the outlet of the lake by Massapoag Brook.

The high-dose alum treatment was highly successful during its first season. Below is a summary of the pre- and post-alum treatment monitoring results at the deep hole of the lake from May through November 2025. Secchi disc readings have increased post-treatment. The average Secchi reading pre-treatment was 2.25 meters and the average Secchi reading post treatment was 4 meters. Total phosphorus values have fluctuated since the treatment, but samples from July to November were below 0.025 mg/L with the sample collected in September indicating the lowest phosphorus levels measured to date at the lake. During the 2025 season, no algal blooms were identified in the lake and Chlorophyll A readings were not extreme during any field visit (TRC Table 10).

TRC Table A-10. Deep Hole Water Quality Parameters Pre- and Post-Alum Treatment

Date	5/21/25	6/4/25	6/12/25	6/18/25	6/25/25	7/28/25	8/18/25	9/29/25	10/27/25	11/20/25
Secchi (m)	2	2.5	3	3.5	4	3.75	3	4.5	4	6.25
Chlorophyll A (ug/L)	2.4	4.0	2.7	2.6	<2.0	<2.0	2.7	3.3	2.21	<2.0
Total Phosphorus (mg/L)	0.022	0.022	0.025	0.016	0.097	0.021	0.024	<0.003	0.017	0.015

Note: Total phosphorus samples collected from the bottom of the deep hole

* Sample events occurred post 2025 alum treatment

Bold values exceed 0.025 mg/L

For additional information on the alum treatment monitoring, please refer to TRC's monitoring report located here: [High Dose Alum Treatment Monitoring Report 2025](#). (update link)

A mussel survey will be conducted in 2026 in accordance with the Natural Heritage & Endangered Species Program (NHESP) list of conditions following their review of the high-dose alum treatment.

LMAC Phycocyanin, Secchi Disk, and Aluminum Testing

LMAC began testing cyanobacteria levels in 2022, using a handheld fluorometer to measure the levels of phycocyanin, a photosynthetic protein that is found only in cyanobacteria. In 2022 we measured levels in the deep hole and added measurements at Veterans Memorial Beach (VMB) and Everwood Day Camp in 2023 - 2025. We also recorded sightings in EPA's BloomWatch app until it experienced technical difficulties.



Cyanobacteria October 2021



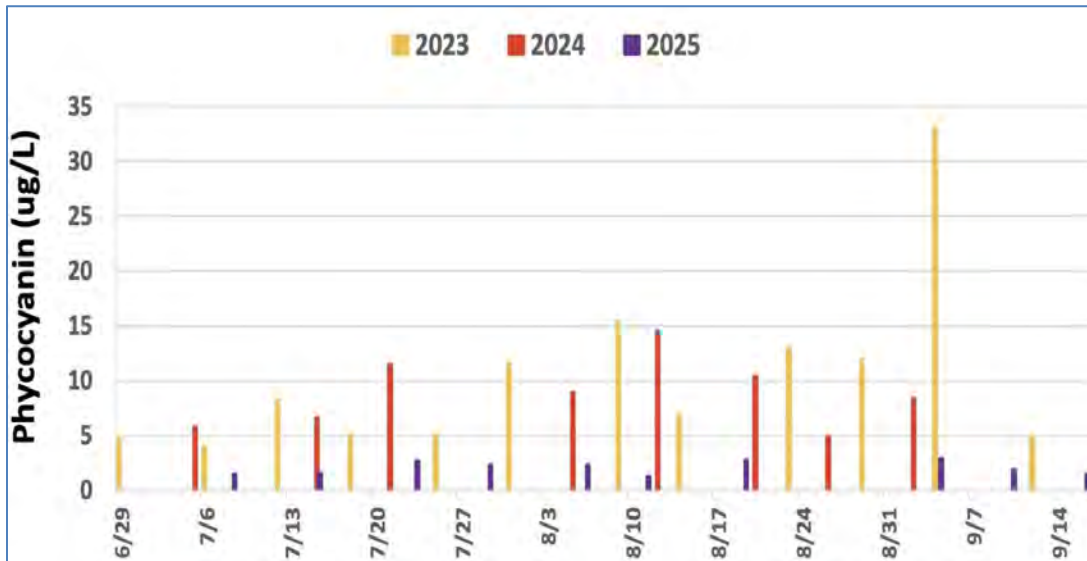
Cyanobacteria September 2023



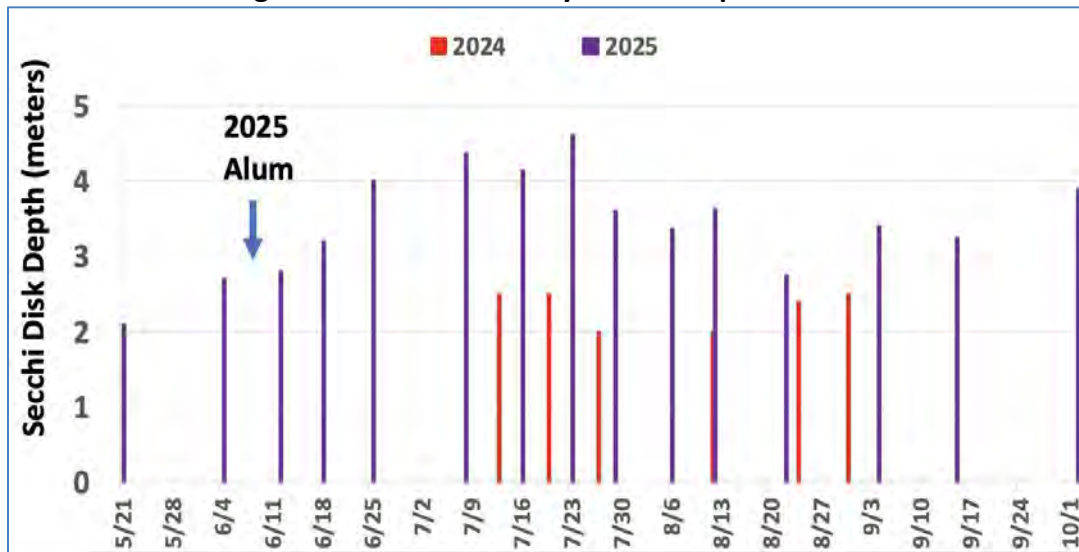
Community Center Beach 2023

In 2024, we began to measure Secchi disk readings, as a measure of water clarity, in the deep hole. Phycocyanin levels decreased compared to prior years following the high-dose alum treatment in June 2025 and Secchi disk depth improved markedly (LMAC Figures A-10 and A-11).

LMAC Figure A-10: Cyanobacteria Levels at Veteran's Memorial Beach 2023-2025
(2025: after alum treatment)



LMAC Figure A-11: Water Clarity in the Deep Hole 2024-2025



LMAC collected monthly samples for aluminum and dissolved aluminum in July and August (LMAC Table A-11). The United States does not have a health-based aluminum drinking water standard; it is for color and odor.

LMAC Table A-11: Total Aluminum Levels Post-Alum Treatment 2025

Month	Veterans Memorial Beach	Community Center Beach	Drinking Water Standards
July	0.11 ml/L	0.12 m/L	Health Based (Canada) 2.9 mg/L
August	0.01 mg/L	0.01 mg/L	Color & Odor (US) 0.05-0.2 mg/L

Note: The US does not have a health-based aluminum drinking water standard.

Neponset River Annual Water Quality Reports

As part of the Community Water Monitoring Network (CWMN) program, NepRWA volunteers collect water quality data from May to October at 41 sites across the watershed. Collected data is submitted to MassDEP. Water quality data includes pH, *E. coli*, phosphorus, and dissolved oxygen (DO). CWMN volunteers sample Sucker Brook, which flows into Lake Massapoag, as well as the sites along Massapoag Brook, the outflow of the lake. Sucker Brook was a frequent source of elevated *E. coli* readings in recent years, and it contributes excess phosphorus to the lake. See NepRWA Table A-12 for results 2022-2025.

NepRWA Table A-12: Sucker Brook Sampling Results May – October 2022-2025

2025	5/8/2025	6/12/2025	7/10/2025	8/14/2025	9/11/2025	10/9/2025
Chlorophyll A (ug/L)	0.669	0.415	2.46	0.566	0.795	1.58
<i>E. coli</i> (MPN/100 mL)	52	279	24200	199	399	11400
TP (mg/L)	0.0413	0.024	0.0494	0.0296	0.0332	0.0549
DO (mg/L)	9.4	9.2	7.48	4.64	8.82	9.49
DO (% saturation)	88	90.5	80.4	85.6	91.1	85.8
DO Temp (C)	12.2	14.2	18.9	22.9	12.9	11.3

2024	5/29/2024	6/13/2024	7/11/2024	8/8/2024	9/12/2024	10/10/2024
Chlorophyll A (ug/L)	8.11	0.618	1.72	0.629	8.36	4.83
Phaeophytin (ug/L)	5.64	1.54	7.18	1.03	10.8	5.49
<i>E. coli</i> (MPN/100 mL)	189	20	246	231	3080	121
TP (mg/L)	0.0325	0.0455	0.0853	0.0463	0.0698	0.0517

2023	5/11/2023	6/8/2023	7/13/2023	8/10/2023	9/14/2023	10/12/2023
Chlorophyll A (ug/L)	0.8	2.39	0.2	0.338	0.232	0.57
<i>E. coli</i> (MPN/100 mL)	148	122	169	109	2480	187
TP (mg/L)	0.028	0.023	0.048	0.048	NA	NA

2022	5/12/2022	6/8/2022	7/14/2022	8/11/2022	9/8/2022	10/13/2022
Chlorophyll A (ug/L)	0.683	0.424	1.03	0.477	0.190	1.07
<i>E. coli</i> (MPN/100 mL)	5	717	933	187	3870	74
TP (mg/L)	0.0495	0.0456	0.0571	0.012	0.0354	0.079

E. coli > 235 MPN/100 mL

TP >0.05 mg/L

Chlorophyll a: oligotrophic =<2, mesotrophic = 2-5, eutrophic = 6-40.

LMAC External Phosphorus Monitoring

During 2022 and 2023, LMAC conducted monthly monitoring of phosphorus levels at lake tributaries, upstream tributaries, and storm drains entering the lake during June-October. In general, the highest phosphorus levels were reported at the outfalls from the Wetland/SHS drainage and 123 Beach St. drainage areas at the northern end of the lake, followed by some of the tributaries entering the lagoon at the southern end. Values above 0.05 mg/L are highlighted in green. For more information, see LMAC Tables A-13 and A-14 below and the tables on the pages posted here: [Inflow Test Results 2023 with comparison](#).

LMAC Table A-13: Phosphorus Levels at Inflows 2023

	2023 Sampling: Targeted Rain Events						
Phosphorus (mg/L)	6/13/2023	6/20/2023	6/27/2023	7/17/2023	8/31/2023	9/26/2023	10/23/2023
Lagoon	0.085	0.028	0.015	0.024			
Lagoon Inflow						0.027	
Everwood Dock	0.016	0.005					
Canoe River			0.030			0.022	
Fletcher's Cove		0.028	0.015				
140 East Foxboro		0.015	0.057	0.049	0.039	0.052	
Opp 123 Beach St			0.085	0.021	0.100	0.107	
Wetland/SHS		0.067	0.152	0.045	0.097	0.094	
Sucker Brook			0.031	0.033	0.022	0.028	
Longmeadow			0.030			0.025	0.022
Landfill Drain S			0.039		0.013		0.025
Landfill Drain N			0.027				0.015
Opp 3 Capen Hill			0.048		0.052	0.191	0.046
240 Massapoag			0.076		0.025	0.124	0.051
308 Massapoag						0.048	0.022
Massapoag/Morse			0.037		0.016		0.045
Rain past 48 hours (in)	0.3	2.4	.5	3.0	.8	1.0	1.0

LMAC Table A-14: Phosphorus Levels at Inflows 2022

	2022 Sampling: 2 of 7 Rain Events							Phos phorus	
Phosphorus (mg/L)	5/23/2022	6/27/2022	7/25/2022	8/22/2022	9/7/2022	9/26/2022	10/31/2022	2-Yr Average	2-Yr Rank
Lagoon								0.038	10
Lagoon Inflow	0.350	0.024	0.038	1.150	0.229	0.019	0.021	0.232	1
Everwood Dock								0.011	16
Canoe River	0.049	0.110	0.400		0.050	0.040	0.024	0.091	6
Fletcher's Cove	0.022	0.010	0.019	0.010	0.027	0.015	0.010	0.017	15
140 East Foxboro	0.133	0.132		0.607	0.131	0.123	0.044	0.126	5
Opp 123 Beach St	0.726	0.157			0.049	0.026	0.035	0.145	2
Wetland/SHS	0.545				0.066	0.069	0.061	0.133	4
Sucker Brook	0.019	0.021	0.032	0.141	0.030	0.012	0.015	0.035	11
Longmeadow	0.032			0.689			0.016	0.136	3
Landfill Drain S	0.021	0.019	0.035		0.032	0.043	0.038	0.029	13
Landfill Drain N	0.021				0.016	0.035	0.010	0.021	14
Opp 3 Capen Hill								0.084	7
240 Massapoag								0.069	8
308 Massapoag					0.041	0.089		0.050	9
Massapoag/Morse								0.033	12
Rain past 48 hours (in)				rain event	post-rain				

NepRWA and LMAC Sucker Brook *E. coli* Testing

NepRWA's monthly testing for *E. coli* levels near the end of Sucker Brook showed high levels in Sept. (2022-2024) and extremely high levels in July 2025, see NepRWA Table A-15. Excessive values above 235 MPN/100 mL are shown in bold.

NepRWA Table A-15: Sucker Brook *E. coli* (MPN/100 mL)

Month/Year	2022	2023	2024	2025
May	5	148	189	52
June	717	122	20	279
July	933	169	246	24,200
Aug	187	109	231	199
Sept	3,870	2,480	3,989	399
Oct	74	187	121	11,400

***Bold** values exceed 235 MPN/ 100 mL*

Source: NepRWA, CWMN

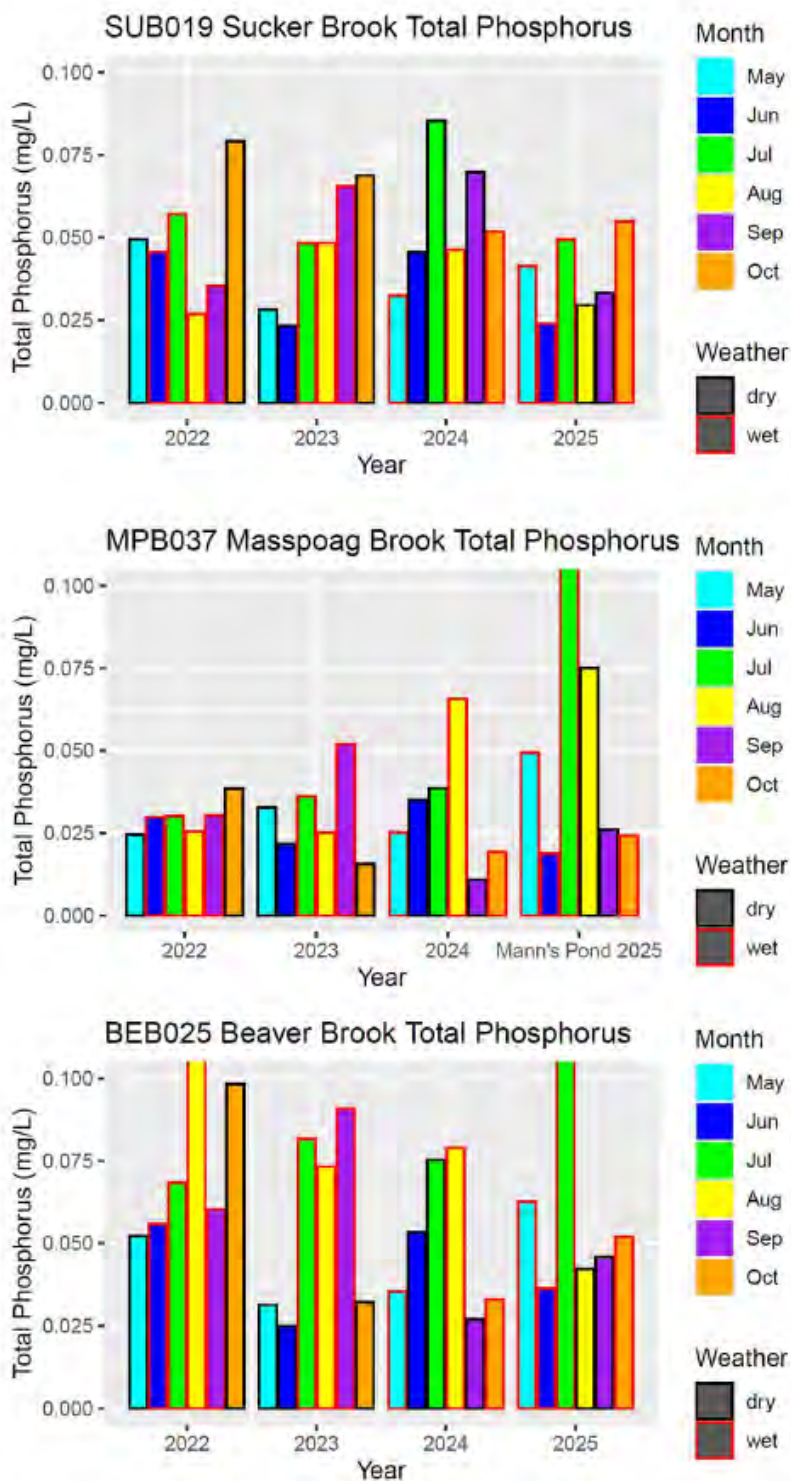
Additional Sucker Brook *E. coli* testing by LMAC during 2022-2023 found the greatest number of elevated *E. coli* readings after heavy rains, which occurred most often during September. LMAC and TRC have done hot spot testing upstream at Sucker Brook to identify sites of *E. coli* contamination, as it is the most consistent site of elevated *E. coli*. We plan DNA testing to identify the presence of human, goose, canine, and/or deer fecal contamination at Sucker Brook and the Community Center Beach swim area.

NepRWA CWMN Sites in Sharon Phosphorus and *E. coli* Trends

NepRWA Figure A-12 on the following page illustrates 2022-2025 trends in phosphorus collected monthly May-October under NepRWA's CWMN program. The Sucker Brook site was added in 2022 at LMAC's request; NepRWA has collected historical data on both Massapoag Brook, downstream from the lake, and on Beaver Brook, which originates in Moose Hill Audubon Sanctuary. Beaver Brook, downstream from the town's Farnham Road composting area, has higher levels of phosphorus than Massapoag Brook. In 2025, NepRWA moved the Massapoag Brook site from downstream of the flume outlet to Mann's Pond, leading to a loss of comparative data.

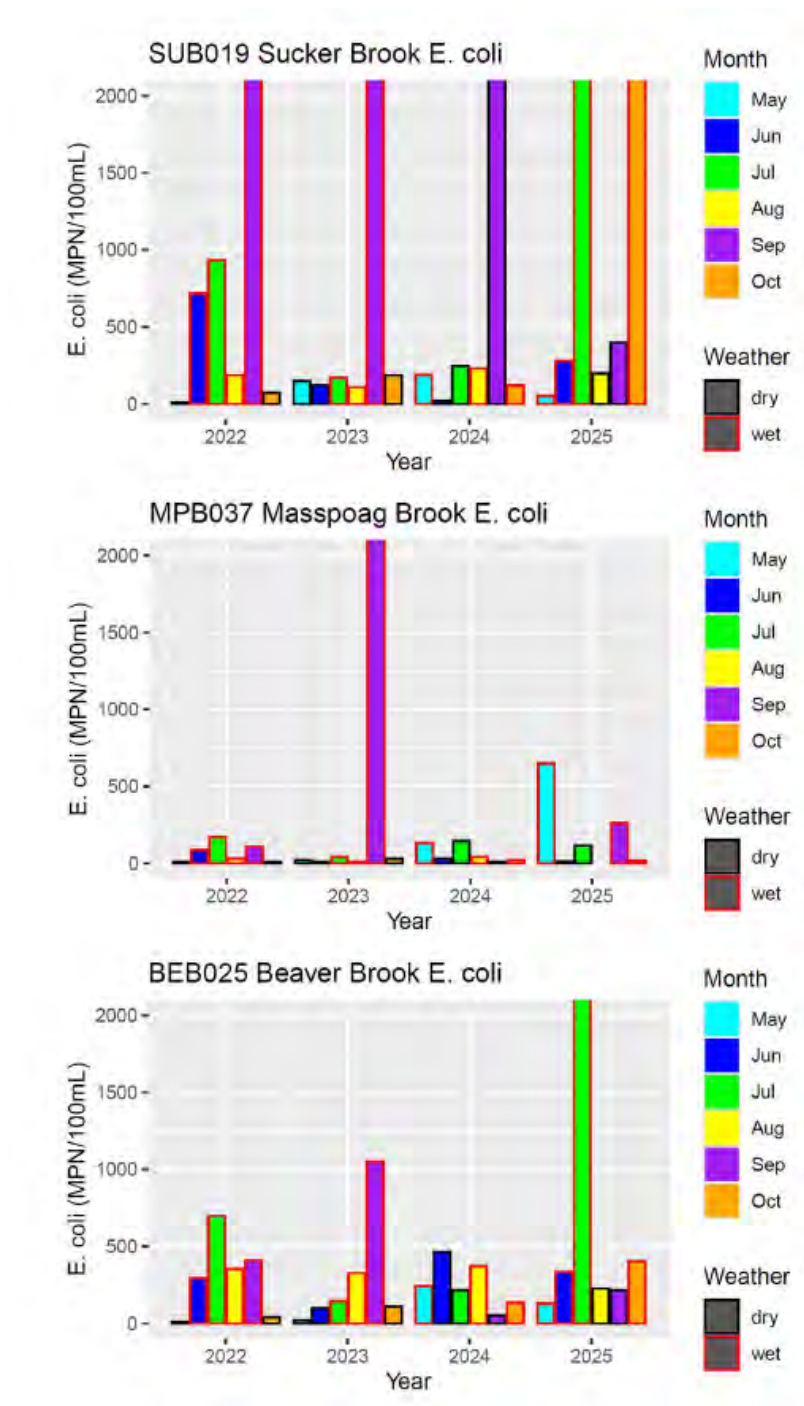
NepRWA Figures A-13 illustrates 2022-2025 trends in *E. coli* collected monthly May-October under NepRWA's CWMN program. The Sucker Brook site was added in 2022 at LMAC's request; NepRWA has collected historical data on both Massapoag Brook, downstream from the lake, and on Beaver Brook, which originates in Moose Hill Audubon Sanctuary. In 2025, NepRWA moved the Massapoag Brook site from downstream of the flume outlet to Mann's Pond, leading to a loss of comparative data. Sucker Brook continues to have elevated *E. coli* levels, especially during or after rain events.

NepRWA Figure A-12: Total Phosphorus at Sucker Brook, Massapoag Brook, Beaver Brook 2022-2025



Source: NepRWA

NepRWA Figure A-13: *E. coli* at Sucker Brook, Massapoag Brook, Beaver Brook 2022-2025

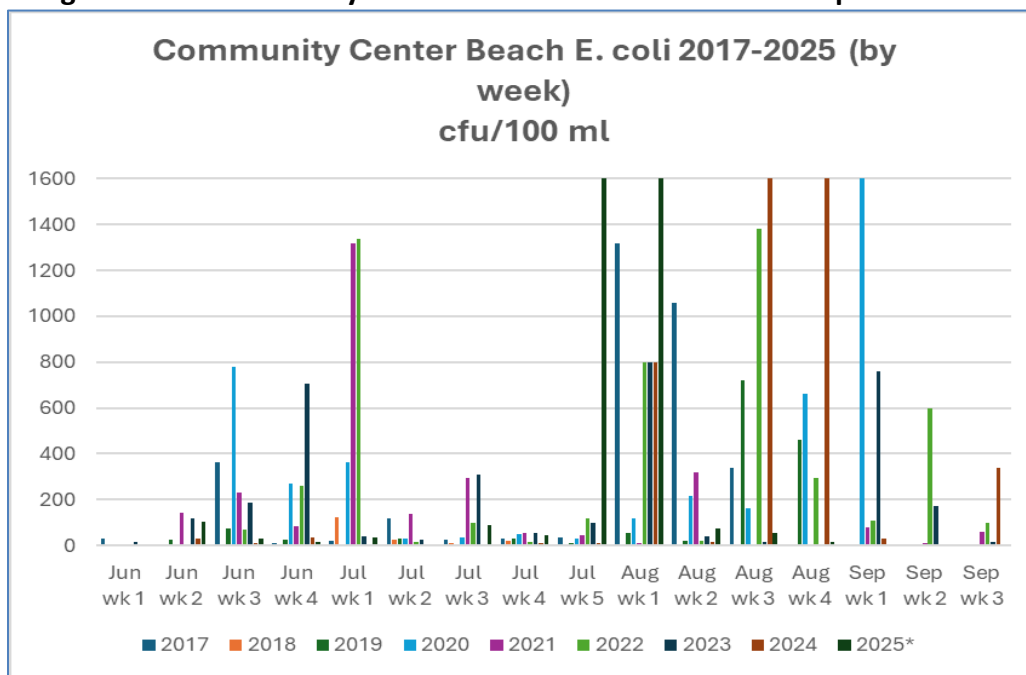


Source: NepRWA

Town of Sharon Swim Beach *E. coli* Testing

The Town of Sharon Board of Health tests its swim beaches weekly for *E. coli* June-September, as do camps located on the lake and Massapoag Yacht Club. The Town's Community Center Beach (CCB), on the southern end, has had the most frequent closings (*E. coli* > 235 cfu/100 ml or Geomean 5 samples > 126 cfu/100 ml), see LMAC Figure A-14 and LMAC Table 16 below for 2017-2025. After eight elevated *E. coli* readings in 2022, the Town closed CCB for swimming in the 2023 and 2024 seasons.

LMAC Figure A-14: Community Center Beach *E. coli* levels June - September 2017-2025



The beach was reopened for the 2025 season; however, elevated *E. coli* levels resulted in its closure from late July till the end of the season in August, with several exceedances over 1,600 CFU/100 ml. Over the past nine years, half of all *E. coli* closures at CCB have occurred in August, with the balance split between June, July and September. Annual reports on swim beach *E. coli* levels are located here: [Lake Dashboard and Water Quality | Town of Sharon MA](#) and at the bottom of [Swimming Beach and Lake Testing | Town of Sharon MA](#).

LMAC Table A-16: Closures of Community Center Beach due to High *E. coli* Levels 2017-2025

Month:	June	July	Aug	Sep	Tot. Close
Closures:	5	6	15	4	30
Percent:	17%	20%	50%	13%	100%

Note: Beach closes when *E. coli* > 235 cfu/100 ml or Geomean 5 samples > 126 cfu/100ml

Source: Town of Sharon Board of Health. Compiled by LMAC

Sharon's main beach, Veterans Memorial Park Beach, Salvation Army Camp Wonderland, Everwood Day Camp's two beaches, and Massapoag Yacht Club have had good water quality, with a combined total of only four elevated readings and two closures during beach seasons 2022-2025, and two more before or after the season.

Invasive and Native Aquatic Weeds

Present Aquatic Plant Assemblage

The most recent plant survey at Lake Massapoag was conducted by TRC in July 2023. The aquatic plant community observed at Lake Massapoag consisted of 16 species, three of which are invasive exotic species (TRC Table 11). Two of the three invasives, fanwort (*Cabomba caroliniana*) and variable-leaf milfoil (*Myriophyllum heterophyllum*), are often associated with the formation of high-biovolume, nuisance-level beds. In contrast, the third invasive species, mudmat (*Glossostigma cleistanthum*), while capable of forming extensive beds, is diminutive in size. Another invasive, brittle naiad (*Najas minor*) was identified at the lake in 2021 but was not observed during subsequent surveys (SOLitude, 2021). Invasive and nuisance species have been managed at Lake Massapoag since the 1960s. A history of plant management activities performed at the lake are described in the following sections, and include winter level drawdown, herbicide use, and DASH.

In 2023, the most frequently observed native aquatic plant species included waterweed (*Elodea nutallii*), stonewort (*Nitella* sp. – a type of macroalgae), watershield (*Brasenia schreberi*), and yellow water lily (*Nuphar variegata*). The floating-leaved lilies and watershields were almost exclusively observed in Fletcher’s Cove and the eastern part of South Cove, as well as in the Lagoon. Although not invasive, waterweed and water lilies have been observed at increasing densities at the lake. Future plant management may need to accommodate these nuisance species.

State-listed endangered and protected species are known to occur in the lake and include toothcup (*Rotala ramosior*) and resupinate bladderwort (*Utricularia resupinata*). Both species are protected under the Massachusetts Endangered Species Act and are classified as Endangered and Threatened, respectively. A botanist survey of endangered plants was conducted by Pondweed Pursuits LLC in August and September 2023, with the report submitted to NHESP later in September, as part of LMAC’s efforts to conduct DASH in additional areas.

TRC Table A-17: Aquatic Plant Species Observed at Lake Massapoag, July 2023

Scientific Name	Common Name	Growth Form	Status
<i>Brasenia schreberi</i>	Watershield	Floating leaved- attached	Native
<i>Cabomba caroliniana</i>	Fanwort	Submerged- attached	Invasive
<i>Eleocharis sp.</i>	Spikerush	Submerged- attached	Native
<i>Elatine sp.</i>	Waterwort	Submerged- attached	Native
<i>Elodea nuttallii</i>	Free-flowered waterweed	Submerged- attached	Native
<i>Glossostigma cleistanthum</i>	Mudmat	Emergent	Invasive
<i>Myriophyllum heterophyllum</i>	Variable-leaf milfoil	Submerged- attached	Invasive
<i>Najas gracillima</i>	Slender waternymph	Submerged- attached	Native
<i>Nuphar variegata</i>	Yellow water-lily	Floating leaved- attached	Native
<i>Nymphaea odorata</i>	White water-lily	Floating leaved- attached	Native
<i>Nitella sp.</i>	Stonewort	Submerged- attached	Native macroalga
<i>Potamogeton epihydrus</i>	Ribbon-leaved pondweed	Submerged-attached	Native
<i>Potamogeton perfoliatus</i>	Clasping-leaved pondweed	Submerged- attached	Native
<i>Utricularia radiata</i>	Floating bladderwort	Floating- unattached	Native
<i>Utricularia minor</i>	Lesser bladderwort	Submerged- unattached	Native
<i>Vallisneria americana</i>	Tape grass	Submerged- attached	Native

Plant Management

Excessive weed and algal growth have been observed at Lake Massapoag since the 1960s. Aquatic plants, particularly the invasive fanwort and variable leaf milfoil, have been managed at the lake using winter drawdown, herbicides, and more recently DASH. Descriptions of the different management techniques are described below.

Winter Drawdown

Excessive weed and algal growth in Lake Massapoag were noted in the 1960s and helped catalyze the Town's formation of the original Lake Massapoag Study Committee (LMSC) in 1969. The town received grant funds and local match to conduct a comprehensive *Diagnostic and Feasibility Study* by IEP in 1981, which was completed in 1984. IEP completed a companion *Update of Aquatic Vegetation Survey* in 1987 to examine the effects of past years' winter drawdown program on nuisance aquatic vegetation, and to guide best practices for weed control in the future. Winter drawdowns had been used since 1970 following the first chemical treatment of the marsh (now lagoon) at the south end of the lake. The predominant plants were non-nuisance with slow growth and no recreational disadvantages, and species diversity was high. The assistant recreation director noted less of a swim area problem than in past years and reported staff were raking fewer plants from the beach than in prior years.

The winter drawdown program was deemed highly successful as both water milfoil and American Elodea decreased since IEP surveys of 1981 and 1982. However, it was noted that vegetation may be slowly changing to those more tolerant to a drawdown. The report recommended changing the winter drawdown frequency from three out of four years to every other year and conducting a new survey every two years. It noted progress in reducing nutrients through capping the town's landfill, enhancing the ability of wetlands entering the southern end of the lake to retain nutrients during the growing season, and plans for the town to construct sewers around the lake to achieve an estimated 40 percent removal of phosphorus.

Unfortunately, the proposed sewer project outlined in a 1989 feasibility study was voted down, and new lake level guidelines were mandated by DEP to ensure sufficient release of lake water downstream to Massapoag Brook and the Neponset River and its watershed. With the adoption of the Policies and Procedures in 1991 and amended in 2000, winter drawdowns were no longer feasible. Lake Massapoag began losing ground against nuisance weeds and experienced growth of invasive weeds, principally fanwort and variable milfoil.

Herbicide

Herbicide treatments were first used to control invasive weeds in Lake Massapoag in the marsh (now lagoon) at the southern end of the lake in 1969. Both the South Cove and Fletcher's Cove were treated with the fluridone in 2014, and the Lagoon was treated with fluridone in 2018. These treatments were complicated, involving lake drawdown and physical separation of the lagoon from the South Cove, due to the presence of the endangered toothcup in shallow water of the South Cove. The lake drawdown for the herbicide treatment in 2014 was detrimental to the enjoyment of the lake that season.

Fluridone treatment is no longer feasible due to the required protection of a second endangered plant species, resupinate bladderwort, which was reported in shallow waters on the western side of the South Cove. The non-selective nature of fluridone can have an impact on native species.

DASH

Based on the limitations of winter drawdown and herbicide treatments, hand-pulling aquatic invasives from the lake is the preferred management method. The LMAC has been using the same contractor, New England Aquatic

Services (NEAS), to hand-pull fanwort and variable-leaf milfoil by the root and suction it onto the boat for disposal. This procedure is called Diver-Assisted Suction Harvesting or DASH. This expensive method is required for fanwort and variable-leaf milfoil removal because both are extremely invasive plants that can propagate from fragments. The goal is not to eradicate the invasive species as that is not feasible. The goal is to bring the growth levels down so that they can be managed with a smaller budget or number of days of DASH.

LMAC Table A-17 shows LMAC's DASH efforts 2017-2025. DASH was funded at 2 days per year until 2020, and this seemed to be sufficient along with the periodic fluridone treatments, which are now problematic for the reasons discussed above. In 2020 it was noted that the Lake Committee was losing ground in its fight against fanwort due to inadequate funding, and the town voted to approve \$17,600 in reserve funds. However, in 2021 no DASH was conducted (16 days of DASH were recommended), due to scheduling issues related to COVID and a two-week lakewide closure in mid-July due to cyanobacteria. Those funds were used for 8 days of DASH in 2022, and repeated in 2023, along with similar amounts of hand pulling of fanwort in the Lagoon and Fletcher's Cove in 2023, and a day of nuisance weed pulling at the east end of Memorial Beach.

In 2023, LMAC raised funding and began ramping up the DASH efforts, with 8 days in South Cove. Plans for DASH in Fletcher's Cove were hampered by low water levels, so LMAC also contracted for hand-pulling that year, adding 11.5 days in Fletcher's Cove, 4 days in the Lagoon, and one day to pull nuisance clasping leaf pondweed in the eastern Memorial Beach swim area.

In 2024 and 2025, LMAC was able to increase to 20-22 days of DASH, due to the prior grant from CPC and an annual donation from Everwood Day Camp. In 2025, fanwort and milfoil expansion was additionally fueled by the alum treatment. While phosphorus levels were reduced, the increase in water clarity allowed more sun to reach the plants in the shallow coves. NEAS estimates 35 days of DASH are needed in the coves in 2026. LMAC is seeking funds for the recommended 35 days of DASH in 2026. Most of the DASH to date has been directed in the South Cove, but there is marked expansion of fanwort in Fletcher's cove which must be addressed.



Pre-Dash S. Cove Aug. 2022 DASH S. Cove late Aug. 2025 Post-DASH S. Cove weeds early Sept. 2025

During the four years 2022-2025, LMAC has expended \$164,025 on invasive weed control, of which 71% has been in the South Cove, 26% in Fletchers Cove, 3% in the Lagoon, and 1% in the Memorial Beach swim area.

LMAC Table A-18: Summary of DASH Efforts 2017-2025

DASH	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Rec days	2	2	2	4	16	25-30	25-30	24	24	35
days	2	2	2	2	0	8	8	22	20	TBD
Days SC	2	2	2		0	8	8	18	13	TBD
Days F	0	0	0		0	0	0	4	7	TBD
gallons	450	NA	1240	1390	0	4,180	5,265	16,440	9765	
gals/day	225		620	695	0	523	658	747	488	
two sessions								Yes	Yes	Planned

Note: Rec = Recommended, SC = South Cove, F = Fletchers Cove

Aquatic Weed Fragment Barrier and Filtergrass

Besides DASH, LMAC has also used funds toward remediating the source of the fanwort infestation. The dense fanwort infestation in the lagoon indicates that it was likely started by someone dumping their home aquarium containing fanwort into the lagoon. Because the South Cove can be seeded by fragments of fanwort flowing from the lagoon, steps were taken to mitigate this process. In 2024, LMAC installed a mesh barrier at the inlet of the lagoon into the South Cove to help prevent fanwort fragments from passing into the South Cove where they can re-root. CPC funds provided \$11,312 for the EverBlue Aquatic Barrier and supplemental filtergrass. Everwood Day Camp provides weekly maintenance to clear weeds trapped by the barrier from entering the cove. The Town's Conservation Administrator manages the control structure at the lagoon entrance to the South Cove to help limit excess water flow, phosphorus and weed transfer.

Invasive Plant Growth Patterns

Despite years of management efforts, beds of fanwort and variable-leaf milfoil remain in the lake, particularly in the lagoon, South Cove, and Fletcher's Cove. Below describes the trends for fanwort and variable-leaf milfoil coverage from 2018 through 2023. Mapping was not conducted in 2024 and 2025 but will be conducted in 2026.

SOLitude Mapping

Following the fluridone treatment in August 2018, SOLitude mapped the aquatic vegetation in the lake (Solitude Figure A-15). Their mapping showed that the lagoon was dense with fanwort (dying off at the time of the survey due to the herbicide treatment). Fanwort was also observed in the eastern portion of the South Cove (Solitude Figure A-15).

SOLitude Figure A-15: Weed Maps/Vegetation Assemblage in Lake Massapoag 2018



Note: Areas of variable-leaf milfoil and fanwort are circled in yellow.

Source: SOLitude, 2018

In July 2019, SOLitude conducted another aquatic plant survey. A small patch of fanwort was observed in the lagoon. Fanwort and variable-leaf milfoil were still observed in the eastern portion of the South Cove and a new patch of both invasive plants was observed in the southeastern corner of the lake by Community Center Beach. A patch of variable leaf milfoil was observed in Fletcher's Cove (Solitude Figure A-16).

SOLitude Figure A-16: Weed Maps/Vegetation Assemblage in Lake Massapoag 2019

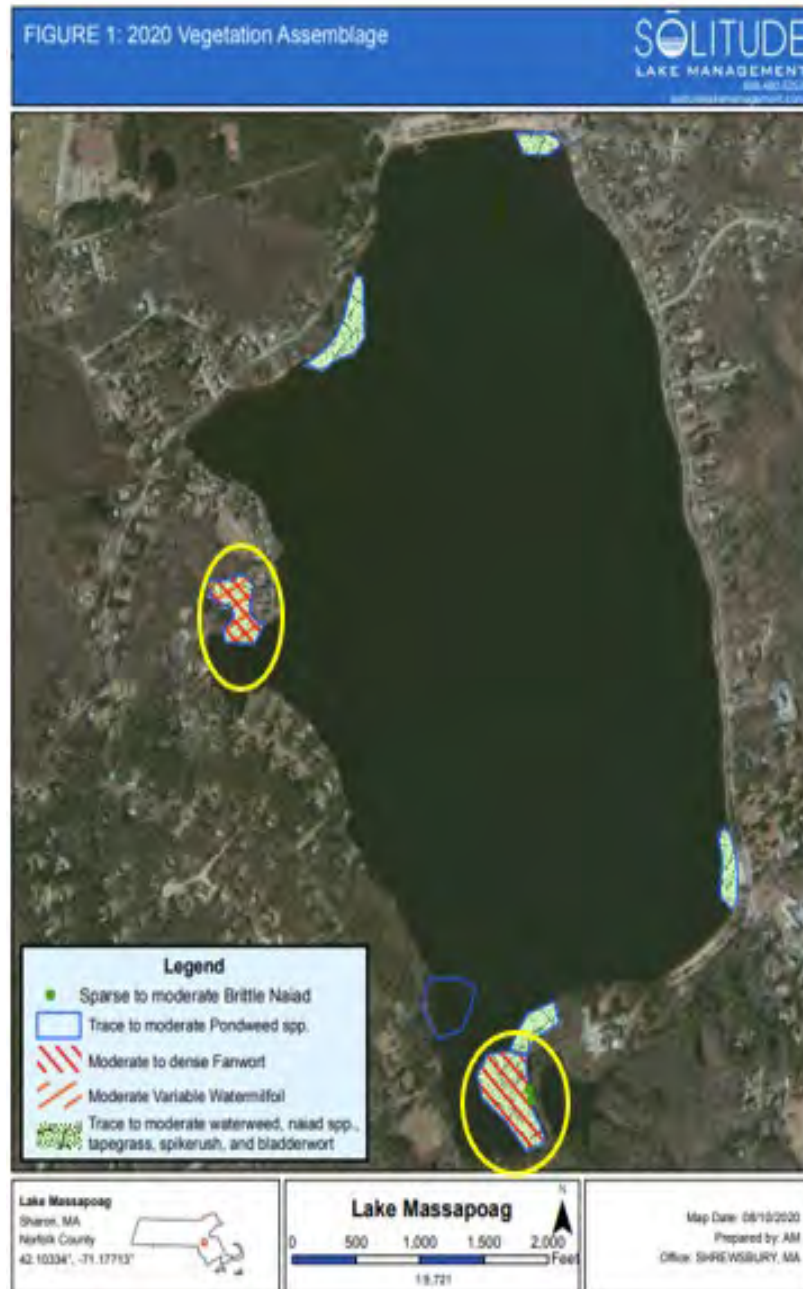


Note: Areas of variable-leaf milfoil and fanwort are circled in yellow.

Source: SOLitude, 2019

In August 2020, fanwort and variable leaf milfoil were not mapped in the lagoon. However, patches of fanwort and variable-leaf milfoil were observed covering a larger area in Fletcher's Cove and the South Cove, compared to 2019 (Solitude Figure A-17).

SOLitude Figure A-17: Weed Maps/Vegetation Assemblage in Lake Massapoag 2020



Note: Areas of variable-leaf milfoil and fanwort are circled in yellow.

Source: SOLitude, 2020

In October 2021, SOLitude mapped fanwort in Fletcher's Cove in the same area that it was observed in 2020. An increase of fanwort and variable-leaf milfoil coverage was observed in the South Cove. Similar to 2020, fanwort and variable leaf milfoil were not mapped in the lagoon (Solitude Figure A-18)

SOLitude Figure A-18: Weed Maps/Vegetation Assemblage in Lake Massapoag 2021



Note: Areas of variable-leaf milfoil and fanwort are circled in yellow.

Source: SOLitude, 2021

In October 2022, TRC conducted a plant mapping effort at the lake. TRC did not observe beds of variable-leaf milfoil. Fanwort was mapped in Fletcher's cove. Fanwort was observed to be dense in the lagoon. Fanwort was observed in the South Cove, but in a smaller area than previously mapped in 2021 (TRC Figure A-19).

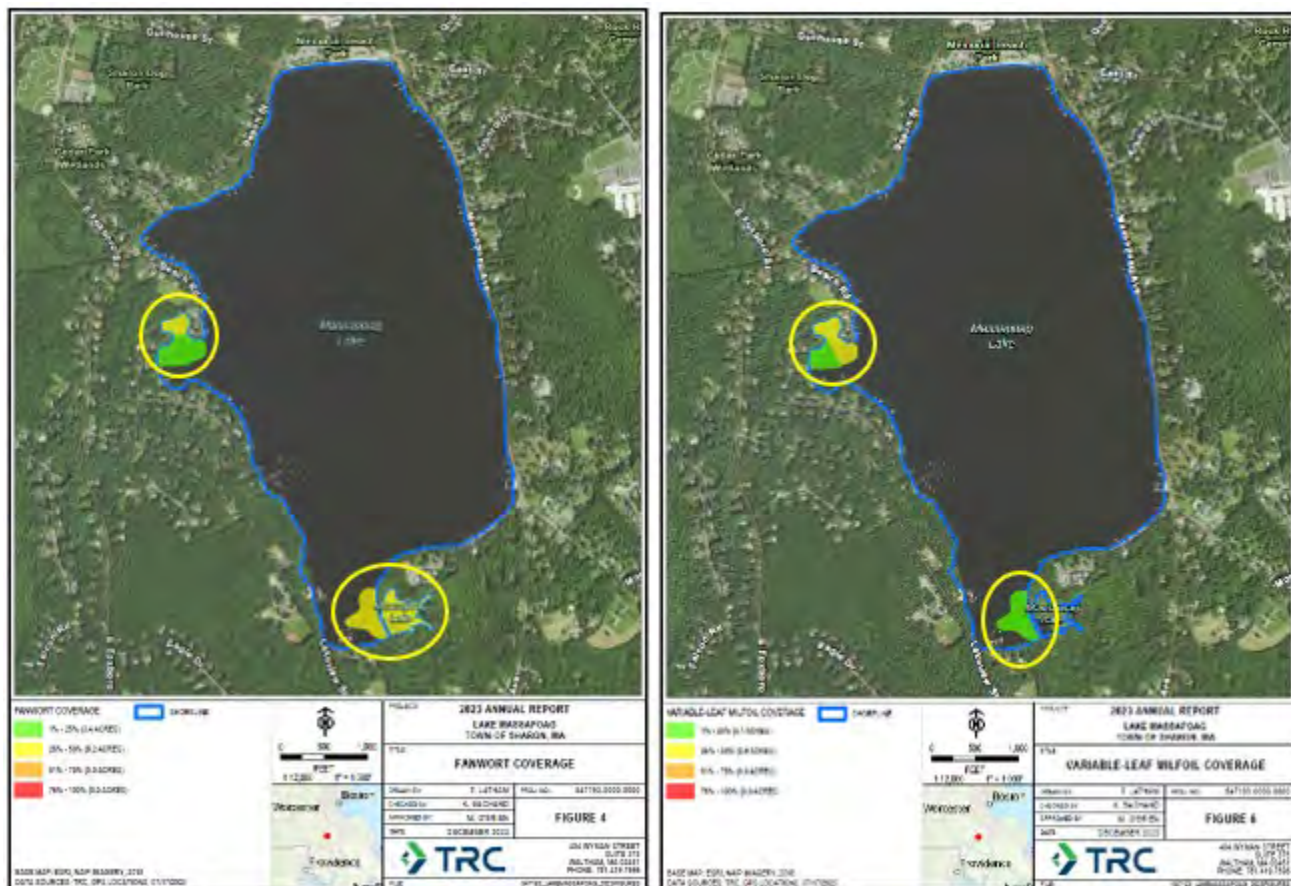
TRC Figure A-19: Fanwort Coverage in Lake Massapoag 2022



Note: Areas of fanwort are circled in yellow. Source: TRC, 2023

In July 2023, TRC mapped fanwort in Fletcher's cove, the lagoon, and South Cove. Fanwort was observed at sparse to moderate densities in Fletcher's cove, indicating an increase in fanwort density compared to 2022. Fanwort coverage area in the South Cove expanded and was mapped to be moderately dense. Fanwort in the lagoon was also mapped to be moderately dense (TRC Figure A-20, left image). Variable-leaf milfoil was also observed in 2023 in Fletcher's Cove and the South Cove but was not observed in the lagoon (TRC Figure A-20, right image).

TRC Figure A-20: Fanwort (Left) and Variable-Leaf (Right) Coverage in Lake Massapoag 2022



Note: Areas of fanwort and variable-leaf milfoil are circled in yellow. Source: TRC, 2024

Water Quality Impairments

Known water quality impairments, as documented in the Massachusetts Department of Environmental Protection (MassDEP) 2022 Massachusetts Integrated List of Waters (MassDEP, 2023a), are listed below. Impairment categories from the Integrated List are as follows:

Table A-19: 2022 MA Integrated List of Waters Categories

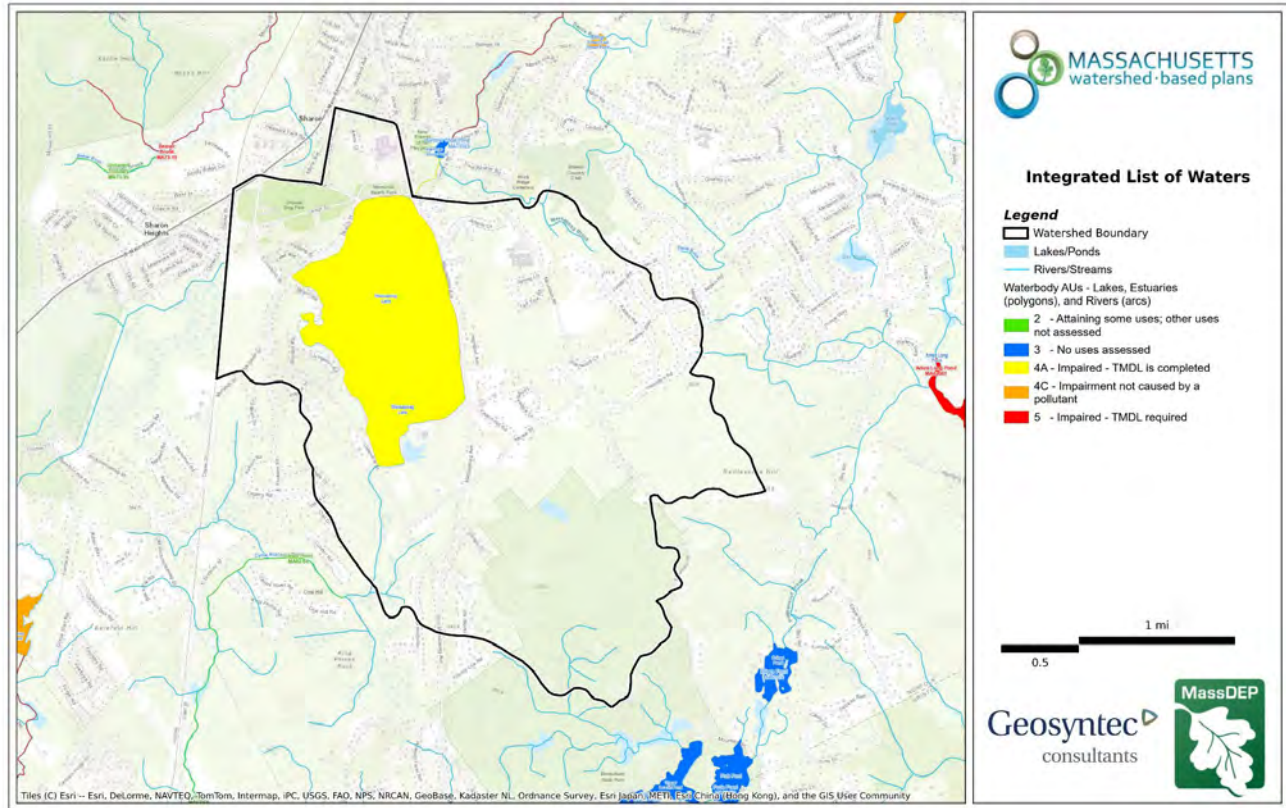
Integrated List Category	Description
1	Unimpaired and not threatened for all designated uses.
2	Unimpaired for some uses and not assessed for others.
3	Insufficient information to make assessments for any uses.
4	Impaired or threatened for one or more uses, but not requiring calculation of a Total Maximum 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-20: Water Quality Impairments (MassDEP 2023a)

Assessment Unit ID	Waterbody	Integrated List Category	Designated Use	Impairment Cause	Impairment Source
MA73030	Massapoag Lake	4A	Fish Consumption	MERCURY IN FISH TISSUE	ATMOSPHERIC DEPOSITION - TOXICS
MA73030	Massapoag Lake	4A	Fish Consumption	MERCURY IN FISH TISSUE	SOURCE UNKNOWN
MA73030	Massapoag Lake	4A	Fish, other Aquatic Life and Wildlife	NON-NATIVE AQUATIC PLANTS	INTRODUCTION OF NON-NATIVE ORGANISMS (ACCIDENTAL OR INTENTIONAL)

Note that the TMDL is related to the mercury content in fish, part of the Northeast Regional Mercury TMDL. The impaired waterbodies listed in **Table A-19** are identified in **Figure A-21**.

Figure A-21: Watershed Water Quality Impairments Map



Note: TMDL shown is Neponset-wide TMDL, not Lake Massapoag-specific TMDL.

Neponset TMDL is linked in Table B-1.

Source: (MassGIS, 2007; MassGIS, 1999; MassGIS, 2001; USGS, 2016; MassGIS, 2023)

Water Quality Goals

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

- For **water bodies with known impairments**, a [Total Maximum Daily Load](#) (TMDL) is established by MassDEP and the United States Environmental Protection Agency (USEPA) as the maximum amount of the target pollutant that the waterbody 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.
- 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](#) (USEPA, 1986) (also known as the “Gold Book”). The Gold Book states that TP should not exceed 50 ug/L in any stream at the point where it enters any lake or reservoir, nor 25 ug/L within a lake or reservoir. For the purposes of developing WBPs, MassDEP has adopted 50 ug/L as the TP target for all streams at their downstream discharge point, regardless of which type of water body to which the stream discharges.

c.) [Massachusetts Surface Water Quality Standards](#) (MassDEP 2022) prescribe the minimum water quality criteria required to sustain a waterbody's designated uses. Massapoag Lake is a Class 'B' waterbody, which means it is suitable for primary and secondary contact recreation, fishing, and other recreational activities. Class 'A' waterbodies are suitable for public drinking water supplies. 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** (e.g., protection of high-quality waters, in-lake phosphorus concentration goal to reduce recurrence of cyanobacteria blooms, etc.).

Table A-21: Surface Water Quality Classification by Assessment Unit

Assessment Unit ID	Waterbody	Class
MA73030	Massapoag Lake	B

Table A-22: Water Quality Goals

Pollutant	Goal	Source
Total Phosphorus (TP)	Total phosphorus should not exceed: --50 ug/L in any stream --25 ug/L within any lake or reservoir	Quality Criteria for Water (USEPA, 1986)
Bacteria	<u>Class B Standards</u> - Primary contact recreation: For <i>E. coli</i>, geometric mean of samples collected within any 90-day or smaller period shall not exceed 126 cfu/100 mL, and no more than 10% of all such samples shall exceed 410 cfu/100 mL. For enterococci, geometric mean of all samples collected within any 90-day or smaller period shall not exceed 35 cfu/100 mL, and no more than 10% of all such samples shall exceed 130 cfu/100 mL. - Waters adjacent to any public or semi-public beach, at a location used for bathing and swimming purposes or waters impacted by combined sewer overflows (CSO) or publicly owned treatment works (POTW) discharges: For <i>E. coli</i>, geometric mean of samples collected within any 30-day or smaller period shall not exceed 126 cfu/100 mL, and no more than 10% of all such samples shall exceed 410 cfu/100 mL. For enterococci, geometric mean of all samples collected within any 30-day or smaller period shall not exceed 35 cfu/100 mL, and no more than 10% of all such samples shall exceed 130 cfu/100 mL.	Massachusetts Surface Water Quality Standards (MassDEP, 2022)
Nonnative Aquatic Macrophytes	DASH treatments have been conducted at Lake Massapoag to target the invasive fanwort and variable-leaf milfoil currently located in the South Cove, Fletcher's Cove, and the Lagoon. The goal is to decrease the presence of these invasive species (from 2022 and 2023 surveys) over time through annual DASH efforts.	See aquatic weed figures and information in the 2022 and 2023 TRC Annual Reports.

Note: There may be more than one water quality goal for bacteria due to different Massachusetts Surface Water Quality Standards Classes for different Assessment Units within the watershed.

Land Use and Impervious Cover Information

Land use information and impervious cover are presented in the tables and figures below. Land use source data is from 2016 and was obtained from MassGIS (2019). The land use and land cover categories were matched with the associated land use category using the methodology identified in the MassDEP guidance document “2016 Massachusetts Small MS4 Permit Pollutant Loading Export Rates applied to the 2016 Massachusetts Land Use/Land Cover GIS Dataset” (MassDEP, 2023b). **Table A-23** includes the area and percentage of watershed of each of these land use categories.

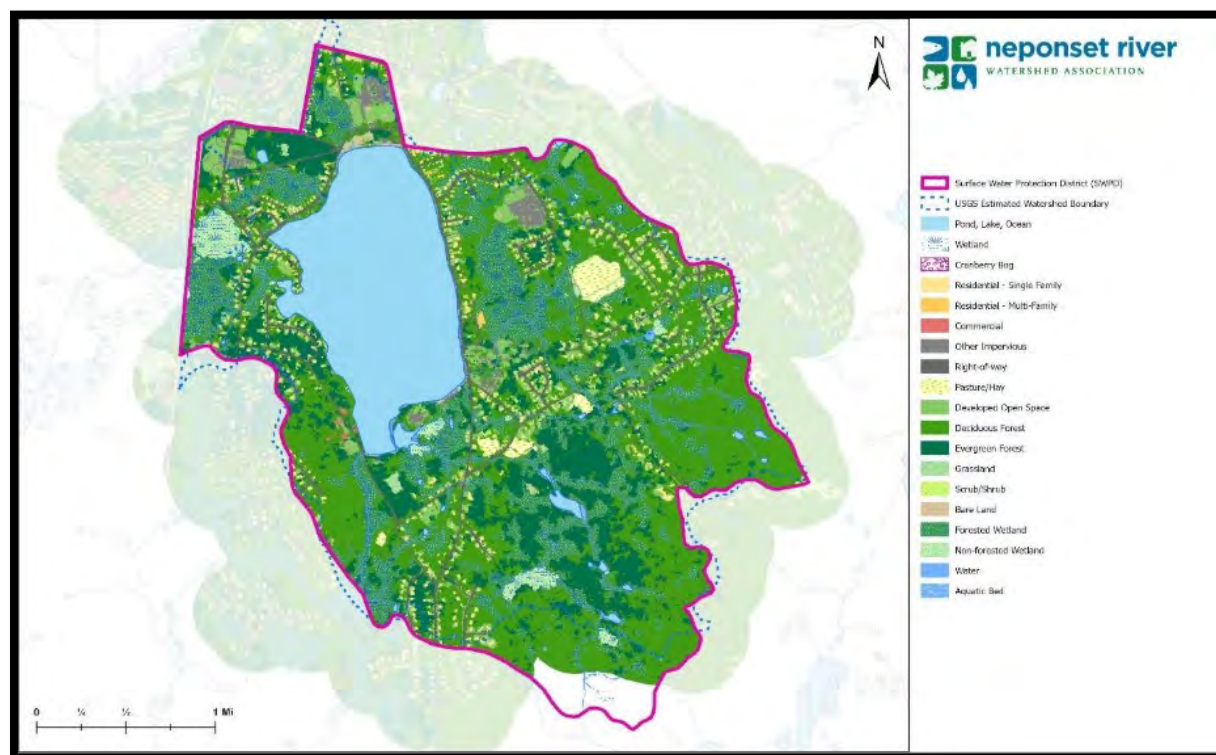
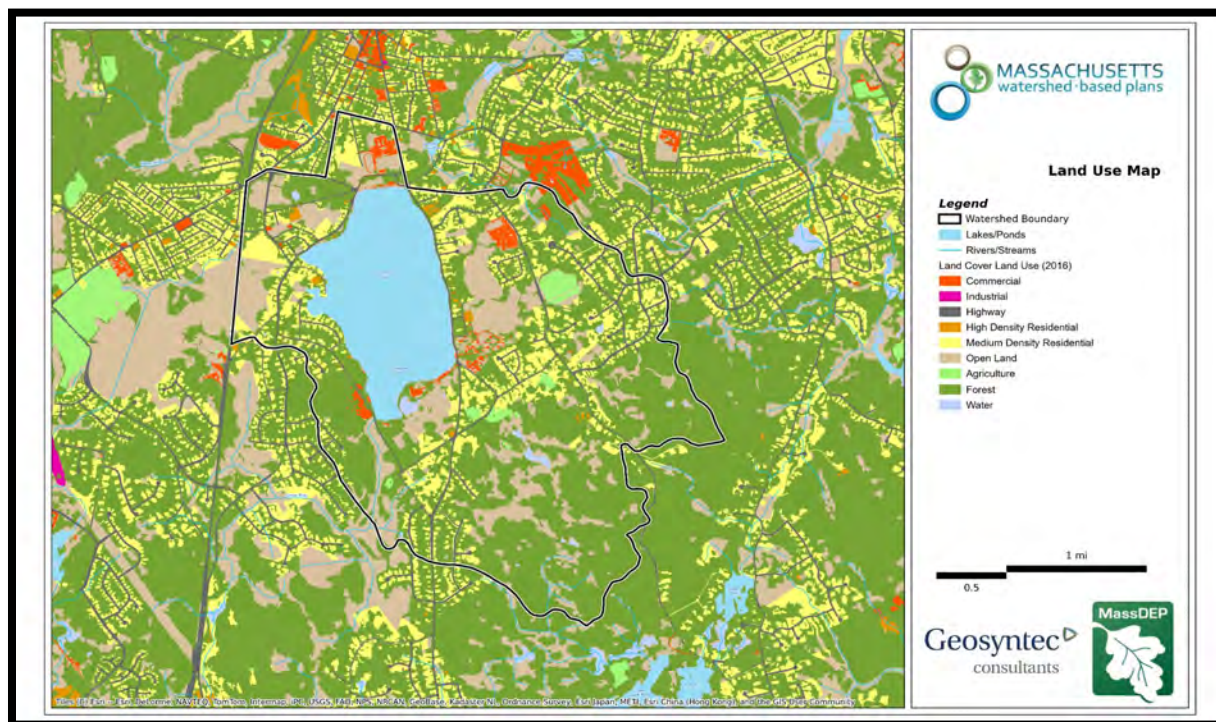
Watershed Land Uses

Table A-23: Watershed Land Uses

Land Use	Area (acres)	% of Watershed
Agriculture	29.71	1.1
Commercial	38.34	1.4
Forest	1293.25	48.5
High Density Residential	10.2	0.4
Highway	103.89	3.9
Industrial	0	0
Medium Density Residential	348.39	13.1
Open Land	432.47	16.2
Water	408.87	15.3

Source: NepRWA

Figure A-22: Comparative Watershed Land Use Map
 (MassGIS, 2007; MassGIS, 2019; MassGIS, 1999; MassGIS, 2001; USGS, 2016) from WBP Tool and
 NepRWA Desktop Analysis



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. The total impervious area was estimated for the watershed based on the land use and impervious cover source data from 2016 (MassGIS, 2019). Impervious areas made up 7.2% of the watershed. See **Table A-24**.

Table A-24: Total Impervious Area (TIA) Values for the Watershed

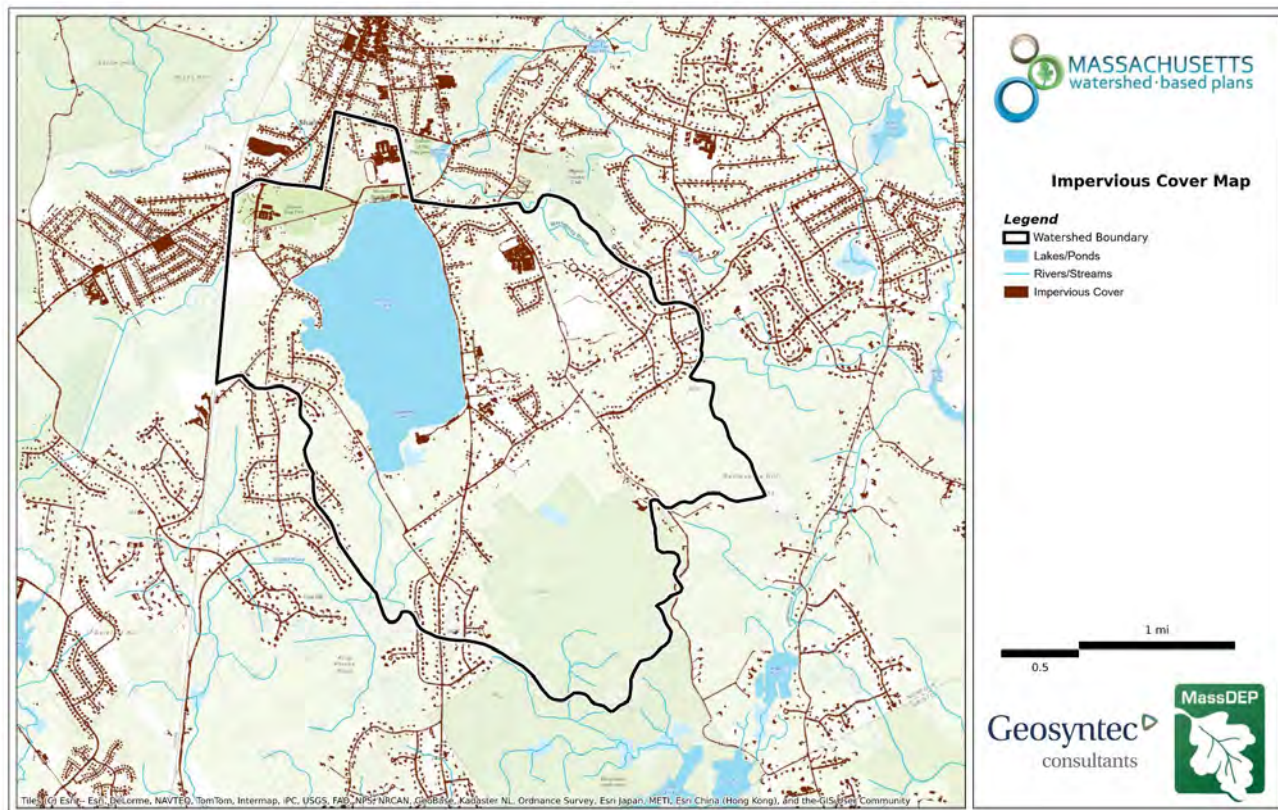
Watershed	Estimated TIA (%)
Lake Massapoag	7.2

The relationship between the total impervious area and water quality can generally be categorized as shown in **Table A-25** (Schueler et al. 2009):

Table A-25: Relationship between Total Impervious Area and water quality (Schueler et al. 2009)

% Watershed Impervious Cover	Stream Water Quality
0-10%	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.
11-25%	These streams show clear signs of degradation. Elevated storm flows begin to alter stream geometry, with evident erosion and channel widening. Stream 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.
26-60%	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-23: Watershed Impervious Surface Map
(MassGIS, 2007; MassGIS, 2019; MassGIS, 1999; MassGIS, 2001; USGS, 2016)



Pollutant Loading

Geographic Information Systems (GIS) data was used for the pollutant loading analysis. The land use data (shown in **Figure A-22**) was intersected with impervious cover data (shown in **Figure A-23**) and United States Department of Agriculture (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.

Pollutant loading for key nonpoint source pollutants in the watershed was estimated by multiplying each land use/cover type area by its pollutant load export rate (PLER) as follows:

$$L_n = A_n * P_n$$

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

The PLERs are an estimate of the annual unattenuated potential total pollutant load exported via stormwater from a given unit area of a particular land cover type. **Table A-26** presents the estimated land-use based TN, TP and TSS pollutant loading in the watershed.

Table A-26: 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)
Agriculture	14	80	0.54
Commercial	56	474	5.97
Forest	214	1,011	28.20
High Density Residential	7	48	0.72
Highway	160	1,138	59.73
Industrial	0	0	0.00
Medium Density Residential	166	1,271	19.03
Open Land	69	675	9.60
TOTAL	686	4,697	123.78
¹ These estimates do not consider loads from point sources or septic systems.			

Source: NepRWA

The PLER values for TN, TP and TSS were obtained from MassDEP and USEPA (MassDEP, 2023b; VHB et al., 2022) (see values provided in **Table A-27**).

Table A-27: Pollutant Loading Export Rates

Land Use & Cover ¹	PLERs (lb./acre/year)		
	(TP)	(TSS)	(TN)
AGRICULTURE, HSG A	0.45	29	2.6
AGRICULTURE, HSG B	0.45	29	2.6
AGRICULTURE, HSG C	0.45	29	2.6
AGRICULTURE, HSG D	0.45	29	2.6
AGRICULTURE, IMPERVIOUS	1.52	649	11.3
COMMERCIAL, HSG A	0.03	7.14	0.3
COMMERCIAL, HSG B	0.12	29.4	1.2
COMMERCIAL, HSG C	0.21	59.8	2.4
COMMERCIAL, HSG D	0.37	91	3.7
COMMERCIAL, IMPERVIOUS	1.78	377	15.0
FOREST, HSG A	0.13	29	0.5
FOREST, HSG B	0.13	29	0.5
FOREST, HSG C	0.13	29	0.5
FOREST, HSG D	0.13	29	0.5
FOREST, HSG IMPERVIOUS	1.52	650	11.3
HIGH DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.3
HIGH DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.2
HIGH DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.4
HIGH DENSITY RESIDENTIAL, HSG D	0.37	91	3.7
HIGH DENSITY RESIDENTIAL, IMPERVIOUS	2.32	439	14.1
¹ HSG = Hydrologic Soil Group			

Land Use & Cover ¹	PLERs (lb./acre/year)		
	(TP)	(TSS)	(TN)
HIGHWAY, HSG A	0.03	7.14	0.3
HIGHWAY, HSG B	0.12	29.4	1.2
HIGHWAY, HSG C	0.21	59.8	2.4
HIGHWAY, HSG D	0.37	91	3.7
HIGHWAY, IMPERVIOUS	1.95	1,477	13.9
INDUSTRIAL, HSG A	0.03	7.14	0.3
INDUSTRIAL, HSG B	0.12	29.4	1.2
INDUSTRIAL, HSG C	0.21	59.8	2.4
INDUSTRIAL, HSG D	0.37	91	3.7
INDUSTRIAL, IMPERVIOUS	1.78	377	15.0
MEDIUM DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.3
MEDIUM DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.2
MEDIUM DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.4
MEDIUM DENSITY RESIDENTIAL, HSG D	0.37	91	3.7
MEDIUM DENSITY RESIDENTIAL, IMPERVIOUS	1.96	439	14.1
OPEN LAND, HSG A	0.03	7.14	0.3
OPEN LAND, HSG B	0.12	29.4	1.2
OPEN LAND, HSG C	0.21	59.8	2.4
OPEN LAND, HSG D	0.37	91	3.7
OPEN LAND, IMPERVIOUS	1.52	650	11.3
¹ HSG = Hydrologic Soil Group			

Source: MassDEP and USEPA (MassDEP, 2023b; VHB et al., 2022)

Pollutant loading information:

Pollutant Loading Analysis

A Geographic Information Systems (GIS) based method was performed by NepRWA for the phosphorus loading analysis, based on the methodology laid out in the MA MS4 permit, using land cover and land use data available from MassGIS from 2016.² Following the state's methodology with the up to date available data, the pollutant loading analysis estimated 875 pounds of phosphorus per year from the surrounding area (Table A-27). The discrepancy between the WBP tool estimate and NepRWA's estimate for total phosphorus is most likely due to differences between land cover and land use within the datasets, as well as different crosswalk values used. See **Appendix C** and additional references for a full explanation.

Lake Loading Response Model (LLRM)

A Lake Loading Response Model (LLRM; AECOM 2009) analysis was performed by TRC to estimate the annual external phosphorus loads. LLRM is an annualized, steady state model that incorporates a watershed loading module for both wet weather runoff and baseflow contributions based on land use export coefficients. Additionally, LLRM allows for inclusion of direct atmospheric loading, waterfowl loading, and internal loading from the sediments as inputs to the model. These and other inputs are then fed into a suite of in-lake models for the purposes of overall model calibration. Model calibration includes the process of evaluating and modifying model inputs and coefficients such that differences between predicted and measured in-lake concentrations are minimized. Once calibrated, the LLRM model can also be used for predictive scenarios to evaluate the impacts of lake management interventions or watershed changes.

The LLRM model developed for Lake Massapoag divided the watershed into seven sub-watersheds for the purpose of external phosphorus load estimation. This allowed the phosphorus loading characteristics for each sub-watershed to be independently adjusted to account for attenuation. Additionally, it provided an opportunity to check watershed phosphorus loading estimates against data collected from larger sources, including Sucker Brook and the Lagoon.

The TRC LLRM model for Lake Massapoag estimated a total external load of 759 lbs/year of phosphorus (Table A-26), of which 590 lbs/year was estimated to be sourced from watershed surface sources. A total 53 lbs/year was estimated to be sourced from direct septic loading of phosphorus to the lake. The septic loading component was based on the shallow groundwater seepage survey and did not take into account additional groundwater inputs from deeper underwater springs. Resident waterfowl inputs were estimated to contribute an additional 11 lbs/year. Atmospheric deposition, which cannot be managed at the watershed scale, provides the balance of the external load at 104 lbs/year.

The LLRM model estimated a total internal load of 606 lbs/year of phosphorus coming from the sediments, assuming a 60-day period release over the deepest 57 acres of the lake. Therefore, the total internal and external load for the lake would be a combined 1,365 lbs/year.

² MassGIS Land Cover/Land Use: <https://www.mass.gov/info-details/massgis-data-2016-land-coverland-use>

The LLRM model was also used to estimate annual phosphorus reduction needed to meet an in-lake phosphorus concentration goal of 0.025 mg/L (i.e., the EPA Gold Book standard). In order to meet the EPA Gold Book standard for phosphorus in the lake, the LLRM model estimates that the annual phosphorus load would need to be reduced to 915 lbs/year. That would require an approximate 450 lbs/year reduction from the current estimated load (1,365 lbs/year).

TRC's *Lake Massapoag Nutrient Budget memo*, summarizing the LLRM methodology and findings, is included in **Appendix H**, which also includes TRC's Sediment Core Study on internal phosphorus loading.

Future data collection and studies of the lake can be used to further refine the models. For example, additional septic system evaluations, and loading from underground springs, may help to further quantify the septic nutrient load and provide answers posed by the individual septic analysis.

Table A-27: Estimated Pollutant Loading Summary by Source

Source	P (lb/yr)
WBP Tool	686
NepRWA Pollutant Load Estimate (PLE)	875
TRC LLRM Model	External: 759 Internal: 606* External + Internal: 1,365 *Assumes 60-day period of release over the deepest 57 acres of the lake.
Independent Septic Analysis	up to 1,316 lbs/yr (Total generated in watershed, need to determine how much goes to the lake), see element B for more information on septic contribution

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

Estimated Pollutant Loads

Table B-1 lists estimated pollutant loads for the following primary nonpoint source (NPS) pollutants: total phosphorus (TP), total nitrogen (TN), total suspended solids (TSS). These estimated loads are based on the pollutant loading analysis presented in Section 4 of Element A.

Water Quality Goals

Water quality goals for primary NPS pollutants are listed in **Table B-1** based on the following:

- TMDL water quality goals (if a TMDL exists for the water body);
- For all water bodies, including impaired waters that have a pathogen TMDL, the water quality goal for bacteria is based on the [Massachusetts Surface Water Quality Standards](#) (MassDEP 2022) that apply to the Water Class of the selected water body.
- If the water body does not have a TMDL for TP, a default target TP concentrations is provided which is based on guidance provided by the USEPA in [Quality Criteria for Water \(1986\)](#), also known as the “Gold Book”. Because there are no similar default water quality goals for TN and TSS, goals for these pollutants are provided in **Table B-1** only if a TMDL exists or alternate goal(s) have been optionally established by the WBP author.
- According to the USEPA Gold Book, total phosphorus should not exceed 50 ug/L in any stream at the point where it enters any lake or reservoir. The water quality loading goal was estimated by multiplying this target maximum phosphorus concentration (50 ug/L) by the estimated annual watershed discharge for the selected water body. To estimate the annual watershed discharge, the mean flow was used, which was estimated based on United States Geological Survey (USGS) “Runoff Depth” estimates for Massachusetts (Cohen and Randall, 1998). Cohen and Randall (1998) provide statewide estimates of annual Precipitation (P), Evapotranspiration (ET), and Runoff (R) depths for the northeastern U.S. According to their method, Runoff Depth (R) is defined as all water reaching a discharge point (including surface and groundwater), and is calculated by:

$$P - ET = R$$

A mean Runoff Depth R was determined for the watershed by calculating the average value of R within the watershed boundary. This method includes the following assumptions/limitations:

- a. For lakes and ponds, the estimate of annual TP loading is averaged across the entire watershed. However, a given lake or reservoir may have multiple tributary streams, and each stream may drain land with vastly different characteristics. For example, one tributary may drain a highly developed residential area, while a second tributary may drain primarily forested and undeveloped land. In this case, one tributary may exhibit much higher phosphorus concentrations than the average of all streams in the selected watershed.
- b. The estimated existing loading value only accounts for phosphorus due to stormwater runoff. Other sources of phosphorus may be relevant, particularly phosphorus from on-site wastewater treatment (septic systems) within close proximity to receiving waters. Phosphorus does not typically travel far within an aquifer, but in watersheds that are primarily unsewered, septic systems and other similar groundwater-related sources may contribute a significant

load of phosphorus that is not captured in this analysis. As such, it is important to consider the estimated TP loading as "the expected TP loading from stormwater sources." *Septic system sources should be separately evaluated to determine whether septic system upgrades or sanitary sewer system conversion would cost-effectively reduce bacteria and nutrient sources in the watershed.*

- c. If the calculated water quality goal is higher than the existing estimated total load; the water quality goal is automatically set equal to the existing estimated total load.

Table B-1: Pollutant Load Estimate (PLE) Reductions Needed

Pollutant	Existing Estimated Total Load	Water Quality Goal	Required Load Reduction
Total Phosphorus	LLRM Total Annual Load (External 759 + Internal 606 lbs/yr) = 1,365 lbs/year	Lake Phosphorus Concentration not to exceed 0.025 mg/L (including external and internal) = 915 lbs/yr	450 (1,365-915) (+10% Contingency Factor) = 495 lbs/yr
Total Nitrogen	4,697 lbs/yr	N/A, not pollutant of interest	
Total Suspended Solids	124 ton/yr	TSS transports P, so a goal for new developments and stormwater management is to remove 80% of TSS	
Bacteria	MSWQS for bacteria are concentration standards (e.g., colonies of fecal coliform bacteria per 100 ml), which are difficult to predict based on estimated annual loading.	Class B. Class B Standards - Primary contact recreation: For <i>E. coli</i>, geometric mean of samples collected within any 90-day or smaller period shall not exceed 126 cfu/100 mL, and no more than 10% of all such samples shall exceed 410 cfu/100 mL. For enterococci, geometric mean of all samples collected within any 90-day or smaller period shall not exceed 35 cfu/100 mL, and no more than 10% of all such samples shall exceed 130 cfu/100 mL. - Waters adjacent to any public or semi-public beach, at a location used for bathing and swimming purposes or waters impacted by combined sewer overflows (CSO) or publicly owned treatment works (POTW) discharges: For <i>E. coli</i>, geometric mean of samples collected within any 30-day or smaller period shall not exceed 126 cfu/100 mL, and no more than 10% of all such samples shall exceed 410 cfu/100 mL. For enterococci, the geometric mean of all samples collected within any 30-day or smaller period shall not exceed 35 cfu/100 mL, and no more than 10% of all such samples shall exceed 130 cfu/100 mL.	Total Maximum Daily Loads of Bacteria for Neponset River Basin

Phosphorus Load Estimates by Watershed Delineation

Over the course of work on this plan, our thinking about the most useful boundary for planning purposes of the watershed has evolved. Initially, individual catchments across the watershed were delineated by NepRWA following the methodology laid out in the catchment delineation report for the MS4 report; see **Appendix C**. The watershed of the lake was defined by the USGS StreamStats boundary with a 500-meter buffer and the storm drain infrastructure around the lake. This definition of the Lake Massapoag watershed was used by TRC in the LLRM to keep consistent with NepRWA when estimating the phosphorus load (see **Table B-1** above).

After further data analysis, including the septic information below, the LMAC decided to define the boundary of the watershed as the Surface Water Protection District (SWPD) as shown in red in **Figure A-3** above. The SWPD is the boundary which the town has adopted for planning and zoning purposes. This decision was made after the phosphorus estimates were done by NepRWA and TRC, and accounts for some of the variance in phosphorus estimates between the WBP online tool, NepRWA's PLE, and TRC's LLRM.

Pollutant Load Criteria

Pollutant load reduction information:

No TMDL Pollutant Load Criteria data exists for Lake Massapoag using DEP's Watershed Based Planning Tool. However, local sampling data and other analysis methods suggest that excess phosphorus is contributing to the deterioration of lake conditions. As stated above, estimated external loads ranged from 759 to 875 lbs/year of external phosphorus load, and 606 lbs/year of internal phosphorus loading from deep lake sediment. TRC's Lake Loading Response Model (LLRM) estimated 1,365 lbs/year from combined external and internal sources. As noted above, TRC performed water quality sampling which showed that phosphorus levels exceeded the recommended 0.025 mg/L at multiple testing sites within the lake; and in order to not exceed this goal the lake should have no more than an estimated 915 lbs/year of phosphorus from external and internal sources. **LMAC therefore sets a goal to reduce the LLRM Total Annual Load to 915 lbs/year, which requires a 495 lbs/year reduction. This is one-quarter of a ton: a significant amount.**

The high dose alum treatment in June 2025 was calculated as a one-third dose for phosphorus inactivation. We estimate a 202 lbs/year reduction based on that treatment, with effects to be somewhat reduced each subsequent year, followed by two additional nutrient inactivation treatments estimated at 5-year intervals and/or implementation of oxygen saturation technology. The Town needs to achieve significant reductions in external phosphorus loading to meet the goal from a combination of stormwater projects, increased stormwater maintenance efforts, homeowner actions, regulatory reforms, adoption of new technologies, reducing wastewater contributions from septic and I/A systems, and animal and pet waste.

Septic Load Contribution: Human Wastewater Phosphorus Load to Watershed

The number of homes and facilities located in the Surface Water Protection District has grown considerably over the past 125 years, see Figure B-1. It includes 928 residences and two small houses of worship, small commercial sites and institutions, and the Sharon High School and Middle School wastewater system, Veterans Memorial Park Beach, Sharon Community Center, Salvation Army's Camp Wonderland and Conference Center, and Everwood Day Camp.

LMAC Septic Figure B-1: Total Wastewater Systems in Surface Water Protection District by Year



Source: Susan Peck, Analysis Of Septic Systems Within The Lake Massapoag Surface Water Protection District.

The lake watershed lacks sewers, and a **large number of homes are within 300 feet of either the lake, or a tributary or wetland that feeds the lake**. Over time, septic leaching fields and soils can become saturated with phosphorus and no longer attenuate it. When the binding sites for phosphorus in soil become saturated, phosphorus levels will begin to increase in the groundwater. There is evidence of this based on data from groundwater monitor wells at Sharon High School (Average Total Phosphorus, Average Dissolved Phosphorus). Because of this, LMAC considers that the phosphorus load from human wastewater may be above what the LLRM model predicts.

The challenge for Lake Massapoag and the Town of Sharon is that even with the best inspection and maintenance, septic systems and even Innovative/Alternative systems are not designed to remove phosphorus. The soil and sediment underneath the leaching field (vadose zone) is supposed to bind the phosphorus before it enters the aquifer. But this does not happen if the phosphorus binding sites become saturated in the soil.

LMAC member Susan Peck did an extensive search of town records to quantify the age and status of household and small commercial wastewater systems which shows the positive impact of Title 5 regulations, and the gaps that remain. See Susan Peck's full report and charts in **Appendix F**, and the following Table B-2 on a mass balance approach to septic load phosphorus contributions.

As shown in LMAC Septic **Table B-2** below, assuming the average person generates 0.6 grams of phosphorus per day, and septic systems remove about 20 percent of phosphorus over time, human wastewater introduces an estimated 1,053 pounds of phosphorus per year into Lake Massapoag's Watershed. Additional research is

required to determine what proportion this phosphorus reaches the lake and how much is attenuated through precipitation and adsorption in the vadose zone below the leaching field, the groundwater, and the swamps and tributaries that feed the lake. The proportion of the current phosphorus load that reaches the lake is expected to increase over time, as the attenuation capacity of the soil is exceeded and residential development continues.

NepRWA's Desktop analysis, TRC's LLRM model, and Peck's mass balance wastewater contribution model represent upper and lower bounds for external phosphorus loading in Lake Massapoag. Additional testing will help to refine the septic load component. Restoring well testing to replace sites that were removed during the new Sharon High School and athletic fields construction and adding additional test wells at other sites near the lake would help gauge the extent and pace of septic phosphorus seepage. It could also generate cost-benefit estimates for large site remediation, such as the SHS system.

LMAC Septic TABLE B-2: Potential Phosphorus Load to Lake Watershed from Septic Systems

Note: 0.0022 grams per pound x 0.6 grams per day = 0.00132 pounds per day = 0.48 pounds per year³

	# of people at Location	Days per year	Avg % of 24-hour day at location	Pounds Phosphorus Excreted in Watershed per year
Residences and two small Houses of Worship (930)	2.4	365	0.75	807
Sharon High School System: High School, Middle School, and Preschool4	2,360	181	0.67	378
Sharon High School System: Public School Administration	90	225	0.67	18
Community Center visitors5 and town staff	350	365	0.1	17
Camp Wonderland	291	75	1	29
Everwood Day Camp	1,050	40	0.67	37
Saphire Estate	270	52	0.67	12
Wonderland Conf. Center	60	90	1	7
Bilingual Montessori School	68	181	0.67	11
Massapoag Yacht Club	40	150	0.1	1
TOTAL EXCRETED				1,316
TOTAL discharged to ground assuming 20% removed in septic tank and leaching field				1,053

³ Science Direct, Kidney Function in Calcium and Phosphate Metabolism, A Normal Phosphate Excretion Rate, <https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/phosphate-excretion>.

⁴ Excludes weekend, evening and summer use of high school, middle school, and Memorial Beach.

⁵ Lower estimate of the average number of people using the facility per preliminary design report for wastewater collection and treatment Weston and Sampson Engineers, Lake Massapoag Restoration Project May 1989.

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

BMP Suitability Index:

The following GIS-based analysis was performed within the watershed to identify high priority parcels for best management practice (BMP) (also referred to as management measure) implementation:

- Each parcel within the watershed was evaluated based on ten different criteria accounting for the parcel ownership, social value, and implementation feasibility (See **Table C-1** for more detail below);
- Each criterion was then given a score from 0 to 5 to represent the priority for BMP implementation based on a metric corresponding to the criterion (e.g., a score of 0 would represent lowest priority for BMP implementation whereas a score of 5 would represent highest priority for BMP implementation);
- A multiplier was also assigned to each criterion, which reflected the weighted importance of the criterion (e.g., a criterion with a multiplier of 3 had greater weight on the overall prioritization of the parcel than a criterion with a multiplier of 1); and
- The weighted scores for all the criteria were then summed for each parcel to calculate a total BMP suitability score.

Table C-1 presents the criteria, indicator type, metrics, scores, and multipliers that were used for this analysis. Parcels with total scores above 60 indicate high potential for BMP implementation suitability and are recommended for further investigation.

Table C-1: Matrix for BMP Suitability Index GIS-based Analysis

Criteria	Indicator Type	METRICS																									Multiplier	Maximum Potential Score		
		Yes or No? YesNo		Hydrologic Soil Group D C or C/D B or B/D A or A/D			Land Use Type								Water Table Depth			Parcel Area			Parcel Average Slope									
							Low and Medium Density Residential	High Density Residential	Commercial	Industrial	Highway	Agriculture	Forest	Open Land	Water	101-200 cm	62-100 cm	31-61 cm	0-30 cm	Greater than 2 acres	Between 1-2 acres	Less than 1 acre	Less than 2%	Between 2% and 15%	Greater than 15%	Less than 50%			Between 51% and 100%	
Is the parcel a school, fire station, police station, town hall or library?	Ownership	5	0																										2	10
Is the parcel's use code in the 900 series (i.e. public property or university)?	Ownership	5	0																										2	10
Is parcel fully or partially in an Environmental Justice Area?	Social	5	0																										2	10
Most favorable Hydrologic Soil Group within Parcel	Implementation Feasibility			5	3	0	0																						2	10
Most favorable Land Use in Parcel	Implementation Feasibility							1	2	4	2	4	5	1	4	X ¹													3	15
Most favorable Water Table Depth (deepest in Parcel)	Implementation Feasibility																5	4	3	0									2	10
Parcel Area	Implementation Feasibility																				5	4	1						3	15
Parcel Average Slope	Implementation Feasibility																							3	5	1			1	5
Percent Impervious Area in Parcel	Implementation Feasibility																									5	2.5		1	5
Within 100 ft buffer of receiving water (stream or lake/pond)?	Implementation Feasibility	5	2																										2	10

Note 1: X denotes that parcel is excluded

Figure C-1 presents the resulting BMP Suitability Index Map for the watershed. The following link includes a Microsoft Excel file with information for all parcels that have a score above 60: [BMP Suitability Index Spreadsheet](#). This analysis solely evaluated individual parcels for BMP implementation suitability and likelihood for the measures to perform effectively within the parcel's features. This analysis does not quantify the pollutant loading to these parcels from the parcel's upstream catchment. When further evaluating a parcel's BMP implementation suitability and cost-effectiveness of BMP implementation, the existing pollutant loading from the parcel's upstream catchment and potential pollutant load reduction from BMP implementation should be evaluated. GIS data used for the BMP Suitability Index analysis included:

- MassGIS (2015a);
- MassGIS (2015b);
- MassGIS (2017a);
- MassGIS (2017b);
- MassGIS (2020);
- MA Dept of Revenue,
- Division of Local Services (2016);
- MassGIS (2005);
- ArcGIS (2020);
- MassGIS (2019);
- MassGIS (2012); and
- ArcGIS (2020b).

Figure C-1: BMP Suitability Index Map
(MassGIS (2015a), MassGIS (2015b), MassGIS (2017a), MassGIS (2017b), MassGIS (2020), MA Department of Revenue Division of Local Services (2016), MassGIS (2005), ArcGIS (2020), MassGIS (2019), MassGIS (2012), ArcGIS (2020b))

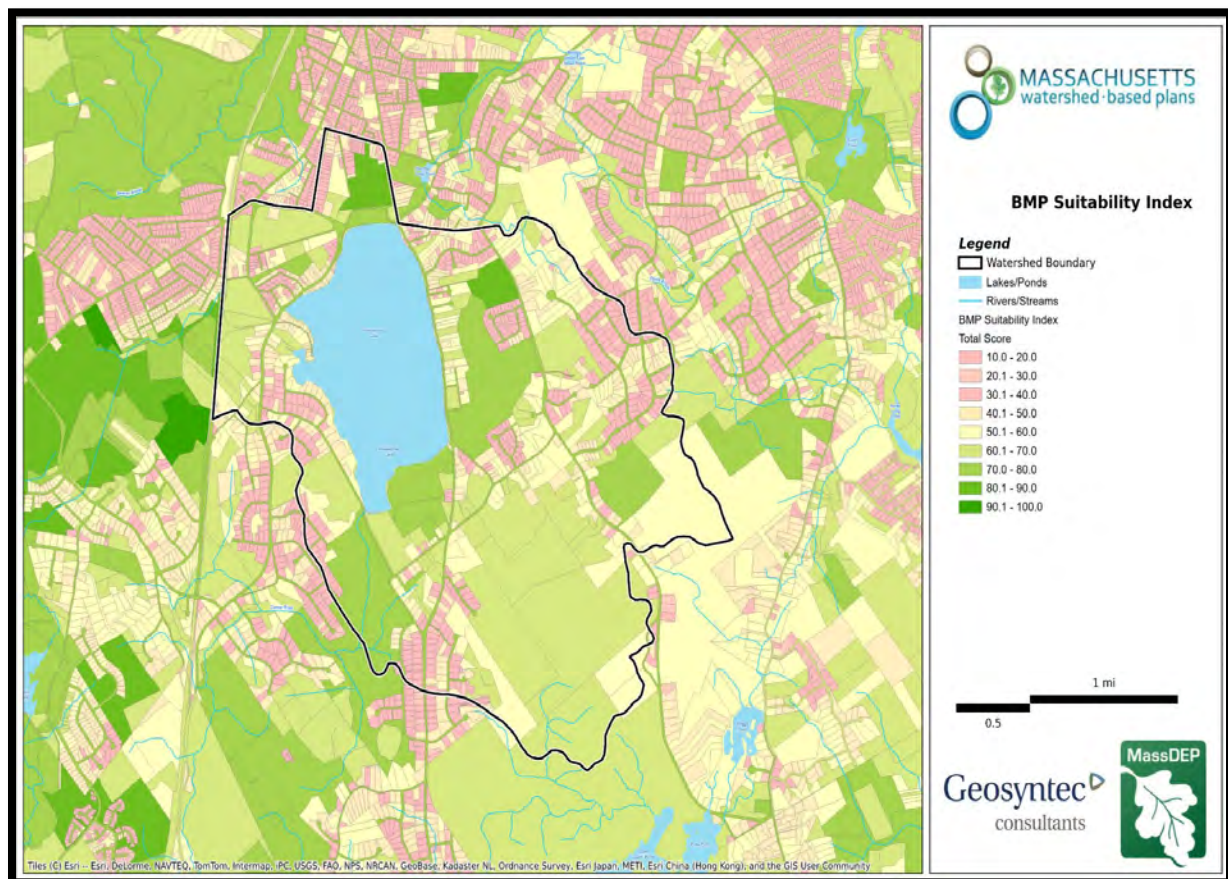


Figure C-2 below illustrates the storm drains around Lake Massapoag for background.

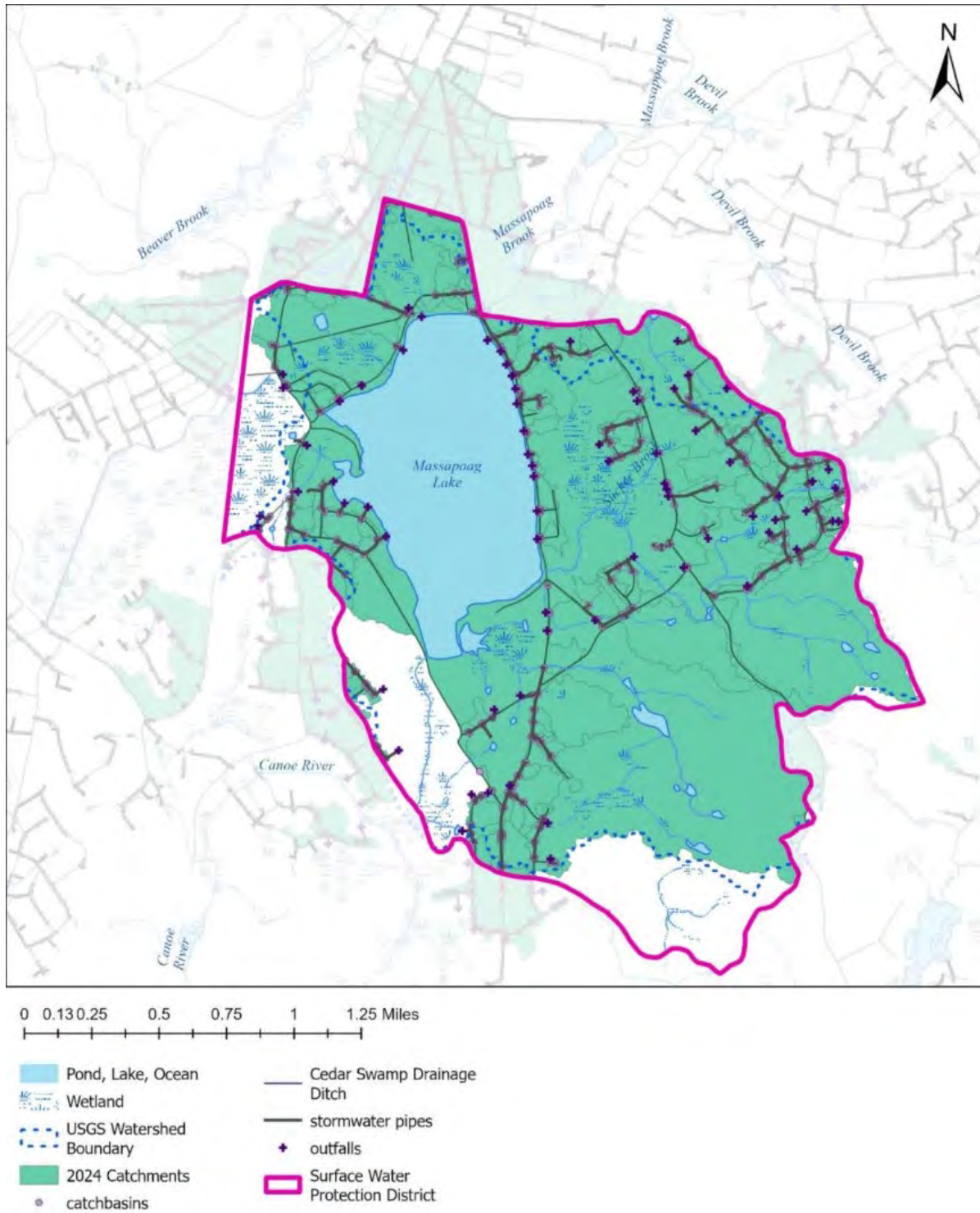
LMAC Figure C-2: Storm Drain Details around Lake Massapoag



Source: Town of Sharon Department of Public Works

Figure C-3 illustrates storm drains within the larger Lake Massapoag watershed. The southeastern area is largely comprised of Borderland State Park.

LMAC Figure C-3: Map of Catchments and Drainage Infrastructure in Lake Watershed



Source: Town of Sharon Department of Public Works

Site Surveys for Potential Stormwater Control Measures (SCMs)

NepRWA performed a Site Selection identification desktop analysis, building on the previous work done by NepRWA on the catchment delineation and estimated phosphorus load. Catchments with high phosphorus were screened for GSI feasibility based on the EPA's BMP site selection Tool.⁶ The EPA site selection tool is similar to the BMP Suitability Index analysis done by the WBP online tool and includes similar GIS data including:

- Land ownership
- Hydrologic Soil Group (HSG)
- Land use
- Depth to groundwater table
- Parcel area/size
- Parcel average slope
- Percent impervious area in parcel

Additionally, this site selection accounted for additional factors that are not present in the BMP Suitability Index in Element C including:

- Phosphorus load (based on PLER analysis previously done)
- Current infrastructure or other obstructions
- Resident and community input about previous flooding history on site or nearby
- Community-identified areas of interest

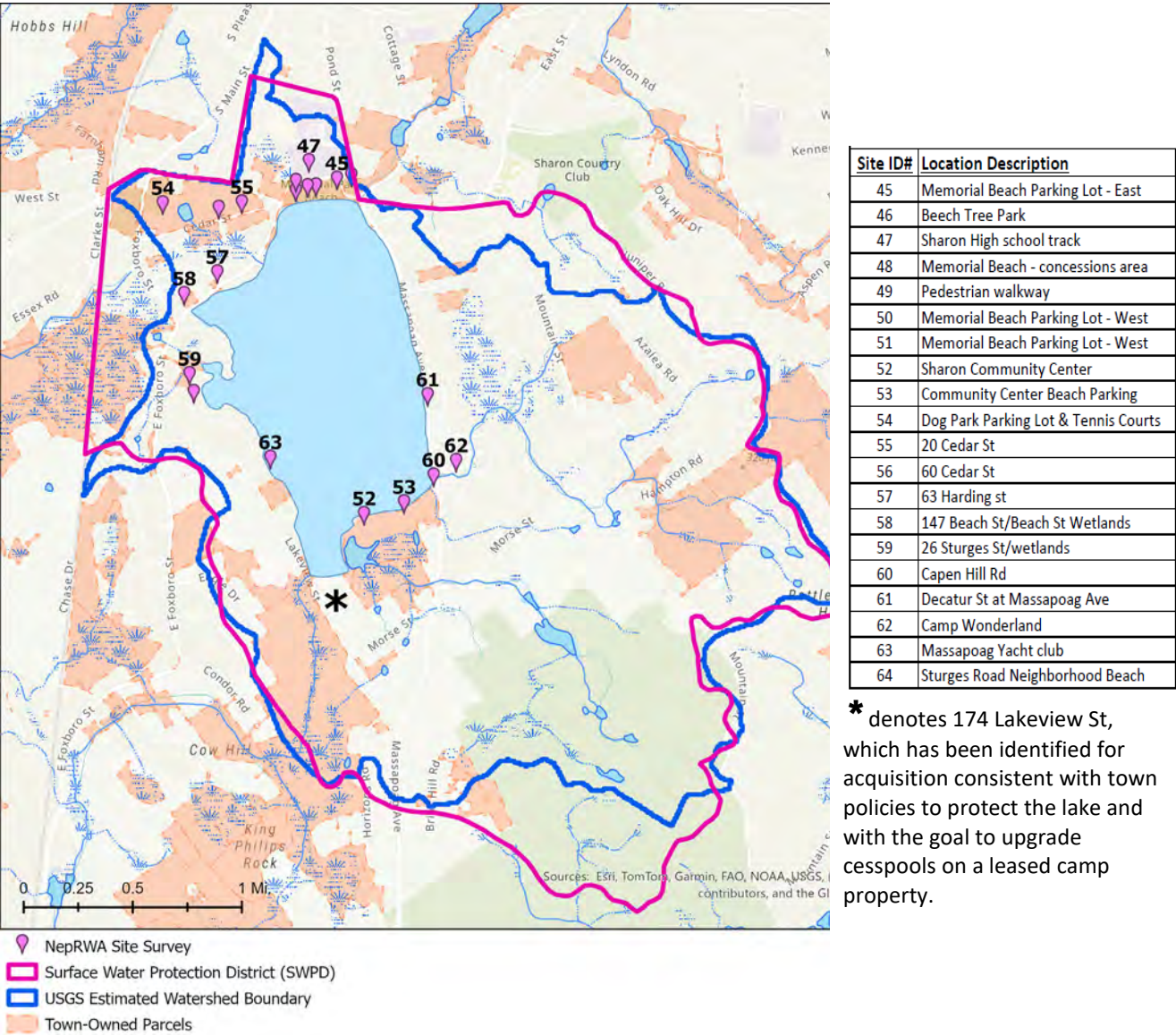
Based on the factors, all the catchments within the Lake Massapoag watershed were given a total score. Using raw score and best professional judgement, along with input from the Lake Massapoag Advisory Committee (LMAC), twenty sites were identified as top priority for potential locations for GSI and a site survey was conducted. Site surveys can be found in **Appendix D**. From the initial top twenty site list, five sites were selected based on survey results and discussion with the LMAC as priorities for green infrastructure to address phosphorus in stormwater runoff during the first five-year planning period, 2026-2050, in addition to researching septic phosphorus contributions to inform research and feasibility of solutions. Additional sites will be selected in future planning periods.

NepRWA assessed 20 sites for stormwater control measures (SCM) based on a GIS desktop analysis, with input from LMAC. The desktop analysis done by NepRWA was based on EPA's BMP site selection tool⁷, and included estimated phosphorus contribution as well as other typical site selection factors including land use, impervious cover, hydrologic soil group (HSG), land ownership, parcel size, and other geological and non-geological factors. For the 20 sites selected for site visits, see NepRWA Figure C-4 below.

Additionally, through discussion LMAC identified Gannett Campus of Everwood Day Camp, 174 Lakeview St, owned by the Elizabeth Peabody House and leased by Everwood, as a priority for acquisition by the Town in past plans. This property needs replacement of its cesspools but is exempt from Title 5 as it has not been sold. A plan for upgrading these systems should be sought among the parties involved.

⁶ EPA BMP Siting Took, 2013. https://19january2021snapshot.epa.gov/sites/static/files/2014-06/documents/bmpsitingtool_userguide.pdf

NepRWA Figure C-4: Sites Surveyed for Potential SCM/BMPs, based on NepRWA Desktop Analysis



Source: NepRWA

Proposed Management Measures:

In 2026-2030, LMAC proposes to proceed with construction and design of an initial five stormwater projects:

- Lot Reconstruction, Drainage and Shoreline Improvements to Memorial Beach Park, West End
- Lot Reconstruction, Drainage and Shoreline Improvements to Memorial Beach Park, East End
- Grassed Channel and Water Quality Swale at Bottom of Lake Avenue (along Beach Street Right of Way)
- Capen Hill Stormwater Improvements
- Massapoag Avenue Stormwater Improvements

Table C-2 presents the proposed management measures as well as the estimated pollutant load reductions and costs. The planning level cost estimates and pollutant load reduction estimates and estimates of BMP footprint were based off information obtained in the following sources and were also adjusted to 2026 values using the Consumer Price Index (CPI) (United States Bureau of Labor Statistics, 2016):

- Geosyntec Consultants, Inc. (2014);
- Geosyntec Consultants, Inc. (2015);
- King and Hagen (2011);
- Leisenring, et al. (2014);
- King and Hagen (2011);
- MassDEP (2016a);
- MassDEP (2016b);
- University of Massachusetts, Amherst (2004);
- USEPA (2020);
- UNHSC (2018);
- Tetra Tech, Inc. (2015);

Table C-2: Proposed Management Measures, Estimated Pollutant Load Reductions and Costs

1. VMB Memorial Beach West End Parking Lot & Drainage Improvement Project FY27

Structural BMPs	
1. VMB Memorial Beach West End Parking Lot & Drainage Improvement Project FY27	
BMP TYPE	EXTENDED DRY DETENTION BASIN W/ SEDIMENT FOREBAY AND SWALE
BMP SIZE (storm depth; inches)	1.50
DRAINAGE AREA (acres)	0.92
BMP LOCATION	Memorial Beach West End Parking - Large lot
LAND USE, COVER TYPE (in drainage area)	% OF DRAINAGE AREA
COMMERCIAL, Impervious	100
EST POLLUTANT LOAD REDUCTIONS	
TN (lbs/yr)	2.63
TP (lbs/yr)	0.48
TSS (lbs/yr)	166.18
ESTIMATED FOOTPRINT (sf)	951.80
ESTIMATED COST (\$)	\$576,032 See Project Appendix A for budget detail (60% project total)

Sharon's DPW completed a successful redesign of the public boat launch area in 2024, with regrading, paving, and construction of a detention basin which overflows into a swale and then enters Massapoag Brook downstream from the lake. This provides a model for the larger beach redesign project.

DPW has now designed a plan for needed drainage improvements, porous paving, green infrastructure, and plantings to regrade, resurface, and add drainage, erosion control, and nutrient runoff control measures to the West and East parking lots at Veterans Memorial Beach. The project will be done in two stages, so that one of the lots remains open during construction. LMAC has added a shoreline improvement plan designed by Raingarden Design Studio and interpretive signage. See **Appendix A** for conceptual and engineering drawings, permits, budgets, TSS calculations, and Hydro CAD.

LMAC Figure C-5: Veterans' Memorial Park Beach Stormwater and Shoreline Improvement Project



Source: Raingarden Design Studio

For additional project information and DPW engineering drawings, see **Appendix A**, projects 1 and 2.

Table C-2 (cont): Proposed Management Measures, Estimated Pollutant Load Reductions and Costs
2. VMB Memorial Beach East End Parking Lot and Drainage Improvement Project: FY28

BMP TYPE	EXTENDED DRY DETENTION BASIN W/ SEDIMENT FOREBAY AND SWALE
BMP SIZE (storm depth; inches)	1.50
DRAINAGE AREA (acres)	0.92
BMP LOCATION	Memorial Beach East End Parking – Small lot
LAND USE, COVER TYPE (in drainage area)	% OF DRAINAGE AREA
COMMERCIAL, Impervious	100
ESTIMATED POLLUTANT LOAD REDUCTIONS	
TN (lbs/yr)	2.63
TP (lbs/yr)	0.48
TSS (lbs/yr)	166.18
ESTIMATED FOOTPRINT (sf)	951.80
ESTIMATED COST (\$)	\$384,022 See Project Appendix A for budget detail (40% project total)

Table C-3: Proposed Management Measures, Estimated Pollutant Load Reductions and Costs
3. Lake Ave/Beach Street Stormwater Runoff Mitigation Project: FY29

BMP TYPE	GRASSED CHANNEL/ WATER QUALITY SWALE
BMP SIZE (storm depth; inches)	1.00
DRAINAGE AREA (acres)	2.43
BMP LOCATION	Lake Ave and Beach St Concept #3
LAND USE, COVER TYPE (in drainage area)	% OF DRAINAGE AREA
MEDIUM DENSITY RESIDENTIAL, Impervious	50
OPEN LAND, Pervious	50
ESTIMATED POLLUTANT LOAD REDUCTIONS	
TN (lbs/yr)	2.41
TP (lbs/yr)	0.53
TSS (lbs/yr)	455.28
ESTIMATED FOOTPRINT (sf)	500
ESTIMATED COST (\$)	\$60,000 See Project Appendix A

Structural BMP concept design plans, budgets, and other documents are included in Project **Appendix A**.

- The Memorial Beach West Lot includes a swale that feeds into the detention basin. The numbers in the table represent the total drainage area for the combined BMPs. However, due to the additional swale, numbers, including estimated total phosphorus reduction, may be underestimated and phosphorus removal rates may be higher than listed. The East End includes a vegetated swale. Both include porous pavement over a 24" stone subbase, shoreline green infrastructure, plantings, and interpretive signage.
- The Lake Ave/Beach Street area has experienced increased runoff and flooding since an uphill owner removed numerous trees and plants from a sloping hillside, causing house-flooding downhill. DPW constructed a berm to direct water down the street. This solved the house flooding but led to excess stormwater crossing Beach Street into the lake. DPW added a storm drain, but it is not large enough and overflows into the lake. Previously the town explored collecting and piping water upstream into a wetland, but the elevation shows it would likely cause other house flooding. The grass channel/swale along Beach Street in the town's right-of-way along the shoreline is designed to reduce direct runoff.
- The Conservation Administrator explored a BMP to channel runoff down Capen Hill Rd. into a proposed constructed wetland near the bottom of the Salvation Army Camp Wonderland property, providing a cost-effective way to infiltrate runoff and allow it to enter Sucker Brook, and avoid the need for street digging, road reconstruction, and underground pipes. After consulting with counsel, the owner declined to pursue it. NepRWA's analysis of Capen Hill Rd showed a relatively narrow drainage area between two sub-basins.
- Massapoag Ave, on the east side of Lake Massapoag, represents an interesting challenge and opportunity to control stormwater runoff entering the Lake. Multiple residents on Massapoag Ave have noted drainage problems and erosion concerns on the lakefront, which is privately owned along Massapoag Ave. Past road redesign widened the roadway and added a bike lane and sidewalk. DPW notes that shorelines have been changed by owners over the years to facilitate lake access and visibility, replacing natural shorelines with beaches and grass that increase runoff. The Massapoag Ave sub-basin is approximately 201.46 acres, and the estimated annual phosphorus load is 69.04 pounds per year; see **Appendix A**.
- The Town will examine options to add SCMs to Massapoag Avenue to reduce runoff and shoreline erosion within the constraints of road standards and the existing right-of-way. In the meantime, DPW may want to consider interim control measures, such as lining the road edge with silt socks, or restoring a bituminous berm curb on the west side of Massapoag Avenue, to reduce erosion, nutrient runoff, and winter salt spreading along the shoreline while a storm drain project is designed. Property owners are encouraged to work with the Conservation Administrator to design and permit lakefront BMPs, such as Sapphire Estate has recently done adding trenching, riprap, and plantings.

Table C-4: Proposed Additional BMPs

Additional BMPs	
BMP TYPE	Pilot/Demonstration: <i>E. coli</i> Mitigation
BMP LOCATION	Community Center Beach
DESCRIPTION	Based on findings of <i>E. coli</i> species source testing, commission feasibility study of alternatives for mitigating <i>E. coli</i> via aeration, oxygenation, and/or oxygen saturation technology (OST), and secure resources to implement
EST POLLUTANT LOAD REDUCTIONS	TBD
ESTIMATED COST (\$)	TBD
BMP TYPE	Interim/Trial: Silt Socks or Bituminous Cape Cod Berm
BMP LOCATION	Massapoag Ave from Rotary to Capen Hill Road, on lake side
DESCRIPTION	As a more extensive drainage diversion project is designed, provide interim mitigation via installing 1 mile of silt socks, or 1 mile of bituminous Cape Cod berm to test if it helps alleviate or concentrates runoff; Town is buying fine brine spray equipment.
EST POLLUTANT LOAD REDUCTIONS	TBD
ESTIMATED COST (\$)	TBD
BMP TYPE	Around the Lake/Love our Lake Walk with Educational Signage
BMP LOCATION	Sidewalks, beaches, and trails around lake border
DESCRIPTION	Interpretive signage for key features, including historical markers and information, lake and water body features, challenges, BMPs, and best practices, and how you can help
EST POLLUTANT LOAD REDUCTIONS	variable based on methods implemented by private homeowners
ESTIMATED COST (\$)	TBD
BMP TYPE	Street Sweeping for Memorial Beach Parking Lot
BMP LOCATION	Memorial Beach Parking Lots - West End and East End
DESCRIPTION	Twice a year street sweeping to remove salt, sand, and other sediment build-up. Street sweeping should occur once in the fall and once in the spring.
EST POLLUTANT LOAD REDUCTIONS	up to 10%
ESTIMATED COST (\$)	DPW
BMP TYPE	Lake-Friendly Landscaping Education and Outreach
BMP LOCATION	around lake border
DESCRIPTION	Lake-friendly landscaping and lawn education focused on residents with lakefront property
EST POLLUTANT LOAD REDUCTIONS	variable based on methods implemented by private homeowners
ESTIMATED COST (\$)	TBD

Element D: Technical and Financial Assistance Needed to Implement Plan

Background

The Town of Sharon [Hazard Mitigation Plan 2025 Update](#), includes measures to manage stormwater runoff to Lake Massapoag and Massapoag Brook to reduce water quality impacts as a High Priority Mitigation Strategy. It projects an **estimated \$800,000 for Stormwater mitigation projects conducted by the Public Works**

Department 2027-2029, with funding sources from DEP Section 319 grants, MVP Action grants, and CPC funds. Given reduced funding and increased competition for state grant programs, the Town may need to consider additional local funding. **Table D-1** presents the funding needed to implement the management measures presented in this watershed plan. The table includes costs for structural and non-structural BMPs, operation and maintenance activities, information/education measures, and monitoring/evaluation activities.

Table D-1: Summary of Funding Needed to Implement the Watershed Plan
(fill in blank cells and update with cost estimates from relevant departments)

Management Measures	Location	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Technical Assistance Needed	Funding Needed
Structural BMPs (from Element C)						
CONSTRUCTED WETLAND W/ SEDIMENT FOREBAY, PLANTINGS, SIGNAGE	Memorial Beach West End Parking, Drainage - Large Lot Walking Path, Shoreline	\$576,032	Clean Basins of Sand & Silt, Sweep Lot every 6 months	Town of Sharon DPW, Conservation Commission	none	Town Capital + MVP Action FY27 (for Shoreline Improvements) + CPA FY27 Match
GRASSED CHANNEL/ WATER QUALITY SWALE, RAIN GARDEN, PLANTINGS, SIGNAGE.	Memorial Beach - East End Parking & Drainage - Small Lot Walking Path, Shoreline	\$384,022	Clean Swale, Sweep Lot every 6 months	Town of Sharon DPW, Conservation Commission	none	Town Capital + MVP Action FY27 (for Shoreline Improvements) + CPA FY28 Match
GRASSED CHANNEL/ WATER QUALITY SWALE	Lake Ave and Beach St (Selected Concept #3)	\$60,000	Clean Swale of Sand & Silt every 6 months	Town of Sharon DPW, Conservation Commission	none	TBA
DESIGN & PERMITTING: DRAINAGE & EROSION CONTROL	Massapoag Avenue	TBA	TBA	Town of Sharon DPW, Conservation Commission	Engineering Consultant	TBA
DESIGN & PERMITTING: DRAINAGE & EROSION CONTROL	Capen Hill Road	TBA	TBA	Town of Sharon DPW, Conservation Commission	Engineering Consultant	TBA

Non-Structural BMPs							
Pollutant or Other Target	Management Measures	Location	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Technical Assistance Needed	Funding Needed
Total Phosphorus, Nonnative Aquatic Macrophytes	Replacement of Aquatic Barrier and Filtergrass	Lagoon entry to South Cove	\$7,350 + \$3,962 = \$11,312 replace every five years 2029	\$1,500 annual cleaning costs + weekly weed clearing	LMAC	EverBlue Lakes	Yes for 2029 replacement, annual cleaning \$1,500 Everwood
Total Phosphorus	Monitoring and Adjustment of Lake Level	Flume outflow, SHS/Wetland and Lagoon inflows	None (unless lake outlet/flume channel need clearing)	Conservation Administrator monitors and adjusts frequently	Conservation Department	None	No, included in Conservation Administrator duties
Nonnative Aquatic Macrophytes	Diver-Assisted Suction Harvesting (DASH)	35 days in South and Fletcher's Cove fanwort and milfoil		\$87,500 for 35 days	LMAC, Town of Sharon Conservation Commission	NEAS	\$37,500 Camp Everwood FY27 match, CPA \$37,500 FY27, \$25,000 LMAC
Native Nuisance Weeds	Swim Area Weed Raking as needed for safety, Spot Raking	Memorial Beach swim area, east side		1 day \$1,250 every 3 years	LMAC, Recreation Department, Conservation	non	LMAC budget
Nonnative Aquatic Macrophytes	Invasive Plant Mapping	Lake Massapoag		Done every 3 years, \$3,600	LMAC	TRC	LMAC budget or CPA FY27
Total Phosphorus, Bacteria	Goose Egg Addling, Deterrence, Control	Lake Massapoag and Lagoon		\$1,200 + to add locations, Rec Staff, USDA APHIS	LMAC, Recreation Dept, Property Owners for APHIS	MA DFW, USDA APHIS	LMAC budget, Rec beach operating budget, APHIS partners TBA
Bacteria	qPCR test & preservation kits + <i>E. coli</i> tests	Sucker Brook & Community Center Beach		\$4,620	LMAC	none	CPA FY27 (10% in CPA FY26)
Total Phosphorus, Bacteria	Incentives for Septic Conversions and Upgrades	Watershed	Assess need following ATM 2025 increase	None	Board of Health, Select Board	none	TBD
Road Salt	Brine Spray Equipment	Target around the Lake	\$265,000	Redeploy salt truck drivers	Department of Public Works	Other towns	\$265,000 Capital Budget FY28

Information/Education (see Element E)						
Management Measures	Location	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Technical Assistance Needed	Funding Needed
Love our Lake Newsletter & Education Brochures	Town Residents (mailed with water bills, at events/offices)		\$10,000	LMAC, NepRWA	NepRWA design services	\$5,600, balance in annual budget
Social Media Campaign	Residents		Town Communications Director	LMAC, NepRWA	NepRWA cross-post events	
Event Tabling, Lake Walks, Presentations	Residents, Community Organizations		LMAC Members	LMAC, SSC, SFOC, scouts, service organizations		
Community Service: Rake the Lake	Residents, Community Organizations		Volunteers	LMAC, Community orgs, pickup by DPW		
Lake-Friendly Landscaping & Cleaning	Residents		Town Conservation Administrator	Conservation, SSC, Sharon Garden Club		
Lake-Friendly Septic Education	Residents		Town Health Engineer	LMAC, DPW, Health Dept.	MASSTC	
Education about P-reduction Wastewater technologies	Residents		LMAC Members		MASSTC	

Monitoring and Evaluation (see Element H/I)						
Management Measures	Location	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Frequency	Funding Needed
CWMN - monthly sampling Sucker Brook May-Oct	Sucker Brook	n/a	\$1,500	NepRWA	monthly	LMAC budget
TRC - monthly lake sampling post-alum Tx per NHESP	Lake Massapoag	n/a	\$20,340	TRC	Bimonthly May-July-Sept	none (in CPA FY25 grant for alum treatment)
Additional wet weather runoff, seepage & outfall testing	Select Shoreline Sites: Massapoag Ave, camps, etc.	n/a	\$9,300	TRC	quarterly	CPA FY27 (10% in CPA FY26)
Mussel Survey post-alum Tx per NHESP	Lake Massapoag 2026	n/a	\$5,500	TBA	one time	none (in CPA FY25 grant for alum treatment)
Cyanobacteria Monitoring	Lake and Beaches	n/a	\$1,100 fluorometer calibration	LMAC	weekly	LMAC budget
Total Funding Needed:						
Funding Sources:						
- Town Funding/LMAC FY26 (received) and FY27 (approved at Town Meeting May 2026) - CPA FY27 Grant: \$103,000, of which \$36,000 is local match for VMB project, \$37,500 weed mitigation, and balance for specialty testing and signage (with Sharon Historical Commission) – approved at Town Meeting May 2026 - Everwood Day Camp donation of \$37,500 for DASH May 2026 to match CPC FY27 request for DASH - MVP FY27 Application: Submitted 2-year grant application 1st qtr 2026 - DEP Sec 604(b) FY27 Application: To submit 2-year grant application 3rd qtr 2026						

Element E: Public Information and Education

Step 1: Goals and Objectives

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

The goal of the watershed information and education program is to educate Sharon residents about the impact of phosphorus on the water quality of Lake Massapoag. The primary focus areas include: lake-friendly landscaping and gardening, septic system maintenance and replacement, and proper use of outdoor cleaning products (e.g. decks, siding, autos, boats).

Step 2: Target Audience

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

The target audience is Sharon residents, particularly lakefront and watershed residents. Our plans are to reach and engage them through community events, community organizations, lake neighborhood events, newsletters, and social media. Additionally, the LMAC will target residents with outdated septic systems for more information on the potential contribution of phosphorus to Lake Massapoag from septic systems.

Step 3: Outreach Products and Distribution

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

In addition to the elements outlined in Table D-2, newsletters, brochures, social media, and events, we plan:

Lake-Friendly Landscaping and Gardening:

- o Develop a trifold brochure on Lake-Friendly Landscaping and Gardening, similar to the Welcome to Sharon/Septic Education brochure, that will be mailed to all households as an LMAC newsletter.
- o Continue educating residents on lake-friendly yard, shoreline and lawn care; working with the Sharon Garden Club on education and promoting best practices, such as through a Lake-Friendly Yard and Garden Tour, to follow up on the presentations we gave at the 2024 Garden Club Forum.
- o Ask the Sharon Men's Club to host a talk on lake-friendly shoreline and yard care, similar to the one they hosted for LMAC and the Town Health Engineer on Caring for Your Septic System in 2024.
- o This work builds on the Love our Lake lawn sign campaign, whose 250 attractive yard signs around town read, "Love our Lake: Less Fertilizer, No Phosphorus." We also distribute Love our Lake stickers to children at town and school events, such as Cottage Street Elementary School's STEAM night.
- o Work with private property owners along Massapoag Ave to prevent erosion and runoff by maximizing stormwater retention on their lots through swales, rain gardens, vegetative borders, etc. The Town's Conservation Agent provides consultation upon request. We will publicize this and consider ways the Town might assist.

Septic Education and Upgrading:

LMAC will publicize its findings on the survey and status of town residential septic systems completed in 2025 and use it to develop recommendations for stronger Title 5 enforcement mechanisms to fill existing gaps:

- Rigorous Enforcement of state and local septic system regulations to ensure that systems are maintained properly and are upgraded as necessary
- Continuing education of residents; camp, school, and venue managers; town officials; people living or working in the watershed, and of visitors to the lake on the importance of minimizing phosphorus discharges into the lake and the ways of doing so such as using phosphorus free cleaning products and fertilizer to the maximum extent feasible and proper septic system use and maintenance.
- Ongoing publicity of the town's low-cost septic betterment loan program, **which received increased funding at 2025 town meeting, and creation of additional financial incentives (e.g. rebates, deferral program, etc.)**
- Evaluating the feasibility and efficacy of creating a watershed water pollution management district to coordinate funding and implementation of BMPs and the routine inspection, pumping, maintenance and repair of septic systems and installation of phosphorus controls. This could include townwide or watershed-wide assessments.

Step 4: Evaluate Information/Education Program

Information and education efforts and how they will be evaluated.

LMAC will track how many people attend events, walks and presentations, and will follow-up with individual assistance when requested, such as consultation on shoreline erosion/runoff control improvements, lake-friendly yards and gardens, and applications to the Town's low-cost septic betterment loan program, etc.

Previous Public Engagement Efforts and Other Information

Ongoing and up to date information regarding Lake Massapoag is available on the Town of Sharon's website at <https://www.sharonma.gov/lake-massapoag-advisory-committee> as well as at the LMAC's website <https://www.lakemassapoag.net/>. LMAC meetings are open to residents to attend.

Additional Resident Concerns at LMAC's Public Hearing on the Draft WBP and at Town Meeting

During the 2025 Annual and Special Town Meeting in May 2025, Massapoag Avenue residents expressed concern about increased runoff and shorefront erosion with a past redesign of Massapoag Avenue. The road reconstruction project added a bicycle lane, brought the road up to state standards regarding travel width and crowning, and redirected runoff from the Arboro Drive storm drains underground to beneath the Pond St. rotary and into Massapoag Brook.

However, it required using the full extent of the town's right-of-way reducing some of the space on the lake side of the road and removed a Cape Cod berm that helped protect shoreline properties from excess runoff. A berm was later reconstructed along a stretch at the northern end of Massapoag Ave, which a neighbor reported has increased runoff to her property. DPW and the Town's Conservation Agent have raised some concerns about the effectiveness of Cape Cod berms, which redirect runoff to openings elsewhere, as reported by the neighbor. Another resident who had requested a curb cut to his shorefront beach when the road was redesigned has asked the town to restore a full granite curb because of excess runoff down Capen Hill Road. DPW noted that conversion of undeveloped shorelines to beaches and grassy areas has led to increased erosion and runoff.

Potential redesign of the roadway and addition of new stormwater control measures (SCM) are recommended for further study and consideration in the next 1-3 years. LMAC explored a potential SCM to reduce runoff down Capen Hill Road that included a constructed wetland at the bottom of the Salvation Army's Camp Wonderland, but its board of directors voted against considering that option on the advice of counsel.

These concerns were repeated at LMAC's public hearing on the draft Watershed-Based Plan in May 2025, along with concerns about the Town's spreading rock salt and sand mix along Massapoag Ave to prevent icing, which washes down the shoreline into the lake and is reported to damage plants. Residents have asked the town to switch to fine salt brine spray instead, which many area towns use and is reported to stay in place longer, with greater effectiveness, and with less environmental impact. If purchasing new equipment takes time, explore if maintenance, plowing, or reserve funds could be used to line the western edge of the roadway with silt socks as a partial barrier for the further spread of rock salt and provide some infiltration for storm runoff and snow melt.

The Town's Conservation Agent has worked with lakefront owners on runoff and erosion control measures, and in suggesting lake-friendly design and plantings. The shoreline reconstruction project by Sapphire Estate provides a model example. The project includes:

- Creation of a channel parallel to the road and filling it with large gravel.
- In the gravel is a drainpipe with holes only on the top side.
- If the road runoff is great enough to fill the channel, the water will not back up onto the street, but rather, will enter the pipe and be discharged to some rip rap down by the water.
- Small storm events will infiltrate in the ditch, and during larger storms, some sediment will still be trapped in the ditch. Water reaching the lake will have less sediment than before.
- The slope that was eroding has been stabilized with hardscaping and vegetation. Some of the infiltrated water will reach the vegetation which may absorb some of the nutrients before they reach the lake.

Elements F & G: Implementation Schedule and Measurable Milestones

Interconnections with Other Town of Sharon Plans

As mentioned in the plan background, to be successful, the Watershed-Based Plan must be integrally connected with other Town plans, objectives, functions, and resources. These include:

- [Sharon Water Department Master Plan](#) (2010)
- Sharon's Comprehensive Plan, *Imagine Sharon: Preserve our Past/Forge our Future* (2019)
- [Sharon Stormwater Management Plan](#) (2019, updated 2022)
- [Sharon Municipal Vulnerability Preparedness Plan](#) (2021)
- [Sharon Hazard Mitigation Plan 2025 Update](#) (2025)
- [Sharon Open Space and Recreation Plan](#) (2025)

In addition, Sharon has a five-year Capital Outlay Plan. Planning for the lake's healthy future must be embedded in all comprehensive and targeted planning efforts as the entire watershed impacts the lake.

Relevant Excerpts from Other Sharon Plans

Imagine Sharon Master Plan (2019)

Imagine Sharon opens, "The Town of Sharon's history can be traced back to its relationship to the area's defining natural resource, Lake Massapoag... The Town purchased Lake Massapoag from the Plymouth Rubber Company in 1936, and the lakefront has since served a number of recreational uses, supporting summer camps and resorts along its shoreline. The Lake and the town's other natural resources remain a source of pride and are integral to the town's character."

The Master Plan includes plans for a bicycle network around the lake, which now has a bike travel lane marked within Massapoag Avenue, and for completing sidewalks along the lake. Sidewalks are being built along Lakeview Avenue in 2025-2027. The lake and water resources are noted in some of the major issues listed:

- The ongoing need to monitor and maintain natural resources to provide for future quantity and quality of drinking water.
- Risks create the need for investment in sustainable and preventive solutions as well as emergency preparedness.
- Connect passive and active recreational spaces, trails, and natural resources, including the lake.
- Increase septic and sewer capacity within the town.

LMAC Recommendations:

1. In the future, LMAC should have a representative on the Master Plan Committee.
2. To complete the sidewalk loop around the lake, DPW should add a crosswalk between the Beach St./Gunhouse intersection and the Veterans Memorial Park Beach gate and walking path.

Sharon Water Management Plan (2010)

Key Elements include:

- Protect groundwater sources
Limit contamination risks from septic systems, fertilizers, road runoff, and hazardous materials.
- Promote conservation
Encourage efficient water use through restrictions, rebates, and education.
- Upgrade infrastructure
Replace aging water mains, improve pumping stations, and modernize meters.
- Plan for growth & demand
Model future water needs based on population growth and variability.
- Emergency preparedness
Develop drought contingency plans and ensure redundancy in supply.

Sharon Stormwater Management Plan (2019, updated 2022)

The Comprehensive Stormwater Management Plan was developed to comply with EPA's [Municipal Separate Storm Sewer System](#) (MS4) stormwater management program. EPA requires municipalities to obtain a permit and implement a plan to reduce pollutants in stormwater runoff before it reaches local waterways. These programs are part of the [National Pollutant Discharge Elimination System \(NPDES\)](#) and are managed by the EPA and state environmental agencies. The programs focus on six "minimum control measures" including public education, illicit discharge detection, and construction site runoff control.

Key aspects of an MS4 program:

- What it is: An MS4 is a system of ditches, curbs, gutters, and pipes that collect and convey stormwater, often from impervious surfaces like roads and parking lots.
- The program's goal: to reduce the amount of pollutants, such as oil, grease, trash, fertilizers, and pesticides, that are carried by stormwater into rivers, lakes, and other water bodies.
- Program requirements: Permit holders must develop and implement a Stormwater Management Program (SWMP) that includes pollution prevention, monitoring, and enforcement.
- Six Minimum Control Measures (MCMs): The required actions are categorized into six specific areas:
 - Public education and outreach
 - Public involvement and participation
 - Illicit discharge detection and elimination (IDDE)
 - Construction site stormwater runoff control
 - Post-construction stormwater management in new development and redevelopment
 - Pollution prevention and good housekeeping for municipal operations

LMAC Table F&G-1: Stormwater Maintenance Checklist (simplified version)

Task	Description	Frequency
Street Sweeping	Sweep streets and municipal parking lots to remove sediment, trash, and pollutants.	Spring & Fall (minimum), plus as needed in high-debris areas
Catch Basin Cleaning	Inspect and clean catch basins to maintain capacity and prevent sediment discharge.	Annually (at least once per year), more often in problem areas
Stormwater BMP Inspections	Inspect detention basins, infiltration systems, rain gardens, swales, and other BMPs.	Annually (minimum), plus after major storms
Stormwater BMP Maintenance	Remove sediment, repair erosion, mow vegetation, and maintain infiltration capacity.	As needed, based on inspection findings
Winter Road Maintenance	Apply salt/sand carefully; calibrate spreaders; use alternative deicers where feasible, develop plan to switch town to salt brine spray.	Throughout winter season
Material Storage & Spill Prevention	Properly store fuels, chemicals, and materials at DPW yards; maintain spill kits.	Ongoing, with quarterly inspections
Storm Drain System Mapping Updates	Update storm sewer system map with new connections or changes.	Annually
Employee Training	Train DPW and municipal staff on stormwater pollution prevention and BMP upkeep.	Annually
Street & Facility Inspections	Inspect municipal garages, parks, and recreational areas for stormwater impacts.	Annually
Reporting & Documentation	Record maintenance activities and submit annual MS4 compliance reports.	Annually

Notes: Summary Table compiled by CoPilot AI. Sharon’s plan emphasizes preventive maintenance: keeping pollutants out of Lake Massapoag and other local waters before they enter the storm drain system. Some tasks (like BMP maintenance or catch basin cleaning) are triggered by inspections—meaning they may occur more frequently if issues are found. All activities are documented in the Operation & Maintenance (O&M) Plan and reported in the Annual MS4 Report to EPA.

LMAC Recommendations:

1. Increase catch basin cleaning and street sweeping on streets around the lake to 3 times per year (spring and twice during fall leaf season); this will require additional personnel and resources.
2. Old outfall pipes and drainage channels that empty wetland areas into the lake should be assessed for addition of stormwater controls. This is complicated by wetlands regulations.
3. Assess if any storm drains are undersized, and if so, increase capacity or add more.
4. Invest in brine spray equipment for pretreating roads near the lake, end use of rock salt.

Sharon Municipal Vulnerability Preparedness (MVP) Plan (2021)

The majority of the plan focuses on potential flooding and other related environmental and health impacts. Additional High Priority items include:

- Develop educational programs that focus on how change will affect Lake Massapoag.
- Develop public education program for change impacts on Town-owned properties, such as Rattlesnake Hill.
- Create a public education campaign on the impacts of change on wetlands and water bodies.
- Continue monitoring of wetlands and water bodies.

Sharon Hazard Mitigation Plan

This plan also has a strong focus on potential flooding and other environmental and health impacts. It notes that rising temperatures, longer growing seasons, and changes in precipitation impact invasive species, including drying of streams and wetlands, and eutrophication of lakes and ponds. Massapoag Lake Dam, a small spillway/gate control structure used solely for management of water levels in Lake Massapoag, is a Significant Hazard dam, but with moderate impacts downstream if it were to fail or overflow.

In its public comments on the draft plan, LMAC noted the additional hazard of excess nutrient inflows into Lake Massapoag resulting from impacts, leading to increased eutrophication, harmful algal blooms (cyanobacteria), degradation of water quality, and beach and lake closures. It gave an example of sites where stormwater control measures and erosion control are needed.

The Plan lists Measures to manage stormwater runoff to Lake Massapoag and Massapoag Brook to reduce water quality impacts as a High Priority Mitigation Strategy, with an estimated \$800,000 for Public Works 2027-2029 from DEP Section 319 grants, MVP Action grants, and CPC funds. Given reduced funding and increased competition for state grant programs, the Town may need to consider local funding.

Table 49: Mitigation Measures for the Hazard Mitigation Strategy

Mitigation Measure	Priority in Update	Lead Implementation	Time Frame	Estimated Cost Range	Potential Funding Sources
FLOOD-RELATED					
5. Measures to manage stormwater runoff to Lake Massapoag and Massapoag Brook reduce water quality impacts (see letter from Lake Massapoag Advisory Commission)	High	Public Works	2027-2029	800K	DEP Water Quality Grants, MVP Grants, CPC funds

LMAC's Recommendations in its public comments (updated to reflect actions taken in 2025):

- The Town's Hazard Mitigation Plan should prominently include hazard mitigation to the lake via mitigation of increased runoff of phosphorus, excess nutrients, septic seepage, etc. and its impact on cyanobacteria, bacteria, and invasive weeds.
- All of the Town's development, open space, recreation, zoning, etc. plans should include lake impacts and how to protect it and incorporate the recommendations of the Watershed-Based Plan 2025-2050 now being developed.
- Core sediment testing in 2024 and a high-dose alum treatment in June 2025, both funded by CPC grants, were successful in reducing internal loading of accumulated phosphorus in deep lake sediment.
- The Watershed-Based Plan includes recommendations for priority projects to reduce external loading of phosphorus via best management practices (BMP) and green infrastructure projects; state funding is available and requires local match.
- LMAC launched a Love our Lake campaign to reduce residential nutrient use and runoff, with a newsletter included in town water bills, Town announcements, the lake website, community organizations, and social media.
- We have begun talking with legislators to increase the ability of towns to enact nutrient reduction measures that have been authorized on Cape Cod and the Island for years, and update and reform measures needed for timely permitting.

LMAC noted runoff down Lake Avenue, pooling along Beach Street, and overflowing directly into Lake Massapoag in recent storms, along with severe beach and sand erosion at Veterans Memorial Park Beach (beach repairs were made in 2025, pending longer term parking area resurfacing and drainage improvements, green infrastructure, and plantings). Plans for the Lake Avenue site are included in the WBP.

Sharon Open Space and Recreation Plan (2025)

“The goals of the Town of Sharon's Open Space and Recreation Plan (OSRP) are to facilitate the preservation and protection of Sharon's natural and recreational resources, and its historic character. Sharon's natural and historic character remains a major attraction and subject of concern to the town's citizens. This natural heritage is also a factor in the economy of Sharon and the quality of life enjoyed by its citizens, but the town is faced with continued population growth, dense development, and financial pressures on its highly residential tax base... Since the submission of its preceding OSRP, Sharon has continued its proactive approach to land and water resource protection, while also experiencing significant changes due to new and proposed residential and commercial developments. The OSRP update continues to identify as high priorities: land preservation, protection of Sharon's water resources, as well as expansion and upgrading of recreational resources.”

Perhaps the town's greatest scenic rest and recreation area is the lake. Some people requested specific updates to town policies to increase their enjoyment of Lake Massapoag. Suggestions included: allowing dogs on the beach for more of the year, creating a bike repair station near the lake, and increasing availability of restrooms. In a survey asking about people's favorite ways to enjoy the lake, swimming led the list at 39%, followed by sitting/ picnicking 34%, boating/water sports 20%, fishing 6%, and winter activities 2%.

Items regarding swimming/boating/fishing facilities, playgrounds, and athletic fields generated the most responses. Perhaps not surprisingly, recreational activities associated with Lake Massapoag (fishing and boating) were largely noted as “adequate” (88% and 91% respectively) while, interestingly, swimming (68% “adequate”) was one of the resources least regarded as “adequate”. The survey was conducted before the June 2025 alum treatment, which resulted in improved water quality and no cyanobacteria sightings during the swim season for the first time in several years.

For those who don’t use the lake, 47% said they were not interested, 45% noted fees, 41% water quality, 16% crowding, 14% parking/access, 8% hours, and 6% overall maintenance. In open-ended responses, some people asked the Town to reopen Community Center Beach (done in 2025 but then closed in late July for the rest of the season due to elevated *E. coli*), reevaluate the fee structure, and extend the season for restroom use.

Table FG-2: Implementation Schedule and Interim Measurable Milestones

Structural & Non-Structural BMPs						
Structural BMPs	EXTENDED DRY DETENTION BASIN W/ SEDIMENT FOREBAY, PLANTINGS, SIGNAGE <i>West Lot Veterans Memorial Beach</i>	FY2026	FY2027	FY2028	FY2029	FY2030
		Con Comm approval, seek funding (2-year MVP & DEP grant), schedule June	Lot and drainage construction, green infra, plantings, signage			
	GRASSED CHANNEL/ WATER QUALITY SWALE, RAIN GARDEN, PLANTINGS, SIGNAGE. <i>East Lot Veterans Memorial Beach</i>	Con Comm approval, seek funding (2-year MVP & DEP grant)	Secure funding (2 nd of 2-year grant), schedule June	Lot and drainage construction, green infrastructure, plantings, signage		
	GRASSED CHANNEL/ WATER QUALITY SWALE <i>Lake Ave and Beach St Concept</i>	Analysis	preliminary concept design, Con comm review	secure funding, schedule	construction	
	CATCH BASINS, CAPE COD BERM, PLANTINGS <i>Massapoag Ave Com Ctr to Rotary</i>		Analysis, preliminary concept design, Con comm review	secure funding, schedule	construction	
	CATCH BASINS, SWALE & PIPE TO WETLANDS <i>Capen Hill Rd to Massapoag Ave</i>			Analysis, preliminary concept design, Con comm review	secure funding, schedule	construction

	Lagoon Aquatic Barrier, Filtergrass Lagoon/S Cove	\$1,500 annual cleaning	\$1,500 annual cleaning	\$1,500 annual cleaning	\$11,925 to replace after 5 yrs (5%/yr inflation)	\$1,500 annual cleaning
Nonstructural BMPs	Street Sweeping for Memorial Beach Parking Lots <i>Memorial Beach Parking Lots: W & E</i>		post construction standard O&M, 2x/yr parking lot sweeping, inspect pipes	post construction standard O&M, 2x/yr parking lot sweeping, inspect pipes	post construction standard O&M, 2x/yr parking lot sweeping, inspect pipes	post construction standard O&M, 2x/yr parking lot sweeping, inspect pipes

LMAC Table FG-3: Actions Summary and Timeline

Category	Action	Year	Completed
Water Quality Monitoring	Perform baseline water quality analysis	2022-2025, ongoing 2026 ff	Yes, ongoing
	Perform annual water quality sampling (bimonthly May-Sept)	2022-2025, ongoing 2026 ff	Yes, ongoing
	Beach and camp <i>E. coli</i> monitoring (weekly June-Sept)	2022-2025, ongoing 2026 ff	Yes, ongoing
	Continue monthly CWMN Sucker Brook sampling	2022-2025, ongoing 2026 ff	Yes, ongoing
	Supplemental Target Testing: runoff, storm drain, seepage	Initial rounds 2024-2025, additional sites 2026	Initial round yes, supplemental repeats and added sites 2026
Vegetation Management	Cove aquatic DASH invasives	Annual DASH late June & Sept	At 20 days/yr, inc. to 35 2026
	Professional weed mapping	Full weed maps 2022 & 2023, then every 2-3 yrs start 2026	Yes, ongoing
	Mussel Survey – NHESP for alum treatment	2026	
Structural BMPs	Plan and apply for funding	WBP 2023-25, projects 2026 ff	Underway and planned 2026
	Complete construction of extended dry detention basin with sediment forebay/swale	West lot June 2027 East lot June 2028	Analysis & plan 2024-2025 ConCom review 2026
	Complete construction of Lake Ave/Beach St swale	2028	Analysis & plan 2025
	Massapoag Ave Drainage and Erosion Control Improvements	2029	
	Capen Hill Drainage Stormwater Improvements	2030	
Non-structural BMPs	Rake the Lake event mid Nov	Annual	2025 (25 people 50+ bags), ongoing
	Wake the Lake event mid-April	Annual	New event, planning 2026
	Increase catch basin cleanings and street sweeping to 3x/yr	2028	
	Begin adoption of salt brine spray pretreatment equipment	2028	New, recommend DPW include in FY28 Town Capital Budget
	Evaluate options for additional internal phosphorus mitigation techniques in 5 years.	2030	
Adaptive Management Plan	Re-evaluate every 5 years and adjust goals as needed.	2030	

Scheduling and milestone information:

LMAC Recommendations

We will monitor progress against these milestones, and adjust the Plan as needed. As part of the planning process, the LMAC created a separate list of priorities and recommendations, which can be found below.

Proposed Additional Testing

See Table HI-1 in the next section.

Elements H & I: Progress Evaluation Criteria and Monitoring

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

Phosphorus and Cyanobacteria

Success will be measured by:

- Phosphorus readings below 0.025 mg/L from in-lake samples
- Phosphorus readings below 0.050 mg/L from tributaries and outfalls
- Reductions in the Phosphorus levels measured at the surface, bottom, and thermocline in the water column in the Deep Hole,
- Reductions in the levels of phycocyanin measured in the lake,
- Reductions in the density of algal growth,
- Increases in Secchi Depth, and
- Reductions in the number, extent and frequency of cyanobacteria blooms:
 - shoreline blooms
 - public beach and/or camp beach closures
 - more extensive blooms and lakewide closures

E. coli

Success will be measured by:

- Reductions in the levels and number of *E. coli* exceedances along Sucker Brook and at CCB, and
- Reductions in the number of beach closures due to elevated *E. coli* levels
- Note: Until sources are identified and remediation plans developed, it is expected that *E. coli* levels will continue to rise at these locations following heavy rains.

Interim Success Measures:

- Identification of the species and potential sources of *E. coli* along Sucker Brook and at Community Center Beach (CCB).
- Development of a mitigation plan for *E. coli* sources and target sites.

A related strategy is Geese Reduction and Deterrence

- Continued reduction in the growth of the resident Canada goose population through egg addling, which has been successful on town-owned land around the lake
- Locate goose nests on private property, assist owners obtain permits, and add these sites to LMAC's egg addling program each spring

- Consider alternatives to the Recreation Department's goose deterrence efforts to obtain more consistent reduction in geese congregating on Veterans Memorial Beach, Community Center Beach, and docks
- Encourage lake abutters to increase goose deterrence efforts and not feed geese
- Ask to Town to open a pilot bow hunting season on geese to help meet the state's target of a 30-35% reduction in the resident goose population

Invasive Weeds

Success will be measured by:

- Reduction in the density and extent of invasive weeds in the Lagoon, South Cove and Fletcher's Cove by 50% in the near term, then by an additional 10% per year,
- Removal of plant-bound phosphorus through DASH weed removal, and
- Reduction in swim area nuisance weed growth at Veteran's Memorial Beach

Indirect Indicators of Load Reduction

Algae Monitoring: In recent years, an increase in the reported incidence of nuisance cyanobacteria blooms has been one of the most notable and visible symptoms of nutrient enrichment and declining water quality. Continued phycocyanin monitoring (weekly July and August, also monthly May, June and September), and plankton ID of the abundance and composition of the lake's algal community will provide a useful metric for understanding water quality trends in response to implementation of the measures recommended under Element C.

Project-Specific Indicators

Wet weather run-off testing will be performed to assess the effectiveness of new BMPs/SCMs in reducing phosphorus.

Direct Measurements

The Town of Sharon will continue to implement the Lake Massapoag Monitoring Program to monitor the progress of the implementation of the 9-E WBP.

Aquatic Plant Mapping

Lake Massapoag aquatic maps have not been mapped since 2023 and are scheduled to be mapped in 2026. To document the spread of invasive and nuisance aquatic plants, aquatic plant mapping is planned to occur every couple of years. Aquatic vegetation will be mapped using a plant rake, underwater video camera, and/or direct visual observation. Mapping events will be completed during the period of maximum plant development in mid-to late summer. Mapping efforts will include the following:

- Mapping of overall plant cover (percent of bottom occupied).
- Mapping of overall aquatic plant biovolume in the pond (percent of vegetative growth in the water column).
- Mapping of extent and density of observed invasive or nuisance plant beds.
- Taxonomic identification of all aquatic plant species observed in the lake.

The coordinates of each mapping position and associated data will be recorded using a GPS and observations will be used to create updated maps of target plant beds.

In-Lake Sampling

In-lake water quality sampling will occur bi-monthly (May, July, and September). Samples will be collected at three locations: the epilimnion (surface), thermocline, and hypolimnion (bottom) of the lake at the deep hole. This sampling is designed to capture a representative spectrum of water quality conditions vertically within the lake. Depending on funding, additional sampling may be conducted at the South Cove.

Water quality will be assessed through direct measurement, as well as the collection of samples for laboratory analysis. Field measurements to be collected at each location will include the following:

- Water transparency (Secchi disk depth) – surface only
- Water temperature
- Dissolved oxygen (concentration and percent saturation)
- Specific conductance
- pH – surface, mid-water column, and bottom
- Turbidity– surface, mid-water column, and bottom

Except as noted, each of these will be measured at one-meter intervals for a vertical profile of the water column.

Additionally, laboratory samples will be collected at each of the sampling locations and analyzed for total phosphorus, dissolved phosphorus, total nitrogen, and chlorophyll a (surface only).

Groundwater Seepage Survey

Based on available funding, additional shoreline segments will be selected for further groundwater seepage investigation and sampling (number of segments tested based on available funding). Two seepage meters will be installed along each of these segments to measure the rate of groundwater in seepage into Lake Massapoag. A portable mini-well (littoral interstitial porewater sampler) will be used to extract shallow groundwater from two locations along each segment. Collected groundwater samples will be tested for total dissolved phosphorus, total nitrogen, specific conductance, pH, and temperature. This event will be targeted for spring-summer 2026 and will be used to provide additional refinement of the external nutrient loading through groundwater.

Shoreline Run-Off

Another shoreline wet weather survey event is proposed at Lake Massapoag. This event will be targeted for a storm event that produces sufficient surface runoff intensity and volume (typically no less than 0.5 inches).

The survey will include installation of unattended runoff samplers at locations along the lake shoreline (number of samples installed based on available funding). These locations will be selected based on input from the Town and evidence of flow concentration (e.g. rills, dry channels). Priority locations include resampling Veterans Memorial Beach to determine if the high nutrient loads collected in 2024 were an anomaly. Collected samples will be tested for total phosphorus, total nitrogen, total suspended solids, and specific conductance, as sample volume allows. This sampling event will be targeted for spring-summer 2026.

Stormwater Outfalls

Another storm drain wet weather survey event is proposed at Lake Massapoag. Water quality samples will be collected at stormwater outfalls (number of samples collected based on available funding). This event will be targeted for a storm event that produces sufficient runoff from impervious surfaces (typically no less than 0.25 inches). Collected samples will be tested for total phosphorus, total nitrogen, total suspended solids, and specific conductance. Additionally, discharge will be estimated at each location to provide an assessment of loading from the measured event. This sampling event will be targeted for spring-summer 2026.

CWMN Testing Schedule

Sucker Brook, which flows into Lake Massapoag, will continue as a designated CWMN site. NepRWA volunteers collect water quality data from May to October, once per month. Water samples are analyzed for *E. coli*, phosphorus, pH, and dissolved oxygen. Collected data is submitted to MassDEP. CWMN volunteers also sample sites along Massapoag Brook, the outflow of the lake. NepRWA also provides annual reports for the CWMN program, which can be found on NepRWA's website here: <https://neponset.org/cwmn-water-quality-reports/>.

TABLE HI-1: Monitoring and Evaluation Summary

Management Measures	Location	Frequency	Cost	Relevant Authorities	Technical Assistance	Funding Needed
Monitoring and Evaluation (see Element H/I)						
CWMN	Sucker Brook	sampling Sucker Brook May-Oct	\$1,500	NepRWA	none	none (in LMAC budget)
qPCR test & preservation kits + <i>E. coli</i> tests	Sucker Brook & Community Center Beach	1-2 rain events	\$4,630	LMAC	none	CPA FY27 request
TRC - bimonthly lake sampling May/July/Sept	Lake Massapoag	n/a	\$20,340	TRC	none	none (in CPA FY25 and FY26 grants for alum treatment monitoring)
Weekly Swim Beach <i>E. coli</i> Testing	Town Beaches, Camps & MYC	n/a	Varies by season length	Board of Health, Camps, MYC	none	none (covered by BOH, Recreation, camp and MYC budgets)
Additional wet weather runoff, seepage & outfall testing	Shoreline Sites: VMB, camps, Massapoag Av	n/a	\$11,545	TRC	none	CPA FY27 request \$9,800, Everwood \$1,400 match, LMAC \$345 match
Mussel Survey post-alum Tx per NHESP	Lake Massapoag 2026	n/a	\$5,500	TBA	none	none (in CPA FY25 grant for alum treatment)
Cyanobacteria Monitoring	Lake and Beaches	weekly, July - August	\$1,100 fluorometer calibration	LMAC	none	LMAC budget
Aquatic Weed Mapping & BioBase Mapping	Coves, add Shoreline 2028	every 2 yrs: 2026, 2028, 2030	\$4,600 - \$5,800	TRC	none	CPA FY27 request

Additional Research on Wastewater Phosphorus Contributions

1. LMAC should continue to research and investigate the contribution of septic system-derived phosphorus in external phosphorus loading to Lake Massapoag. This includes:
 - Add test wells downstream of Sharon High School and other locations to document and quantify septic/wastewater P plumes
 - Conduct additional research on the factors that influence phosphorus attenuation and transport through the watershed, including swamps and underground springs
 - Revise and update the Lake Loading Response Model (LLRM) based on findings.
2. If findings support a significant contribution of septic phosphorus to lake phosphorus load:
 - Evaluate the cost and feasibility of installing phosphorus controls on the Sharon High School wastewater treatment plant that contributes about a quarter (316 pounds) of the estimated human derived phosphorus to the lake.
 - Evaluate the cost and feasibility of urine diversion and/or the installation of phosphorus pretreatment at all or a portion of the septic systems in the watershed.
 - Identify funding sources, including a potential “lake protection fee” on residents in the surface protection district. Research the feasibility of creating a wastewater protection district.

Adaptive Management

LMAC will continue to meet monthly and receive, review and compile reports about lake health and the efficacy of phosphorus reduction methods across external, internal, and septic loading sources; progress in reducing elevated *E. coli* and Community Center Beach closures; and progress in mitigating invasive weeds in the coves on an annual basis. We will assess progress in planning, completing, and evaluating structural BMPs, non-structural BMPs, and educational efforts for impact and effectiveness. Based on the data, progress, and success in seeking and leveraging new resources and funding, LMAC will revise and update the plan every 5 years.

A key part of our Adaptive Management Strategy is to work with other town boards, committees, and departments to achieve greater alignment and synergy on projects, efforts, financing, initiatives, and administrative and regulatory changes needed to accomplish these goals. They range from short to medium and longer-term, and from those that can be accomplished by the Town of Sharon, to those requiring cooperative and state action.

Element J: Recommendations

In Element J, LMAC has added a series of Recommendations into the Watershed-Based Plan for Lake Massapoag 2026-2050. Following the 1984 plan, a series of policy, program, regulatory and zoning changes at the state and local levels, along with major multi-year investments were needed to improve and safeguard lake water quality. A coordinated set of updates, reforms, and innovations in state and local policies, programs, regulations, and zoning, and promotion of adoption of new technologies and conservation measures, will be needed for Sharon to meet its goals for long term, sustained reduction of watershed phosphorus inputs into Lake Massapoag.

Recommendations For Discussion and Feedback from Town Boards:

Proposed Non-Structural Management Measures: LMAC Activities, Operations, Funding,

LMAC Relationship to the Town

1. LMAC has representatives from the Select Board, Conservation Commission, Planning Board, and Recreation Advisory Board, and the Town Conservation Administrator and a Select Board liaison regularly attend. Increase LMAC interconnections with additional town staff and boards and committees, including ZBA.
2. All of the Town's future development, open space, recreation, zoning, and other plans should include lake impacts, and incorporate appropriate recommendations of the Watershed-Based Plan.
3. LMAC should have a representative on the next Master Plan committee.

Plan for Staff Capacity and Staffed Operational Management of Lake Management Actions

Move toward part-time professional staff or contract model to sustain momentum and implement the ambitious plan for the lake with increased operational responsibilities.

- The Town will likely need a part-time Lake Manager, with a departmental home. Consider staff and consultant options, including a shared position with other towns.
- The Conservation Commission says it cannot be the lead agent for a resource over which it has regulatory approval and oversight responsibility.
- Some cities and towns have a Department of Conservation and Natural Resources, or a Parks and Recreation Department which includes lakes.
- In Sharon, Parks are split between Recreation (facilities & programs) and DPW (maintenance). Consider where a lake manager position would be housed or identify staff to take on operational responsibilities.

Rationale: Operational Management, Financial Management, Fundraising

LMAC's operational responsibilities have increased significantly in four years FY2023-FY2026:

- Conduct a Watershed-Based Plan for Lake Massapoag 2026-2050, based on extensive water quality testing, watershed assessment, and assessment of stormwater control measures (SCMs) and best management practices (BMPs).
- High-dose alum treatment June 2025 with a 33% dose to inactivate internal phosphorus for 5-10 years, then it will require deep hole oxygen saturation technology (OST) or a second alum treatment.
- Significant expansion of DASH efforts to limit growth of invasive weeds from 2 days a year to 20+ days in two cycles early and late season.
- Pilot aquatic weed barrier and filtergrass at the Lagoon entry to the South Cove, with weekly clearing of weeds by Everwood Day Camp.
- Love our Lake Campaign, with collaborative presentations, lake walks, tabling at events, a lawn sign campaign, periodic newsletters, flyers, social media, and special events, such as an EPA training on cyanobacteria and a Rake the Lake volunteer event.
- Managing contracts with five lake/watershed consultants: TRC, NepRWA, SOLitude, EverBlue Lakes, and Water and Wetlands; two invasive weed contractors; an aquatic botanist and mussel

biologist required for NHESP permitting and monitoring; and a goose control/egg adding service. This is done within the framework of state and town bidding requirements.

- Filing applications, abutter notification, public hearings, permits, and compliance for 3 lake management actions with Conservation Commission, DEP, and MESA/NHESP.
- Proposal writing, grant and contract management, and reporting for 3 grants cycles: CPC, DEP 304(b) and upcoming DEP Section 319, and MA EEA's MVP Action; and annual donations from Everwood Day Camp for invasive weed and phosphorus mitigation in the South Cove.
- Over FY2023-FY2026, LMAC has leveraged \$872,500 in grants against the Town's 4-year operating budget total of \$160,466, a 5.4:1 ratio.
- We will need expanded resources to implement the Watershed-Based Plan in the face of likely reductions in state and federal funding programs and increased competition.

Looking ahead to five years 2026-2030:

- Ongoing lake and inflow monitoring, in-house cyanobacteria and Secchi disk, seasonal wetlands contributions, PCR testing, septic seepage testing.
- Implement 2-3 priority SCM/BMP projects from the 9-E WBP, with DPW in the lead.
- Based on PCR findings, develop options and implementation project(s) for mitigation to address elevated *E. coli* at Sucker Brook and Community Center Beach.
- Increased weed mitigation efforts (target 35 days DASH up from 20), consider mitigation of additional weeds, comprehensive weed mapping every 2 years.
- Promote lake-friendly landscaping, plantings, rain gardens, etc. among lake and wetlands abutters with Conservation Department and local organizations such as the Men's Club, Sharon Garden Club, Sustainable Sharon Coalition, and Sharon Forward Foundation.
- Well testing to assess phosphorus plume extent from wastewater systems at Sharon High School and Camp Wonderland, and plumes from other properties around the lake.
- Based on findings, ask the Town to establish a new Wastewater Management Advisory Committee to develop options for secondary treatment to reduce P levels and funding.
- Assess best options for the second round of internal phosphorus inactivation, target 2030-2035 (deep hole oxygen saturation technology or another alum treatment).

Need for Additional Public and Private Resources

In its 2025 Hazard Mitigation Plan, the Town of Sharon identified planned stormwater control investments of \$800,000 for 2027-2029 to be funded by Community Preservation Commission (CPC) grants for local match, state MVP Action Grants, and MassDEP Section 319 grants.

However, stormwater control projects will only meet CPC guidelines if they are located on Town open space or recreation land (such as VMB lot and drainage improvement project or the lake itself), and federal budget cuts will reduce funding and increase competition for state grants.

Need for Increased Annual Maintenance Funding for Invasive Weed Management and Other Activities

In 2023, CPC provided a catch-up investment for invasive weed removal, along with LMAC allocating \$25,000 (about 50%) of its annual budget to invasive weed mitigation via DASH, matched by \$25,000 from Everwood Day Camp in 2024 and 2025.

About 75% of DASH has been directed to the South Cove, and Everwood reports much better control this year. However, Fletcher's Cove has gotten much worse and requires a catch-up investment to gain better control. Everwood has agreed to match a CPC grant request for FY27 DASH of \$37,500, so all LMAC's efforts can focus on Fletcher's Cove. The Town should increase annual maintenance funds for invasive weeds to keep them from interfering with recreational use, and from further spreading around the lake shoreline, increasing future impacts and costs. LMAC plans further education about lawn fertilizers fueling lake weed growth, and to ask the legislature to give cities and towns the same powers as on Cape Cod and the Islands to regulate fertilizer use.

With the end of DEP Section 304(b) and MVP Action state grants for the Watershed-Based Plan, LMAC has reduced funding for outreach and communications. We can only produce two instead of four Love our Lake newsletters to mail with Town water bills, and are short on funding for new Love our Lake materials targeting lake-friendly landscape and shorefront design, new Love our Lake signs which could focus on how lawn fertilizers also fuel lake weeds, etc.

Potential Additional Revenue Sources to Consider

- Targeted sponsors for newsletters and events (new April Wake the Lake, Nov. Rake the Lake)
- Targeted donations for cove weed mitigation (like Everwood for South Cove)
- Formation of a Lake Association/Friends 501(c)(3) for education, fundraising, and volunteers
- Surcharge or voluntary donations for weed mitigation added to seasonal beach, boat launch, and kayak storage passes, power boat registrations, fishing licenses; voluntary donations requested from owners of sailboats, paddle craft, and private docks
- Consider a Stormwater Management District and Enterprise (like Dedham and Milton)
- Consider a future Wastewater Management District and Enterprise
- Earmark Town tax revenues (and lease income) from lakefront nonresidential parcels to fund ongoing invasive weed mitigation and water quality monitoring and improvements
- Legislative earmark (concrete project, under \$100K)
- Addition to CPC percentage and/or allocation of undesignated funds for lake health
- Real estate transfer tax or voluntary donation

Recommendations for Departments, Board, and Committee Actions and Initiatives

Here are LMAC's recommendations for departments, boards, and committees to consider to protect the health of the lake, noting the target for action. We ask for feedback, suggestions, cost estimates, and other ideas.

Recreation Department (for pathogen mitigation)

1. Extend seasonal hours for bathroom facilities at VMB from April 1 - October 31 daily (or at minimum weekends and holidays) for beach and park users to reduce human wastewater and phosphorus from swimmers. Keep a porta potty near the building for summer evening, early spring and late fall use.
2. Extend extra trash can service from Memorial Day through Labor Day (the year-round ones maintained by DPW were overflowing on holiday weekends before and after the beach season).
3. Given recent history of elevated E coli levels at CCB, either do not open the beach for swimming until diagnosis and remediation of contaminating sources is completed or open it only through July. Close CCB preemptively during heavy rains (over ½ inch) and during the next day, unless it tests satisfactory.
4. Explore options and potential funding sources for adding bathroom facilities to CCB as the porta potty likely results in more human wastewater and phosphorus from swimmers in the lake.
5. Charge lifeguards and/or beach staff with chasing geese off the beach and out of the swim areas at CCB and VMB, as necessary on a surfboard, unless border collie service is expanded. Consider these actions for more sustained geese deterrence:
 - [Goosinator](#) (cost \$5,600), amphibious remote control, uses golf courses, beaches, parks staffed by Rec Dept summer staff and/or Property Tax Work-off Program volunteers
 - [Swan Pedal Boat](#) (cost \$5,500/sale \$4,400 + S&H for commercial, or under \$1,000 personal version) for each beach, staffed by Rec Dept summer staff and/or volunteers
 - [Away with Geese](#) lights (industrial/steel auger & cage and/or floating) at VMB and CCB (\$450 ea) and green lasers
 - Encourage residents to purchase and place swan decoys on kayaks and paddleboards
 - Assist LMAC in a collaborative effort to meet the goal of reducing resident goose population 30-35% annually by working with USDA APHIS, as recommended by Mass Wildlife. This can be done in collaboration with other property owners who face depredation impacts.
6. Consider a collaborative Around the Lake/Love our Lake walk utilizing existing and the new sidewalk loop to be completed, beach paths, and lakeside trails, in collaboration with Sharon Forward Foundation, Sharon Friends of Conservation, Sharon Historical Commission, Sharon Historical Society, Sustainable Sharon Coalition, and Scout Troops re Eagle and Silver Award projects. Add some interpretive historical, water body features, and ecological signage. Fix broken board on bridge over lagoon inlet and add signs at entrance to the Lagoon path/trail from Community Center Beach and Community Center parking lot.

Department of Public Works (for external phosphorus loading)

1. Clean catch basins around the lake semi-annually.
2. Exceed MS4 requirements by sweeping streets that border the lake directly three times annually, to remove organic debris, sand, and other pollutants before they can be washed into the lake by rain.
3. Inspect annually and fix grading at VMB where gullies run down the beach; as needed after heavy rains.
4. Continue twice a year pickup of invasive weeds removed from the lake.
5. Annual fall leaf pickup of bags from LMAC's Rake the Lake event, and Town residents.

6. To control erosion, pull back exposed sand at VMB to higher areas of the beach when lake water levels are low.
7. Explore the possibility of adding phosphorus entrapment to catch basins.
8. Invest in brine spray equipment for pretreating roads for safety and around the lake starting in FY27, minimize use of rock salt which damages shoreline plants, exacerbating erosion and nutrient runoff.
9. To complete the sidewalk loop around the lake, DPW can add a crosswalk between the Beach St./Gunhouse intersection and the Veterans Memorial Park Beach gate and walking path.
10. Assess options for stormwater control along Massapoag Avenue, at the bottom of Lake Ave, Capen Hill, etc. Work with property owners to plant tall grasses and native plants along the western edge of Massapoag Ave. to stabilize soil, absorb nutrients, filter pollutants, slow runoff, and discourage geese crossing to beaches, fields, yards and wetlands. [with LMAC and Conservation Department]

Conservation Department (for nutrient reduction, erosion control, lake level management)

1. Create a Guide with documentation for the control structures at the lagoon and near SHS to control phosphorus entry and prevent flooding, to ensure knowledge transfer in the future.
2. Consider whether any updates needed to the discharge guidelines in “Procedures and Schedules for Controlling the Water Level” (and replace the older pdf with a cleaner typed copy).
3. The flume channel under the roadway should be assessed periodically to ensure it is structurally sound. The open channel across the rotary from the flume house has field stone walls that show some signs of weakness but there is no risk to public safety. If that were to happen, the walls would need to be rebuilt.
4. Longer term, renovation will be needed to the flume house, built 1930s, as wood shows signs of decay.
5. Shoreline Nature Plant Distribution: Pilot growing seedlings of buttonbush and other shoreline native species to give away to lakefront property owners. Priority will be given to residents with property directly on the lake. Conservation Dept. Land Management funds will be used.
6. Highlight and publicize technical assistance to lake abutters on shoreline plantings, erosion control, green infrastructure, docks requirements, deterring geese, combatting invasive species, etc. Use the Sapphire Estate shorefront project as an example.

LMAC (for external phosphorus loading and pathogen mitigation)

1. Encourage lake-friendly landscaping, runoff and erosion control, lawn alternatives, reduced fertilizer usage, etc. to reduce phosphorus entering the lake, and also nitrogen which fuels invasive weed growth.
2. Invite and assist private property owners with a goose nest on their property to apply for a free egg addling permit and add it to LMAC’s annual egg addling contract on Town-owned property in April. Contract with USDA Animal Plant Hazard Information Service (APHIS) to help meet the MA Division of Fish and Wildlife goal to reduce the year-round resident Canada Goose population by 35% as they crowd out ducks and other waterfowl.
3. Hold educational walks around the lake in May to expand the pilot Wake Up the Lake event. Organize volunteers for an annual Rake the Lake in November to clear and bag leaves along the shoreline for pickup by DPW. Encourage lakefront property owners to rake leaves away from shorelines each fall.

4. Continue the Love our Lake educational campaign through developing new materials, presentations and tabling at events, Lake Information Walks, social media posts, newsletters mailed with spring and fall water bills, meetings with residents and stakeholders, and meetings with other boards and committees.
5. Work with other lake communities, regional associations, and state representatives for changes allowing MA cities and towns to have the ability to limit the timing of lawn fertilization, as on Cape Cod and the Islands, to protect lakes, ponds, rivers, and wetlands from excess phosphorus.
6. In the future, LMAC should have a representative on the Master Plan Committee.

Camps (for pathogens mitigation and external phosphorus loading)

1. Continue to explore with Everwood Day Camp mitigation strategies for the management and replacement of cesspools to upgrade wastewater controls on the Gannett property.
2. Add stormwater controls to fix excess runoff channel under building Gannett stairway.
3. Discuss with Camp Wonderland installing composting toilets near overnight cabins that are currently distant from toilet facilities connected to wastewater treatment.

Review of Administrative and Regulatory Changes

In addition, LMAC will work with the Town to address gaps in administrative and regulatory structures (bylaws and regulations) to increase protection of Lake Massapoag from phosphorus loading from various sources, from shoreline erosion, elevated *E. coli*, invasive weeds, and other threats to lake health and its safe recreational use and enjoyment.

Board of Health (for pathogen mitigation)

1. Increase funding and exercise existing authority to order or conduct inspections of suspected failing septic systems in the surface water protection district.
2. Monitor property transfers on an ongoing basis and identify systems that have no record of required inspection upon transfer and require that the inspection be conducted. Work with area realtors, and explore additional mechanisms, to ensure home buyers understand that an inspection is required prior to transfer.
3. Set up a monitoring and notification system to ensure septic systems are properly maintained and pumped with sufficient frequency.
 - Send a notification explaining the importance of pumping and that pumping is overdue to homeowners who have not pumped their system in four years.
 - Monitor and require that annual pumping occurs for homes whose septic permit or ZBA variance mandates annual pumping.
 - Send all new residents a “Welcome to your septic system” package explaining the importance of pumping and the proper use and maintenance of these systems.
 - Send a notification to owners of homes with a garbage disposal explaining that disposals are illegal and requesting their removal due to their ability to overload septic systems and cause them to fail prematurely.
4. Consider establishing a wastewater management district within the surface water protection district, similar to those established by other MA municipalities with sewers.

5. Strictly enforce the rules of Title 5 and Article 7 regarding replacement systems and new construction. The regulations are intended to ensure that newly constructed or expanded home meet the current stringent Title 5 standards, and replacement systems for existing homes meet them to the maximum extent feasible.
6. Seek funds to provide reimbursement for installing [Urine Diverting Toilets](#) (such as Ecoflush) or adding phosphorus pretreatment to residents with septic systems that are within 300 feet from the shoreline. Urine comprises almost all of household phosphorus waste since removal of phosphorus from detergents.

Planning Board (for external phosphorus loading and pathogen mitigation)

1. Work with the planning board to add to the list of lake protective conditions automatically applied to variances in the surface water protection district.
2. Consider a stormwater management enterprise district to generate revenue for needed improvements and local matching funds, *as is being done in some other area cities and towns.*
3. Create an overlay district for special protections within the surface water protection district.

Zoning Board of Appeals (for external phosphorus loading and pathogen mitigation)

Work with the Zoning Board of Appeals to fully consider lake impacts when granting variances to zoning rules.

- For example, the two-acre zoning around the lake was expressly adopted to protect it from the pollution associated with septic systems, lawns, and other impacts associated with dense housing development in the watershed. The considerations used to weigh the effects of increasing existing nonconformance and potential mitigation measures are different from those appropriate to other neighborhoods. Request that the board consider adding advanced phosphorus and disinfection treatment, and limit phosphorus and nitrogen fertilizer use when granting special permits to houses in close proximity to the lake.

Potential Bylaw Amendments (E coli and phosphorus control)

1. If DNA testing identifies domestic fowl, farm animals or horses as a source of *E. coli* contamination at Community Center Beach, work with the animals' owners and consider passing a bylaw to regulate handling of waste from those species; seek state law changes if needed.
2. Consider passing a bylaw, similar to the current rule on cesspools, that homes in the surface water protection district (and the groundwater protection district) that are less than four feet above the high groundwater level automatically fail a required Title 5 inspection and are therefore replaced upon transfer.
3. Work with the Board of Health to implement the definition of bedroom included in the state Title 5 regulations. Currently the town's definition is less stringent than Title 5 (it undercounts bedrooms by exempting below grade habitable rooms and rooms that automatically count as bedrooms regardless of their design because the house has more than 9 total rooms). While local standards can be more stringent than state standards, they cannot be less so, and state standards apply regardless of local bylaws. This will address the current relative ease with which open space in a home can be converted into bedrooms. See the two definitions of a bedroom. Amend Article 7 to conform.

Recommendations for Updates in State Laws and Programs

LMAC also requests the following actions to be taken at the state level.

1. The special powers granted to municipalities on Cape Cod and the Islands should be extended statewide. All municipalities need the ability to regulate fertilizer applications and facilitate upgrade of septic systems to protect freshwater ecosystems and reduce excess nutrients fueling cyanobacteria blooms. Both administrative and legislative action are needed.
2. Update Dept. of Fish and Wildlife regulations to give control and mitigation of invasive weeds and cyanobacteria priority over protecting state-listed species as it improves the habitat for their long-term survival (federally listed endangered species would still be protected under NHESP). Extend waivers for streamlined permitting available to drinking water systems to public recreational water bodies (or Great Ponds).
3. Authorize/instruct DEP to permit pilots of new technologies for cyanobacteria and weed mitigation that combine aeration, enzymes to digest and reduce muck, and micronutrients to support beneficial species. They increase oxygenation, healthy species and lake volume, and reduce cyanobacteria, harmful bacteria and invasive weeds. Enable pilots of organic barley hay which inhibit cyanobacteria growth. Both are used in other states and internationally.
4. **New:** Amend Title 5 regulations to end or time limit interfamily transfer exemptions, and/or require all properties without a sewer hookup to pass Title 5 inspection every 20-25 years. Provide state funding sources via a refundable state septic/wastewater treatment installation tax credit, or a program modelled on the Property Tax Deferral Program (septic/wastewater installation tax deferral program enabling homeowners to defer property taxes cumulatively up to the amount expended on new septic or wastewater system compliance costs). Consider state or local CPC funded rebates of up to \$20K-\$25K for new systems as on Eastern Long Island.
5. The Commonwealth should provide greater resources for lake restoration, including alum treatments to bind phosphorus accumulated in lake sediment over decades and oxygen saturation technology (OST), to reduce cyanobacteria growth. This is needed to complement the focus on reducing phosphorus inflow.
6. **New:** Extend Wetland Protection Act from 100 to 200 feet of a lake, river, wetland or waterbody. This would include residential and commercial farming, greenhouses, and fowl and animal husbandry.
7. **New:** Massachusetts should create a statewide incentive program for excess phosphorus pollution control and reduction along the lines of the MassSave program, EPA's WaterSense Program, and Town Water Conservation programs to provide education, information, home assessments, rebates, tax incentives, and other measures to support adoption of ways to mitigate excess wastewater, lawn, and home phosphorus sources.

LIST OF APPENDICES (see separate pdf documents)

- A. WBP Projects: 1 and 2 VMB West and East 3 Lake Ave, 4 Capen Hill, 5 Massapoag Ave, with Project Addenda (HydroCAD Reports for 1, 2 and 3)**
- B. WBP Master Budget Sheet**
- C. NepRWA, Combined Catchment Delineation and Pollutant Loading Estimate**
- D. NepRWA, Site Selection Memo and Surveys**
- E. Storm Drain Outfalls Survey, Josh Philibert**
- F. Analysis of Septic Systems Within the Lake Massapoag Surface Water Protection District, Susan Peck**
- G. TRC, External Phosphorus Sampling Memos**
- H. TRC, Nutrient Budget and Sediment Core Study**

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USEPA. (2020). "General Permits for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems in Massachusetts (as modified); Appendix F – Requirements for MA Small MS4s Subject to Approved TMDLs." 7 December 2020.

VHB, University of New Hampshire Stormwater Center, South New England Program State Agencies, USEPA Region. (2022). "[New England Stormwater Retrofit Manual](#)" July 2022.

Internal References

Internal References with Links: Existing Resources Related to Lake Massapoag

Report/Resource Name	Location/Link
Historical Reports (1984-2021)	
Diagnostic and Feasibility Study of Lake Massapoag (IEP 1984)	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/lake-consultant-reports
Update of Aquatic Vegetation Survey, Phytoplankton & Water Quality Analyses at Lake Massapoag (IEP 1987)	same
Saran Twombly, Final Evaluation of the Management Policy for Lake Massapoag (August 20, 1997)	same
Restoration and Revitalization of the Sharon Great Cedar Swamp, DEC, (2012)	same
Lake Massapoag Year-End Report (Lycott 2014)	same
Lake Massapoag Annual Reports (SOLitude 2016-2021)	same
TRC In-Lake Water Quality Reports (2022-2025)	
Water Quality & Aquatic Plant Mapping 2022 (TRC 2023)	same
Lake Massapoag Annual Report 2023 (TRC 2024)	same
TRC, Lake Massapoag Alum Monitoring Report 2025	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/lake-dashboard-and-water-quality
TRC Wet Weather, Seepage, Hot Spot Results (2024-25)	
TRC Water Quality Sampling Memos (2023-2025): Storm Drain Survey Results Wet Weather Shoreline Results Groundwater Seepage Survey Results Hot Spot Sampling at Sucker Brook and Lagoon August and September 2024 Water Quality Results	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/building-blocks-of-the-watershed-based-plan
Alum Feasibility & Treatment Reports (2023-2025)	
Lake Massapoag Sediment Sampling Report (TRC 2023)	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/lake-consultant-reports
Lake Massapoag Sediment Coring and Nutrient Inactivation Dosing Study (TRC 2024)	same
High Dose Alum Treatment Monitoring Report Dec 2025	same
Alum Treatment Report (SOLitude, 2025)	same
Pollutant Loading Estimates (NepRWA)	

Lake Massapoag Catchment Delineation Update and Pollutant Load Estimate Full Report (2024) – NepRWA	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/building-blocks-of-the-watershed-based-plan
Site Selection Considerations for Stormwater Control Measures (NepRWA)	same
Lake Loading Response Model (TRC)	
Lake Massapoag Nutrient Budget Memo on the Lake Loading Response Model (TRC 2025)	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/building-blocks-of-the-watershed-based-plan
BMPs, SCMs, and Outfall/Storm Drain Surveys	
BMP Site Visit Surveys (2024) – NepRWA	same
Josh Philibert, Outfalls Smoke Tested and Monitored (2024)	same
Endangered Species Survey (2023)	
Rare & Endangered Species Vegetation Survey (2023) - Pondweed Pursuits	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/plant-surveys-and-botanist-reports
Invasive Weed Treatment Reports 2014-2018	
Lake Massapoag Invasive Aquatic Plant Control Project Summary (2014) - Oxbow Associates	same
Lake Massapoag Invasive Aquatic Plant Control Project Summary (2018) - Oxbow Associates	same
Wastewater System Analyses	
Analysis Of Septic Systems Within The Lake Massapoag Surface Water Protection District (Susan Peck 2025)	https://www.sharonma.gov/2035/Wastewater-System-Analyses
Weston & Sampson Executive Summary of Preliminary Design Report for Wastewater Collection and Treatment (Weston & Sampson 1989)	same
Other Historical Reports	
Lake Massapoag Study Committee Timeline 1970-2021	https://www.townofsharon.net/lake-massapoag-advisory-committee/pages/lake-dashboard-and-water-quality
Lake Massapoag Study Committee 1990 Monitoring Report	same



Appendix A: Projects Watershed-Based Plan for Lake Massapoag 2026-2050

6/12/26

Projects: 1 and 2. Veterans Memorial Beach West and East
3. Lake Ave/Beach St
4. Capen Hill Rd/Massapoag Ave
5. Massapoag Avenue

TABLE OF CONTENTS

Projects 1 & 2: Veterans' Memorial Beach Memo & Permits	3
Conceptual Plan: Veterans' Memorial Beach Stormwater & Shoreline Improvements	5
Engineering Drawing: Veterans' Memorial Beach Improvements	6
Excess Phosphorus, Drainage, and Erosion Challenges to be Addressed:	7
Major Redesign of the West and East Parking Lots, Drainage, Shoreline, Plantings, & Walking Paths Using Nature-Based Solutions	7
Project Budget and Opinion of Probable Project Costs:.....	8
TSS Removal Calculation: West Lot- 82 Gunhouse Street	10
TSS Removal Calculation: East Lot- Small Parking Lot at Lake Massapoag	11
Project 3. Lake Ave/Beach St Stormwater Improvement Project.....	12
Design/Planning/Permitting Phase	12
Flooding, Runoff, Excess Phosphorus, and Erosion Challenges to be Addressed	13
Bioretention Basin/Vegetated Swale: Conceptual Sketch	14
TRC Conceptual Plan for Lake Ave Dry Water Quality Swale (showing design 3 of 4).....	15
TSS Calculations	16
Project 4. Capen Hill Stormwater Improvement Project.....	17
Preliminary Planning/Design/Exploration Phase.....	17
Flooding, Runoff, Excess Phosphorus, and Erosion Challenges to be Addressed	18
Conceptual Design	19
Project 5. Massapoag Ave Stormwater and Shoreline Improvement Project	20
Massapoag Avenue Runoff.....	21
Flooding, Runoff, Excess Phosphorus, and Erosion Challenges to be Addressed	22
5A. Exploring Options for Massapoag Avenue: Town of Sharon.....	22
5B. Exploring Options for Massapoag Avenue: Improvement Projects by Shoreline Residence Property Owners	23
Addendum: HydroCAD Report, Veteran's Memorial West Lot	24
Addendum: HydroCAD Report, Veteran's Memorial East Lot.....	43
Addendum: HydroCAD Report, Lake Ave/Beach St	78

Projects 1 & 2: Veterans' Memorial Beach Memo & Permits



TOWN OF SHARON DEPARTMENT OF PUBLIC WORKS

217 REAR SOUTH MAIN STREET, P.O. BOX 517
SHARON, MASSACHUSETTS 02067
TEL: (781) 784-1525 FAX: (781) 784-1508

BUILDING ENGINEERING/GIS FORESTRY OPERATIONS WATER

MEMORANDUM

TO: Josh Philibert, Conservation Administrator
Peg Arguimbau, Chair
Jon Wasserman, Vice Chair
Conservation Commission

FROM: Kyle Dubuc, Town Engineer

DATE: February 18, 2026

SUBJECT: Massapoag Parking Lot Redesign Project – Project Narrative

The Town of Sharon's Department of Public Works has designed the following drainage enhancements for two parking lots located on 82 Gunhouse Street. These are beach parking lots during beach season and the west lot serves as a parking lot for junior high school students during the academic year. The design aims to minimize the parking area and add green space where motor vehicles are currently parked, enhance the existing drain paths with improved low-impact development strategies, and treat runoff.

Project Background

The two existing parking lots are constructed of a mixture of bituminous concrete and compacted gravel and stone dust. Existing stormwater conveyance is accomplished via overland flow to nearby wetlands and water resources without interception of runoff or Total Suspended Solids (TSS) removal. Flows from the existing west parking lot during a 100-year storm peak at 10.28 cubic feet per second, whereas the east parking lot next to the Boat Ramp Parking Lot peaks at 3.85 cubic feet per second. The existing parking layout is not delineated correctly, and due to parking in shaded areas, regular use, and maintenance activities, the compact stone dust and gravel area has expanded beyond what is needed. The parking lots are a recreational hotspot with heavy use and a center point for Sharon residents.

Proposed Design

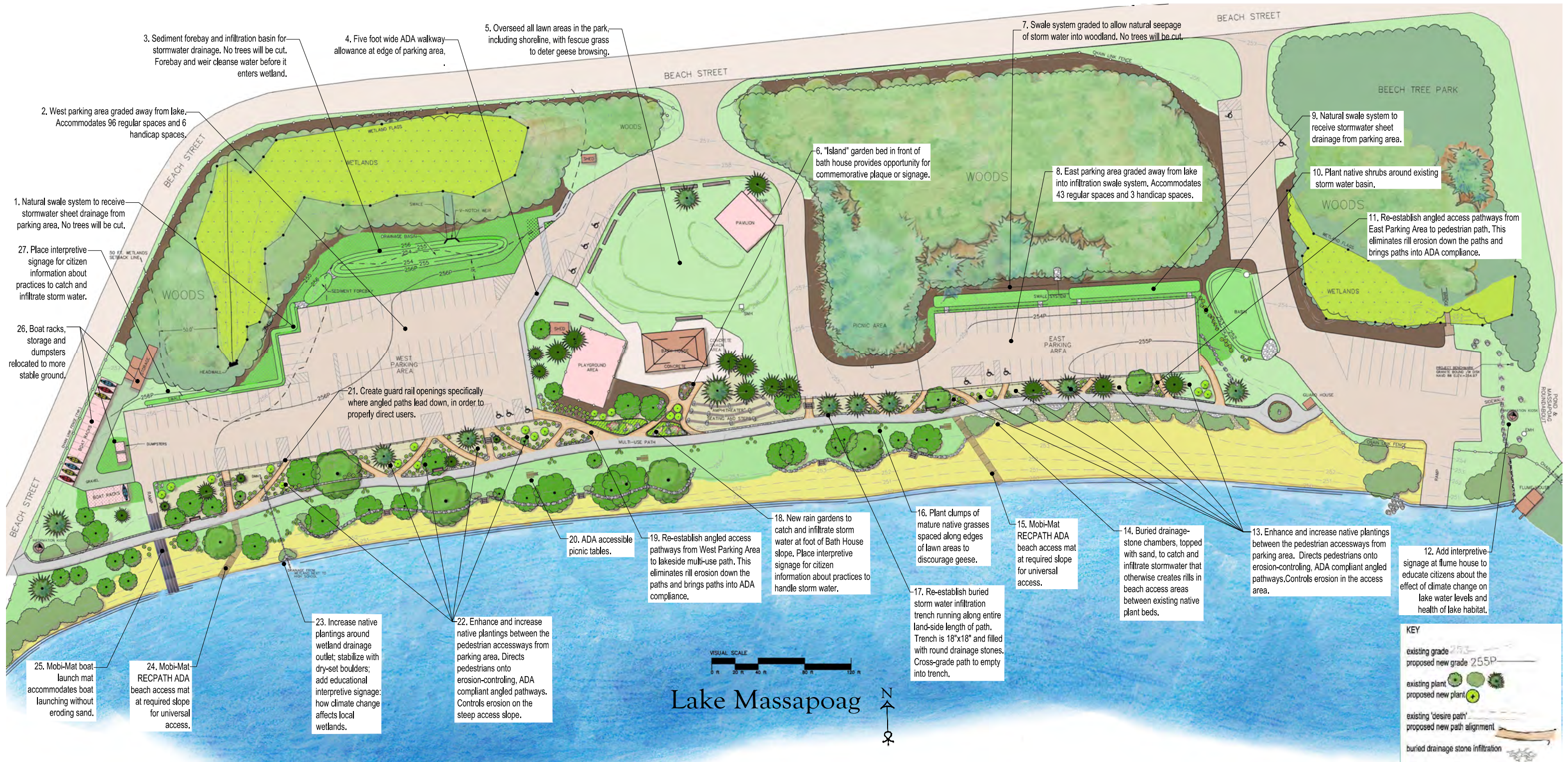
The proposal is to excavate the existing parking lots and pave with porous asphalt and add two (2) detention basins with overflow control to add TSS removal and disperse runoff. The proposed design reduces the 100-year storm peak flows for the west lot to 2.96 cubic feet per second and 3.28 cubic feet per second for the east lot (combined parking lot wetland outflow). The west lot will be sloped, utilize a v-notch weir to minimize scouring, and provide a proper overflow rate for the basin. In contrast, the east lot will be sloped to drain toward the wooded area north of the parking lot. Both designs meet the 100-year rainstorm event demands and are designed per TR-55 "Urban Hydrology for Small Watersheds and the Massachusetts Stormwater Handbook using the NRCS method for capacity. You will find the HydroCAD calculations to support the design attached. 12,000 S.F. of new green space is proposed on the west lot, and 3,120 S.F. is

proposed on the east lot. These green spaces have been gained due to a more efficient parking layout design, allowing the parking capacity to remain relatively unchanged. There is no direct change to wetland grading other than a naturalized swale connection after the v-notch weir hydraulically links the stormwater to the wetland via a designed overflow swale connection.

Conclusion

The project, as proposed, is a net gain for both environmental impacts and use. Adding a sidewalk for pedestrian safety for high school students, circular delineated traffic flow, and curbed paved areas allow for safe travel within the parking lot. In addition, expanding green space, low-impact development strategies, and additional runoff detention time will improve the quality of discharge to our natural resources. Currently, the DPW is only seeking approval for both parking lots.

NOI original "Proposed Parking and Stormwater Plan" filed 10/29/2024 by Kevin M Davis, PE
Update and/or Final Revision Date: 2/2/2026
DEP File number: 280-0664
Conservation Commission Hearing: 2/19/2026



Veterans' Memorial Beach Stormwater and Shoreline Improvement Project

PHASE 1 ILLUSTRATIVE PLAN

A joint project of:

Town of Sharon Recreation Department
219 Massapoag Avenue
Sharon, Massachusetts 02067
781.784.1530
flivera@townofsharon.org

Lake Massapoag Advisory Committee
90 South Main Street
Sharon, Massachusetts 02067
781.784.1511
lakecom@townofsharon.org

Town of Sharon Conservation Commission
219 Massapoag Avenue
Sharon, Massachusetts 02067
781.784.1511
sharonconcom@townofsharon.org

Town of Sharon Department of Public Works
217r South Main Street
Sharon, Massachusetts 02067
781.784.1525 kweber@townofsharon.org

Veterans' Memorial Park Beach
LAKE MASSAPOAG
SHARON, MASSACHUSETTS

project stage: PROPOSED IMPROVEMENTS

date: February 26, 2026

graphic design: **RAINGARDEN DESIGN STUDIO**
AMANDA SLOAN, LANDSCAPE ARCHITECT 617 . 365 . 6477

Engineering Drawing: Veterans' Memorial Beach Improvements



Excess Phosphorus, Drainage, and Erosion Challenges to be Addressed:
Major Redesign of the West and East Parking Lots, Drainage, Shoreline, Plantings, & Walking Paths with Interpretive Signage Using Nature-Based Solutions



VMB East Runoff Erosion Feb 2024 VMB East Interim Repairs Sept 2024 VMB West Lot Erosion Sept 2024 VMB West Lot Flooding Erosion Runoff VMB West Interim Repairs Oct 2024



Bituminous Concrete LAKE MASSAPOAG BEACH PARKING LOT ROUGH ORDER MAGNITUDE OPINION OF PROBABLE PROJECT COST					
ITEM	QTY	UNIT	UNIT PRICE	EXTENDED PRICE	NOTES
CONSTRUCTION COSTS					
Mobilization/Demobilization	1	LS	-	-	Included within price of other items
Excavation of Parking Lot	1893.827	CY	\$ 50	\$ 94,691	Lorusso - unclassified Excavation - SERSG DPW Services for 3/1/25 - 2/28/26
Furnish and Install 12" Gravel Subbase	1,420	CY	\$ 35	\$ 49,713	LAL Construction Co - processed gravel in place - SERSG DPW Services for 3/1/25 - 2/28/26
Furnish and Install 4" Bituminous Concrete	4,261	SY	\$ 31	\$ 132,094	Lorusso - Playgrounds/Parking Lots - SERSG DPW Services for 3/1/25 - 2/28/26
Striping	1	LS	\$ 4,000	\$ 4,000	Vendor quote Lorusso Corp on 11/10/25
Furnish and Install Guardrails	360	LF	\$ 36	\$ 12,960	Estimate from Peter O'Cain
Furnish and Install Fencing	330	LF	\$ 30	\$ 9,900	Estimate from Peter O'Cain
SUBTOTAL WEST PARKING LOT CONSTRUCTION COSTS				\$ 303,359	
Mobilization/Demobilization	1	LS	-	-	Included within price of other items
Excavation of Parking Lot	740.7407	CY	\$ 50	\$ 37,037	Lorusso - unclassified Excavation - SERSG DPW Services for 3/1/25 - 2/28/26
Furnish and Install 12" Gravel Subbase	556	CY	\$ 35	\$ 19,444	LAL Construction Co - processed gravel in place - SERSG DPW Services for 3/1/25 - 2/28/26
Furnish and Install 4" Bituminous Concrete	1,667	SY	\$ 31	\$ 51,667	Lorusso - Playgrounds/Parking Lots - SERSG DPW Services for 3/1/25 - 2/28/26
Striping	1	LS	\$ 4,000	\$ 4,000	Vendor quote Lorusso Corp on 11/10/25
Furnish and Install Guardrails	360	LF	\$ 36	\$ 12,960	Estimate from Peter O'Cain
Furnish and Install Fencing	330	LF	\$ 30	\$ 9,900	Estimate from Peter O'Cain
SUBTOTAL EAST PARKING LOT CONSTRUCTION COSTS				\$ 135,008	
Construction of Swales, Detention Basins, and Plunge Pools	1	LS	\$ 73,500	\$ 73,500	Updated Vendor quote R.J. Gabriel Construction Company Inc on 11/24/25
Shoreline Work (hardscape, planting, and signage)	1	LS	\$ 100,000	\$ 100,000	
SUBTOTAL WEST AND EAST PARKING LOT CONSTRUCTION COSTS				\$ 611,867	

CONCEPTUAL OPINION OF CONSTRUCTION COSTS \$ 611,867

10% Owner Controlled Contingency \$ 61,186.69

TOTAL PROJECT COST \$ 673,054

Veterans' Memorial Beach Stormwater and Shoreline Improvement Project

Project Task	Total Grant	Cash Match
Tasks to be Completed by June 30, 2027		
Task 1: Construction Project- Memorial Beach West Parking Lot Drainage Improvements		
Sub-task 1.1 Kick-off meeting with Town, EEA and Core Team	\$ 750.00	\$ 75.00
Sub-task 1.2 Monthly progress reports (template provided)	\$ 1,500.00	\$ 150.00
Sub-task 1.3 Project Case Study (required at end of project; template provided)	\$ 250.00	\$ 25.00
Sub-task 1.4 Construction of drainage swales, plunge pool and detention basin near West Parking Lot	\$ 49,000.00	\$ 4,900.00
Total Task 1 Cost	\$ 51,500.00	\$ 5,150.00
Task 2: Mobilize , Site Preparation and Management:		
Sub-task 2.1 Mobilize, Site Preparation and Management:	\$ 10,000.00	\$ 1,000.00
Total Task 2 Cost	\$ 10,000.00	\$ 1,000.00
Task 3: Hardscape Site Improvements		
Sub-task 3.1 Re-establish angled access pathways from all parking areas to pedestrian path	\$ 10,000.00	\$ 1,000.00
Sub-task 3.2 Buried drainage-stone chambers between existing native plant beds.	\$ 3,750.00	\$ 375.00
Sub-task 3.3 Re-establish buried storm water infiltration trench running along entire path.	\$ 18,850.00	\$ 1,885.00
Sub-task 3.4 Cross-grade path to empty into trench.	\$ 10,000.00	\$ 1,000.00
Sub-task 3.5 Stabilize wetland drainage outlet with dry-set boulders.	\$ 5,000.00	\$ 500.00
Total Task 3 Cost	\$ 47,600.00	\$ 4,760.00
Task 4: Owner's Project Manager		
Sub-task 4.1 Hiring OPM services	\$ 15,000.00	\$ 1,500.00
Total Task 4 Cost	\$ 15,000.00	\$ 1,500.00
TOTAL PROJECT COST FY27	\$ 124,100.00	\$ 12,410.00

Tasks to be Completed by June 30, 2028		
Task 11: Construction Project- Memorial Beach East Parking Lot Drainage Improvements		
Sub-task 11.1 Kick-off meeting with Town, EEA and Core Team	\$ 750.00	\$ 75.00
Sub-task 11.2 Monthly progress reports (template provided)	\$ 1,500.00	\$ 150.00
Sub-task 11.3 Project Case Study (required at end of project; template provided)	\$ 250.00	\$ 25.00
Sub-task 11.4 Construction of drainage swales near East Parking Lot	\$ 24,500.00	\$ 2,450.00
Total Task 11 Cost	\$ 27,000.00	\$ 2,700.00
Task 12: Mobilize , Site Preparation and Management:		
Sub-task 12.1 Mobilize, Site Preparation and Management:	\$ 10,000.00	\$ 1,000.00
Total Task 12 Cost	\$ 10,000.00	\$ 1,000.00
Task 13: Planting Site Improvements		
Sub-task 13.1 Overseed all lawn areas in the park, including shoreline, with goose-resistant seed mix	\$ 7,000.00	\$ 700.00
Sub-task 13.2 Plant native shrubs around existing storm water basin	\$ 4,400.00	\$ 440.00
Sub-task 13.3 Enhance and increase native plantings between pedestrian ways from parking area	\$ 9,400.00	\$ 940.00
Sub-task 13.4 Plant clumps of mature native grasses spaced along edges of lawn areas	\$ 10,600.00	\$ 1,060.00
Sub-task 13.5 New rain gardens at foot of Bath House slope	\$ 10,000.00	\$ 1,000.00
Sub-task 13.6 Increase native plantings around wetland drainage outlet.	\$ 5,000.00	\$ 500.00
Total Task 13 Cost	\$ 46,400.00	\$ 4,640.00
Task 14: Recreation Safety, Accessibility and Erosion Control		
Sub-task 14.1 ADA Picnic Tables	\$ 17,600.00	\$ 1,760.00
Sub-task 14.2 Benches	\$ 10,500.00	\$ 1,050.00
Sub-task 14.3 MobiMats	\$ 8,500.00	\$ 850.00
Total Task 14 Cost	\$ 36,600.00	\$ 3,660.00
Task 15: Signage		
Sub-task 15.1 Furnish and installation of interpretive signage	\$ 25,000.00	\$ 2,500.00
Total Task 15 Cost	\$ 25,000.00	\$ 2,500.00
Task 16: Geese Deterrence		
Sub-task 16.1 Installation of Away with Geese lighting	\$ 2,900.00	\$ 290.00
Total Task 16 Cost	\$ 2,900.00	\$ 290.00
Task 17: Owner's Project Manager		
Sub-task 17.1 Hiring OPM services	\$ 15,000.00	\$ 1,500.00
Total Task 17 Cost	\$ 15,000.00	\$ 1,500.00
TOTAL PROJECT COST FY28	\$ 162,900.00	\$ 16,290.00
TOTAL PROJECT COST OVERALL	\$ 287,000.00	\$ 28,700.00

Note: Town of Sharon capital budget to pay for West and East Lot Construction costs (first two subtotals on prior page).
Town submitted MVP Action grant for site drainage and shoreline improvements, accessibility and interpretive signage.

TSS Removal Calculation: West Lot- 82 Gunhouse Street

- INSTRUCTIONS:
- 1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
 - 2. Select BMP from Drop Down Menu
 - 3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: 82 Gunhouse Street

TSS Removal
Calculation Worksheet

B	C	D	E	F
BMP ¹	TSS Removal Rate ¹	Starting TSS Load*	Amount Removed (C*D)	Remaining Load (D-E)
Grass Channel	0.50	1.00	0.50	0.50
Sediment Forebay	0.25	0.50	0.13	0.38
Infiltration Basin	0.80	0.38	0.30	0.08
Street Sweeping - 9%	0.09	0.08	0.01	0.07
	0.00	0.07	0.00	0.07

Total TSS Removal = 93%

Separate Form Needs to
be Completed for Each
Outlet or BMP Train

Project: Massapoag Large Parking Lot
Prepared By: Kevin Davis, P.E.
Date: 12/10/2024

*Equals remaining load from previous BMP (E)
which enters the BMP

Non-automated TSS Calculation Sheet
must be used if Proprietary BMP Proposed
1. From MassDEP Stormwater Handbook Vol. 1

TSS Removal Calculation: East Lot- Small Parking Lot at Lake Massapoag

INSTRUCTIONS:

- 1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
- 2. Select BMP from Drop Down Menu
- 3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: SMALL PARKING LOT AT LAKE MASSAPOAG

TSS Removal Calculation Worksheet	B	C	D	E	F
	BMP ¹	TSS Removal Rate ¹	Starting TSS Load*	Amount Removed (C*D)	Remaining Load (D-E)
	Street Sweeping - 9%	0.09	1.00	0.09	0.91
	Grass Channel	0.50	0.91	0.46	0.46
	Infiltration Basin	0.80	0.46	0.36	0.09
	Infiltration Basin	0.80	0.09	0.07	0.02
	Constructed Stormwater Wetland	0.80	0.02	0.01	0.00

Total TSS Removal =

100%

Separate Form Needs to
be Completed for Each
Outlet or BMP Train

Project:

MASSAPOAG

Prepared By:

KEVIN M. DAVIS

Date:

12/17/2024

Non-automated TSS Calculation Sheet
must be used if Proprietary BMP Proposed
1. From MassDEP Stormwater Handbook Vol. 1

*Equals remaining load from previous BMP (E)
which enters the BMP

Project 3. Lake Ave/Beach St Stormwater Improvement Project

Design/Planning/Permitting Phase

3. Lake Ave/Beach St. Vegetated Swale

Flooding, Runoff, Excess Phosphorus, and Erosion Challenges to be Addressed

Conceptual Plan

Engineering Drawing

TSS

HydroCAD: See addendum.

Flooding, Runoff, Excess Phosphorus, and Erosion Challenges to be Addressed

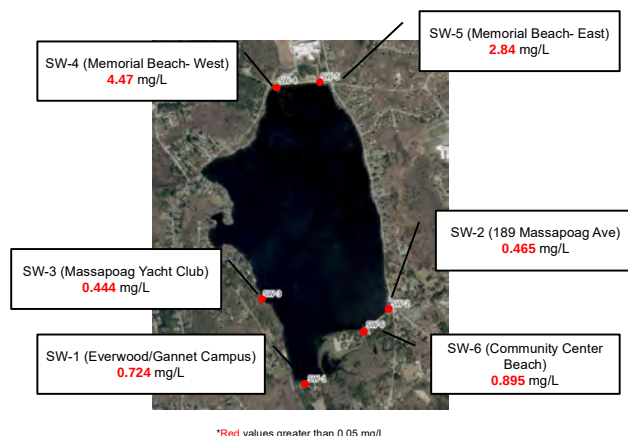
Homeowner cut down trees on slope at top of Lake Ave which flooded next door owner's basement.

Town added the berm to redirect runoff down Lake Ave and a storm drain to collect it; it is not sufficient for heavy rainstorms.

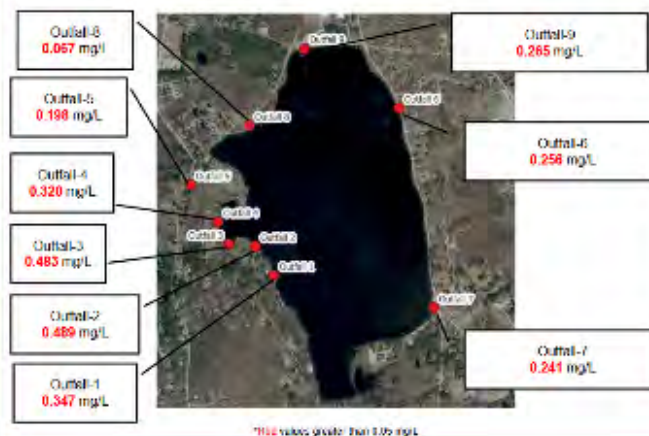
Lake Avenue and Beach Street



TRC Testing- Stormwater Runoff

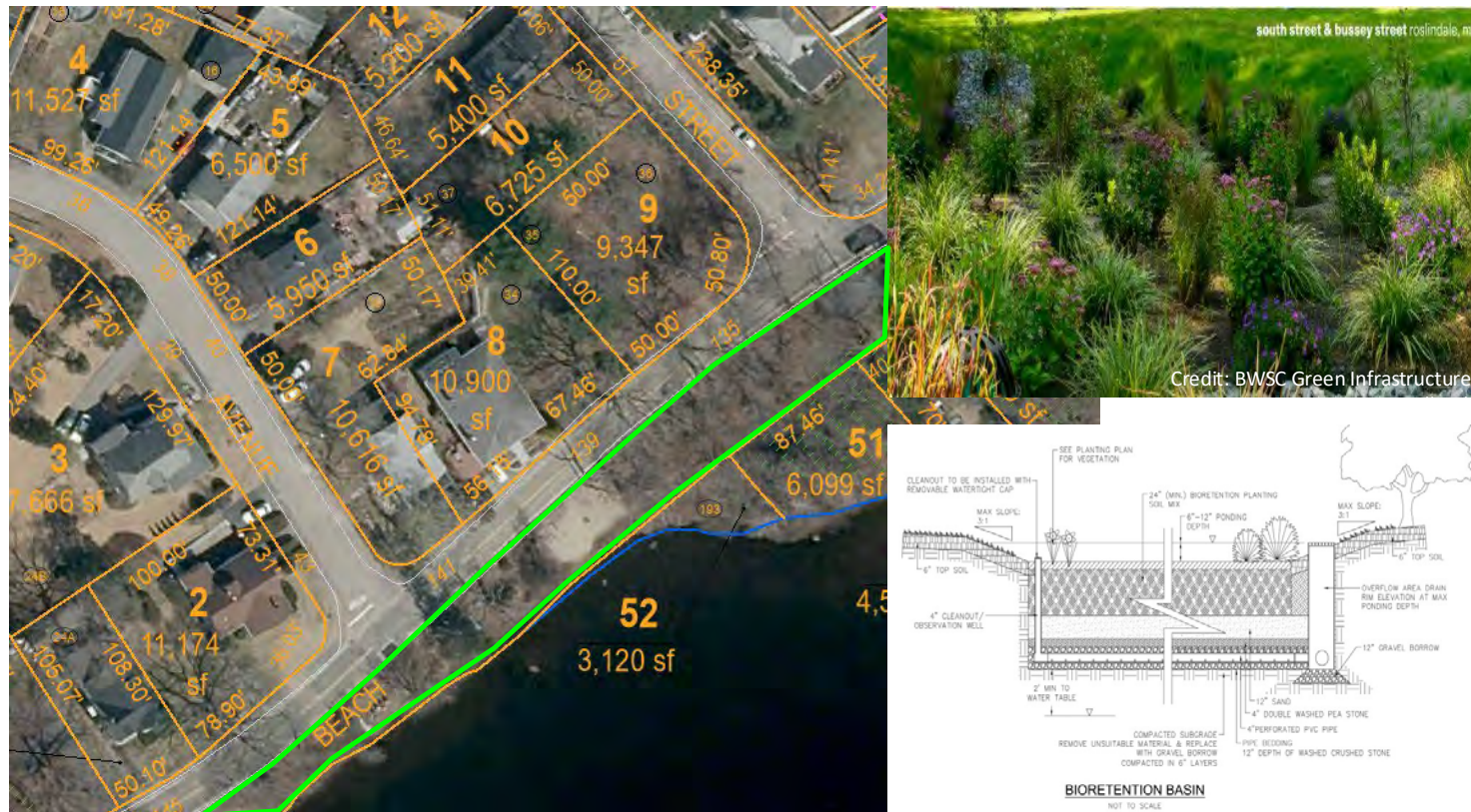


TRC Testing- Storm Drain

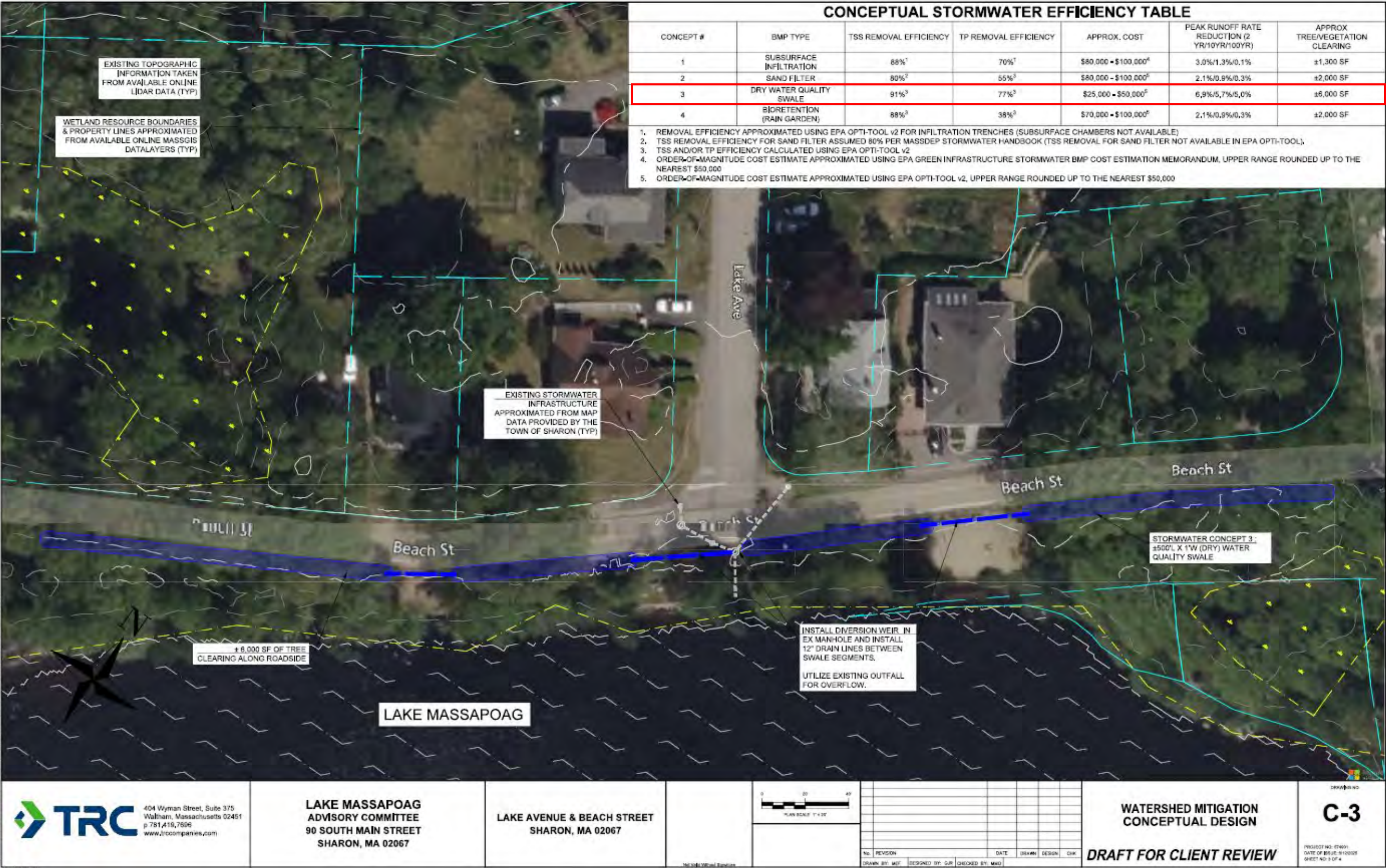


While this site was not sampled directly, see high P runoff all around the lake and at outfalls

Potential for Detention Area in Right-of-Way



TRC Conceptual Plan for Lake Ave Dry Water Quality Swale (showing design 3 of 4)



TSS Calculations

Conceptual BMP Pollutant Removal Estimate

Lake Avenue, Sharon MA

BMP 3 - Dry Water Quality Swale

6/16/2025

Impervious Area Treated, ac	1.21
Drainage Area Treated, ac	2.43
Order of Magnitude Construction Cost	\$50,000

Approximate Pollutant Analysis, lb/yr ±

Pollutant	Loading	BMP Loading	Removal Rate	Removed	\$/lb removed (20 yrs)
TSS	2,337.00	567.891	91%	514.51	\$ 5
TP	10.35	2.515	77%	1.94	\$ 1,291

Notes:

1. Loading and pollutant removal rates obtained from EPA Opti-Tool (For Infiltration Trench).
2. BMP Loading = loading/10 ac x Equivalent Drainage Area
3. Pounds removed = Captured x removal rate
4. \$/lb removed based on 20 years of removal (\$/lb removed = cost/(lbs removed x 20))

Project 4. Capen Hill Stormwater Improvement Project

Preliminary Planning/Design/Exploration Phase

4. Capen Hill

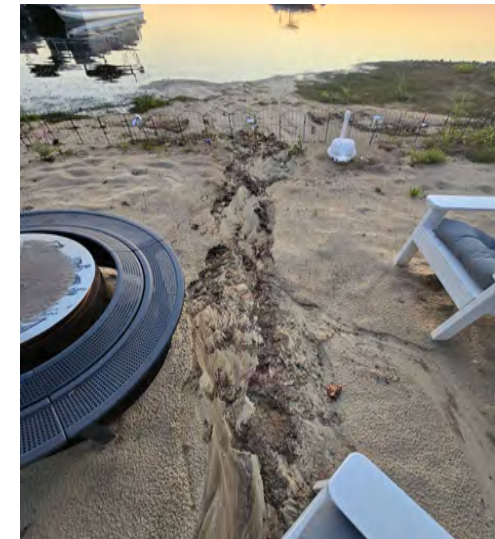
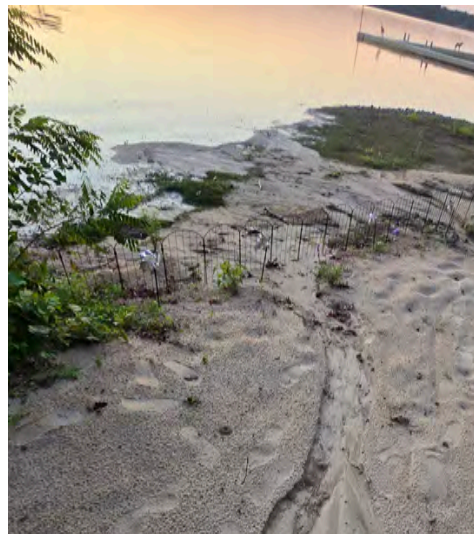
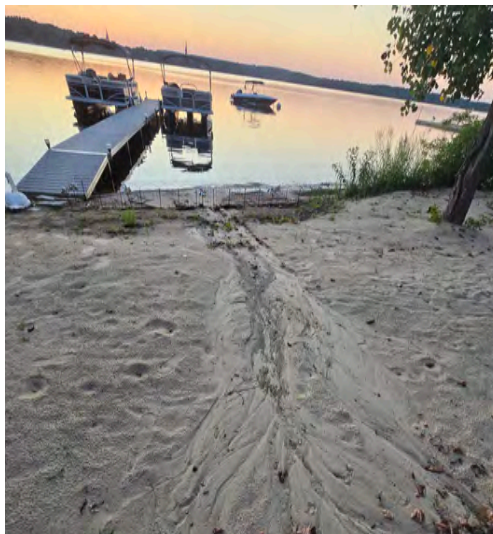
Flooding, Runoff, Excess Phosphorus, and Erosion Challenges to be Addressed

Conceptual Design

Flooding, Runoff, Excess Phosphorus, and Erosion Challenges to be Addressed



Top left: May 2023 washout from flooding at 189 Massapoag Ave, bottom of Capen Hill Rd. Top center and right: March 2025 pooling; stormwater runoff enters curb cut. Installed two French drains, geese deterrent low fencing, added 4 tons of gravel and 8 tons at 187 Massapoag Ave, planted 10 evergreen trees. Bottom: shoreline after heavy rain mid-August 2025. Requests full granite curb to help mitigate, which will also deflect some of the water down the street. The uphill source of problem also needs to be addressed through additional storm drains on Capen Hill Rd and a system for infiltration.



Potential for Detention Basin for Capen Hill Road



Note: The Town Conservation Administrator asked the Salvation Army if it would consider allowing adding a constructed wetland to its property to divert and infiltrate runoff down Capen Hill Rd, but the organization declined on the advice of counsel. A more extensive drainage and diversion project will need to be designed. It will examine the capability of storm drains to be installed to direct stormwater into the wetlands behind the Community Center for greater attenuation and seasonal phosphorus control. Regarding beach flooding at the bottom of the hill, the owner has done some remediation by adding a pit of gravel at and is exploring options for the adjacent parcel they purchased. LMAC asks the Town to consider restoring the full granite curb

Project 5. Massapoag Ave Stormwater and Shoreline Improvement Project

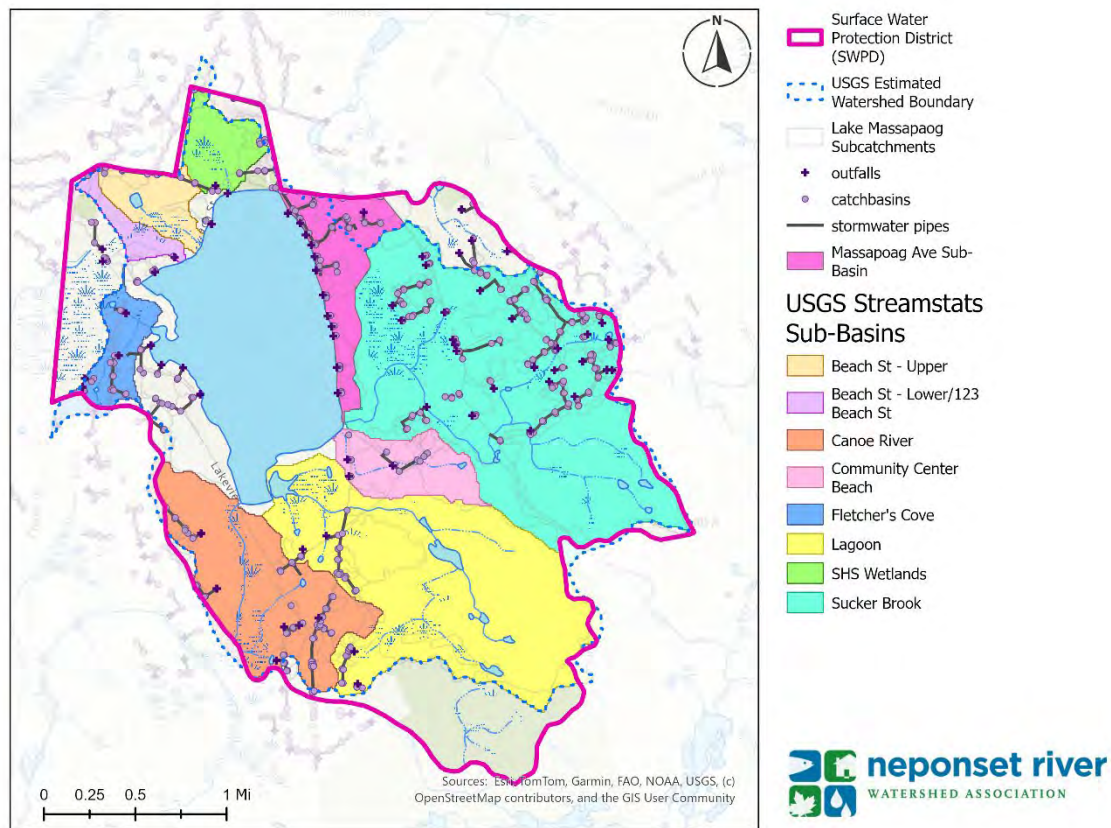
Exploratory Planning/Design Phase

Flooding, Runoff, Excess Phosphorus, and Erosion Challenges to be Addressed

Exploration Concepts

Massapoag Avenue Runoff

Massapoag Avenue, on the east side of Lake Massapoag, represents an interesting challenge and opportunity to control stormwater runoff entering the Lake. Multiple residents on Massapoag Ave have noted drainage problems and erosion concerns on the lakefront, which is privately owned on Massapoag Ave. The approximate catchment for this area was isolated from the PLER analysis done by NepRWA by combining individual sub-catchments in that area that were not already part of another USGS-delineated sub-basin and intersected Massapoag Ave or were connected by drainage infrastructure. For the large catchment around Lake Massapoag that partly intersects the Massapoag Ave sub-basin, the phosphorus contribution was estimated by multiplying the total phosphorus load by the proportion of the catchment area within the sub-basin. The Massapoag Ave sub-basin (see bright pink in the map below) is approximately 201.5 acres and the estimated annual phosphorus load is 69 pounds per year.



Flooding, Runoff, Excess Phosphorus, and Erosion Challenges to be Addressed

Massapoag Avenue Runoff



5A. Exploring Options for Massapoag Avenue: Town of Sharon

1. **Interim Measures: Reconstruct Cape Cod Berm, and/or Pilot Test Silt Socks along Massapoag Ave to observe drainage**
2. **Prioritize Massapoag Ave for use of new Salt Brine Spray truck next year to reduce salt damaging vegetation and erosion**
3. **Incent Shoreline Owners to install a vegetated buffer for both erosion/runoff and geese control**
4. **Begin initial design and planning of major drainage improvements and road reconstruction from Capen Hill Rd to Arboro Drive, where underground drainpipes were installed to connect storm drains to Massapoag Brook**

5B. Exploring Options for Massapoag Avenue: Improvement Projects by Shoreline Residence Property Owners

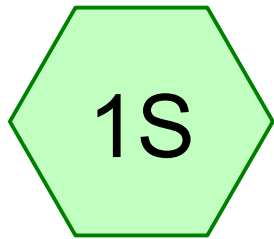
Saphire Estate: Before Pictures



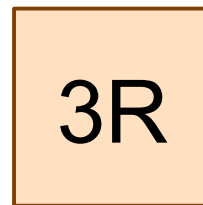
Saphire Estate: After Pictures (2026)



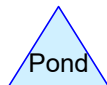
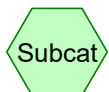
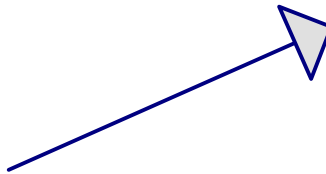
Addendum: HydroCAD Report, Veteran's Memorial West Lot



Existing Parking



Wetlands



Routing Diagram for HydroCAD-Report-LargeParking-11-20-2024-Existing

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Project Notes

Rainfall events imported from "HydroCAD-Report-Existing-04-24-2024.hcp"

Rainfall events imported from "HydroCAD-Report-Existing-04-24-2024.hcp"

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Page 3

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-year	Type III 24-hr		Default	24.00	1	3.42	2
2	10-year	Type III 24-hr		Default	24.00	1	5.08	2
3	25-year	Type III 24-hr		Default	24.00	1	6.12	2
4	100-year	Type III 24-hr		Default	24.00	1	7.72	2

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Page 4

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.194	96	Gravel surface, HSG A (1S)
1.194	96	TOTAL AREA

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Page 5

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
1.194	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
1.194		TOTAL AREA

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Page 6

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
1.194	0.000	0.000	0.000	0.000	1.194	Gravel surface	1S
1.194	0.000	0.000	0.000	0.000	1.194	TOTAL AREA	

HydroCAD-Report-LargeParking-11-20-2024-Existing

Type III 24-hr 2-year Rainfall=3.42"

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Page 7

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Parking

Runoff Area=1.194 ac 0.00% Impervious Runoff Depth>2.80"

Tc=0.0 min CN=96 Runoff=4.41 cfs 0.279 af

Reach 3R: Wetlands

Inflow=4.41 cfs 0.279 af

Outflow=4.41 cfs 0.279 af

Total Runoff Area = 1.194 ac Runoff Volume = 0.279 af Average Runoff Depth = 2.80"

100.00% Pervious = 1.194 ac 0.00% Impervious = 0.000 ac

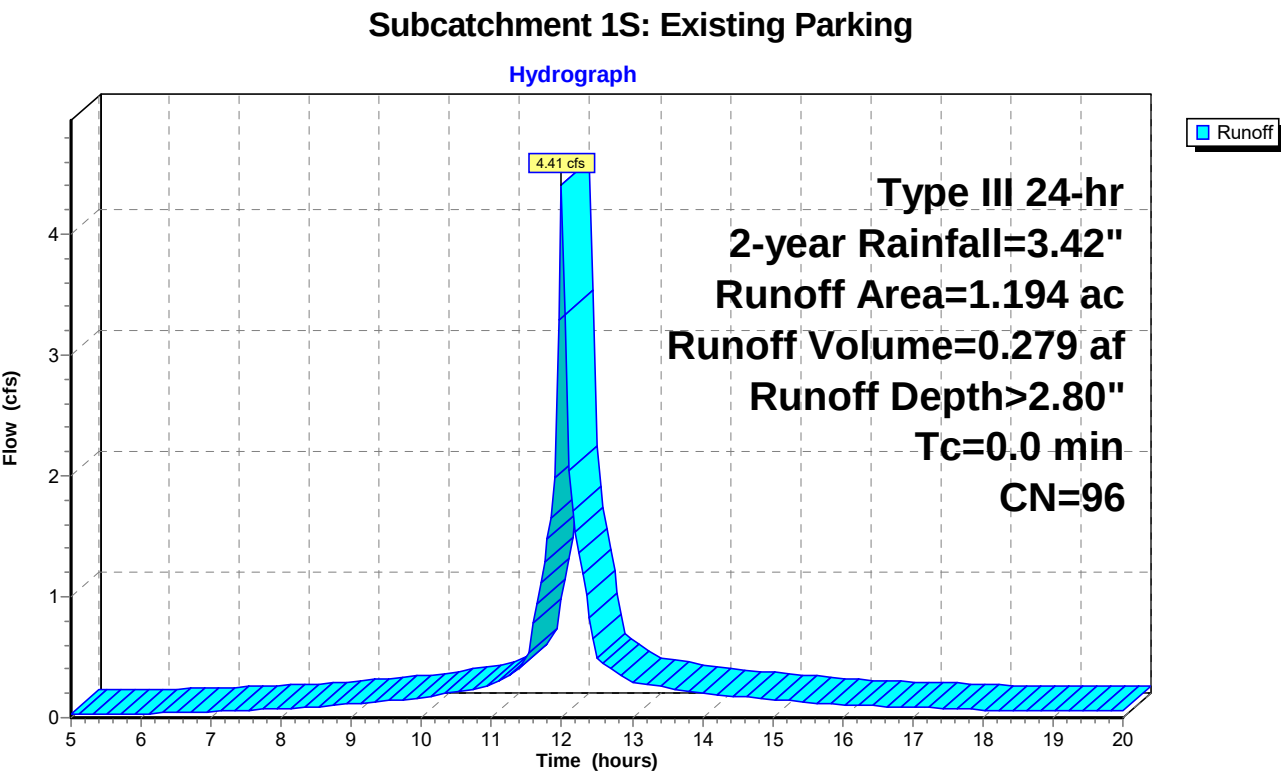
Summary for Subcatchment 1S: Existing Parking

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 4.41 cfs @ 12.00 hrs, Volume= 0.279 af, Depth> 2.80"
Routed to Reach 3R : Wetlands

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.42"

Area (ac)	CN	Description
1.194	96	Gravel surface, HSG A
1.194		100.00% Pervious Area



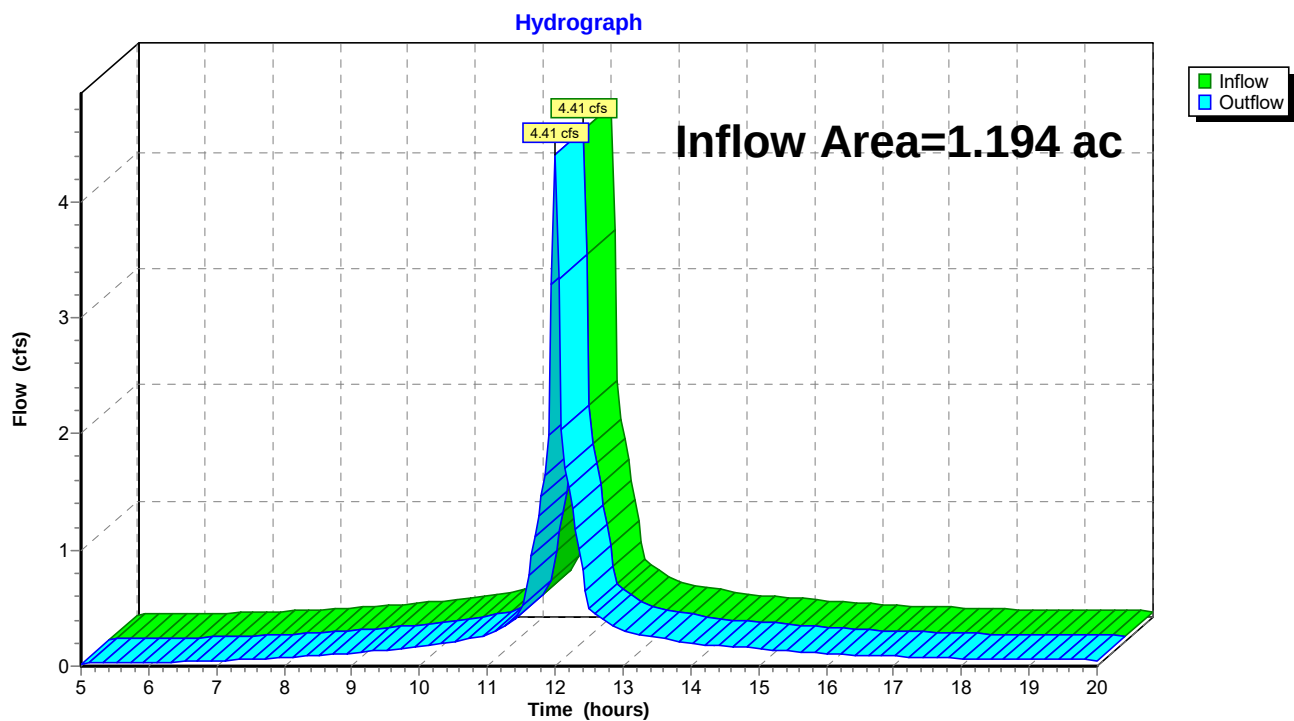
Summary for Reach 3R: Wetlands

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 1.194 ac, 0.00% Impervious, Inflow Depth > 2.80" for 2-year event
Inflow = 4.41 cfs @ 12.00 hrs, Volume= 0.279 af
Outflow = 4.41 cfs @ 12.00 hrs, Volume= 0.279 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Reach 3R: Wetlands



Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Parking Runoff Area=1.194 ac 0.00% Impervious Runoff Depth>4.33"
Tc=0.0 min CN=96 Runoff=6.69 cfs 0.431 af

Reach 3R: Wetlands Inflow=6.69 cfs 0.431 af
Outflow=6.69 cfs 0.431 af

Total Runoff Area = 1.194 ac Runoff Volume = 0.431 af Average Runoff Depth = 4.33"
100.00% Pervious = 1.194 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Existing Parking

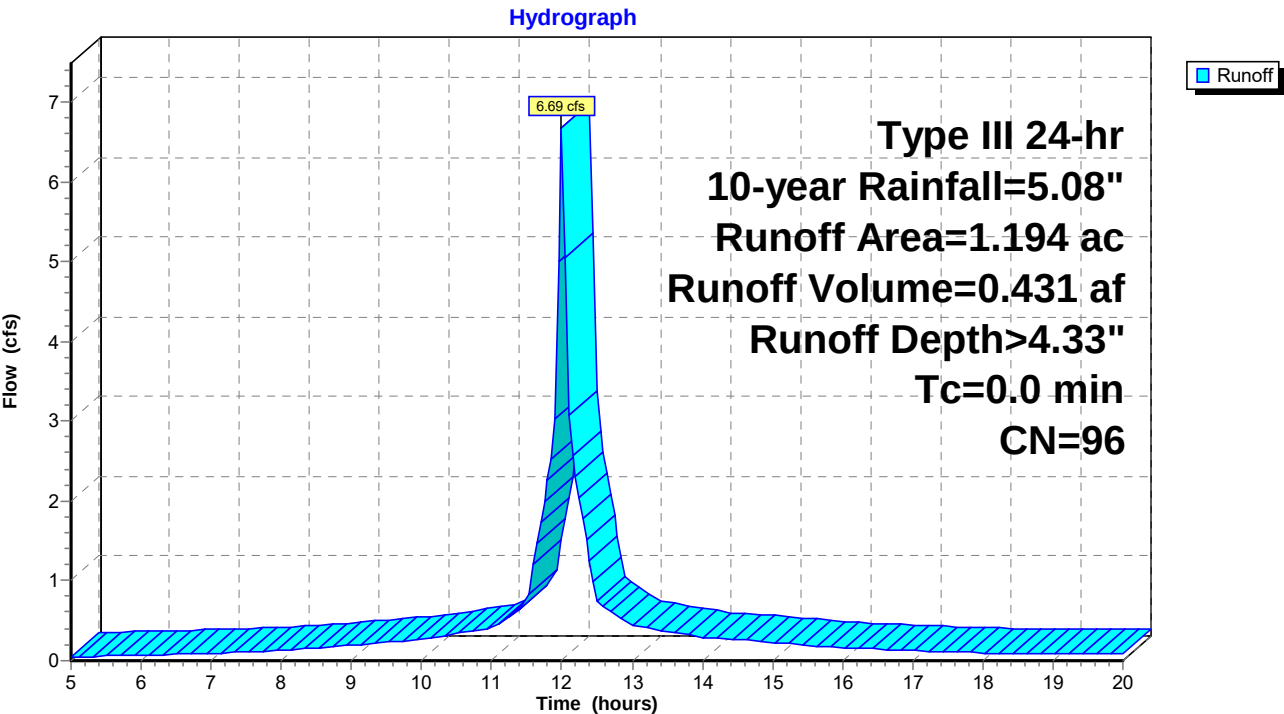
[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 6.69 cfs @ 12.00 hrs, Volume= 0.431 af, Depth> 4.33"
Routed to Reach 3R : Wetlands

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=5.08"

Area (ac)	CN	Description
1.194	96	Gravel surface, HSG A
1.194		100.00% Pervious Area

Subcatchment 1S: Existing Parking



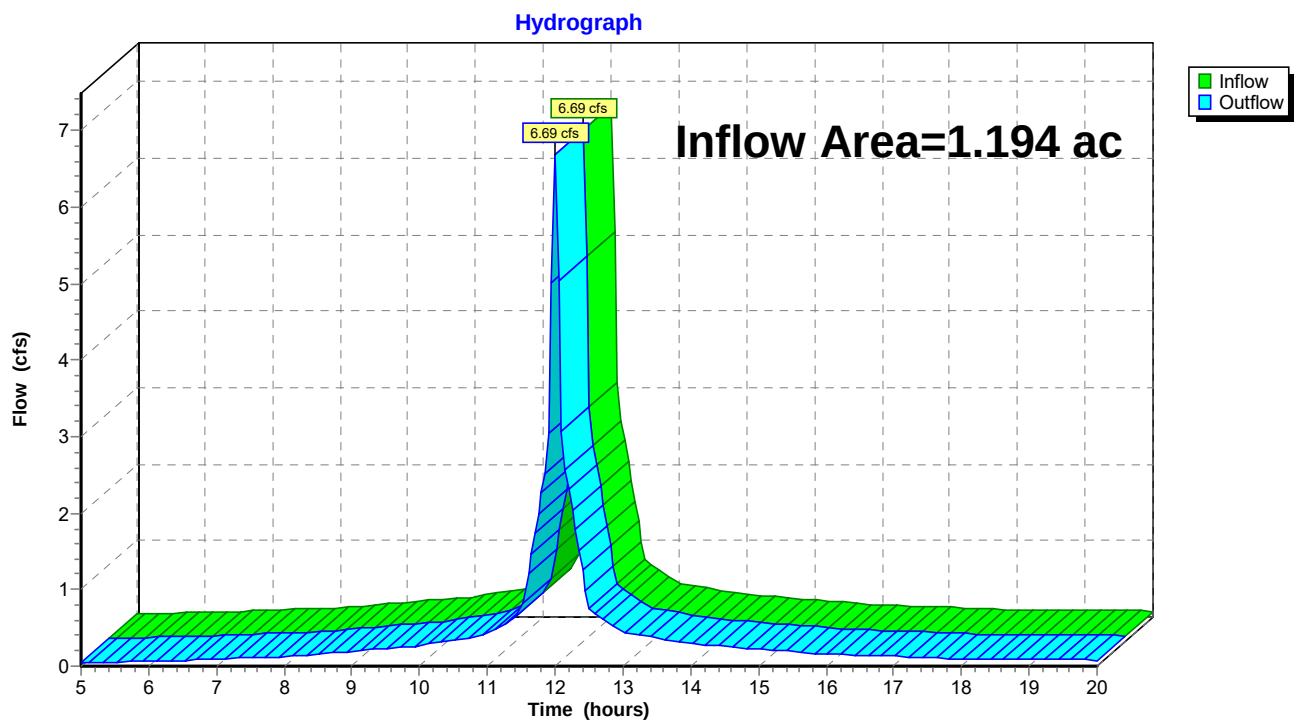
Summary for Reach 3R: Wetlands

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 1.194 ac, 0.00% Impervious, Inflow Depth > 4.33" for 10-year event
Inflow = 6.69 cfs @ 12.00 hrs, Volume= 0.431 af
Outflow = 6.69 cfs @ 12.00 hrs, Volume= 0.431 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Reach 3R: Wetlands



Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Parking Runoff Area=1.194 ac 0.00% Impervious Runoff Depth>5.29"
Tc=0.0 min CN=96 Runoff=8.10 cfs 0.526 af

Reach 3R: Wetlands Inflow=8.10 cfs 0.526 af
Outflow=8.10 cfs 0.526 af

Total Runoff Area = 1.194 ac Runoff Volume = 0.526 af Average Runoff Depth = 5.29"
100.00% Pervious = 1.194 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Existing Parking

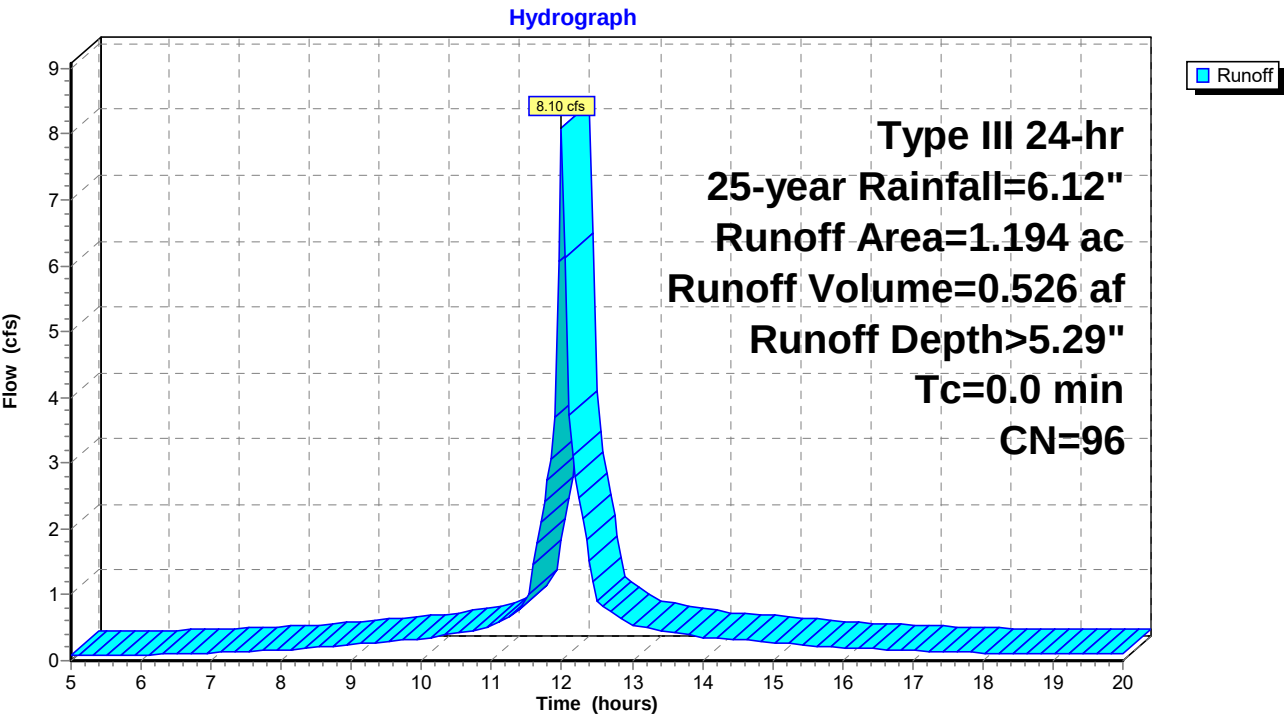
[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 8.10 cfs @ 12.00 hrs, Volume= 0.526 af, Depth> 5.29"
Routed to Reach 3R : Wetlands

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-year Rainfall=6.12"

Area (ac)	CN	Description
1.194	96	Gravel surface, HSG A
1.194		100.00% Pervious Area

Subcatchment 1S: Existing Parking



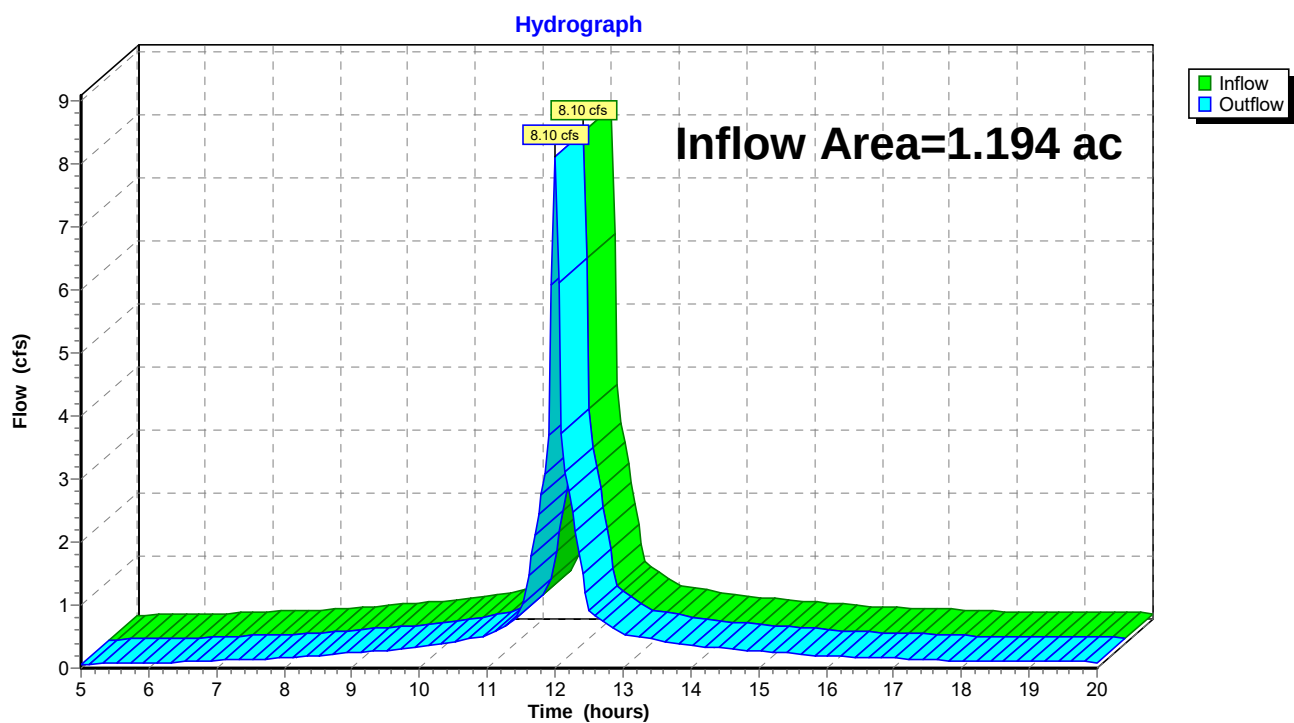
Summary for Reach 3R: Wetlands

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 1.194 ac, 0.00% Impervious, Inflow Depth > 5.29" for 25-year event
Inflow = 8.10 cfs @ 12.00 hrs, Volume= 0.526 af
Outflow = 8.10 cfs @ 12.00 hrs, Volume= 0.526 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Reach 3R: Wetlands



Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Parking Runoff Area=1.194 ac 0.00% Impervious Runoff Depth>6.75"
Tc=0.0 min CN=96 Runoff=10.28 cfs 0.672 af

Reach 3R: Wetlands Inflow=10.28 cfs 0.672 af
Outflow=10.28 cfs 0.672 af

Total Runoff Area = 1.194 ac Runoff Volume = 0.672 af Average Runoff Depth = 6.75"
100.00% Pervious = 1.194 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Existing Parking

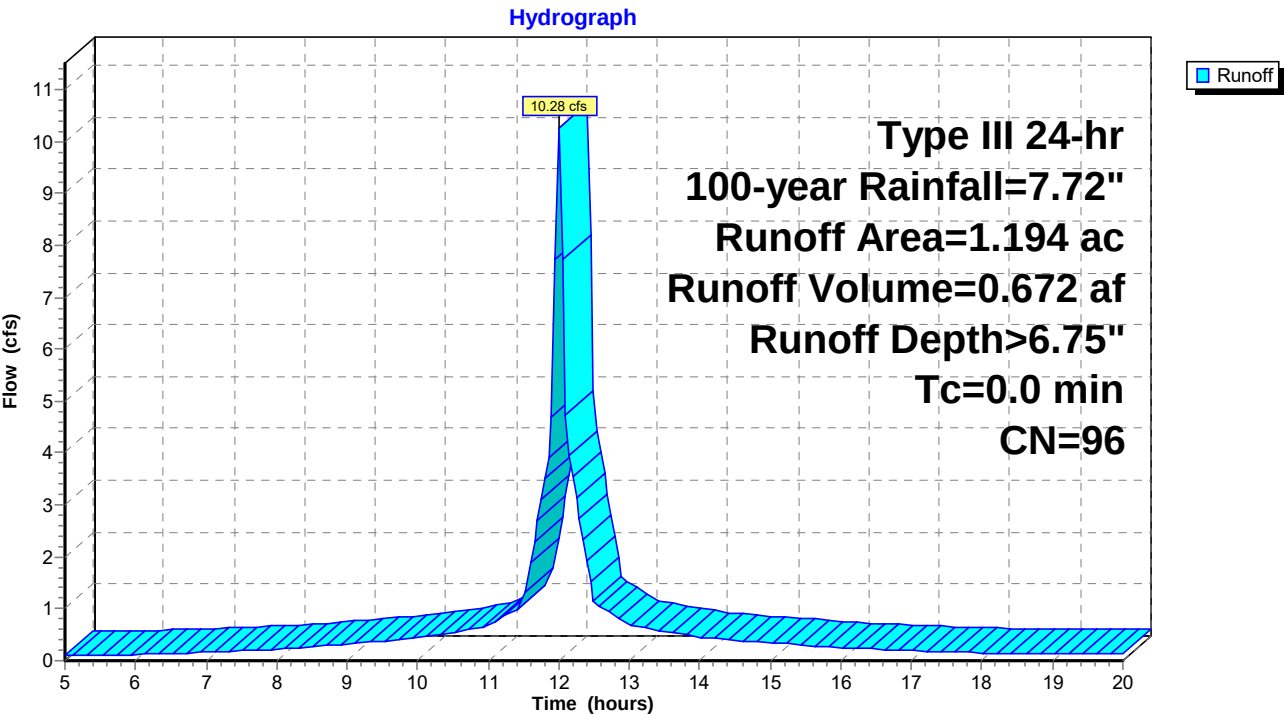
[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 10.28 cfs @ 12.00 hrs, Volume= 0.672 af, Depth> 6.75"
Routed to Reach 3R : Wetlands

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=7.72"

Area (ac)	CN	Description
1.194	96	Gravel surface, HSG A
1.194		100.00% Pervious Area

Subcatchment 1S: Existing Parking



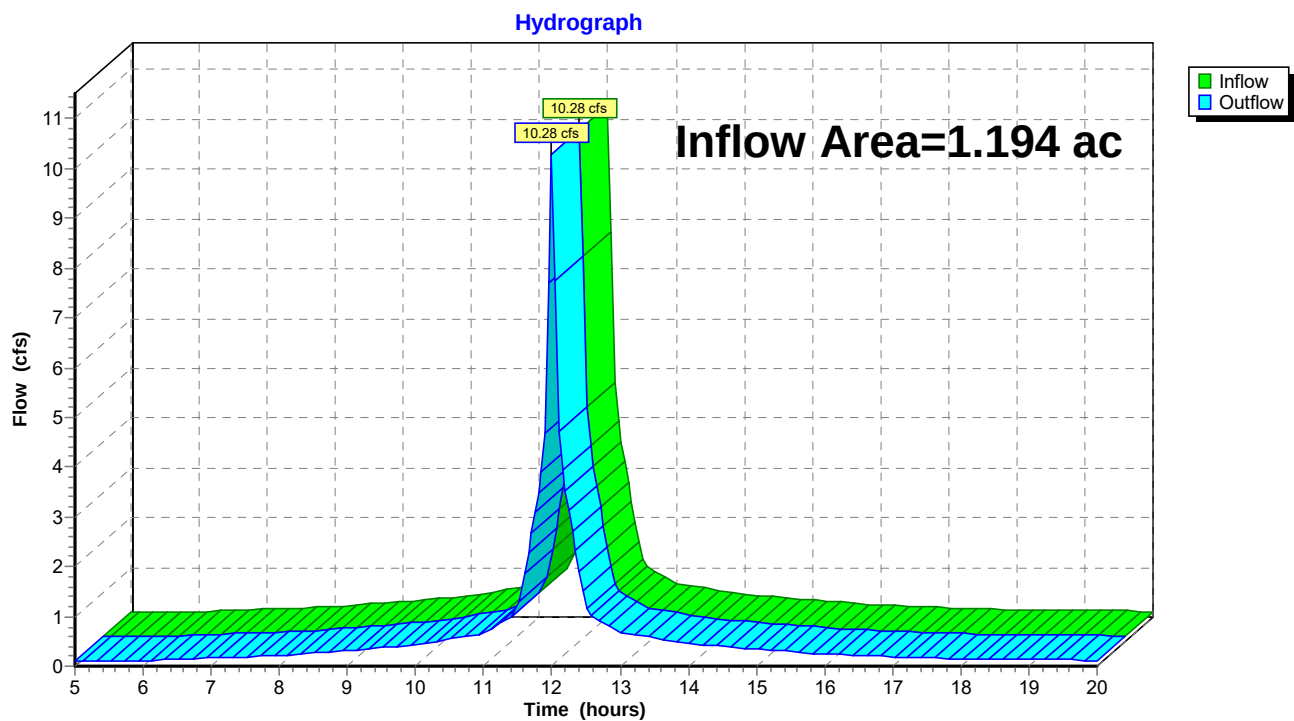
Summary for Reach 3R: Wetlands

[40] Hint: Not Described (Outflow=Inflow)

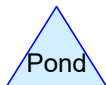
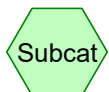
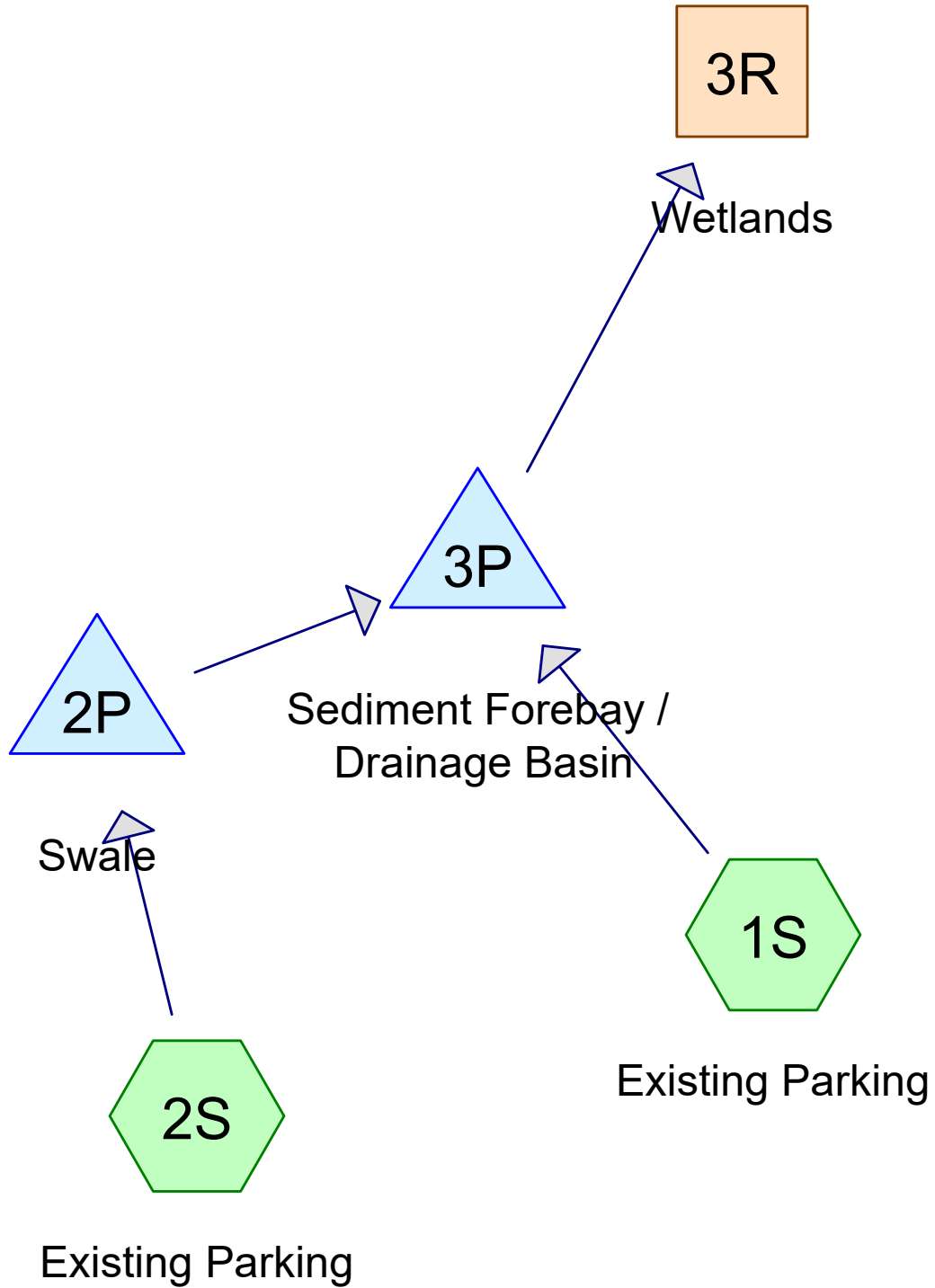
Inflow Area = 1.194 ac, 0.00% Impervious, Inflow Depth > 6.75" for 100-year event
Inflow = 10.28 cfs @ 12.00 hrs, Volume= 0.672 af
Outflow = 10.28 cfs @ 12.00 hrs, Volume= 0.672 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Reach 3R: Wetlands



Addendum: HydroCAD Report, Veteran's Memorial East Lot



Project Notes

Rainfall events imported from "HydroCAD-Report-Existing-04-24-2024.hcp"

Rainfall events imported from "HydroCAD-Report-Existing-04-24-2024.hcp"

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Page 3

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-year	Type III 24-hr		Default	24.00	1	3.42	2
2	10-year	Type III 24-hr		Default	24.00	1	5.08	2
3	25-year	Type III 24-hr		Default	24.00	1	6.12	2
4	100-year	Type III 24-hr		Default	24.00	1	7.72	2

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Page 4

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.918	98	Paved parking, HSG A (1S, 2S)
0.918	98	TOTAL AREA

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Page 5

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.918	HSG A	1S, 2S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.918		TOTAL AREA

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Page 6

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.918	0.000	0.000	0.000	0.000	0.918	Paved parking	1S, 2S
0.918	0.000	0.000	0.000	0.000	0.918	TOTAL AREA	

HydroCAD-Report-LargeParking-11-20-2024-Prop

Type III 24-hr 2-year Rainfall=3.42"

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Page 7

Time span=0.00-20.00 hrs, dt=0.001 hrs, 20001 points

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Parking

Runoff Area=0.718 ac 100.00% Impervious Runoff Depth>3.04"
Flow Length=200' Tc=5.0 min CN=98 Runoff=2.48 cfs 0.182 af

Subcatchment 2S: Existing Parking

Runoff Area=0.200 ac 100.00% Impervious Runoff Depth>3.04"
Flow Length=50' Tc=5.0 min CN=98 Runoff=0.69 cfs 0.051 af

Reach 3R: Wetlands

Inflow=0.00 cfs 0.000 af
Outflow=0.00 cfs 0.000 af

Pond 2P: Swale

Inflow=0.69 cfs 0.051 af
Primary=0.69 cfs 0.051 af

Pond 3P: Sediment Forebay / Drainage Basin

Peak Elev=254.79' Storage=7,413 cf Inflow=3.17 cfs 0.232 af
Discarded=0.06 cfs 0.066 af Primary=0.00 cfs 0.000 af Outflow=0.06 cfs 0.066 af

Total Runoff Area = 0.918 ac Runoff Volume = 0.232 af Average Runoff Depth = 3.04"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.918 ac

Summary for Subcatchment 1S: Existing Parking

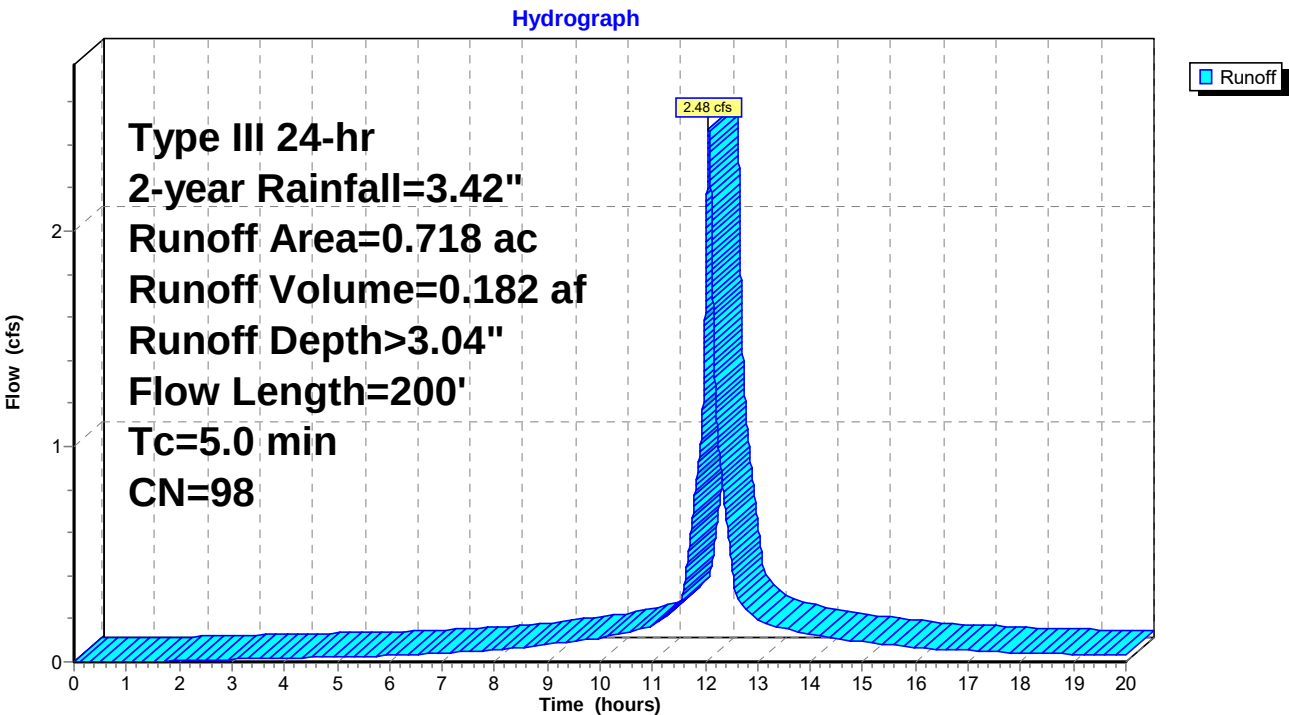
Runoff = 2.48 cfs @ 12.07 hrs, Volume= 0.182 af, Depth> 3.04"
Routed to Pond 3P : Sediment Forebay / Drainage Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs
Type III 24-hr 2-year Rainfall=3.42"

Area (ac)	CN	Description
0.718	98	Paved parking, HSG A
0.718		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	200		0.67		Direct Entry, DE

Subcatchment 1S: Existing Parking



Summary for Subcatchment 2S: Existing Parking

Runoff = 0.69 cfs @ 12.07 hrs, Volume= 0.051 af, Depth> 3.04"
 Routed to Pond 2P : Swale

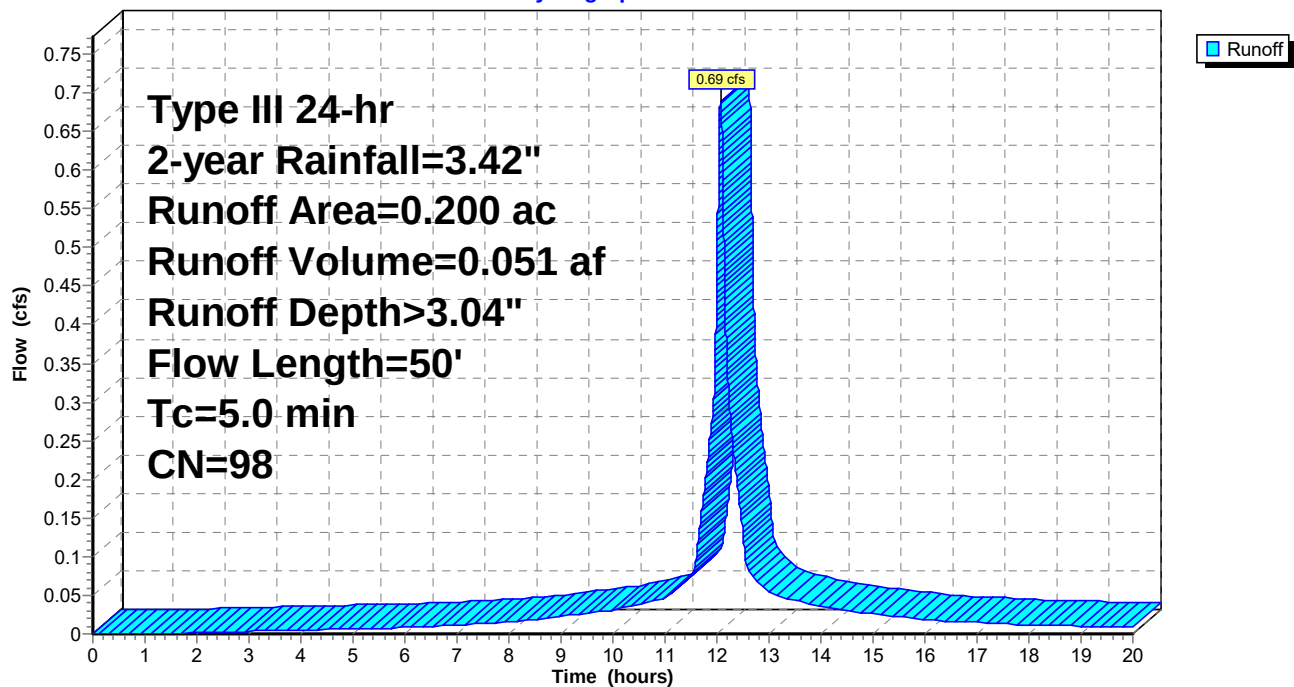
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs
 Type III 24-hr 2-year Rainfall=3.42"

Area (ac)	CN	Description
0.200	98	Paved parking, HSG A
0.200		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	50		0.17		Direct Entry, DE

Subcatchment 2S: Existing Parking

Hydrograph



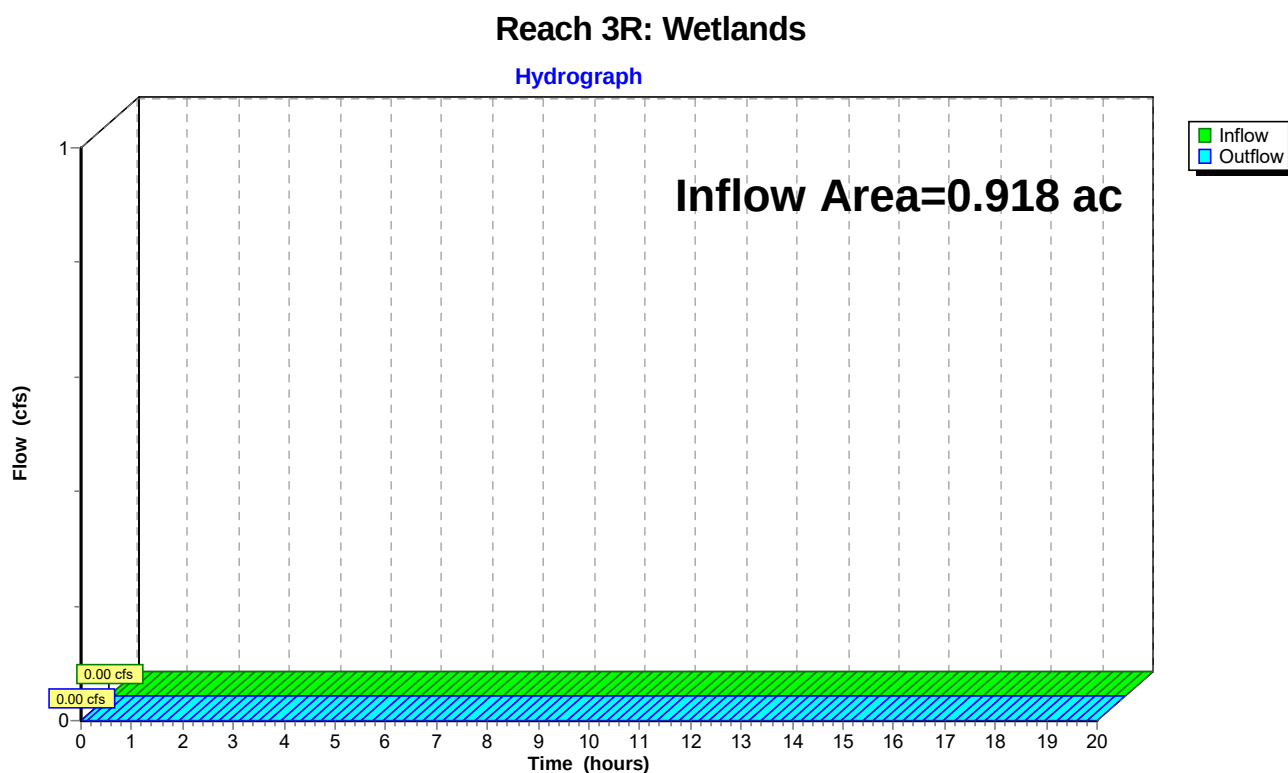
Summary for Reach 3R: Wetlands

Overland flow to wetlands via swale

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.918 ac, 100.00% Impervious, Inflow Depth = 0.00" for 2-year event
Inflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs

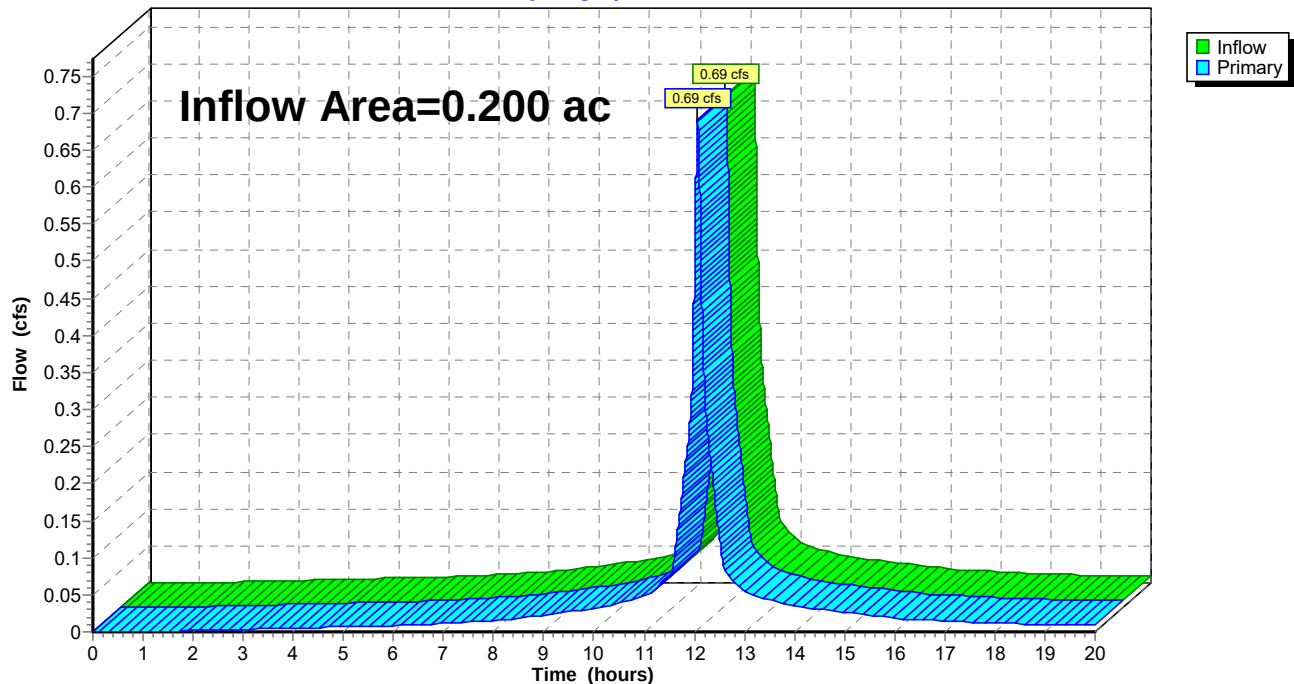


Summary for Pond 2P: Swale

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.200 ac, 100.00% Impervious, Inflow Depth > 3.04" for 2-year event
Inflow = 0.69 cfs @ 12.07 hrs, Volume= 0.051 af
Primary = 0.69 cfs @ 12.07 hrs, Volume= 0.051 af, Atten= 0%, Lag= 0.0 min
Routed to Pond 3P : Sediment Forebay / Drainage Basin

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs

Pond 2P: Swale**Hydrograph**

Summary for Pond 3P: Sediment Forebay / Drainage Basin

Inflow Area = 0.918 ac, 100.00% Impervious, Inflow Depth > 3.04" for 2-year event
 Inflow = 3.17 cfs @ 12.07 hrs, Volume= 0.232 af
 Outflow = 0.06 cfs @ 17.18 hrs, Volume= 0.066 af, Atten= 98%, Lag= 306.8 min
 Discarded = 0.06 cfs @ 17.18 hrs, Volume= 0.066 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
 Routed to Reach 3R : Wetlands

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs
 Peak Elev= 254.79' @ 17.18 hrs Surf.Area= 5,548 sf Storage= 7,413 cf

Plug-Flow detention time= 239.2 min calculated for 0.066 af (28% of inflow)
 Center-of-Mass det. time= 65.1 min (791.6 - 726.5)

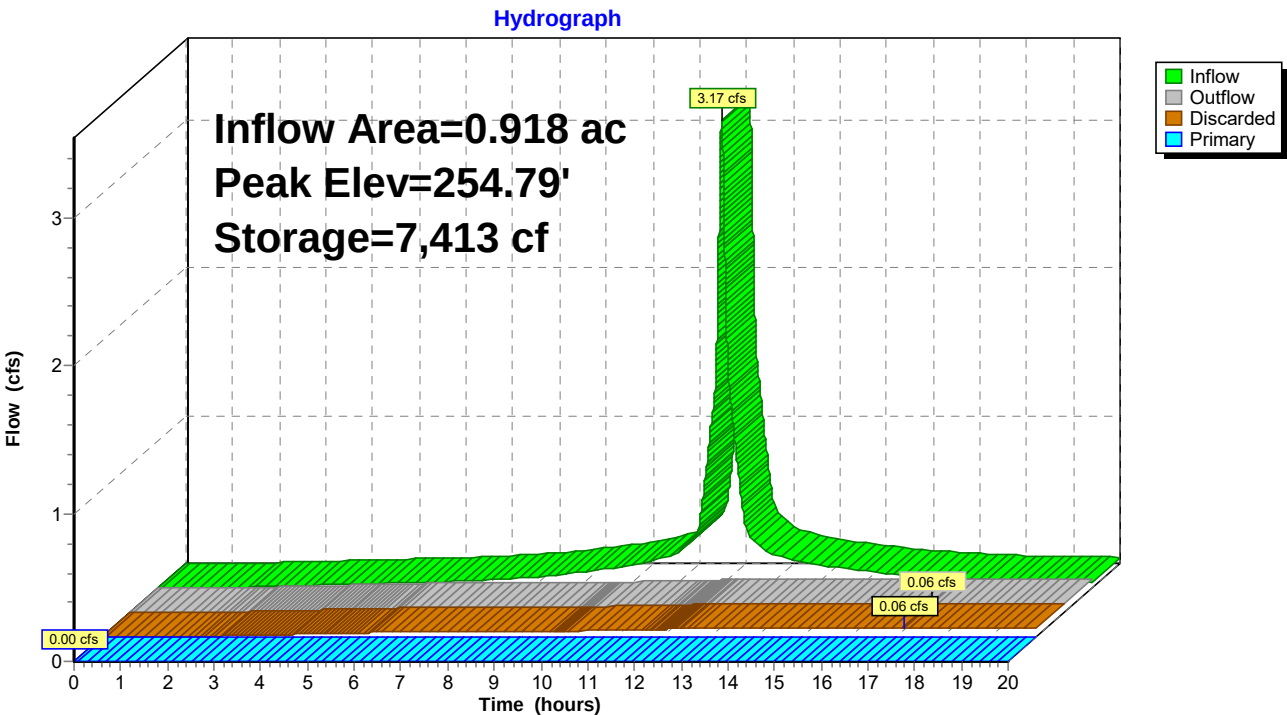
Volume	Invert	Avail.Storage	Storage Description
#1	253.05'	12,609 cf	20.00'W x 135.00'L x 3.00'H Detention Basin Z=3.0
#2	253.30'	3,474 cf	20.00'W x 30.00'L x 3.00'H Sediment Forebay Z=3.0
		16,083 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	254.95'	90.0 deg x 2.0' long x 1.00' rise Sharp-Crested Vee/Trap Weir Cv= 2.50 (C= 3.13)
#2	Discarded	253.05'	0.500 in/hr Exfiltration over Surface area Conductivity to Groundwater Elevation = 2.00'

Discarded OutFlow Max=0.06 cfs @ 17.18 hrs HW=254.79' (Free Discharge)
 ↑**2=Exfiltration** (Controls 0.06 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=253.05' (Free Discharge)
 ↑**1=Sharp-Crested Vee/Trap Weir** (Controls 0.00 cfs)

Pond 3P: Sediment Forebay / Drainage Basin



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Type III 24-hr 10-year Rainfall=5.08"

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Page 14

Time span=0.00-20.00 hrs, dt=0.001 hrs, 20001 points

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Parking

Runoff Area=0.718 ac 100.00% Impervious Runoff Depth>4.62"
Flow Length=200' Tc=5.0 min CN=98 Runoff=3.70 cfs 0.276 af

Subcatchment 2S: Existing Parking

Runoff Area=0.200 ac 100.00% Impervious Runoff Depth>4.62"
Flow Length=50' Tc=5.0 min CN=98 Runoff=1.03 cfs 0.077 af

Reach 3R: Wetlands

Inflow=0.47 cfs 0.086 af
Outflow=0.47 cfs 0.086 af

Pond 2P: Swale

Inflow=1.03 cfs 0.077 af
Primary=1.03 cfs 0.077 af

Pond 3P: Sediment Forebay / Drainage Basin

Peak Elev=255.12' Storage=9,357 cf Inflow=4.73 cfs 0.353 af
Discarded=0.07 cfs 0.075 af Primary=0.47 cfs 0.086 af Outflow=0.55 cfs 0.161 af

Total Runoff Area = 0.918 ac Runoff Volume = 0.353 af Average Runoff Depth = 4.62"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.918 ac

Summary for Subcatchment 1S: Existing Parking

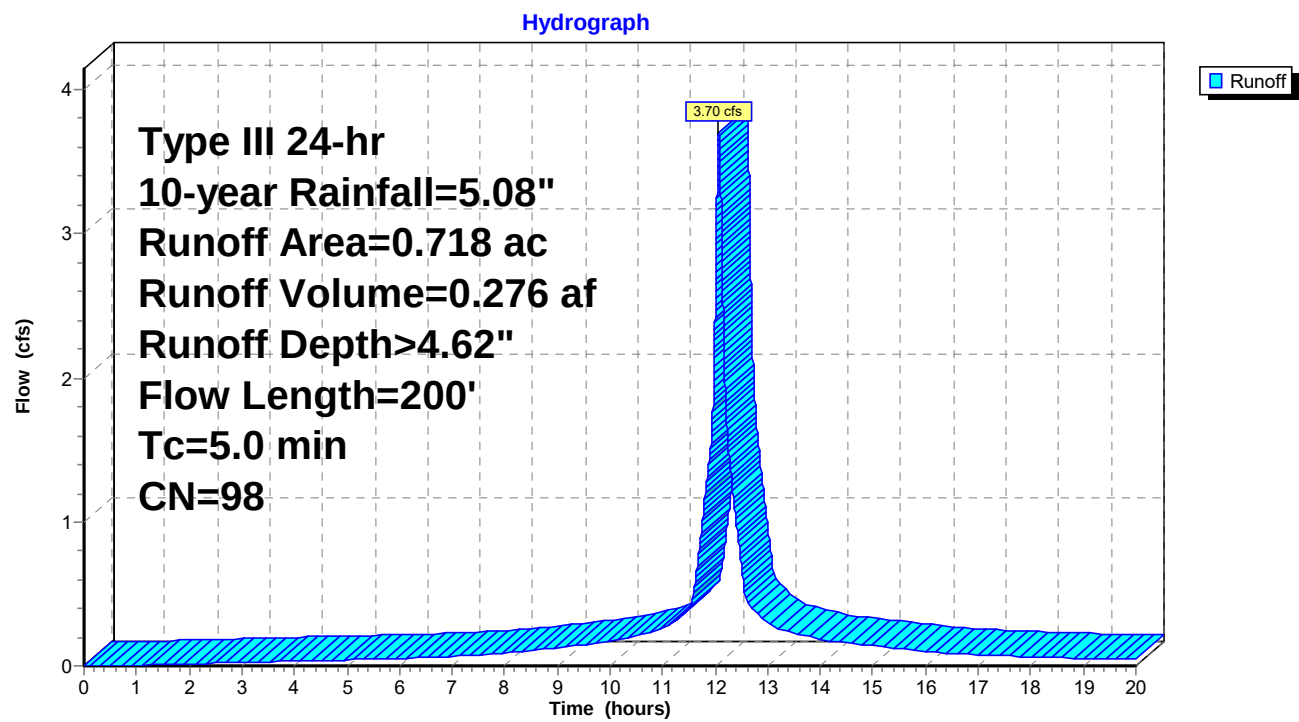
Runoff = 3.70 cfs @ 12.07 hrs, Volume= 0.276 af, Depth> 4.62"
Routed to Pond 3P : Sediment Forebay / Drainage Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs
Type III 24-hr 10-year Rainfall=5.08"

Area (ac)	CN	Description
0.718	98	Paved parking, HSG A
0.718		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	200		0.67		Direct Entry, DE

Subcatchment 1S: Existing Parking



Summary for Subcatchment 2S: Existing Parking

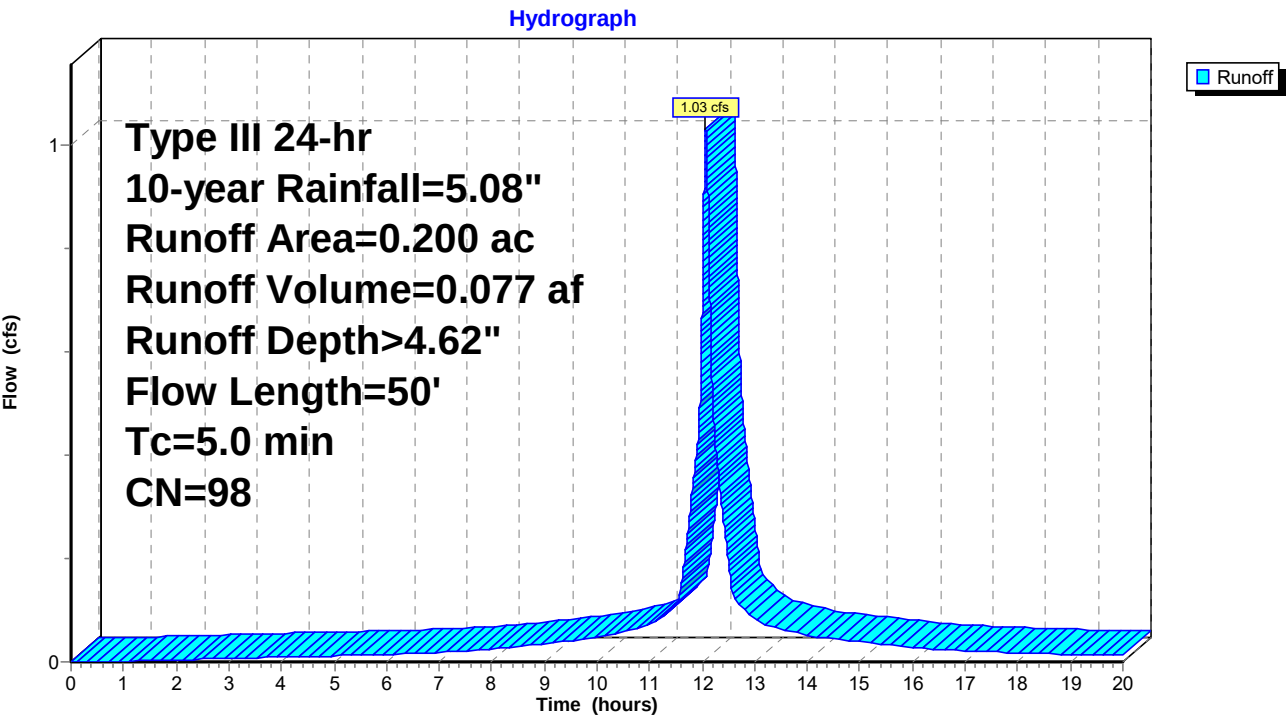
Runoff = 1.03 cfs @ 12.07 hrs, Volume= 0.077 af, Depth> 4.62"
Routed to Pond 2P : Swale

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs
Type III 24-hr 10-year Rainfall=5.08"

Area (ac)	CN	Description
0.200	98	Paved parking, HSG A
0.200		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	50		0.17		Direct Entry, DE

Subcatchment 2S: Existing Parking



Summary for Reach 3R: Wetlands

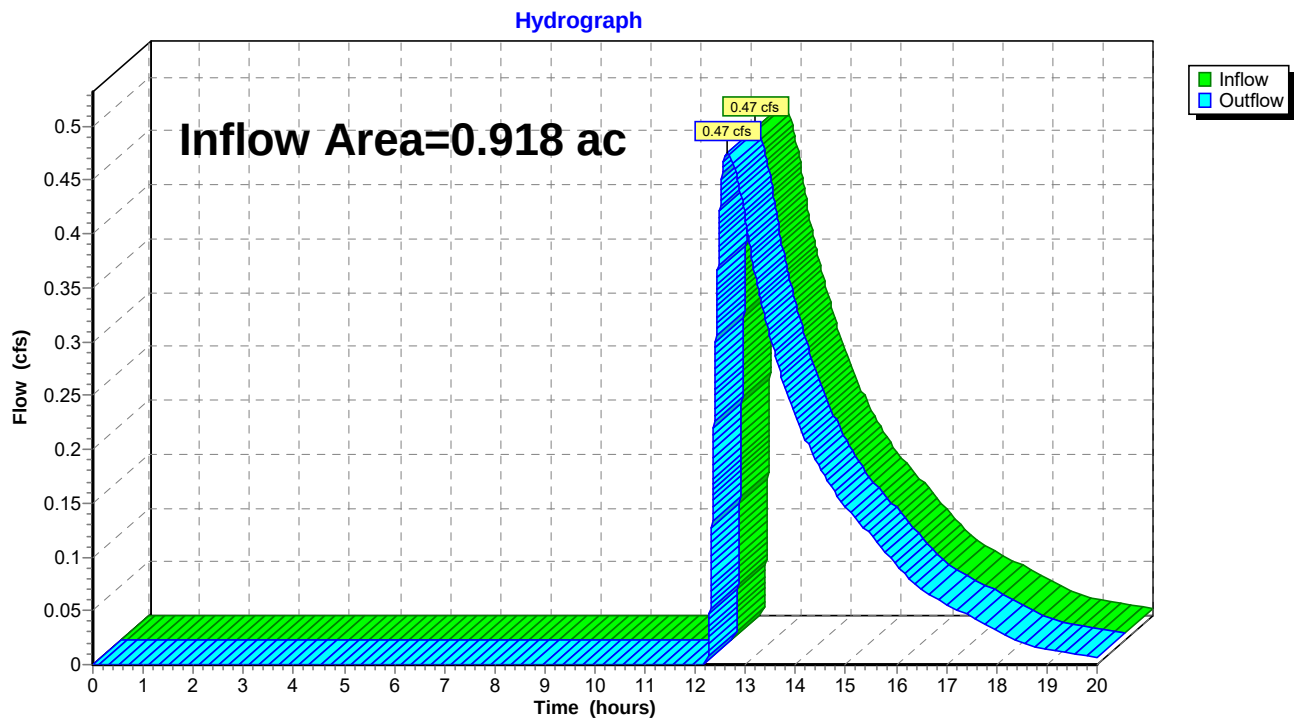
Overland flow to wetlands via swale

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.918 ac, 100.00% Impervious, Inflow Depth > 1.13" for 10-year event
Inflow = 0.47 cfs @ 12.63 hrs, Volume= 0.086 af
Outflow = 0.47 cfs @ 12.63 hrs, Volume= 0.086 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs

Reach 3R: Wetlands

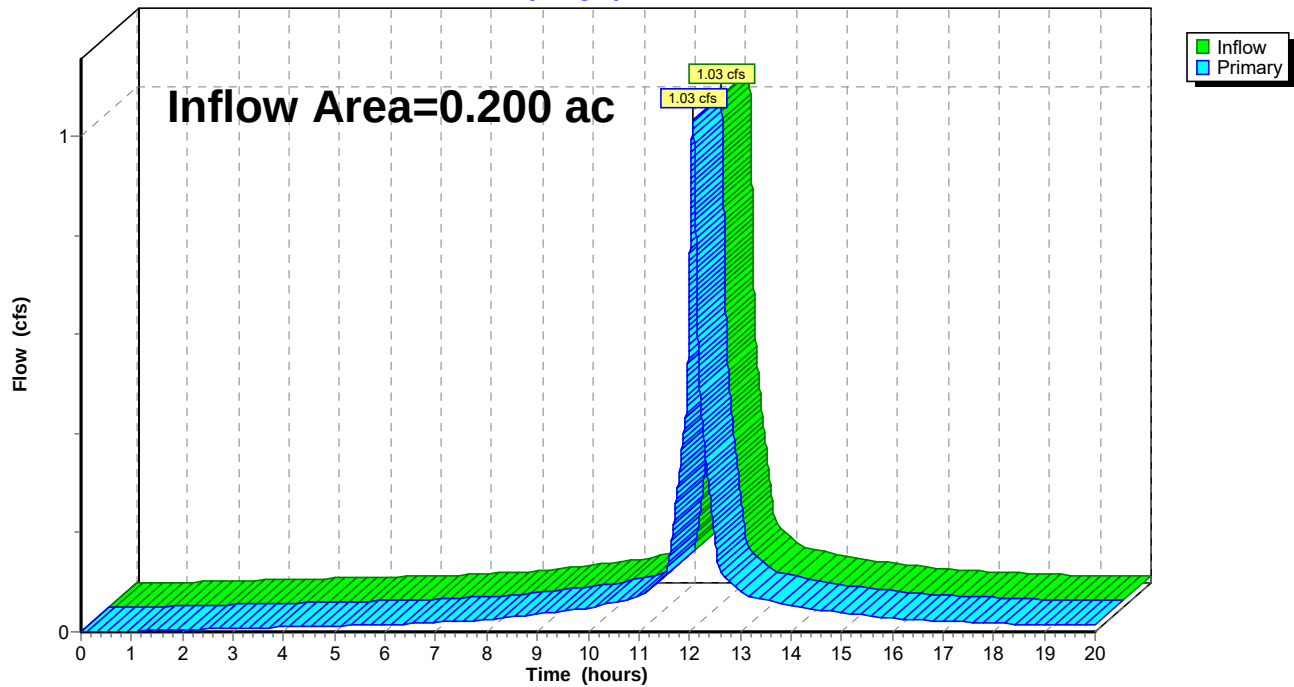


Summary for Pond 2P: Swale

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.200 ac, 100.00% Impervious, Inflow Depth > 4.62" for 10-year event
Inflow = 1.03 cfs @ 12.07 hrs, Volume= 0.077 af
Primary = 1.03 cfs @ 12.07 hrs, Volume= 0.077 af, Atten= 0%, Lag= 0.0 min
Routed to Pond 3P : Sediment Forebay / Drainage Basin

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs

Pond 2P: Swale**Hydrograph**

Summary for Pond 3P: Sediment Forebay / Drainage Basin

Inflow Area = 0.918 ac, 100.00% Impervious, Inflow Depth > 4.62" for 10-year event
 Inflow = 4.73 cfs @ 12.07 hrs, Volume= 0.353 af
 Outflow = 0.55 cfs @ 12.63 hrs, Volume= 0.161 af, Atten= 88%, Lag= 33.5 min
 Discarded = 0.07 cfs @ 12.63 hrs, Volume= 0.075 af
 Primary = 0.47 cfs @ 12.63 hrs, Volume= 0.086 af
 Routed to Reach 3R : Wetlands

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs
 Peak Elev= 255.12' @ 12.63 hrs Surf.Area= 6,047 sf Storage= 9,357 cf

Plug-Flow detention time= 209.5 min calculated for 0.161 af (45% of inflow)
 Center-of-Mass det. time= 90.9 min (810.3 - 719.4)

Volume	Invert	Avail.Storage	Storage Description
#1	253.05'	12,609 cf	20.00'W x 135.00'L x 3.00'H Detention Basin Z=3.0
#2	253.30'	3,474 cf	20.00'W x 30.00'L x 3.00'H Sediment Forebay Z=3.0
		16,083 cf	Total Available Storage

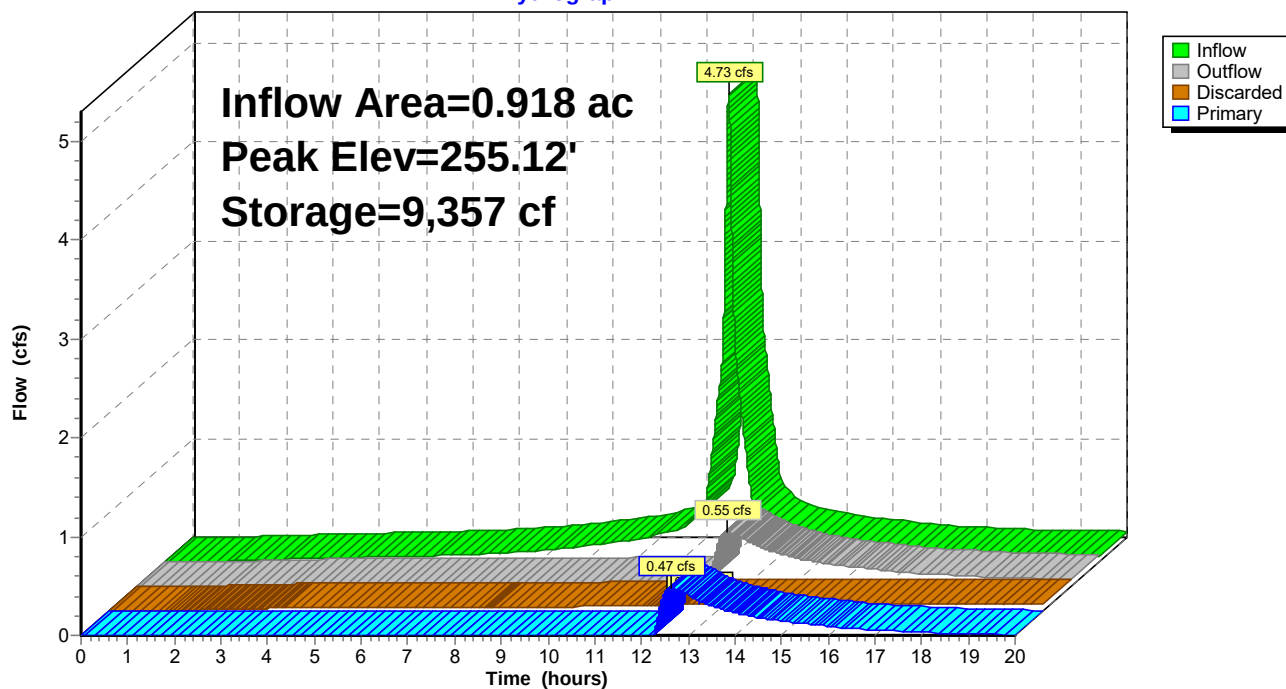
Device	Routing	Invert	Outlet Devices
#1	Primary	254.95'	90.0 deg x 2.0' long x 1.00' rise Sharp-Crested Vee/Trap Weir Cv= 2.50 (C= 3.13)
#2	Discarded	253.05'	0.500 in/hr Exfiltration over Surface area Conductivity to Groundwater Elevation = 2.00'

Discarded OutFlow Max=0.07 cfs @ 12.63 hrs HW=255.12' (Free Discharge)
 ↑ **2=Exfiltration** (Controls 0.07 cfs)

Primary OutFlow Max=0.47 cfs @ 12.63 hrs HW=255.12' (Free Discharge)
 ↑ **1=Sharp-Crested Vee/Trap Weir** (Weir Controls 0.47 cfs @ 1.27 fps)

Pond 3P: Sediment Forebay / Drainage Basin

Hydrograph



HydroCAD-Report-LargeParking-11-20-2024-Prop

Type III 24-hr 25-year Rainfall=6.12"

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Page 21

Time span=0.00-20.00 hrs, dt=0.001 hrs, 20001 points

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Parking

Runoff Area=0.718 ac 100.00% Impervious Runoff Depth>5.61"
Flow Length=200' Tc=5.0 min CN=98 Runoff=4.47 cfs 0.336 af

Subcatchment 2S: Existing Parking

Runoff Area=0.200 ac 100.00% Impervious Runoff Depth>5.61"
Flow Length=50' Tc=5.0 min CN=98 Runoff=1.24 cfs 0.094 af

Reach 3R: Wetlands

Inflow=1.36 cfs 0.158 af
Outflow=1.36 cfs 0.158 af

Pond 2P: Swale

Inflow=1.24 cfs 0.094 af
Primary=1.24 cfs 0.094 af

Pond 3P: Sediment Forebay / Drainage

Peak Elev=255.28' Storage=10,349 cf Inflow=5.71 cfs 0.429 af
Discarded=0.07 cfs 0.078 af Primary=1.36 cfs 0.158 af Outflow=1.43 cfs 0.235 af

Total Runoff Area = 0.918 ac Runoff Volume = 0.429 af Average Runoff Depth = 5.61"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.918 ac

Summary for Subcatchment 1S: Existing Parking

Runoff = 4.47 cfs @ 12.07 hrs, Volume= 0.336 af, Depth> 5.61"
 Routed to Pond 3P : Sediment Forebay / Drainage Basin

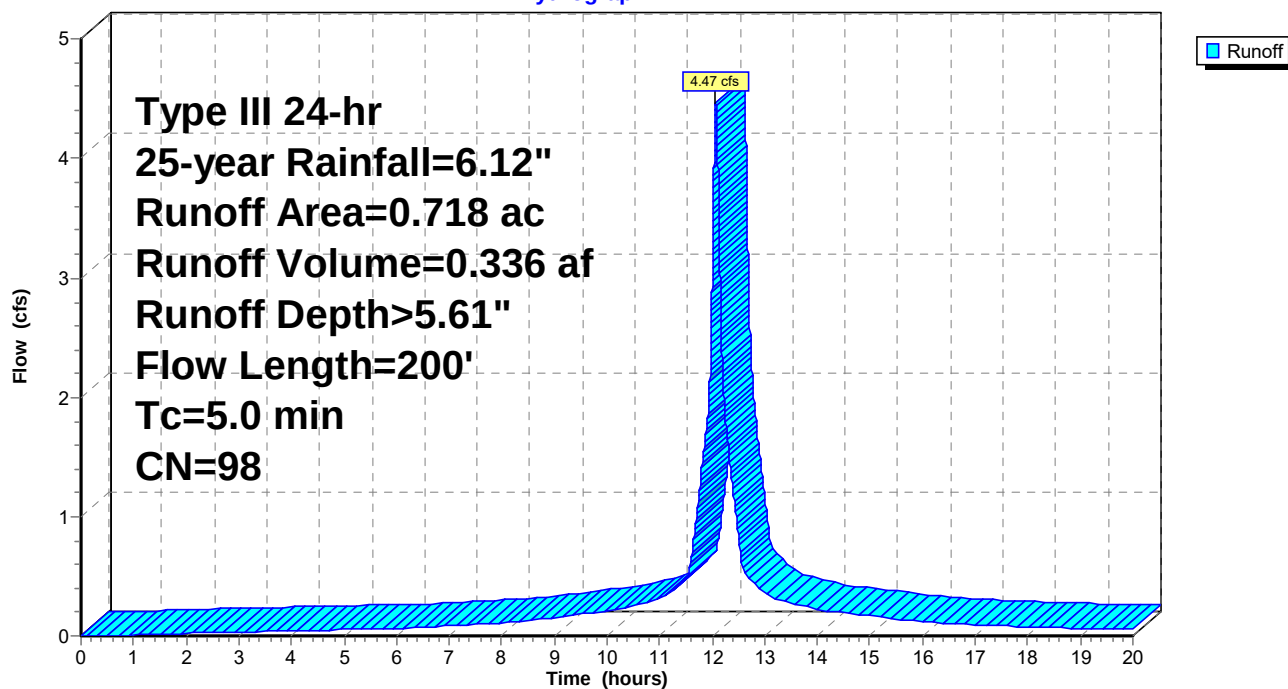
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs
 Type III 24-hr 25-year Rainfall=6.12"

Area (ac)	CN	Description
0.718	98	Paved parking, HSG A
0.718		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	200		0.67		Direct Entry, DE

Subcatchment 1S: Existing Parking

Hydrograph



Summary for Subcatchment 2S: Existing Parking

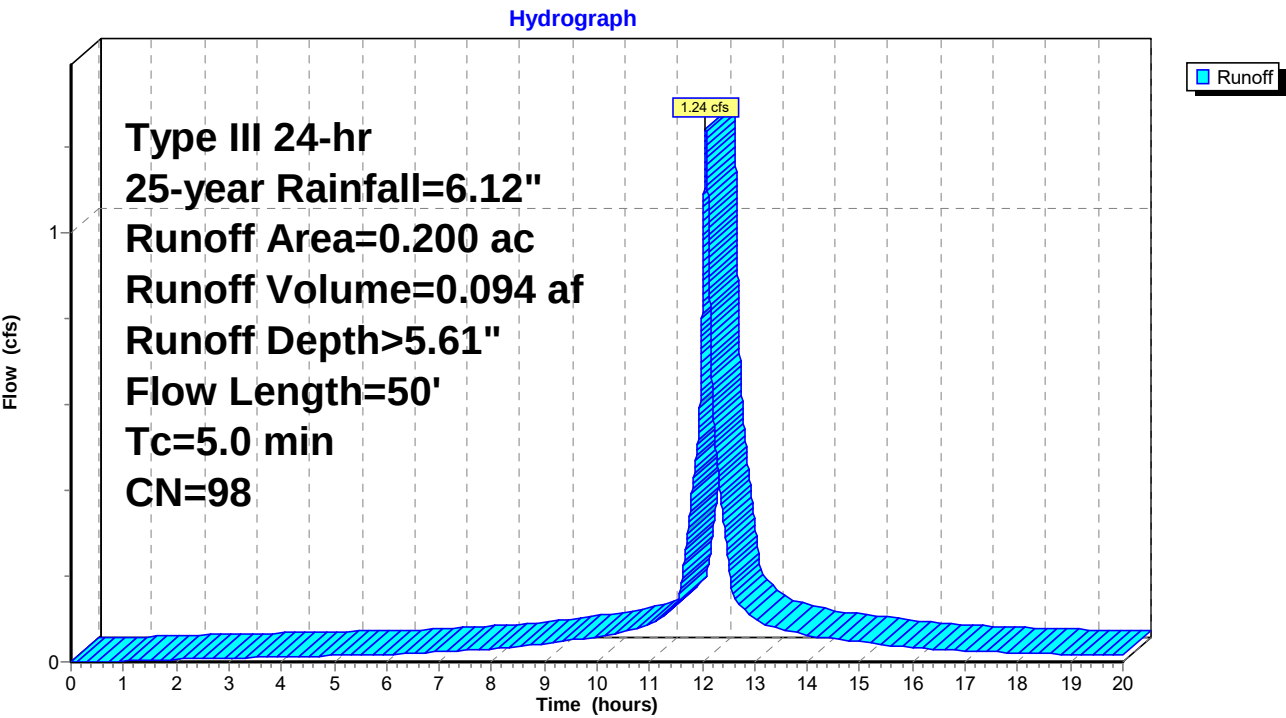
Runoff = 1.24 cfs @ 12.07 hrs, Volume= 0.094 af, Depth> 5.61"
Routed to Pond 2P : Swale

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs
Type III 24-hr 25-year Rainfall=6.12"

Area (ac)	CN	Description
0.200	98	Paved parking, HSG A
0.200		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	50		0.17		Direct Entry, DE

Subcatchment 2S: Existing Parking



Summary for Reach 3R: Wetlands

Overland flow to wetlands via swale

[40] Hint: Not Described (Outflow=Inflow)

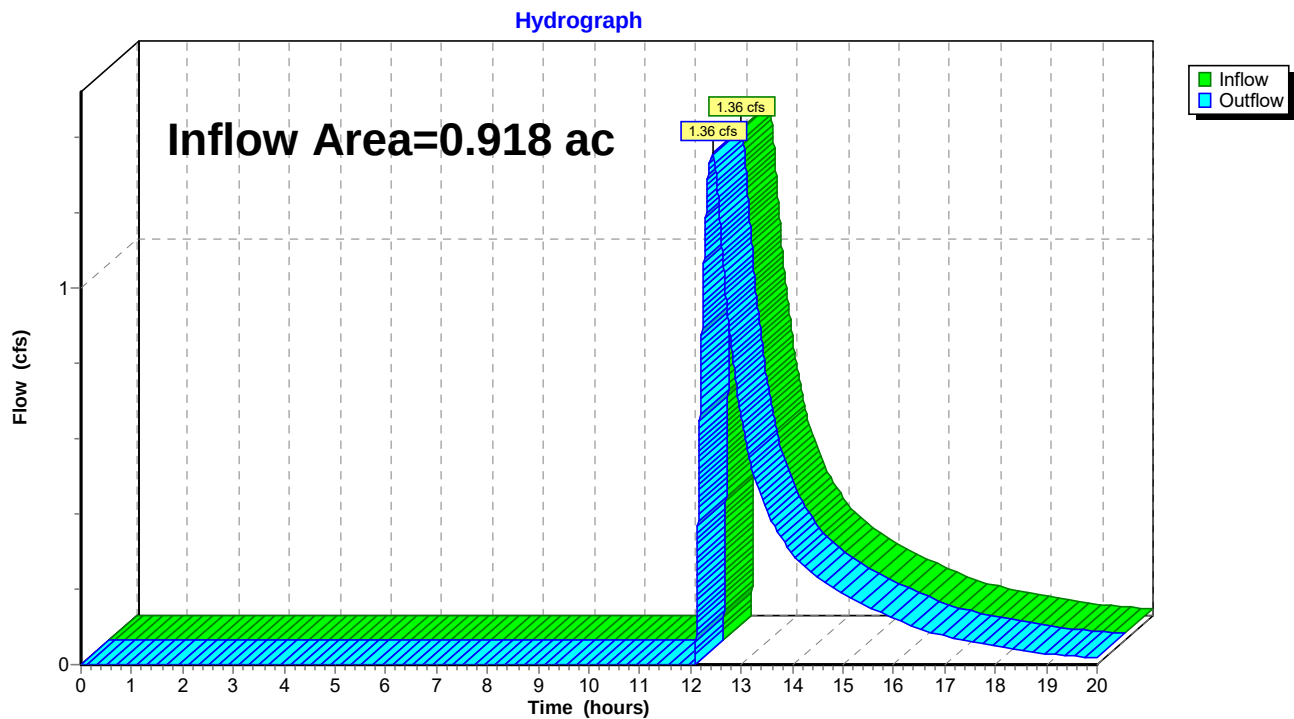
Inflow Area = 0.918 ac, 100.00% Impervious, Inflow Depth > 2.06" for 25-year event

Inflow = 1.36 cfs @ 12.43 hrs, Volume= 0.158 af

Outflow = 1.36 cfs @ 12.43 hrs, Volume= 0.158 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs

Reach 3R: Wetlands

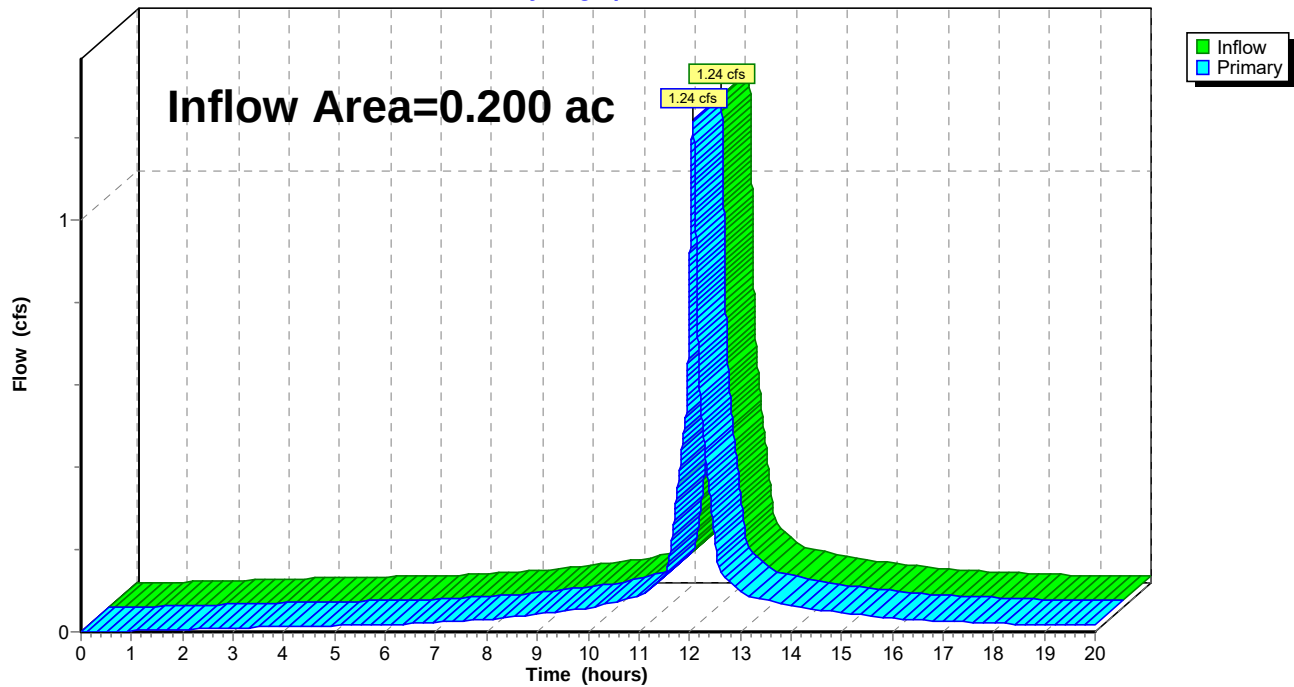


Summary for Pond 2P: Swale

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.200 ac, 100.00% Impervious, Inflow Depth > 5.61" for 25-year event
Inflow = 1.24 cfs @ 12.07 hrs, Volume= 0.094 af
Primary = 1.24 cfs @ 12.07 hrs, Volume= 0.094 af, Atten= 0%, Lag= 0.0 min
Routed to Pond 3P : Sediment Forebay / Drainage Basin

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs

Pond 2P: Swale**Hydrograph**

Summary for Pond 3P: Sediment Forebay / Drainage Basin

Inflow Area = 0.918 ac, 100.00% Impervious, Inflow Depth > 5.61" for 25-year event
 Inflow = 5.71 cfs @ 12.07 hrs, Volume= 0.429 af
 Outflow = 1.43 cfs @ 12.43 hrs, Volume= 0.235 af, Atten= 75%, Lag= 21.2 min
 Discarded = 0.07 cfs @ 12.43 hrs, Volume= 0.078 af
 Primary = 1.36 cfs @ 12.43 hrs, Volume= 0.158 af
 Routed to Reach 3R : Wetlands

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs
 Peak Elev= 255.28' @ 12.43 hrs Surf.Area= 6,291 sf Storage= 10,349 cf

Plug-Flow detention time= 183.5 min calculated for 0.235 af (55% of inflow)
 Center-of-Mass det. time= 84.3 min (800.9 - 716.6)

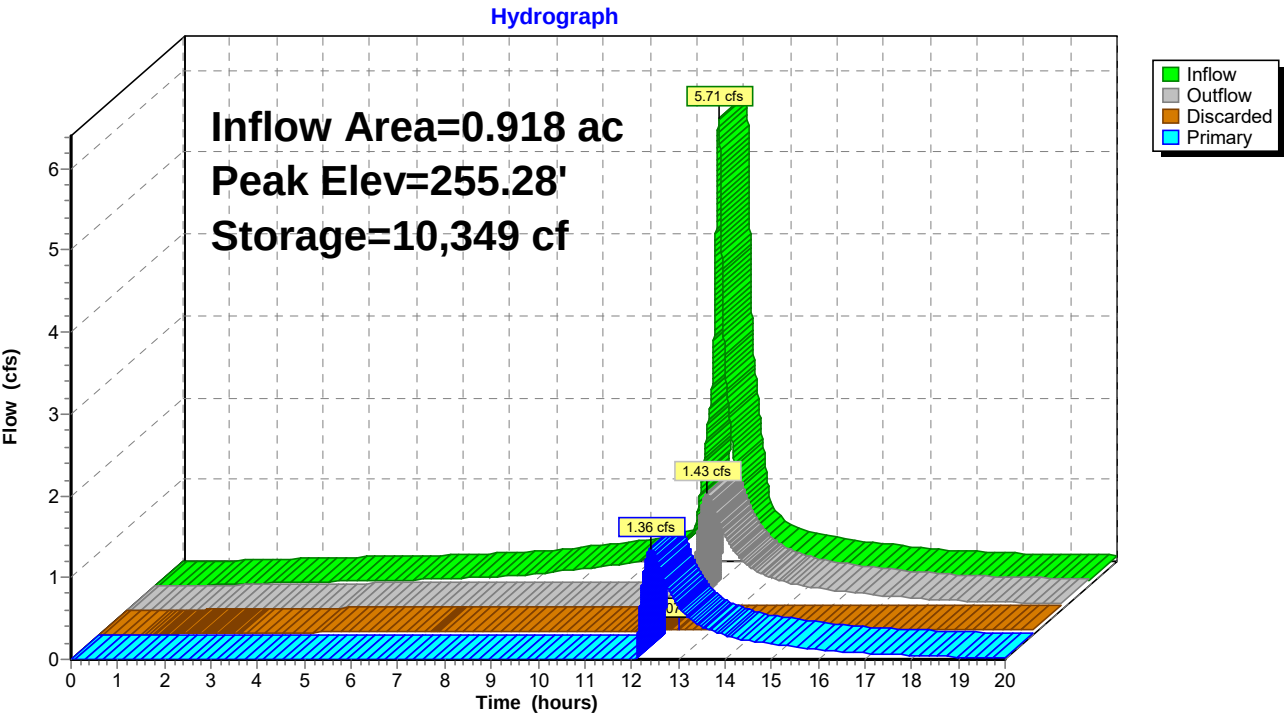
Volume	Invert	Avail.Storage	Storage Description
#1	253.05'	12,609 cf	20.00'W x 135.00'L x 3.00'H Detention Basin Z=3.0
#2	253.30'	3,474 cf	20.00'W x 30.00'L x 3.00'H Sediment Forebay Z=3.0
		16,083 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	254.95'	90.0 deg x 2.0' long x 1.00' rise Sharp-Crested Vee/Trap Weir Cv= 2.50 (C= 3.13)
#2	Discarded	253.05'	0.500 in/hr Exfiltration over Surface area Conductivity to Groundwater Elevation = 2.00'

Discarded OutFlow Max=0.07 cfs @ 12.43 hrs HW=255.28' (Free Discharge)
 ↑ **2=Exfiltration** (Controls 0.07 cfs)

Primary OutFlow Max=1.35 cfs @ 12.43 hrs HW=255.28' (Free Discharge)
 ↑ **1=Sharp-Crested Vee/Trap Weir** (Weir Controls 1.35 cfs @ 1.75 fps)

Pond 3P: Sediment Forebay / Drainage Basin



HydroCAD-Report-LargeParking-11-20-2024-Prop

Type III 24-hr 100-year Rainfall=7.72"

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Page 28

Time span=0.00-20.00 hrs, dt=0.001 hrs, 20001 points

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Parking

Runoff Area=0.718 ac 100.00% Impervious Runoff Depth>7.14"
Flow Length=200' Tc=5.0 min CN=98 Runoff=5.64 cfs 0.427 af

Subcatchment 2S: Existing Parking

Runoff Area=0.200 ac 100.00% Impervious Runoff Depth>7.14"
Flow Length=50' Tc=5.0 min CN=98 Runoff=1.57 cfs 0.119 af

Reach 3R: Wetlands

Inflow=2.96 cfs 0.269 af
Outflow=2.96 cfs 0.269 af

Pond 2P: Swale

Inflow=1.57 cfs 0.119 af
Primary=1.57 cfs 0.119 af

Pond 3P: Sediment Forebay / Drainage

Peak Elev=255.48' Storage=11,652 cf Inflow=7.22 cfs 0.546 af
Discarded=0.08 cfs 0.082 af Primary=2.96 cfs 0.269 af Outflow=3.04 cfs 0.351 af

Total Runoff Area = 0.918 ac Runoff Volume = 0.546 af Average Runoff Depth = 7.14"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.918 ac

Summary for Subcatchment 1S: Existing Parking

Runoff = 5.64 cfs @ 12.07 hrs, Volume= 0.427 af, Depth> 7.14"

Routed to Pond 3P : Sediment Forebay / Drainage Basin

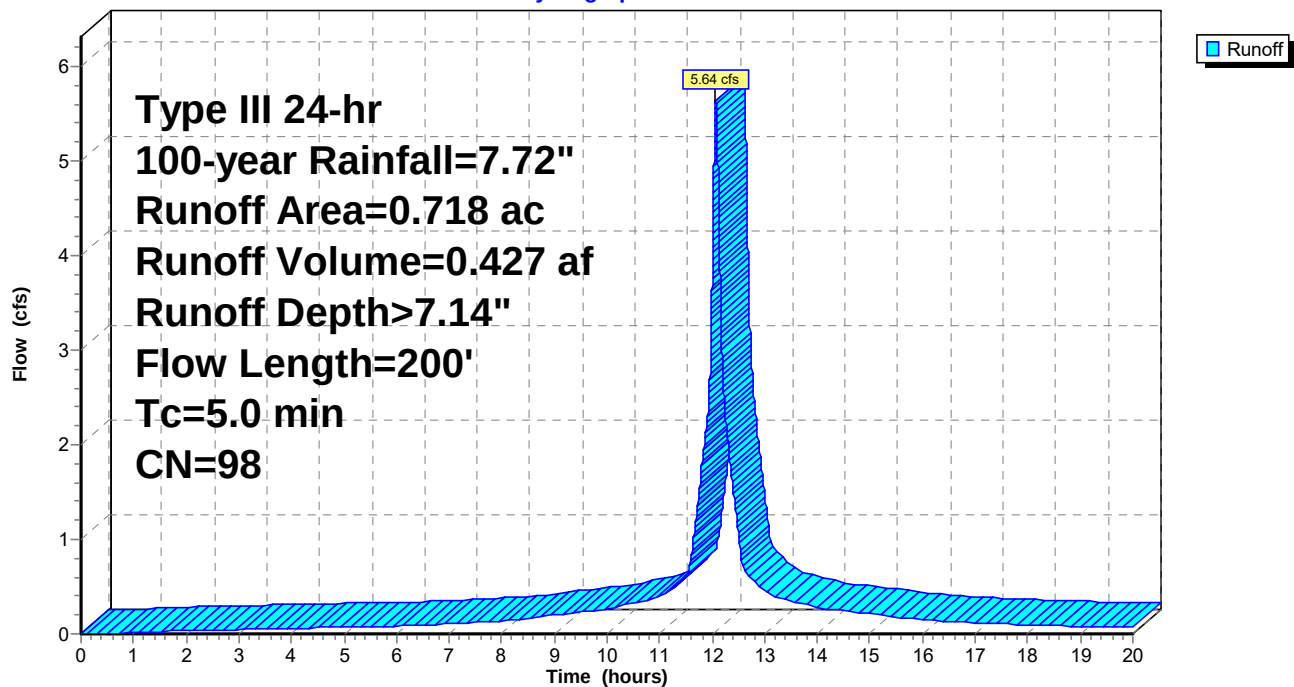
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs
Type III 24-hr 100-year Rainfall=7.72"

Area (ac)	CN	Description
0.718	98	Paved parking, HSG A
0.718		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	200		0.67		Direct Entry, DE

Subcatchment 1S: Existing Parking

Hydrograph



Summary for Subcatchment 2S: Existing Parking

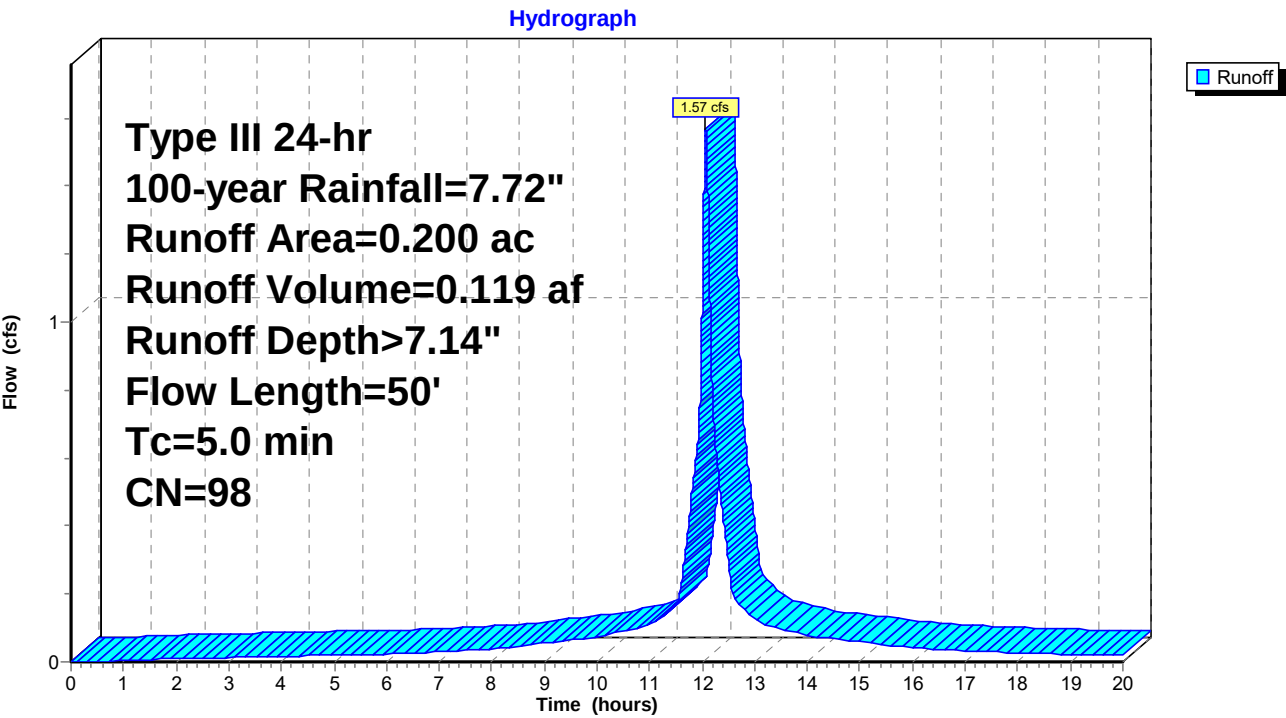
Runoff = 1.57 cfs @ 12.07 hrs, Volume= 0.119 af, Depth> 7.14"
Routed to Pond 2P : Swale

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs
Type III 24-hr 100-year Rainfall=7.72"

Area (ac)	CN	Description
0.200	98	Paved parking, HSG A
0.200		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	50		0.17		Direct Entry, DE

Subcatchment 2S: Existing Parking



Summary for Reach 3R: Wetlands

Overland flow to wetlands via swale

[40] Hint: Not Described (Outflow=Inflow)

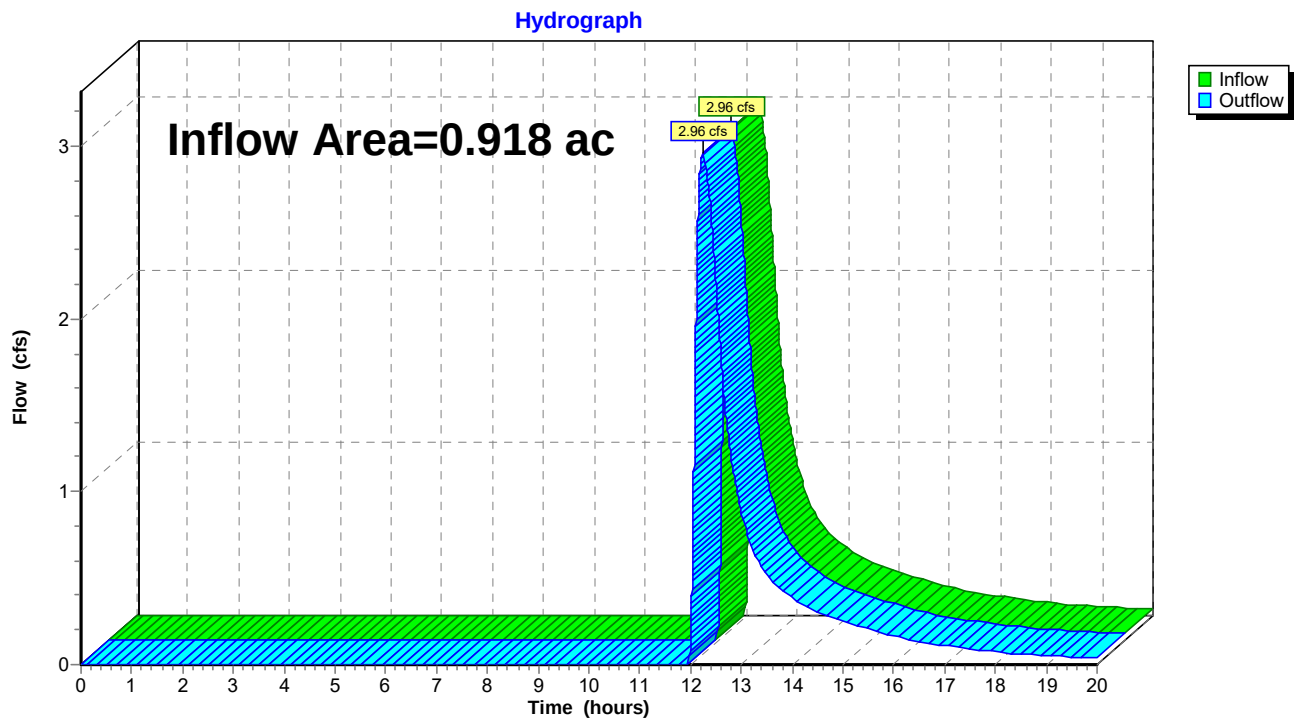
Inflow Area = 0.918 ac, 100.00% Impervious, Inflow Depth > 3.52" for 100-year event

Inflow = 2.96 cfs @ 12.24 hrs, Volume= 0.269 af

Outflow = 2.96 cfs @ 12.24 hrs, Volume= 0.269 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs

Reach 3R: Wetlands

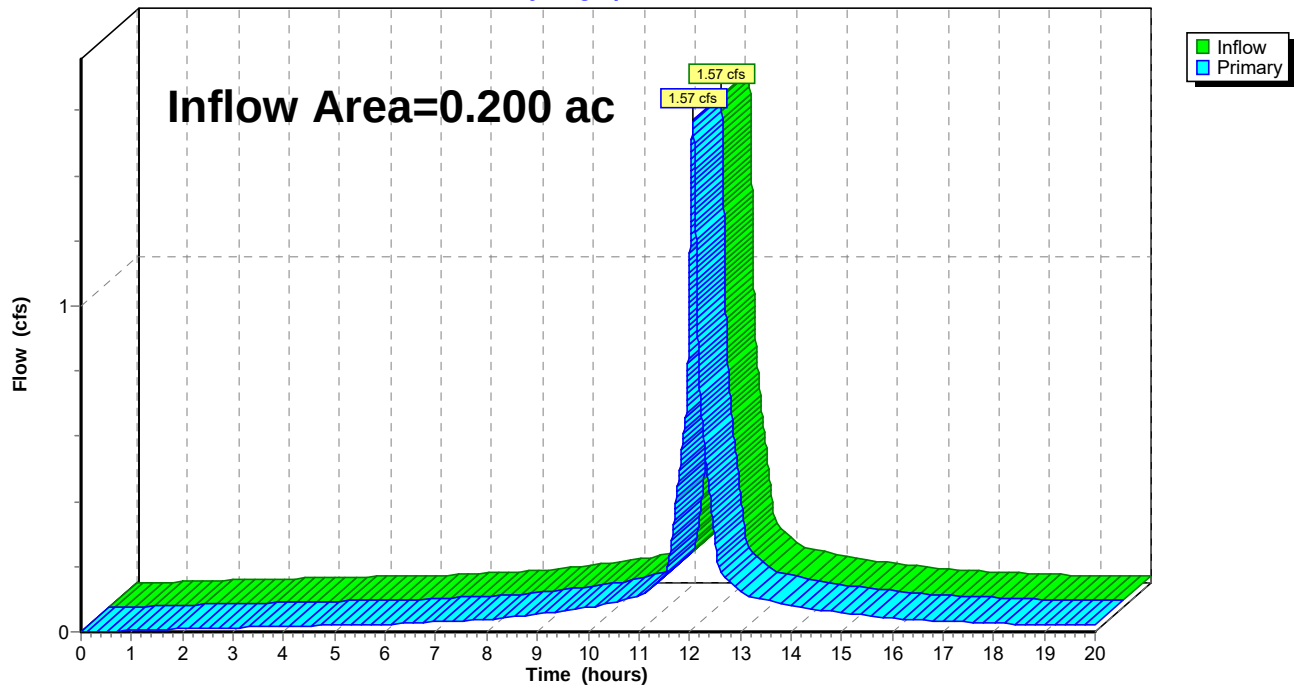


Summary for Pond 2P: Swale

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.200 ac, 100.00% Impervious, Inflow Depth > 7.14" for 100-year event
Inflow = 1.57 cfs @ 12.07 hrs, Volume= 0.119 af
Primary = 1.57 cfs @ 12.07 hrs, Volume= 0.119 af, Atten= 0%, Lag= 0.0 min
Routed to Pond 3P : Sediment Forebay / Drainage Basin

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs

Pond 2P: Swale**Hydrograph**

Summary for Pond 3P: Sediment Forebay / Drainage Basin

Inflow Area = 0.918 ac, 100.00% Impervious, Inflow Depth > 7.14" for 100-year event
 Inflow = 7.22 cfs @ 12.07 hrs, Volume= 0.546 af
 Outflow = 3.04 cfs @ 12.24 hrs, Volume= 0.351 af, Atten= 58%, Lag= 10.2 min
 Discarded = 0.08 cfs @ 12.24 hrs, Volume= 0.082 af
 Primary = 2.96 cfs @ 12.24 hrs, Volume= 0.269 af
 Routed to Reach 3R : Wetlands

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.001 hrs
 Peak Elev= 255.48' @ 12.24 hrs Surf.Area= 6,604 sf Storage= 11,652 cf

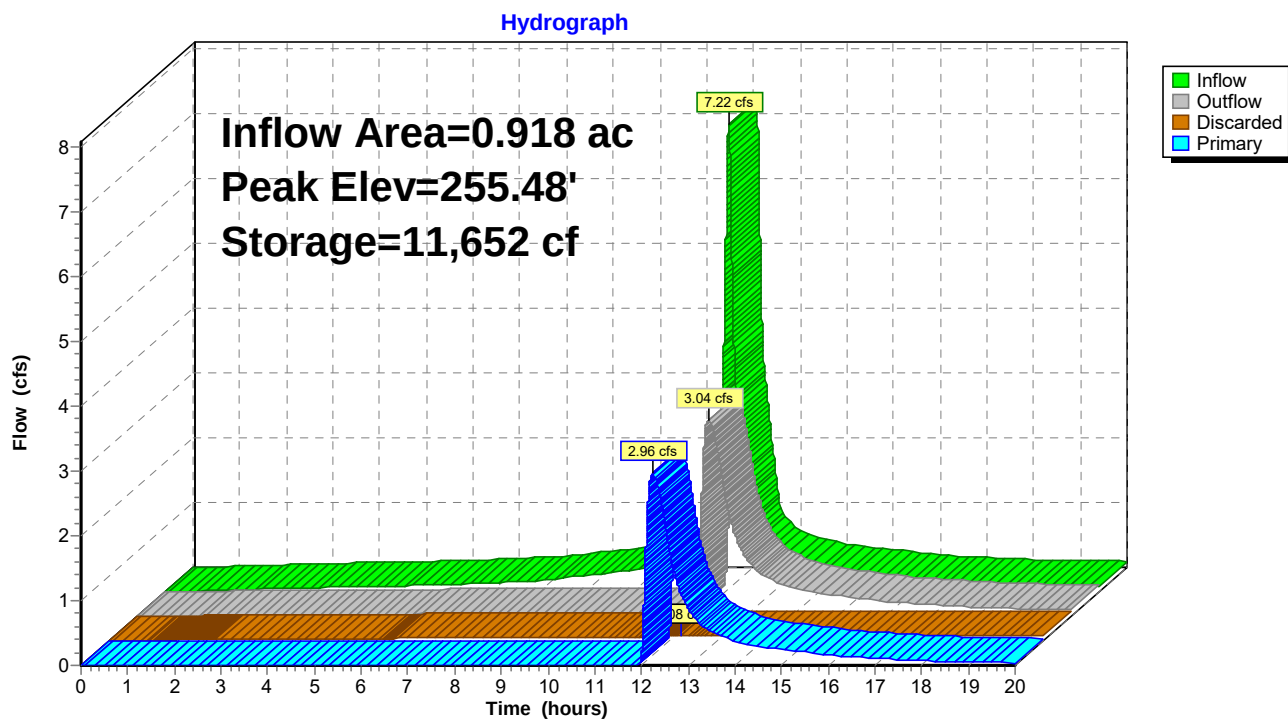
Plug-Flow detention time= 162.8 min calculated for 0.351 af (64% of inflow)
 Center-of-Mass det. time= 79.1 min (792.6 - 713.5)

Volume	Invert	Avail.Storage	Storage Description
#1	253.05'	12,609 cf	20.00'W x 135.00'L x 3.00'H Detention Basin Z=3.0
#2	253.30'	3,474 cf	20.00'W x 30.00'L x 3.00'H Sediment Forebay Z=3.0
		16,083 cf	Total Available Storage

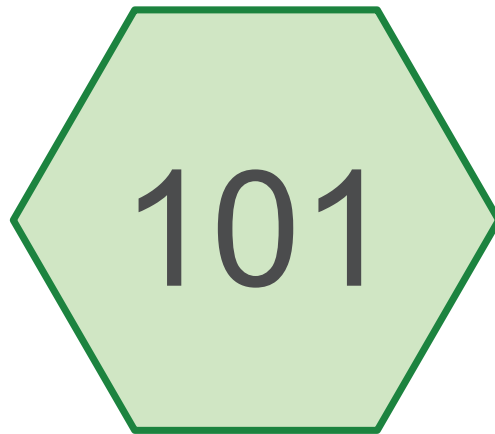
Device	Routing	Invert	Outlet Devices
#1	Primary	254.95'	90.0 deg x 2.0' long x 1.00' rise Sharp-Crested Vee/Trap Weir Cv= 2.50 (C= 3.13)
#2	Discarded	253.05'	0.500 in/hr Exfiltration over Surface area Conductivity to Groundwater Elevation = 2.00'

Discarded OutFlow Max=0.08 cfs @ 12.24 hrs HW=255.48' (Free Discharge)
 ↑ **2=Exfiltration** (Controls 0.08 cfs)

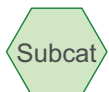
Primary OutFlow Max=2.96 cfs @ 12.24 hrs HW=255.48' (Free Discharge)
 ↑ **1=Sharp-Crested Vee/Trap Weir** (Weir Controls 2.96 cfs @ 2.19 fps)

Pond 3P: Sediment Forebay / Drainage Basin

Addendum: HydroCAD Report, Lake Ave/Beach St



Subcat 101



574901 - Lake Ave Concept Plan Post

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Page 2

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-yr	Type III 24-hr		Default	24.00	1	3.20	2
2	10-yr	Type III 24-hr		Default	24.00	1	4.80	2
3	25-yr	Type III 24-hr		Default	24.00	1	5.50	2
4	100-yr	Type III 24-hr		Default	24.00	1	6.80	2

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Type III 24-hr 2-yr Rainfall=3.20"

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Page 3

Summary for Subcatchment 101: Subcat 101

Runoff = 4.32 cfs @ 12.01 hrs, Volume= 11,798 cf, Depth> 1.34"
 Routed to Pond 103P : Infiltration Chambers

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 6.00-24.00 hrs, dt= 0.05 hrs
 Type III 24-hr 2-yr Rainfall=3.20"

Area (ac)	CN	Description	Land Use
0.003	61	>75% Grass cover, Good, HSG B	Open Space
0.041	61	>75% Grass cover, Good, HSG B	Open Space
0.055	61	>75% Grass cover, Good, HSG B	Open Space
0.015	61	>75% Grass cover, Good, HSG B	Open Space
0.031	61	>75% Grass cover, Good, HSG B	Open Space
0.002	61	>75% Grass cover, Good, HSG B	Open Space
0.000	61	>75% Grass cover, Good, HSG B	Open Space
0.505	61	>75% Grass cover, Good, HSG B	Open Space
0.004	61	>75% Grass cover, Good, HSG B	Open Space
0.002	61	>75% Grass cover, Good, HSG B	Open Space
0.077	61	>75% Grass cover, Good, HSG B	Open Space
0.007	61	>75% Grass cover, Good, HSG B	Open Space
0.006	61	>75% Grass cover, Good, HSG B	Open Space
0.039	61	>75% Grass cover, Good, HSG B	Open Space
0.057	61	>75% Grass cover, Good, HSG B	Open Space
0.221	61	>75% Grass cover, Good, HSG B	Open Space
0.152	55	Woods, Good, HSG B	Woods
1.031	98	Paved roads w/curbs & sewers, HSG B	Roadway
0.029	98	Roofs, HSG B	Roofs
0.045	98	Roofs, HSG B	Roofs
0.004	98	Roofs, HSG B	Roofs
0.001	98	Roofs, HSG B	Roofs
0.029	98	Roofs, HSG B	Roofs
0.040	98	Roofs, HSG B	Roofs
0.002	98	Roofs, HSG B	Roofs
0.000	98	Roofs, HSG B	Roofs
0.027	98	Roofs, HSG B	Roofs
0.002	98	Roofs, HSG B	Roofs
0.004	98	Roofs, HSG B	Roofs
2.431	79	Weighted Average	
1.217		50.05% Pervious Area	
1.214		49.95% Impervious Area	

574901 - Lake Ave Concept Plan Post

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Type III 24-hr 2-yr Rainfall=3.20"

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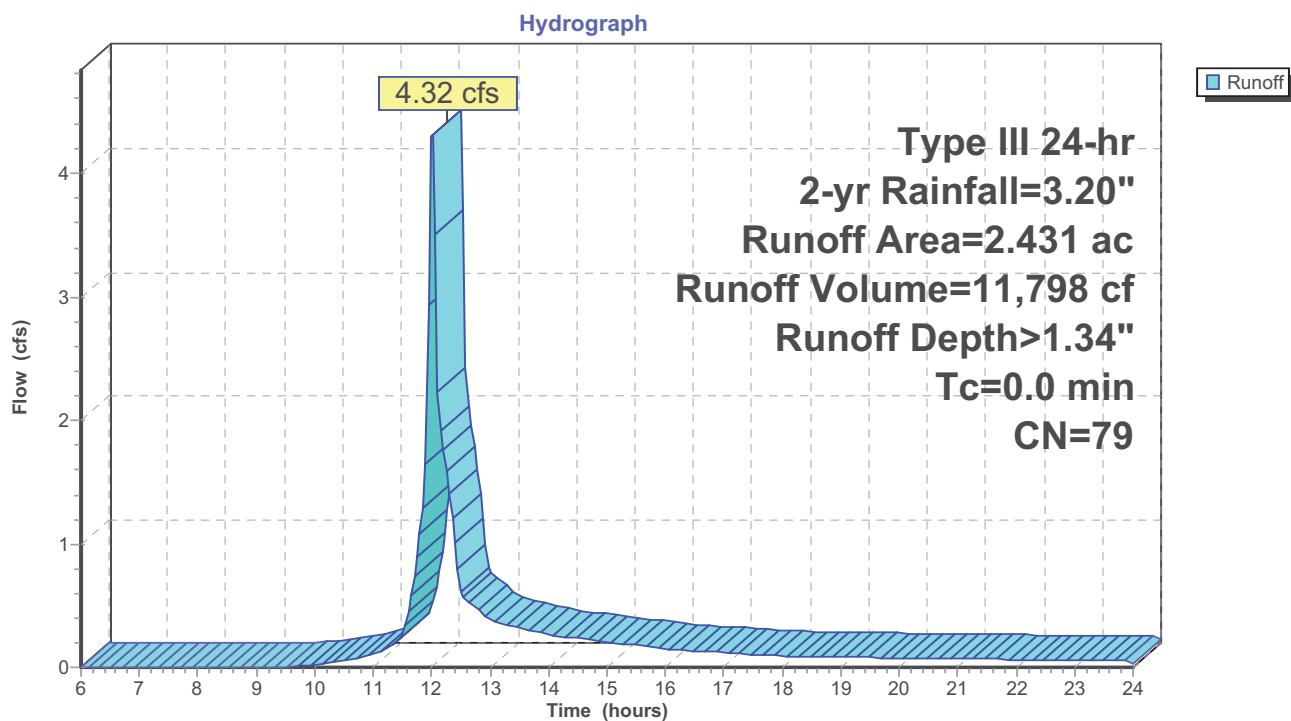
Page 4

Pollutant Loading for 10.00" Rainfall, Pj=1.000

Subcat 49.95% Impervious, Rv= 0.500, Runoff= 5.00"

Area (acres)	Land Use	TSS (pounds)	TP (pounds)
1.064	Open Space	0.00	0.00
1.031	Roadway	0.00	0.00
0.183	Roofs	0.00	0.00
0.152	Woods	0.00	0.00
2.431	Total	0.00	0.00

Subcatchment 101: Subcat 101



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Type III 24-hr 10-yr Rainfall=4.80"

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Page 5

Summary for Subcatchment 101: Subcat 101

Runoff = 8.62 cfs @ 12.00 hrs, Volume= 23,215 cf, Depth> 2.63"
 Routed to Pond 103P : Infiltration Chambers

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 6.00-24.00 hrs, dt= 0.05 hrs
 Type III 24-hr 10-yr Rainfall=4.80"

Area (ac)	CN	Description	Land Use
0.003	61	>75% Grass cover, Good, HSG B	Open Space
0.041	61	>75% Grass cover, Good, HSG B	Open Space
0.055	61	>75% Grass cover, Good, HSG B	Open Space
0.015	61	>75% Grass cover, Good, HSG B	Open Space
0.031	61	>75% Grass cover, Good, HSG B	Open Space
0.002	61	>75% Grass cover, Good, HSG B	Open Space
0.000	61	>75% Grass cover, Good, HSG B	Open Space
0.505	61	>75% Grass cover, Good, HSG B	Open Space
0.004	61	>75% Grass cover, Good, HSG B	Open Space
0.002	61	>75% Grass cover, Good, HSG B	Open Space
0.077	61	>75% Grass cover, Good, HSG B	Open Space
0.007	61	>75% Grass cover, Good, HSG B	Open Space
0.006	61	>75% Grass cover, Good, HSG B	Open Space
0.039	61	>75% Grass cover, Good, HSG B	Open Space
0.057	61	>75% Grass cover, Good, HSG B	Open Space
0.221	61	>75% Grass cover, Good, HSG B	Open Space
0.152	55	Woods, Good, HSG B	Woods
1.031	98	Paved roads w/curbs & sewers, HSG B	Roadway
0.029	98	Roofs, HSG B	Roofs
0.045	98	Roofs, HSG B	Roofs
0.004	98	Roofs, HSG B	Roofs
0.001	98	Roofs, HSG B	Roofs
0.029	98	Roofs, HSG B	Roofs
0.040	98	Roofs, HSG B	Roofs
0.002	98	Roofs, HSG B	Roofs
0.000	98	Roofs, HSG B	Roofs
0.027	98	Roofs, HSG B	Roofs
0.002	98	Roofs, HSG B	Roofs
0.004	98	Roofs, HSG B	Roofs
2.431	79	Weighted Average	
1.217		50.05% Pervious Area	
1.214		49.95% Impervious Area	

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Type III 24-hr 10-yr Rainfall=4.80"

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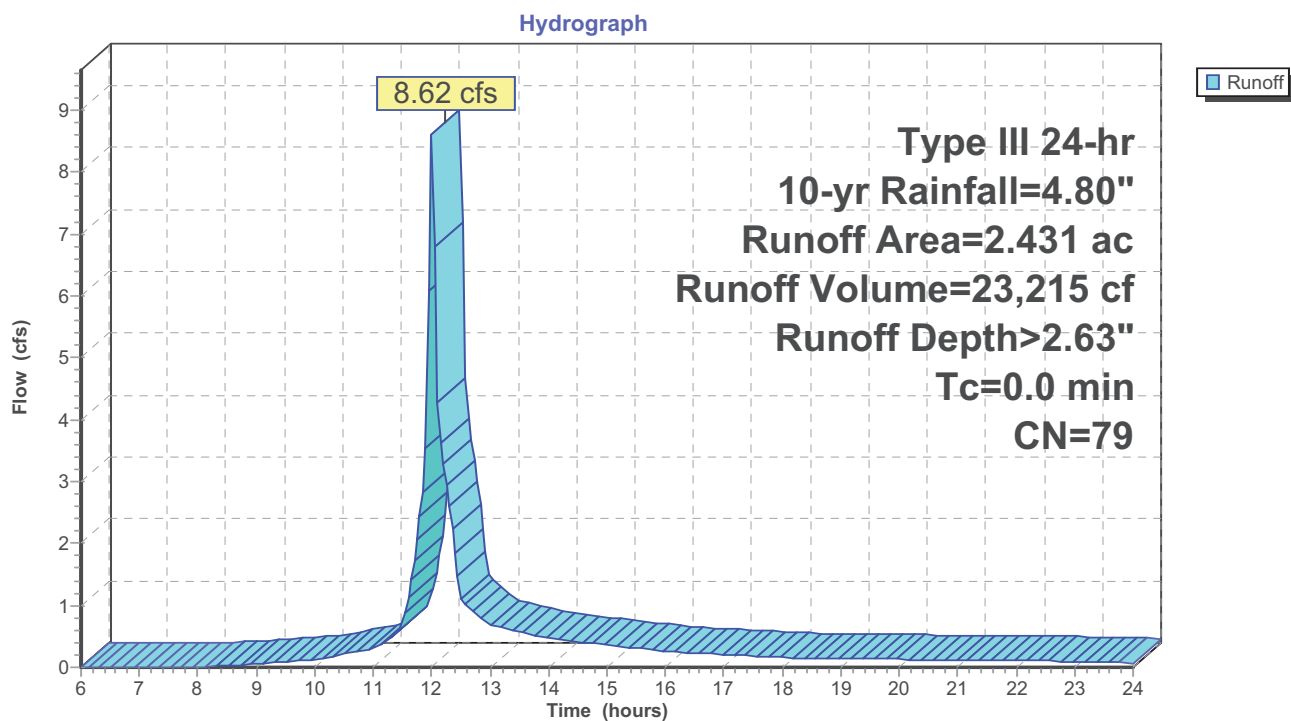
Page 6

Pollutant Loading for 10.00" Rainfall, Pj=1.000

Subcat 49.95% Impervious, Rv= 0.500, Runoff= 5.00"

Area (acres)	Land Use	TSS (pounds)	TP (pounds)
1.064	Open Space	0.00	0.00
1.031	Roadway	0.00	0.00
0.183	Roofs	0.00	0.00
0.152	Woods	0.00	0.00
2.431	Total	0.00	0.00

Subcatchment 101: Subcat 101



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Type III 24-hr 25-yr Rainfall=5.50"

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Page 7

Summary for Subcatchment 101: Subcat 101

Runoff = 10.59 cfs @ 12.00 hrs, Volume= 28,567 cf, Depth> 3.24"
 Routed to Pond 103P : Infiltration Chambers

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 6.00-24.00 hrs, dt= 0.05 hrs
 Type III 24-hr 25-yr Rainfall=5.50"

Area (ac)	CN	Description	Land Use
0.003	61	>75% Grass cover, Good, HSG B	Open Space
0.041	61	>75% Grass cover, Good, HSG B	Open Space
0.055	61	>75% Grass cover, Good, HSG B	Open Space
0.015	61	>75% Grass cover, Good, HSG B	Open Space
0.031	61	>75% Grass cover, Good, HSG B	Open Space
0.002	61	>75% Grass cover, Good, HSG B	Open Space
0.000	61	>75% Grass cover, Good, HSG B	Open Space
0.505	61	>75% Grass cover, Good, HSG B	Open Space
0.004	61	>75% Grass cover, Good, HSG B	Open Space
0.002	61	>75% Grass cover, Good, HSG B	Open Space
0.077	61	>75% Grass cover, Good, HSG B	Open Space
0.007	61	>75% Grass cover, Good, HSG B	Open Space
0.006	61	>75% Grass cover, Good, HSG B	Open Space
0.039	61	>75% Grass cover, Good, HSG B	Open Space
0.057	61	>75% Grass cover, Good, HSG B	Open Space
0.221	61	>75% Grass cover, Good, HSG B	Open Space
0.152	55	Woods, Good, HSG B	Woods
1.031	98	Paved roads w/curbs & sewers, HSG B	Roadway
0.029	98	Roofs, HSG B	Roofs
0.045	98	Roofs, HSG B	Roofs
0.004	98	Roofs, HSG B	Roofs
0.001	98	Roofs, HSG B	Roofs
0.029	98	Roofs, HSG B	Roofs
0.040	98	Roofs, HSG B	Roofs
0.002	98	Roofs, HSG B	Roofs
0.000	98	Roofs, HSG B	Roofs
0.027	98	Roofs, HSG B	Roofs
0.002	98	Roofs, HSG B	Roofs
0.004	98	Roofs, HSG B	Roofs
2.431	79	Weighted Average	
1.217		50.05% Pervious Area	
1.214		49.95% Impervious Area	

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Type III 24-hr 25-yr Rainfall=5.50"

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Page 8

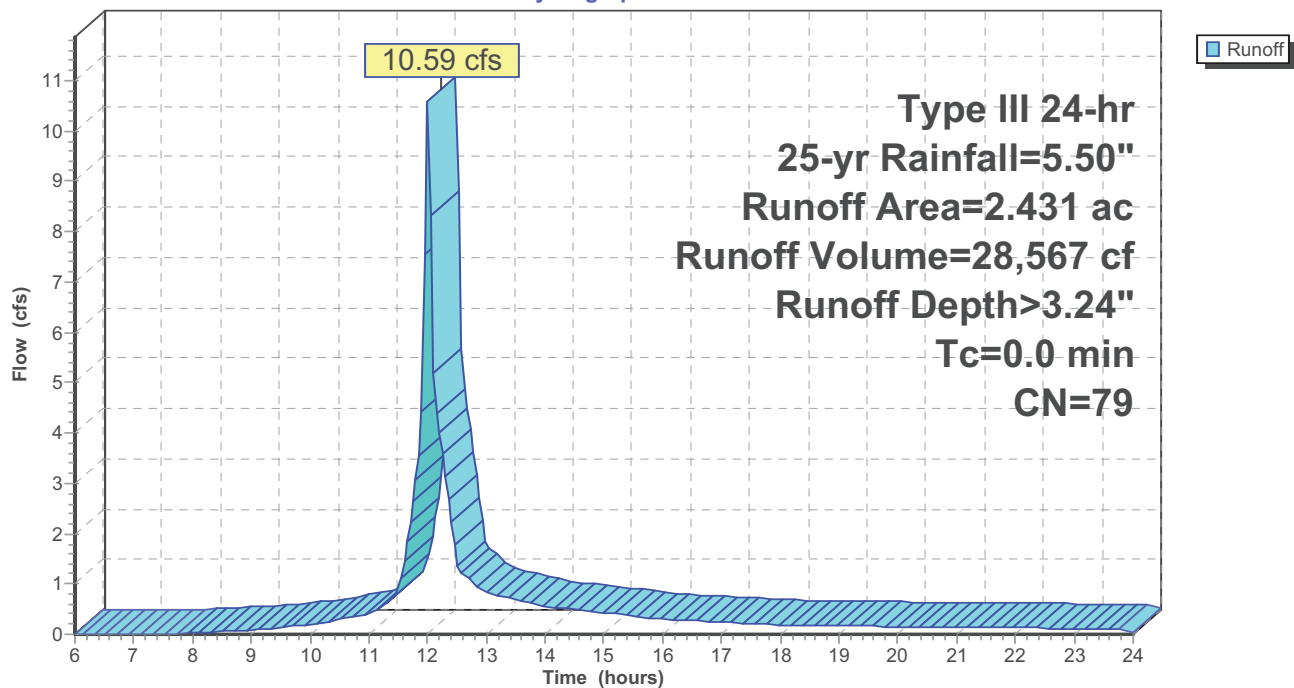
Pollutant Loading for 10.00" Rainfall, Pj=1.000

Subcat 49.95% Impervious, Rv= 0.500, Runoff= 5.00"

Area (acres)	Land Use	TSS (pounds)	TP (pounds)
1.064	Open Space	0.00	0.00
1.031	Roadway	0.00	0.00
0.183	Roofs	0.00	0.00
0.152	Woods	0.00	0.00
2.431	Total	0.00	0.00

Subcatchment 101: Subcat 101

Hydrograph



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Type III 24-hr 100-yr Rainfall=6.80"

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Page 9

Summary for Subcatchment 101: Subcat 101

Runoff = 14.32 cfs @ 12.00 hrs, Volume= 38,850 cf, Depth> 4.40"
 Routed to Pond 103P : Infiltration Chambers

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 6.00-24.00 hrs, dt= 0.05 hrs
 Type III 24-hr 100-yr Rainfall=6.80"

Area (ac)	CN	Description	Land Use
0.003	61	>75% Grass cover, Good, HSG B	Open Space
0.041	61	>75% Grass cover, Good, HSG B	Open Space
0.055	61	>75% Grass cover, Good, HSG B	Open Space
0.015	61	>75% Grass cover, Good, HSG B	Open Space
0.031	61	>75% Grass cover, Good, HSG B	Open Space
0.002	61	>75% Grass cover, Good, HSG B	Open Space
0.000	61	>75% Grass cover, Good, HSG B	Open Space
0.505	61	>75% Grass cover, Good, HSG B	Open Space
0.004	61	>75% Grass cover, Good, HSG B	Open Space
0.002	61	>75% Grass cover, Good, HSG B	Open Space
0.077	61	>75% Grass cover, Good, HSG B	Open Space
0.007	61	>75% Grass cover, Good, HSG B	Open Space
0.006	61	>75% Grass cover, Good, HSG B	Open Space
0.039	61	>75% Grass cover, Good, HSG B	Open Space
0.057	61	>75% Grass cover, Good, HSG B	Open Space
0.221	61	>75% Grass cover, Good, HSG B	Open Space
0.152	55	Woods, Good, HSG B	Woods
1.031	98	Paved roads w/curbs & sewers, HSG B	Roadway
0.029	98	Roofs, HSG B	Roofs
0.045	98	Roofs, HSG B	Roofs
0.004	98	Roofs, HSG B	Roofs
0.001	98	Roofs, HSG B	Roofs
0.029	98	Roofs, HSG B	Roofs
0.040	98	Roofs, HSG B	Roofs
0.002	98	Roofs, HSG B	Roofs
0.000	98	Roofs, HSG B	Roofs
0.027	98	Roofs, HSG B	Roofs
0.002	98	Roofs, HSG B	Roofs
0.004	98	Roofs, HSG B	Roofs
2.431	79	Weighted Average	
1.217		50.05% Pervious Area	
1.214		49.95% Impervious Area	

574901 - Lake Ave Concept Plan Post

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Type III 24-hr 100-yr Rainfall=6.80"

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Page 10

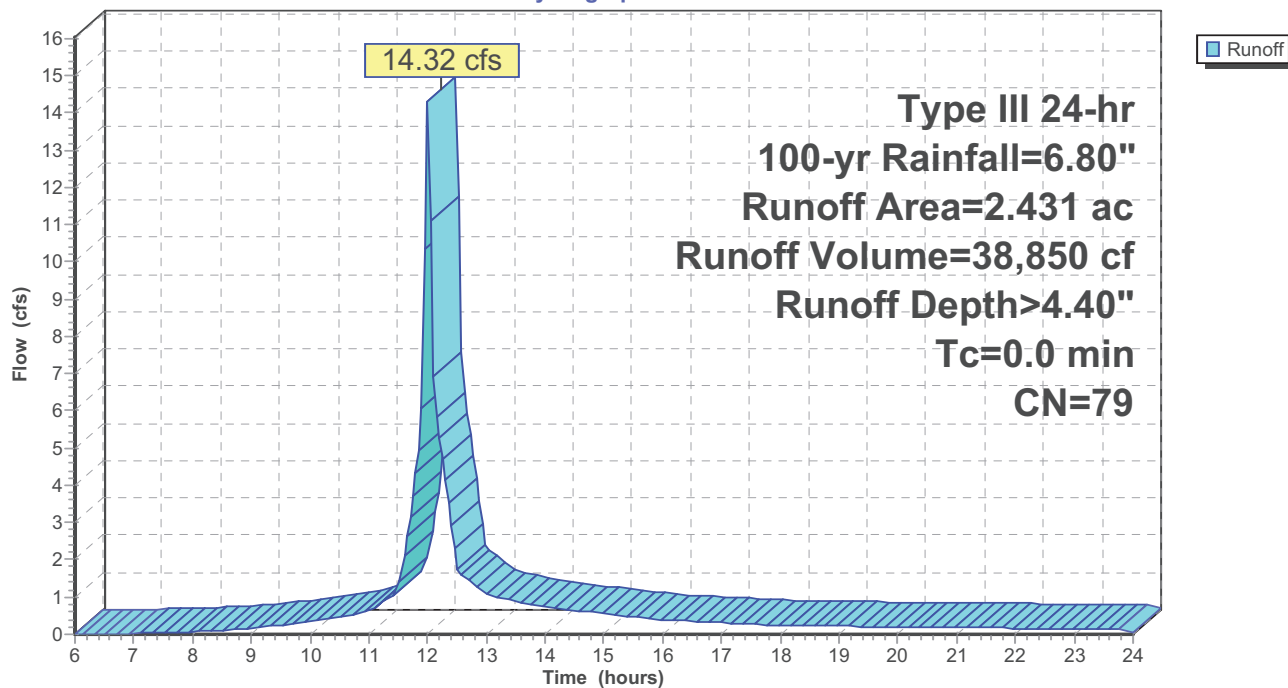
Pollutant Loading for 10.00" Rainfall, Pj=1.000

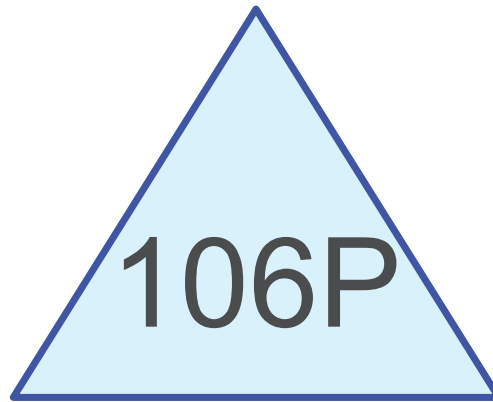
Subcat 49.95% Impervious, Rv= 0.500, Runoff= 5.00"

Area (acres)	Land Use	TSS (pounds)	TP (pounds)
1.064	Open Space	0.00	0.00
1.031	Roadway	0.00	0.00
0.183	Roofs	0.00	0.00
0.152	Woods	0.00	0.00
2.431	Total	0.00	0.00

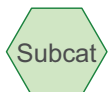
Subcatchment 101: Subcat 101

Hydrograph





Dry WQ Swale



Routing Diagram for 574901 - Lake Ave Concept Plan Post
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Page 2

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-yr	Type III 24-hr		Default	24.00	1	3.20	2
2	10-yr	Type III 24-hr		Default	24.00	1	4.80	2
3	25-yr	Type III 24-hr		Default	24.00	1	5.50	2
4	100-yr	Type III 24-hr		Default	24.00	1	6.80	2

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Type III 24-hr 2-yr Rainfall=3.20"

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Page 3

Summary for Pond 106P: Dry WQ Swale

Inflow Area = 105,912 sf, 49.95% Impervious, Inflow Depth > 1.34" for 2-yr event
 Inflow = 4.32 cfs @ 12.01 hrs, Volume= 11,798 cf
 Outflow = 4.03 cfs @ 12.03 hrs, Volume= 11,422 cf, Atten= 7%, Lag= 1.4 min
 Discarded = 0.01 cfs @ 12.03 hrs, Volume= 561 cf
 Primary = 4.02 cfs @ 12.03 hrs, Volume= 10,861 cf

Routing by Stor-Ind method, Time Span= 6.00-24.00 hrs, dt= 0.05 hrs
 Peak Elev= 253.83' @ 12.03 hrs Surf.Area= 1,171 sf Storage= 710 cf

Plug-Flow detention time= 25.7 min calculated for 11,390 cf (97% of inflow)
 Center-of-Mass det. time= 8.1 min (848.5 - 840.4)

Volume	Invert	Avail.Storage	Storage Description
#1	253.00'	1,695 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
253.00	570	403.0	0	0	570
254.50	1,806	421.0	1,695	1,695	1,902

Device	Routing	Invert	Outlet Devices
#1	Discarded	253.00'	0.520 in/hr Exfiltration over Surface area
#2	Primary	253.50'	6.0' long x 1.00' rise Sharp-Crested Rectangular Weir 2 End Contraction(s) 0.5' Crest Height

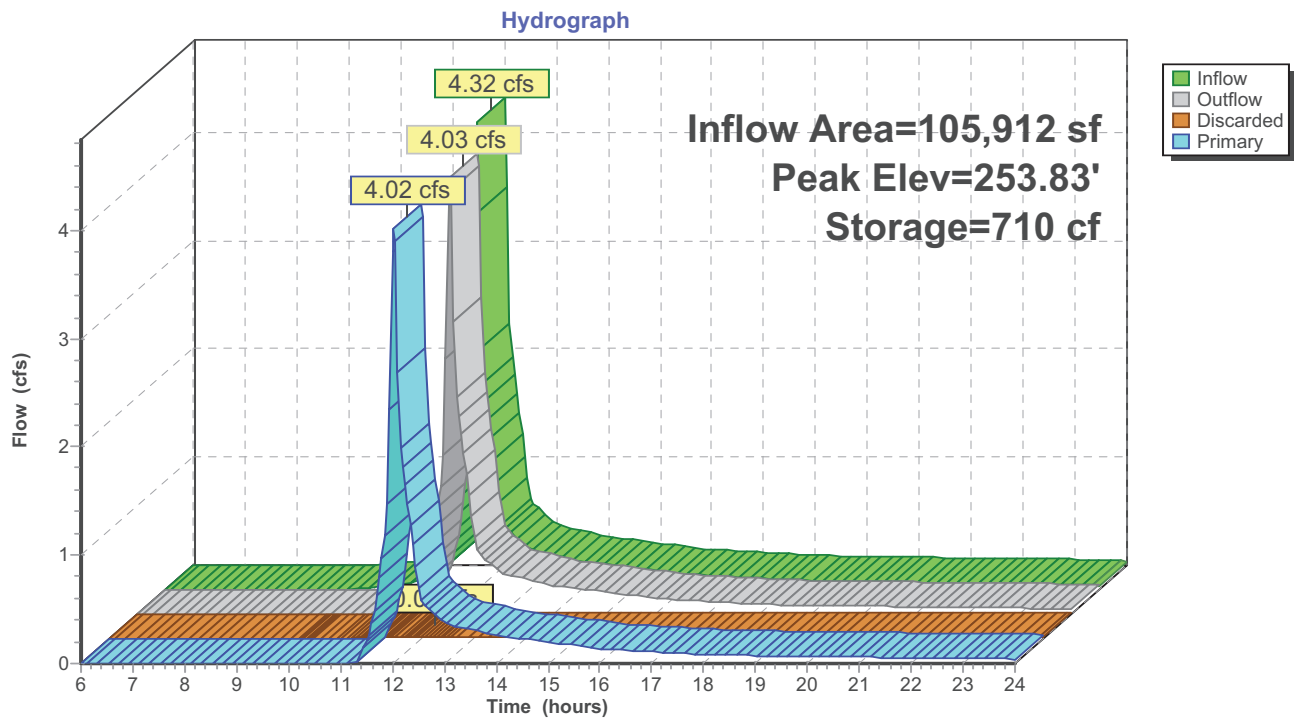
Discarded OutFlow Max=0.01 cfs @ 12.03 hrs HW=253.82' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=3.86 cfs @ 12.03 hrs HW=253.82' (Free Discharge)

↑**2=Sharp-Crested Rectangular Weir** (Weir Controls 3.86 cfs @ 2.01 fps)

Pond 106P: Dry WQ Swale



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Type III 24-hr 10-yr Rainfall=4.80"

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Page 5

Summary for Pond 106P: Dry WQ Swale

Inflow Area = 105,912 sf, 49.95% Impervious, Inflow Depth > 2.63" for 10-yr event
 Inflow = 8.62 cfs @ 12.00 hrs, Volume= 23,215 cf
 Outflow = 8.15 cfs @ 12.02 hrs, Volume= 22,833 cf, Atten= 5%, Lag= 1.0 min
 Discarded = 0.02 cfs @ 12.02 hrs, Volume= 634 cf
 Primary = 8.13 cfs @ 12.02 hrs, Volume= 22,199 cf

Routing by Stor-Ind method, Time Span= 6.00-24.00 hrs, dt= 0.05 hrs
 Peak Elev= 254.02' @ 12.02 hrs Surf.Area= 1,335 sf Storage= 945 cf

Plug-Flow detention time= 15.7 min calculated for 22,833 cf (98% of inflow)
 Center-of-Mass det. time= 5.9 min (826.6 - 820.7)

Volume	Invert	Avail.Storage	Storage Description
#1	253.00'	1,695 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
253.00	570	403.0	0	0	570
254.50	1,806	421.0	1,695	1,695	1,902

Device	Routing	Invert	Outlet Devices
#1	Discarded	253.00'	0.520 in/hr Exfiltration over Surface area
#2	Primary	253.50'	6.0' long x 1.00' rise Sharp-Crested Rectangular Weir 2 End Contraction(s) 0.5' Crest Height

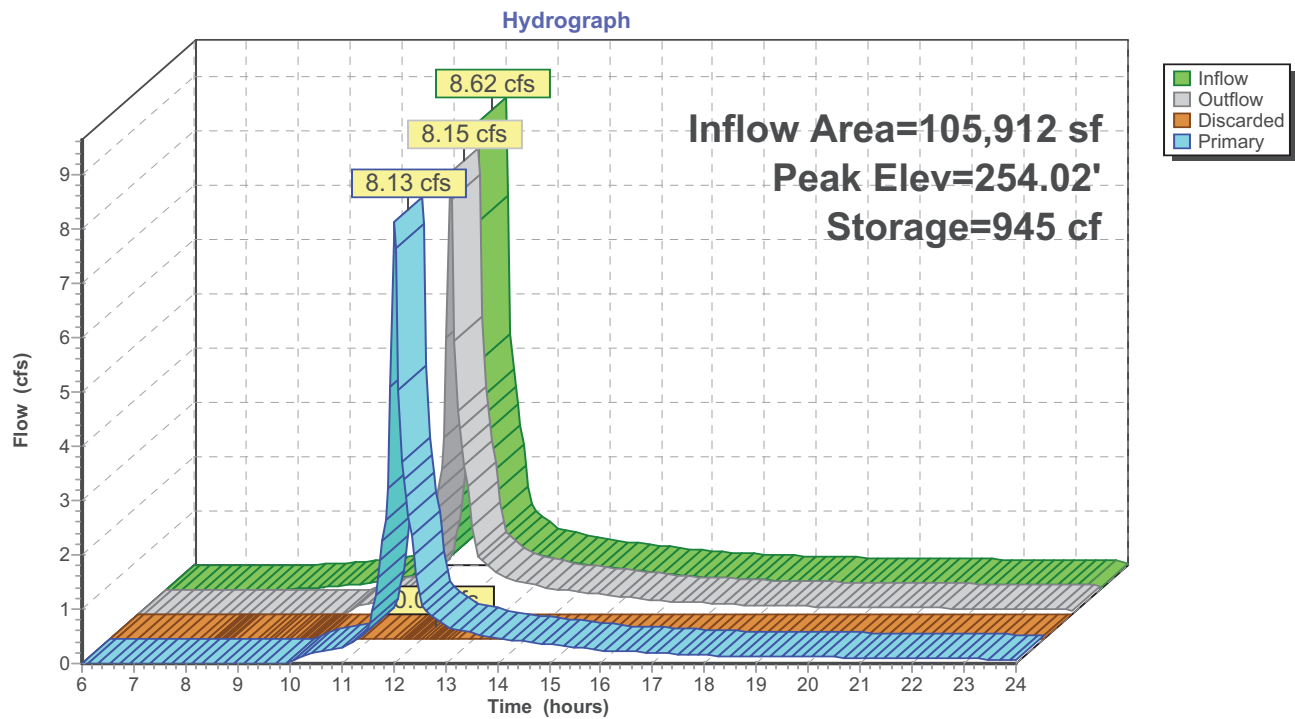
Discarded OutFlow Max=0.02 cfs @ 12.02 hrs HW=254.00' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=7.77 cfs @ 12.02 hrs HW=254.00' (Free Discharge)

↑**2=Sharp-Crested Rectangular Weir** (Weir Controls 7.77 cfs @ 2.61 fps)

Pond 106P: Dry WQ Swale



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Type III 24-hr 25-yr Rainfall=5.50"

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Page 7

Summary for Pond 106P: Dry WQ Swale

Inflow Area = 105,912 sf, 49.95% Impervious, Inflow Depth > 3.24" for 25-yr event
 Inflow = 10.59 cfs @ 12.00 hrs, Volume= 28,567 cf
 Outflow = 10.04 cfs @ 12.02 hrs, Volume= 28,182 cf, Atten= 5%, Lag= 1.0 min
 Discarded = 0.02 cfs @ 12.02 hrs, Volume= 661 cf
 Primary = 10.03 cfs @ 12.02 hrs, Volume= 27,521 cf

Routing by Stor-Ind method, Time Span= 6.00-24.00 hrs, dt= 0.05 hrs
 Peak Elev= 254.09' @ 12.02 hrs Surf.Area= 1,402 sf Storage= 1,044 cf

Plug-Flow detention time= 13.5 min calculated for 28,182 cf (99% of inflow)
 Center-of-Mass det. time= 5.4 min (820.2 - 814.8)

Volume	Invert	Avail.Storage	Storage Description
#1	253.00'	1,695 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
253.00	570	403.0	0	0	570
254.50	1,806	421.0	1,695	1,695	1,902

Device	Routing	Invert	Outlet Devices
#1	Discarded	253.00'	0.520 in/hr Exfiltration over Surface area
#2	Primary	253.50'	6.0' long x 1.00' rise Sharp-Crested Rectangular Weir 2 End Contraction(s) 0.5' Crest Height

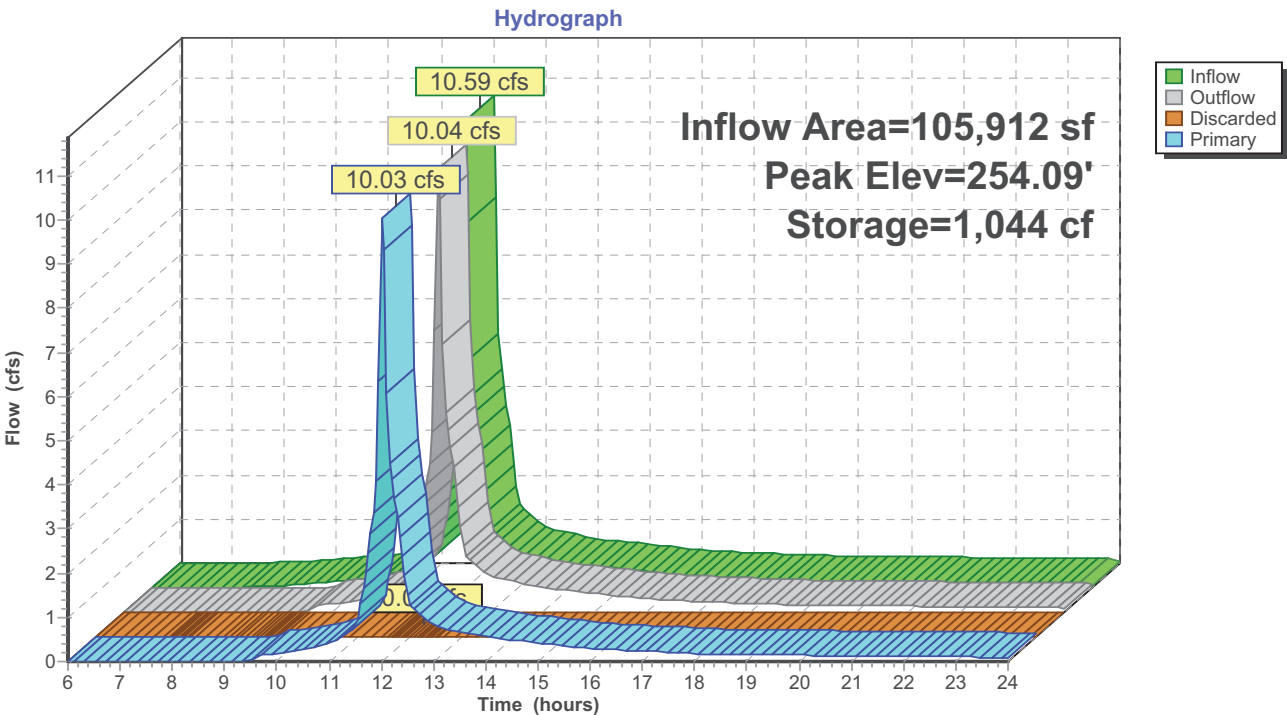
Discarded OutFlow Max=0.02 cfs @ 12.02 hrs HW=254.08' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=9.58 cfs @ 12.02 hrs HW=254.08' (Free Discharge)

↑**2=Sharp-Crested Rectangular Weir** (Weir Controls 9.58 cfs @ 2.83 fps)

Pond 106P: Dry WQ Swale



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Type III 24-hr 100-yr Rainfall=6.80"

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Page 9

Summary for Pond 106P: Dry WQ Swale

Inflow Area = 105,912 sf, 49.95% Impervious, Inflow Depth > 4.40" for 100-yr event
 Inflow = 14.32 cfs @ 12.00 hrs, Volume= 38,850 cf
 Outflow = 13.62 cfs @ 12.02 hrs, Volume= 38,462 cf, Atten= 5%, Lag= 0.9 min
 Discarded = 0.02 cfs @ 12.02 hrs, Volume= 705 cf
 Primary = 13.61 cfs @ 12.02 hrs, Volume= 37,756 cf

Routing by Stor-Ind method, Time Span= 6.00-24.00 hrs, dt= 0.05 hrs
 Peak Elev= 254.22' @ 12.02 hrs Surf.Area= 1,519 sf Storage= 1,224 cf

Plug-Flow detention time= 10.8 min calculated for 38,462 cf (99% of inflow)
 Center-of-Mass det. time= 4.7 min (810.7 - 806.0)

Volume	Invert	Avail.Storage	Storage Description
#1	253.00'	1,695 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
253.00	570	403.0	0	0	570
254.50	1,806	421.0	1,695	1,695	1,902

Device	Routing	Invert	Outlet Devices
#1	Discarded	253.00'	0.520 in/hr Exfiltration over Surface area
#2	Primary	253.50'	6.0' long x 1.00' rise Sharp-Crested Rectangular Weir 2 End Contraction(s) 0.5' Crest Height

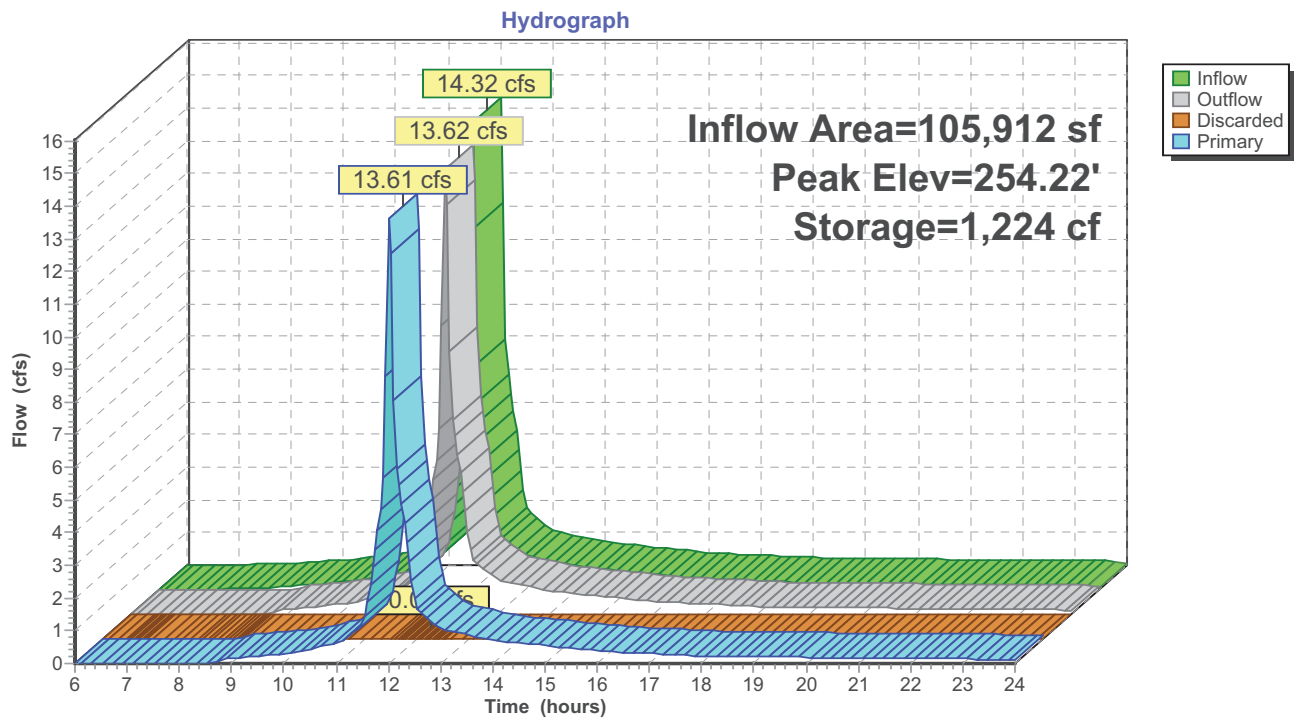
Discarded OutFlow Max=0.02 cfs @ 12.02 hrs HW=254.20' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=13.01 cfs @ 12.02 hrs HW=254.20' (Free Discharge)

↑**2=Sharp-Crested Rectangular Weir** (Weir Controls 13.01 cfs @ 3.19 fps)

Pond 106P: Dry WQ Swale





Appendix B: Master Budget Sheet: Watershed-Based Plan for Lake Massapoag 2026-2050

5/11/26

DRAFT APPENDIX B

Watershed-Based Plan 2026-2030 Draft Master Budget Worksheet

Lake Massapoag Advisory Committee

Date:

5/11/2026

TABLE 1 Stormwater Projects

DPW

DRAFT WATERSHED BASED PLAN			Annual Cost Estimates 2026-2030						Five-Year Totals 2026-2050					25 Yr Total
BUDGETS Annual/ 5-year			2026	2027	2028	2029	2030	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2026-2050	
Stormwater Projects			Inflation:	10%	10%	10%	10%							
VMB West	Excavation		\$ 142,037	\$ 156,241				\$ 156,241					\$ 156,241	
Project 1	24" Stone Storage Bed Subba		\$ 99,426	\$ 109,369				\$ 109,369					\$ 109,369	
(not yet	Porous Asphalt/Striping		\$ 153,139	\$ 168,453				\$ 168,453					\$ 168,453	
updated)	Guardrails, Fencing		\$ 22,860	\$ 25,146				\$ 25,146					\$ 25,146	
	Swales, Basins, etc. (60%)		\$ 44,100	\$ 48,510				\$ 48,510					\$ 48,510	
	Shoreline Assets (60%)		\$ 45,000	\$ 49,500				\$ 49,500					\$ 49,500	
	Interpretive Signage (60%)		\$ 15,000	\$ 16,500				\$ 16,500					\$ 16,500	
	Contingency		\$ 67,200	\$ 73,920				\$ 73,920					\$ 73,920	
	Total		\$ 588,762	\$ 647,638				\$ 647,638					\$ 647,638	
	Maintenance		Inflation:	10%	10%	10%	10%							
VMB East	Excavation		\$ 55,556	\$ 61,112				\$ 61,112					\$ 61,112	
Project 2	24" Stone Storage Bed Subba		\$ 38,889	\$ 42,778				\$ 42,778					\$ 42,778	
(not yet	Porous Asphalt/Striping		\$ 62,333	\$ 68,566				\$ 68,566					\$ 68,566	
updated)	Guardrails, Fencing		\$ 22,860	\$ 25,146				\$ 25,146					\$ 25,146	
	Swales etc. (40%)		\$ 29,400	\$ 32,340				\$ 32,340					\$ 32,340	
	Shoreline Assets (40%)		\$ 30,000	\$ 33,000				\$ 33,000					\$ 33,000	
	Interpretive Signage (40%)		\$ 10,000	\$ 11,000				\$ 11,000					\$ 11,000	
	Contingency		\$ 44,800	\$ 49,280				\$ 49,280					\$ 49,280	
	Total		\$ 293,838	\$ 323,222				\$ 323,222					\$ 323,222	
	Maintenance		TBA	TBA	TBA	TBA	TBA							
Total VMB			\$ 882,600	\$ 970,860	\$ -			\$ 970,860					\$ 970,860	
Lake Ave/Beach	Swale		\$ 50,000	\$ 55,000	\$ 60,500			\$ 60,500					\$ 60,500	
Project 3	Other					TBA	TBA						\$ -	
	Maintenance												\$ -	
Interim:	Silt Socks					TBA	TBA						\$ -	
Total			\$ 50,000	\$ 55,000	\$ 60,500			\$ 60,500					\$ 60,500	
Capen Hill Rd	Planning and Design		Estimate	Estimate				Estimate					\$ -	
Project 4	Drainage				TBA	TBA	TBA						\$ -	
	Infiltration				TBA	TBA	TBA	Estimate					\$ -	
	Total				TBA	TBA	TBA						\$ -	
	Maintenance				TBA	TBA	TBA						\$ -	
Interim:	Silt Socks		TBA	TBA	TBA	TBA	TBA						\$ -	
Total													TBA	
Massapoag Ave	Planning and Design		Estimate	Estimate				Estimate					\$ -	
Project 5	CC Berm (or siltsocks)		\$ 52,800	\$ 52,800	TBA	TBA	TBA	\$ 52,800					\$ 52,800	
	Drainage				TBA	TBA	TBA						\$ -	
	Shoreline				TBA	TBA	TBA						\$ -	
	1 Curb (189 Massapoag Ave)	TBA	TBA	TBA	TBA	TBA	TBA						TBA	
	Total				TBA	TBA	TBA						\$ -	
	Maintenance				TBA	TBA	TBA						\$ -	
Interim:	Silt Socks (or berm)		\$ 31,680	\$ 31,680	TBA	TBA	TBA	\$ 31,680					\$ 31,680	
Total														
Total Stormwater				\$ 1,023,660	\$ 60,500			\$ 1,084,160					\$ 1,084,160	
Safe Beach Access	Ped Crossing Gunhouse		Estimate	TBA				TBA					TBA	

TABLE 2 Nutrient Inactivation				LMAC										
DRAFT WATERSHED BASED PLAN				Annual Cost Estimates 2026-2030					Five-Year Totals 2026-2050					25 Yr Total
BUDGETS Annual/ 5-year				2026	2027	2028	2029	2030	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2026-2050
Nutrient Inactivation				2025 =	\$ 545,650									(if last 5 yrs:)
Alum (expected)	Dose #2 & 3	If lasts 5 yrs						\$ 632,558	\$ 632,558	\$ 733,767				\$ 1,366,325
Future internal loading or low dose treatment based on progress											TBA	TBA	TBA	TBA
OR														
Oxygen Saturation Tech		(OST)	After treatment 1, 2 or 3											
	OST Study						study		\$ -					\$ -
	Equipment							buy or lease	\$ -					\$ -
	Installation							install	\$ -					\$ -
	Electricity							operate	operate	operate	operate	operate	operate	\$ -
	Maintenance							maintain	maintain	maintain	maintain	maintain	maintain	\$ -
	Total OST								\$ -					\$ -

Alum costs estimated at 3% per year (compounded 16% for 5 years), includes alum \$450K, core sampling dosing study (\$20,650) + permitting and monitoring (\$75K). Two scenarios: last 5 yrs, last 10 yrs.

TABLE 3 Weed Management			LMAC										
DRAFT WATERSHED BASED PLAN			Annual Cost Estimates 2026-2030					Five-Year Totals 2026-2050					25 Yr Total
BUDGETS Annual/ 5-year			2026	2027	2028	2029	2030	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2026-2050
Weed Management													
South Cove	DASH*	Days	15	15	15	15	15	75	75	75	75	75	375
(Everwood Match	\$2,500	Cost	\$37,500	\$37,500	\$37,500	\$37,500	\$37,500	\$ 187,500	\$ 187,500	\$ 187,500	\$ 187,500	\$ 187,500	\$ 937,500
Fletchers	DASH*	Days	20	15	10	10	10	65	50	50	50	50	265
LMAC	\$2,500	Cost	\$50,000	\$37,500	\$25,000	\$25,000	\$25,000	162500	\$125,000	\$125,000	\$125,000	\$125,000	\$ 662,500
Lagoon	Hand Pull	Days			5			5	5	5	5	5	25
	\$1,250	Every 5 years			\$ 6,250			\$ 6,250	\$ 6,250	\$ 6,250	\$ 6,250	\$ 6,250	\$ 31,250
VMB Area	Rake	Every 3 years	\$ 1,250			\$ 1,250		\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 12,500
Spot Other Areas	DASH	Every year	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 12,500	\$ 12,500	\$ 12,500	\$ 12,500	\$ 12,500	\$ 62,500
Total LMAC Weed Mitigation (not SC)			\$ 53,750	\$ 40,000	\$ 33,750	\$ 28,750	\$ 27,500	\$ 183,750	\$ 146,250	\$ 146,250	\$ 146,250	\$ 146,250	\$ 768,750
Weed Mapping	LMAC	Biannual	\$ 3,100		\$ 3,289		\$ 3,489	\$ 9,878	\$ 7,629	\$ 9,879	\$ 10,265	\$ 11,460	\$ 49,110
Total LMAC Weed Mitigation and Mapping			\$ 56,850	\$ 40,000	\$ 37,039	\$ 28,750	\$ 30,989	\$ 193,628	\$ 153,879	\$ 156,129	\$ 156,515	\$ 157,710	\$ 817,860
Everwood Match (South Cove)			\$37,500	\$37,500	\$37,500	\$37,500	\$37,500	\$ 187,500	\$187,500	\$187,500	\$187,500	\$ 187,500	\$ 937,500

Aquatic barrier and weed mapping cost figures estimated at 3%/year (compounded at 16% for 5 years); assumes no increase in DASH rates but expect some increases.

Will be some NHESP permitting costs to renew permit and some occasional costs to meet requirements of mapping and monitoring endangered species.

* It is hoped the amount of DASH required will not just stabilize but be reduced with consistent effort, these projections assume stabilized after catchup in Fletchers Cove, stabilized in South Cove.

TABLE 4 CCB E. coli Mitigation			LMAC										
DRAFT WATERSHED BASED PLAN			Annual Cost Estimates 2026-2030					Five-Year Totals 2026-2050					25 Yr Total
BUDGETS Annual/ 5-year			2026	2027	2028	2029	2030	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2026-2050
E. coli Mitigation CCB		PCR testing											
Aeration/Oxygenation													
	Feasibility Study							\$ -					\$ -
	Equipment							\$ -					\$ -
	Installation							\$ -					\$ -
	Electricity							\$ -					\$ -
	Maintenance							\$ -					\$ -
	Total Aer/Oxygenation							\$ -					\$ -
Bathroom Facilities (?)								\$ -					\$ -

TABLE 5 Lagoon Phosphorus Mitigation Project			LMAC										
DRAFT WATERSHED BASED PLAN			Annual Cost Estimates 2026-2030					Five-Year Totals 2026-2050					25 Yr Total
BUDGETS Annual/ 5-year			2026	2027	2028	2029	2030	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2026-2050
Lagoon	Aq Barrier	Every 5 years				\$ 13,122		\$ 13,122	\$ 15,221	\$ 17,657	\$ 20,482	\$ 23,759	\$ 90,241
	Cleaning*	Yearly	\$ 1,500	\$ 1,500	\$ 1,500	\$ 1,500	\$ 1,500	\$ 7,500	\$ 7,500	\$ 7,500	\$ 7,500	\$ 7,500	\$ 37,500
Feasibility Study/Permit/Pilot:			TBA	TBA					TBA				
Muck Removal Tx (not yet NHESP approved)									TBA				
Barley Hay Bales pilot**									TBA				
EutroSorb, Phoslock, etc									TBA				

*Not capital, but needed maintenance. The Aquatic Barrier also reduces weed transit from lagoon to South Cove. **Some efficacy in Western MA, experimental.

TABLE 6 E. coli Mitigation Sucker Brook LMAC

DRAFT WATERSHED BASED PLAN		Annual Cost Estimates 2026-2030					Five-Year Totals 2026-2050					25 Yr Total
BUDGETS Annual/ 5-year		2026	2027	2028	2029	2030	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2026-2050
E. coli Mitigation SB	PCR testing							TBA				
Feasibility Study:								TBA				
Aeration/Oxygenation								TBA				
Pilot Melaleuca (antibacterial)*								TBA				
(replace Japanese Knotweed)								TBA				

* Some efficacy in Australia, test if survive winter, experimental

TABLE 7 Geese Control Collaborative: Rec, LMAC, Stakeholders (Schools, Farm, Golf Courses, Camps, etc) Note potential savings on Rec Deterrence, Cleaning

DRAFT WATERSHED BASED PLAN		Annual Cost Estimates 2026-2030					Five-Year Totals 2026-2050					25 Yr Total
BUDGETS Annual/ 5-year		2026	2027	2028	2029	2030	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2026-2050
Geese Control												
Reduction	Egg Addling	\$ 1,200										
Deter/Harrass	Border Collie Service	\$ 4,000										
Staff Options	Beach Staff deterrence	TBA										
	Off-Season deterrence	TBA										
Savings from	Lower Clean/Maintenance	TBA										
Option	Goosinator	\$ 6,000										
Option	Swan Pedal Boat	\$ 5,000										
2 Ind Unit+Cages	Away with Geese Lights*	\$ 2,000										
Depredation	Site Visit, Plan	TBA										
	USDA Contract	TBA	seek cost sharing									

* Industrial Unit \$434, Industrial Cage \$449, Dock Unit \$429, Water Unit \$439

TABLE 8 Septic Phosphorus Mitigation Project LMAC (create a new Wastewater Advisory Committee), DPW, Sharon Schools

DRAFT WATERSHED BASED PLAN		Annual Cost Estimates 2026-2030					Five-Year Totals 2026-2050					25 Yr Total
BUDGETS Annual/ 5-year		2026	2027	2028	2029	2030	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2026-2050
Restore Wastewater Well Testing		TBA	TBA									
Feasibility Study/Permit/Pilot:		TBA	TBA					TBA				
Eco-Flush Toilets								TBA				
Secondary Treatment SHS								TBA				
Update Local Septic Regs								TBA				
Create Wastewater Improvement District												

TABLE 9 Acquire Lakefront Property/Upgrade Syste Select Board

DRAFT WATERSHED BASED PLAN		Annual Cost Estimates 2026-2030					Five-Year Totals 2026-2050					25 Yr Total
BUDGETS Annual/ 5-year		2026	2027	2028	2029	2030	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2026-2050
174 Lakeview St. (Gannett property)*												
	Acquisition	Estimate	TBA	TBA			TBA					\$ -
	Upgrade wastewater	Estimate	TBA	TBA			TBA					\$ -
Caretaker Cottag	Upgrade wastewater	Estimate	TBA	TBA			TBA					\$ -

*Elizabeth Peabody House leases to Everwood which would be a stakeholder partner in this process. Explore funding via sale of parcel next to Town Hall and if acquisition/upgrade gives access to state grants.

TABLE 10 Flume House and Channel Conservation

DRAFT WATERSHED BASED PLAN		Annual Cost Estimates 2026-2030					Five-Year Totals 2026-2050					25 Yr Total
BUDGETS Annual/ 5-year		2026	2027	2028	2029	2030	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2026-2050
Asessess Repairs and Restoration			TBA	TBA			TBA or	TBA				
Seek CPC and/or Historic Preservation Funding				TBA	TBA	TBA	TBA or	TBA				
Assess, Clear Entry/Channel as Needed												

TABLE 11 Salt Brine Spray Equipment DPW: In DPW Capital Budget, included in LMAC recommendations in WBP

DRAFT WATERSHED BASED PLAN		Annual Cost Estimates 2026-2030					Five-Year Totals 2026-2050					25 Yr Total
BUDGETS Annual/ 5-year		2026	2027	2028	2029	2030	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2026-2050
Truck			TBA	TBA								
Operating Costs			TBA	TBA								

TABLE 12 Lake Massapoag Interpretive Walk Collaborative: Planning, Rec, Conservation, Historical, LMAC, NPOs, Scouts, etc.

DRAFT WATERSHED BASED PLAN		Annual Cost Estimates 2026-2030					Five-Year Totals 2026-2050					25 Yr Total
BUDGETS Annual/ 5-year		2026	2027	2028	2029	2030	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2026-2050
Planning Phase	(MVP Planning Grant 2.0)		\$ 50,000									
Implementation	(MVP Planning Grant 2.0)			\$ 50,000								

Appendix C:

**LAKE MASSAPOAG
CATCHMENT
DELINEATION UPDATE
& POLLUTANT LOADING
ESTIMATE**

Anna Yie

Summary: Catchment Delineation and Pollutant Loading Estimate

The goal of this project is to protect Lake Massapoag by preventing the entry of pollutants, especially phosphorus, from upstream sources using green stormwater infrastructure (GSI), also known as stormwater control measures (SCMs) or best management practices (BMPs). Excess phosphorus can lead to excessive growth of algae which leads to low dissolved oxygen levels, potential for algal toxins, and other degraded conditions for aquatic life. In order to site SCMs for maximum efficiency, it is important to identify where the water is entering Lake Massapoag and what levels of phosphorus are coming from those water sources. This involves two main steps: a catchment delineation and nutrient (phosphorus) pollutant loading estimate.

Catchment Delineation

The goal of a catchment or watershed delineation is to identify all the upland areas that contribute runoff to Lake Massapoag and are currently contributing to the nutrient pollution load of the Lake¹. The watershed for Lake Massapoag is all the land surrounding the lake where precipitation from snow and rain eventually ends up flowing into the lake. A catchment is an area where water collects in the landscape. Watersheds and catchments are delineated using relevant geographic data:

- DEM (Digital Elevation Model)²: a detailed elevation (topographic) map of the area
- Storm drains and pipes: the location of stormwater infrastructure that captures water falling into storm drains that connect to Lake Massapoag
- Pour point: the point at which water exits the watershed. For Lake Massapoag, this is where Lake Massapoag flows out into Massapoag Brook

Pollutant Loading Estimate for Phosphorus

The total estimated load for Lake Massapoag is **875 pounds of phosphorus per year** from the surrounding area. This estimate is based on the Massachusetts MS4 General Permit methodology to calculate baseline watershed phosphorus loads. An annual phosphorus load is calculated for each subcatchment delineated above based on land cover, land use, and hydrologic soil group (HSG). These are summed across the watershed to give an estimate of the total phosphorus contribution from the area surrounding the lake.

¹ USGS Watersheds Overview: <https://www.usgs.gov/special-topics/water-science-school/science/watersheds-and-drainage-basins>

² MassGIS Digital Elevation Model (DEM): <https://www.mass.gov/info-details/massgis-data-lidar-dem-and-shaded-relief>

Catchment Delineation

Overview

The catchment delineation was done following the protocol written by the Neponset River Watershed Association (NepRWA) and the Metropolitan Area Planning Council (MAPC).³ The results of this catchment delineation were compared to the initial delineation that was completed in 2017 and provided by the town of Sharon.

Study Area

The catchment delineation was performed for the area around Lake Massapoag. The goal was to examine all the upland areas that contribute runoff to Lake Massapoag and are currently contributing to the nutrient pollution load of the Lake.

An initial study area was approximated using the United States Geological Survey (USGS) Streamstats Tool to approximate the watershed for the lake.⁴ The point used to generate the polygon was the exit point of the lake, located at the northeast corner near the rotary/intersection of Pond St, Quincy St, East St, and Massapoag Ave where outflow from Lake Massapoag is released into Massapoag Brook.

StreamStats Report

Region ID: MA
Workspace ID: MA20231205215128324000
Clicked Point (Latitude, Longitude): 42.11072, -71.17576
Time: 2023-12-05 16:51:48 -0500

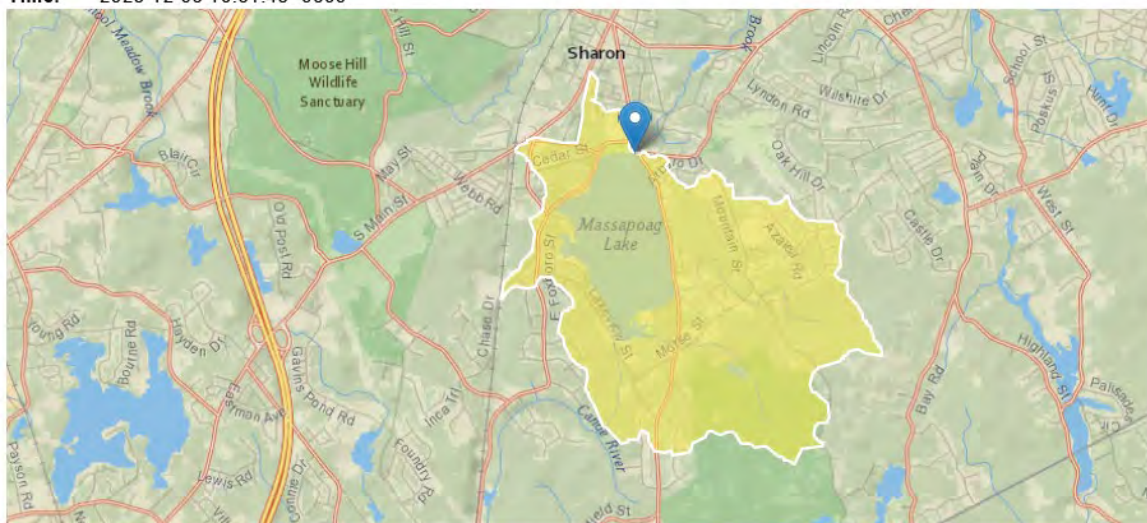


Figure 1. Excerpt from automatically generated USGS StreamStats Report showing Lake Massapoag Watershed

³ MAPC. "Outfall Catchment Mapping and Ranking." 2017. https://yourcleanwater.org/wp-content/uploads/2018/02/MAPC_Stormwater_Catchment-2018.pdf

⁴ USGS. Streamstats Exploration Tool. <https://streamstats.usgs.gov/ss/>

To make sure that all relevant upland areas were included, an additional 500 meter buffer was added around the USGS estimated watershed to define the study area. This was compared to the 2017 catchments provided by the town. The 2017 catchments that fed into Lake Massapoag fit well within the buffered area. The buffer included some areas that do not drain into Lake Massapoag (for instance, areas that drain into Massapoag and Beaver Brook or the Taunton River), these areas were excluded from further analysis.

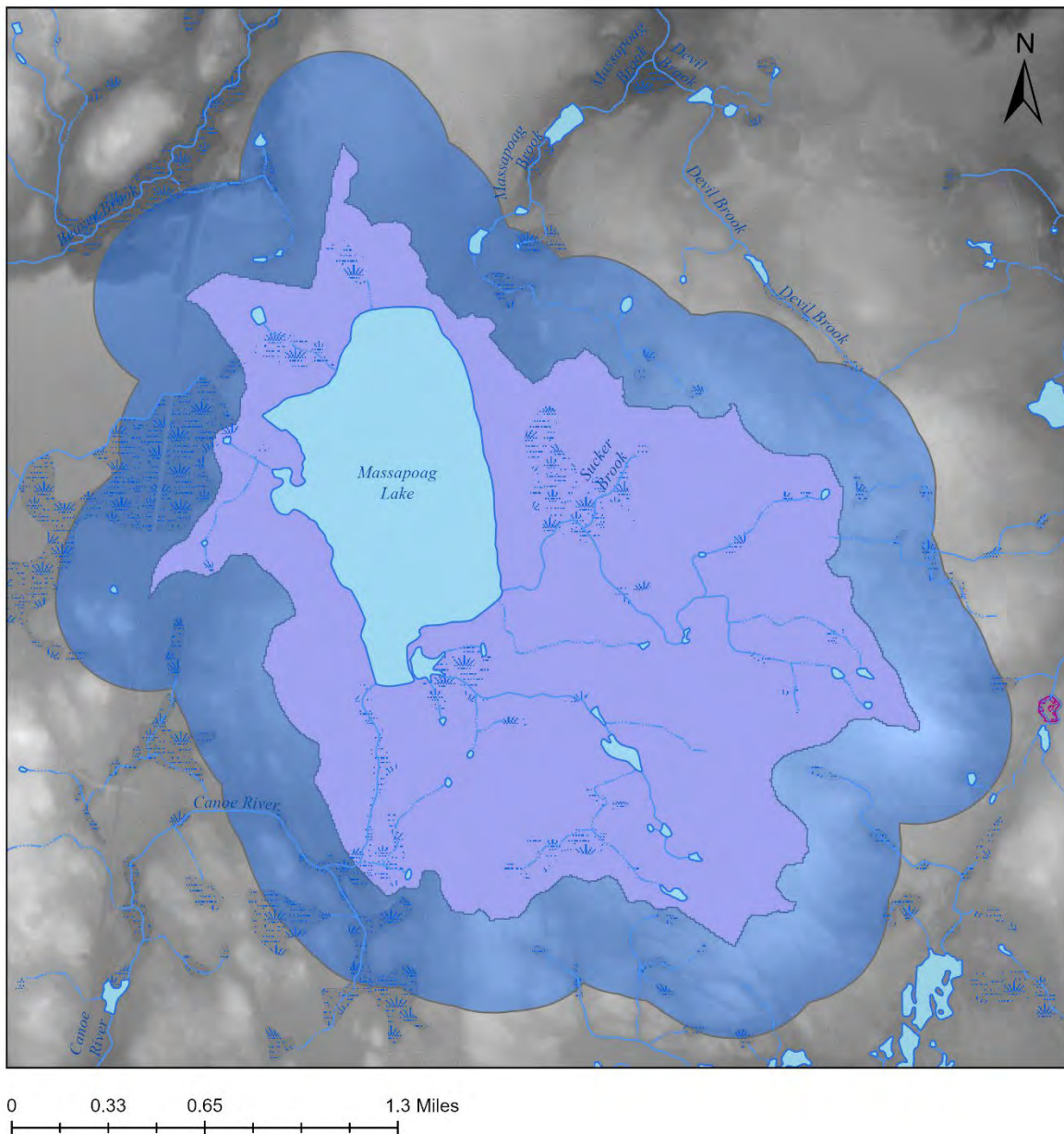


Figure 2. USGS generated watershed extent for Lake Massapoag overlayed by 500m buffer.

Methodology

Input Datasets

Dataset Name (shorthand)	Source	Link (date published/updated)
USGS 1 Meter 19 x31y467 MA_CentralEastern_2021_B21 and USGS 1 Meter 19 x32y467 MA_CentralEastern_2021_B21 (1mDEM)	USGS	https://www.sciencebase.gov/catalog/item/63c78d1bd34e06fef14edd0d (2021)
1:25,000 hydrography (water)	MassGIS	https://www.mass.gov/info-details/massgis-data-massdep-hydrography-125000 (December 2019)
Roads	MassGIS/Mass DOT	https://www.mass.gov/info-details/massgis-data-massgis-massdot-roads (December 2023)
MAPC Massachusetts Land Parcel Database (parcels)	MAPC	https://datacommon.mapc.org/browser/datasets/360 (May 2019)
Catch basins	Town of Sharon	Provided by Town of Sharon (2023)
Stormwater Pipes	Town of Sharon	Provided by Town of Sharon (2023)
Outfalls	Town of Sharon	Provided by Town of Sharon (2023)

The catchment delineation methodology used the MAPC Stormwater Catchment toolkit and performed in ArcMap 10.8 and ArcGIS Pro.⁵ The methodology is grouped into three main steps: pre-processing the DEM, enhancing the DEM, and delineating the catchments. A DEM (Digital Elevation Model) is a detailed elevation (topographic) map of an area.

Pre-processing the DEM

Two tiles from the 1-meter (1m) resolution DEM USGS dataset (see table above) were mosaiced together into a single DEM.

Enhancing the DEM

Following the methodology, the DEM was further enhanced using the water features, gutters, and road crowns. The MAPC methods used a burn value ratio of -1:-1:2, which was preserved

⁵ MAPC Stormwater Catchment Toolkit. <https://github.com/MAPC/stormwater-toolkit>

between the water features, gutters, and road crowns respectively, however the values were multiplied by a factor of 5 to provide visual clarity.

The raster calculator tool was used to modify the pre-processed DEM to create one enhanced DEM as the output for the subcatchment delineation.

Subcatchment Delineation

Subcatchment Delineation was performed in ArcGIS Pro following the workflow process outlined in the original methodology. Settings were left as default unless otherwise specified. An overview of the watershed delineation tools available in ArcGIS Pro can be found online⁶. The outfall for the Lake Massapoag watershed was designated at the northeast corner of the lake, where Lake Massapoag flows out into Massapoag Brook.

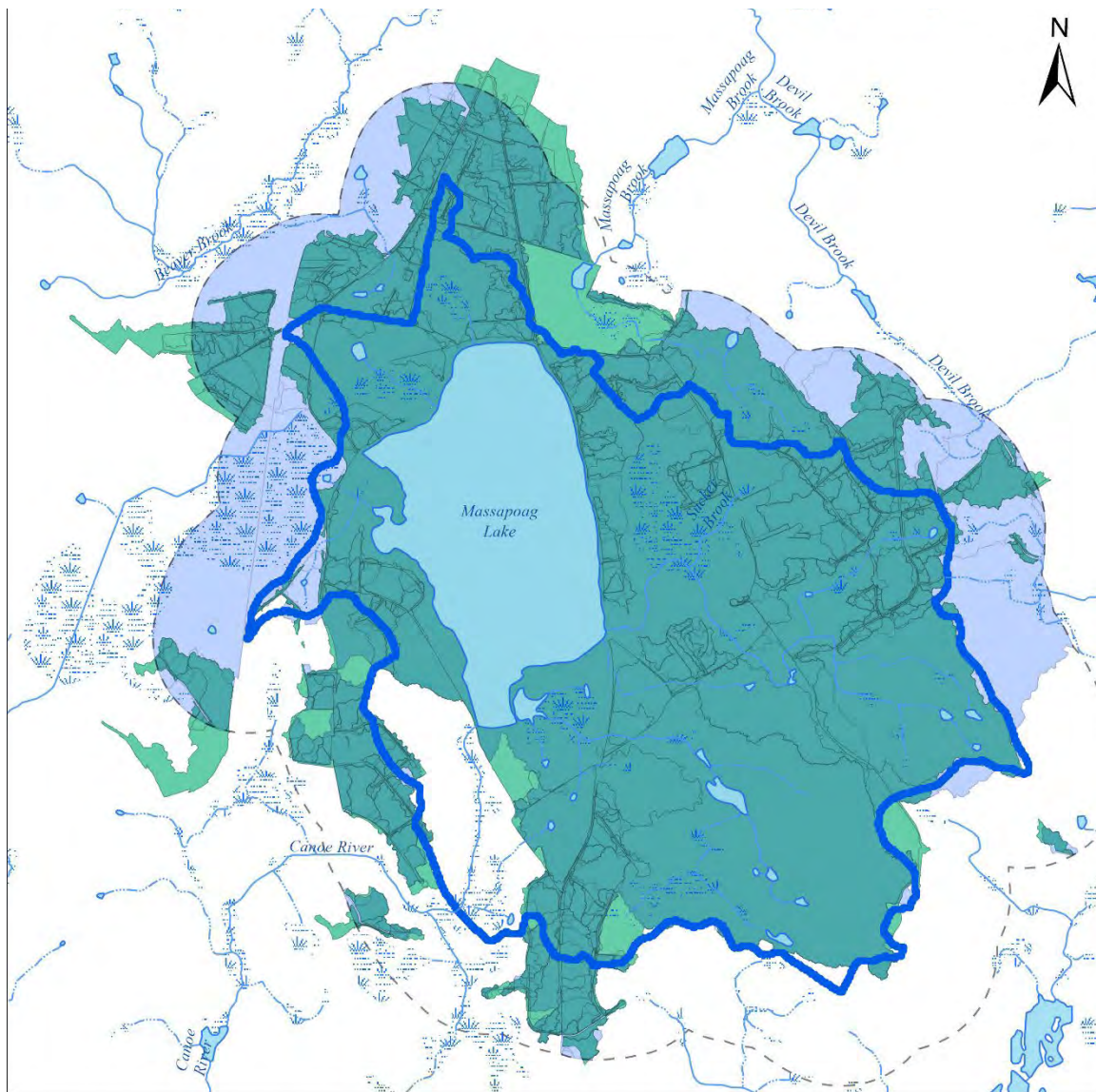
For the subcatchment delineation, the data inputs are listed above (see methodology section). Following the watershed delineation tool, the following geoprocessing steps were performed:

- Fill Sinks
- Flow Direction
- Flow Accumulation
- Snap to Pour Points
- Watershed Delineation

Corresponding visual output for each sub-step of the process (where available) is located in the appendix.

Updated subcatchments were compared to the original 2017 catchment delineation. Marginal differences in subcatchments can be attributed to increased accuracy in the 1m DEM as well as different values used during the analysis process. Areas in light green represent new catchment area for Lake Massapoag from 2017 to 2024. Very few areas that were not already included in the catchment for Lake Massapoag were added between analysis. As stated above, those areas that are known to flow into other nearby waterbodies (Massapoag Brook, Beaver Brook, Canoe River) will not be included in the evaluation for potential sites for green infrastructure.

⁶ ArcGIS Pro Hydrology Toolset concepts: Watershed: <https://pro.arcgis.com/en/pro-app/3.1/tool-reference/spatial-analyst/how-watershed-works.htm>



0 0.13 0.25 0.5 0.75 1 1.25 Miles

- Pond, Lake, Ocean
- Wetland
- USGS Watershed Boundary
- 2024 Catchments
- 2017 Catchments (clipped to buffer)

Figure 3. Comparison of 2017 and 2024 catchments around Lake Massapoog. Light green areas represent newly added catchments in 2024, darker green is area that was included in 2017 and is also included in 2024.

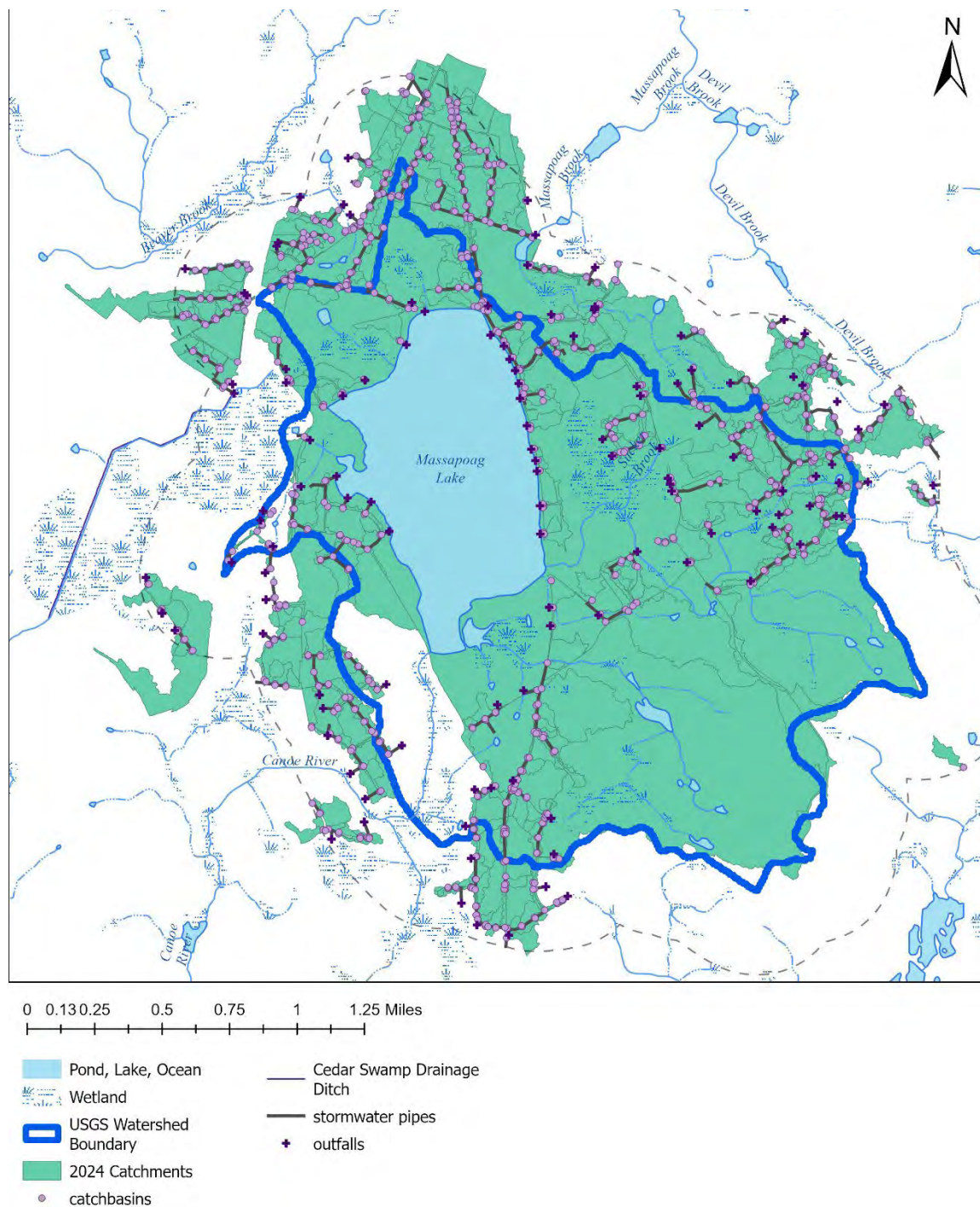


Figure 4. 2024 catchments with nearby stormwater infrastructure (catch basins, pipes, and outfalls).

Aggregating Catchments

Similar to the MAPC protocol, subcatchments were assigned to outfalls. Subcatchments were joined to the catchbasin point layer using a spatial join (match option: closest, search radius: 5 m). The pairwise dissolve tool was then used to dissolve the subcatchments based on the

associate outfall. The resulting layer aggregates many small catchments based on the ultimate outfall point.

Discussion

Site Visit

A site visit was performed on Thursday, May 16. Previous to the site visit, trace amounts of rain had been recorded twice over the past three days along with 1.12" of precipitation occurring on the day of the site visit.⁷ Three sites were visited at Lake Massapoag: Memorial Beach Parking Lot (including the boat launch area), South Cove, and Camp Everwood/Canoe River.

Parking Lot:

The water level appeared high relative to previous visits. There were multiple instances of large puddles and overflowing catchbasins (Beach St). No outfall pipes into the lake were observed near the catchbasins on Beach Street. Water coming in from the outfall underneath the high school parking area seemed contaminated, appeared dark brown but without odor. Information provided by the LMAC stated that tannic acid has been previously observed from this outfall. The outfall also has numerous high phosphorus readings as well as high *E. coli* after rain events⁸. The catchbasins outside high school directly outside parking entrance did not appear overflowed.

South Cove and Lagoon:

South Cove and Lagoon flow patterns followed predicted catchments. Water was observed flowing into the south cove from adjacent wetland area near the community center underneath a pedestrian footbridge, with no nearby visible outfall pipes.

The 2017 catchments, as well as the catchment for the lake delineated by the USGS and Massachusetts Online Watershed Based Plan tool included an area towards the southwest corner of Lake Massapoag currently owned by the Everwood Camp. Previous discussions with town and lake committee staff had suggested that the majority Canoe River does not flow into Lake Massapoag. A very short segment of Canoe River flows into Lake Massapoag. Road signage indicates Canoe River flows to Taunton. Observation that day showed water flowing from Canoe River into Lake Massapoag underneath the street, although the flow was reduced compared to the inflow from the wetland in the South Cove and Lagoon. Speaking with the camp director revealed that Canoe River sometimes flows into Lake Massapoag, depending on the water height in the lake and season. Generally, the flow is minimal. However, given this information and observations, the updated catchments have been amended to include the area previously defined as subcatchment for Lake Massapoag.

⁷ NOAA Climate Data for Boston/Norton, MA. Milton Area, May 2024.

<https://www.weather.gov/wrh/Climate?wfo=box>

⁸ Information from correspondence with LMAC chair Laura Russell.

Pollutant Loading Estimate

Overview

The estimation of pollutant loads was done following the protocol written by the Neponset River Watershed Association (NepRWA) and updated for Pioneer Valley region communities by PVPC.⁹ The estimation was based on the updated catchments created in the previous analysis. The methods used to calculate phosphorus are based on Attachment 1 of Appendix F of the Massachusetts MS4 2016 permit.¹⁰

Study Area

The nutrient loading estimate was performed on the same study area as the catchment delineation.

Methodology

Input Datasets

Dataset Name (shorthand)	Source	Link (date published/updated)
2024 Updated Catchments	NepRWA	Created by NepRWA (2024)
2016 Land Cover/Land Use (LCLU)	MassGIS	https://www.mass.gov/info-details/massgis-data-2016-land-coverland-use (May 2019)
Soil Survey Geographic (SSURGO) Database (HSG)	USDA	https://www.mass.gov/info-details/massgis-data-soils-ssurgo-certified-nrcs (November 2021), downloaded via Mass Mapper

Creation of a Base Shapefile and New Fields

An intersect was performed between the LCLUL and HSG layers (named LakeMass_catchmsegm) to create a base shapefile containing information for land cover, land use, and soil type within the study area (2024 catchments). Each record (segment) in the created shapefile represents areas with specific land cover, land use, and soil types within a catchment. A Phosphorus Loading Category [PLCRSS] was generated for each segment based on land use information. When land use information was not sufficient, land cover information was used.¹¹ Based on [PLCRSS] and cover type (impervious vs pervious), a Phosphorus Load Export Rate [PLER] was assigned for each segment. For areas where HSG was unknown, HSG C

⁹ NepRWA & PVPC, 2021. "Appendix to Nutrient Source Identification Report Methods."

<https://yourcleanwater.org/wp-content/uploads/2021/10/Methods-Appendix-June-30-20201.pdf>

¹⁰ EPA, 2016. "MA MS4 General Permit Appendix F – Requirements for Discharges to Impaired Waters with an Approved TMDL". <https://www3.epa.gov/region1/npdes/stormwater/ma/2016fpd/appendix-f-2016-ma-sms4-gp.pdf>

¹¹ See Table 2A In NepRWA & PVPC 2021 Methods (above)

was assumed for assigning the [PLER] value.¹² The table below shows the crosswalk between land use codes, phosphorus source category by land use, and associated [PLER] values:

Assigning Phosphorus Loading Category [PLCRSS] and associate [PLER] value			
[USEGENCODE] Value (land use code)	Phosphorus Source Category by Land Use	P Load Export Rate, lbs/acre/yr	
		<i>Impervious</i>	<i>Pervious</i>
15, 29, 31 5, 16, 19, 39	Commercial and Industrial (Commlnd)	1.78	<i>See HSG table below</i>
10, 11	Multi-family and High Density Residential (HDR)	2.32	<i>See HSG table below</i>
12	Medium-Density Residential (MDR)	1.96	<i>See HSG table below</i>
13, 38	Low Density Residential (LDR)	1.52	<i>See HSG table below</i>
18	Highway (HWY)	1.34	<i>See HSG table below</i>
3, 4, 35, 37, 40	Forest (For)	1.52	0.13
6, 7, 8, 9, 17, 24, 25, 34	Open Land (Open)	1.52	<i>See HSG table below</i>
1, 2, 23, 26, 36	Agriculture (Ag)	1.52	0.45

PLER Rate by Soil Type	
HSG Group	P Load Export Rate (lb/acre/yr)
HSG A and A/D	0.03
HSG B and B/D	0.12
HSG C	0.21
HSG C/D	0.29
HSG D	0.37

Directly Connected Impervious Area (DCIA) is only present where impervious area exists. DCIA estimates were based on the Sutherland equations within the EPA guidance document.¹³ [DCIA_M] and [DCIA_E] values were assigned based on Table 4 in the NepRWA Methodology.

¹² EPA. 2016. "MA MS4 General Permit Appendix F – Requirements for Discharges to Impaired Waters with an Approved TMDL". <https://www3.epa.gov/region1/npdes/stormwater/ma/2016fpd/appendix-f-2016-ma-sms4-gp.pdf>

¹³ EPA, 2014. "Estimating Change in Impervious Area (IA) and Directly Connected Impervious Areas (DCIA) for Massachusetts Small MS4 Permit" <https://www3.epa.gov/region1/npdes/stormwater/ma/MADCIa.pdf>

The following fields were added:

LakeMass_catchmsegm Added Fields			
New Field	Description	Derived From	Units
CatchAreaAc	The area in acres of each catchment	Calculate geometry from the 2024 Updated Catchments shapefile	acres
Seg_Acre	Area of each record	Calculate geometry	acres
Imp_Acre	Area of each record with impervious cover	Calculate geometry (only records with “Impervious” entry for cover name. All non-impervious records will have a “0” for this field)	acres
PLCRSS	The phosphorus loading category assigned from land type.	Table 1-2 in Attachment 1 of Appendix F of the 2016 MS4 General Permit	n/a
PLER	the numerical phosphorus loading rate assigned to a record based on land type.	Table 1-2 in Attachment 1 of Appendix F of the 2016 MS4 General Permit	n/a
DCIA_M	Multiplier from the applicable Sutherland equation to estimate directly connected impervious area for a record. Note that entry is <null> for all non-impervious records.	Table 1-2 in Attachment 1 of Appendix F of the 2016 MS4 General Permit	n/a
DCIA_E	the exponent from the applicable Sutherland equation to estimate directly connected impervious area for a record. Note that entry is <null> for all non-impervious records.	Table 1-2 in Attachment 1 of Appendix F of the 2016 MS4 General Permit	n/a
P_Load_lbyr	Estimated phosphorus for each segment	Field Calculator: [Seg_Acre]*[PLER]	lbs/year

Impa_Pct	The percent of impervious area in a record	Field Calculator: ([Imp_Acre]/[CatchAreaAc])*100	Percent
Catch_pct	The percentage of the total catchment represented by a record	Field Calculator: ([Seg_Acre]/[CatchAreaAc])*100	percent
DCIA_pct	An estimate of directly connected impervious area as a percentage of the total catchment area	Field Calculator: ([Imp_Pct^[DCIA_E])*[DCIA_M]	percent
DCIA_acre	An estimate of the amount of directly connected impervious area associated with a record	Field calculator: ([DCIA_pct]/100)*[CatchAreaAc]	acres

Final Shapefile Creation

A pairwise dissolve was performed based on the original catchments ID, and fields were generated using the SUM function. The output was a shapefile where each record represents one catchment where the information (impervious area, phosphorus load, DCIA area, etc.) were added together from each segment within the catchment's boundaries. The following fields were added:

LakeMass_catchments Added Fields			
New Field	Description	Derived From	Units
SUM_Seg_Acre	Sum of area of each record within a catchment, equal to the area of the catchment	SUM (Seg_Acre), value was checked by calculating the geometry of each catchment using the calculate geometry feature (in acres)	acres
SUM_Impa_Acre	Sum of impervious area of each record within a catchment	<i>Created in pairwise dissolve</i>	acres
SUM_P_Load_lbyr	Total phosphorus load for each catchment	<i>Created in pairwise dissolve</i>	Lb/yr

SUM_DCIA_acre	Sum of DCIA area of each record within a catchment	<i>Created in pairwise dissolve</i>	acres
Pctimp	Percentage of catchment that is impervious	Field Calculator: [Sum_Impa_Acre]/[SUM_Seg_Acre]*100	Percent
Pctdcia	Percentage of catchment that is DCIA	Field Calculator: [Sum_DCIA_Acre]/[SUM_Seg_Acre]*100	percent
Pload_norm	Phosphorus load for each catchment relative to the total size of the catchment	Field Calculator: [SUM_P_Load_lbyr]/[SUM_Seg_Acre]	Lb/yr/acre
Pload_contrpct	Phosphorus load contribution of the catchment relative to total p load of lake	Field Calculator: ([SUM_P_Load_lbyr]/934.97)*100]	percent

Results & Discussion

The total estimated phosphorus load for Lake Massapoag is estimated at 875 lbs/year (397 kg). This value was derived from summing the phosphorus load for each catchment in the lake's watershed. For comparison, see table below for lakes in Massachusetts estimated phosphorus loads. Note that these lakes all have phosphorus TMDL requirements, and therefore are likely to be higher in phosphorus than Lake Massapoag, which does not have a lake-specific phosphorus TMDL, nor does the Neponset River watershed currently have a watershed-wide phosphorus TMDL.

Lake, Basin	Lake Size (acre)	Watershed (acre)	Estimated Phosphorus Load (lb/year)	Source
Lake Massapoag, Neponset River Watershed	392	2,817	875	
Lake Quinsigamond, Blackstone River Watershed	475	13,344	3,792	https://www.mass.gov/doc/final-tmdls-of-phosphorus-for-lake-quinsigamond-and-flint-pond/download

Lake Boon, SuasCo River Watershed	163	1,690	807	https://www.mass.gov/doc/final-tmdls-of-phosphorus-for-lake-boon-boons-pond-0/download
Indian Lake, Blackstone River Basin	193	1,964	1,155	https://www.mass.gov/doc/final-tmdls-of-phosphorus-for-indian-lake/download
White Island Pond, Buzzards Bay Watershed	291	1,428	1,188	https://www.mass.gov/doc/final-tmdl-of-total-phosphorus-for-white-island-pond/download

Figures 5-7 (below) show phosphorus load per catchment: total (flat), relative to catchment size, and as a contributor to the total phosphorus load of Lake Massapoag. Because of the large range of size difference between catchments, the larger catchments contribute a significant portion of the total phosphorus load due to their area but have small contributing loads per acre. This is mostly likely due to land use and cover type. Figure 8 shows the top 50 catchments by annual phosphorus contribution.

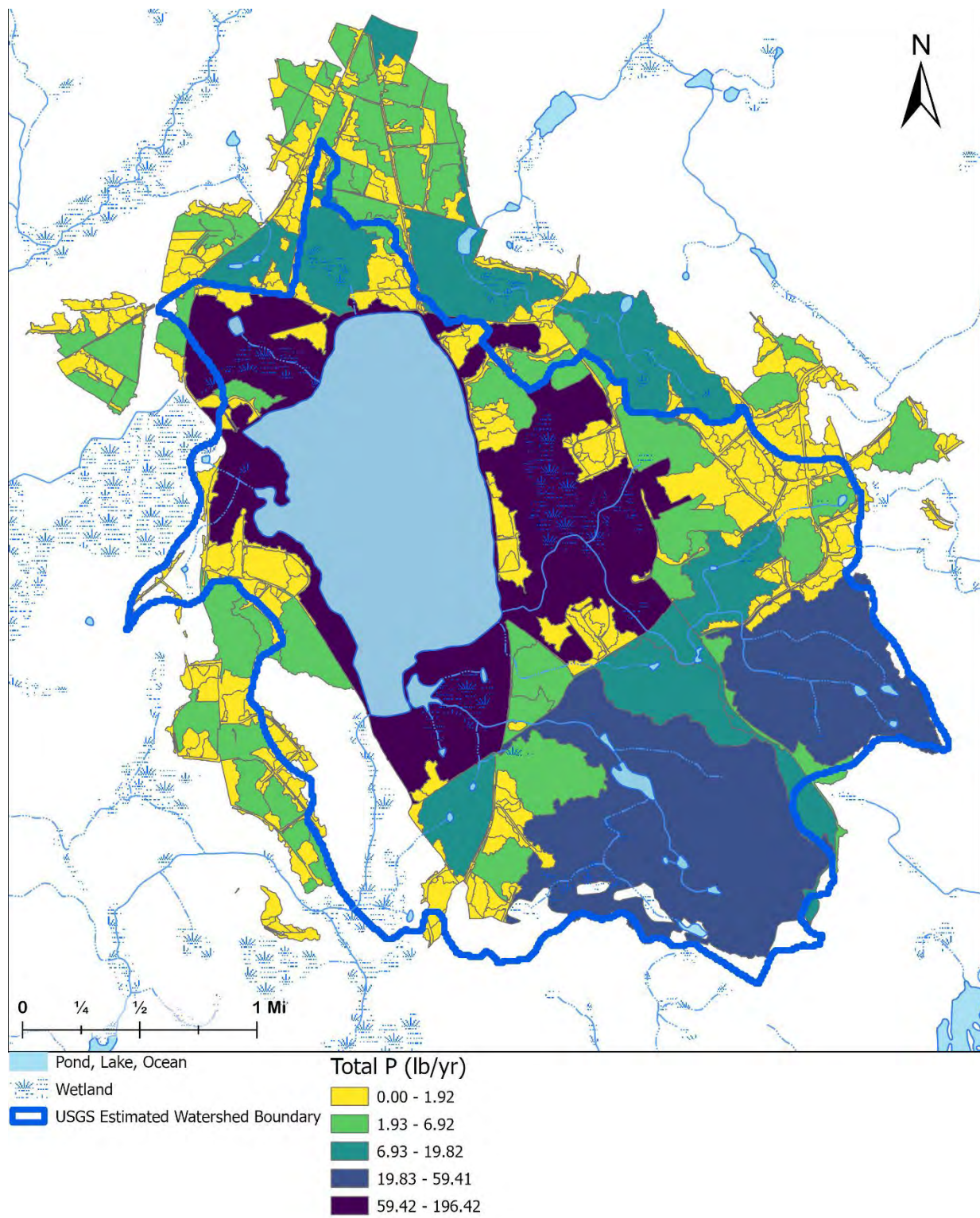


Figure 5. Total Phosphorus (P) load by catchment in lbs/year.

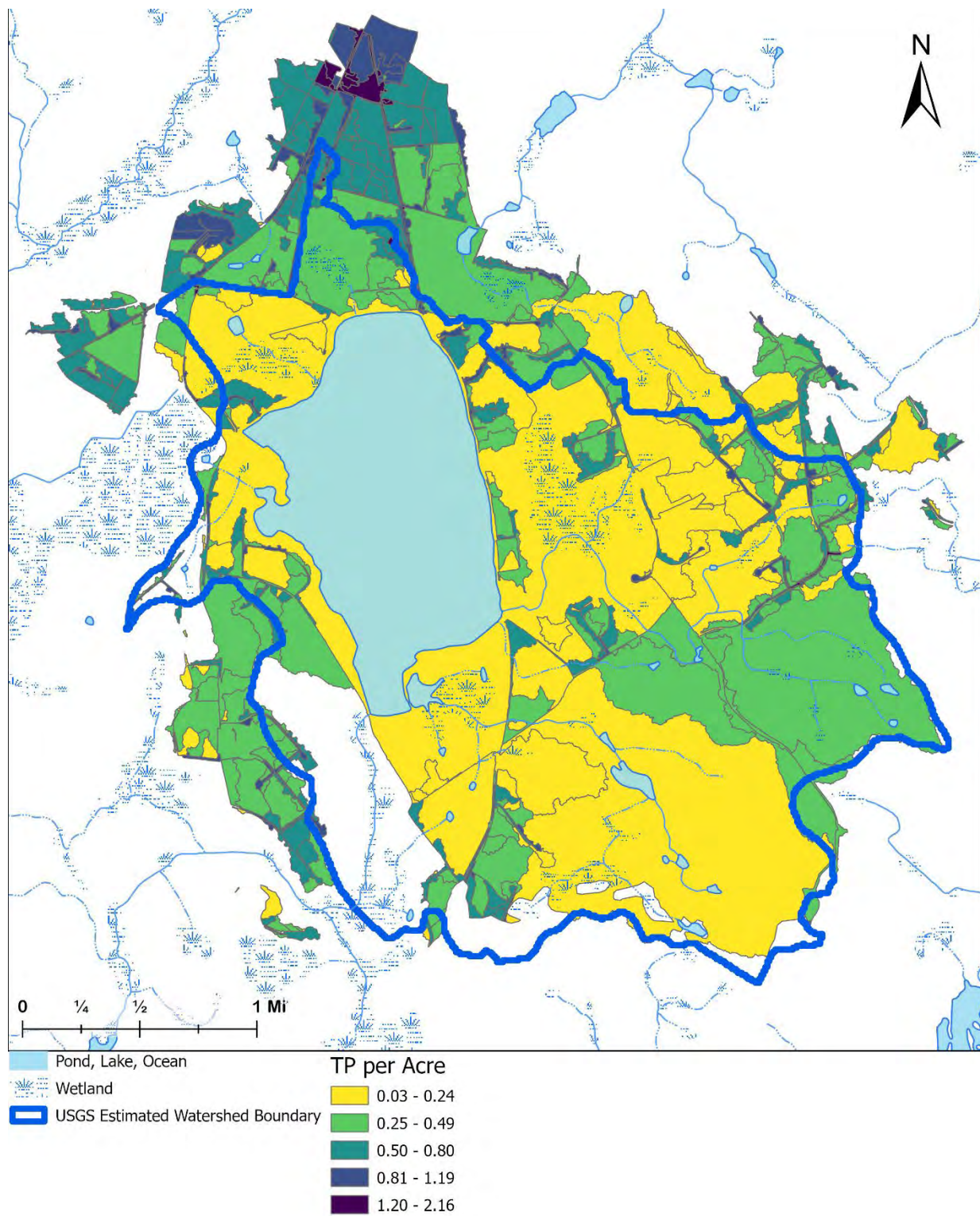


Figure 6. Total Phosphorus (P) load normalized by catchment acreage.

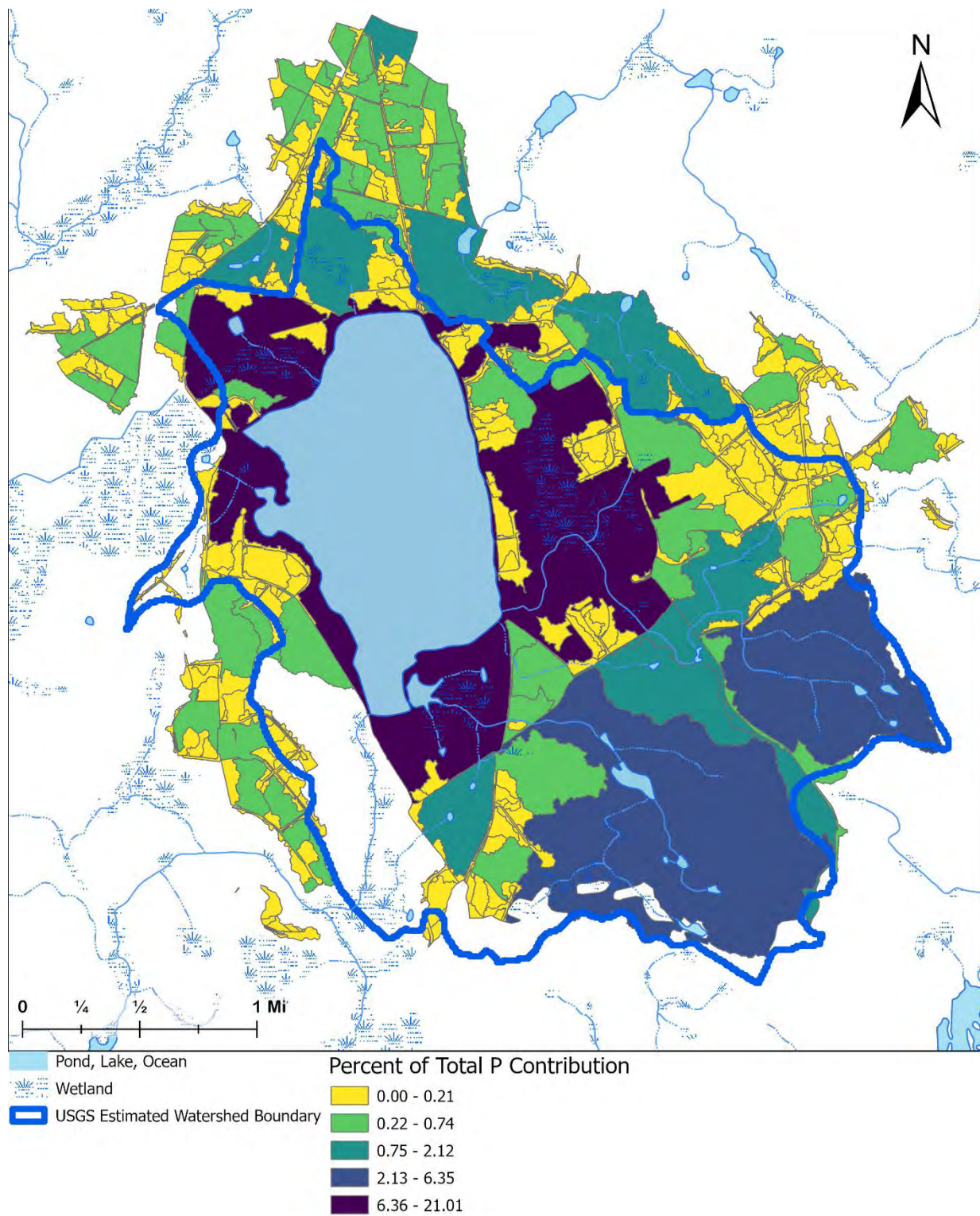


Figure 7. Percentage of Total Phosphorus (TP) contribution relative to Lake Massapoag Watershed

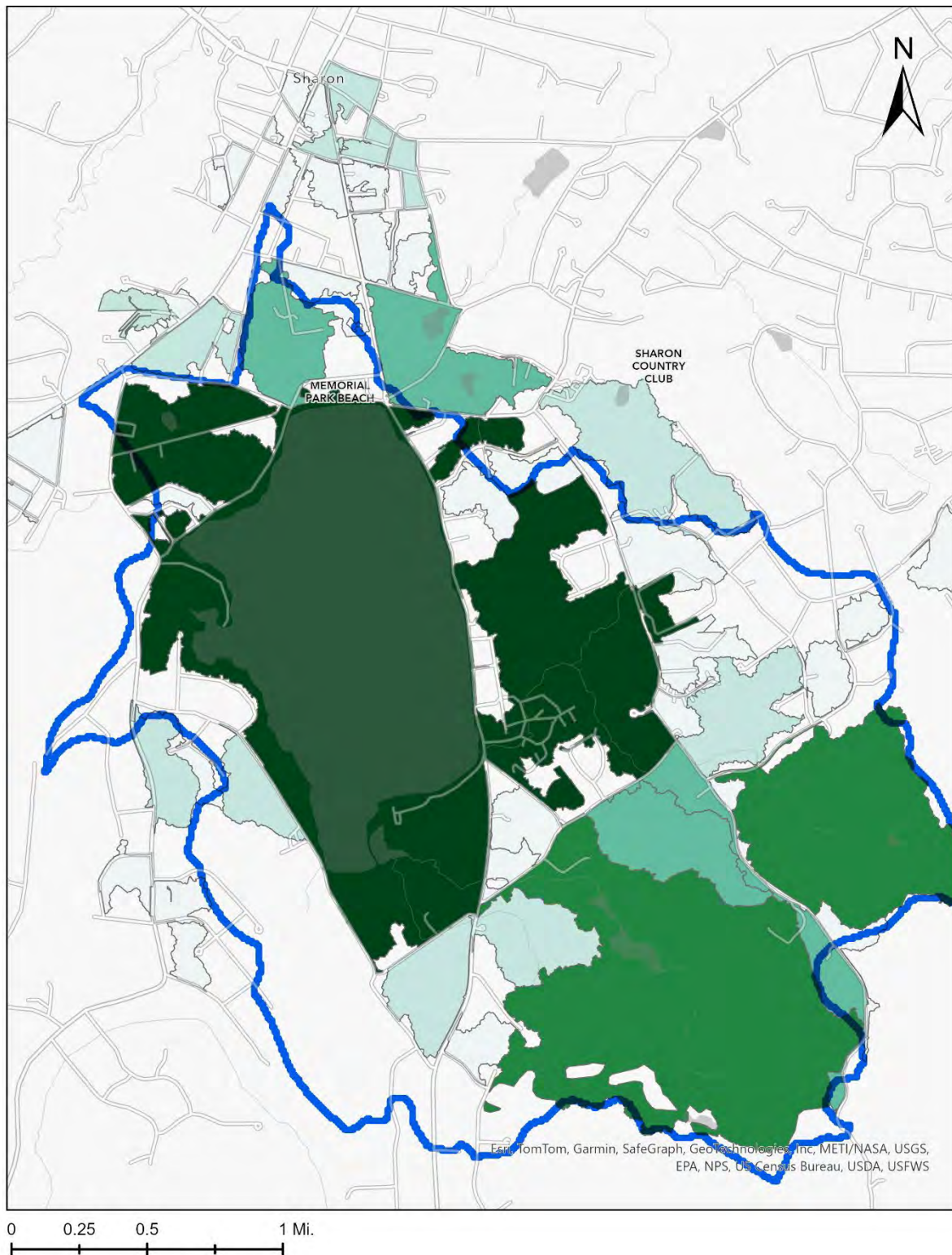
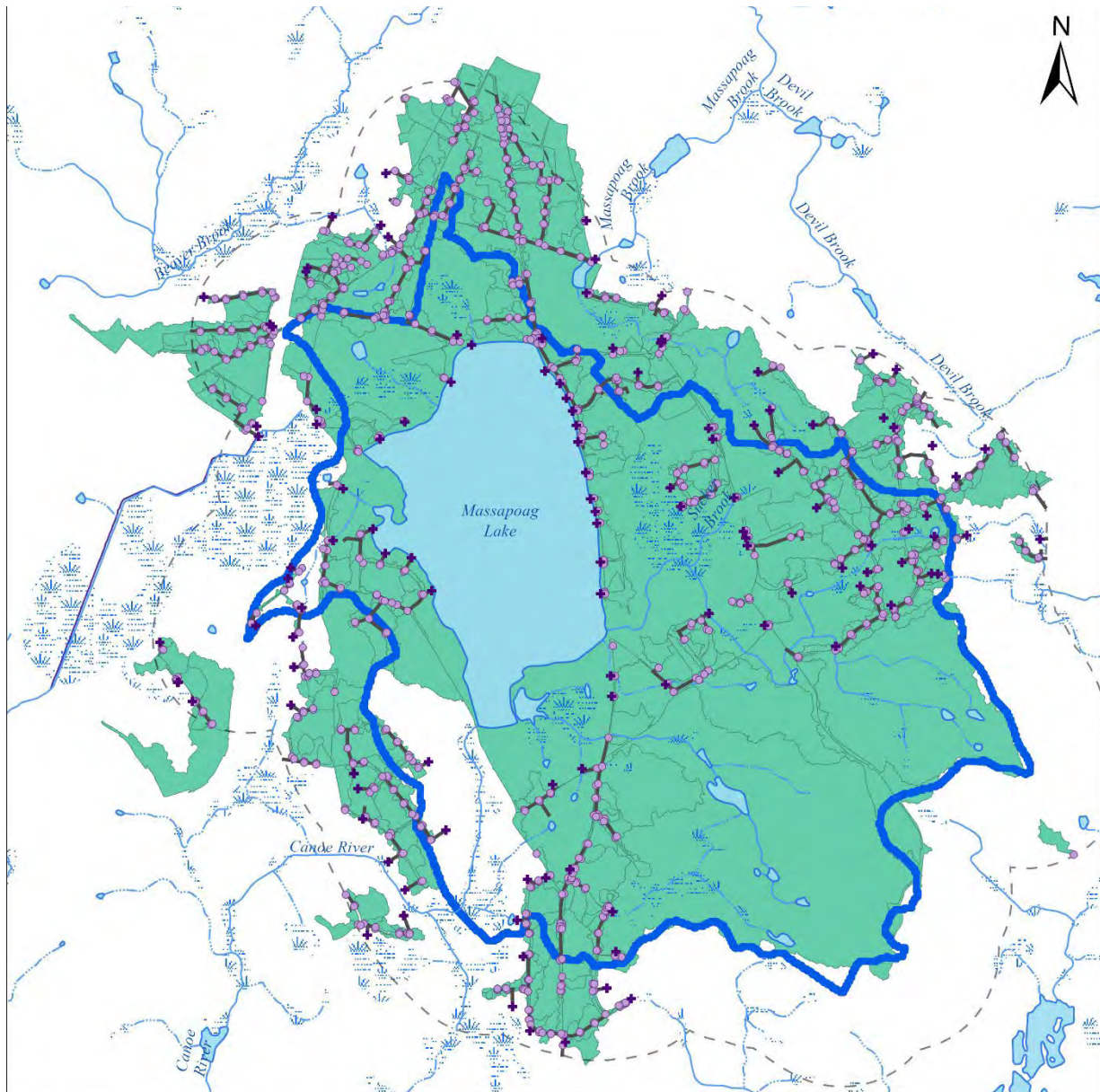


Figure 8. Top 50 contributing catchments based on estimated annual total phosphorus contribution to Lake Massapoag. Darker green represents higher amounts of phosphorus.

Appendices

Appendix A: Fullsize 2024 Map of Catchments and Local Stormwater Infrastructure



0 0.130.25 0.5 0.75 1 1.25 Miles

- | | |
|-------------------------|----------------------------|
| Pond, Lake, Ocean | Cedar Swamp Drainage Ditch |
| Wetland | stormwater pipes |
| USGS Watershed Boundary | outfalls |
| 2024 Catchments | |
| catchbasins | |

Appendix B: Stepwise Image Outputs from Catchment Delineation Process

Step

1. Fill Sinks

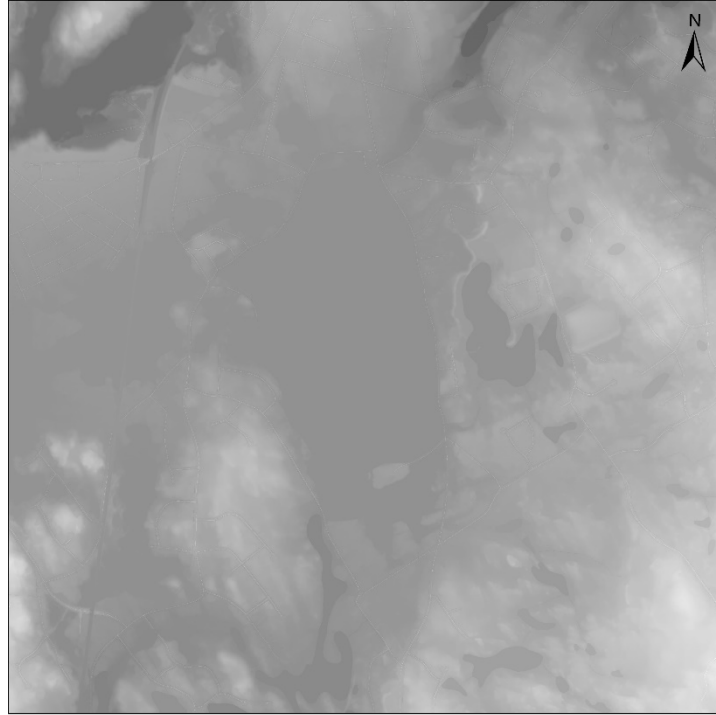
Input: enhanced DEM

Settings:

no Z value input

Output: Filled sink DEM

Output Image

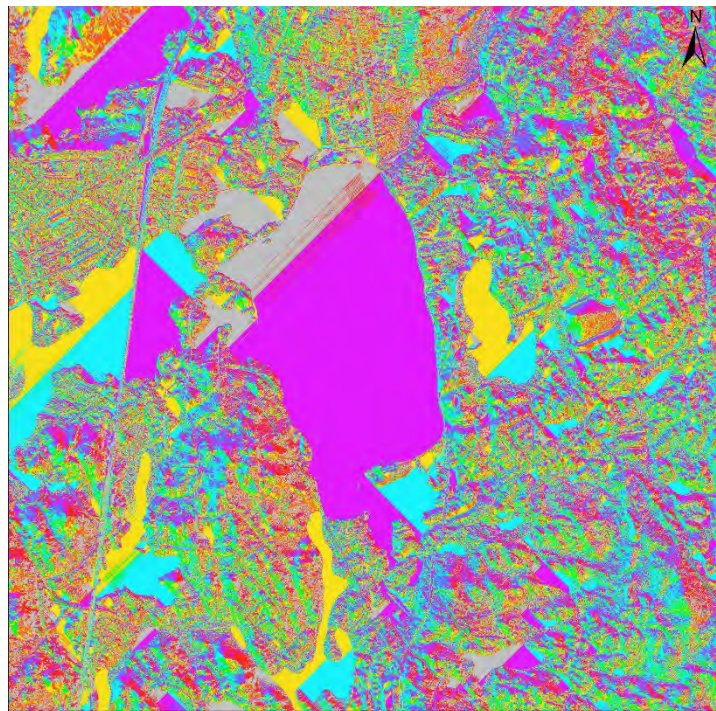


2. Flow Direction Raster
Input: filled sink DEM

Settings:

D8 type

Output: Flow direction raster



Note: cause of striations in upper quadrant of Lake Massapoag unclear, however did not affect catchment output

3. Flow Accumulation Raster

Input: flow direction raster

Settings:

Output data type: float

Input flow direction type: D8



0 0.075 0.15 0.3 0.45 0.6 0.75 Miles

Note: Flow accumulation raster

Symbology set to histogram equalize in order to visualize flow

4. Snap to Pour Points

Input: catchbasins_clip
(clipped to USGS+500m
buffer study area), flow
accumulation raster

Settings:

Pour point field = number
Snap distance = 10m, based
on visual inspection and
MAPC protocol

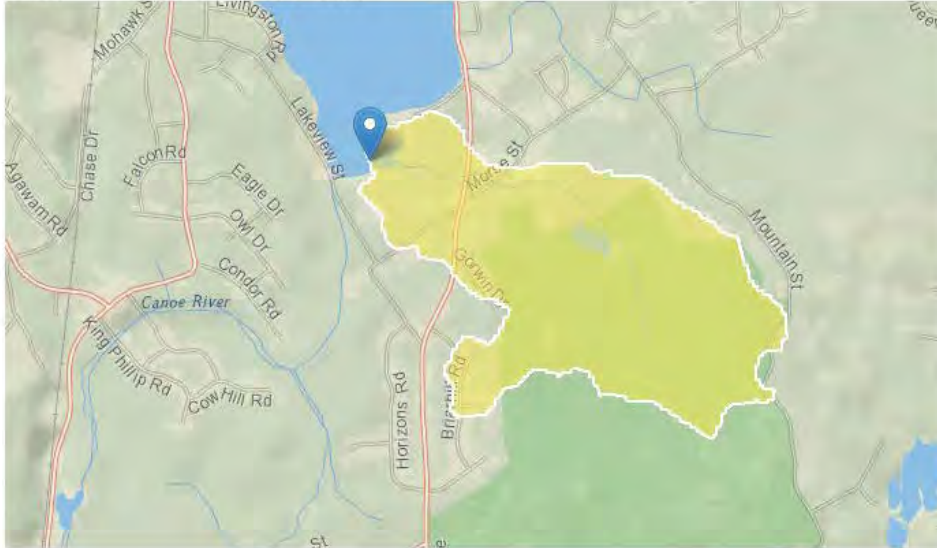
No corresponding visual output

Appendix C: Supplemental USGS Streamstats Inflow Maps

Lagoon

StreamStats Report

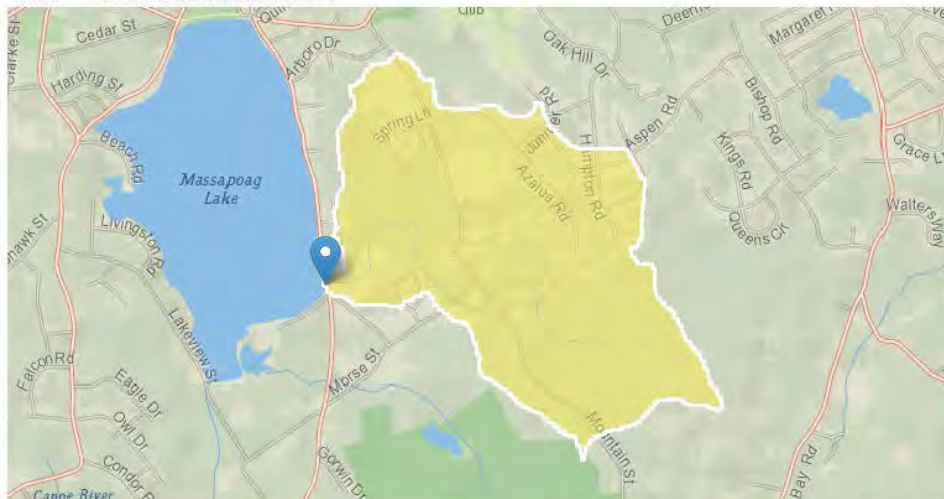
Region ID: MA
Workspace ID: MA20230223171446025000
Clicked Point (Latitude, Longitude): 42.09290, -71.17613
Time: 2023-02-23 12:15:13 -0500



Sucker Brook

StreamStats Report

Region ID: MA
Workspace ID: MA20230223135243606000
Clicked Point (Latitude, Longitude): 42.09709, -71.17023
Time: 2023-02-23 08:53:05 -0500



123 Beach St StreamStats Report

Region ID: MA

Workspace ID: MA20230301194415424000

Clicked Point (Latitude, Longitude): 42.10658, -71.18278

Time: 2023-03-01 14:44:39 -0500



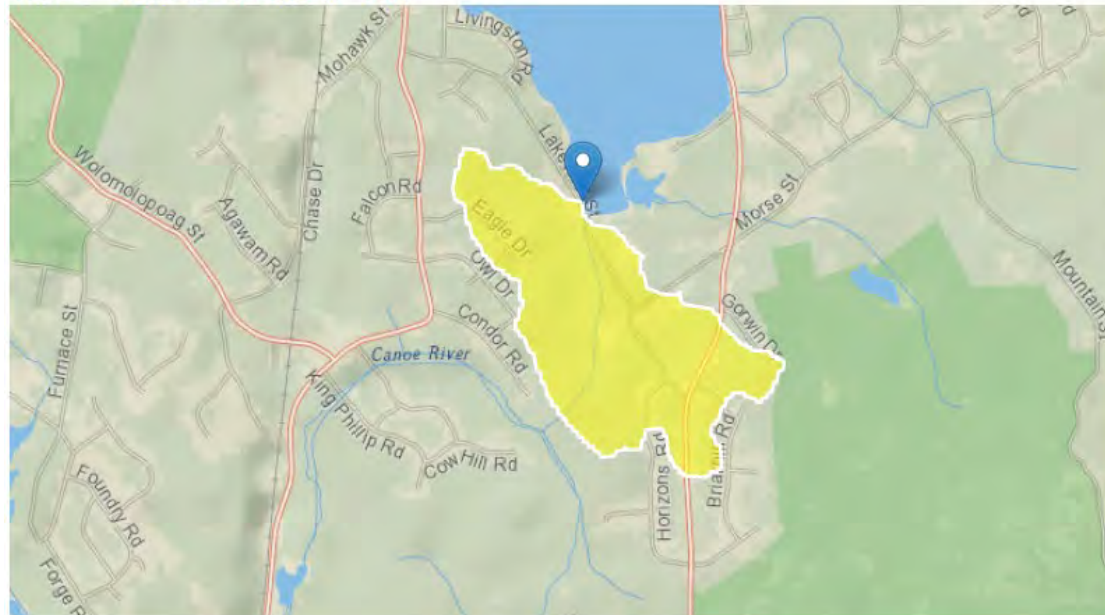
Canoe R StreamStats Report

Region ID: MA

Workspace ID: MA20230319193201612000

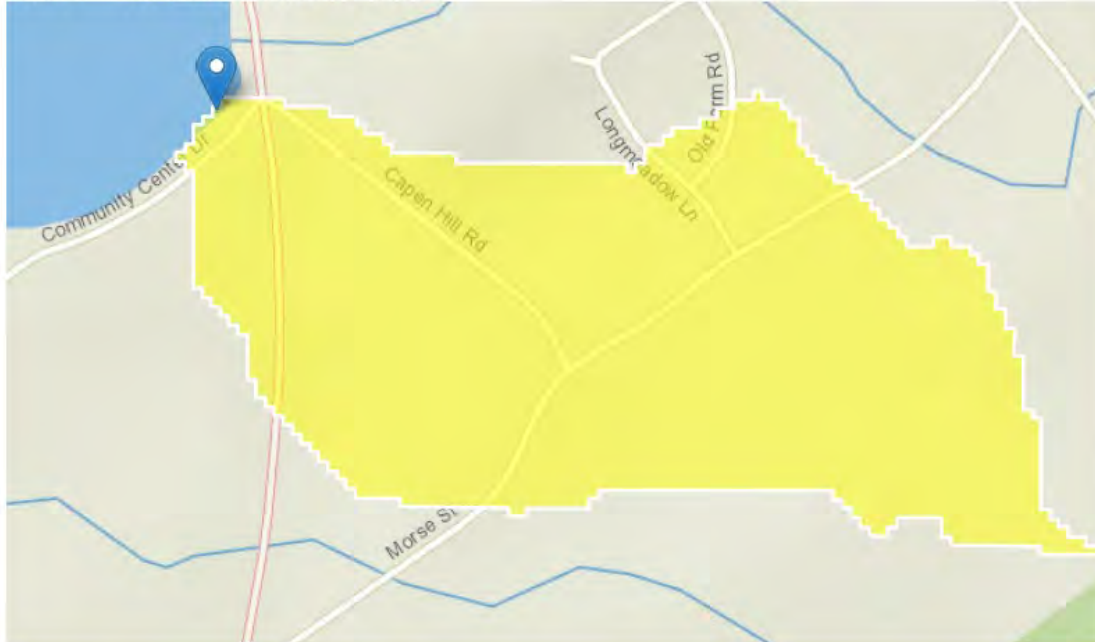
Clicked Point (Latitude, Longitude): 42.09260, -71.17864

Time: 2023-03-19 15:32:19 -0400



Com Center Dr StreamStats Report

Region ID: MA
Workspace ID: MA20230301195001462000
Clicked Point (Latitude, Longitude): 42.09653, -71.17068
Time: 2023-03-01 14:50:25 -0500



Mid Beach St StreamStats Report

Region ID: MA
Workspace ID: MA20230301193824242000
Clicked Point (Latitude, Longitude): 42.10758, -71.18156
Time: 2023-03-01 14:38:45 -0500



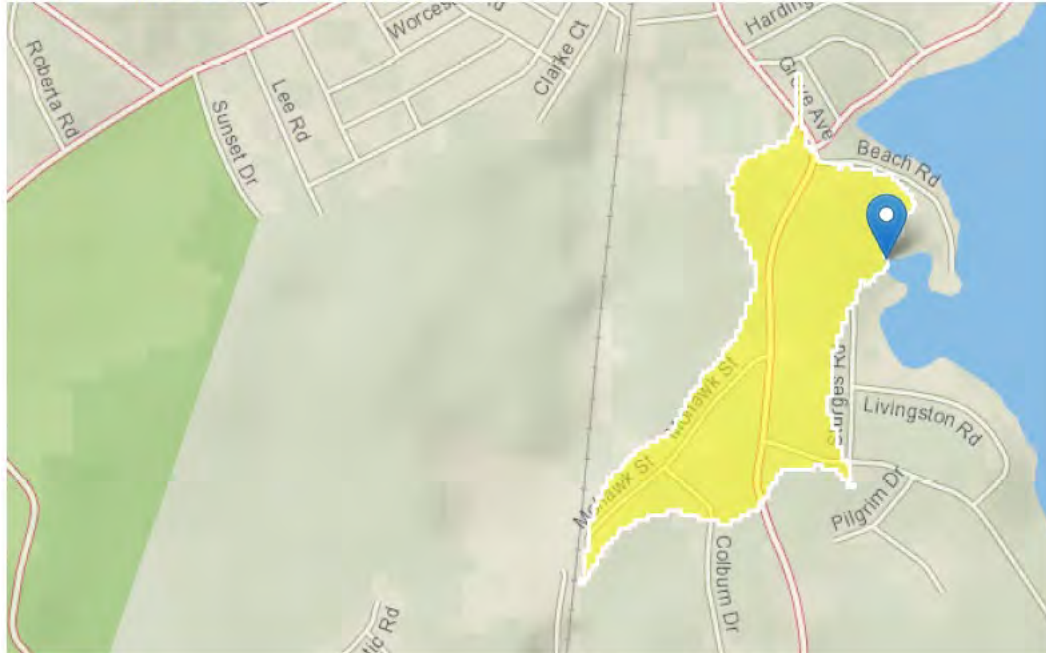
Fletchers Cove StreamStats Report

Region ID: MA

Workspace ID: MA20230301192200262000

Clicked Point (Latitude, Longitude): 42.10254, -71.18555

Time: 2023-03-01 14:22:20 -0500



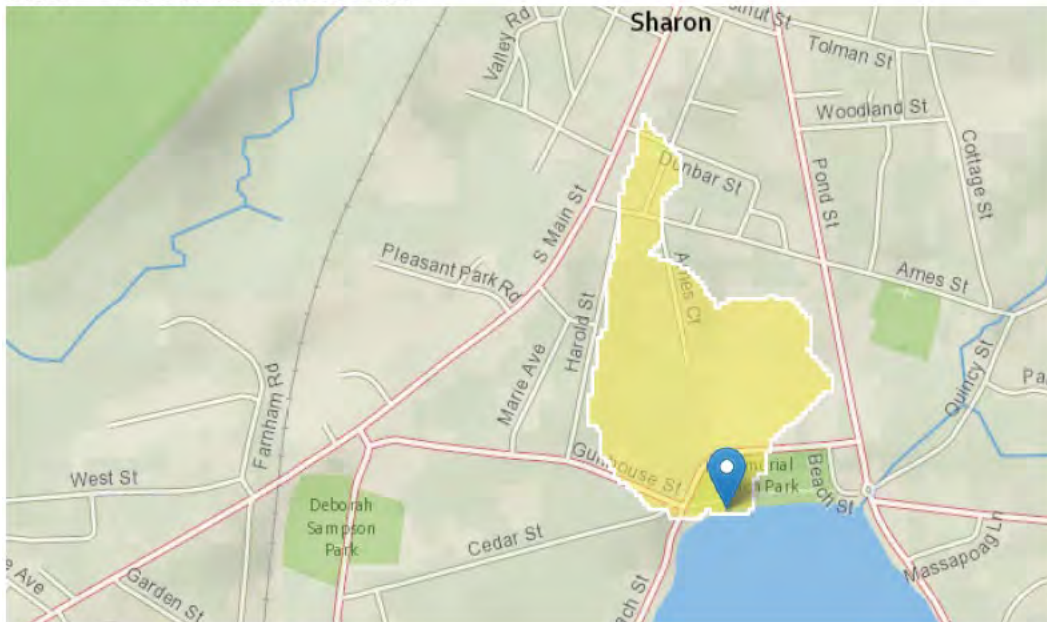
SHS/Wetlands StreamStats Report

Region ID: MA

Workspace ID: MA20230301192956222000

Clicked Point (Latitude, Longitude): 42.11053, -71.17930

Time: 2023-03-01 14:30:17 -0500



Appendix D:

**LAKE MASSAPOAG SITE
SELECTION PROCESS
AND BMP SITE SURVEYS**

Anna Yie

Site Selection Process Overview

The goal of the site selection process is to identify priority sites for green stormwater infrastructure (GSI) within the watershed of Lake Massapoag. Green stormwater infrastructure is sometimes also referred to as stormwater control measures (SCMs), nature-based solutions (NBS), or best management practices (BMPs). Implementing GSI practices can reduce the amount of pollutants entering Lake Massapoag by using natural processes and/or infiltrating stormwater, preventing nutrients like phosphorus from entering the lake.

Site Selection Identification

Desktop Analysis

This step built upon the previous work done to identify the annual phosphorus load for Lake Massapoag and the primary areas contributing phosphorus to the lake system. Catchments with high phosphorus were screened for GSI feasibility based on the EPA's BMP site selection Tool.¹ Factors include:

- Land use
- Percent impervious cover
- Hydrologic Soil Group (HSG)
- Road/right of way
- Depth to groundwater table
- Land ownership
- Slope
- Size
- Phosphorus load (based on PLER analysis previously done)
- Current infrastructure or other obstructions

Based on the factors, all the catchments within the Lake Massapoag watershed were given a total score. Using raw score and best professional judgement, along with input from the Lake Massapoag Advisory Committee (LMAC), twenty sites were identified as potential locations for GSI and a site survey was conducted.

TRC Water Quality Testing

Multiple types of water quality testing performed by TRC provided additional insight into phosphorus loading around Lake Massapoag and identified potential areas for further testing. The figure below shows the locations and type of water quality testing performed.

¹ https://19january2021snapshot.epa.gov/sites/static/files/2014-06/documents/bmpsitingtool_userguide.pdf

Sample ID	Location Description	Total Phosphorus (mg/L)
SW-1	Everwood/Gannet	0.724
SW-2	189 Massapoag Ave	0.465
SW-3	Massapoag Yacht Club	0.444
SW-4	Memorial Beach (West Side)	4.47
SW-5	Memorial Beach (East Side)	2.84
SW-6	Community Center Beach	0.895

*Red values greater than 0.025 mg/L



Figure 1. Results of wet weather shoreline sampling and map of sampling locations, from TRC memo November 20, 2024.

Sample ID	Location Description	Total Phosphorus (mg/L)
Outfall-1	7-11 Livingston Road	0.347
Outfall-2	19-21 Livingston Road	0.489
Outfall-3	31 Livingston Road	0.483
Outfall-4	25 Sturges Road	0.32
Outfall-5	140 E. Foxboro Street	0.198
Outfall-6	Massapoag Ave at Arboro Drive	0.256
Outfall-7	Sucker Brook	0.241

*Red values greater than 0.025 mg/L



Figure 2. Results of storm drain sampling and map of sampling locations, from TRC memo January 13, 2025.

Sample Location	Description	Dissolved Phosphorus (mg/L)
GW-1	By Beach Street and Beach Road intersection, on western side of lake	0.07
GW-2	Along Livingston Road, on western side of lake	0.035
GW-3	By the Everwood Gannett Campus, on southern side of lake.	0.148
GW-4	By Community Center Beach, on southeastern side of lake.	0.045
GW-5	By eastern end of Memorial Beach, on northern side of lake.	0.252
GW-6	By western end of Memorial Beach, on northern side of lake.	0.085

*Red values greater than 0.025 mg/L



Figure 3. Results of groundwater seepage survey and map of sampling locations, from TRC memo October 28, 2024.

Community-Identified Areas of Interest

In addition to sites and areas identified in the desktop site selection and TRC sampling sites, residents of the community and members of the LMAC identified areas of interest and have been identified below.

Site List

Based on a discussion with a subset of the LMAC, five top sites were identified as priorities for further consideration for SCM installation: Capen Hill Rd, Beach St, Lakeview Ave, Sturges Rd, and Sucker Brook (highlighted below).

Site Name/Location	Identification Method	Notes
Memorial Beach Parking Lot – East	Desktop analysis	Town drafted plans for SCM
Beech Tree Park/Memorial Beach Boat Ramp	Desktop analysis	SCM installation completed by Town Fall 2024
Sharon High School Track and Adjacent Wetland	Desktop analysis	connected to outfall tested by TRC
Memorial Beach Walking Paths/Pedestrian Walkway and	Desktop analysis	Multiple opportunities on parcel, town created designs for

Memorial Beach Parking Lot - West		parking lot (west) Fall 2024, not built
Sharon Community Center	Desktop analysis	
Community Center Beach Parking	Desktop analysis	
Deborah Sampson Park & surrounding area	Desktop analysis	
Cedar St	Desktop analysis	Multiple sites along Cedar street (back entrance to Sharon Dog Park as well as other town-owned land)
Harding St and Beach St	Desktop analysis	Nuisance flooding noted in past
Grove Ave and Beach St	Desktop analysis	
Sturges Rd Wetlands	Desktop analysis	
Capen Hill Road	Desktop analysis	Also consider uphill of Capen Hill ROW
Decatur St at Massapoag Ave	Desktop analysis	
Camp Wonderland	Desktop analysis	Ongoing water quality testing at Sucker Brook, elevated <i>E. coli</i>
Lake Ave and Beach St/123 Beach St (Beach St Wetlands)	Desktop analysis	ROW is wider than current street, additional area for SCMs available on town-owned land. Noted flooding issues on lake Ave during wet weather
Sturges Rd Neighborhood Beach	Desktop analysis, community identified	
Lagoon	TRC Testing Site	
South Cove	TRC Testing Site, community identified	
Everwood Day Camp, Lakeview Ave	Community identified	Some uncertainty about exact edge of Lake Massapoag watershed, flow into and out of lake from Canoe River can be seasonal
Sucker Brook	Community identified	See note above regarding Camp Wonderland

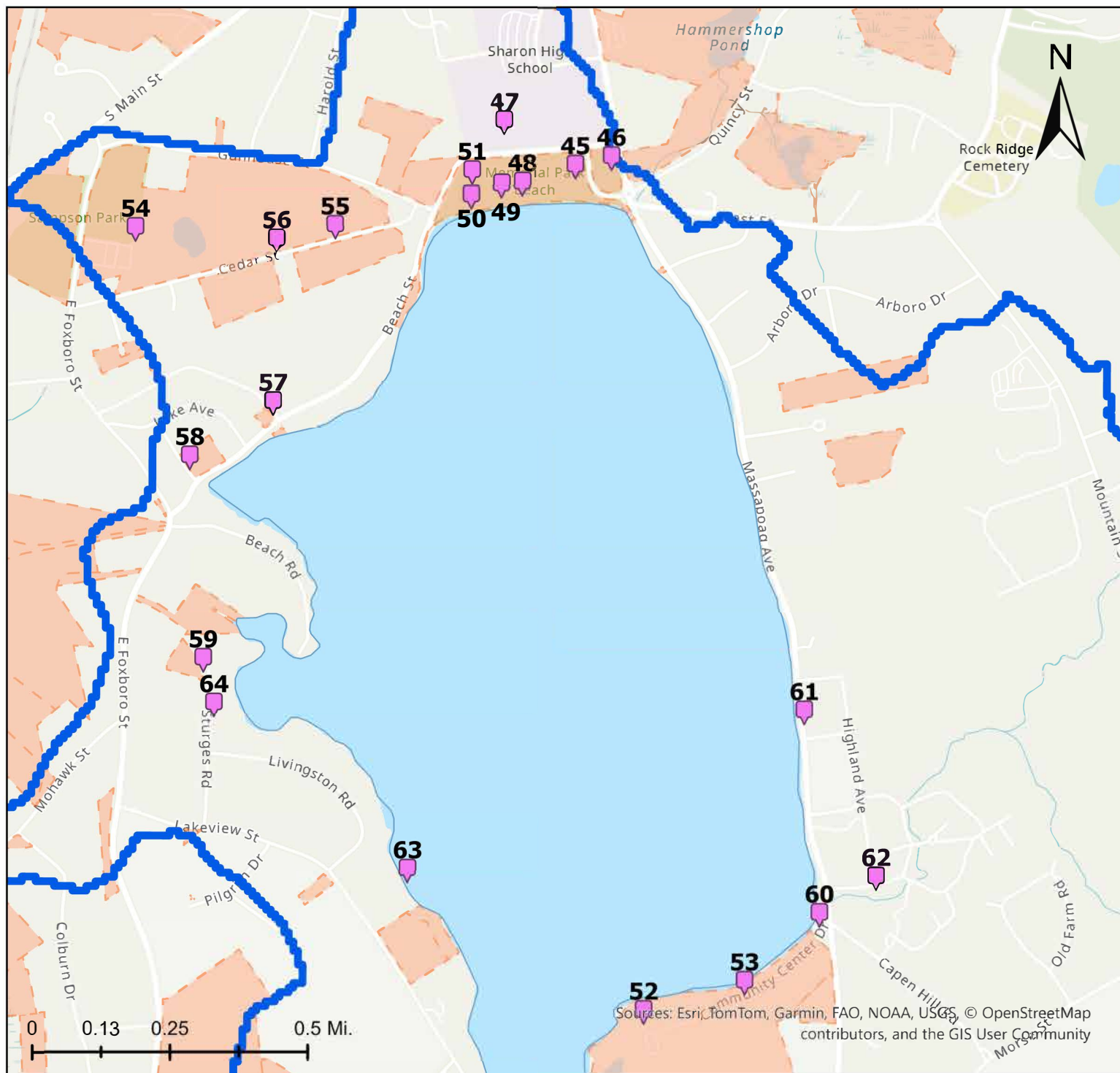
References

Storm Drain Sampling Memo, TRC, January 13 2024

Wet Weather Shoreline Sampling Memo, TRC, November 20 2024

Groundwater Seepage Sampling Memo, TRC, revised November 2024

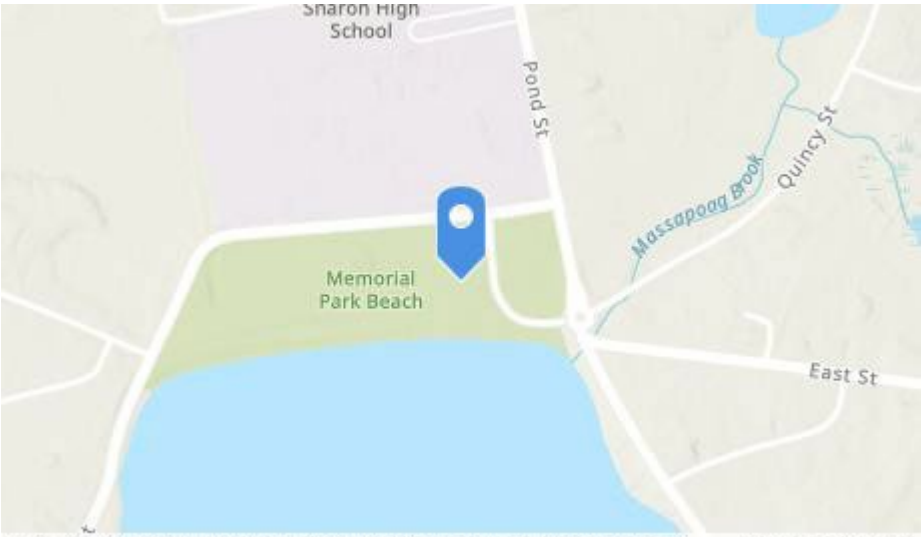
Catchment Delineation and Phosphorus Loading Estimate Report, NepRWA, November 2024



BMP Parcel Survey Results

Assessed by: Anna

Date Assessed: 07/19/2024 1:57 PM

ID#: OID_45	
Description: Memorial Beach Parking Lot - East	Weather: Sun
	
PARCEL CHARACTERISTICS	
Land Use 1: Parking	High Vehicle Traffic? Yes
Land Use 2:	If yes, description: Parking lot
Soil Type: HSG A, HSG B	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: Beach access
Waste Storage/Dumpsters? No	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: High Potential	
Site ID:	Catch Basin Inlet Grate?
High Groundwater? No	Curb Inlet?
If yes, description:	Drainage Depression/Pathway?
If other:	Existing Drainage Condition:
Bedrock? No	Drainage Blocked or Clogged?
Exposed Rock?	Drainage Damage?
Boulders?	Unmaintained Drainage:
Other Rock? -	Site Erosion?
Slope? Other - Slightly away from lake	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? Yes	Fiber Optics Cables?
If yes, description: Litter	Gas Lines?
Drainage Infrastructure? Unknown	Overhead Wires?
Manhole?	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area: Parking lot or adjacent area

Existing BMP? No

Does existing drain network discharge to wetland or stream? No

What is the existing BMP?

Constructability: Easy

BMP Opportunities: Permeable pavers, bioswale along edge of parking lot, basin in wooded area

Proposed BMP Type: Rain Garden, Bioretention Cell, Infiltration Cell, Sediment Forebay, Permeable Pavement

Other:

BMP Photo 1



BMP Photo 2



BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

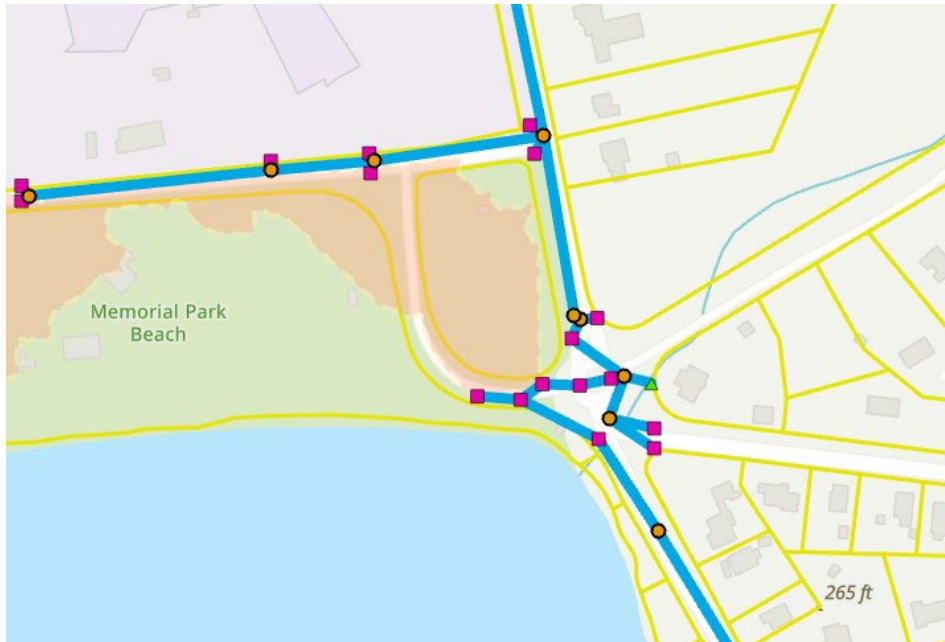
Date Assessed: 07/19/2024 2:07 PM

ID#: OID_46	
Description: Beech Tree Park	Weather: Sun
	
PARCEL CHARACTERISTICS	
Land Use 1: Open space	High Vehicle Traffic? No
Land Use 2: wetlands	If yes, description:
Soil Type: HSG A, HSG B	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: Footpaths and bridge
Waste Storage/Dumpsters? No	Active Landscaping Program? Yes

BMP SITE DESCRIPTION	
BMP Opportunity Potential: High Potential	
Site ID:	Catch Basin Inlet Grate?
High Groundwater? Yes	Curb Inlet?
If yes, description: wetlands	Drainage Depression/Pathway?
If other:	Existing Drainage Condition:
Bedrock? No	Drainage Blocked or Clogged?
Exposed Rock?	Drainage Damage?
Boulders?	Unmaintained Drainage:
Other Rock? -	Site Erosion?
Slope? Yes -	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? No	Fiber Optics Cables?
If yes, description:	Gas Lines?
Drainage Infrastructure? No	Overhead Wires?
Manhole?	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area: Permeable area, low space under foot bridge, grassy areas

Existing BMP?	Does existing drain network discharge to wetland or stream? No
What is the existing BMP?	Constructability: Moderate
BMP Opportunities: Swale, improve current walkways (already permeable)	BMP Photo 1 
Proposed BMP Type: Rain Garden, Bioretention Cell, Infiltration Cell, Permeable Pavement, Stormwater Planters	
Other:	

BMP Photo 2



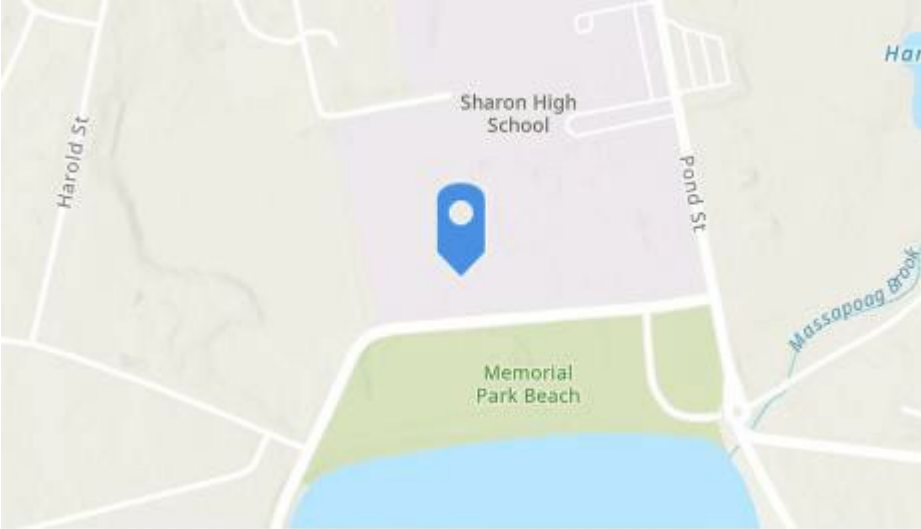
BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

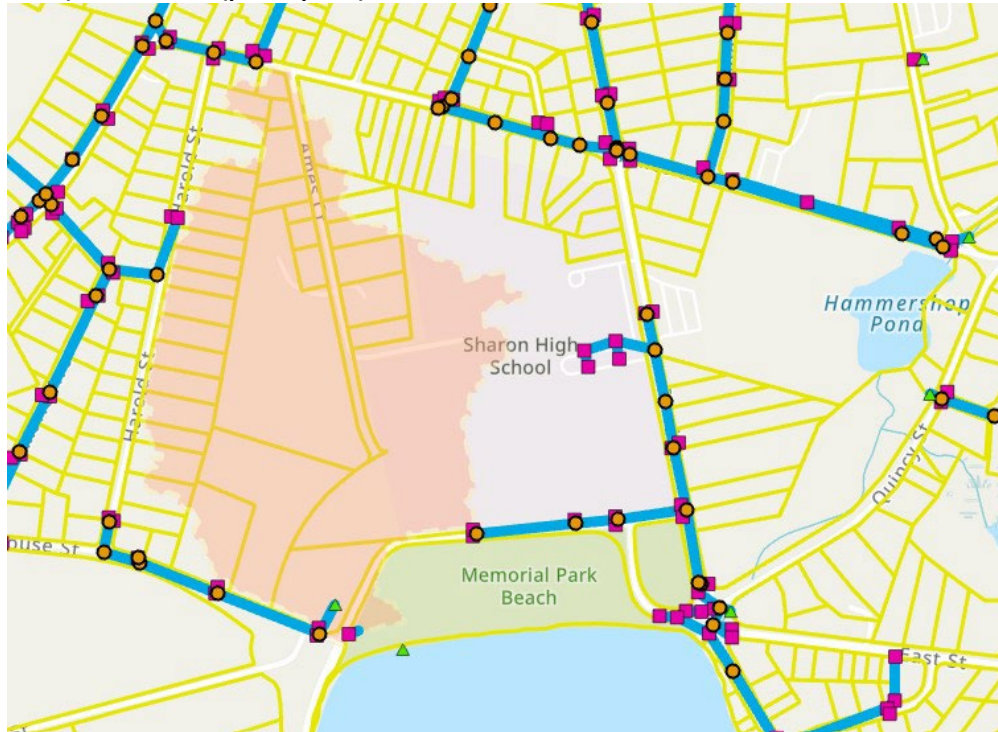
Date Assessed: 07/19/2024 2:19 PM

ID#: OID47	
Description: Sharon High School Track (SHS Track)/Adjacent Wetland	Weather: Sun
 Esri, NASA, NGA, USGS, FEMA Esri Community Maps Contrib... Powered by Esri	
PARCEL CHARACTERISTICS	
Land Use 1: Open space	High Vehicle Traffic? No
Land Use 2: Wetlands	If yes, description:
Soil Type: HSG A	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: School athletic field
Waste Storage/Dumpsters? Yes	Active Landscaping Program? Yes

BMP SITE DESCRIPTION	
BMP Opportunity Potential: Medium Potential	
Site ID:	Catch Basin Inlet Grate?
High Groundwater? No	Curb Inlet?
If yes, description:	Drainage Depression/Pathway?
If other:	Existing Drainage Condition:
Bedrock? No	Drainage Blocked or Clogged?
Exposed Rock?	Drainage Damage?
Boulders?	Unmaintained Drainage:
Other Rock? -	Site Erosion?
Slope? No -	If other:
Is the site flat? Yes -	Additional Utilities: Yes
Trash/Sediment Build-up? Yes	Fiber Optics Cables? Unknown
If yes, description: Litter, leaves along fencing	Gas Lines? Unknown
Drainage Infrastructure? Unknown	Overhead Wires? Yes
Manhole?	Other Utility? Yes

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area: Triangle of area near entry to track

Existing BMP? No

Does existing drain network discharge to wetland or stream? No

What is the existing BMP?

Constructability: Moderate

BMP Opportunities: Pre sediment forebay

BMP Photo 1

Proposed BMP Type: Rain Garden



Other: Connected to OID_50 via pipe

BMP Photo 2



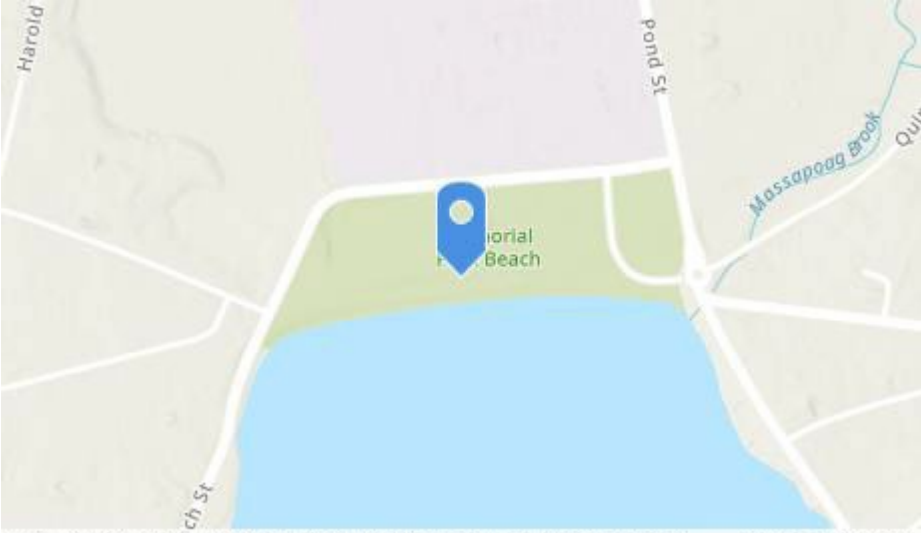
BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

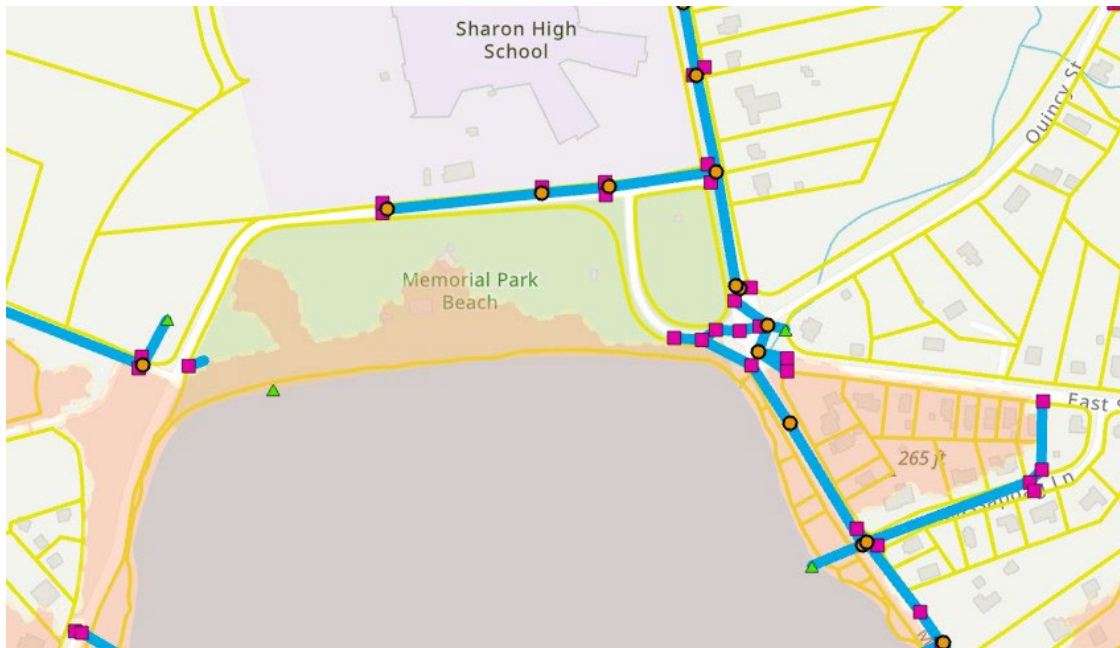
Date Assessed: 07/19/2024 2:28 PM

ID#: OID48	
Description: stepped area outside concessions and bathrooms	Weather: Sun
	
PARCEL CHARACTERISTICS	
Land Use 1: Recreation	High Vehicle Traffic? No
Land Use 2:	If yes, description:
Soil Type: HSG B, HSG D	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: Snack bar, picnic area
Waste Storage/Dumpsters? No	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: High Potential	
Site ID:	Catch Basin Inlet Grate?
High Groundwater? No	Curb Inlet?
If yes, description:	Drainage Depression/Pathway?
If other:	Existing Drainage Condition:
Bedrock? No	Drainage Blocked or Clogged?
Exposed Rock?	Drainage Damage?
Boulders?	Unmaintained Drainage:
Other Rock? -	Site Erosion?
Slope? Yes -	If other:
Is the site flat? No -	Additional Utilities: Yes
Trash/Sediment Build-up?	Fiber Optics Cables? No
If yes, description:	Gas Lines? No
Drainage Infrastructure? Unknown	Overhead Wires? No
Manhole?	Other Utility? Yes

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area: Steps (current gravel and grass)

Existing BMP? No

Does existing drain network discharge to wetland or stream? No

What is the existing BMP?

Constructability: Easy

BMP Opportunities: Permeable pavement, grass swale/infiltration

Proposed BMP Type: Infiltration Cell, Constructed Wetland, Permeable Pavement

Other:

BMP Photo 1



BMP Photo 2



BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

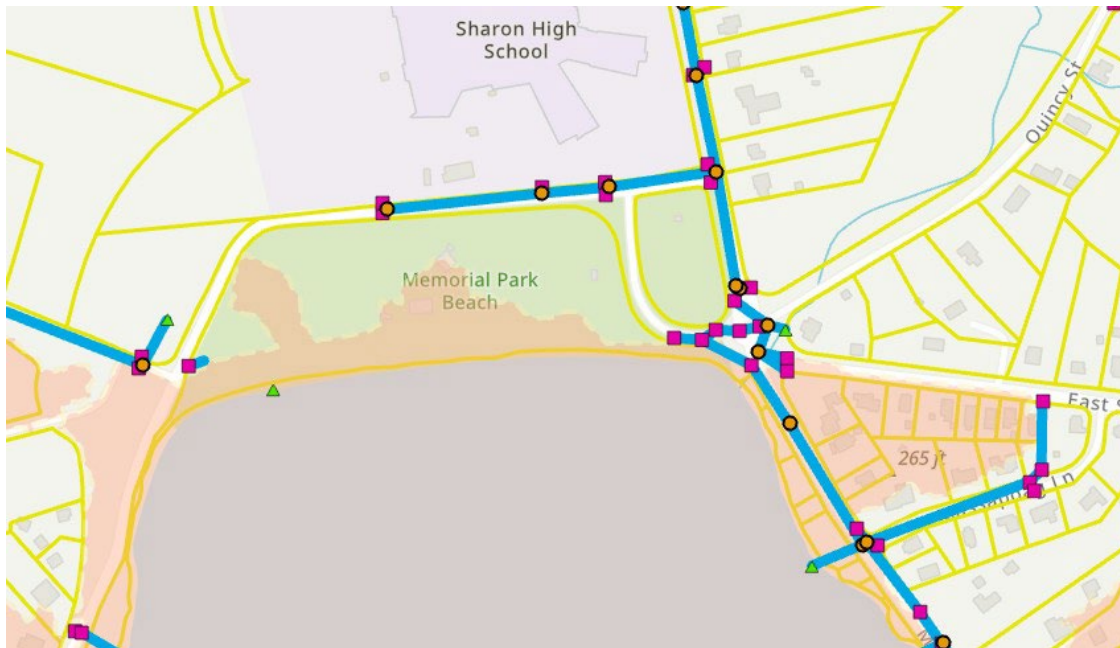
Date Assessed: 07/19/2024 2:34 PM

ID#: OID49	
Description: Pedestrian walkway	Weather: Sun
 Esri, NASA, NGA, USGS, FEMA Esri Community Maps Contrib... Powered by Esri	
PARCEL CHARACTERISTICS	
Land Use 1: Open space	High Vehicle Traffic? No
Land Use 2:	If yes, description:
Soil Type: HSG A, HSG B, HSG D	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: Footpath
Waste Storage/Dumpsters? No	Active Landscaping Program? Yes

BMP SITE DESCRIPTION	
BMP Opportunity Potential: High Potential	
Site ID:	Catch Basin Inlet Grate? No
High Groundwater? No	Curb Inlet? No
If yes, description:	Drainage Depression/Pathway? No
If other:	Existing Drainage Condition: Natural
Bedrock? No	Drainage Blocked or Clogged? No
Exposed Rock?	Drainage Damage? No
Boulders?	Unmaintained Drainage: Yes
Other Rock? -	Site Erosion? Yes
Slope? No -	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? Yes	Fiber Optics Cables?
If yes, description: Flow paths visible in gravel from water	Gas Lines?
Drainage Infrastructure? Yes	Overhead Wires?
Manhole? No	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area: Pedestrian path + 30 ft grassy stretch

Existing BMP? No	Does existing drain network discharge to wetland or stream? No
What is the existing BMP?	Constructability: Moderate
BMP Opportunities: Permeable pavers, infiltration, riprap	BMP Photo 1 
Proposed BMP Type: Infiltration Cell, Permeable Pavement, Stormwater Planters	
Other:	

BMP Photo 2



BMP Photo 3

BMP Parcel Survey Results

Assessed by: Anna

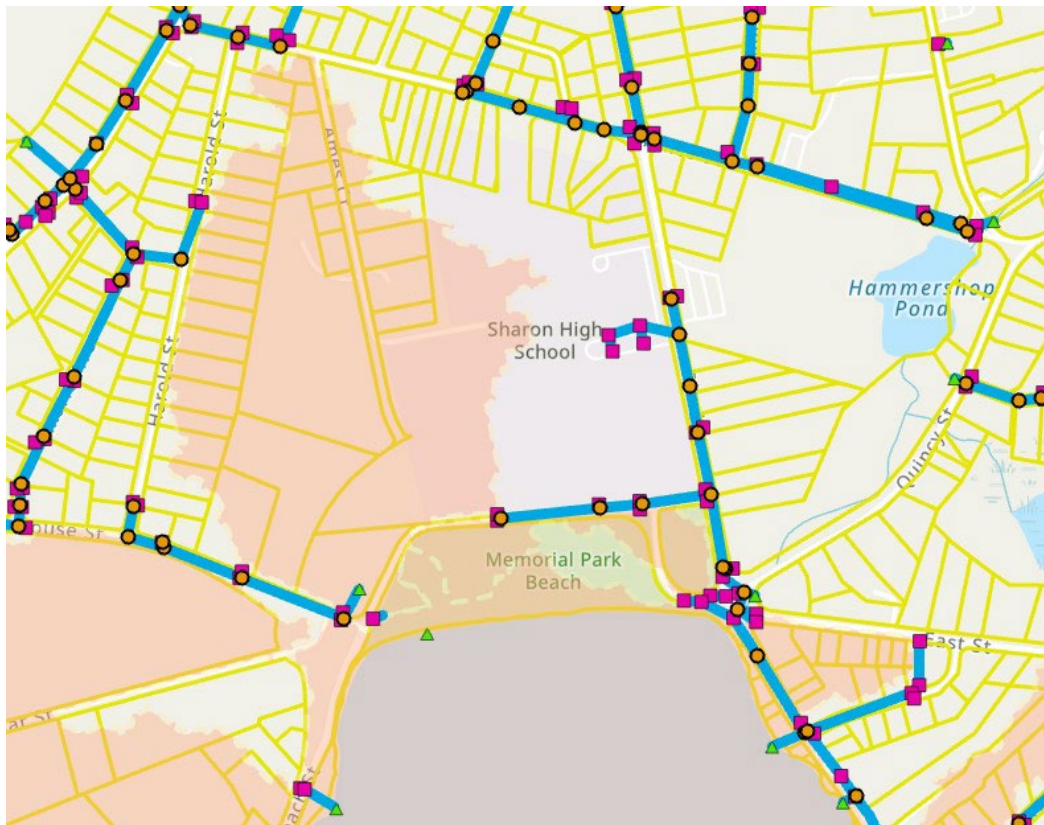
Date Assessed: 07/19/2024 2:41 PM

ID#: OID50	
Description: Memorial Beach Parking Lot - West	Weather: Sun
	
PARCEL CHARACTERISTICS	
Land Use 1: Open space	High Vehicle Traffic? Yes
Land Use 2:	If yes, description: Parking lot
Soil Type: HSG A, HSG B, HSG D	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: Footpath
Waste Storage/Dumpsters? No	Active Landscaping Program? Yes

BMP SITE DESCRIPTION	
BMP Opportunity Potential: High Potential	
Site ID:	Catch Basin Inlet Grate? No
High Groundwater? No	Curb Inlet? No
If yes, description:	Drainage Depression/Pathway? No
If other:	Existing Drainage Condition: Parking lot collects to outfall to lake
Bedrock? No	Drainage Blocked or Clogged? No
Exposed Rock?	Drainage Damage? No
Boulders?	Unmaintained Drainage: Yes
Other Rock? -	Site Erosion? Yes
Slope? Yes -	If other:
Is the site flat? No -	Additional Utilities: No
Trash/Sediment Build-up? No	Fiber Optics Cables?
If yes, description:	Gas Lines?
Drainage Infrastructure? Yes	Overhead Wires?
Manhole? Yes	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area: Current BMP

Existing BMP? Yes

Does existing drain network discharge to wetland or stream? No

What is the existing BMP? Preseasons t forebay

Constructability: Moderate

BMP Opportunities: Too undersized, outlet in lake

BMP Photo 1

Proposed BMP Type: Rain Garden, Bioretention Cell, Infiltration Cell, Hydrodynamic Separator, Oil and Grit Separator, Sediment Forebay

Other:



BMP Photo 2



BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

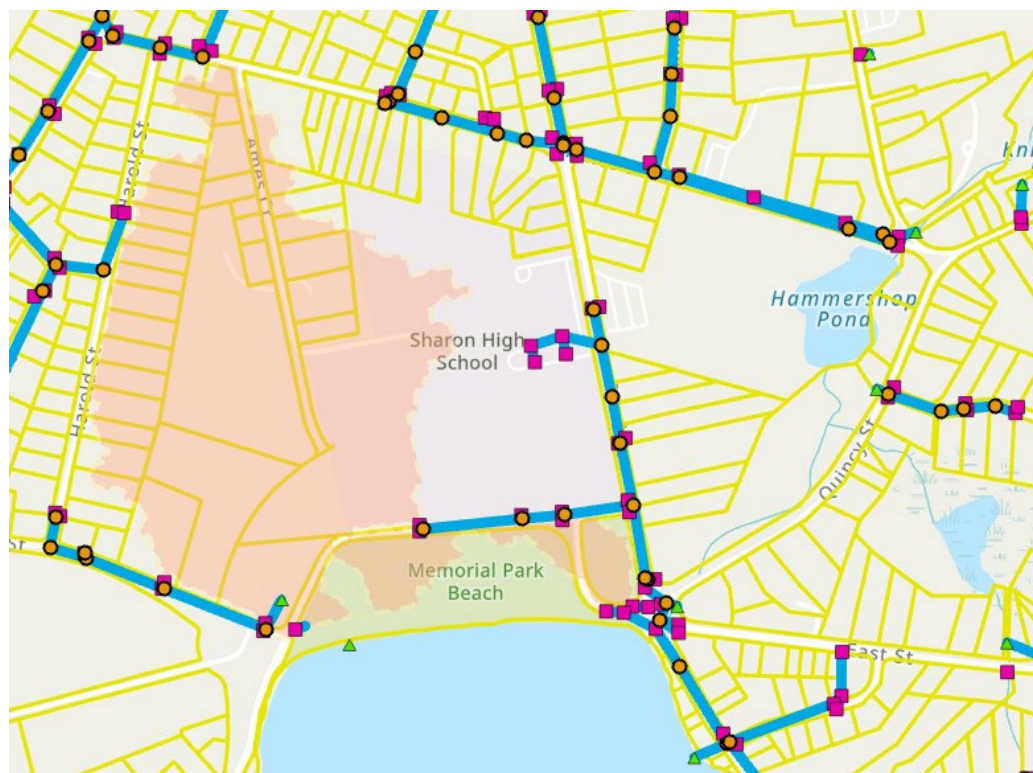
Date Assessed: 07/19/2024 2:46 PM

ID#: OID51	
Description: Memorial Beach Parking Lot – West (2)	Weather: Sun
	
PARCEL CHARACTERISTICS	
Land Use 1: Parking lot gravel	High Vehicle Traffic? Yes
Land Use 2:	If yes, description: Parking lot
Soil Type: HSG A, HSG B, HSG D	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: Walking path
Waste Storage/Dumpsters? Yes	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: High Potential	
Site ID:	Catch Basin Inlet Grate? No
High Groundwater? No	Curb Inlet? No
If yes, description:	Drainage Depression/Pathway? No
If other:	Existing Drainage Condition: Drains to lake. Small puddles in lot
Bedrock? No	Drainage Blocked or Clogged? No
Exposed Rock?	Drainage Damage? No
Boulders?	Unmaintained Drainage: No
Other Rock? -	Site Erosion? No
Slope? Yes -	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? Yes	Fiber Optics Cables?
If yes, description: Along road side of parking lot.	Gas Lines?
Drainage Infrastructure? Yes	Overhead Wires?
Manhole? Yes	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area: Lot or around lot edge

Existing BMP? Yes

Does existing drain network discharge to wetland or stream? Yes

What is the existing BMP? Outfall

Constructability: Easy

BMP Opportunities: nfiltration on center of lot, sediment forebay along parking edge

Proposed BMP Type: Rain Garden, Infiltration Cell, Sediment Forebay, Permeable Pavement, Stormwater Planters

Other:

BMP Photo 1



BMP Photo 2



BMP Photo 3

BMP Parcel Survey Results

Assessed by: Anna

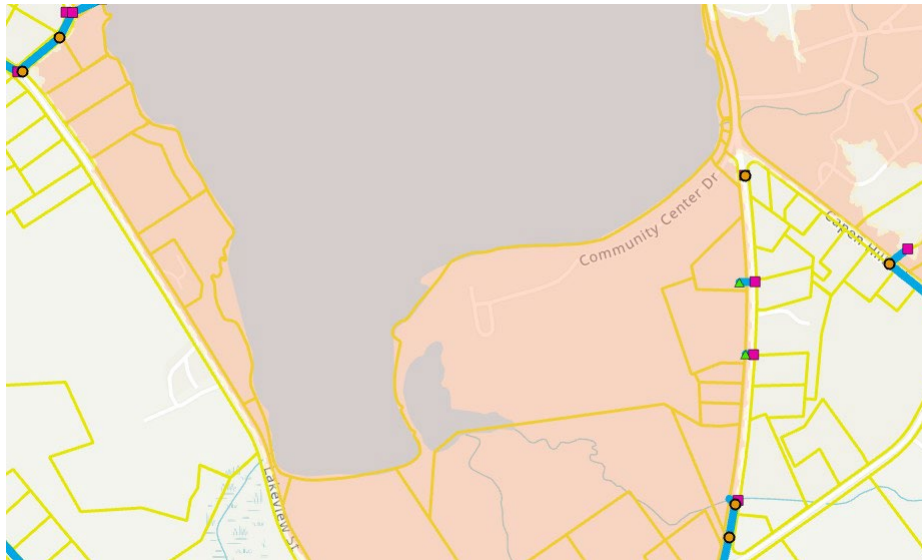
Date Assessed: 08/08/2024 1:54 PM

ID#: OID52	
Description: Sharon community center	Weather: Sun
 Esri, NASA, NGA, USGS, FEMA Esri Community Maps Contrib... Powered by Esri	
PARCEL CHARACTERISTICS	
Land Use 1: Open space rec	High Vehicle Traffic? Yes
Land Use 2: Parking	If yes, description: Parking
Soil Type: HSG A	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: Visitors to rec center
Waste Storage/Dumpsters? Yes	Active Landscaping Program? Yes

BMP SITE DESCRIPTION	
BMP Opportunity Potential: High Potential	
Site ID: Poi1 Aug 8	Catch Basin Inlet Grate? No
High Groundwater? No	Curb Inlet? No
If yes, description:	Drainage Depression/Pathway? No
If other:	Existing Drainage Condition: Good
Bedrock? No	Drainage Blocked or Clogged? Yes
Exposed Rock?	Drainage Damage? No
Boulders?	Unmaintained Drainage: Yes
Other Rock? -	Site Erosion? No
Slope? Yes -	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? No	Fiber Optics Cables?
If yes, description:	Gas Lines?
Drainage Infrastructure? Yes	Overhead Wires?
Manhole? Yes	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area: Green lawn in front of comm center

Existing BMP? No

Does existing drain network discharge to wetland or stream? Yes

What is the existing BMP?

Constructability: Easy

BMP Opportunities: Parking lot, underground storage, infiltration garden

BMP Photo 1



Proposed BMP Type: Infiltration Cell, Permeable Pavement, Stormwater Planters

Other:

BMP Photo 2



BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

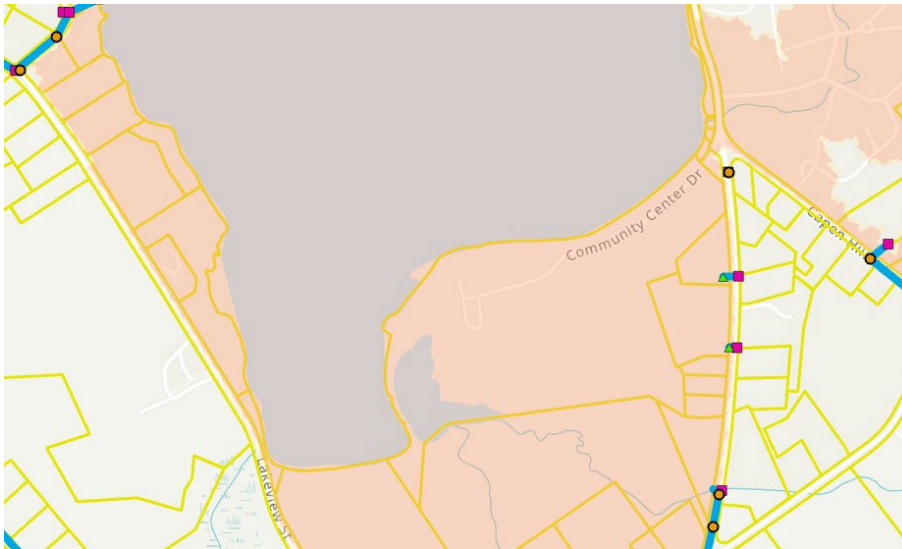
Date Assessed: 08/08/2024 2:03 PM

ID#: OID53	
Description: Comm center beach parking	Weather: Sun
	
PARCEL CHARACTERISTICS	
Land Use 1: Parking	High Vehicle Traffic? Yes
Land Use 2:	If yes, description: Parking lot
Soil Type: HSG A, HSG B	High Pedestrian Traffic? No
Uncovered Loading Bay? No	If yes, description:
Waste Storage/Dumpsters? Yes	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: High Potential	
Site ID: Poi 2 Aug 8	Catch Basin Inlet Grate? Yes
High Groundwater? No	Curb Inlet? No
If yes, description:	Drainage Depression/Pathway? Yes
If other:	Existing Drainage Condition: Gravel, infiltration?
Bedrock? No	Drainage Blocked or Clogged? No
Exposed Rock?	Drainage Damage? No
Boulders?	Unmaintained Drainage: Yes
Other Rock? -	Site Erosion? Yes
Slope? No -	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? No	Fiber Optics Cables?
If yes, description:	Gas Lines?
Drainage Infrastructure? Yes	Overhead Wires?
Manhole? No	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area:

Existing BMP? No

Does existing drain network discharge to wetland or stream? No

What is the existing BMP?

Constructability: Easy

BMP Opportunities: Increase parking infiltration, sediment forebays

BMP Photo 1



Proposed BMP Type: Bioretention Cell, Infiltration Cell, Oil and Grit Separator, Sediment Forebay, Permeable Pavement

Other:

BMP Photo 2



BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

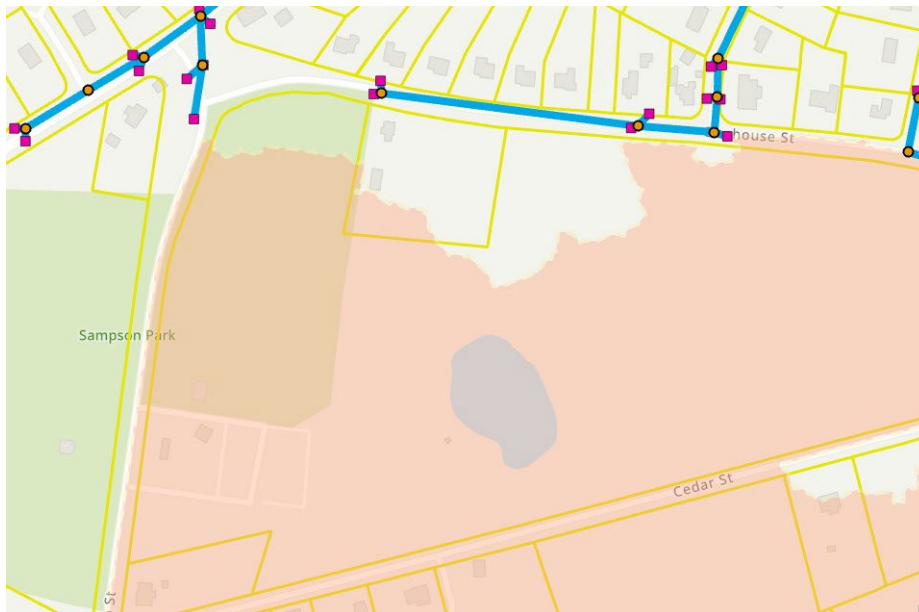
Date Assessed: 08/08/2024 2:44 PM

ID#: OID54	
Description: Tennis/dog parking lot	Weather: Rain
	
PARCEL CHARACTERISTICS	
Land Use 1: Parking	High Vehicle Traffic? Yes
Land Use 2: Open space/rec	If yes, description: Parking lot
Soil Type: HSG A	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: Park
Waste Storage/Dumpsters? Yes	Active Landscaping Program? Yes

BMP SITE DESCRIPTION	
BMP Opportunity Potential: High Potential	
Site ID:	Catch Basin Inlet Grate? No
High Groundwater? No	Curb Inlet? No
If yes, description:	Drainage Depression/Pathway? Yes
If other:	Existing Drainage Condition:
Bedrock? No	Drainage Blocked or Clogged? No
Exposed Rock?	Drainage Damage? No
Boulders?	Unmaintained Drainage: No
Other Rock? -	Site Erosion?
Slope? No -	If other:
Is the site flat? Yes -	Additional Utilities:
Trash/Sediment Build-up? Yes	Fiber Optics Cables?
If yes, description: Sand along edges of paved area	Gas Lines?
Drainage Infrastructure? Yes	Overhead Wires?
Manhole? No	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area:

Existing BMP? No

Does existing drain network discharge to wetland or stream? No

What is the existing BMP?

Constructability: Easy

BMP Opportunities:

BMP Photo 1

Proposed BMP Type: Bioretention Cell, Infiltration Cell, Oil and Grit Separator, Sediment Forebay, Permeable Pavement



Other:

BMP Photo 2



BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

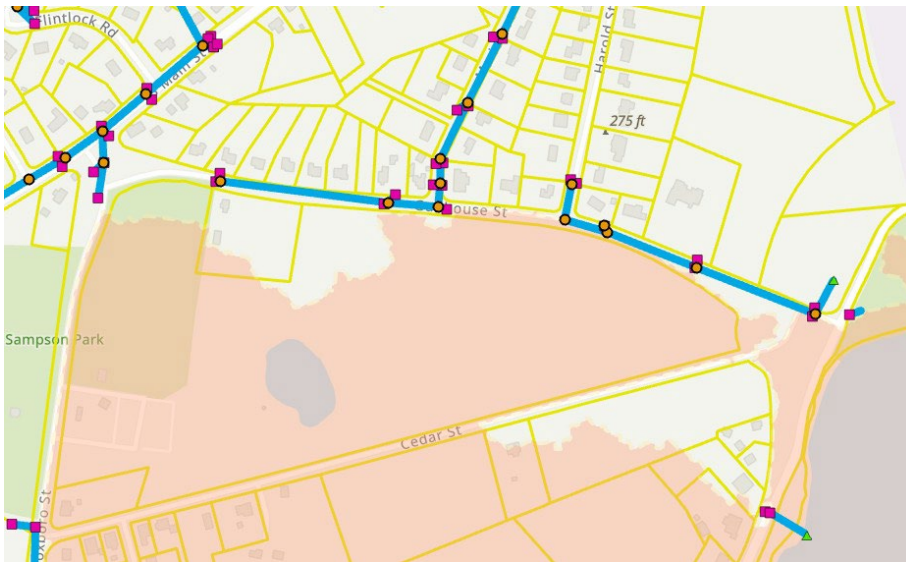
Date Assessed: 09/19/2024 2:50 PM

ID#: OID55	
Description: 20 cedar st	Weather:
	
PARCEL CHARACTERISTICS	
Land Use 1: Open space	High Vehicle Traffic? No
Land Use 2:	If yes, description:
Soil Type: HSG A	High Pedestrian Traffic? No
Uncovered Loading Bay? No	If yes, description:
Waste Storage/Dumpsters? No	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: Low Potential	
Site ID:	Catch Basin Inlet Grate?
High Groundwater? No	Curb Inlet?
If yes, description:	Drainage Depression/Pathway?
If other:	Existing Drainage Condition:
Bedrock? No	Drainage Blocked or Clogged?
Exposed Rock?	Drainage Damage?
Boulders?	Unmaintained Drainage:
Other Rock? -	Site Erosion?
Slope? No -	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? No	Fiber Optics Cables?
If yes, description:	Gas Lines?
Drainage Infrastructure? No	Overhead Wires?
Manhole?	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: BMP Area (blue), Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area: Roadside. Parking?

Existing BMP? No

Does existing drain network discharge to wetland or stream? No

What is the existing BMP?

Constructability: Easy

BMP Opportunities: Catchbasin with green filter

BMP Photo 1

Proposed BMP Type: Rain Garden, Bioretention Cell, Infiltration Cell, Hydrodynamic Separator, Oil and Grit Separator, Sediment Forebay, Permeable Pavement



Other:

BMP Photo 2



BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

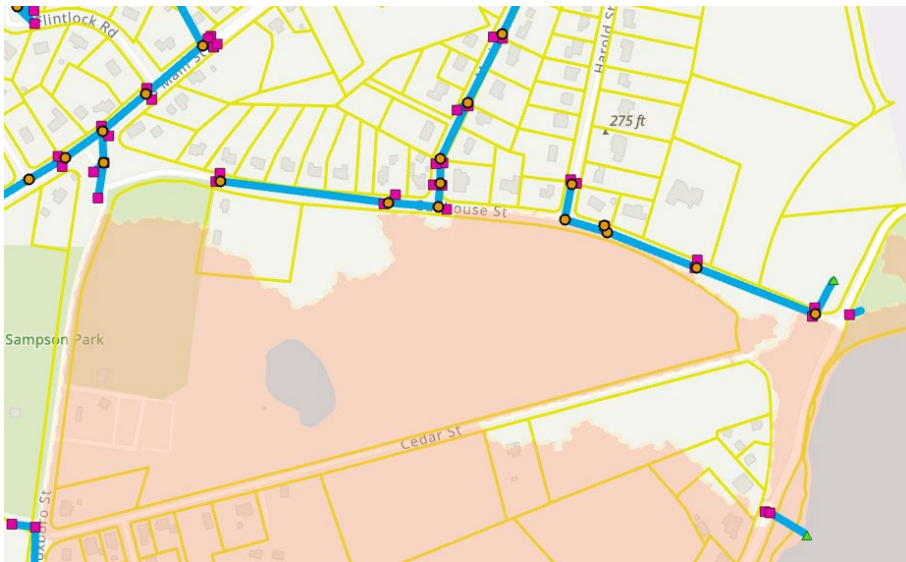
Date Assessed: 09/19/2024 2:50 PM

ID#: OID56	
Description: 60 cedar st	Weather:
	
PARCEL CHARACTERISTICS	
Land Use 1: Open space	High Vehicle Traffic? No
Land Use 2:	If yes, description:
Soil Type: HSG A	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: Park - dog space project
Waste Storage/Dumpsters? No	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: Medium Potential	
Site ID:	Catch Basin Inlet Grate?
High Groundwater? No	Curb Inlet?
If yes, description:	Drainage Depression/Pathway?
If other:	Existing Drainage Condition:
Bedrock? No	Drainage Blocked or Clogged?
Exposed Rock?	Drainage Damage?
Boulders?	Unmaintained Drainage:
Other Rock? -	Site Erosion?
Slope? Yes -	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? No	Fiber Optics Cables?
If yes, description:	Gas Lines?
Drainage Infrastructure? Unknown	Overhead Wires?
Manhole?	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area:

Existing BMP? No

Does existing drain network discharge to wetland or stream? No

What is the existing BMP?

Constructability: Easy

BMP Opportunities: Parking area of dog park

BMP Photo 1



Proposed BMP Type: Infiltration Cell, Sediment Forebay, Permeable Pavement

Other:

BMP Photo 2



BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

Date Assessed: 09/19/2024 2:58 PM

ID#: OID57	
Description: 63 Harding st	Weather:
	
PARCEL CHARACTERISTICS	
Land Use 1: Open space	High Vehicle Traffic? No
Land Use 2:	If yes, description:
Soil Type: HSG A	High Pedestrian Traffic? No
Uncovered Loading Bay? No	If yes, description:
Waste Storage/Dumpsters? No	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: Medium Potential	
Site ID:	Catch Basin Inlet Grate? Yes
High Groundwater? No	Curb Inlet? No
If yes, description:	Drainage Depression/Pathway? No
If other:	Existing Drainage Condition: Functional
Bedrock? No	Drainage Blocked or Clogged? No
Exposed Rock?	Drainage Damage? No
Boulders?	Unmaintained Drainage: No
Other Rock? -	Site Erosion? Yes
Slope? Yes -	If other:
Is the site flat? No -	Additional Utilities: Yes
Trash/Sediment Build-up? No	Fiber Optics Cables? No
If yes, description:	Gas Lines? No
Drainage Infrastructure? Yes	Overhead Wires? Yes
Manhole? No	Other Utility? No

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area:

Existing BMP? No

Does existing drain network discharge to wetland or stream? No

What is the existing BMP?

Constructability:

BMP Opportunities:

BMP Photo 1

Proposed BMP Type: Rain Garden, Bioretention Cell, Infiltration Cell, Constructed Wetland, Sediment Forebay



Other:

BMP Photo 2



BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

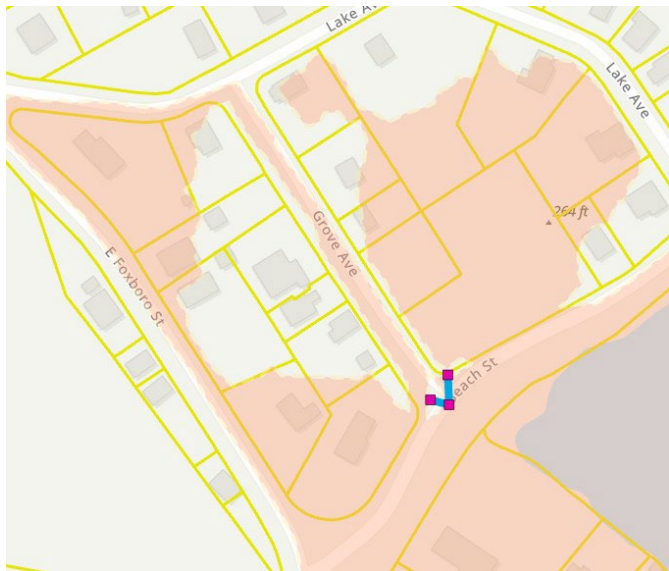
Date Assessed: 09/23/2024 3:00 PM

ID#: OID58	
Description: Grove Ave	Weather:
	
PARCEL CHARACTERISTICS	
Land Use 1: Open space	High Vehicle Traffic? No
Land Use 2:	If yes, description:
Soil Type: HSG A, HSG B, HSG D	High Pedestrian Traffic? No
Uncovered Loading Bay? No	If yes, description:
Waste Storage/Dumpsters? No	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: Low Potential	
Site ID:	Catch Basin Inlet Grate? Yes
High Groundwater? No	Curb Inlet? No
If yes, description:	Drainage Depression/Pathway? Yes
If other:	Existing Drainage Condition: Functional but poor
Bedrock? No	Drainage Blocked or Clogged? No
Exposed Rock?	Drainage Damage? No
Boulders?	Unmaintained Drainage: Yes
Other Rock? -	Site Erosion? No
Slope? Yes -	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? No	Fiber Optics Cables?
If yes, description:	Gas Lines?
Drainage Infrastructure? Yes	Overhead Wires?
Manhole? No	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area:

Existing BMP? No

Does existing drain network discharge to wetland or stream? Yes

What is the existing BMP?

Constructability: Moderate

BMP Opportunities:

BMP Photo 1

Proposed BMP Type: Sediment Forebay



Other:

BMP Photo 2



BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

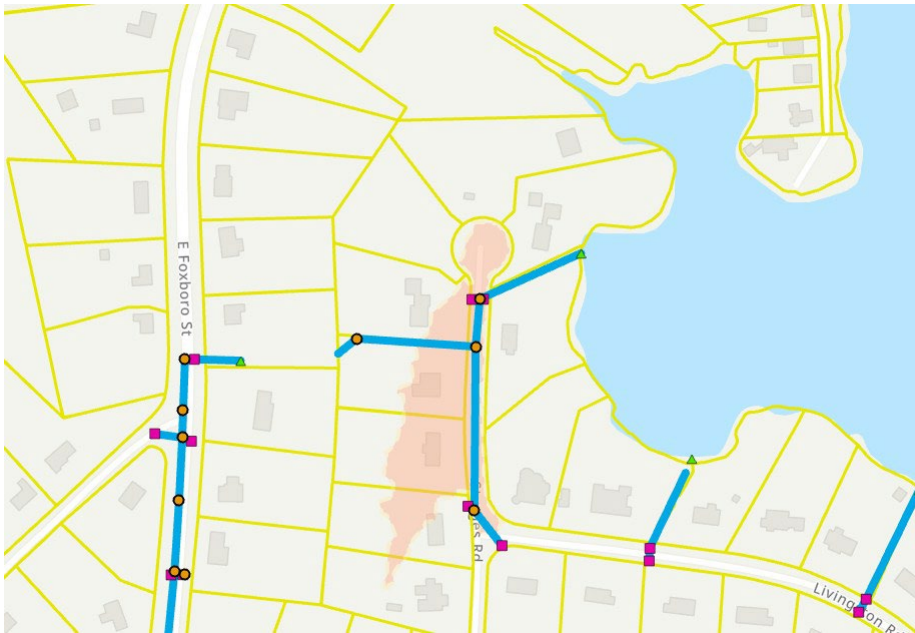
Date Assessed: 09/23/2024 3:00 PM

ID#: OID59	
Description: 26 sturges Rd/wetlands	Weather:
 Esri, NASA, NGA, USGS, FEMA Esri Community Maps Contrib... Powered by Esri	
PARCEL CHARACTERISTICS	
Land Use 1: Open space	High Vehicle Traffic? No
Land Use 2:	If yes, description:
Soil Type: HSG A	High Pedestrian Traffic? No
Uncovered Loading Bay? No	If yes, description:
Waste Storage/Dumpsters? No	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: Medium Potential	
Site ID:	Catch Basin Inlet Grate?
High Groundwater? No	Curb Inlet?
If yes, description:	Drainage Depression/Pathway?
If other:	Existing Drainage Condition:
Bedrock? No	Drainage Blocked or Clogged?
Exposed Rock?	Drainage Damage?
Boulders?	Unmaintained Drainage:
Other Rock? -	Site Erosion?
Slope? Yes -	If other:
Is the site flat? Yes -	Additional Utilities: Yes
Trash/Sediment Build-up? Yes	Fiber Optics Cables? No
If yes, description: Edge of cul de sac across from lake	Gas Lines? No
Drainage Infrastructure? No	Overhead Wires? Yes
Manhole?	Other Utility? No

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area:

Existing BMP? No

Does existing drain network discharge to wetland or stream? Yes

What is the existing BMP?

Constructability: Moderate

BMP Opportunities: Remove curb, channel into wetland with sediment for way

Proposed BMP Type: Water Quality Swale, Hydrodynamic Separator, Oil and Grit Separator, Sediment Forebay

Other:

BMP Photo 1



BMP Photo 2



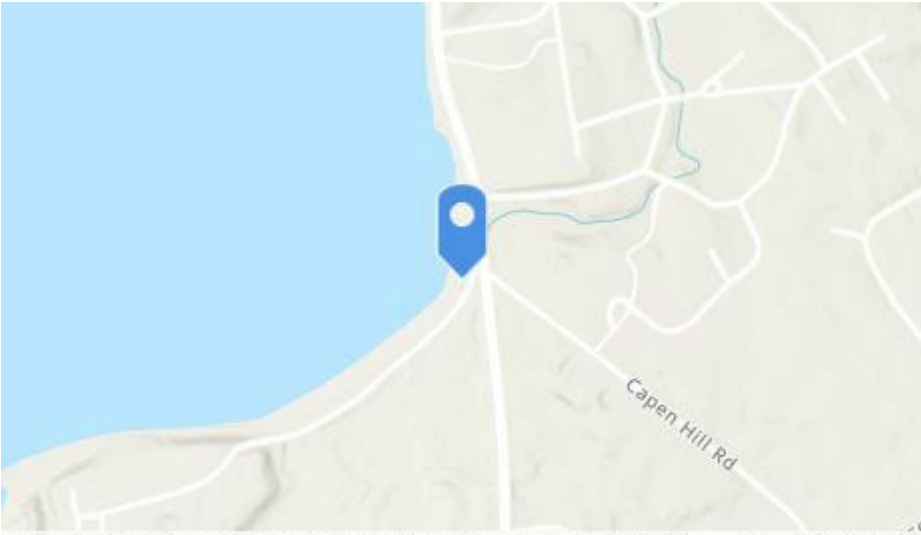
BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

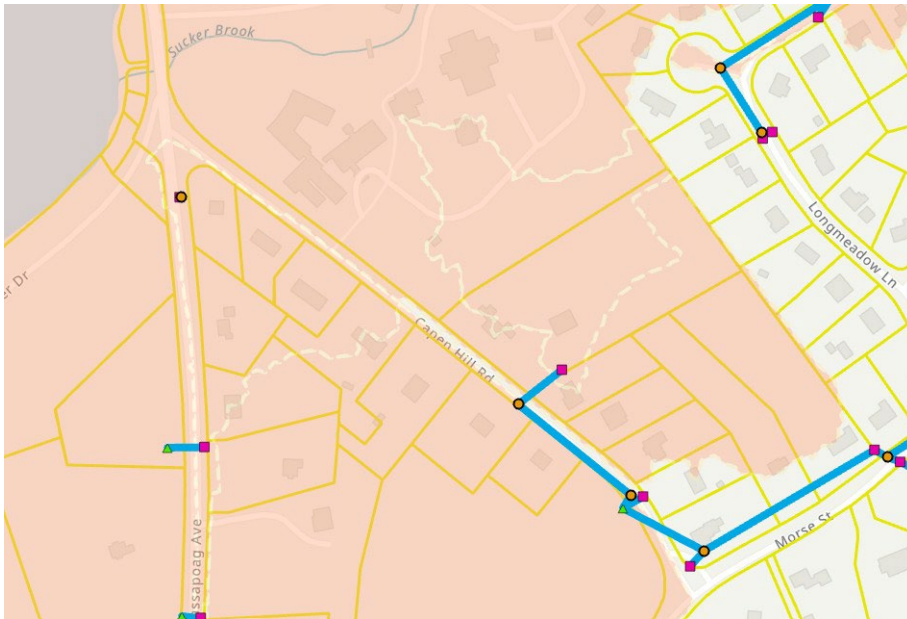
Date Assessed: 09/23/2024 3:00 PM

ID#: OID60	
Description: Capen Hill Rd	Weather:
 Esri, NASA, NGA, USGS, FEMA Esri Community Maps Contrib... Powered by Esri	
PARCEL CHARACTERISTICS	
Land Use 1: ROW	High Vehicle Traffic? Yes
Land Use 2:	If yes, description: Row
Soil Type: HSG A, HSG B, HSG D	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: Near community center
Waste Storage/Dumpsters? No	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: Medium Potential	
Site ID:	Catch Basin Inlet Grate?
High Groundwater? No	Curb Inlet?
If yes, description:	Drainage Depression/Pathway?
If other:	Existing Drainage Condition:
Bedrock? No	Drainage Blocked or Clogged?
Exposed Rock?	Drainage Damage?
Boulders?	Unmaintained Drainage:
Other Rock? -	Site Erosion?
Slope? Yes -	If other:
Is the site flat? Yes -	Additional Utilities: Yes
Trash/Sediment Build-up? No	Fiber Optics Cables? No
If yes, description:	Gas Lines? Yes
Drainage Infrastructure? No	Overhead Wires? Yes
Manhole?	Other Utility? No

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area:

Existing BMP? No

Does existing drain network discharge to wetland or stream? Yes

What is the existing BMP?

Constructability: Moderate

BMP Opportunities: ROW options. Look for opportunities upstream (further up Capen Hill) within ROW space

BMP Photo 1



Proposed BMP Type: Rain Garden, Bioretention Cell, Infiltration Cell, Sediment Forebay

Other:

BMP Photo 2



BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

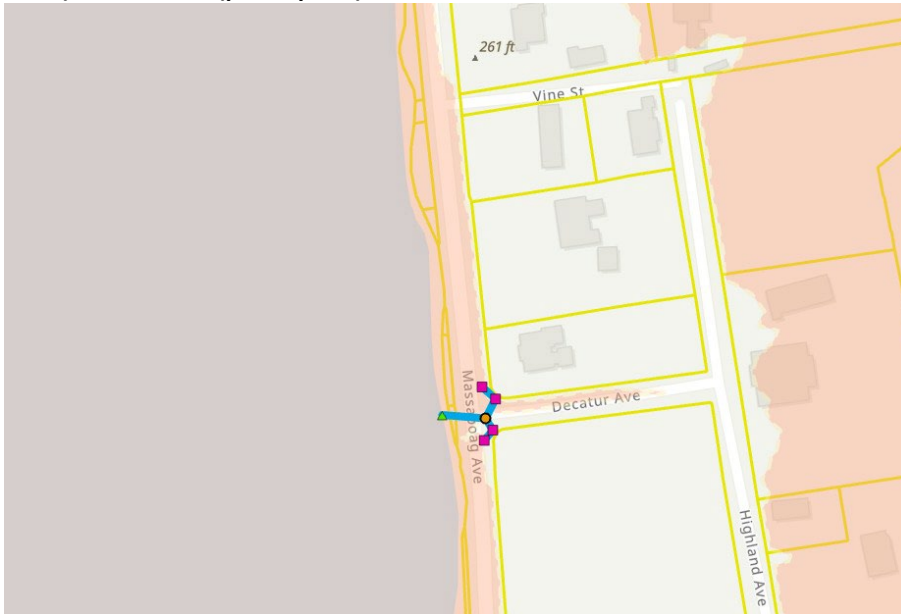
Date Assessed: 09/23/2024 3:00 PM

ID#: OID61	
Description: Decatur st at Massapoag Ave	Weather:
	
PARCEL CHARACTERISTICS	
Land Use 1: Row	High Vehicle Traffic? Yes
Land Use 2:	If yes, description: Row
Soil Type: Unknown	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: Walking path
Waste Storage/Dumpsters? No	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: Low Potential	
Site ID:	Catch Basin Inlet Grate? Yes
High Groundwater? No	Curb Inlet? No
If yes, description:	Drainage Depression/Pathway?
If other:	Existing Drainage Condition: Functional
Bedrock? No	Drainage Blocked or Clogged? No
Exposed Rock?	Drainage Damage? No
Boulders?	Unmaintained Drainage: No
Other Rock? -	Site Erosion? Yes
Slope? Yes -	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? No	Fiber Optics Cables?
If yes, description:	Gas Lines?
Drainage Infrastructure? Yes	Overhead Wires?
Manhole? No	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area:

Existing BMP? No	Does existing drain network discharge to wetland or stream? No
What is the existing BMP?	Constructability: Moderate
BMP Opportunities: Row?	BMP Photo 1 
Proposed BMP Type: Rain Garden, Oil and Grit Separator, Sediment Forebay, Permeable Pavement, Stormwater Planters	
Other:	

BMP Photo 2



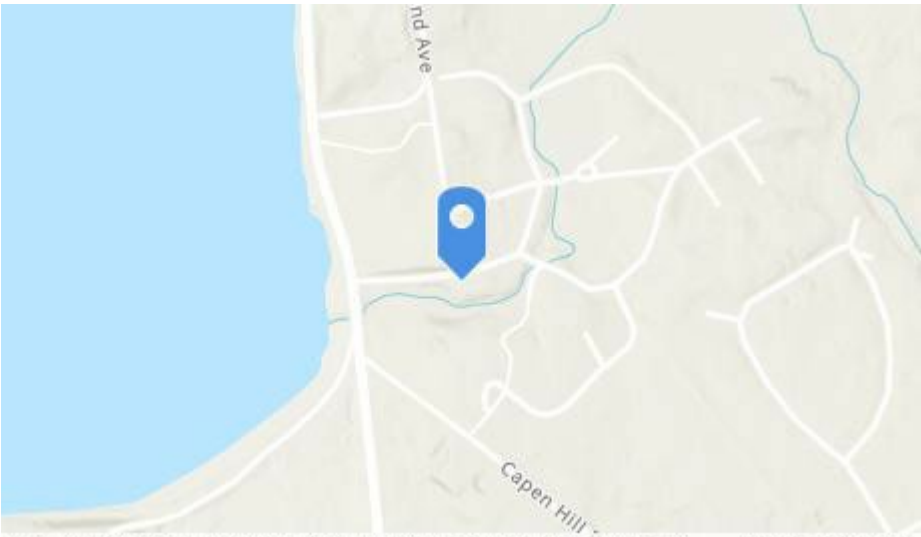
BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

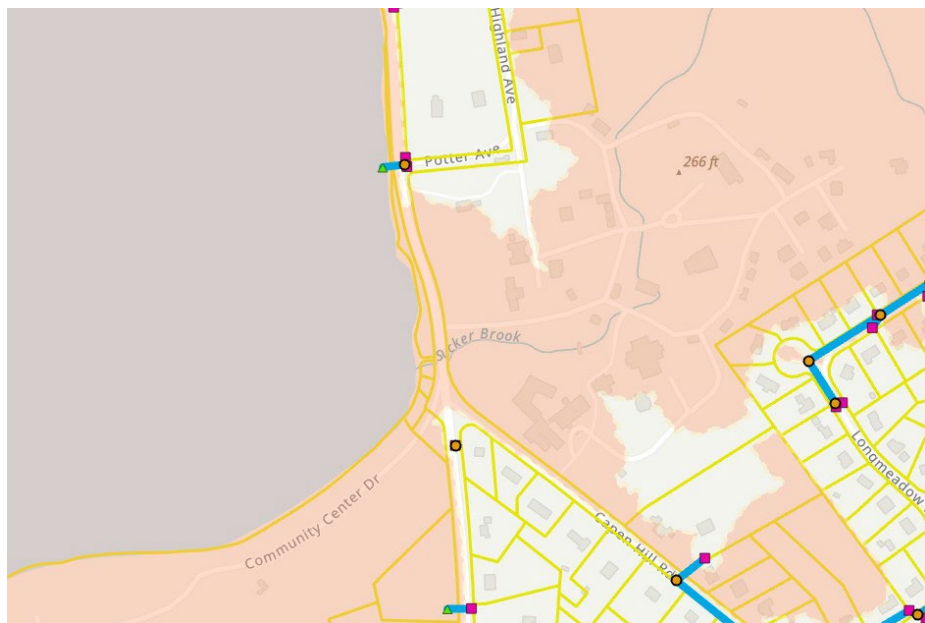
Date Assessed: 09/23/2024 3:00 PM

ID#: OID62	
Description: Camp wonderland	Weather:
	
PARCEL CHARACTERISTICS	
Land Use 1: Open space	High Vehicle Traffic? No
Land Use 2:	If yes, description:
Soil Type: HSG A	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description: Park
Waste Storage/Dumpsters? No	Active Landscaping Program? Yes

BMP SITE DESCRIPTION	
BMP Opportunity Potential: High Potential	
Site ID:	Catch Basin Inlet Grate?
High Groundwater? No	Curb Inlet?
If yes, description:	Drainage Depression/Pathway?
If other:	Existing Drainage Condition:
Bedrock? No	Drainage Blocked or Clogged?
Exposed Rock?	Drainage Damage?
Boulders?	Unmaintained Drainage:
Other Rock? -	Site Erosion?
Slope? Yes -	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? No	Fiber Optics Cables?
If yes, description:	Gas Lines?
Drainage Infrastructure? No	Overhead Wires?
Manhole?	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area:

Existing BMP? No

Does existing drain network discharge to wetland or stream? Yes

What is the existing BMP?

Constructability: Easy

BMP Opportunities: Under picnic area

BMP Photo 1

Proposed BMP Type: Rain Garden, Bioretention Cell, Infiltration Cell



Other: Note: Sucker Brook is a source of elevated *E. coli*

BMP Photo 2

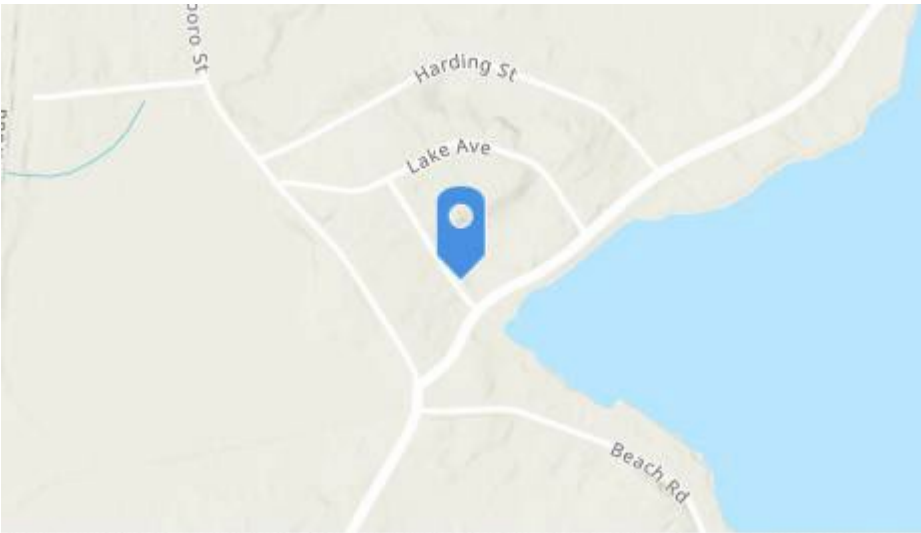


BMP Photo 3

BMP Parcel Survey Results

Assessed by: Anna

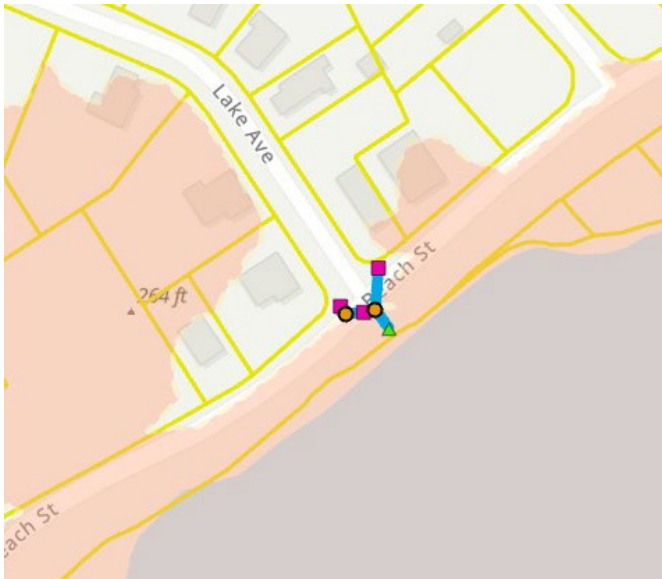
Date Assessed: 09/23/2024 3:00 PM

ID#: OID63	
Description: 147 Beach St (Beach St Wetlands and Lake Ave)	Weather:
	
Esri, NASA, NGA, USGS, FEMA Esri Community Maps Contrib... Powered by Esri	
PARCEL CHARACTERISTICS	
Land Use 1: Open space	High Vehicle Traffic? No
Land Use 2:	If yes, description:
Soil Type: HSG A, HSG B, HSG D	High Pedestrian Traffic? No
Uncovered Loading Bay? No	If yes, description:
Waste Storage/Dumpsters? No	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: Low Potential	
Site ID:	Catch Basin Inlet Grate? Yes
High Groundwater? No	Curb Inlet? No
If yes, description:	Drainage Depression/Pathway? Yes
If other:	Existing Drainage Condition: Functional but poor
Bedrock? No	Drainage Blocked or Clogged? No
Exposed Rock?	Drainage Damage? No
Boulders?	Unmaintained Drainage: Yes
Other Rock? -	Site Erosion? No
Slope? Yes -	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? No	Fiber Optics Cables?
If yes, description:	Gas Lines?
Drainage Infrastructure? Yes	Overhead Wires?
Manhole? No	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area:

Existing BMP? No

Does existing drain network discharge to wetland or stream? Adjacent to wetlands

What is the existing BMP?

Constructability: Moderate

BMP Opportunities: ROW space (see note in other)

BMP Photo 1



Proposed BMP Type: Sediment Forebay, rain garden,

Other: ROW is wider than current street, available area along Beach St that is town owned. Additionally, Lake Ave has history of flooding issues due to water running down Lake Ave during wet weather.

BMP Photo 2



BMP Photo 3



BMP Parcel Survey Results

Assessed by: Anna

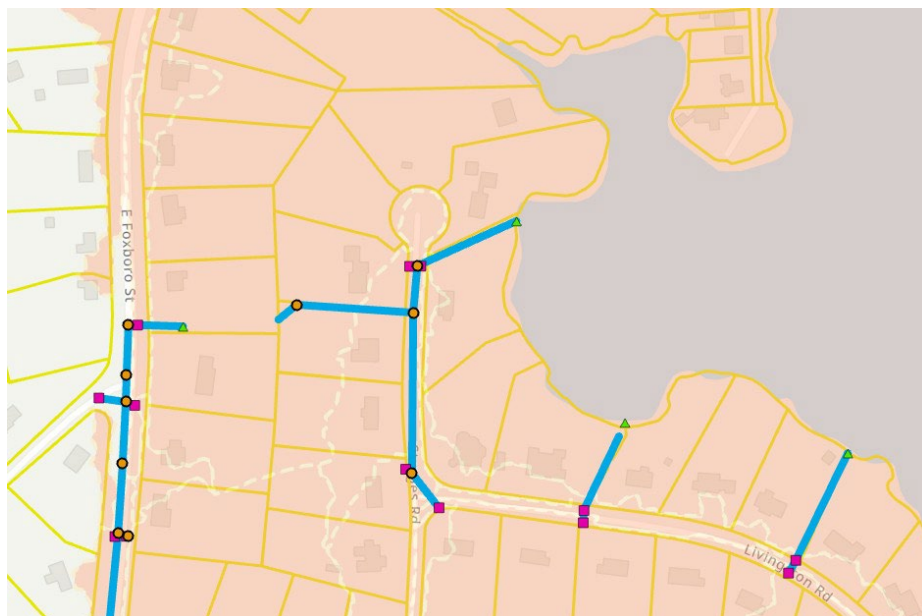
Date Assessed: 09/23/2024 3:00 PM

ID#: OID64	
Description: Sturges Rd Neighborhood beach	Weather:
 Esri, NASA, NGA, USGS, FEMA Esri Community Maps Contrib... Powered by Esri	
PARCEL CHARACTERISTICS	
Land Use 1: Open space	High Vehicle Traffic? No
Land Use 2:	If yes, description:
Soil Type: HSG A	High Pedestrian Traffic? Yes
Uncovered Loading Bay? No	If yes, description:
Waste Storage/Dumpsters? No	Active Landscaping Program? No

BMP SITE DESCRIPTION	
BMP Opportunity Potential: Medium Potential	
Site ID:	Catch Basin Inlet Grate?
High Groundwater? No	Curb Inlet?
If yes, description:	Drainage Depression/Pathway?
If other:	Existing Drainage Condition:
Bedrock? No	Drainage Blocked or Clogged?
Exposed Rock?	Drainage Damage?
Boulders?	Unmaintained Drainage:
Other Rock? -	Site Erosion?
Slope? Yes -	If other:
Is the site flat? Yes -	Additional Utilities: No
Trash/Sediment Build-up? No	Fiber Optics Cables?
If yes, description:	Gas Lines?
Drainage Infrastructure? No	Overhead Wires?
Manhole?	Other Utility?

EXISTING BMP AND PROPOSALS

Site Map: Catchment Area (orange), Parcel (yellow), Outfall (green triangle), Storm pipe (blue line), Man Hole (orange circle), Catch basin (pink square)



Suggested BMP Area:

Existing BMP? No

Does existing drain network discharge to wetland or stream? No

What is the existing BMP?

Constructability: Easy

BMP Opportunities: Infiltration

Proposed BMP Type: Rain Garden, Bioretention Cell, Water Quality Swale, Infiltration Cell, Sediment Forebay

Other:

BMP Photo 1



BMP Photo 2



BMP Photo 3





Appendix E: Storm Drain Outfalls Survey for Watershed-Based Plan for Lake Massapoag 2026-2050

Josh Philibert,
Conservation
Administrator,
Town of Sharon

Outfalls Smoke Tested and Monitored Lake Massapoag Eastern Shore

1. Parcel is 55 Massapoag Ave. Owner – Evelyn Rohrbacher. Three pipes cast into retaining wall across from Arborio Drive. No drainage easement or public property nearby. Access from the water or through the woods between parcels. Shown on GIS Drainage Group.



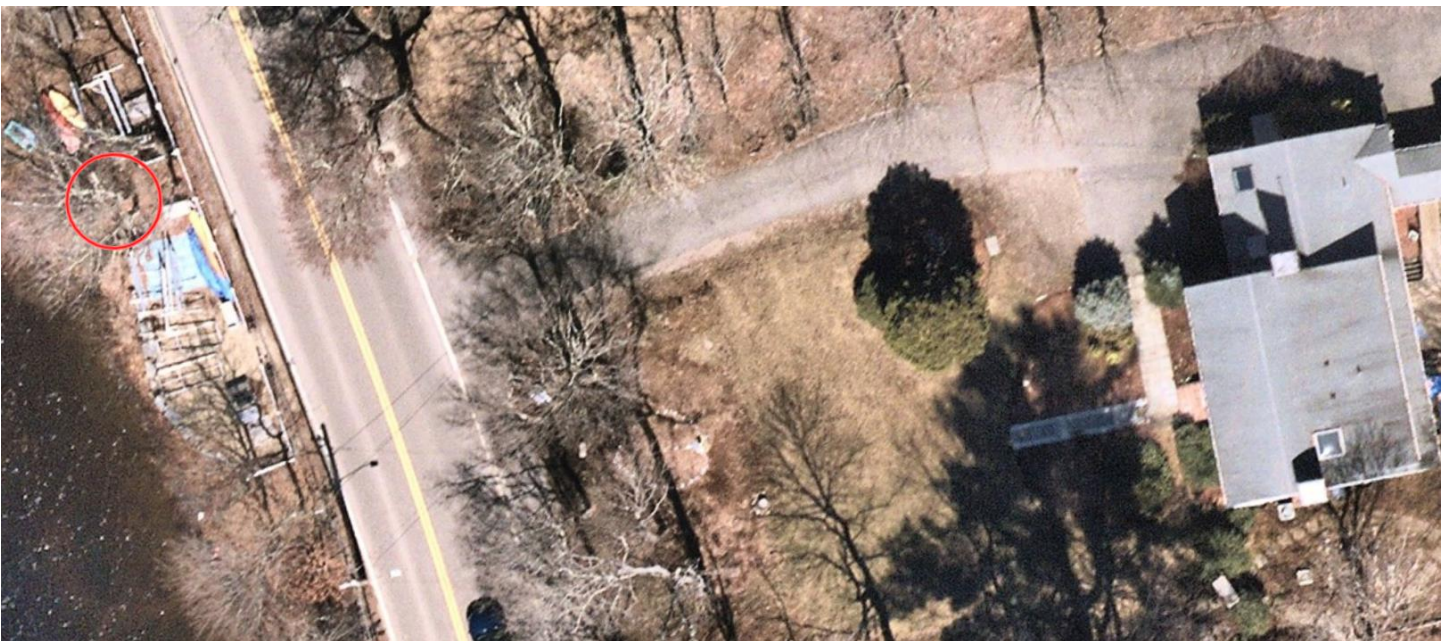
2. Parcel is the waterfront at 90 Massapoag Ave. between the house lots for 90 and 100 Massapoag Ave. (these are adjacent parcels). Owner – William Tanzer. The pipe is across from the driveway for 100 Massapoag Ave. Access is off the street by the fence. No easement present. Shown on GIS Drainage Group.



3. Parcel is 116 Massapoag Ave. Owner – Bryan Cetlin. Reinforced concrete pipe in the brush across the street from the driveway at 116 Massapoag Ave. Pipe is shown on GIS Drainage Group. Catch basin in the road.



4. Parcel is 120 Massapoag Ave. Owner Edna McNeil. Pipe is shown on GIS Drainage Group, across from the driveway to 130 Massapoag Ave. No easement shown. Catch basin on roadway.

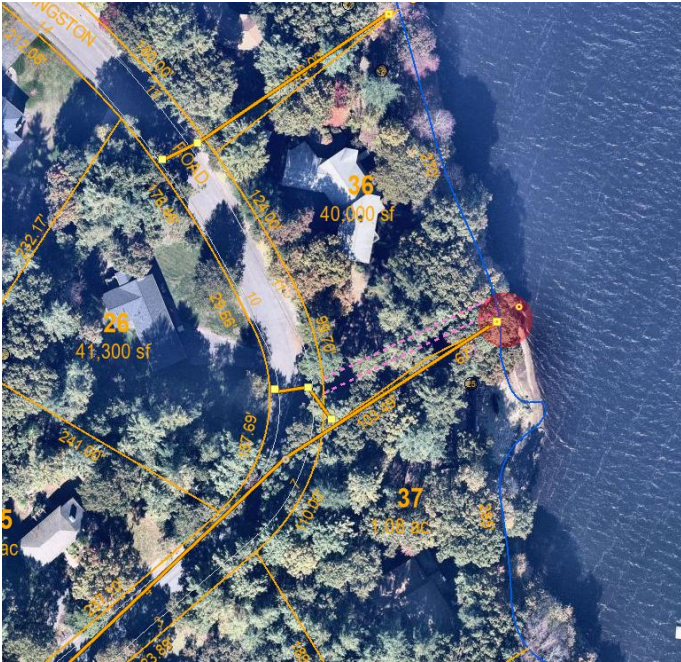


Lake Massapoag Fletchers Cove and Western Shore to the South

5. There is a drainage easement on 31 Livingston Road that discharges near the lake. The location is shown on the GIS Drainage Group. There is some vegetation between the outfall and the lake.



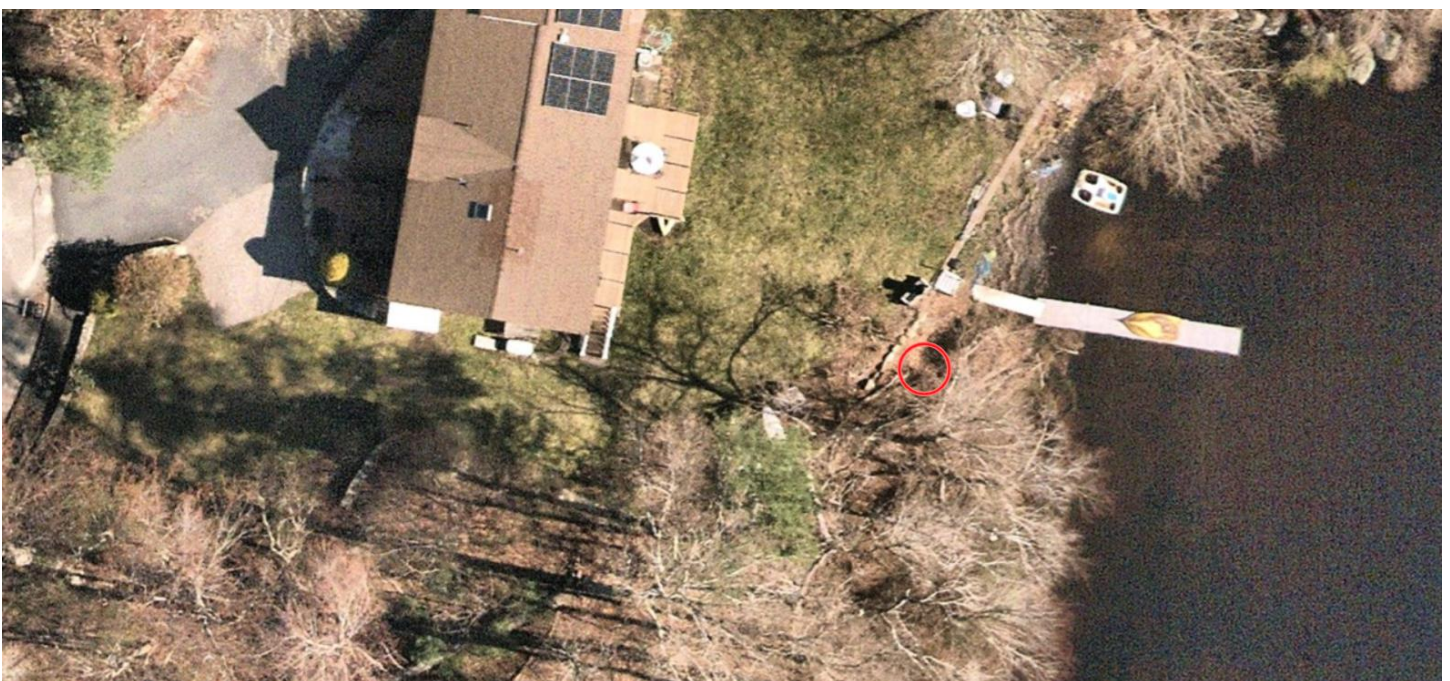
6. The parcel at 11 Livingston Road has a drainage easement that leads to an outfall. The pipe is shown on the GIS Drainage Group between 7 and 11 Livingston Road. There is a storm drain at the street. There is a good deal of erosion in the sand on the shore. We did not find an outfall between 13 and 19 Livingston Road. It may be set back away from the lake edge.



7. Between 19 and 21 Livingston Road is a drainage easement with a RCP storm drain outfall. The outfall is accessible from the street by walking between the yards or from the water's edge. This outfall is not shown on the GIS Drainage Group. The house in the back of the first image is 21 Livingston Road.



8. To the left of the dock at 25 Sturges is an outlet. The town GIS shows an outlet in a different location, but there is no indication of an outlet as shown. There is an easement that extends from Sturges Road to the outlet shown in the images below.





N.B. There are two catch basins shown on the town GIS with an outlet between 11 and 15 Livingston (these are adjacent parcels). There are no catch basins on the road at this location and no indication of an outlet.



Appendix F:
SEPTIC SYSTEM SURVEY
FOR WATERSHED-BASED
PLAN FOR LAKE
MASSAPOAG 2026-2050

Susan Peck

ANALYSIS OF SEPTIC SYSTEMS WITHIN THE LAKE MASSAPOAG SURFACE WATER PROTECTION DISTRICT

April 7, 2026

By Susan Peck, M.A. Environmental Health Management, Harvard School of Public Health for the Lake Massapoag Advisory Committee

Table of Contents

Introduction.....	1
Section 1. Septic Systems: What They Are, How They Work, What Makes Them Fail	4
How do they work?	4
What reduces a Septic System's ability to protect the environment or human health?	5
Section 2. How Did Title 5 And Town Of Sharon Rules Improve The Effectiveness Of Septic Systems?	7
Section 3. How Do Septic Systems Impact Nutrient Pollution	8
Nitrogen.....	9
Phosphorus.....	9
Section 4. How Protective Are Septic Systems In The Surface Water Protection District?.....	13
Title 5 Inspections.....	13
System Pumping.....	20
Garbage Disposals.....	21
Homeowner Education and Information.....	22
How well are the systems designed?	23
Post-1996 Systems.....	24
Pre 1996 Septic Systems	25
Section 5. Systems Of Concern	30
System Attributes of Concern	30
Counts of Systems of Particular Concern	35
Section 6. Zoning Board Of Appeals Variances	37
Section 7. Recommendations (Draft)	38
Ensuring the continued effectiveness of the Septic Systems around the lake	38
Controlling Phosphorus	41
Section 8. The Database.....	42

Introduction

In response to concerns that failing or badly designed septic systems are contributing to water quality problems in Lake Massapoag, the Lake Massapoag Advisory Committee requested an assessment of the status of the septic systems in the surface water protection district (SWPD) -- the part of town from which ground and surface waters flow into the lake. This report provides the findings from a review of all of the information on septic systems installed in the SWPD in the online digitized Property Files maintained by the Department of Public Work's Engineering Division as of 2024 when the information on each lot in the SWPD was pulled from the town's property data base. The report would not have been possible without the patient help of the Engineering Division, and the author is grateful for their assistance. The information collected on the systems and the computations used to create this report is stored in an Excel Workbook.

Based on this file review, it can be reasonably asserted that the 933 residential and smaller nonresidential commercial or institutional systems (Bilingual Montessori School of Sharon, Sapphire Estate, Congregation Adath Sharon, the Evangelical Baptist Church, and Massapoag Yacht Club), as well as the Sharon High School (also serving Memorial Beach and the Middle School campus which includes the Preschool and Sharon Public School Administration Staff), Sharon Community Center, Everwood Day Camp, and The Salvation Army Camp Wonderland and Conference Center systems located in the SWPD are not now a meaningful source of pathogenic contamination. This represents a change since 1995 when the state upgraded "Title 5", the statewide septic systems regulations originally promulgated in 1971 and tightened in 1978 with new, more stringent standards and the Sharon Engineering Division, Health Department, and Board of Health began working diligently and expertly to enforce the new, more protective and more complex requirements. In addition to upgrading the design and installation standards, these new rules required the completion of "Title 5" inspection and, if necessary, repair or replacement of septic systems prior to the transfer of a home to a non-immediate family member.

Since the new standards went into effect in 1996, all of the large non-residential systems have been upgraded to current standards with the exception of the Camp Gannett portion of Everwood which is leased from the nonprofit owner and former camp operator Elizabeth Peabody House. There are also some remaining questions about the adequacy of the systems at Camp Wonderland and the Salvation Army Convention Center complex due to the high E. coli counts in Sucker Brook, although a Massachusetts Department of Environmental Protection inspection several years ago did not reveal any problems. The Sharon Middle School campus and Memorial Beach restrooms were upgraded through connection to the new system at the High School.

The systems at the Camp Wonderland and Conference Center, Everwood Day Camp, Sharon High School, and the Community Center were too complex to include in the analysis and have been excluded in the summary counts included in the rest of the report

In 1995, when Title 5 took effect, there were 873 residential and small commercial/institutional systems in the SWPD. As of 2023 an additional 60 homes had been constructed and were subject to the new more protective standards, and 78% of the “pre 1996 systems” had been replaced, repaired, or shown through inspection to be both functioning properly and located above groundwater. Specifically:

- 374 (43%) had been replaced with 1996+ Systems in compliance with the new rules). This work included removing at least 103 cesspools (simple perforated tanks or cinder block underground structures that allow untreated wastewater to flow directly into the soil and were banned from new construction in the late 1960s) and 271 other systems that were either releasing wastewater directly into the groundwater, not treating the wastewater properly and/or allowing it to break out on the surface of the yard.
- Of the remaining 499 pre1996 systems in the watershed:
 - 186 (21%) systems had been shown through a Title 5 inspection to be functioning properly and located entirely above groundwater at the time of inspection.
 - 118 (14%) systems had replaced or repaired components (such as leaking or broken septic tanks, distribution boxes, and piping). 90 of these repairs were triggered by a “conditional pass” on a Title 5 inspection, and 28 were undertaken without a conditional pass.
 - This leaves 195 unreplaced, uninspected, or unrepaired pre-1996 systems in the SWPD -- 39% of the remaining systems and, 22% of systems present in 1995.

Much of this progress has been due to the mandatory Title 5 System inspections that are required when a property changes hands. 300 (80%) of the 374 properties with an upgraded system were transferred to a new owner since Title 5 went into effect. Only 74 of the upgrades occurred without an ownership change that mandated an inspection. In addition, over three quarters of the repairs or replacement of septic system components resulted from an inspection.

However, many systems have never been subject to the Title 5 inspection requirement and Title 5 compliance is not universal. 146 systems have not been inspected because they are either a pre1996 system that has not changed hands since 1995 or a 1996+ system that has not changed hands since it was installed. Further 202 of the most recent transfers were exempt from the inspection requirement because the new owner was a parent, child, sibling, or spouse. Finally, based on the information the required inspection was not conducted upon the most recent transfer of 108 systems. As a result, 53% of the systems

in the watershed have never been inspected: 45% of the 499 pre 1996 systems, and 63% of the 434 systems installed after Title 5 took effect in 1996.

Timely septic tank pumping and the avoidance of garbage disposals, which are banned in Sharon, are both key to proper system function. Failing to regularly pump a system and the use of garbage disposals can lead to premature system failure resulting in raw sewage spilling into the yard or the home. Title 5 inspectors have observed that garbage disposals at 31% of the residences in the surface water protection district that they have inspected. The town tracks septic tank pumping. 59% of the systems have been pumped in the last five years, 19 % have not been pumped in 15 or more years since installation. This includes 73 pre 1996 systems that do not appear to have been pumped.

However, while the septic systems in the watershed are largely preventing pathogens from reaching the lake, they are not preventing Phosphorus, a nutrient that promotes weeds, algae, and cyanobacteria growth in the lake. Properly designed, installed, and maintained septic systems remove only a small percentage of phosphorus from the wastewater. In the initial years after installation, phosphorus is removed by adsorption onto particles in the column of soil between the bottom of the system and the top of the underlying groundwater table. Eventually the adsorption sites in soil are depleted and the phosphorus moves, untreated, with the groundwater directly into the lake or into the brooks and swamps that feed Lake Massapoag. An estimated 1053 pounds of phosphorus in human waste is discharged to groundwater in the surface water protection district each year. This number includes the discharge from the wastewater treatment system at the High School as well as the camps, conference center and community center.

This report has the following sections

- Section 1 Septic System: What they are, how they work, and what makes them fail
- Section 2: How the 1995 Title 5 made Septic Systems more protective of the environment?
- Section 3: How Septic Systems affect the nutrient pollution that fuels algae and cyanobacteria growth in the lake
- Section 4: How well are the systems in the SWPD are functioning?
- Section 5: To what extent do the septic systems in the SWPD Septic Systems meet the current design standards?
- Section 6: Systems of Concern
- Section 7: Zoning Board of Appeals role in septic management

Section 1. Septic Systems: What They Are, How They Work, What Makes Them Fail

Modern septic systems consist of a septic tank and a soil absorption system (SAS). The septic tank is a settling tank that removes most of the solids and fats from the wastewater before it flows to the SAS. The SAS is a series of underground perforated pipes or chambers that further treats the wastewater through the action of “good” naturally occurring microbes and releases the cleansed wastewater underground where it flows down to the groundwater below the system. Some systems include small treatment units that remove additional organic material and nitrogen.

How do they work?

When the wastewater from toilets, sinks, showers and washing machines enters the septic tank, the fats and oils in the wastewater float to the top and the solids settle to the bottom where they and any disease-causing pathogenic microorganisms (bacteria, viruses, fungi, protozoa) are partially consumed by the “good” microorganisms in the tank. Because the settling process takes time, the wastewater must remain in the tank long enough for this separation to occur. Current standards require 48 hours of settling and as a result, modern septic tanks must be large enough to hold on average two days’ worth of wastewater.

As new wastewater enters the tank, an equivalent amount of the partially treated wastewater is pushed out to the SAS through a pipe situated below the bottom of the fat layer and above the level of the settled solids. The SAS is preceded by a “Distribution Box”, that improves treatment efficiency by evenly distributing the septic tank effluent throughout the SAS. Like the septic tank, the SAS is also sized so that the wastewater stays in the system long enough for “good” microbes to digest the remaining organic material in the wastewater and to kill most of the remaining pathogenic microbes and parasites that can cause disease.

The treated wastewater gradually flows out of the SAS into the soil below. As the wastewater percolates down to the groundwater table, soil microbes and conditions kill off or remove the remaining pathogens and organic matter. In addition, for the first years after SAS installation, the soil filters out most of phosphorus in the wastewater.

Once the treated effluent reaches the groundwater, it is slowly carried (a few feet or less per day, depending on the type of soil) to the lake or to swamps and streams that feed the lake. Further biological treatment and phosphorus filtration is limited in the groundwater due to its temperature and oxygenation, however any remaining pathogens and bacteria will die off over time. Because of the treatment and filtration of the soil and the die off of pathogens in the groundwater, the greater the separation of the bottom of the SAS from groundwater and the more distant the SAS from the lake or surface water that feeds the lake, the cleaner the wastewater reaching the lake.

What reduces a Septic System's ability to protect the environment or human health?

Systems will not protect public health and the environment if they are not functioning properly or were not properly designed and installed. They are not functioning properly if untreated sewage backs up into the home or overflows onto the ground, sidewalks, streets, surface water, or into storm drains.

This can happen if:

- The septic tank has become overloaded with fats and solids or clogged by other substances that they are not designed to handle.
- The SAS has become clogged with tree roots, excess fats and solids spilling over from an overfull septic tank, or by an impermeable mat of organic material which formed at the bottom of the SAS due to excess loading or too little oxygen in the system to digest organic material.
- The distribution system is leaking or broken or does not distribute the septic tank effluent properly
- The septic tank or pipes are leaking because they are corroded or broken
- The pump to a raised system failed.
- A special "advanced treatment" system is not operating properly.

These problems are generally caused by improper maintenance and use of the system.

The main culprits are:

- Putting substances down the drain or toilet that the system is not designed to handle or that can kill the microorganisms that make it function. These include chemicals such as paints, strong acids and bases or cleaning chemicals, pharmaceuticals, paper products other than septic safe toilet paper such as wipes, sanitary products, paper towels, cigarette butts or other solid material, excess fats and oils, and food waste. Garbage grindings can quickly overwhelm a system.
- Not maintaining pumps and advanced treatment systems properly so the wastewater isn't adequately treated.
- Driving, parking or construction on top of underground components which can damage them as well as deprive the good microbes of the oxygen needed to keep the SAS operating properly.
- Allowing trees or large bushes to grow on top of SAS or septic tank which can cause roots to infiltrate the system and either break components or cause the SAS to clog.
- Not pumping solids and oils and fats out of a septic tank regularly.

Failing to pump out a septic tank causes a cascade of problems. As the tank fills with solids and fats, there is decreasing room for the incoming wastewater. As a result, the amount of time the wastewater remains in the tank decreases, and by extension the removal of solids and fats declines. This means that increasing levels of fats and solids

remain in the wastewater that flows into the distribution box and the SAS. Eventually the tank will become so full that the accumulated solids and fats reach the outfall pipe and are washed out of the tank with the wastewater.

Excess solids and fats can clog the bottom of the field directly. They also can overwhelm the biological action that breaks down organic material. When that stops, not only is the wastewater not treated, the mat or clog at the bottom of the field gets thicker and thicker until the wastewater starts backing up in the SAS. These materials can also damage the distribution box with the result that the wastewater is loaded into the SAS unevenly putting an added strain on the areas that receive a higher burden. When the septic tank can no longer drain out of the SAS into the ground it either backs up into the yard, or into the home.

In addition to protecting the SAS, regular pumping can provide early warning of silent failures while they can be fixed without replacing the entire system. The pumping technicians often identify early signs of SAS back up or damaged distribution boxes, corroding or leaking tanks or piping, or signs that the homeowner is disposing of things that should not be put down the drain. They also can provide homeowners with an assessment of how frequently a system should be pumped.

A properly functioning system is only as good as the design and installation:

- The soils must be suitable for a leaching field – some soils are so “tight” that the wastewater cannot percolate out of the system as fast as it comes in, resulting in backups.
- It must be high enough above the groundwater table for the remaining pathogens that survived the septic tank and SAS to die off before reaching the groundwater (i.e. the greater the distance between the bottom of the SAS and the groundwater the greater the removal of pathogens).
- It must be far enough from surface waters and wells, water lines and property lines to protect them from contamination from pathogens in the soil or groundwater or should any part of the system fail.
- It must be sized and configured to accommodate:
 - the number of people using it – measured by the number of bedrooms in the home,
 - the nature of the site, and
 - the porosity of the soil (how quickly the wastewater can flow through the soil below the SAS)
- The installation must adhere to the engineering plans, and not disturb the soil in ways that will prevent the wastewater from percolating through the system and not damage any system components.

Properly designed, located, installed, maintained and used systems can easily last and continue to protect the environment for decades. Not following these guidelines can cause

any system to fail, irrespective of its age. However older systems may be more likely to have leaking or corroded components, or a field that is gradually clogging up.

Section 2. How Did Title 5 And Town Of Sharon Rules Improve The Effectiveness Of Septic Systems?

Changes to the State Title 5 regulations and Sharon's Board of Health Article 7 bylaws increased the ability of the town's septic systems to protect public health and the environment in the following ways:

- Title 5 increased the required distance between the bottom of the SAS-and groundwater, from 3 feet to 4 feet thereby ensuring better treatment.
- Sharon's Article 7 regulations were more stringent, requiring that the bottom of all SAS in the surface water protection and groundwater protection districts be at least 5' above the groundwater table.
- Title 5 required a more rigorous analysis and documentation of the groundwater depth to take account of groundwater fluctuations thereby ensuring that when built the system would have sufficient separation during all weather conditions including severe drought or periods of heavy rainfall.
- Title 5 increased the required size of septic tanks and the soil absorption system, and later required the use of more advanced two chamber septic tanks:
 - Larger septic tanks allow for the removal of more fats and solids, because the wastewater remains in the tank for a longer period
 - Larger soil absorption system provides more surface area for the removal of contaminants and reduce the likelihood that they will overflow or back up.
- Sharon's Article 7 also increased system quality by:
 - Stipulating that all cesspools automatically fail a required Title 5 inspection and therefore must be replaced upon the transfer of a home to a non-immediate family member.
 - Requiring that septic tanks that are over 25 years old be replaced with a more advanced 2 chamber tank upon the transfer of the property unless an in-depth inspection shows them to be sound.
- Title 5 required a more rigorous analysis of soil types to ensure that the SAS was properly sized to handle the wastewater. Title 5 ensures the quality of the siting, design, and installation of septic systems by requiring that this work be performed by state licensed soil evaluators, engineers, and septic installers, and that everything be clearly documented on plans and reports.

- Title 5 required that effective March 1, 1995, septic systems must be inspected by licensed Title 5 System Inspectors and, if found necessary, replaced or repaired by licensed installers prior to:
 - the transfer of the property to a new owner, by purchase, gift, or inheritance. Only transfers to an immediate family member – a spouse, sibling, child or parent, or a family trust are exempt from this inspection and repair requirement. (Note a Title 5 inspection is also not required if a homeowner obtains a mortgage without transferring ownership.)
 - any expansion in the number of bedrooms in a home served by a residential system, or changes in the use of a commercial or institutional or industrial building served by a septic system.
- As of 2024 Sharon Article 7 also requires an inspection when the living area of a home is expanded.

The inspection rule dramatically accelerated the rate at which problem septic systems are identified and repaired or replaced. Prior to the requirement, failures only came to the homeowner's attention or were fixed when the system was overflowing into their yard or backing up into their home. Barely functioning systems could limp along for years, even under a new owner. There are also unrecognized failures of individual components such as leaking pipes, leaking or overfilled septic tanks, or collapses of the "distribution boxes" that disperse the effluent evenly throughout the SAS. When they fail the SAS will often fail shortly thereafter.

Not only do these silent failures cause environmental damage, fixing them in a timely manner can prevent catastrophic failures. Furthermore, the inspections can reveal overt failures of design such as releasing wastewater right into groundwater, or the system being too close to a water supply or wetland or surface water which would only have been discovered indirectly through contaminated wells, brooks or lakes. By requiring expert inspections at the time of sale, both hidden and obvious septic system problems are identified and fixed at a time when the homeowner is most likely to have the funds to make the necessary repairs.

Section 3. How Do Septic Systems Impact Nutrient Pollution

It is important to note that no matter how well-designed, installed, used, and maintained, conventional septic systems do not remove the nutrients that fuel algae, weeds and cyanobacteria growth in the lake. They are designed to handle pathogens and organic material. Only minimal amounts of phosphorus and nitrogen in the solid material are removed, and that happens when the tank is pumped out. Most phosphorus and nitrogen are dissolved in wastewater, and they flow out of the SAS untreated.

Nitrogen

Nitrogen is a nutrient of concern in two situations, neither of which apply to Lake Massapoag. Excess Nitrogen can result in nitrite pollution in drinking water wells. Excess Nitrogen can also fuel algae, weed, and cyanobacteria growth in water that is “Nitrogen limited”, meaning that Nitrogen levels are too low to support their growth even though all of the other necessary nutrients are available. Typically, marine shoreline waters are Nitrogen limited, while freshwater bodies such as Lake Massapoag are Phosphorus limited: algae, plants and cyanobacteria will continue growing until all of the phosphorus has been used up and the addition of Phosphorus will fuel additional growth.

Nitrogen can be removed from onsite septic systems provided they are equipped with advanced Nitrogen removal technology. Around the lake, if a homeowner requests a variance from the SAS size or depth to groundwater, this technology can be added to remove more dissolved organic material and pathogens from the wastewater than the SAS alone. Sharon has 48 advanced systems, many that remove nitrogen.

MA DEP requires additional nitrogen treatment when there are more than 4 bedrooms per acre in a drinking water protection area. The SWPD contains about 1.26 bedrooms per acre which is well below the nitrogen loading that is protective of drinking water. There is no indication that nitrogen levels in the lake are contributing to weed and algae issues.

Bedrooms per acres were calculated as follows:

- Acres in the SWPD = 2,665
- Bedrooms in the SWPD = 3,177
- “ Bedroom Equivalents” from the High School Treatment Plant = 185
 - 20,400 gallons per day effluent
 - 110 gallons per day per bedroom (Title 5 design Standard)
 - 20,400 gpd/110 gpd = 185 bedroom equivalents
- Total bedrooms = 3,362 (3,177+185)
- Bedrooms per acre: 1.26 (3,362 bedrooms/2,665 acres)

While this analysis does not include septic system use at the Community Center and the two summer camps, there is enough margin left over to be well within the 4 bedroom per acre limit.

Phosphorus

Phosphorus in domestic wastewater largely comes from urine, although a relatively small amount can be added from dishwashing detergents, some personal care products, and some cleaning products. The contribution from cleaning products was far higher in the mid to late 1900s before phosphorus was banned from laundry detergents and limited in

automatic dishwasher detergents. Estimates vary but septic systems remove about 10%-30% of the phosphorus present in domestic wastewater, as the solids settle in the tank and are subsequently pumped out. The remainder of the phosphorus is dissolved in wastewater.

The dissolved phosphorus flows untreated from the septic tank into the SAS and from there into the soil. For the first years after an SAS is installed, almost all of the remaining phosphorus is filtered out of the effluent by the soil underlying the SAS, as it is adsorbed onto soil particles. Over time however, this removal stops as the adsorption sites in the soil get “filled” with phosphorus. The amount that can be adsorbed depends on the nature of the soil. Calciferous soils, soils with iron oxides, and soils that are anoxic or acidic can hold more phosphorus than other soils. But eventually, regardless of the type of soil, the adsorption sites get filled, and the dissolved phosphorus starts flowing directly into the groundwater. Furthermore, if soil conditions change due to a rise in the groundwater table, sudden heavy rainfall or other factors, the soils can start to release the formerly bound phosphorus to the groundwater.

Once in the groundwater, phosphorus will be carried to the lake or surface water that flows into the lake. As a result, septic systems, no matter how well-designed and maintained, cannot, in and of themselves, protect the lake from phosphorus. In short, it will take years, but eventually almost every pound of phosphorus that goes into the septic system will ultimately end up in the lake, because once it is in the groundwater there is no mechanism to remove it. While it can be converted to and from various compounds, unless it is drawn up through tree roots into trees, the phosphorus itself remains and cannot be converted into another element. Because it has nowhere else to go it travels with the groundwater to the lake. Because of the slow speed with which groundwater moves, this may not become apparent for many years. The years of septic flow from the newer year-round homes built in the SWPD over the past 50 years may be only just starting to show up in lake. Unlike Nitrogen, there are no readily available systems for removing phosphorus from septic system effluent. Two available but not widely deployed include urine separation and

	#	# of people at Location	Days per year at location	Avg % of 24 hour day at location	Pounds Phosphorus per person per day*	Pounds Phosphorus Excreted in Watershed per year @0.00132 lbs/day
					0.00132	
Houses and Small Houses of Worship	930	2.4	365	0.75		807
Sharon High School System**						
High School, Middle School, Preschool students and staff		2360	181	0.67		378
Public School Administration		90	225	0.67		18
Community Center visitors*** and town staff		350	365	0.1		17
Camp Wonderland		291	75	1		29
Everwood Day Camp		1050	40	0.67		37
Saphire Manor		270	52	0.67		12
Wonderland Conference Center		60	90	1		7
Bilingual Montessori School of Sharon		68	181	0.67		11
Massapoag Yacht Club		40	150	0.1		1
TOTAL						1316
TOTAL discharged to ground assuming 20% removed in septic tank and pumped out						1053

[*Science Direct, Kidney Function in Calcium and Phosphate Metabolism, A Normal Phosphate Excretion Rate,.](https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/phosphate-excretion)
[https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/phosphate-excretion.](https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/phosphate-excretion)

Notes: .0022 grams per pound x .6 grams per day = 0.00132 pounds per day = .48 pounds per year

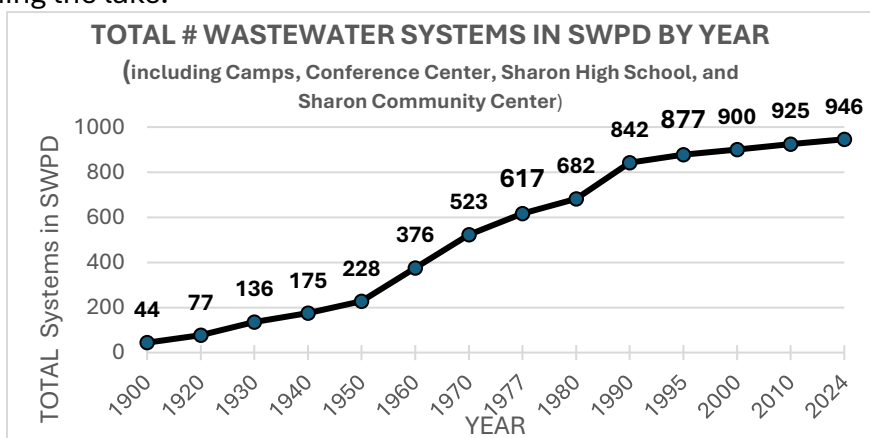
** Excludes weekend, evening and summer use of high school and middle school, and Memorial Beach

*** Lower estimate of the average number of people using the facility per preliminary design report for wastewater collection and treatment Weston and Sampson Engineers, Lake Massapoag Restoration Project May 1989

collection, and small pre-treatment tanks installed upstream of the SAS. As shown in the table below, approximately 1316 pounds of human derived phosphorus is released to wastewater systems of which about 1,053 pounds is discharged to the ground each year by people living, working, visiting or going to school in the Lake Massapoag watershed. About two thirds (807) pounds comes from residents, and about 316 pounds from the high school system. The remainder comes from the camps, community center, Sapphire Manor, the Wonderland conference center and the Bilingual Montessori School. This doesn't count phosphorus from other sources such as cleaning products or fertilize, nor summer and evening use of the high school and middle school

This projected amount of human-derived phosphorus exceeds the total "external" loading of phosphorus, which includes loading from tributaries, storm drains, direct land runoff, and near shore groundwater seepage. Loading of phosphorus was estimated using two standard land-use-based models that only take into account septic systems within 300 feet of the shoreline. The MS4 was developed to calculate stormwater flow, and predicted 875 pounds per year of phosphorus loading. The Lake Loading Response model, also developed for calculating stormwater runoff but which can be adjusted to include septic discharge throughout the watershed, and was calibrated with monitoring data, predicted an external loading of 724-788 pounds per year and an additional "internal loading" --- phosphorus bound to lake sediments of 910+ pounds per year.

It will be important to resolve the discrepancy between the amount of phosphorus being introduced into the watershed and the model predictions. If the models are underestimating actual phosphorus loadings from septic systems, the phosphorus control solutions we develop could be inadequate. Alternatively, it could be that the models are accurate when calibrated based on water quality data, and the phosphorus from the past 40 years of construction hasn't yet reached the lake because of the amount of time required for the soils under SAS to become saturated with phosphorus coupled with the very slow movement of groundwater. However, based on current understanding of phosphorus behavior in soil and groundwater, it could arrive. The chart below shows the growth in the number of wastewater systems in the watershed over time. The phosphorus from rapid increases to the phosphorus loading between the 60s and the 90s may only now be reaching the lake.



It is possible that some of the phosphorus becomes permanently trapped in the swamps and soils surrounding the lake or that the “internal loading” estimate also includes phosphorus entering the bottom of the lake with through seepage and springs, or some combination of all of the above factors.

Section 4. How Protective Are Septic Systems In The Surface Water Protection District?

While Sharon has made a great deal of progress, there are still some systems of potential concern because they have not been updated, inspected, or maintained properly.

Systems are of greatest concern if they are:

- Not functioning properly – the SAS is backing up into the home or overflowing onto the ground, septic tanks are overflowing, or pipes, tanks, distribution boxes are leaking untreated sewage into the ground.
- Not designed properly – the SAS is in or too close to groundwater or too close to surface waters or wells, the SAS and septic tank are too small to adequately treat the wastewater (which will increase the chance of system failure), the system is a cesspool, or a cesspool serving as a septic tank connected to a leaching field.

The concern rises with proximity to the lake to the lake.

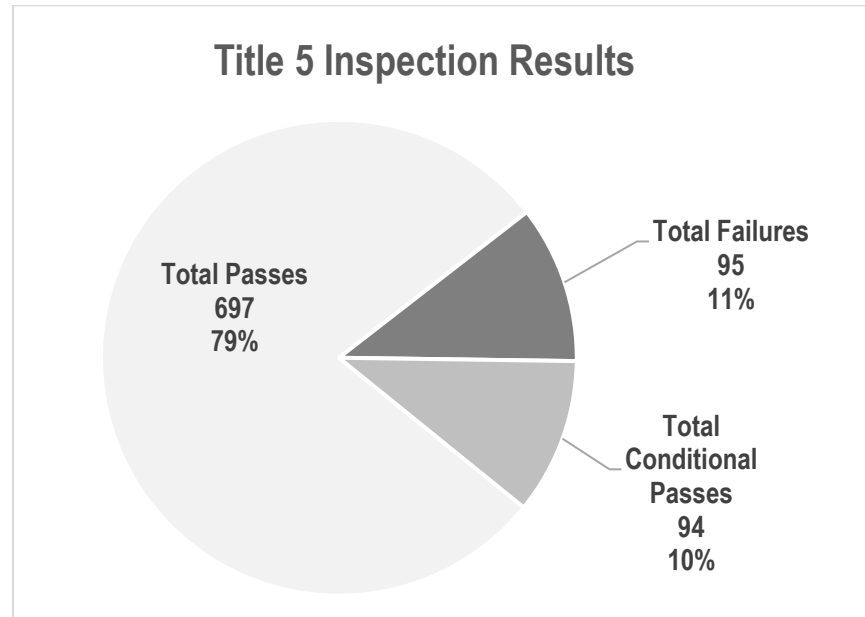
Title 5 Inspections

Mandatory Title 5 Inspections are the most effective tool for identifying and replacing or repairing failing systems, as evidenced by the number of systems that have been replaced and repaired since the requirement took effect. In the 17 years from 1978 -1995, 112 pre-1978 systems were replaced. In the 17 years (1996-2013) after the advent of mandatory inspections the number of pre-1978 system replaced almost doubled to 222.

Of the 783 residential and small nonresidential systems in the watershed when Title 5 was promulgated 347 have upgraded their systems to meet the more stringent 1996 Title 5 standards. Most of these upgrades resulted directly from a mandatory Title 5 inspection at transfer or indirectly because systems were replaced in advance of the transfer in lieu of conducting an inspection. Only 74 new systems have been installed at properties that have not changed hands since the mandatory inspections went into effect or changed hands more than two years after their most recent post 1995 transfer.

Inspection Results

As of 2024 a total of 886 Title 5 inspections had been conducted at 544 of the 933 systems included in this analysis. 240 of these systems had more than one inspection. The chart below shows the results.



- 697 (79%) resulted in a pass
- 189 (21%) revealed a problem:
 - 94 (10%) resulted in a conditional pass (CP), which meant the inspector found a component other than the SAS that had to be repaired or replaced (17 septic tanks, 9 piping, 72 distribution boxes). Eight inspections identified 2 components that needed repair or replacement.
 - 95 (11%) resulted in failure – meaning the SAS was located directly in the groundwater or was too badly clogged or otherwise damaged to operate properly and had to be replaced. A failure usually results in the replacement of the entire system because of the age and size of the septic tank and distribution box.

These numbers reflect the total number of inspections that have been conducted since March 1995. The results are similar when examined on a system-by-system basis. A problem was detected at about a third of the most recent inspection of each system. Among 545 inspected systems 68% (372) passed, 17% (91) failed, and 15% (84) conditionally passed their last inspection.

Even though only two thirds of the systems passed their latest inspection, every inspection eventually results in a fully functioning system. The regulations require that problems

identified by a Title 5 inspection be fixed within two years and the files show all failures and conditional passes (CP) have been addressed. Although systems may fail again in the future, that is relatively infrequent. Of the 240 systems that have been inspected more than once, 55% passed all inspections, and 81% passed the most recent inspection after a prior failure or CP. Only 15 (6%) locations had two or more inspections that identified problems.

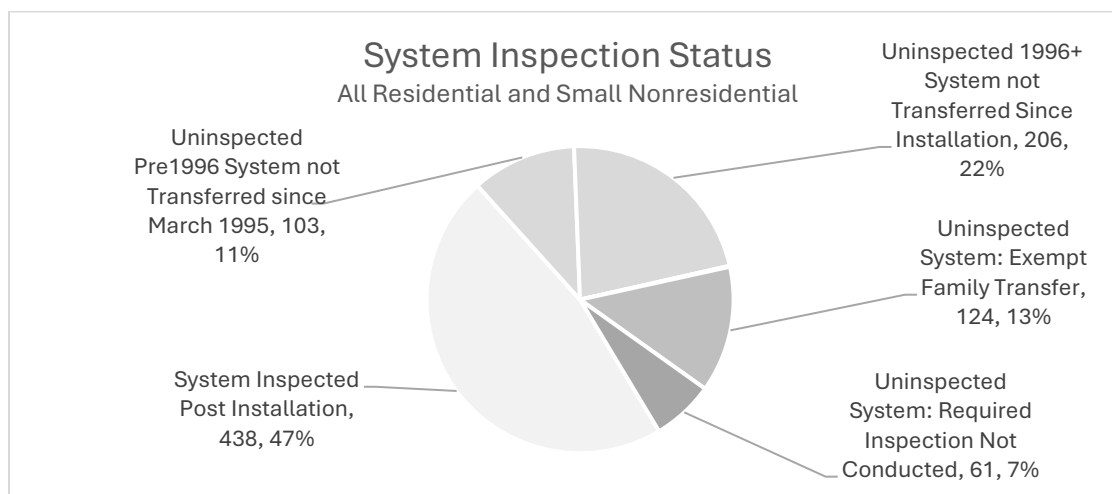
- Three sites failed twice. At one of these sites the failing system was not replaced until after the second failure. At the other two, the pre-1996 system failed, and the first 1996+ system that replaced it also failed.
- 6 sites had one or more CPs prior to a complete system failure and installation of a new 1996+ system
- 6 sites had more than one CP.

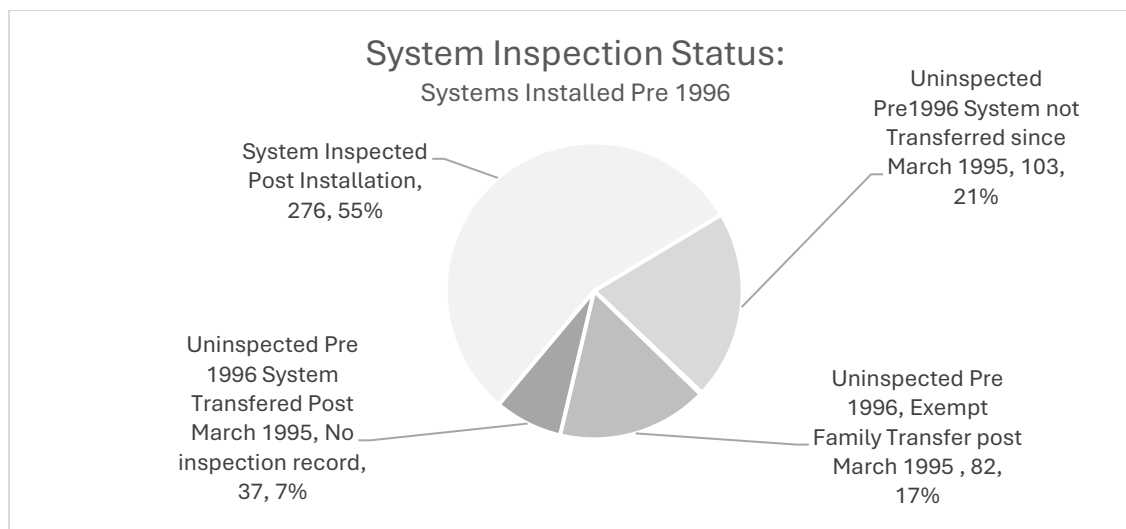
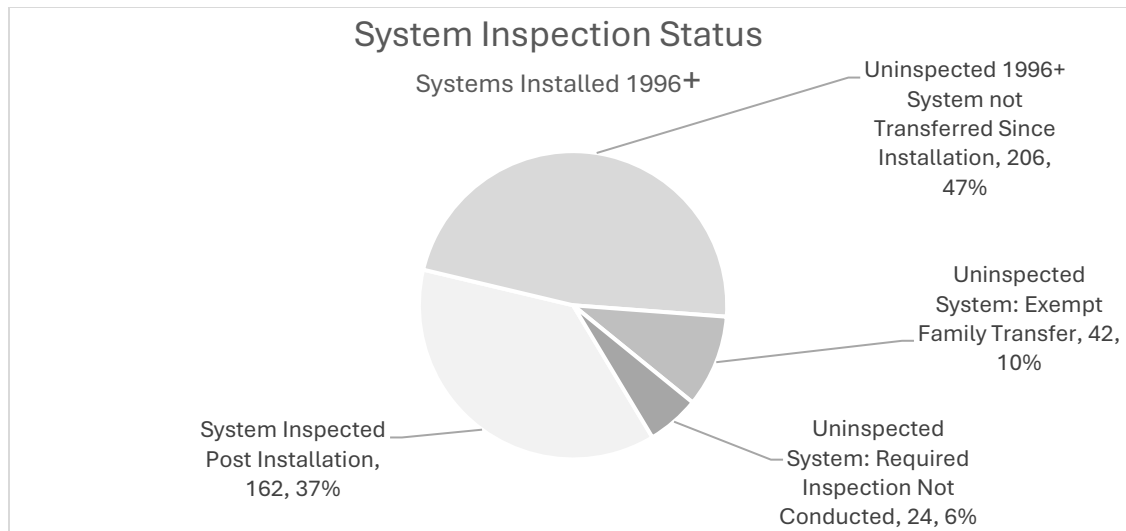
Mandatory Title 5 Inspections upon property transfer have had a significant impact on the quality and performance of the septic systems in the SWPD. Failures of required inspections have directly resulted in the repair or replacement of 189 septic systems.

Inspection Status

The charts below show the inspection status of the 933 residential and small nonresidential systems included in this analysis for

- all systems
- systems installed since the more protective standards went into effect in 1996 (1996+ systems)
- systems installed before 1996 (pre 1996 systems) built under less stringent standards.





As shown in the first chart of the 933 residential and small nonresidential systems in the watershed, 47% (438) of the currently installed systems have had at least one inspection.

Of the 495 that have *not* been inspected

- 33% (309) (have not been subject to the mandate because they have not changed hands since March of 1995
 - 103 properties with pre 1996 systems
 - 206 properties with 1996+ systems (these systems are of lesser concern because many are relatively new)
- 13% (124) have not been subject to the inspection requirement because their only transfers have been “exempt interfamily transfers” between parents and children,

siblings, or spouses. An interfamily transfer was assumed if the sale amount was less than \$100.

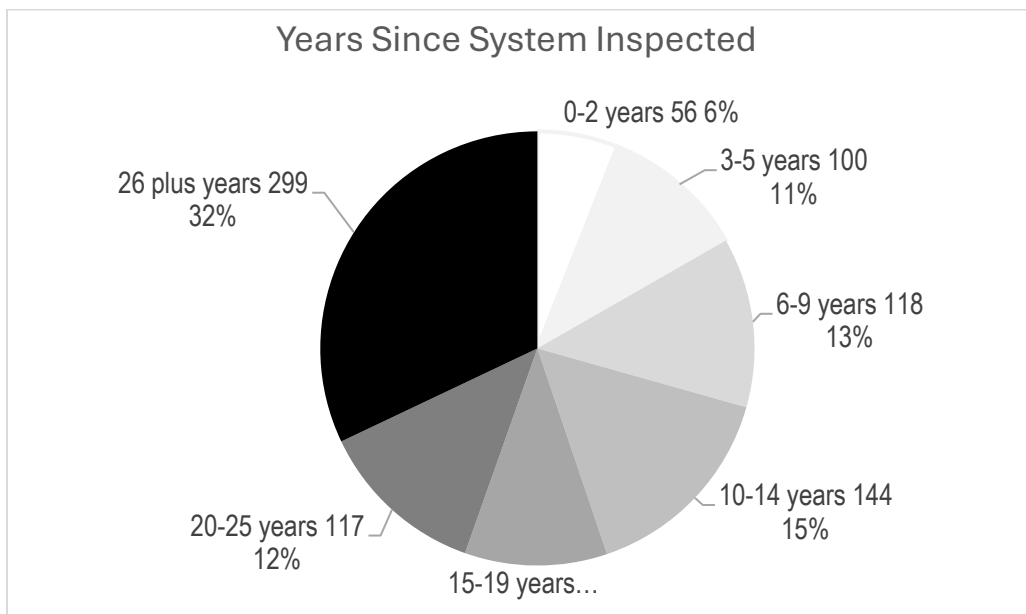
- 7% (61) should have been inspected but there is no record that the inspection occurred. (It is possible that an inspection was conducted and not in the files or that it was an interfamily transfer with a high dollar value such as when one sibling buys out another's share.

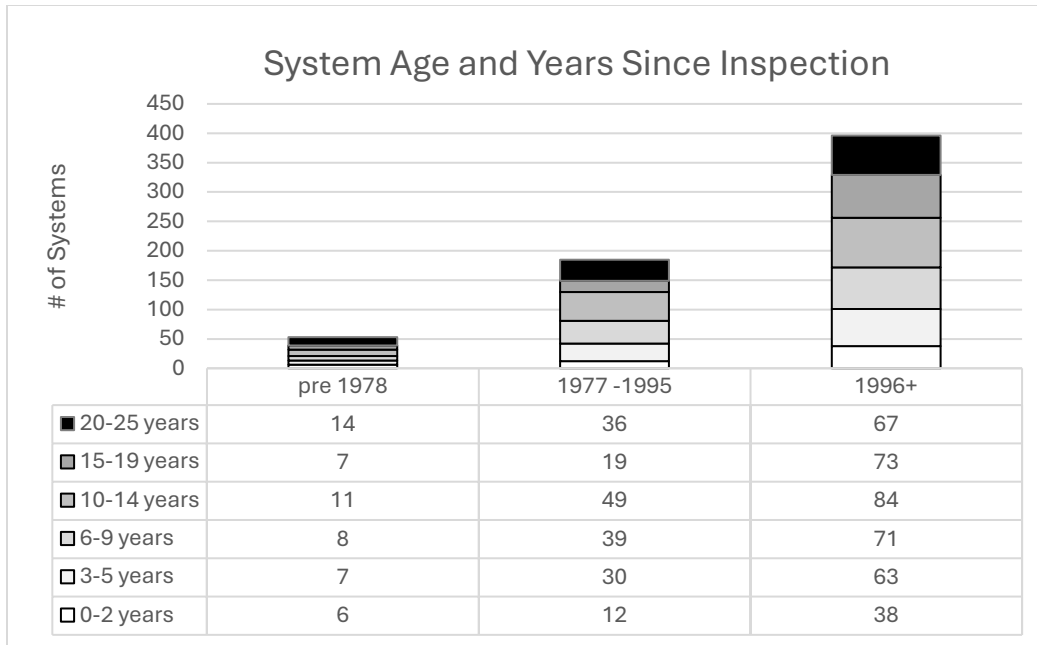
Inspections may happen independent of a sale. Inspections have occurred at 39 systems that either have not changed hands since the inspection requirement went into effect or have not changed hands more than three years after their 1996+ system was installed. An additional 89 have taken place at systems more than one year following the most recent ownership change.

Elapsed Time Since Inspection

The length of time since a system was last inspected is another measure of proper system functionality. The more recent the inspection, the more likely the system is still in good working order. The charts below show the number of years since systems were last inspected or if never inspected, the number of years since installation. Years are grouped into the following increments the past 0-2, 3-5, 6-9, 10-14, 15-19, 20-24, and >25 years).

The charts present the data for the entire watershed and by system age. Looking at the watershed as a whole, just under 30% (270) of the systems have been inspected within the past nine years. Just over 30% (299) have not been inspected in the past 25 years or since their installation more than 25 years ago.





Elapsed time since the most recent inspection does not seem to be affected by system age. Just over half (260) of the 400 remaining pre 1996 systems have not been inspected in over 25 years. Similarly, half (38) of the 86 1996+ systems that were installed more than 25 years ago have not been inspected since installation. In every other frequency group, the proportions of the systems are roughly the same regardless of system age. This is likely because inspections are largely driven by property transfers.

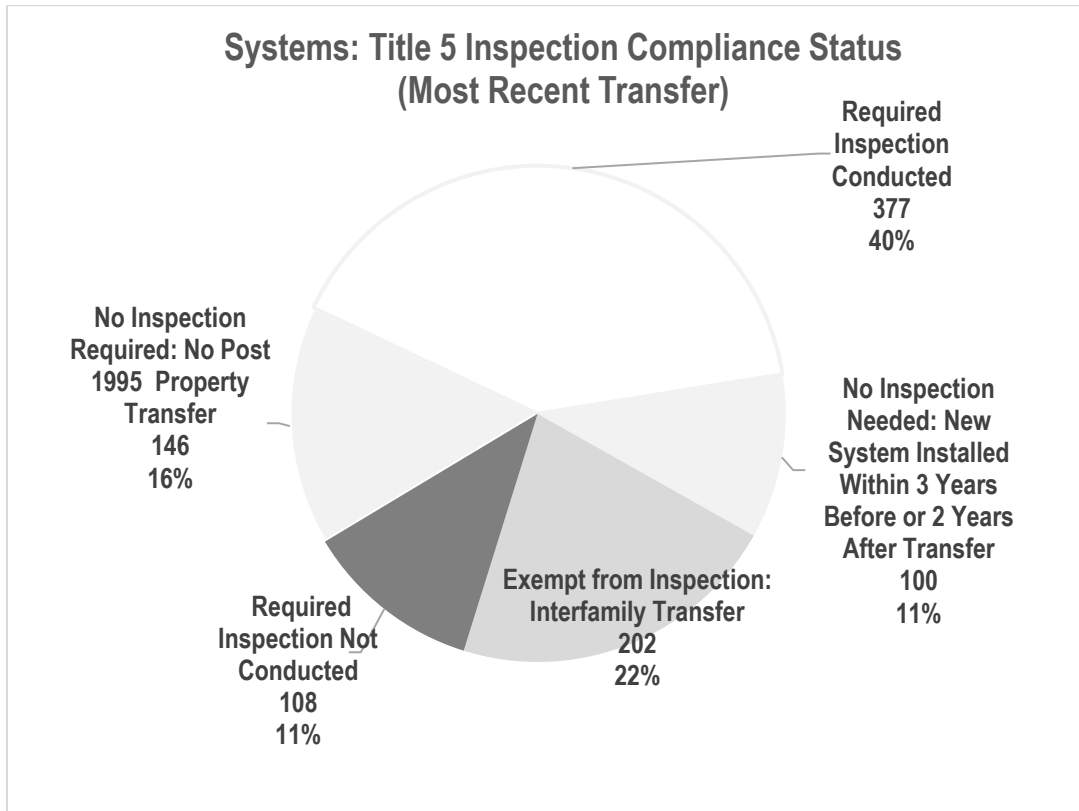
Compliance with the Title 5 Inspection Requirements.

The chart below shows how systems complied with the inspection requirement at the most recent property transfer:

Please note that these numbers vary from the raw inspection counts included above because they reflect the response to the last transfer of the property, rather than the current status of the system. A system may have been inspected before or after the most recent transfer.

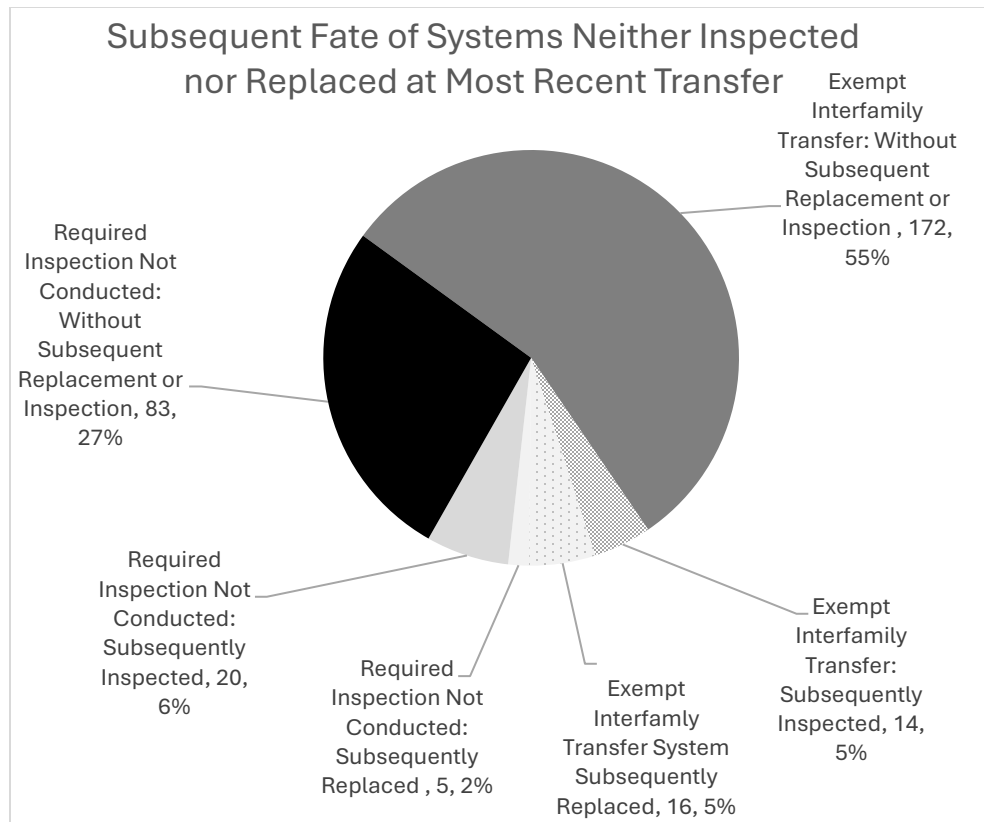
- 146 systems have never been inspected because they have not been required to. Because the system has not changed hands since it was installed, or was a new system for a newly constructed home.
- 100 existing systems were replaced within the time period three years before and 2 years after the property was most recently transferred, thereby obviating the need for a Title 5 inspection.
- 202 systems were exempt from inspection at the most recent transfer because the property was transferred between family members of the first degree: spouses, parents, children, or siblings, or into a family trust. (Note, this number is larger than the 82 of “never inspected systems” that were exempt from inspection at the

most recent post 1996 transfer. Some of these 202 systems may have been voluntarily inspected more than 1 year after the most recent transfer or inspected more than 3 years prior to the most recent transfer.



- 108 homes do not appear to have been inspected at the most recent transfer despite being subject to the requirement. It is possible an inspection was conducted and not submitted to the town. Alternatively, the mandate may have been ignored. Towns generally lack the resources to enforce inspection requirement. Lenders typically enforce the inspection mandate because they have a financial interest in the property. Without an enforcement mechanism, buyers and sellers in cash sales may have knowingly or unknowingly skipped the required inspection. (Note: this number is higher than the

In some instances, systems that were neither inspected nor replaced at the time of their most recent transfer are inspected or replaced at a later date. The charts below show the proportions of systems that were subsequently inspected and or replaced,

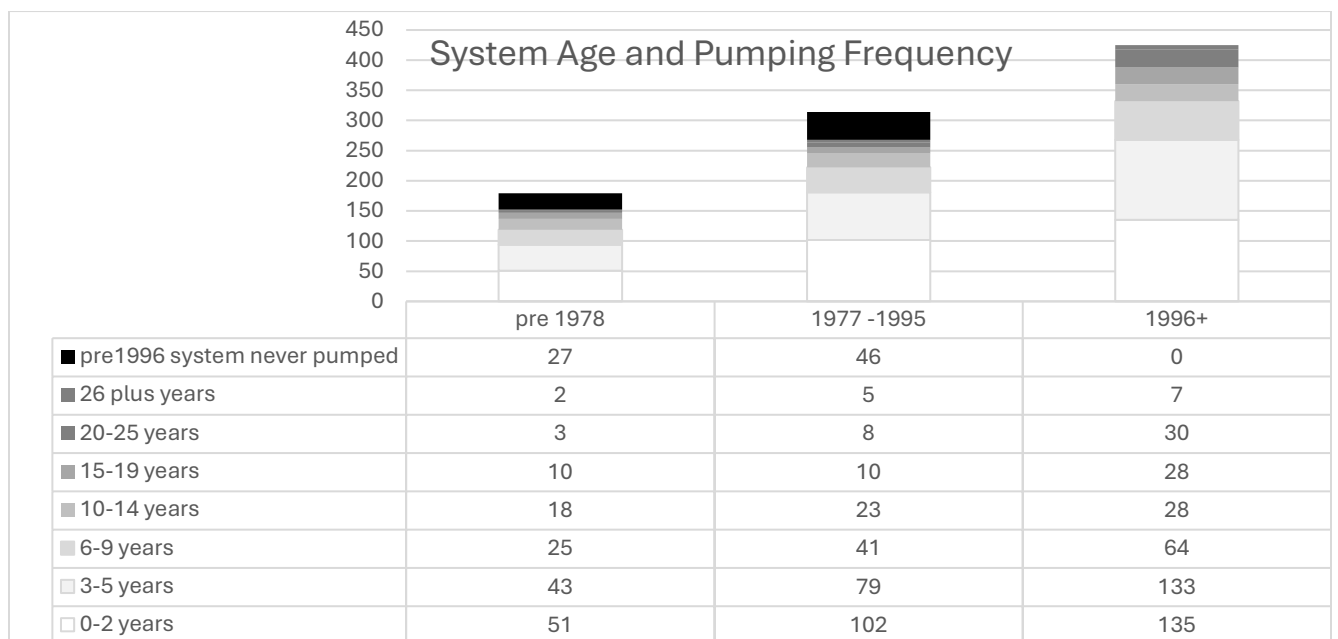
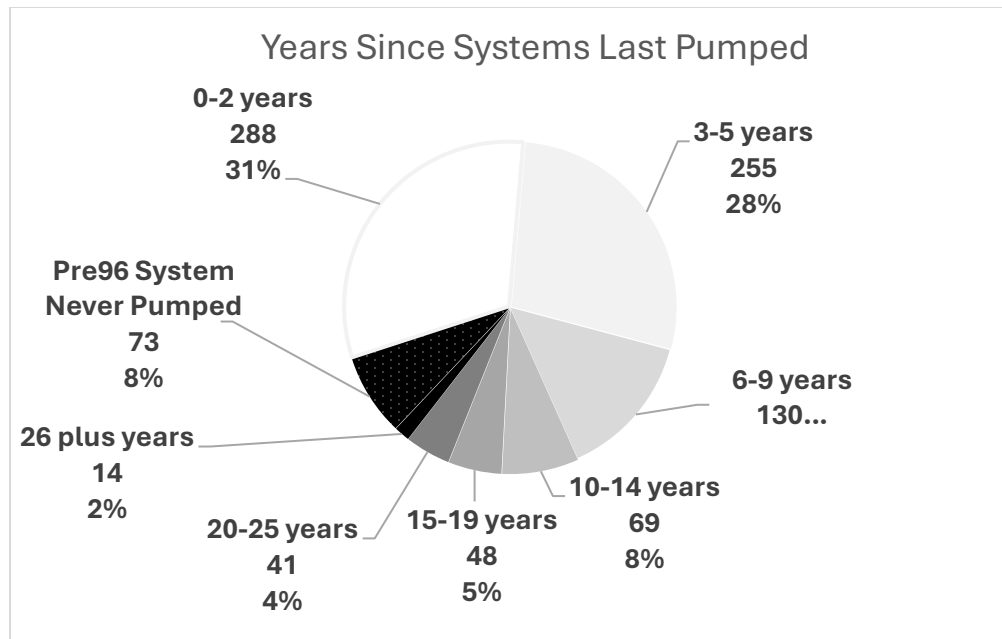


30 (16%) of the 202 Interfamily transfers that were exempt from inspection were subsequently addressed: 14 systems were inspected and did not require replacement, and 16 were replaced. 25 (23%) of the 108 systems that were not inspected as required at the last transfer were also addressed at a later date. 15 were inspected without a system replacement and 5 systems were replaced.

Because Title 5 Inspections identify “silent problems,” it is important to ensure that all required inspections in fact occur, so that our pre-1995 and post-1995 systems continue to be repaired and upgraded as needed. Unfortunately, as powerful as the inspection mandate is, compliance is not as good as it should be, and some systems that have never been inspected, triggered the inspection requirement.

System Pumping

The Sharon Board of Health requires that all septic tank pumping companies operating in Sharon obtain a town license and submit a report on each pump-out performed. The data indicate that 58% of the systems were either pumped out or installed within the past 5 years, and almost three quarters of them have been pumped or installed in the past 9 years. The 73 pre 1996 systems that have never been pumped represent 8% of the total systems in the watershed. The availability of pumping data gives the town the ability to notify homeowners that pumping could be overdue. The two charts show the years since systems were last pumped (or installed, if never pumped for all systems and by system age.



Garbage Disposals

In sink garbage disposals are banned in Sharon because they overload the septic tank with additional fats and oils, and ground up organic matter that cannot be readily broken down. The state requires Title 5 inspectors to report on the presence or absence of a disposal as part of the inspection. As shown in the table below, 31% of the 545 inspected homes in the SWPD had disposals, and 25% of the inspected homes on the streets that border or end at the lake have disposals despite the ban.

Table 1 shows this data broken out for systems installed before 1978 when the first statewide standards took effect, from 1978 to 1995 when the original Title 5 was in place, and on or after 1996 when the new Title 5 standards became mandatory. It also lists the streets that were considered “near the lake”.

SYSTEMS WITH DISPOSALS

	All Systems			Systems Near Lake		
	# Inspected	# With Disposals	%	# Inspected	# With Disposals	%
Homes	545	170	31%	198	50	25%
By System Age						
1996+	269	63	23%	130	30	23%
Pre 1996	276	107	39%	68	20	29%
1978-1995	210	89	42%	45	15	33%
Pre 1978	66	18	27%	23	5	22%

Homeowner Education and Information

Preventing homeowners from abusing their septic systems is a matter of education. Many residents, particularly those that have lived in sewerred areas for most of their lives, do not fully understand how their systems work and what substances must be kept out of their toilets and drains. The Town and its Lake Massapoag Advisory Committee (LMAC) have developed and distributed information to homeowners about the proper care of their septic systems including:

- That they have a septic system
- What can and cannot safely go down the drain
- Where they are located in their yard so homeowners avoid inadvertently damaging them through construction, parking ,or landscaping
- The importance of pumping their septic tank every few years
- The need to have a contract in place for the monitoring and maintenance of advanced systems
- The need to follow special conditions in their septic system permits or variances for home construction issued by the Zoning Board of Appeals, which are binding on both the owners that obtained the variance as well as subsequent owners. These can include conditions such as annual pumping or bedroom limitation.

The town and LMAC’s public education efforts are boosted by other town practices.

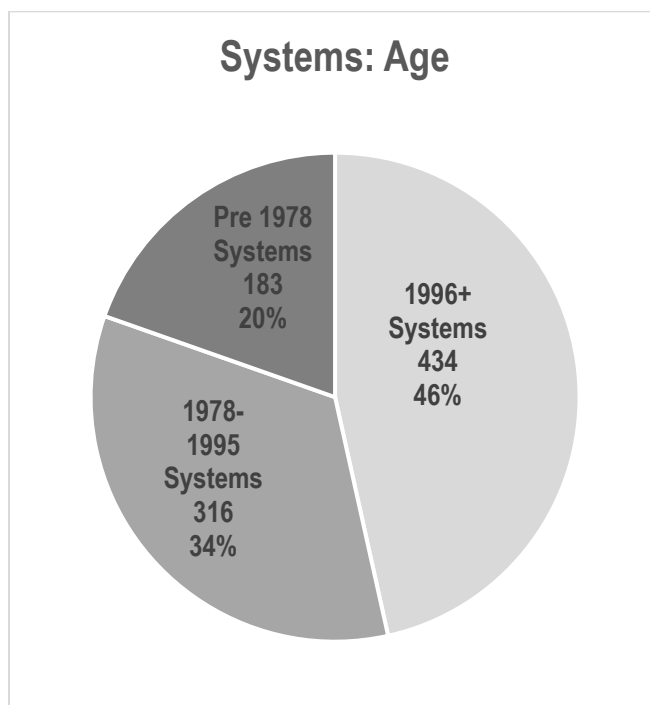
- Recently Sharon contracted the Barnstable County Septic Management program to monitor and enforce homeowner compliance with advanced septic system monitoring and maintenance requirements.

- Information about the design and location and past inspections of all except 32 systems is available online either in the digitized “Property Files”, or for systems installed since 2023 in the Online Permitting file. This practice makes it possible for homeowners to learn what they need to know to protect the system from inadvertent damage and see the recommendations for past Title 5 Inspections, and comply with special requirements imposed by the Board of Health when the system was permitted, or by the Zoning Board of Appeals if the home needed a special permit to be constructed or expanded, and recommendations from past Title 5 inspectors.

How well are the systems designed?

The quality of the design is a function of system age, and the design standards and practices in place when it was installed. Systems can be divided into three “quality groups” from highest to lowest.

- Systems installed on or after 1996, the effective date of the new Title 5 rules (1996+ systems)
- Systems installed between 1978 and 1995 when the first relatively stringent statewide standards were in place (1978-1995 Systems)
- Systems installed before 1978 (pre 1978 Systems --the year the minimal state sanitary code adopted in 1971 was significantly upgraded). This group includes all of the remaining cesspools – one piece in ground systems in which the fats and solids settle out of the wastewater and from which gradually seeps into the surrounding soil.



There are 31 systems in the watershed for which there is no information in the files. These are all located at houses built in 1960 or earlier, and due to the construction date are assumed to be cesspools. There are an additional 12 known cesspools, some of which are connected to an overflow pit.

Post-1996 Systems

Just under half (47%) of the 933 residential and small nonresidential systems in the watershed were installed after the more stringent septic system standards went into effect in 1996. 60 of these systems were installed at new houses, the remaining 374 were replacements of pre 1996 systems at existing homes.

- 37% (162) have had a Title 5 inspection more than one year after the system was installed, resulting in 15 repairs or replacement of system components
- 63% (272) have not been inspected. Of these:
 - 248 were exempt from inspection
 - 206 had not been transferred more than 3 years after installation
 - 42 were transferred between parents and children, spouses, or siblings
 - 24 skipped a required inspection
- 3 systems were repaired without a Title 5 inspection

This leaves 269 uninspected 1996+ systems in the watershed. However, all except 86 of these systems are under 26 years old, and they were subject to higher standards than pre1996 systems. They have been designed and installed by licensed professionals, and licensed professionals have made the depth to ground water and soil suitability and percolation rate determinations. SAS depth to groundwater was measured from high groundwater, and septic tanks and SAS are larger and therefore provide more opportunity for treatment than was required before 1996. The plans fully document all of the calculations and determinations used to design the system and show the site of the test pits used to establish groundwater depth.

Systems for new or expanded homes must be constructed in full compliance with the regulations. The standards allow for variances of a limited number of requirements, but only if the system provides equal environmental protection and the owner can show that they will have lost substantially all economic benefit from the use of the property unless the rules are varied.

Replacement systems at existing homes are subject to a less stringent standard-- "Maximum Feasible Compliance." Greater lenience is necessary because sometimes it is impossible to design a fully compliant replacement system given the constraints of an existing lot. Per Title 5:

"In determining whether full compliance is feasible, the Approving Authority should appropriately consider not only physical possibility as dictated by the conditions of

the site, but also the economic feasibility of the upgrade costs. The Approving Authority should emphasize protection of water resources and treatment of the sanitary sewage.”

The standards for variances are subject to Board of Health interpretation and that interpretation may be different from site to site within a town as well as among towns, depending on their unique circumstances. Because of this variability, applicants and their engineers may present plans that will allow them to build non-compliant systems on unsuitable sites, or that will save the applicant money at the expense of the protection of water resources and public health based on their engineer’s experience in other towns.

Sharon is one of the very few relatively densely developed suburban towns in the state that relies almost entirely on septic systems and public or private drinking water wells, as well as having a sensitive, recreationally important lake within a highly developed watershed. Issuing financially desirable but not strictly necessary variances can present more potential problems than would arise in towns that do have our unique environmental conditions.

The town needs to continue to maintain a strict interpretation of maximum feasible compliance in the Surface Water Protection District, particularly with reference to setbacks to tributaries to the lake and the Town of Sharon’s 5-foot depth to groundwater requirement for the systems in the District. If variances are absolutely necessary for an existing home, it should ensure that the potential damage is minimized by requiring offsetting protective measures such as the installation of an alternative system.

Pre 1996 Septic Systems

The table below shows the current status of all systems in place at the end of 1995 when the new Title 5 requirements took effect. It includes whether the current system was built before 1978 (when there were no state rules), 1978 – 1995 (when the first Title 5 regulations were in effect), or has been replaced with a new “1996+ system” that is compliant with the new more stringent Title 5 requirements. The table shows the number of systems that were subject to inspection, the number inspected, and the number upgraded or repaired.

- 374 of the 873 homes in the surface water protection district as of 1995 have replaced their pre-1996 with a 1996+ system. At least 103 of these were cesspools or cesspools connected to “overflow” leaching fields
- 276 of the remaining 499 pre-1996 systems have been shown to be functioning properly by passing a Title 5 inspection or conditionally passing an inspection and being subsequently repaired
 - 90 of these inspected systems have repaired a component since installation
 - A required inspection was skipped at 37 of the 223 uninspected systems

- 28 of the systems repaired or replaced a component without an inspection
- This leaves 195 (39%) of the remaining 499 pre-1996 systems (22% of the original 873 pre-1996 systems) that have never been replaced, repaired or inspected.

Systems installed 1978-1995

316 (34%) of the 933 residential systems in the SWPD were installed between 1978 and 1995, when the first comprehensive statewide septic system design requirements were in effect. Standards were set for septic tank and leaching field size, though these components were allowed to be smaller than what has As of 1995 there were 371 systems in the watershed installed between 1978-1995. Since that year 55 of these have been replaced with a 1996+ system leaving 316 1978-1995 systems. Of these:

- 55 of the remaining 316 1978-1975 systems have been shown to be functioning properly by passing a Title 5 inspection or conditionally passing an inspection and being subsequently repaired
 - 33 of these inspected systems have repaired or replaced a component after 1995.
 - A required inspection was skipped by 22 of the 106 uninspected systems
- 15 of the systems repaired or replaced a component without an inspection

This leaves 91 (29%) of the remaining 316 1978-1995 systems (10% of the original 873 pre-1996 systems) that have never

Groundwater at the time the test pit was dug was considered sufficient. Also, the procedures for determining groundwater levels and soil types were more informal, and systems did not need to be designed by a licensed engineer.

- been replaced, repaired or inspected.

Systems installed prior to 1978

184 (20%) of the systems in the SWPD were installed prior to 1978 the state first strengthened the statewide standards went into effect. 107 of these were installed prior to 1971 when the very first statewide standards were promulgated. Prior to that year, systems could be simple cesspools (perforated cinder block chambers or tanks in the ground that allow wastewater to flow directly into the soil) , depth to groundwater was not always considered or determined, system design was not always documented.

Over time, cesspool use declined, and the norm was to at least ensure that the system was not wholly or partially in the groundwater. However, the plans did not always document groundwater depth or the depth of the bottom of the system. There were no statewide standards as to the size of the septic tank or SAS, and builders were allowed to fill wetlands with soil or gravel in order to install buildings and septic systems. Documentation does not appear until the 1950s, and while it got more formal over time, it was largely dependent upon the practice of the septic system designer/installer.

At present 12 of the residential and small nonresidential systems are known to be cesspools or cesspools with an overflow leaching area. There is no information in the files for 31 of systems. Because the homes were built between 1735 and 1960, they were all assumed to have been installed prior to 1978 and to be cesspools.

Post 1995 Fate and Inspection Status of Systems in Place as of 1995							
	All Systems			Systems Near Lake			
	# systems	% of systems in place in 1995 (873)	% of systems in place in 2024 (933)	# systems	% of systems in place in 1995 (873)	% of systems in place in 2024 (933)	% of systems near the lake in 2024 (381)
Number of Pre 1996 Systems (residential, small commercial/institutional) in 2024	933			381		44%	
# systems in place as of 1995	873		94%	348		37%	91%
# /% that installed 1996+ system	374	43%	40%	178	20%	19%	47%
# Remaining pre 1996 Systems as of 2024	499	57%	53%	170	19%	18%	45%
# /% pre 1996 systems with 1 or more T5 Inspections	276	32%	30%	68	8%	7%	18%
#/% repaired replaced components with inspection	90	10%	10%	9	1%	1%	2%
#/% uninspected	223	26%	24%	102	12%	11%	27%
#% exempt- not transferred	103	12%	11%	43	5%	5%	11%
#% exempt family sale	82	9%	9%	43	5%	5%	11%
#/% skipped required inspection	37	4%	4%	16	2%	2%	4%
#/% repaired replaced components with No inspection	28	3%	3%	9	1%	1%	2%
# /% Old Systems of Concern: Neither inspected, nor repaired without an inspection	195	22%	21%	93	11%	10%	24%

	All Systems			Systems Near Lake			
	# systems	% of systems in place in 1995 (873)	% of systems in place in 2024 (933)	# systems	% of systems in place in 1995 (873)	% of systems in place in 2024 (933)	% of systems near the lake in 2024 (381)
By System age			.		.		
# 1978-1995 Systems as of 1995	371	43%	41%	98	11%		26%
# /% that installed 1996+ system	55	6%	6%	16	2%	2%	4%
#/% repaired replaced components with inspection	57	7%	6%	4	0%	0%	1%
#/% uninspected	106	12%	11%	37	4%	4%	10%
#% exempt- not transferred	45	5%	5%	14	2%	2%	4%
#% exempt family sale	38	4%	4%	17	2%	2%	4%
#/% skipped required inspection	22	3%	2%	6	1%	1%	2%
#/% repaired replaced components with no inspection	15	2%	2%	15	2%	2%	4%
# Systems of concern neither inspected nor component repaired	91	10%	10%	33	4%	4%	9%
# pre 1978 Systems as of 1995	502	58%	54%	250	29%	27%	66%
# /% that installed 1996+ system	319	37%	34%	162	19%	17%	43%
# Remaining pre 1978 Systems as of 2024	183	21%	20%	88	10%	9%	23%
# /% pre 1978 systems with 1 or more T5 Inspections	66	8%	7%	23	3%	2%	6%
#/% repaired replaced components with inspection	33	4%	4%	9	1%	1%	2%
#/% uninspected	117	13%	13%	-55	-6%	-6%	-14%
#% exempt not transferred	58	7%	6%	43	5%	5%	11%
#% exempt family sale	44	5%	5%	43	5%	5%	11%
#/% skipped required inspection	15	2%	2%	16	2%	2%	4%
#/% had one or more components repaired/replaced on pre title 5 system since 1995 without a Title 5 inspection	13	1%	1%	5	1%	1%	1%
# Systems of concern neither inspected nor component repaired	104	12%	11%	60	7%	6%	16%

As of 1995 there were 502 pre 1978 systems in the watershed. Since then, 319 have been replaced with a 1996+ system.

- 66 of the remaining 183 Pre1978 systems (35 of the pre 1971 systems) systems have been shown to be functioning properly by passing a Title 5 inspection or conditionally passing an inspection and being subsequently repaired
 - 33 of these inspected systems have repaired or replaced a component after 1995.
 - A required inspection was skipped by 15 of the 117 uninspected system
- 13 of the pre 1971 systems (3 of the pre 1971 systems) repaired or replaced a component without an inspection
- This leaves 104 (56%) of the remaining 183 pre 1978 systems (11% of the original 873 pre-1996 systems) (70 of the pre 1971 systems) that have never been replaced, repaired or inspected.

Depth to Groundwater in pre 1996 systems

Unless the system is in failure, the biggest concern for pre-1996 septic systems is the depth to groundwater. Unfortunately, while passing a Title 5 inspection means that the system has sound components and is functioning properly, it does not mean that the SAS meets the current groundwater separation standard: systems only fail if all or part of the SAS is located directly in the groundwater.

There is reasonably good depth to groundwater information in the files for 52 (18%) of the pre-1978 systems and 203 (64%) of the 1978-1995 systems. Groundwater separation had to be estimated for the 178 pre-1996 systems for which groundwater separation was not documented in the files. The estimates are based on three factors:

- System height: top to bottom height of the SAS
- depth of the SAS in the ground
- depth of the groundwater

These factors are always included in the 1996+ plans, often included on the plans prepared from 1978 to 1995, and only sometimes for the pre 1978 systems.

- System Height
 - Cesspools are however high from bottom to top the installer chose to make them but were assumed to be 6' tall
 - Seepage pits are typically 6' from bottom to top,
 - Half pits and galleys are typically 4' from bottom to top
 - "beds", "fields", "flow diffusers" and "chambers are usually 1-2' from bottom to top.
- System Depth: The SAS was assumed to be 1-2 feet below the surface. In systems without pumps (most pre-1995 systems do not have pumps), the septic tank is generally just below the level of the sewer pipe out of the house, which in turn is below the lowest sink, bath or toilet drain. For some homes this can be quite deep, for others such as ranches, the outfall will be closer to the surface. The top of the

SAS is generally slightly below the outfall from the septic tank. This will be an underestimate for some systems.

- Groundwater Depth: Estimated by adjusting the depth to groundwater found on septic system plans for adjacent homes for the difference in elevation between the two homes found on the elevation mapping data on EN-US, TOPOGRAPHIC - MAP.COM

The table below shows the counts of systems and their proximity to groundwater.

	All Systems	Near Lake	Away from Lake
Totals	933	381	552
Known Depth to Groundwater >4'	670	250	420
Unknown Depth to Groundwater Likely < 4 feet	163	67	96
Unknown Depth to Groundwater Likely > 4 feet	100	64	36

Section 5. Systems Of Concern

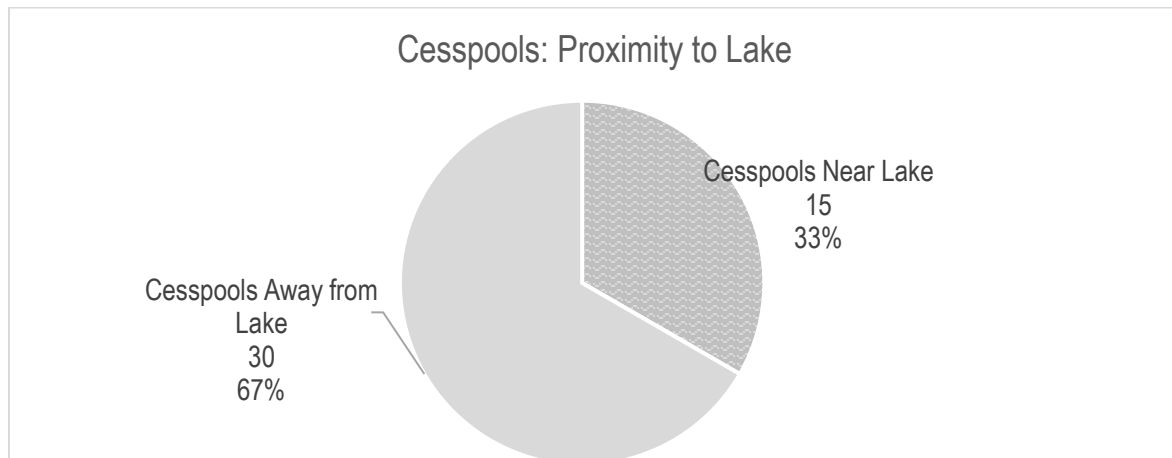
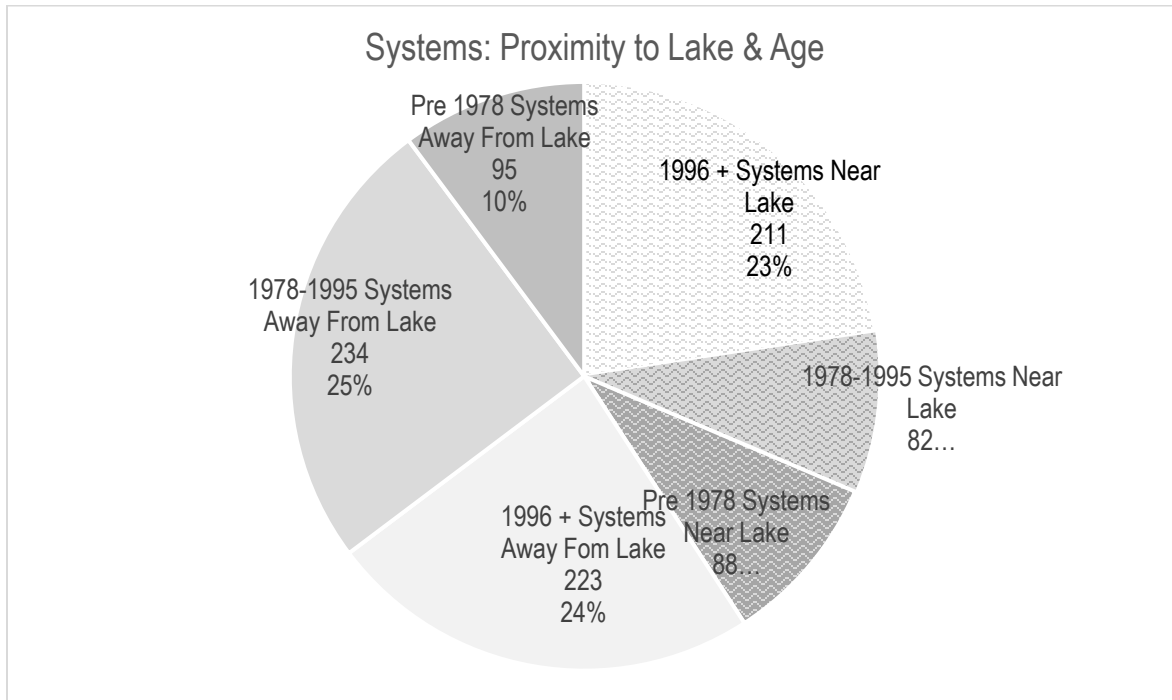
The extent of the potential risk an individual septic system poses to the lake or public health depends on the interplay of its design, installation date, depth to groundwater, location, and inspection status.

System Attributes of Concern

Attributes of systems that can be indicative of a problem are discussed below, and the factors influencing the level of concern for each of these attributes are presented from greatest to least risk. Because the actual risk of any system depends on a mix of its attributes, charts showing the numbers of systems with combinations potentially adverse characteristics are presented after the descriptions.

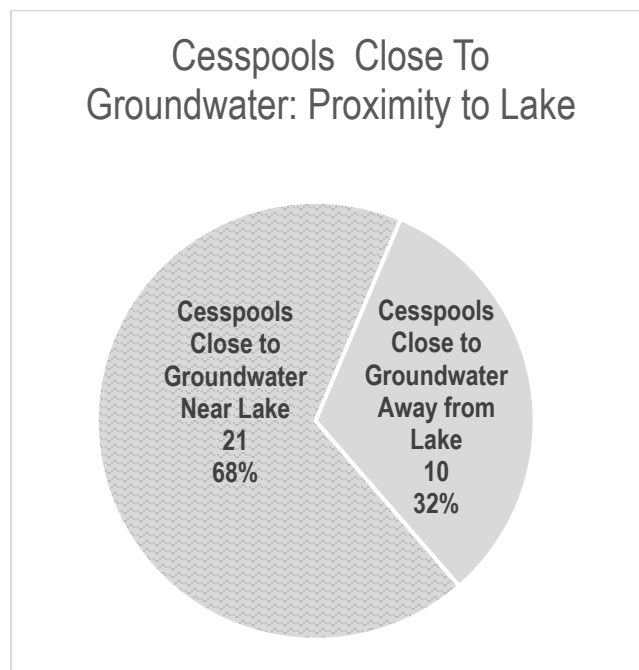
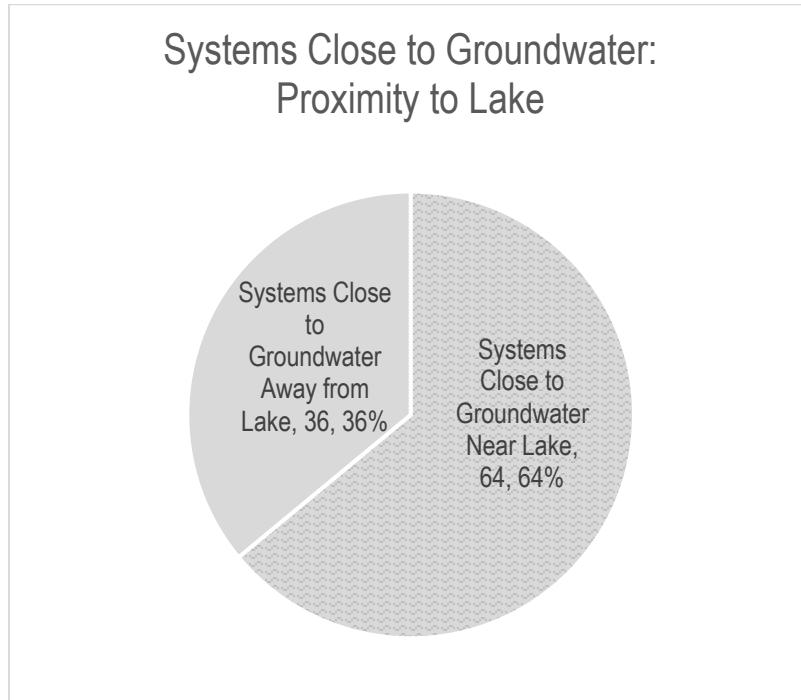
- System Installation Date/Design Standards
 1. Cesspools or Systems built prior to 1978 for which there is no information
45 of the systems installed before 1978 are known or suspected to be stand-alone cesspools (40) or cesspools that act as septic tanks and overflow to soil absorption systems (10). There was no septic information in the files for 31 systems. These were assumed to be cesspools due to the years the homes were built, 1935-1960 and the lack of any design information
 2. Pre-1978 systems because of a combination of age and design standards
 3. 1978–1995 systems because of a combination of age and design standards
 4. 20 plus years post-1996 systems because components can start to wear out
 5. Newer post 1996 systems (no added risk)

- Hydraulic proximity to the lake. Systems closer to the lake or a tributary pose a greater the potential risk
 - Systems on streets along the lake or that end at the lake
 - Systems that are not on streets along the lake or that end at the lake



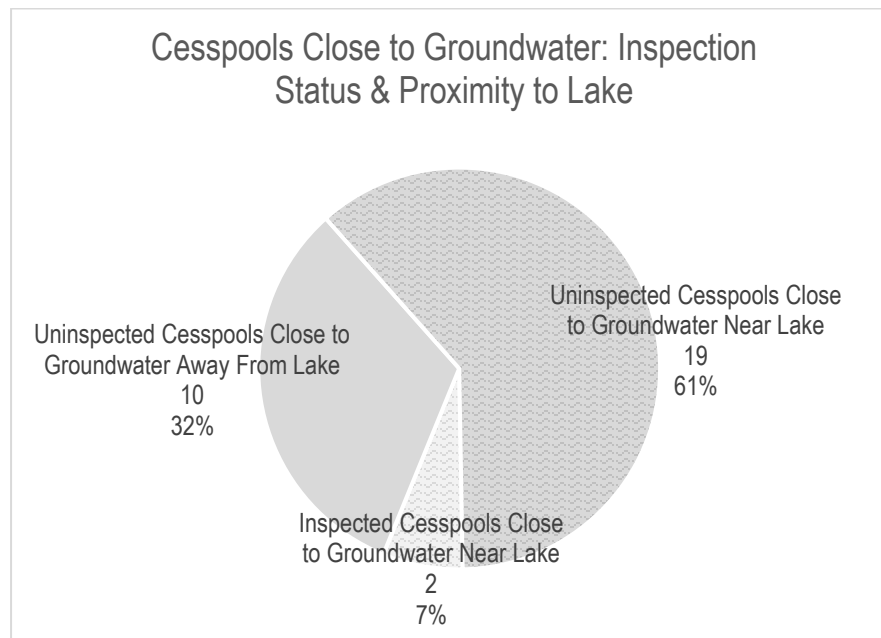
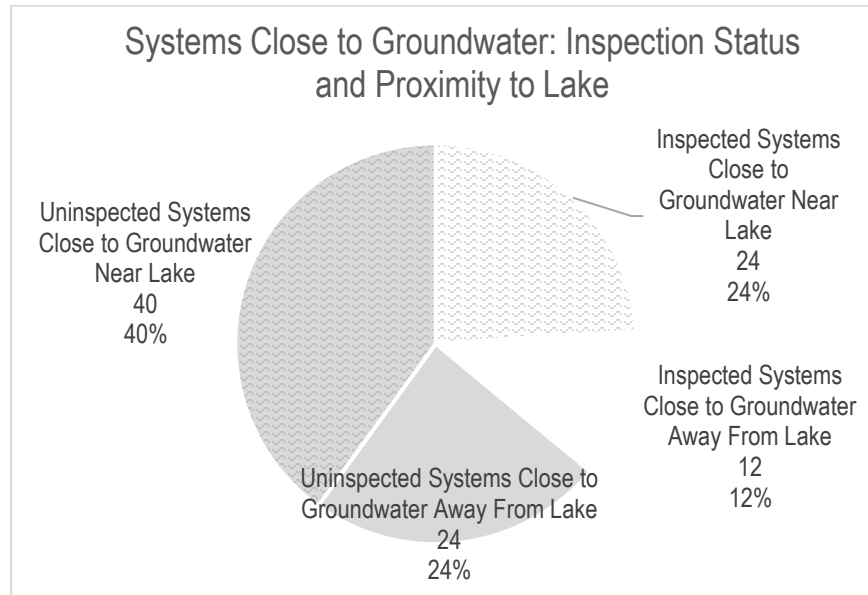
- Depth to Groundwater. Risk declines as separation from the bottom of the leaching field to the groundwater table increases.
 - Are known or suspected to have less than a 4' separation from groundwater without an alternative system
 - Have an unknown separation from groundwater

3. Are known to have a 4' separation from groundwater
4. Are known to have a 5' or greater depth to ground water (no risk)

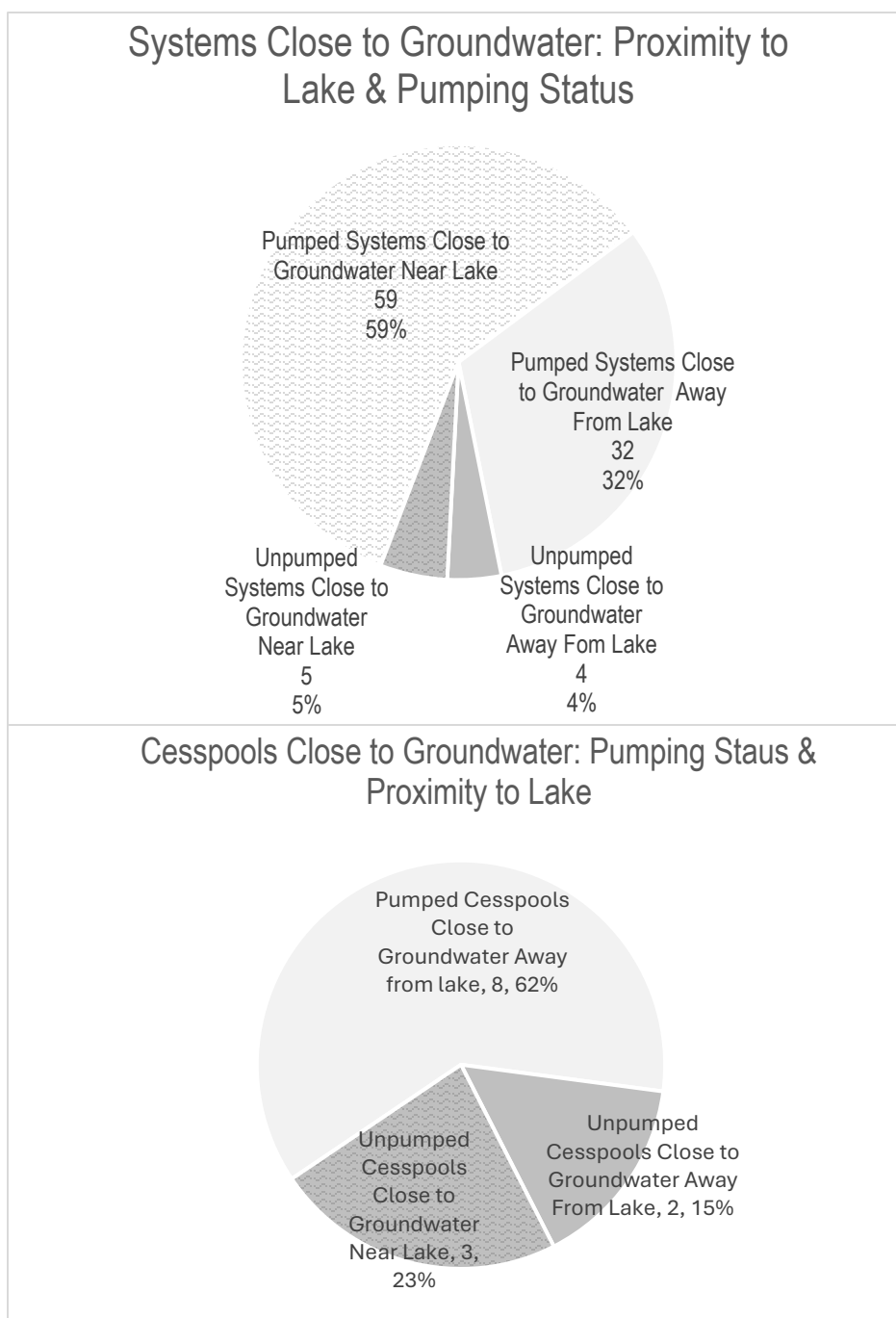


- Inspection Status:
 1. Never inspected pre-1996 systems

2. No inspection within 26 years or 26 within 26 years of installation, the chance of failure of a system or a component increases with age
3. Were last inspected pre 2001 when inspectors were less experienced and there was less readily available data on groundwater depth. The information about groundwater depth in an area available to an inspector increases with the number of post1996 systems installed in the vicinity.
4. Recent inspection (no added risk)



- Pumping Status: The potential risk increases as the elapsed time between installation and pumping.
 1. Not pumped within 25 years of most recent pumping or installation
 2. Not pumped within 10 years of most recent pumping or installation
 3. Not pumped within 5 years of most recent pumping or installation
 4. Not pumped within 2 years of installation (no added risk)



- Presence of a garbage disposal. Garbage disposals put increased strain on septic systems.
 1. A garbage disposal on an infrequently pumped system
 2. A garbage disposal with a system pumped every year
 3. No garbage disposal (no added risk)

Counts of Systems of Particular Concern

The Table below combines the above factors to put systems into risk categories, and includes counts and inspection status for each category. Pumping is not included explicitly because it is captured by uninspected systems. Systems that have been inspected have also been pumped. The presence or absence of a garbage disposal warrants a letter from the town.

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SYSTEMS OF CONCERN FROM HIGHEST TO LEAST										
	Systems Near Lake					Systems Away From Lake				
SYSTEMS OF CONCERN	# sys-tems	Not inspected since installed	Not Trans-ferred	Interfamily transfer exempted from T5 Inspection no subsequent inspection or system replacement	Missed Required T5 inspection with no excuse and no subsequent inspection or system replacement	# sys-tems	not inspected since installed	Not Trans-ferred	Interfamily transfer exempted from T5 Inspection no subsequent inspection or system replacement	Missed Required T5 inspection with no excuse and no subsequent inspection or system replacement
No Septic information (assumed to be cesspool) due to home age and lack of information in the files	22	22	10	10	2	9	9	4	3	2
Cesspool	6	5	3	2	0	6	6	4	2	0
SAS <4' separation from groundwater	43	28	7	14	7	26	17	6	6	5
SAS with unknown separation to groundwater estimated to be > 4' above groundwater	61	48	13	23	12	92	50	18	16	16
never inspected pre 1978 systems not included above	9	9	6	3	0	19	19	10	8	1
never inspected pre 1978-1995 systems not included above near lake	9	9	6	1	0	.				
never inspected pre 1978 systems not included above not near lake						19	19	10	20	1
never inspected pre 1978-1995 systems not included above away from the lake						43	43	20	13	10
pre 1978 systems not inspected in 25 years near lake not included above	9	9	6	3	0					
1978 -1995 systems not inspected in 25 years near lake not included above	11	9	6	1	2					
96+ systems not inspected in 25 years since installed near lake (dn)	15	5	1	3	1	.				
96+ systems not inspected in 25 years since installed away from lake (dn)						23	16	3	11	2

Section 6. Zoning Board Of Appeals Variances

The Sharon Zoning Board of Appeals also plays a role in protecting the lake from the impacts of septic systems. Current zoning rules require 2 acres for house lots. These rules were put in place in order to protect the lake water quality. Because many of the homes in the surface water protection district, particularly those closest to the lake were built before these rules were put in place they are on “nonconforming lots”. Homeowners are required to get approval from the Zoning Board of Appeals prior to increasing habitable or non-habitable space in houses on non-conforming lots. Expanding a home without increasing bedrooms does not require a new expanded septic system, unless the BOH required Title 5 inspection finds that the system has a failed soil absorption system, is a cesspool, or is in groundwater.

However, expanding a home can create spaces that could easily be used as bedrooms and Title 5 has strict rules for counting bedrooms that are irrespective of the room’s intended purpose: *“Where the total number of rooms for single family dwellings exceeds eight, not including bathrooms, hallways, unfinished cellars and unheated storage areas, the number of bedrooms presumed shall be calculated by dividing the total number of rooms by two then rounding down to the next lowest whole number. The applicant may design a system using design flows for a smaller number of bedrooms than are presumed in this definition by granting to the Approving Authority a deed restriction limiting the number of bedrooms to the smaller number.”* Note also that Title 5 does not exclude finished basement rooms from counting as a bedroom, as long as it is 70 sq ft or larger, has at least one window (of size), and has electrical service and ventilation.

Again because of the lake’s sensitivity to contamination, particularly phosphorus which is not permanently controlled by septic systems and is directly related to the number of residents in a home, it is important that the ZBA and the Board of Health continue to maintain vigilant review of bedroom counts, and the need for deed restrictions when these new homes exceed the number of bedrooms that their system is designed to handle when approving these variances.

When the ZBA issues a variance for expansion in a nonconforming lot, they include standard conditions related to ground and surface water protection:

- Water conserving showerhead, water conserving faucets, and water conserving flush toilet
- All fertilizers, pesticides and herbicides used at the Premises shall be organic and of low nitrogen content variety (Sometimes low phosphorus too)
- Existing septic system shall meet any current requirements set forth by the Board of Health. And sometimes the septic system shall be maintained in accordance with the requirements of the Sharon Board of Health

- There shall be no in sink garbage disposers or disposals at the premises
- No sodium chloride (road salt) shall be used on any driveways or walkways at the premises
- Only laundry detergents with no phosphorous shall be used at the premises, and only dishwashing detergents with low phosphorous shall be used at the premises
- Sometimes annual system pumping is required
- Sometimes Leaders for roof gutters must be directed into dry wells
- Sometimes bedroom restrictions (although converting a room into a bedroom without a building permit is technically not allowed)

One or more zoning variances were found at 68 of the homes in the SWPD. Because they were not a focus of the analysis this may not represent a complete count.

Section 7. Recommendations (Draft)

There are two potential threats to the lake from the 933 residential and small commercial septic systems and the larger systems at Camp Wonderland and Conference Center, Camp Everwood, the Community Center and Sharon High School: contamination with disease causing pathogens (bacteria, viruses, and other microorganisms) and increased phosphorus loading that fuels the growth of cyanobacteria, algae, and weeds.

Ensuring the continued effectiveness of the Septic Systems around the lake

With a few exceptions, the existing systems are capable of protecting the lake from pathogens. However, even the best system can fail to protect public health and the environment over time as its components age, if it is abused by overloading or disposing of substances that it cannot handle, or by not properly pumping and maintaining it. The town needs to have systems in place that

- ensure that existing failing and inadequate systems that are too small for the number of users are identified and corrected so they do not cause harm
- continue to ensure that new systems meet the current rigorous design and installation standards and are adequately sized for the number users that the system can be expected to serve
- understand how to use and maintain their systems so that they do not fail prematurely.

Accordingly, it is recommended that the town:

- Identify the oldest uninspected systems suspected of being less than 4' above high groundwater within 300 feet of the lake or a tributary or storm drain to the lake and
 - If a required inspection was not completed on the last transfer and the system has not been inspected or replaced since the transfer, require the homeowner to conduct the inspection
 - If the home has not been subject to the Title 5 inspection requirement, inspect the system to determine if it is posing a public health threat, and if so, work with the homeowner, including potentially providing a no interest loan to get the system replaced or repaired as appropriate.
 - If it has passed an inspection and is less than 4' from high groundwater, work with the homeowner to get the system replaced as soon as possible

- Consider passing a bylaw similar to the current rule on cesspools that homes in the surface water protection district (and the groundwater protection district) that are less than four feet above the high groundwater level automatically fail a required Title 5 inspection and are therefore replaced upon transfer

- Ensure required Title 5 Inspections are conducted by:
 - Identify the systems that appear to have failed to complete a required inspection and require that the inspection be conducted.
 - Ensure that all future required inspections are completed by
 - Working with area realtors to ensure their clients understand that an inspection is required prior to transfer,
 - Reviewing all recent sales to determine if a required inspection was conducted, and if it wasn't contact the purchaser to ensure it is done in a timely manner.
 - Explore if there is some mechanism the town can use to ensure that potential buyers understand that a Title 5 is required prior to the purchase of a home with a septic system

- Ensure systems are properly maintained and pumped with sufficient frequency by
 - Sending homeowners who have not pumped their system in three or five years a notification explaining the importance of pumping and that pumping is overdue
 - Identifying the homes whose septic permit or ZBA variance mandate annual pumping and require that annual pumping occurs
 - Sending all new residents a "Welcome to your septic system" package explaining the importance of pumping as well as the proper use and maintenance of these systems
 - Sending a notification to owners of homes with a garbage disposal explaining that disposals are illegal and requesting their removal due to their ability to overload septic systems and cause them to fail prematurely.
 - Considering establishing a wastewater management district in the surface water protection district (and groundwater protection district?) similar to those in municipalities with sewers. A district would allow the town to charge a fee to

assume the management, pumping, maintenance, repair and replacement of the septic systems within the district. It would protect the lake (and town wells if the groundwater protection districts are included) from contamination from inadequate, poorly running systems. It would also relieve the homeowner of the need to complete a Title 5 inspection prior to sale and alleviate the fear of an unexpected repair or replacement expense. The town would be able to take advantage of economies of scale in the costs of managing, repairing and replacing the systems unavailable to individual homeowners.

- Work with the Board of Health to
 - Amend Article 7 to be consistent with the bedroom definition Title 5 adopted to address the relative ease with which open space in a home can be converted into private spaces suitable for bedrooms. While local standards can be more stringent than state standards, they cannot be less so.
“310 CMR 15.002 Definitions: “Bedroom - A room providing privacy, intended primarily for sleeping and consisting of all of the following:
 - (a) floor space of no less than 70 square feet;*
 - (b) for new construction, a ceiling height of no less than seven feet three inches;*
 - (c) for existing houses and for mobile homes, a ceiling height of no less than seven feet zero inches;*
 - (d) an electrical service and ventilation; and*
 - (e) at least one window.**Living rooms, dining rooms, kitchens, halls, bathrooms, unfinished cellars and unheated storage areas over garages are not considered bedrooms. Single family dwellings shall be presumed to have at least three bedrooms. Where the total number of rooms for single family dwellings exceeds eight, not including bathrooms, hallways, unfinished cellars and unheated storage areas, the number of bedrooms presumed shall be calculated by dividing the total number of rooms by two then rounding down to the next lowest whole number. The applicant may design a system using design flows for a smaller number of bedrooms than are presumed in this definition by granting to the Approving Authority a deed restriction limiting the number of bedrooms to the smaller number.”*
 - Ensure that variances for new construction are only issued when the variance is equally protective and homeowner has lost “*essentially all economic benefit of the property*”
 - Ensure that variances for replacement systems meet the maximum feasible compliance standard, including requiring additional treatment to offset the low depth to groundwater or small-sized system.
- Work with the Zoning Board of Appeals to fully consider the impacts on the lake when granting variances to zoning rules. The two acre zoning around the lake was expressly adopted to protect it from the pollution associated with septic systems, lawns, and

other impacts associated with dense housing development in the watershed. The considerations used to weigh the effects of increasing existing nonconformance are different than those appropriate to other neighborhoods.

- Work with the Planning Board to add to the list of lake protective conditions automatically applied to variances in the surface water protection district.

Controlling Phosphorus

Phosphorus pollution from septic systems remains a substantial threat to the lake, as shown by a mass balance assessment of 1319 pounds of phosphorus in human waste produced in the watershed each year by watershed residents, students, visitors, and workers. This is a potentially significant source of phosphorus that needs to be addressed. The number suggests that phosphorus loading to the lake from external sources in the Town of Sharon's 2025 Watershed Based Plan may be underestimated. Those models considered external phosphorus loading to come from tributaries and inlets, street and land runoff, and near-shore ground water seepage. Neither of the models took into account most of the septic systems in the watershed, and did not take into account that Lake Massapoag is fed by underground springs. It is possible that phosphorus from the recent (in hydrogeological time) development in the watershed could be still making its way through the soil and groundwater and has not yet reached the lake, or some or all could be permanently (or temporarily) captured in the swamps surrounding the lake. To what extent septic system-derived phosphorus presents a current or future problem remains to be determined.

Accordingly, it is recommended that the town:

- Continue to research and investigate the contribution of septic system-derived to external phosphorus loading, by rerunning the LLMS model to account for all of the septic systems in the lake. This would include conducting additional research on the factors that influence phosphorus attenuation and transport through the Lake Massapoag watershed including the role of swamps and underwater springs in the lake.
- In the meantime:
 - Implement the comparatively inexpensive stormwater management measures recommended by LMAC's consultants NepRWA and TRC
 - Evaluate the cost and feasibility of installing phosphorus controls on the Sharon High School wastewater treatment plant that contributes about a quarter (316 pounds) of the estimated human-derived phosphorus to the lake.
 - Evaluate the cost and feasibility of urine diversion toilets and the installation of phosphorus pretreatment at all or a portion of the septic systems in the watershed.

- Research various funding sources, including considering a “lake protection fee” designed to raise funds to protect a resource that is enjoyed by the entire town.
- Consider the development of a wastewater management district in the Lake as discussed above.

Section 8. The Database

The information collected in the file review is stored in an Excel Workbook that was started by an Engineering Division Intern. The database includes basic information about each property in the SWPD from the town assessors’ records as well as the septic system information gleaned from the files, and various analyses. The “original” with all of the calculations used to create the tables is “locked” so the data will not be lost. However, a copy called DATA FOR ANALYSIS BY FILTERING is the first worksheet in the workbook. The columns have been reordered and grouped into categories so that they make a little more sense. The data in the cells has been locked, however you can change column widths and row heights, you can sort and most importantly you can filter on columns. For example, if you would like to identify all the properties with cesspools you can filter on the word “cesspool” in *column AP* <cesspool> (in the section titled “Issues of Concern”). You will then see everything in the database about those properties: address, owner, date installed, inspection information, house construction year, proximity to groundwater whether or not it is on a street near the lake, type of system, number of bedrooms, and other data. If you want to see how many and which ones of those have had an inspection you can then also filter on *column BW* <Home or Location had one or more title 5 inspections>.

The complete list of column headings is provided in the appendix. There are a lot of data and many analytical columns. The reader should be able to get a great deal of information out of the chart provided.

Appendix G: TRC
EXTERNAL PHOSPHORUS
SAMPLING MEMOS:
STORM DRAIN
OUTFALLS, RUNOFF,
GROUNDWATER SEEPAGE,
HOT SPOTS

MEMORANDUM

TO: Town of Sharon- Lake Massapoag Advisory Committee
FROM: Margaret O'Brien
SUBJECT: Storm Drain Sampling Results
COPY TO:

DATE: January 13, 2025
Amended June 23, 2025
TRC PROJECT NO.: 569556.0000.0000

Dear Committee,

Below please find a summary of the wet weather storm drain sampling results.

Storm Drain Sampling

TRC conducted storm drain sampling on November 21, 2024, during a 0.64-inch rain event in Sharon, MA. TRC investigated 8 storm drains that discharged into Lake Massapoag. Of the eight storm drains, only six were observed to be flowing at the time of sampling and were therefore sampled. The two outfalls that were observed to be dry during the sampling visit were the 123 Beach Street outfall and the Veterans Memorial Beach outfall. TRC also observed the lake tributaries as potential sampling opportunities to make up for the lack of storm drain outfall samples collected due to no flow conditions. Canoe River and the Lagoon inlet to the South Cove were both observed to be dry. Sucker Brook was observed to be flowing and was therefore sampled from the outfall at Massapoag Avenue. The outfalls sampled are listed below in Table 1 and shown in Figure 1.

TRC conducted additional storm drain sampling on May 31, 2025 during a 0.16-inch rain event to re-sample the 123 Beach Street Outfall and the Veterans Memorial Beach outfall that were observed to be dry during the 2024 sampling event. TRC also collected an additional sample at Sucker Brook.

TRC collected water samples for laboratory analysis of the following analytes: total phosphorus, total nitrogen, and total suspended solids (TSS). TRC collected field measurements for specific conductance. TRC also measured discharge in the field at all outfall locations, with the exception of Sucker Brook in November¹. TRC calculated discharge by measuring water depth and water velocity at each outfall.

Table 1. Wet Weather Shoreline Sampling Locations

Sample ID	Outfall Type	Location Description
Outfall-1	Storm Drian	7-11 Livingston Road
Outfall-2	Storm Drain	19-21 Livingston Road
Outfall-3	Storm Drain	31 Livingston Road
Outfall-4	Storm Drain	25 Sturges Road
Outfall-5	Storm Drain	140 E. Foxboro Street
Outfall-6	Storm Drain	Massapoag Ave at Arboro Drive

¹ The late time of day, limited visibility due to loss of daylight, and safety concerns due to proximity of the roadway prohibited additional field data collection at Sucker Brook, including the collection of discharge measurements. Only laboratory samples for total phosphorus, total nitrogen, and TSS were collected. Additionally, specific conductance was included as a laboratory analysis rather than collected as a field measurement.

and localized algal growth, even if these inputs do not end up tipping the scale much from a lake-wide loading perspective.

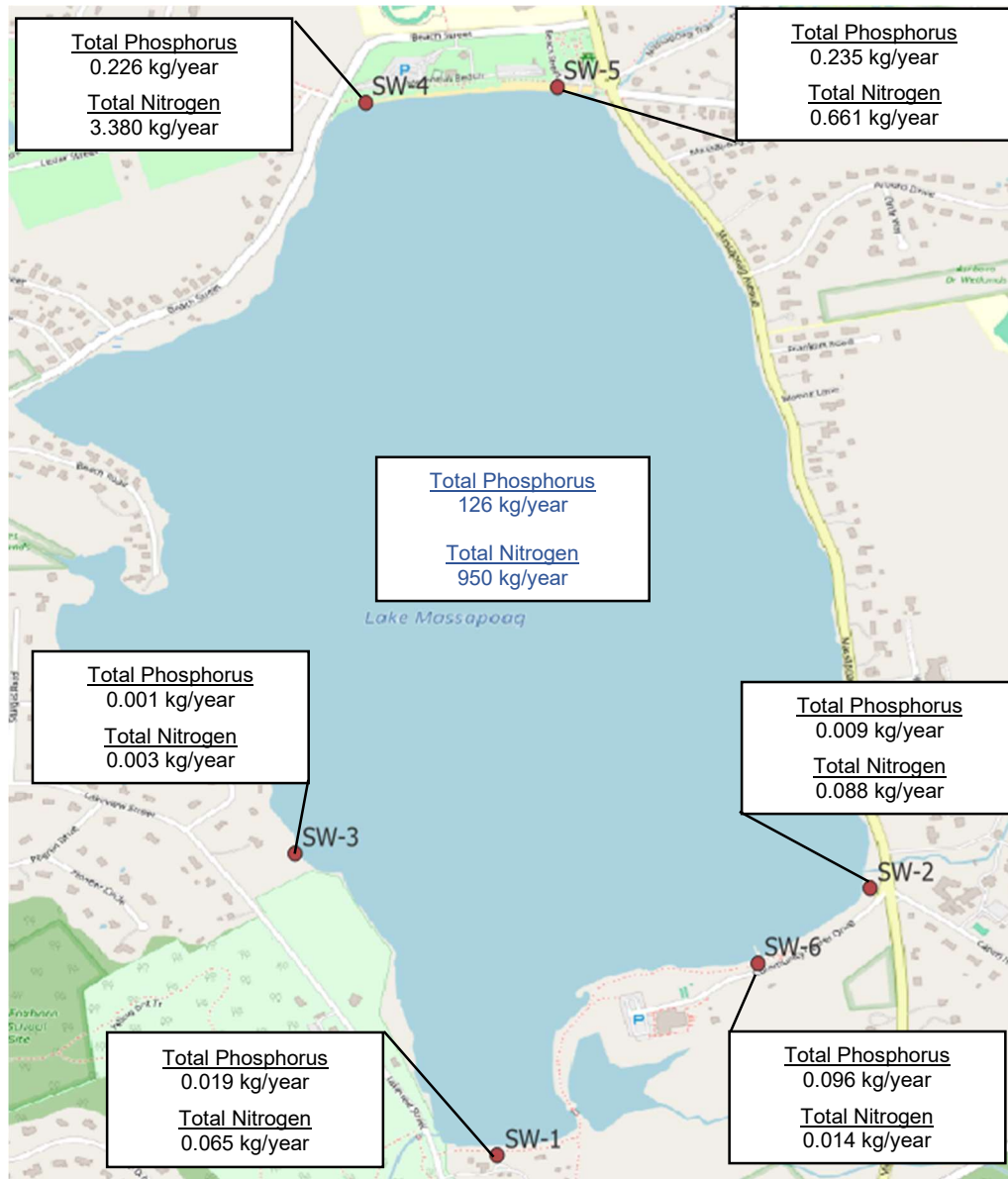


Figure 3. Summary of Nutrient Loads at Each Shoreline Sampler Catchment Area and the Total Calculated Runoff Nutrient Load (shown in blue)

Table 1. Wet Weather Shoreline Sampling Locations

Sample ID	Outfall Type	Location Description
Outfall-7	Tributary	Sucker Brook
Outfall-8	Storm Drain	123 Beach Street
Outfall-9	Storm Drain	VMB Outfall

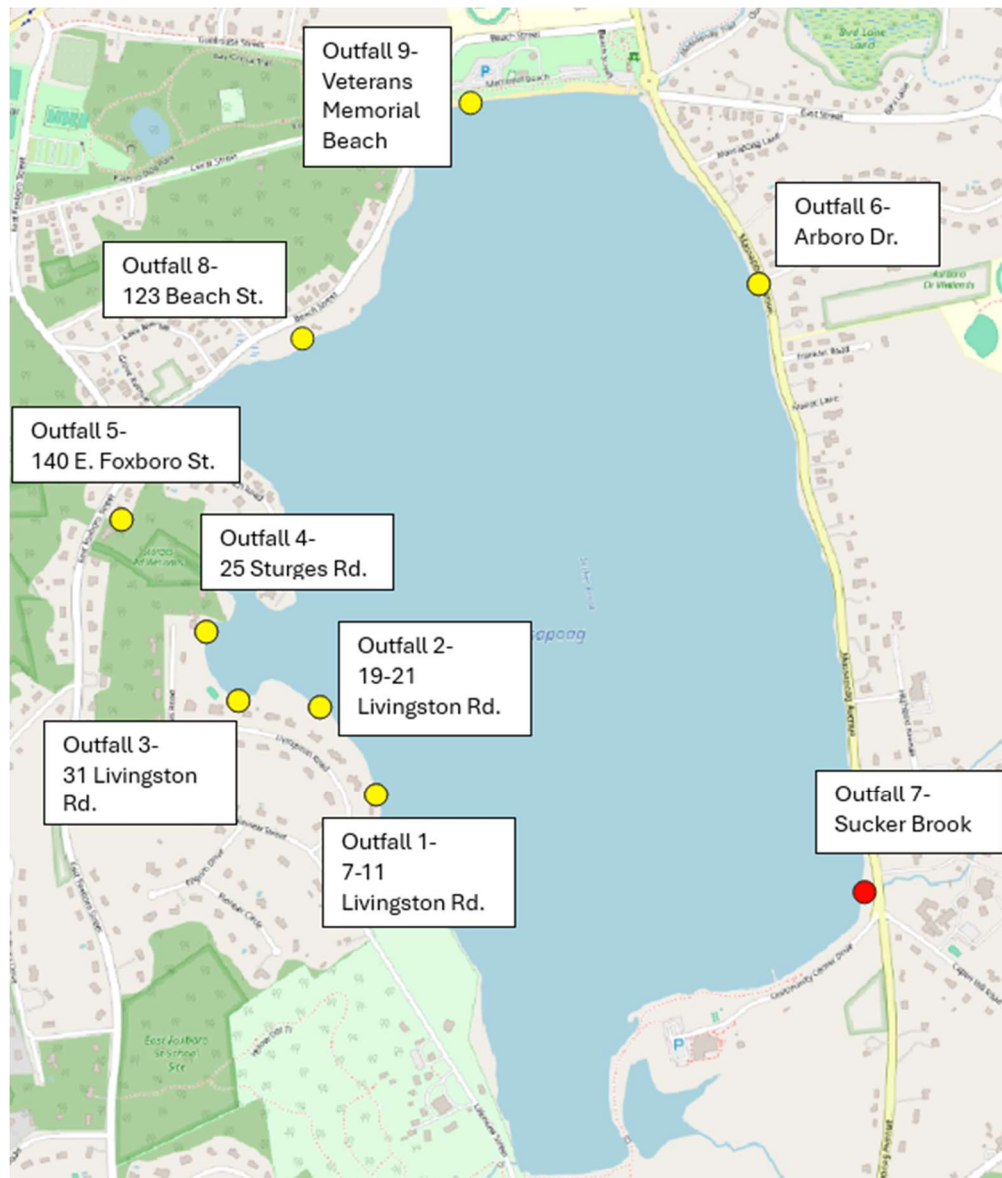


Figure 1. Wet Weather Outfall Sampling Locations at Lake Massapoag

Note: storm drain outfalls shown in yellow, tributary outfall shown in red

Results

For the November 2024 results, total phosphorus concentrations were elevated in all of the samples collected. Total phosphorus values ranged from 0.198 mg/L to 0.489 mg/L with the most elevated concentrations collected from Outfall 2 (19-21 Livingston Road) and Outfall 3 (31 Livingston Road) (Table 2). Total nitrogen values were elevated in five of the seven locations sampled. Total nitrogen ranged from 0.089 mg/L to 2.75 mg/L with the most elevated concentration collected from Outfall 2 (19-21 Livingston Road) (Table 2). TSS and specific conductivity were relatively low in all of the samples collected with the exception of Sucker Brook. Sucker Brook had the highest specific conductivity and TSS values compared to the other locations. These values indicate some amount of sediment loading into the lake, particularly from Sucker Brook.

Table 2. Wet Weather Storm Drain Data, November 21, 2024

Sample ID	Nitrite (mg/L)	Nitrate (mg/L)	TKN (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Sp. Conductivity (µS/cm)
Outfall-1	<0.010	0.12	1.12	1.24	0.347	29	29.0
Outfall-2	<0.010	0.55	2.2	2.75	0.489	19	45.6
Outfall-3	<0.010	0.13	1.25	1.38	0.483	12	35.4
Outfall-4	<0.010	0.05	0.94	0.99	0.32	25	22.9
Outfall-5	<0.010	0.12	0.77	0.89	0.198	16	24.5
Outfall-6	<0.010	0.35	1.01	1.36	0.256	12	74.7
Outfall-7	<0.010	0.15	2.26	2.41	0.241	90	179*

***Note:** Specific conductance at Sucker Brook was measured by the laboratory rather than collected as a field measurement. This value was reported by the laboratory as umhos/cm which is equivalent to µS/cm.

The results from May 2025 show that the total phosphorus concentration is elevated from Outfall 9 (VMB Outfall). The results from Outfall 8 (123 Beach Outfall) show slightly elevated concentrations but is the lowest total phosphorus concentration collected from a storm drain in November 2024 and May 2025. Total phosphorus collected at Outfall-7 (Sucker Brook) was lower in May, 0.032 mg/L, compared to November, 0.241 mg/L. Total nitrogen concentrations were elevated in both Outfall 8 and 9. TSS and specific conductivity was relatively low in Outfall 8 and 9.

Sample ID	Nitrite-Nitrate (mg/L)	TKN (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Sp. Conductivity (µS/cm)
Outfall-7	NS	NS	NS	0.032	NS	240.7
Outfall-8	<0.02	1.69	1.69	0.067	3.6	130.0
Outfall-9	0.07	2.77	2.84	0.265	21	240.0

To approximate annual loading, the area drained and inches of annual precipitation were multiplied to yield a total stormwater discharge volume. The discharge volume was then multiplied with average nutrient concentrations (based on the November and May stormwater sampling event) to produce approximate annualized load values.

NepRWA's catchment analysis identified all upland areas that contribute runoff to Lake Massapoag and are currently contributing to the nutrient pollution load of the lake. Therefore, TRC used NepRWA's catchment analysis data to calculate the total area of contributing catchment. TRC excluded the area surrounding the lake that is captured by direct runoff (i.e. areas that aren't associated with a stormwater outfall), to focus this assessment on point-source pollutant contributions. Therefore, the estimated total stormwater catchment area is approximately 2,089 acres. TRC assumed an average of 3.75 feet of rainfall per year and estimated that approximately 10% of annual precipitation will be discharged through the stormwater outfalls. Based on these estimations, approximately 34,120,250 cubic feet of rain will discharge through the outfalls located within NepRWA's identified catchment areas on an annual basis. Based on the sampling results from the stormwater outfalls, the average concentration of total phosphorus in runoff was 0.30 mg/L and the average concentration of total nitrogen in runoff was 1.64 mg/L. Therefore, approximate annual nutrient loads from stormwater outfalls into Lake Massapoag would be approximately 293 kg of phosphorus and 1,587 kg of nitrogen.

As a tributary outfall, Sucker Brook was excluded from these calculations. This nutrient loading estimate focuses solely on point-source discharge from stormwater outfalls.

Discussion

Based on sampling of the November and May storm events, storm drain outfalls contribute high levels of nutrients to Lake Massapoag. It should be noted that storm drain water quality results presented here are based on two storm events, and there may be variability in storm water nutrient concentrations depending on the season, precipitation amount, recent precipitation history, and precipitation intensity.

Figure 2 shows the total estimated annual nutrient load from the eight storm drain outfalls, as well as individual loading estimates for each storm drain (note that annual loading totals do not include Sucker Brook as discharge could not be measured at that sampling location).

Excessive amounts of nutrients in stormwater runoff can contribute to lake eutrophication, which can ultimately lead to algal blooms. Excessive nutrient loads from stormwater runoff may be attributed to several factors including but not limited to fertilizer use, pet/geese waste, decomposing organic matter, and/or erosion of soils.

The total effects of storm drain inputs will not be fully understood until the rest of the Lake Massapoag system has been evaluated. At that point, it will be possible to compare the relative contribution of nutrients from storm drain runoff to those of different nutrient sources (e.g. non-point source discharges) into Lake Massapoag. However, it is clear from this study that high concentration of nutrients can be mobilized directly into the lake during intense precipitation events.

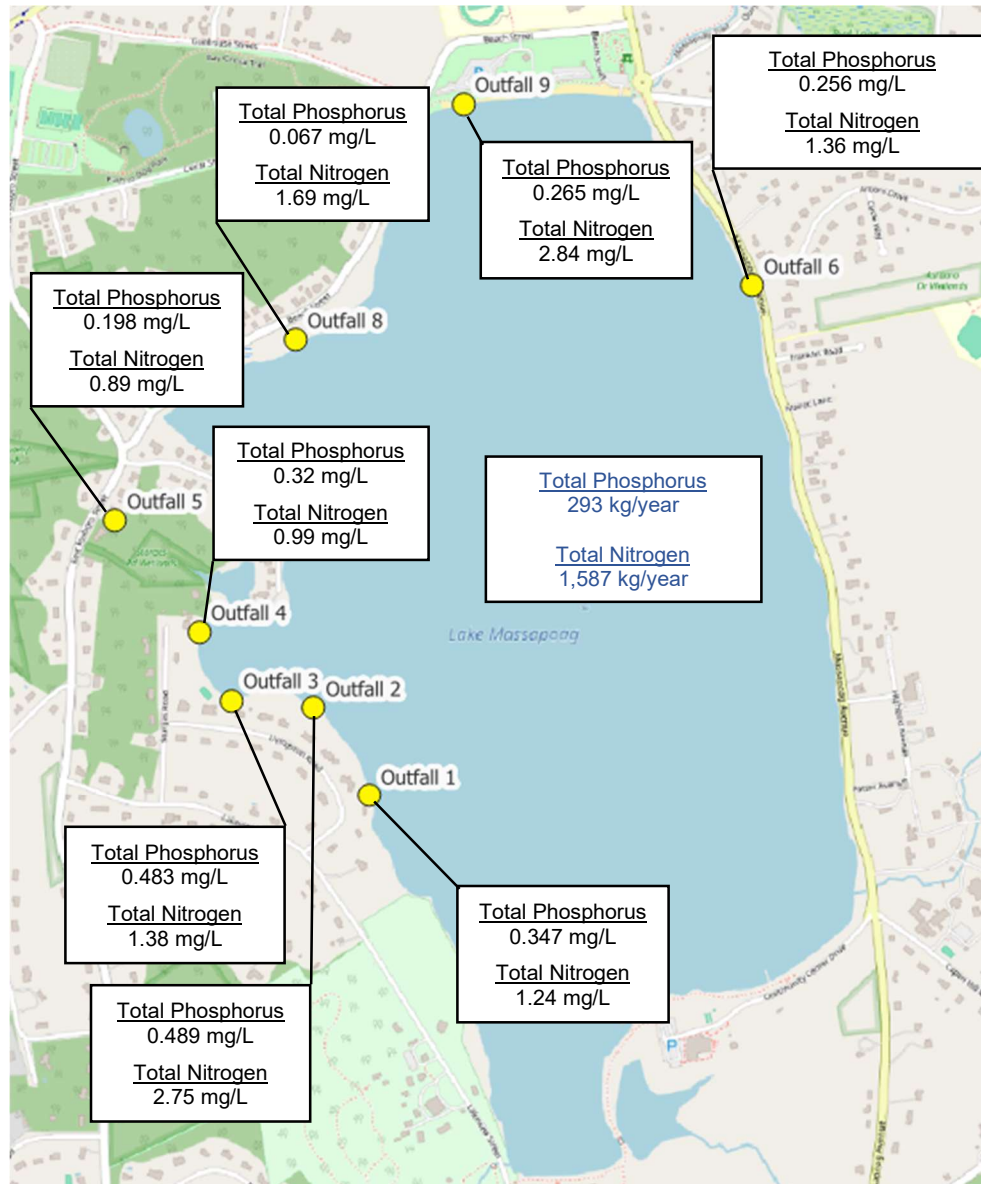


Figure 2. Summary of Nutrient Results at Each Storm Drain Outfall Sampled and the Total Calculated Storm Drain Nutrient Load (shown in blue)

MEMORANDUM

TO: Town of Sharon- Lake Massapoag
Advisory Committee
DATE: November 20, 2024
FROM: Margaret O'Brien
TRC PROJECT NO.: 569556.0000.0000
SUBJECT: Shoreline Sampling Results
COPY TO:

Dear Committee,

Below please find a summary of the wet weather shoreline sampling results.

Wet Weather Shoreline Sampling

TRC installed six GKY, Inc. first-flush unattended samplers on June 26, 2024 and collected the samplers the next morning immediately following a rain event. Unattended samplers, also referred to in this memo as shoreline samplers, were installed in locations based on input from the Town and where there was evidence of flow concentration (e.g., rills, dry channels). Samplers were installed to be flush with soil grade. Descriptions of the sample locations are detailed in Table 1 and shown on Figure 1.

The total rainfall received during the event was 1.77 inches, (as measured at the Norwood Memorial Airport in Norwood, Massachusetts). The storm event lasted a total of 5 hours between approximately 7:00 PM to approximately 12:00 AM. Samplers were installed with collection ports flush with the ground surface and the sampling receptacle just below grade. Following the storm, TRC retrieved the samplers and, where volume was sufficient, tested the collected runoff for specific conductance, nutrients (total nitrogen, total phosphorus), and total suspended solids (TSS). Where volume was insufficient to test all analytes, total phosphorus was prioritized, followed by total nitrogen, TSS, and specific conductance. TRC noted that several of the samplers appeared to be slightly dislodged, likely due to the torrent of rain that washed through during the deployment period. This likely resulted in decreased runoff collection, resulting in lower volumes than they would otherwise have been expected during a precipitation event of this magnitude.



Table 1. Wet Weather Shoreline Sampling Locations

Sample ID	Location Description
SW-1	Everwood/Gannet
SW-2	189 Massapoag Ave
SW-3	Massapoag Yacht Club
SW-4	Memorial Beach (West Side)
SW-5	Memorial Beach (East Side)
SW-6	Community Center Beach

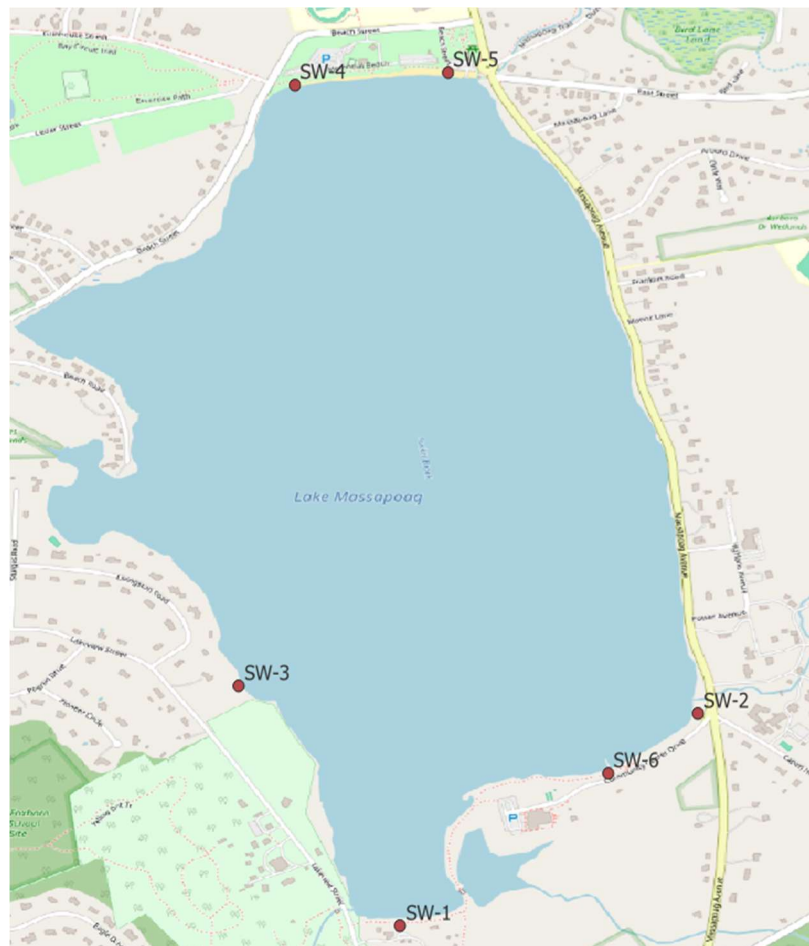


Figure 1. Wet Weather Shoreline Sampler Locations at Lake Massapoag

Results

Total phosphorus and total nitrogen were reported for all locations. Sample volume was low in several of the shoreline samplers. Therefore, the lab performed a combined nitrite and nitrate analysis on the samples from SW-2, SW-3, SW-4 and SW-6. However, nitrite is expected to represent a minimal portion of the total reported nitrogen value. TSS and specific conductance was only measured at SW-1 and SW-5 where there was enough sample volume to do so.

All sites tested high for total nitrogen (>1 mg/L) and total phosphorus (>0.025 mg/L) (Table 2). Certain sites, in particular SW-4, at the west end of Memorial Beach near the dock, had extremely high concentrations of total nitrogen (66.8 mg/L) and total phosphorus (4.47 mg/L). SW-5, located at the east end of Memorial Beach by the kayak storage, had the second highest concentration of total nitrogen (8.0 mg/L) and total phosphorus (2.84 mg/L). Of the sampled sites, the site with the lowest concentrations of total nitrogen and phosphorus was SW-3, at the Massapoag Yacht Club. Although only two shoreline samplers had sample volume sufficient to test TSS, both of the tested samples yielded very high concentrations of TSS. Direct runoff of TSS at these levels could contribute to localized and short-term

elevation of lake turbidity until settling occurs, thereby reducing the penetration of light at depth in the water column. Additionally, elevated nutrient loads tend to be associated with high TSS as nutrients can bind to soil particles.

Table 2. Wet Weather Runoff Data, June 26, 2024

Sample ID	Nitrite (mg/L)	Nitrate (mg/L)	Nitrate-Nitrite (mg/L)	TKN (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Conductivity (umhos/cm)
SW-1	0.03	0.29	NS	2.12	2.44	0.724	340	45
SW-2	NS	NS	0.26	4.32	4.58	0.465	NS	NS
SW-3	NS	NS	0.06	1.7	1.76	0.444	NS	NS
SW-4	NS	NS	0.42	66.4	66.8	4.47	NS	NS
SW-5	<0.010	0.38	NS	7.62	8.0	2.84	2,200	26
SW-6	NS	NS	0.35	5.89	6.24	0.895	NS	NS

NS= Due to low sample volume, analyte not analyzed

After conducting field sampling, TRC calculated the catchment areas for each shoreline sampler based on publicly available LiDAR-derived contours. Catchment areas were determined to be relatively small, ranging from approximately 150 to 1,040 square feet. Using these areas, estimating the percent of rain infiltrated based on slopes and presence of pervious cover, and assuming an average of 3.75 feet of rain per year, TRC calculated the annual nutrient loads for each catchment area (Table 3). The calculated nutrient loads show that the catchment area at SW-4, for example, contributes approximately 3.38 kg of total nitrogen and 0.226 kg of total phosphorus into the lake per year. This amount is not surprising given the high concentrations of total nitrogen and total phosphorus from this shoreline sampler (66.8 mg/L and 4.47 mg/L, respectively).

Table 3. Nutrient Load by Catchment Area

Sample ID	Total Nitrogen (kg/year)	Total Phosphorus (kg/year)
SW-1	0.065	0.019
SW-2	0.088	0.009
SW-3	0.003	0.001
SW-4	3.380	0.226
SW-5	0.661	0.235
SW-6	0.096	0.014

TRC then scaled up the exercise to estimate nutrient loading for the areas around Lake Massapoag that will most likely contribute to the direct runoff into the lake. TRC calculated the runoff area around the lake by using the sheet flow areas identified in NepRWA's 2024 Catchment Analysis and subtracting the drainage areas of surrounding tributaries. TRC minimized the potential runoff areas by only looking at an approximately 85-foot buffer around the lake. This distance was determined by measuring the farthest distance a catchment area was extended from the shoreline. This runoff area was then broken up into six sections and each section was associated with a nearby shoreline sampler. Based on the spacing of the runoff samplers, some were attributed to a smaller area while others were attributed to a larger area. These

representative areas for each shoreline sampler are shown in varying colors in Figure 2 and described in Table 4.

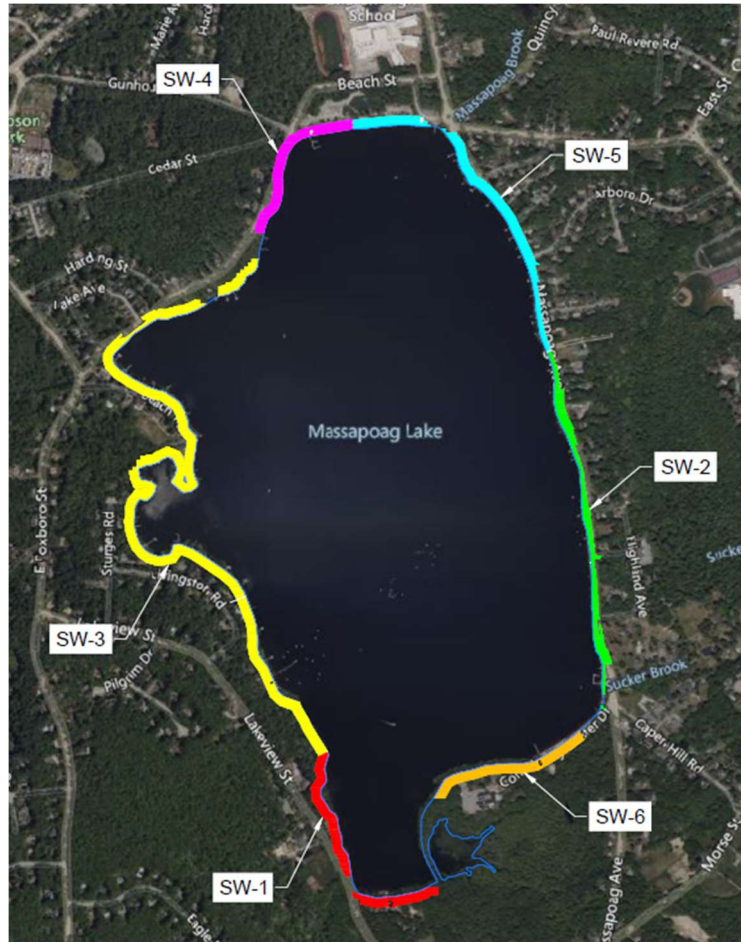


Figure 2. Representative Areas Associated with Each Shoreline Sampler

Once the representative areas for each shoreline sampler were identified, TRC made several assumptions to calculate an annual nutrient load from runoff. First, TRC assumed an average rainfall of 3.75 feet of rain per year. Second, because slopes can vary over a given area, TRC assumed that in all areas, two-thirds of the rainfall would become sheet flow while one-third of rainfall would infiltrate into the ground. TRC used these assumptions to calculate the total nitrogen and phosphorus loads over each representative area (Table 4). TRC estimates the phosphorus load from the total runoff area around Lake Massapoag to be approximately 126 kg/year (Table 4). TRC estimates the nitrogen load from the total runoff area around the lake to be approximately 950 kg/year (Table 4). A summary of results is presented in Figure 3.

Table 4. Nutrient Load by Representative Area

Sample ID	Representative Lake Area (Ft ²)	% of Total Area	Total Nitrogen (kg/year)	Total Phosphorus (kg/year)
SW-1	159,426	10%	27	8
SW-2	323,561	21%	104	11
SW-3	617,272	40%	76	19
SW-4	121,969	8%	571	38
SW-5	211,210	14%	118	42
SW-6	121,827	8%	53	8
TOTAL	1,555,266	100%	950	126

Discussion

High rates of nutrient loading were identified in runoff during the June 26th storm event, particularly in the Memorial Beach area. The sampled storm event was observed to be particularly intense based on the total rainfall and observations of slightly dislodged shoreline samplers. It should be noted that runoff water quality results presented here are based off of one storm event, and there may be variability in results depending on the season, precipitation amount, and precipitation intensity.

One of the greatest contributors of nutrient inputs from runoff is erosion of soils into the lake. Soil particles can have nutrients either adsorbed to them or part of their soil matrix (i.e. organic debris). When it rains, runoff can collect these soil particles, depositing them into the lake. The two TSS values obtained during this study indicated that excessive amounts of suspended solids were present in the collected runoff. Therefore, it is likely that eroded soils transported by runoff are being deposited directly into the lake and adding to nutrient inputs. Stabilizing slopes along the lake and diverting runoff from beach areas can help to minimize the input of nutrients from eroded soils.

Several additional factors, include fertilizer use and the presence of geese and/or pet waste, can also cause high nutrient inputs from runoff.

Fertilizer is used to provide plants with the necessary nutrients they need to grow and thrive, including nitrogen, phosphorus, and potassium. However, excessive use of fertilizer can lead to excess nutrient runoff from the homeowner's property directly into the lake. This can then accelerate eutrophication of the lake which can allow for potentially toxic algal blooms that can be detrimental to the lake ecosystem and can potentially be harmful to lake residents.

Pet and geese waste contains nutrients that can speed up the eutrophication process. When pet and geese waste washes into lakes and streams, it decays and uses up oxygen in the water column, in addition to releasing nutrients. The presence of waste within a waterbody can also become a health issue, as it can contain harmful bacteria and parasites.

The total effects of runoff inputs will not be fully realized until the rest of the Lake Massapoag system has been evaluated. At that point, it will be possible to compare the relative contribution of nutrients from runoff to those of different nutrient sources (e.g. point source discharges) into Lake Massapoag. However, it is clear from this study that high concentration of nutrients can be mobilized directly into the lake during intense precipitation events. During the warm season, these slugs of nutrients could allow for short-term

and localized algal growth, even if these inputs do not end up tipping the scale much from a lake-wide loading perspective.

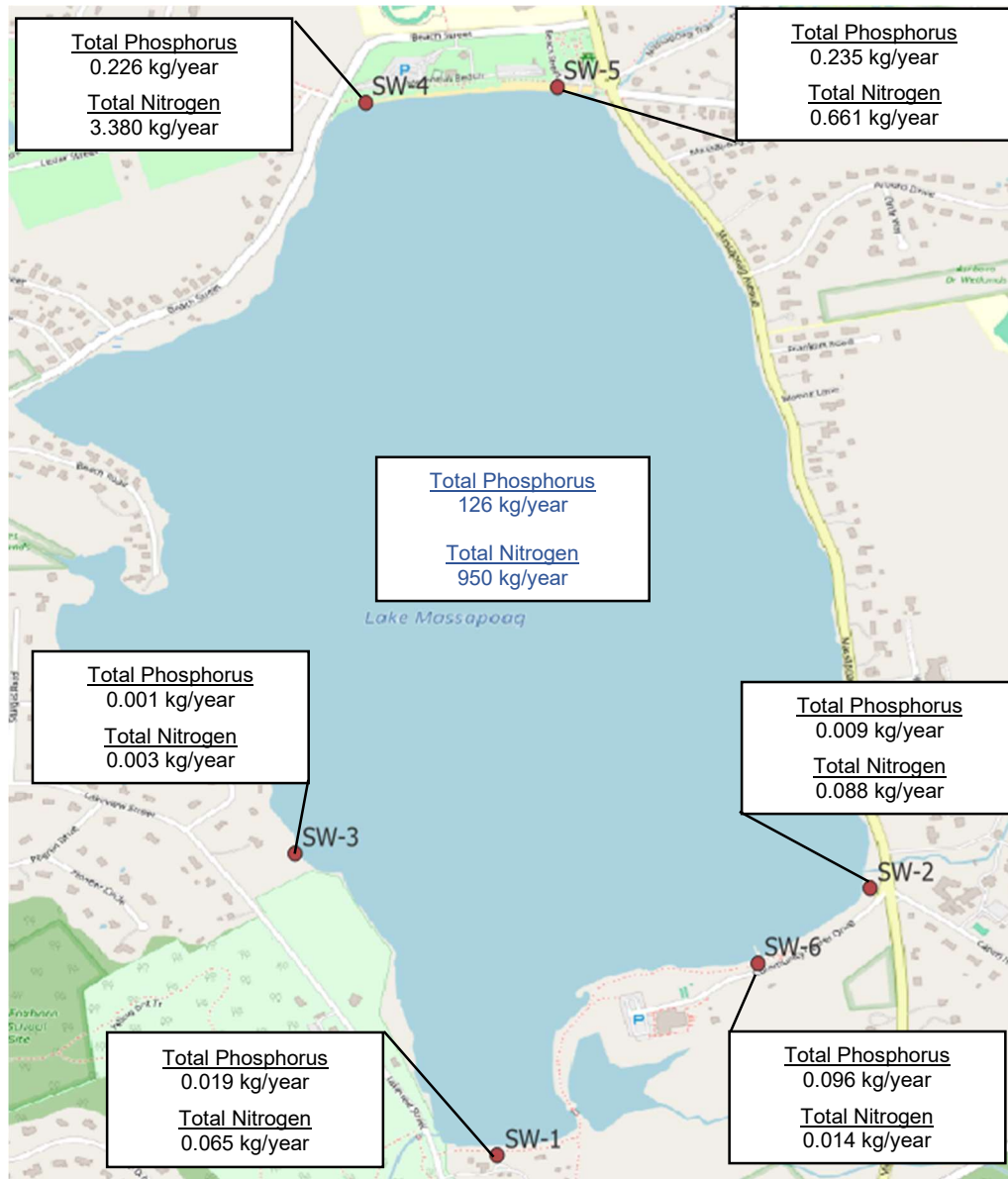


Figure 3. Summary of Nutrient Loads at Each Shoreline Sampler Catchment Area and the Total Calculated Runoff Nutrient Load (shown in blue)

MEMORANDUM

TO: Town of Sharon- Lake Massapoag
Advisory Committee

DATE: October 28, 2024,
Revised November 20,
2024

FROM: Margaret O'Brien

TRC PROJECT NO.: 569556.0000.0000

SUBJECT: Lake Massapoag Groundwater Seepage Survey Results

COPY TO:

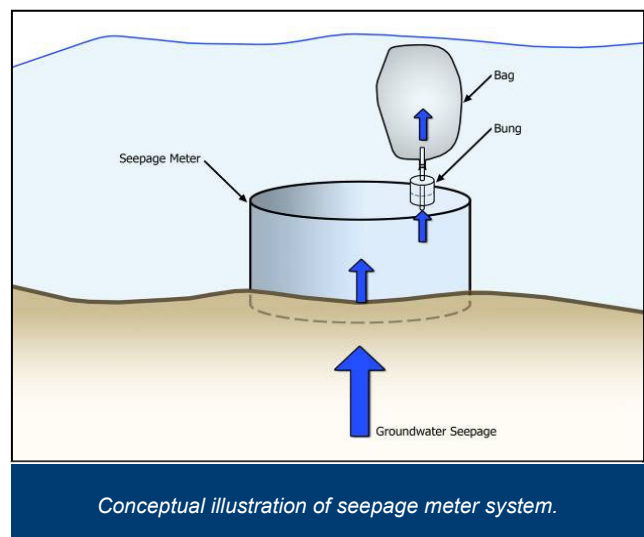
Dear Committee,

Below please find a summary of the groundwater seepage survey results.

Groundwater Quantity and Quality

To assess groundwater inputs directly, a groundwater seepage survey was conducted on September 18, 2024, to measure the quantity of groundwater entering and/or exiting the lake along the immediate shoreline where groundwater in-seepage is typically the highest and most influenced by human behaviors and activities.

A seepage meter is a device that allows the rate of seepage influent to or effluent from the lake to be measured. The device is sealed off from surface water influence by advancing the barrel of the meter into lake sediments and then primed with a known volume of water using watertight tubing and receptacles. Seepage meters are usually installed in soft sediments (silt or sand), where they can be deployed deeply enough to prevent lifting of the devices through wave action and ensure that changes in water volume are due to groundwater seepage. Once the devices have been installed, they are allowed to sit undisturbed for several hours before measuring seepage rates. Over this time period, in-seepage causes the volume of water to increase in the meter while out-seepage causes it to decrease.



During the survey, twelve seepage meters were deployed along six key shoreline segments (i.e. two meters at each shoreline) around Lake Massapoag (Figure 1) to estimate the rate of in- or out-seepage. These study shorelines were distributed evenly around the lake, given the physical constraints of the shoreline, to ensure characterization of overall seepage conditions. Due to rocky conditions, seepage meters were not able to be installed on the eastern shoreline of the lake along Massapoag Avenue, so that shoreline segment was moved to capture the eastern end of Memorial Beach. Three seepage meters were observed

to be removed from the shoreline upon retrieval. These include one meter at shoreline segments GW-2, GW-3, and GW-5; therefore, only measurements from one meter were obtained from these shorelines.



Figure 1. Seepage Meter Locations at Lake Massapoag

On the day of the survey, seepage of groundwater was predominantly positive, suggesting net in-seepage to the lake. Seepage rates were highest in the southern half of the lake at GW-2, GW-3, and GW-4, with decreasing inflows on the northern half of the lake at GW-1, GW-5, and GW-6 (Table 1). GW-2, which had the highest seepage rate, may be influenced by the groundwater from Great Cedar Swamp, based on groundwater contour maps provided by Horsley Witten Group (2011). GW-1 may also be influenced seasonally by groundwater flows, based on groundwater contour maps (Horsley Witten Group, 2011).

Table 1. Summary of Measured Seepage Rates at Lake Massapoag

Sample Location	Description	Average Seepage Rate (L/m ² /day)
		September 18, 2024
GW-1	By Beach Street and Beach Road intersection, on western side of lake	0.5
GW-2	Along Livingston Road, on western side of lake	3.6

Sample Location	Description	Average Seepage Rate (L/m ² /day)
		September 18, 2024
GW-3	By the Everwood Gannett Campus, on southern side of lake.	2.9
GW-4	By Community Center Beach, on southeastern side of lake.	2.0
GW-5	By eastern end of Memorial Beach, on northern side of lake.	0.3
GW-6	By western end of Memorial Beach, on northern side of lake.	0.9

Shallow Groundwater Quality Monitoring

In conjunction with the seepage meters described previously, shallow porewater samples from each of the six previously described shoreline locations using a stainless-steel Littoral Interstitial Porewater (LIP) sampler. The LIP sampler is essentially a mini-well that extracts groundwater from sediments for water quality testing. A minimum of three porewater samples were extracted from representative points along each of the shoreline locations and, to ensure that water obtained by the LIP was groundwater; temperature, pH, and specific conductance were measured and compared to surface water quality measurements. Once confirmed, samples were composited into a single representative sample for each shoreline segment and sent to the laboratory for analysis of the following:

- Total phosphorus
- Dissolved phosphorus
- Total nitrogen

Dissolved phosphorus concentrations in shallow groundwater were all above 0.025 mg/L. GW-5 had the highest dissolved phosphorus concentration of 0.252 mg/L (Table 2) but had the lowest in-seepage rate of 0.3 L/m²/day (Table 1). Therefore, GW-5 only had the fourth highest daily load of dissolved phosphorus at 0.87 mg/m²/day (Table 3). GW-3 had the second highest dissolved phosphorus concentration of 0.148 mg/L (Table 2) and had the second highest in-seepage rate of 2.9 L/m²/day (Table 1). Therefore, GW-3 had the highest daily load of dissolved phosphorus at 0.43 mg/m²/day (Table 3).

Nitrite was not detected above laboratory detection limits in all samples. Nitrate was only detected in GW-1 and GW-4 above laboratory detection limits. TKN was detected in all samples exceeding 1.0 mg/L. GW-4 had the highest total nitrogen concentration of 5.09 mg/L (Table 2) and the third highest in-seepage rate of 2.0 L/m²/day. Therefore, GW-4 had the second highest daily load of total nitrogen at 10.3 mg/m²/day (Table 3). GW-2 had the second highest total nitrogen concentration of 4.38 mg/L (Table 2) and the highest in-seepage rate of 3.6 L/m²/day (Table 1). Therefore, GW-2 had the highest daily load of total nitrogen at 15.8 mg/m²/day (Table 3).

Table 2. Porewater Quality Data, September 18, 2024

Sample ID	Nitrite (mg/L)	Nitrate (mg/L)	TKN (mg/L)	Total Nitrogen (mg/L)	Dissolved Phosphorus (mg/L)	Total Phosphorus (mg/L)
GW-1	<0.010	<0.02	2.96	2.96	0.07	0.25
GW-2	<0.010	1.7	2.68	4.38	0.035	1.77
GW-3	<0.010	<0.02	1.74	1.74	0.148	4.8
GW-4	<0.010	2.94	2.15	5.09	0.045	0.997
GW-5	<0.010	<0.02	3.59	3.59	0.252	1.18
GW-6	<0.010	<0.02	1.32	1.32	0.085	1.27

Table 3. Daily Groundwater Loads

Sample ID	Nitrite (mg/m ² /day)	Nitrate (mg/m ² /day)	TKN (mg/m ² /day)	Total Nitrogen (mg/m ² /day)	Dissolved Phosphorus (mg/m ² /day)	Total Phosphorus (mg/m ² /day)
GW-1	0.0025*	0.0050*	1.5	1.5	0.035	0.12
GW-2	0.018*	6.1	9.7	15.8	0.13	6.4
GW-3	0.015*	0.029*	5.1	5.1	0.43	14.1
GW-4	0.010*	6.0	4.4	10.3	0.091	2.0
GW-5	0.0017*	0.0034*	1.2	1.2	0.087	0.41
GW-6	0.0047*	0.0094*	1.2	1.2	0.080	1.2

* Concentrations were below laboratory detection limits; therefore, half of the detection limit was assumed for this calculation.

Phosphorus values in excess of 0.025 mg/L are considered to be detrimental to lake water quality and all sites exhibited higher than desirable conditions. Total nitrogen values that exceed 1.0 mg/L may indicate a septic or fertilizer influence (in this study total nitrogen is assumed to be represented by the sum of nitrate nitrogen and TKN). Given this, total nitrogen exceeded 1.0 mg/L at all sites. Based on these results, it is evident that groundwater seepage is being influenced by human activity (e.g. septic systems and/or fertilization) from the surrounding land.

Discussion

Based on a coarse extrapolation of the seepage rates measured by this study, approximately 77,600,000 gallons of groundwater water infiltrate into the lake per year. Assuming groundwater seepage occurs within the 0-10 foot contour, nutrient loading rates would be approximately 24.1 kilograms (kg) of dissolved phosphorus, 344 kg of nitrate per year, and 998 kg of nitrogen (including both nitrate and TKN forms) (Summary of results represented on Figure 2). The 0-10 foot contour range was selected based on the assumption that accumulations of fine sediments overlying deeper portions of the lake bottom can act as a “cap”, inhibiting groundwater infiltration into the lake. The 0-10 foot area targets the zone of shallow groundwater infiltration most likely impacted by human activity (e.g. failing septic systems, fertilizer inputs). Groundwater inputs to the lake may also be supplemented by shallow or deep springs. In an email from a past WMAC member, groundwater springs are feeding the lake but the amount of groundwater from springs is “hard to estimate” (P.Lauenstein, personal communication, October 2024). The focus of this study remains to quantify shallow groundwater infiltration in areas most likely impacted by human activity.

Septic systems that function correctly should have a minimal phosphorus signature because the fraction of phosphorus leached into the ground readily adsorbs onto particles in the soil matrix, rather than migrating toward the lake. Failing or poorly sited septic systems may result in discharge of phosphorus-rich wastewater into nearby water bodies. Additionally, septic systems that have been in operation for many years may load phosphorus to nearby water bodies at a higher rate, due to the saturation of binding sites for phosphorus in the soil over time.

Nitrogen is typically much more mobile through soil than phosphorus and may generate a plume that reaches the lake quickly. Even septic systems that are regularly pumped and functioning properly typically remove less than half of the nitrogen. Therefore, nitrogen concentrations in groundwater can be orders of magnitude higher where septic systems are prevalent.

The total effects on the inputs from groundwater will not be fully realized until the rest of the system has been evaluated and we can compare the relative contribution of nutrients from groundwater to those of different nutrient sources into Lake Massapoag. However, it is clear from this study that human activity (e.g. septic systems, fertilizer use) around the lake do have an influence on the groundwater quality inflowing into the lake.

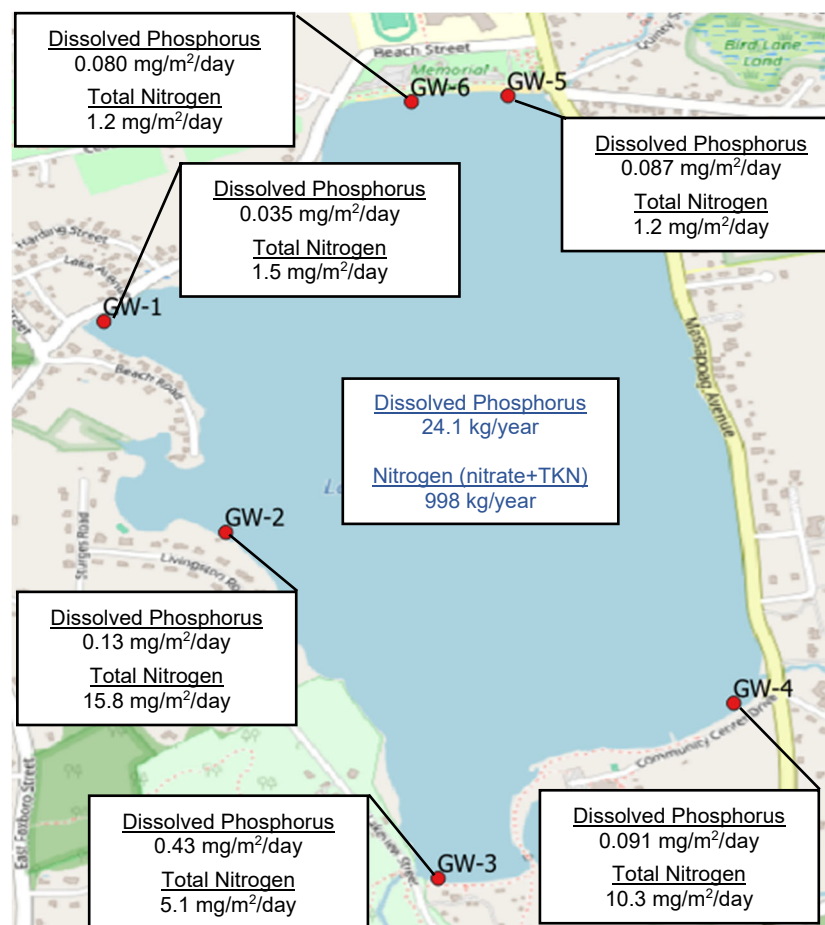


Figure 2. Summary of Daily Nutrient Loads at Each Seepage Sample Location and the Total Calculated Groundwater Seepage Nutrient Load For 0-10 Feet (shown in blue)

References:

Horsley Witten Group, Inc. 2011. "Summary of Groundwater Mapping for the Sharon Great Cedar Swamp Restoration Project." Dated June 30, 2011. Prepared for the Massachusetts Division of Ecological Restoration.

MEMORANDUM

TO: Town of Sharon- Lake Massapoag
Advisory Committee
DATE: June 24, 2025
FROM: Margaret O'Brien
TRC PROJECT NO.: 608686.0000.0000
SUBJECT: Hot Spot Sampling Results
COPY TO:

Dear Committee,

Below please find a summary of the hot spot survey sampling results.

Sucker Brook – *E. Coli* Sampling

TRC conducted an initial wet-weather site visit on August 7, 2024 at Sucker Brook. Surface water samples were collected from the stream and analyzed for *E. coli* (MPN method). In order to capture the impact of run-off from wet-weather conditions, TRC sampled during a storm that produced at least 0.25 inches of rain. During this sampling event, eight locations were evaluated (Figure 1). Five of the eight proposed sample locations were observed to be flowing, and samples from these locations were collected and labeled as SB-1 through SB-5. No flow was observed at three locations, so no samples were collected from sites SB-6 through SB-8.

TRC returned to Sucker Brook during another wet-weather event on May 22, 2025. During this sampling event, flow was observed at sites SB-6 through SB-8, and samples were collected from these remaining sites. Wet weather sample results are shown in Table 1.

Fecal coliform bacteria, including *E. coli*, occur in the intestines of humans and other warm-blooded animals. Although these bacteria may not directly cause illness, they serve as indicators of fecal contamination and possible pathogens. Possible sources of *E. coli* in surface water include sewage or animal waste contamination. Results of the Sucker Brook sampling were compared to the Massachusetts Department of Public Health (MDPH) standard for *E. coli* in freshwater beaches, which is 235 cfu/ 100 mL.

E. coli concentrations at all locations exceeded the 235 cfu/100mL standard (which is equivalent to 235 MPN/100 mL), with values ranging from 866.44 MPN/100 mL to 4,600 MPN/100 mL. High *E. coli* concentrations indicate a potential fecal contamination issue in waters flowing into Lake Massapoag. It should be noted that the water quality results presented here are based on two storm events, and there may be variability in storm water bacteria concentrations depending on the season, precipitation amount, recent precipitation history, and precipitation intensity.

Table 1. Sucker Brook *E. Coli*

Sample ID	<i>E. Coli</i> (MPN/100ml)
SB-1	866.44
SB-2	1986.29
SB-3	1416.61
SB-4	1203.33

Table 1. Sucker Brook *E. Coli*

Sample ID	E. Coli (MPN/100ml)
SB-5	1299.65
SB-6	1000
SB-7	4600
SB-8	>2419.6

Notes: > = Reported as a greater than value because undiluted result was above lab calibration range.

Sucker Brook – Total Phosphorus Sampling

TRC conducted additional sampling at the Sucker Brook outfall for total phosphorus on two occasions in May and June of 2025. A sample was collected during a wet-weather event on May 31, 2025, and a sample was collected during a dry-weather event on June 4, 2025. Results are presented in Table 2.

Total phosphorus concentration was greater in the sample collected during dry weather (0.051 mg/L) than in the sample collected during wet weather (0.031 mg/L). These results may indicate a potential septic component in Sucker Brook baseflow, as groundwater baseflow would dominate the channel in dry weather conditions while stormwater would dilute groundwater inputs during wet weather. However, this pattern was not observed during previous sampling efforts conducted by LMAC; total phosphorus concentrations have historically been higher in samples collected during wet weather than in samples collected during dry weather..

Table 2. Sucker Brook Total Phosphorus

Sample ID	Total Phosphorus (mg/L)	Weather Event
SB-1	0.032	Wet
SB-1	0.051	Dry

Lagoon Tributaries – Total Phosphorus Sampling

On May 22, 2025, TRC conducted sampling of the tributaries inletting into the Lake Massapoag lagoon, located at the southern end of the lake. Three of the four tributaries targeted for sampling (Figure 1) were observed to be flowing and were sampled (LT-1, LT-2, and LT-4). One tributary (LT-3) was dry and no indications of recent flow were observed. In order to capture the impact of wet weather runoff, TRC sampled during a storm that produced at least 0.25 inches of rain. Samples were submitted to a laboratory for analysis of total phosphorus. Sample results are shown in Table 3.

Phosphorus levels in the lagoon tributaries were considered excessive (>0.05 mg/L) during the May 2025 sampling event; concentrations ranged from 0.119 mg/L to 0.16 mg/L. These results indicate that high amounts of phosphorus may potentially be entering the lagoon from its tributaries. It should be noted that the water quality results presented here are based on one storm event, and there may be variability in storm water nutrient concentrations depending on season, precipitation amount, recent precipitation history, and precipitation intensity.

Table 3. Lagoon Tributary Total Phosphorus

Sample ID	Total Phosphorus (mg/L)
LT-1	0.16
LT-2	0.119
LT-4	0.136

Filter Grass BMP – Total Phosphorus Sampling

On May 22, 2025, TRC sampled upstream and downstream of the BMPs, a filter grass and an aquatic barrier, that were installed at the outlet of the lagoon into the South Cove on June 27, 2024. The purpose of the BMPs is to limit the invasive species fanwort (*Cabomba caroliniana*) from entering the South Cove. However, LMAC wished to investigate the effectiveness of the technology in reducing phosphorus levels in water entering the South Cove from the lagoon.

To test the effectiveness of the BMPs in regard to phosphorus reduction, TRC collected one surface water sample (BMP-1) and one duplicate (BMP-1D) directly upstream of the filter grass strip and one surface water sample (BMP-2) and one duplicate (BMP-2D) directly downstream of the filter grass strip in the South Cove (Figure 1). These surface water samples were analyzed for total phosphorus and dissolved phosphorus. Sampling was conducted in conjunction with the lagoon tributary sampling during a rain event. Sample results are shown in Table 4.

Total phosphorus concentrations in upstream and downstream samples ranged from 0.020 mg/L to 0.032 mg/L. Comparing these results to the samples collected from the lagoon tributaries (LT-1, LT-2, and LT-4) indicates that the lagoon and surrounding wetlands provide attenuation of phosphorus prior to entering into the South Cove.

Average total phosphorus concentrations and average dissolved phosphorus concentrations were slightly lower in samples collected downstream of the filter grass than in samples collected upstream of the filter grass. However, due to sampling limitations it is not possible to evaluate if either total or dissolved phosphorus concentrations differed significantly between upstream and downstream samples.

Table 4. Phosphorus Upstream and Downstream of Filter Grass

Sample Location	Sample ID	Total Phosphorus (mg/L)	Dissolved Phosphorus (mg/L)
Upstream	BMP-1	0.032	0.024
Upstream	BMP-1D	0.020	0.014
Downstream	BMP-2	0.024	0.014
Downstream	BMP-2D	0.021	0.012



Figure 1. Sucker Brook (orange) and Lagoon (blue) Sampling Locations.

Appendix H:
LAKE MASSAPOAG
NUTRIENT BUDGET
(LAKE LOADING
RESPONSE MODEL)
AND SEDIMENT
CORE STUDY



MEMORANDUM

TO: Town of Sharon- Lake Massapoag
Advisory Committee

DATE: December 15, 2025

FROM: Margaret O'Brien

TRC PROJECT NO.: 574901.0000.0000

SUBJECT: Lake Massapoag Nutrient Budget

COPY TO:

Dear Committee,

A Lake Loading Response Model (LLRM; AECOM 2009) analysis was performed by TRC to develop a phosphorus budget for Lake Massapoag, including estimates of the annualized internal and external phosphorus loads. LLRM has traditionally been used in Massachusetts to support the development of Total Maximum Daily Loads (TMDLs) and other water quality restoration plans (including Watershed-Based Plans) where lake-watershed interactions are involved.

LLRM is an annualized, steady state model that incorporates both a lake loading and a lake response module. The lake loading module incorporates external watershed sources for both wet weather runoff and baseflow contributions based on land use export coefficients. Known point sources can also be allocated from the watershed. Watersheds can be further divided into up to ten subwatersheds to accommodate differing characteristics of contributing catchments. This may be helpful for understanding differences in how source load reductions from geographically distinct portions of the watershed would impact water quality in the lake. Additionally, LLRM allows for inclusion of direct atmospheric loading, waterfowl loading, direct septic system loading, and internal loading from the sediments as inputs to the lake loading model. Where sufficient data are available, the outputs from the lake loading module can be calibrated for each sub-watershed.

The results of the lake loading module, together with additional inputs, are then fed into a suite of in-lake models for the purposes of overall model calibration. Model calibration includes the process of evaluating and modifying model inputs and coefficients such that differences between predicted and measured in-lake concentrations are minimized. The model predicted values include the following eutrophication-linked parameters:

- Nutrients (e.g., phosphorus concentration)
- Phytoplankton growth (as chlorophyll a)
- Water clarity (Secchi disk)

Once calibrated, the LLRM model can be used to identify the reduction in loading needed to achieve the desired numerical water quality goal. It can also be used for predictive scenarios to evaluate the impacts of lake management interventions or watershed changes.

Lake Massapoag Model Setup

The LLRM model requires the user to enter custom input values or, in some cases, confirm the default values already built into the model. Inputs are required for both the lake loading and lake response modules. Although inputs can include actual measured values (i.e., data), literature values or best professional judgment can be used where data are not available. Additional information on the inputs used for Lake Massapoag is provided in Table 1.

Table 1. LLRM Model Input Descriptions and Sources

Input	Source	Notes
Lake Loading Model		
Hydrology - Standard Water Yield	USGS	Annual mean discharge for the East Branch Neponset River at Canton, MA (USGS stream gage #1105500)
Precipitation	PRISM Climate Group	Basin-averaged mean annual for 1980-2010 period
Evapotranspiration	Northeast Regional Climate Center	Boston average for 1991-2020 period
Runoff Export Coefficients for Precipitation and Phosphorus	Various literature values (pre-loaded into LLRM)	
Baseflow Export Coefficients for Precipitation and Phosphorus	Various literature values (pre-loaded into LLRM)	
Direct Atmospheric Deposition of Phosphorus	Various literature values (pre-loaded into LLRM)	Includes both dry and wet deposition
Internal Loading	TRC	Calculated values from 2024 alum dosing study
Waterfowl Loading per Bird	Various literature values (pre-loaded into LLRM)	Number of waterfowl based on TRC opportunistic observations
Direct Septic System Load	TRC	Calculated values from 2024 groundwater seepage survey
Watershed Delineation	NepRWA	Includes non-contiguous land areas connected via stormwater conveyances
Land Cover/Land Use	MassGIS	2016 statewide layer
Watershed Routing Pattern	TRC	All sub-watersheds are terminal discharges (i.e., drain to Lake Massapoag)
Load Attenuation for Phosphorus	TRC	Used default of 0.85 except for Sub-watersheds 1 (Sucker Brook) and 3 (Lagoon), where observed water quality data allowed for iterative adjustment of attenuation to improve model calibration
Lake Response Model		
Phosphorus Load to Lake	From Lake Loading Model	
Influent Total Phosphorus Concentration	From Lake Loading Model	
Effluent Total Phosphorus Concentration	TRC	Surface water quality samples closest to outlet, 2022-2024
Inflow	From Lake Loading Model	
Lake Area	TRC	Calculated from shoreline delineation in GIS
Lake Volume	TRC	Calculated by multiplying lake area times mean depth

Note that the lake loading module incorporates watershed septic system nutrient loading as a function of land use with associated baseflow export coefficients. However, the lake loading module allows the user to also incorporate a higher direct loading rate for septic systems that are relatively close to the lake and more likely to discharge directly into the lake as groundwater in-seepage, rather than baseflow into a surface wetland or stream. There are two options that can be used to quantify these direct septic system inputs. The user can either enter a measured value (e.g., one obtained through a shallow seepage survey) or develop an estimate based on the number of septic systems, average users per system, and average number of days of use per system (i.e., seasonal vs. year-round) for septic systems within a certain distance

of the lake. For the model run described in this memo, TRC used a measured in-seepage rate from a recent study. This rate was applied as a uniform average in-seepage rate and was not split by sub-watershed.

The LLRM model developed for Lake Massapoag made use of watershed boundaries provided by the Neponset River Watershed Association (NepRWA). This watershed was then divided into seven sub-watersheds for the purpose of external phosphorus load estimation (Figure 1). This allowed the phosphorus loading characteristics for each sub-watershed to be independently adjusted to account for differences in attenuation. Additionally, it provided an opportunity to check watershed phosphorus loading estimates against water quality field data collected from potentially larger sources, including Sucker Brook and the Lagoon.

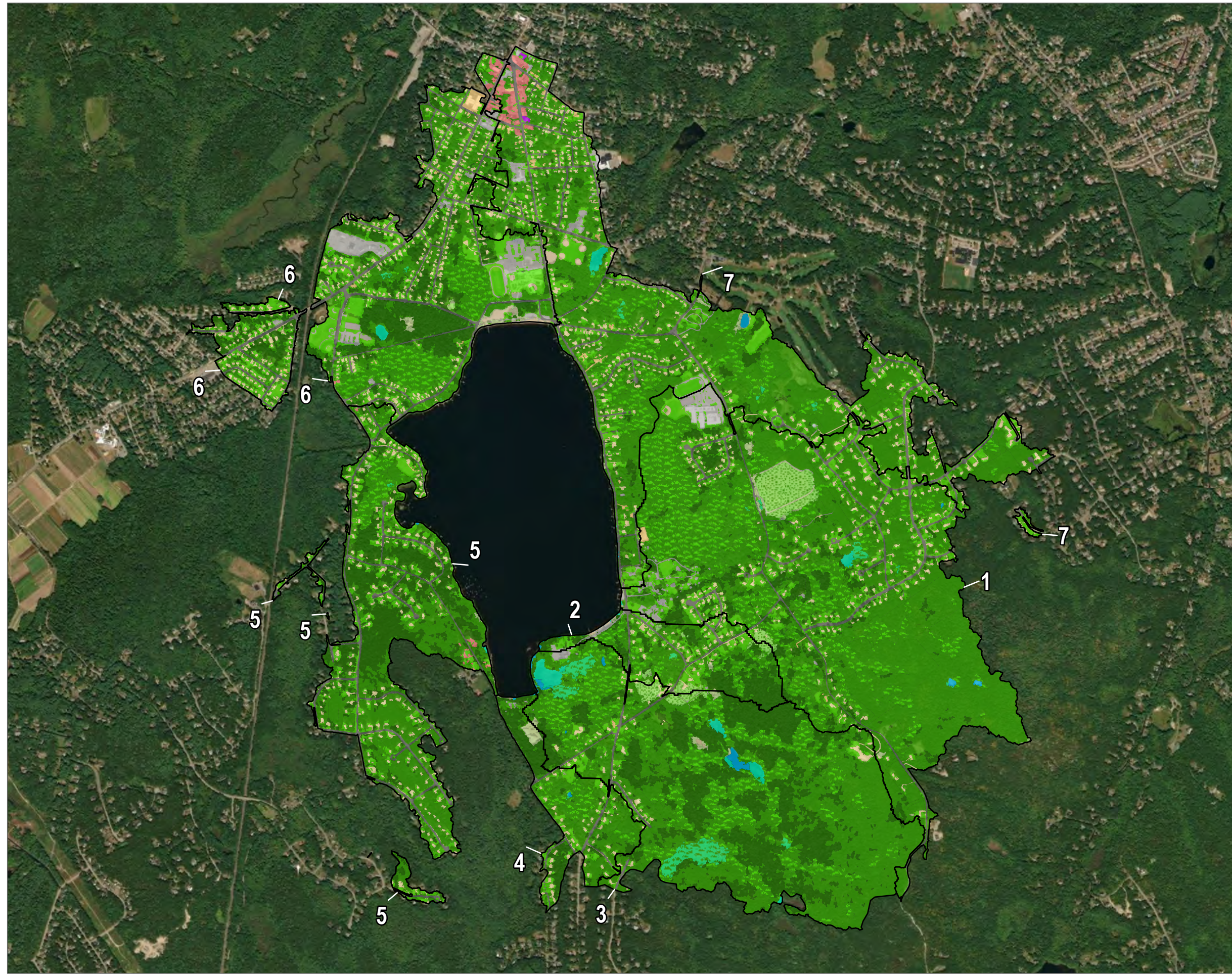
The MassGIS statewide 2016 land cover/land use layer was used to assign runoff and baseflow export coefficients for areas within each sub-watershed. Due to the fact that the MassGIS land cover/land use categories do not line up exactly with those described in LLRM, some categories were reassigned or simplified (Table 2).

Table 2. Lake Massapoag Land Cover/Land Use Inputs

Land Cover/Land Use Category	Sub-watershed Area (ha)							Total Watershed Area (ha)
	1	2	3	4	5	6	7	
Pasture	7.5	1.3	2.0	0.0	0.0	0.0	0.0	10.8
Forest	143.7	17.5	120.7	19.2	69.1	61.7	102.1	534.2
Non-forested Open Space	31.1	6.8	5.7	5.2	17.9	34.6	38.5	139.8
Developed Impervious	25.7	4.3	4.9	3.5	17.9	40.0	34.6	131.0
Water*	0.3	0.1	1.1	0.1	0.1	0.0	0.4	2.1
Wetland	60.1	6.4	53.9	3.9	4.6	16.7	19.3	164.8
Total	268.4	36.4	188.3	32.0	109.6	153.0	194.9	982.6

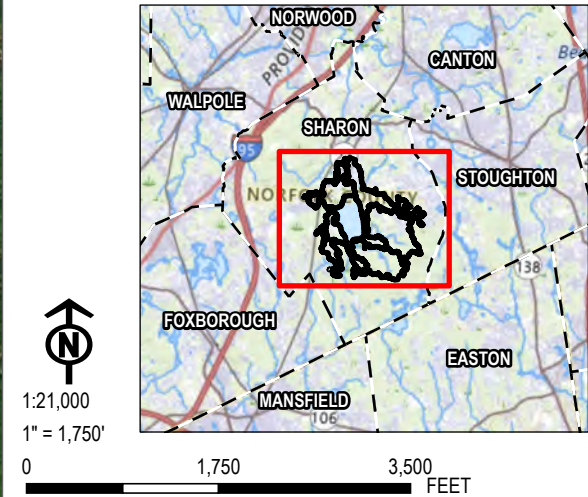
*Does not include Lake Massapoag

Coordinate System: NAD 1983 UTM Zone 18N, Map Rotation: 0
- Saved By: JCORSO on 12/15/2025, 08:48:33 AM, File Path: T:\1-PROJECTS\MA Lakes\574901_LakeMassapoag.aprx, Layout Name: Fig 1 Sub-Watershed Land Use



- SUB-WATERSHED BOUNDARY
- RESIDENTIAL - SINGLE FAMILY
- RESIDENTIAL - MULTI-FAMILY
- COMMERCIAL
- INDUSTRIAL
- MIXED USE - PRIMARILY RESIDENTIAL
- MIXED USE - PRIMARILY COMMERCIAL
- OTHER IMPERVIOUS
- RIGHT-OF-WAY
- PASTURE/HAY
- DEVELOPED OPEN SPACE
- DECIDUOUS FOREST
- EVERGREEN FOREST
- GRASSLAND
- SCRUB/SHRUB
- BARE LAND
- FORESTED WETLAND
- NON-FORESTED WETLAND
- WATER
- AQUATIC BED

BASE MAP: ESRI "WORLD IMAGERY" ONLINE SERVICE LAYER; [DATE OR QUAD]
DATA SOURCES: TRC, MA GIS



TOWN OF SHARON
MASSAPOAG LAKE
SHARON, MA

SUB-WATERSHED LAND USE

DRAWN BY: J. CORSO	PROJ. NO.: 574901.0000.0000
CHECKED BY: J. FREDENBURG	FIGURE 1
APPROVED BY: M. O'BRIEN	
DATE: DECEMBER 2025	

650 SUFFOLK STREET
SUITE 200
LOWELL, MA 01854
PHONE: 978.970.5600

Model Calibration

Water quality data sampled by LMAC and NepRWA for the 2022-2024 period were used to calibrate phosphorus loading from Sub-watersheds 1 (Sucker Brook) and 3 (Lagoon) in the lake loading module. The calibration for Sub-watershed 1 was achieved by adjusting the basin attenuation coefficients within typical ranges, as defined in the user manual and QAPP (AECOM 2009). However, the observed phosphorus concentrations for Sub-watershed 3 were so high that they could not be calibrated, even with basin attenuation coefficients at unrealistic levels (e.g., 1.00 for phosphorus). This suggests that land use alone cannot explain the phosphorus concentrations observed, so some additional but unknown factor is causing phosphorus levels to be elevated in this sub-watershed (e.g., internal loading within the Lagoon, point source discharge in the watershed). For the purposes of calibration, an “unknown” point source was added to Sub-watershed 3 to bring the modeled output within 20% of the observed value.

Once the model was calibrated to provide reasonable predictions of current phosphorus levels, it was then re-run under the water quality goal scenario (i.e., one in which in-lake phosphorus concentrations met the EPA Gold Book standard of 0.025 mg/L). To derive the load reduction needed to meet this goal, the total phosphorus loading that would yield an in-lake concentration of 0.025 mg/L was iteratively solved in LLRM. This iterative solution was found using Excel’s “Goal Seek” function.

Model Results

The LLRM model for Lake Massapoag estimated a total external load of 759 lbs/year of phosphorus (Table 1), of which 590 lbs/year was estimated to be sourced from watershed surface sources and 53 lbs/year was from direct septic loading of phosphorus to the lake. Resident waterfowl inputs were estimated to contribute an additional 11 lbs/year. Atmospheric deposition, which cannot be managed at the watershed scale, provided the balance of the external load at 104 lbs/year. The LLRM model estimated a total internal load of 606 lbs/year of phosphorus coming from the sediments, assuming a 60-day period release over the deepest 57 acres of the lake. Therefore, the total annual phosphorus load for the lake was estimated to be approximately 1,365 lbs/year (Table 3).

Table 3. Lake Massapoag Nutrient Budget Load Summary

Load Sources	Phosphorus (lbs/year)	Water (cu. ft/year)
Atmospheric	104.1	35,987,188
Internal	606.4	0
Waterfowl	11.0	0
Septic System	53.1	0
<i>Total Direct Loads</i>	<i>774.7</i>	<i>35,987,188</i>
Runoff	578.5	96,566,264
Baseflow	11.8	144,849,395
<i>Total Watershed Loads</i>	<i>590.3</i>	<i>241,415,659</i>
Total Load	1365.0	277,402,847

The annualized phosphorus loads by sub-watershed are presented in Table 4. The highest load and yield (load per unit area) were predicted to come from Sub-watershed 6. This makes sense because Sub-watershed 6 is the most urbanized and has the highest proportion of impervious surfaces in the Lake Massapoag watershed. Sub-watershed 7, which includes Massapoag Ave and areas to the east and north of the lake, had the second highest load and yield. The lowest load was predicted to come from Sub-watershed 4 while the lowest yield was predicted to come from Sub-watersheds 1 and 3.

Table 4. Lake Massapoag Nutrient Budget Watershed Loading by Sub-Watershed

Load Sources	Sub-Watershed Phosphorus Load						
	1	2	3	4	5	6	7
Runoff (lbs/year)	99.5	24.0	39.2	17.7	74.7	153.6	143.0
Baseflow (lbs/year)	2.0	0.4	30.5*	0.3	1.2	2.0	2.1
<i>Total Sub-Watershed Loads (lbs/year)</i>	<i>101.6</i>	<i>24.3</i>	<i>69.8</i>	<i>18.0</i>	<i>75.9</i>	<i>155.6</i>	<i>145.1</i>
<i>Total Sub-Watershed Yield (lbs/ha/year)</i>	<i>0.4</i>	<i>0.7</i>	<i>0.4</i>	<i>0.6</i>	<i>0.7</i>	<i>1.0</i>	<i>0.8</i>

*Elevated baseflow contribution due to addition of an unknown point source for calibration purposes. Actual nature of this contribution (runoff vs. baseflow) is not known.

The LLRM model was also used to estimate annual phosphorus reduction needed to meet an in-lake phosphorus concentration goal of 0.025 mg/L (i.e., the EPA Gold Book standard). In order to meet the EPA Gold Book standard for phosphorus in the lake, the LLRM model estimates that the annual phosphorus load would need to be reduced to 915 lbs/year. That would require an approximate 450 lbs/year reduction from the current estimated load (1,365 lbs/year).

Conclusions

One of the most interesting outcomes of the lake loading modeling was that phosphorus loading observed in Sub-watershed 3 is much higher than would be expected by land use/land cover, which is mostly forest and wetlands. Therefore, it is recommended that this sub-watershed be further studied to help identify or at least bracket the upstream source(s).

The lake response module predicts much higher chlorophyll *a* and lower Secchi disk depths than recent data collection indicates is actually being observed in the lake. This suggests that some unaccounted factor is helping to keep these values in check. Zooplankton grazing pressure is one possibility, although there is not enough data to confirm this hypothesis. Another possibility is that chlorophyll *a* and Secchi disk are being underestimated by the current monitoring due to surface (epilimnion) sampling bias. It could be that Lake Massapoag algal growth is mostly in the form of deep phytoplankton and/or benthic algae. Additional observation from these areas in the lake could help confirm one way or another.

Future data collection and studies of the lake can also be used to further refine the model. For example, additional septic system evaluations may help to better quantify the septic nutrient load and answer some remaining unresolved questions.



Lake Massapoag Sediment Coring and Nutrient Inactivation Dosing Study

Lake Massapoag, Sharon, Massachusetts

Project No. 570766

February 2024

Prepared For:

Lake Massapoag Advisory Committee

Town of Sharon

Prepared By:

Margaret O'Brien (TRC)

Matt Ladewig, CLM (TRC)

Keith Pilgrim, PhD (BEC Engineering & Geology, P.C.)



Lake Massapoag Sediment Coring and Nutrient Inactivation Dosing Study

Contents

1. Introduction.....	1
2. Approach	1
3. Results	4
4. Recommendations	5
5. References	9

Figures

Figure 1	Sediment Sampling Locations
Figure A	Willner-type Coring Device in Use
Figure B	Simplified Phosphorus Fractionation Scheme for Lake Bottom Sediments
Figure C	Concentrations of Fe-P at Core Depth

Tables

Table 1	Summary of Sediment Characteristics and Composition
Table 2	Estimated Internal Phosphorus Loading Rates from Fe-P and Org-P
Table 3	Calculated Full Dose and Recommended Dose for 25-ft Contour
Table 4	Calculated Full Dose and Recommended Dose for 20-ft Contour

Appendices

Appendix A	Sediment Phosphorus Fractionation Lab Tables
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1. Introduction

Lake Massapoag is an approximately 389-acre lake located entirely in the Town of Sharon. The lake consists of three coves; Horton's Cove, Fletcher's Cover, and the South Cove. The lake receives inflows from the Lagoon and several small tributaries, including a Canoe River tributary into the southern portion of the lake, and Sucker Brook into the southeast portion of the lake. The lake outflow is through Massapoag Brook to the north, which eventually flows into the Neponset River.

Under the *Final Massachusetts Integrated List of Waters for the Clean Water Act 2022 Reporting Cycle* (MassDEP 2023), Lake Massapoag is listed as a Category 4a water body (i.e., TMDL is completed) and is impacted by the following impairments:

1. Mercury in fish tissue
2. Non-native aquatic plants

Other management issues identified at Lake Massapoag include the following:

3. Harmful algal blooms
4. Nutrient/eutrophication biological indicators
5. Total phosphorus
6. Chlorophyll A/ Phycocyanin
7. *E. coli*
8. Beach closures due to *E. coli* or cyanobacteria

With the possible exception of the first impairment, these impairments and management issues are highly interrelated. For example, excessive total phosphorus is likely to result in eutrophication and harmful algal blooms, which likewise results in increased concentrations in chlorophyll A and phycocyanin in the water, shutting down the public beach and the summer day camps present along the shoreline. Excessive total phosphorus and eutrophic systems can also lead to excessive plant growth, fueling the growth of non-native plants (particularly fanwort, *Cabomba caroliniana*) observed in the lake. This suggests that the reduction of phosphorus concentrations in Lake Massapoag could have cascading benefits to multiple impairments and identified issues.

Several in-lake management options are currently being evaluated as means to improve water quality over the short term while watershed controls (septic and stormwater) are investigated and implemented to provide longer term reductions in nutrient loading. One potential option being investigated is the potential benefits from nutrient inactivation (e.g., alum treatment) that targets the internal release of phosphorus from the sediments.

Past sediment grab sampling conducted by TRC in 2022 and 2023 identified the extent of iron-bound and loosely sorbed (mobile) phosphorus in deep lake sediments that experience prolonged seasonal depletion of dissolved oxygen (TRC 2022; TRC 2023a). These observations indicated the potential for deep lake sediments to serve as a significant source for internal phosphorus loading within the lake.

While helpful, these results were from sediment grabs, which are a composite of sediments from an approximate 6-inch depth. To better delineate baseline conditions and provide detailed information needed for development of nutrient inactivation management recommendations, TRC recommended the collection and analysis of sediment cores from the lake.

The study approach, results, and recommendations are provided in the following sections.

2. Approach

TRC, accompanied by Dr. Keith Pilgrim of BEC Engineering & Geology, PC (BEC), visited Lake Massapoag on November 20, 2023 to collect sediment cores. Each element of the field program is described in more detail in the following sections.

Five sediment cores (LM1 through LM5) were collected using a gravity coring device (Willner-type coring device) modified to allow for the extrusion of sections from each core (Figure A). LM3 location was selected to target a resampling of the deep hole while the rest of the coring locations were expanded to provide a more representative distribution of samples from previously unsampled areas of the lake below the 25-foot contour (Figure 1).

Once retrieved, each core was sliced on-site in 2 cm increments for the top 10 cm of sediment. Additional sections were taken from each core at 13 to 15 cm and 18 to 20 cm deep. The exception was LM3 where samples were collected at 10 to 12 cm and 12 to 15 cm because the core could not push further into the more consolidated sediment at this location. The top layer of sediment is typically the most active layer, where phosphorus releases to the water column (internal phosphorus loading) while the deeper sediment provides an indication of historical conditions.

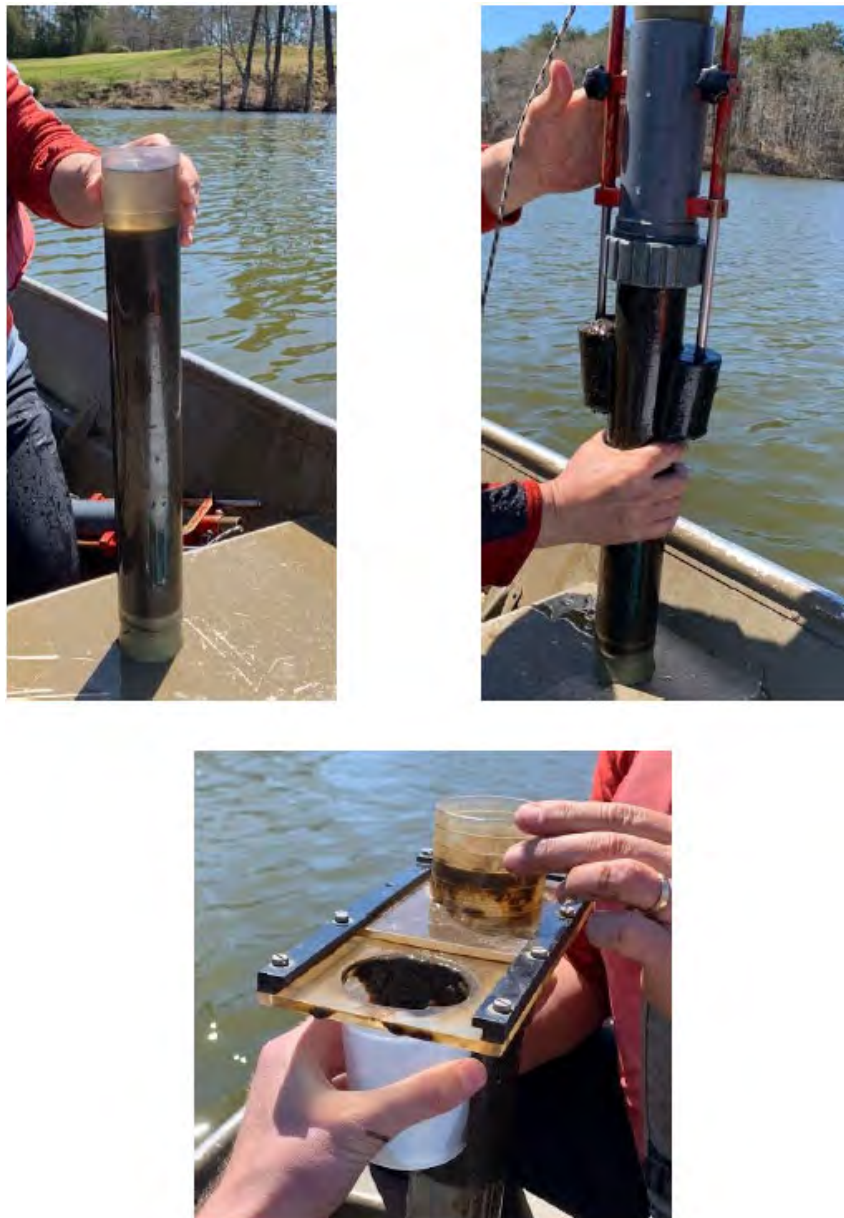


Figure A. Willner-type Coring Device in Use

Clockwise from upper right: the coring device upon retrieval at the surface, the core slicing head used to section the core, and the full core showing the sediment-water interface.

In total, 35 sections (i.e., 7 sections per core) were obtained. Sections were shipped on ice to the BEC phosphorus fractionation laboratory, where they were analyzed for different phosphorus forms or “fractions” according to the sequential fractionation method published by Psenner and Pucsko (1988). Phosphorus in bottom sediments is typically either bound to inorganic chemicals (e.g., calcium, manganese, iron, magnesium, and aluminum) or incorporated into organic matter (e.g., DNA, lipids, and phosphonates). Sequential fractionation makes use of acids, bases, reducing compounds, and an oxidizer to release these different types of phosphorus sequentially, and quantify the amount of phosphorus bound to iron and manganese (Fe-P), calcium and magnesium (Ca-P), and aluminum (Al-P), as well as the amount incorporated into organic matter (Org-P). The process is summarized in Figure B.

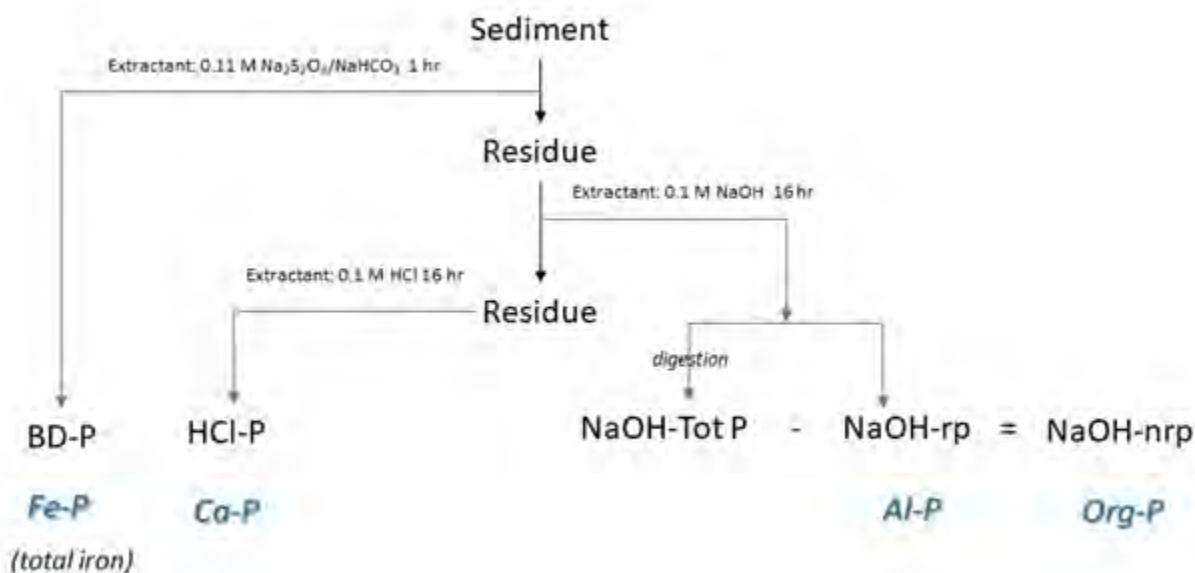


Figure B. Simplified Phosphorus Fractionation Scheme for Lake Bottom Sediments

In the natural environment, the dissolution of Fe-P in bottom sediments is responsible for most of the internal phosphorus release and loading to the water column when dissolved oxygen is low. However, the Org-P fraction decomposes as a function of temperature and can also contribute to internal loading where iron and dissolved oxygen levels are too low to recapture and bind it in the sediments as Fe-P. In contrast, Al-P and Ca-P fractions are stable under the environmental conditions present in most lake sediments, even when dissolved oxygen is not readily available.

In addition to the phosphorus fractionation analysis, each sample was also analyzed for moisture content, loss on ignition (percent carbon), and density. Total iron was analyzed from the Fe-P extraction for a subset of samples.

For quality assurance purposes, duplicate samples were analyzed at a 10% rate.

3. Results

Results of the water quality baseline monitoring and sediment phosphorus fractionation analysis are presented in the following sections.

A summary of the sediment properties and phosphorus fractionation results for the top four centimeters of sediment is provided in Table 1. Full sediment phosphorus fractionation laboratory results tables and charts are provided in Appendix A.

The sediment in general was highly inorganic in nature (approximately 74% of sediment solids by weight were inorganic). Sediment density was higher compared to lakes with a great proportion of organic solids. Water content of sediment was lower compared to the other lakes in the region (e.g., Santuit Pond) but similar to other deep lakes (e.g., Silver Lake).

Based on the laboratory results received from BEC (Table 1), iron-bound and loosely sorbed phosphorus (Fe-P) was the primary extractable phosphorus fraction, comprising approximately 50% of the total sediment phosphorus in surficial sediments (defined here as the top four centimeters) of each core on a dry-weight basis. The highest concentration of Fe-P observed was at LM4, the most southerly site, however values across all samples were observed to be near or above 1.0 mg/g (dry weight) in the top four cm of sediment (Figure C).

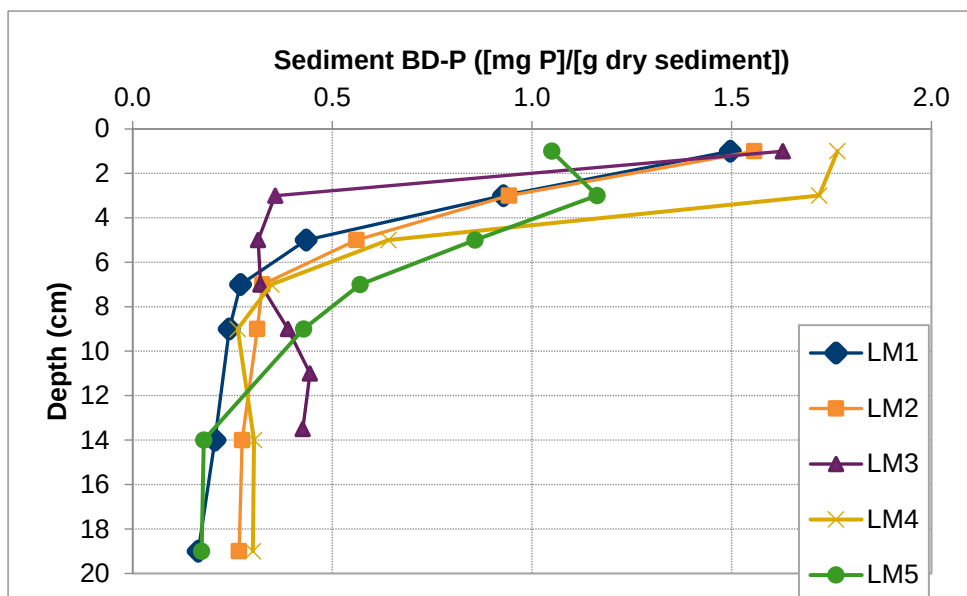


Figure C. Concentrations of Fe-P at Core Depth

Organically bound phosphorus (Org-P) constituted the second most abundant phosphorus fraction (with the exception of LM3, collected at the deep hole).

Extractable iron concentrations were on average 143 mg Fe/g (dry weight) in the top four cm of sediment. This equates to approximately 50 times more iron than total phosphorus in Lake Massapoag sediments and indicates that iron is plentiful enough to readily capture phosphorus in the presence of oxygen. This likely helps to intercept and attenuate the amount of phosphorus released into the water column from Org-P as the organic matter decays. The high concentrations of Fe-P lend support to this. However, when sediments become anoxic, as happens in the deeper portions of Lake Massapoag over much of the summer and early autumn, the Fe-P itself will eventually release from the sediments. Therefore, Fe-P is likely to be the primary source of internal phosphorus release into Lake Massapoag from deep sediments.

Table 1. Summary of Sediment Characteristics and Composition

Sed. Core ID	Approx Water Depth (ft)	Composition: Avg of Top 4 cm				Composition: Avg of Top 4 cm (mg/g dry sediment)					
		Sediment Density (g/cm ³)	% Moisture	% Organic Solids	% Inorganic Solids	Reducible Extractable Iron (Fe)	Iron and Loosely Sorbed P (Fe-P)	Organically Bound P (Org-P)	Calcium Bound P (Ca-P)	Aluminum Bound P (Al-P)	Total P
LM1	38	1.04	93%	26%	74%	154	1.21	0.65	0.14	0.42	2.42
LM2	33	1.05	89%	25%	75%	137	1.25	0.74	0.15	0.55	2.69
LM3	45	1.06	85%	31%	69%	139	0.99	0.51	0.59	0.65	2.75
LM4	28	1.05	90%	26%	74%	105	1.74	0.79	0.17	0.61	3.31
LM5	38	1.04	91%	24%	76%	179	1.11	0.40	0.16	0.40	2.06
Average	36	1.05	90%	26%	74%	143	1.26	0.62	0.24	0.53	2.65

Estimates of maximum potential internal loading (as mg phosphorus per meter squared (m²) of lake bottom sediment per day) are provided in Table 2. The estimates are based on relationships derived from published research (Pilgrim et al. 2007). The highest Fe-P concentration (and highest potential release rate of 28.21 mg/ m² per day) occurred in core LM4. However, sediments in each core exhibited a maximum internal phosphorus release rate exceeding 12 mg/ m² per day. For illustration purposes, the average rate of 19.93 mg/ m² per day would be the equivalent of more than 4.60 kg of phosphorus per day if only the deepest (i.e., deeper than the 25-ft contour) areas of the lake are included, and a total of 414 kg of phosphorus per year (assuming a 90-day period of anoxia). The 1984 *Diagnostic/Feasibility Study for Lake Massapoag* identified total phosphorus loading to be between 312 to 617 kg of phosphorus per year (IEP, Inc., 1984). Although the 1984 study did not identify internal loading as a significant component of the total phosphorus load, comparing our results suggest that internal loading is likely a significant component. Completion of an updated nutrient budget will provide a more accurate ratio of the proportion of internal loading related to the total phosphorus load. If areas as shallow as 20 ft are included, this would equate to a release rate of more than 10.16 kg of phosphorus per day. TRC notes that this value is assuming the average phosphorus release rate is uniform between the 20 and 25-ft contour; however, anoxia is less persistent in this shallower area.

Table 2. Estimated Internal Phosphorus Loading Rates from Fe-P

Sediment Core ID	Maximum Internal P Release Rate (mg/ m ² per day) Iron and Loosely Sorbed P (Fe-P)
LM1	12.80
LM2	20.72
LM3	23.62
LM4	28.21
LM5	14.31
Average	19.93

4. Recommendations

One way to address the observed issue of sediment phosphorus release at Lake Massapoag would be to increase the amount of an alternative, phosphorus-binding substrate in the sediments. The alternative substrate would need to be capable of maintaining a stable bond under the environmental conditions observed at the bottom of the lake, which include prolonged periods of seasonal anoxia. This approach would inactivate the phosphorus currently present in the lake regardless of the dissolved oxygen concentration, although external sources of phosphorus would still need to be controlled to prevent problems from redeveloping. Of the options available, aluminum is widely used to treat potable water sources, has the longest track record of safe and effective use as a phosphorus inactivation agent, and has been used for this purpose in a number of water bodies in Massachusetts, including drinking water reservoirs and sensitive kettle ponds on Cape Cod (Wagner et al. 2017). Additionally, aluminum is one of

the most widely distributed and common metals on Earth and is already present in Lake Massapoag sediments. The most frequently used method of increasing the available aluminum as a phosphorus-binding agent is through the careful application of aluminum sulfate (alum), often in conjunction with sodium aluminate to serve as a buffering agent.

Table 3 identifies the estimated amount of aluminum that would need to be added to Lake Massapoag sediments to convert readily released Fe-P to strongly bound Al-P.

Although the bulk of sediment phosphorus could be targeted with a single massive alum dose, this approach is not currently recommended at Lake Massapoag. In any alum treatment, some portion of the alum will sink below the active sediment layer (~top four centimeters in Lake Massapoag) or crystallize (age) before it can achieve its full potential for phosphorus inactivation. Another portion will end up moving downslope and concentrating in the deepest part of the lake before it is able to fully capture targeted phosphorus in the area where it was originally applied. Together, these factors impact the efficiency of an alum treatment. The very high concentrations of sediment iron and the steep slopes to the east and west of the Lake Massapoag deep hole mean that more alum will be “lost” to these inefficiency factors. Therefore, applying the full dose at once would be relatively inefficient and less cost-effective than an incremental alum treatment approach.

The incremental alum treatment approach would involve a smaller but still substantial initial application (equal to approximately one-third of the full dose), which is expected to inactivate over half of the currently present Fe-P in the active sediment layer. This incremental approach will allow the aluminum flocculent more time to become incorporated into the sediments before applying the full dose. On its own, the one-third alum dose would be anticipated to permanently inactivate more than 500 kg of phosphorus in the active sediment layer of Lake Massapoag and immediately reduce the internal phosphorus load by more than 200 kg/yr. However, newly deposited sediments and Org-P in the existing sediments will continue to serve as sources of phosphorus release in the future as organic matter decomposes over time. Therefore, if other management interventions are not implemented to substantially reduce external phosphorus loading and improve dissolved oxygen in deep waters of Lake Massapoag, the Town should plan to apply the second third of the full dose after approximately five to ten years to counter this input of new phosphorus-rich sediments and extend the benefits of the original treatment. Similarly, another third of the full dose may be warranted after an additional five to ten years. This timeline is approximate and intended as general guidance for planning purposes. If other interventions are successfully implemented concurrent with or soon after the initial alum treatment dose, it is possible that additional alum treatments would not be needed. Regardless of the approach taken, monitoring is recommended to more precisely determine if and when additional alum treatments or other management interventions are warranted in the future.

It is recommended that sediments in the deepest part of Lake Massapoag be the focus of sediment dose alum treatments. These deep areas are where anoxic conditions are likely to occur over the course of the growing season. Sediments in areas shallower than this are not likely to be as impacted by seasonal anoxia and therefore have less potential to release phosphorus at high rates. Additionally, sediments in shallow areas would be more likely to be of concern to NHESP for their ability to support known rare species in the lake.

Based on vertical dissolved oxygen profiles recently collected from Lake Massapoag, two possible scenarios are presented for consideration. In the first scenario, the area within the 25-foot contour (as mapped by the Massachusetts Division of Fisheries and Wildlife in 2019) would be targeted because it contains the sediments most severely impacted by extended duration of seasonal anoxia and represents the highest potential for release of phosphorus. An initial (i.e., one-third full dose) alum treatment focusing on this area would target approximately 57 acres and consist of the application of nearly 51,000 gallons of alum and sodium aluminate (Table 3). In the second scenario, the area within the 20-foot contour would be targeted. This area represents a more conservative estimate of sediments impacted by some level of anoxia over the course of the growing season. An initial (i.e., one-third full dose) alum treatment focusing on this area would target approximately 126 acres and consist of the application of nearly 112,000 gallons of alum and sodium aluminate (Table 4). These treatment areas are provided for illustration of recommended upper and lower bounds for sediment nutrient inactivation. However, the final treatment area should be selected to reflect the Town's goals for phosphorus removal as refined by potential budgetary and environmental permitting limitations.

Table 3. Calculated Full Dose and Recommended Dose for 25-ft Contour

Element	Value		Unit
Aluminum Dosing	Full Dose (Not Recommended)	1/3 Dose (Recommended)	
Targeted Binding Ratio Al:Al-P formed	50	50	
Estimated Active Layer	4	4	cm
Initial Aluminum Dose	223.3	74	g Al/m ²
Alum and Sodium Aluminate Treatment Volumes			
Treatment Area	57	57	acre
Total Mass Aluminum Applied	51,425	17,142	kg
Liquid Alum Composition	0.22	0.22	kg Al/gallon
Liquid Sodium Aluminate Composition	0.57	0.57	kg Al/gallon
Total Treatment Volume as Alum	231,959	77,320	gallon
Targeted Ratio of Alum to Sodium Aluminate	2:1	2:1	
Recommended Alum Dose	101,478	33,826	gallon
Recommended Sodium Aluminate Dose	50,739	16,913	gallon
Recommended Alum Dose	1,783	594	gallons/acre
Recommended Sodium Aluminate Dose	892	297	gallons/acre

Table 4. Calculated Full Dose and Recommended Dose for 20-ft Contour

Element	Value		Unit
Aluminum Dosing	Full Dose (Not Recommended)	1/3 Dose (Recommended)	
Targeted Binding Ratio Al:Al-P formed	50	50	
Estimated Active Layer	4	4	cm
Initial Aluminum Dose	223.3	74	g Al/m ²
Alum and Sodium Aluminate Treatment Volumes			
Treatment Area	126	126	acre
Total Mass Aluminum Applied	113,507	37,836	kg
Liquid Alum Composition	0.22	0.22	kg Al/gallon
Liquid Sodium Aluminate Composition	0.57	0.57	kg Al/gallon
Total Treatment Volume as Alum	511,991	192,664	gallon
Targeted Ratio of Alum to Sodium Aluminate	2:1	2:1	
Recommended Alum Dose	223,984	74,661	gallon
Recommended Sodium Aluminate Dose	111,993	37,331	gallon
Recommended Alum Dose	1,783	594	gallons/acre
Recommended Sodium Aluminate Dose	892	297	gallons/acre

If using a buffered alum approach, we recommend that aluminum be applied at a 2:1 ratio of alum (aluminum sulfate) and sodium aluminate (sodium, aluminum, and hydroxide) injected simultaneously into the water column. This will buffer the treatment with a goal of maintaining pH within the desired band of 6 to 8 SU. Depending on the pH at initiation of treatment, this ratio may need to be altered slightly. However, the 2:1 ratio has performed admirably in other sediment dose applications to softwater ponds on the Cape, eastern Massachusetts, and Rhode Island when applied in spring, after water temperatures have warmed to approximately 6°C (43°F). This allows for good flocculent formation while also avoiding periods when ambient water quality puts more stress on aquatic life.

Although polyaluminum chloride (PAC) could also be used for the nutrient inactivation treatment, it is harder to obtain in large volumes and may prove cost-prohibitive when compared to buffered alum. Another alum alternative is Aqual-P, a proprietary, zeolite-based product that has not been widely used in the US but shows some potential for use in phosphorus inactivation and other water quality improvement applications. Other non-aluminum based nutrient inactivation agents, such as the proprietary product EutroSORB, could also be considered. Some EutroSORB products offered by the manufacturer disclose lanthanum modified bentonite (LMB) as the active phosphorus-binding agent. Lanthanum is a rare earth metal that has been successfully used to inactivate phosphorus.

Given the high sediment availability of iron, Lake Massapoag also has potential to benefit substantially from oxygenation of deep waters for phosphorus control. Oxygen saturation technology (OST) is just one method of oxygenation and it should be evaluated against other available technologies for feasibility at Lake Massapoag. Although it is beyond the scope of this study to assess the feasibility of accomplishing deep lake oxygenation, TRC recommends that the Town consider this in-lake management approach as a potential part of a comprehensive lake management program.

Finally, it is recommended that any nutrient inactivation project be accompanied by pre-, during, and post-treatment monitoring. This will allow changes in water quality to be documented and quantified while also ensuring that the treatment is implemented in way that avoids or minimizes impacts to protected resources.

5. References

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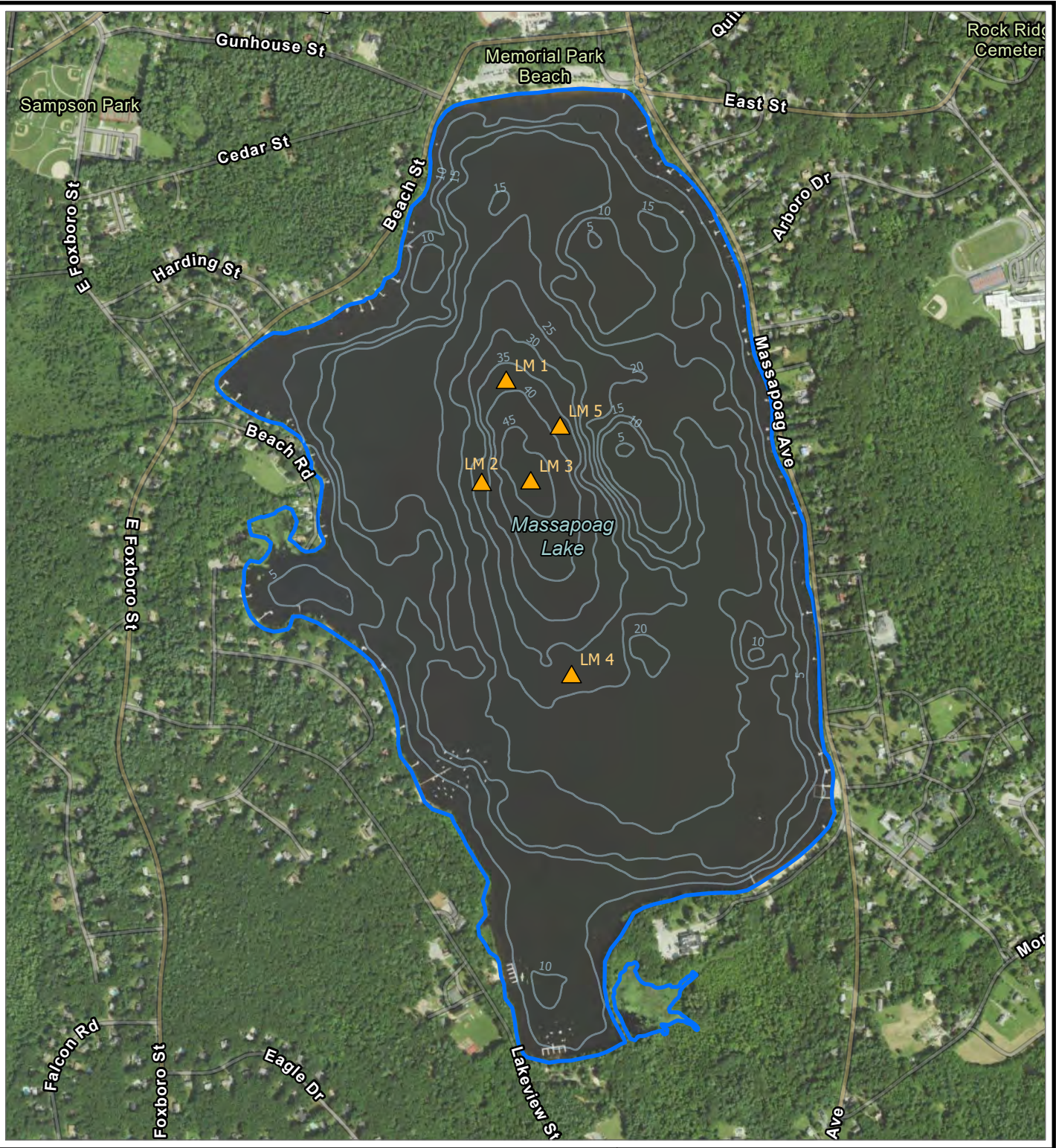
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Figures

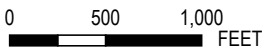
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 BATHYMETRY CONTOURS (5 FOOT INTERVAL)

 SEDIMENT SAMPLE LOCATION

 SHORELINE



1:12,000 1" = 1,000'

BASE MAP: ESRI, NAIP IMAGERY, 2018
DATA SOURCES: TRC, GPS LOCATIONS, 2023
MASSGIS, INLAND WATER BATHYMETRY, 2019

PROJECT:		ALUM DOSING PLAN LAKE MASSAPOAG TOWN OF SHARON, MA	
TITLE:		SEDIMENT SAMPLING LOCATIONS NOVEMBER 20, 2023	
DRAWN BY:	S. DEHAINAUT	PROJ. NO.:	570766.0000.0000
CHECKED BY:	K. BACHAND	FIGURE 1	
APPROVED BY:	M. O'BRIEN		
DATE:	JANUARY 2024		
		10 HEMINGWAY DRIVE 2ND FLOOR EAST PROVIDENCE, RI 02915 PHONE: 401.330.1236	
FILE:		570766_LAKEMASSAPOAG_SEDCORINGOTHERFIGURES	

Appendix A

Sediment Phosphorus Fractionation Lab Tables

RESULTS OF SEDIMENT CHEMICAL ANALYSIS

Core	Interval (cm)		Mid (cm)	General Properties			Phosphorus Fraction (mg P/ gram dry sediment)					Extractable Iron (mg Fe/g dry)
				% Moisture	% LOI	Density (g/cm3)	Fe-P	Al-P	Org-P	Ca-P	Total P	
LM1	0	2	1	94%	27%	1.03	1.497	0.378	0.660	0.128	2.663	232
LM1	2	4	3	91%	25%	1.04	0.929	0.454	0.641	0.161	2.185	141
LM1	4	6	5	87%	23%	1.07	0.435	0.370	0.495	0.154	1.454	-
LM1	6	8	7	82%	21%	1.09	0.270	0.221	0.393	0.175	1.059	-
LM1	8	10	9	83%	21%	1.09	0.242	0.195	0.379	0.155	0.972	-
LM1	13	15	14	83%	21%	1.09	0.206	0.161	0.357	0.144	0.869	-
LM1	18	20	19	83%	21%	1.09	0.164	0.085	0.338	0.133	0.720	-
LM2	0	2	1	88%	27%	1.05	1.557	0.539	0.809	0.150	3.054	211
LM2	2	4	3	90%	24%	1.05	0.943	0.554	0.667	0.156	2.320	132
LM2	4	6	5	86%	22%	1.07	0.561	0.554	0.612	0.154	1.881	-
LM2	6	8	7	87%	21%	1.07	0.325	0.399	0.573	0.158	1.454	-
LM2	8	10	9	85%	21%	1.08	0.312	0.363	0.340	0.176	1.192	-
LM2	13	15	14	83%	20%	1.09	0.274	0.209	0.369	0.156	1.008	-
LM2	18	20	19	82%	21%	1.10	0.267	0.255	0.368	0.173	1.062	-
LM3	0	2	1	84%	41%	1.06	1.628	0.988	0.553	1.021	4.190	138
LM3	2	4	3	87%	21%	1.07	0.357	0.318	0.465	0.168	1.308	69
LM3	4	6	5	84%	21%	1.08	0.314	0.221	0.421	0.168	1.123	-
LM3	6	8	7	84%	24%	1.08	0.320	0.150	0.385	0.127	0.982	-
LM3	8	10	9	85%	22%	1.08	0.389	0.161	0.375	0.133	1.058	-
LM3	10	12	11	85%	21%	1.08	0.444	0.109	0.376	0.133	1.062	-
LM3	12	15	13.5	84%	22%	1.09	0.426	0.096	0.361	0.120	1.003	-
LM4	0	2	1	88%	26%	1.06	1.765	0.469	0.821	0.149	3.204	212
LM4	2	4	3	91%	26%	1.04	1.719	0.755	0.749	0.188	3.412	154
LM4	4	6	5	89%	23%	1.05	0.640	0.546	0.643	0.156	1.986	-
LM4	6	8	7	87%	22%	1.07	0.347	0.350	0.565	0.159	1.422	-
LM4	8	10	9	86%	23%	1.07	0.263	0.338	0.334	0.173	1.108	-
LM4	13	15	14	84%	20%	1.09	0.304	0.237	0.234	0.140	0.914	-
LM4	18	20	19	83%	20%	1.09	0.301	0.230	0.227	0.137	0.895	-
LM5	0	2	1	91%	25%	1.04	1.050	0.435	0.428	0.154	2.067	218
LM5	2	4	3	92%	24%	1.04	1.163	0.371	0.364	0.159	2.057	175
LM5	4	6	5	90%	24%	1.05	0.857	0.404	0.397	0.166	1.824	-
LM5	6	8	7	86%	22%	1.07	0.569	0.370	0.365	0.162	1.466	-
LM5	8	10	9	84%	21%	1.09	0.428	0.315	0.311	0.171	1.224	-
LM5	13	15	14	83%	20%	1.09	0.178	0.123	0.120	0.159	0.580	-
LM5	18	20	19	83%	20%	1.09	0.173	0.090	0.087	0.159	0.508	-

1. Phosphorus Fractionation Definitions:

Fe-P = Iron-bound and loosely sorbed phosphorus

Al-P = Aluminum-bound phosphorus

Org-P = Organically bound phosphorus

Ca-P = Calcium-bound phosphorus

2. Reducible-extractable iron is an extract of the iron-bound phosphorus extraction (BD step).

RESULTS OF SEDIMENT CHEMICAL ANALYSIS

Core	Interval (cm)		Mid (cm)	General Properties			Phosphorus Fraction (mg P/ gram wet sediment)				Extractible Iron (mg Fe/g wet)
				% Moisture	% LOI	Density (g/cm3)	Fe-P	Al-P	Org-P	Ca-P	
LM1	0	2	1	94%	27%	1.03	0.0885	0.0223	0.0390	0.0076	13.7
LM1	2	4	3	91%	25%	1.04	0.0842	0.0411	0.0581	0.0146	12.8
LM1	4	6	5	87%	23%	1.07	0.0586	0.0498	0.0667	0.0207	-
LM1	6	8	7	82%	21%	1.09	0.0475	0.0389	0.0689	0.0307	-
LM1	8	10	9	83%	21%	1.09	0.0416	0.0335	0.0652	0.0266	-
LM1	13	15	14	83%	21%	1.09	0.0356	0.0277	0.0617	0.0249	-
LM1	18	20	19	83%	21%	1.09	0.0274	0.0142	0.0562	0.0221	-
LM2	0	2	1	88%	27%	1.05	0.1795	0.0621	0.0932	0.0173	24.3
LM2	2	4	3	90%	24%	1.05	0.0902	0.0530	0.0638	0.0149	12.6
LM2	4	6	5	86%	22%	1.07	0.0774	0.0765	0.0845	0.0213	-
LM2	6	8	7	87%	21%	1.07	0.0439	0.0538	0.0773	0.0212	-
LM2	8	10	9	85%	21%	1.08	0.0455	0.0529	0.0495	0.0257	-
LM2	13	15	14	83%	20%	1.09	0.0457	0.0348	0.0614	0.0259	-
LM2	18	20	19	82%	21%	1.10	0.0491	0.0468	0.0676	0.0318	-
LM3	0	2	1	84%	41%	1.06	0.2555	0.1550	0.0867	0.1602	21.7
LM3	2	4	3	87%	21%	1.07	0.0477	0.0425	0.0622	0.0225	9.3
LM3	4	6	5	84%	21%	1.08	0.0506	0.0355	0.0677	0.0270	-
LM3	6	8	7	84%	24%	1.08	0.0504	0.0235	0.0605	0.0200	-
LM3	8	10	9	85%	22%	1.08	0.0599	0.0248	0.0578	0.0205	-
LM3	10	12	11	85%	21%	1.08	0.0680	0.0167	0.0575	0.0204	-
LM3	12	15	13.5	84%	22%	1.09	0.0703	0.0159	0.0595	0.0197	-
LM4	0	2	1	88%	26%	1.06	0.2057	0.0547	0.0957	0.0173	24.8
LM4	2	4	3	91%	26%	1.04	0.1588	0.0698	0.0692	0.0174	14.2
LM4	4	6	5	89%	23%	1.05	0.0692	0.0590	0.0695	0.0169	-
LM4	6	8	7	87%	22%	1.07	0.0445	0.0449	0.0725	0.0204	-
LM4	8	10	9	86%	23%	1.07	0.0361	0.0463	0.0458	0.0237	-
LM4	13	15	14	84%	20%	1.09	0.0493	0.0384	0.0378	0.0227	-
LM4	18	20	19	83%	20%	1.09	0.0511	0.0391	0.0385	0.0233	-
LM5	0	2	1	91%	25%	1.04	0.0959	0.0397	0.0391	0.0141	19.9
LM5	2	4	3	92%	24%	1.04	0.0948	0.0302	0.0297	0.0130	14.2
LM5	4	6	5	90%	24%	1.05	0.0864	0.0407	0.0400	0.0167	-
LM5	6	8	7	86%	22%	1.07	0.0817	0.0530	0.0525	0.0232	-
LM5	8	10	9	84%	21%	1.09	0.0693	0.0510	0.0503	0.0277	-
LM5	13	15	14	83%	20%	1.09	0.0311	0.0215	0.0209	0.0278	-
LM5	18	20	19	83%	20%	1.09	0.0301	0.0157	0.0151	0.0277	-
LM4 DUP	2	4	3	-	-	-	0.1566	0.0743	0.0737	0.0166	-
LM5 DUP	2	4	3	-	-	-	0.0971	0.0367	0.0362	0.0135	-

1. Phosphorus Fractionation Definitions:

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2. Reducible-extractable iron is an extract of the iron-bound phosphorus extraction (BD step).