MASSACHUSETTS
watershed·based plans

DRAFT FOR PUBLIC REVIEW

WATERSHED-BASED PLAN

Lake Wyola

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MassDEP
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Department of Environmental Protection

Contents

Executive Summary

Introduction

The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds, and present the information in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows the United States Environmental Protection Agency's (EPA's) recommended format for "nine-element" watershed plans. The Franklin Regional Council of Governments (FRCOG) developed this WBP with funding, input, and collaboration from the Massachusetts Department of Environmental Protection (MassDEP).

This WBP was prepared for the Lake Wyola watershed, which is in the towns of Shutesbury and Wendell, Massachusetts (with a very small portion in Montague and Leverett). Lake Wyola is a 124-acre lake with a watershed area of 4,295 acres. It receives water from four perennial streams: Skerry Brook, Fiske Brook, the outlet of Ames Pond, and South Brook.

This WBP for Lake Wyola builds on 25 years of assessment, planning, and Best Management Practice (BMP) implementation to improve water quality in Lake Wyola. Most notably, this plan builds on the 2003 s.319-funded work of the Department of Environmental Management (project number not found), and incorporates the studies and community dialogue that has occurred in the interim. Comprehensive Environmental Inc. conducted field inspections at locations within the Lake Wyola watershed in April of 2022 to assist the FRCOG with the identification of potential BMP implementation opportunities.

Impairments and Pollution Sources

Lake Wyola is a category 4A water on draft 2022 Massachusetts Integrated List of Waters 303(d) list due to phosphorus and nutrient/eutrophication impairments. Volunteer monitoring has indicated that the lake has very low total phosphorus and the DEP has acknowledged the validity of volunteer data over DEP data.[1] Biological indicators for eutrophication are also no longer present in the lake. A "preventative" Total Maximum Daily Load (TMDL) for phosphorus was completed for this lake in 2001 and approved by the USEPA in April 2002.

Community feedback gathered to date indicates a concern about excess sediment at several locations in the lake. For any phosphorus and sediment loading that is occurring, stormwater runoff from nearby roads, lawns, and piped stormwater outfalls, erosion of nearby unpaved roads, and stream erosion from fluvial geomorphic impairments are likely a direct source. Other possible sources of pollution considered in the analysis include agriculture and resource extraction sites, forest, septic systems, boat wakes, and underground storage tanks. Groundwater withdrawal is also assessed as a potential driver of pollutant concentrations.

Goals, Management Measures, and Funding

Water quality goals for this WBP are focused on reducing phosphorus and sediment loading to Lake Wyola. This WBP includes an adaptive sequence to establish and track specific water quality goals. First, an interim goal has been established to reduce sediment loading by 5.6 tons and to reduce phosphorus loading by any amount in the next 5 years.

It is expected that goals will be accomplished primarily through installation of structural BMPs to capture stormwater runoff and reduce pollutant loading, as well as implementation of non-structural BMPs (e.g., road

[1] MassDEP 2002

and BMP management), and watershed education and outreach. Engineering studies will be needed to determine the location of and types of structural BMPs.

Funding for both structural and nonstructural BMPs could be obtained from a variety of sources including grant funding, Town funds, volunteer efforts, and other sources.

Public Education and Outreach

Public education and outreach will be aimed at educating Shutesbury Town staff, students, and residents about the health of Lake Wyola, including the potential sources of nonpoint source pollution (contaminants released in a wide area rather than from one single source, such as a pipe) and fluvial geomorphic impairments (disturbance to stream channel shape, water flow, and sediment movement in a stream channel). Education and outreach will help to promote a comprehensive approach to ongoing stormwater management, including road BMPs and residential BMPs.

The public education and outreach goals can be achieved by engaging Town of Shutesbury staff, members of the Lake Wyola Association (LWA) [2] and Lake Wyola Advisory Committee (LWAC), [3] Lake Wyola-area residents, including renters and those who are not members of the lake association, local students, and town-wide residents through online resources, a local presentation, in-situ informational signage and tours, and a variety of other means. It is expected that these programs will be evaluated by tracking attendance at events and other tools applicable to the type of outreach performed. The LWA and LWAC can be leveraged to liaison with community members.

Implementation Schedule and Evaluation Criteria

Project activities will be implemented based on the information outlined in the following elements for inspection, implementation of structural BMPs, public education and outreach activities, and a schedule for periodic updates to the WBP. Other indirect evaluation metrics are also included, such as the number/hours/miles of road management and BMP management. The long-term goal of this WBP is to delist Lake Wyola from the Massachusetts Integrated List of Waters 303(d) list, as well as to greatly reduce the amount of stormwater and mobilized sediment entering the lake.

[2] The Lake Wyola Association (LWA) is a private non-profit, membership-based organization. Membership is voluntary. Not all property owners around the lake are members of the LWA.

[3] The purpose of the LWAC is to serve as a liaison between Town government, the Lake Wyola Association, and the lake community as a whole. It aims to promote the preservation, maintenance, and enhancement of the lake as a natural and recreational resource. Its purview includes protection of water quality from septic systems and other sources of contamination, nuisance weed and sediment removal, erosion and runoff control, and dam safety. Regular water quality assessment and oversight of the dam are also the responsibility of the committee.

Introduction

What is a Watershed-Based Plan?

Purpose & Need

The purpose of a Massachusetts watershed-based plan (WBP) is to identify past and current water quality conditions and known and likely causes and sources of nonpoint source pollution (NPS) in a watershed. It will also help stakeholders to recognize data gaps, prioritize the NPS problems, identify appropriate best management practices and watershed-based strategies for addressing the problems, and develop proposals to fund the work using 319 nonpoint source competitive grant funds or similar programs. The goal of WBPs and projects aimed at reducing nonpoint source pollution is to restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows the United States Environmental Protection Agency's (EPA's) recommended format for "nine-element" watershed plans, as described below.

All states are required to develop WBPs, but not all states have taken the same approach. Most states develop WBPs only for selected watersheds. Massachusetts Department of Environmental Protection's (MassDEP) 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.

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

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

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

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

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

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

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

General Watershed Information

This WBP was prepared for waterbodies located within the Lake Wyola watershed in Shutesbury, Wendell, Leverett, and Montague. The watershed is an FY 2022 319 priority waterbody with a Recovery Potential Index score of 57.[4] Waterbodies include Lake Wyola (MA34103), Skelly Brook, Fiske Brook, Plympton Brook, Fiske Pond, McAvoy Pond, Tyler Pond, Ames Brook, Ames Pond, South Brook, and Footit's Bog. The entire watershed measures 4,285 acres (approximately 6.7 square miles).

Table A-1: General Watershed Information

Watershed Name (Assessment Unit ID):	Lake Wyola (MA34103)
Major Basin:	CONNECTICUT
Watershed Area (within MA):	4285.4 (ac)
Water Body Size:	128 (ac)

[4] The Recovery Potential Screening Tool was developed by the U.S. EPA Office of Water to support prioritization planning for watershed restoration and protection Massachusetts. Recovery potential is the likelihood of an impaired water to attain a desired condition given its ecological capacity, exposure to stressors, and the social context affecting restoration efforts. Lake Wyola's score of 57 was the third highest of the ten scored water resources in Franklin County in the FY 2022 s.319 RFR cycle. Scoring higher on the index suggests a waterbody can recover quickly from the impairment. Lake Wyola was ranked based on the assumption that it currently has a phosphorus impairment, which evidence presented in this WBP suggests it does not.

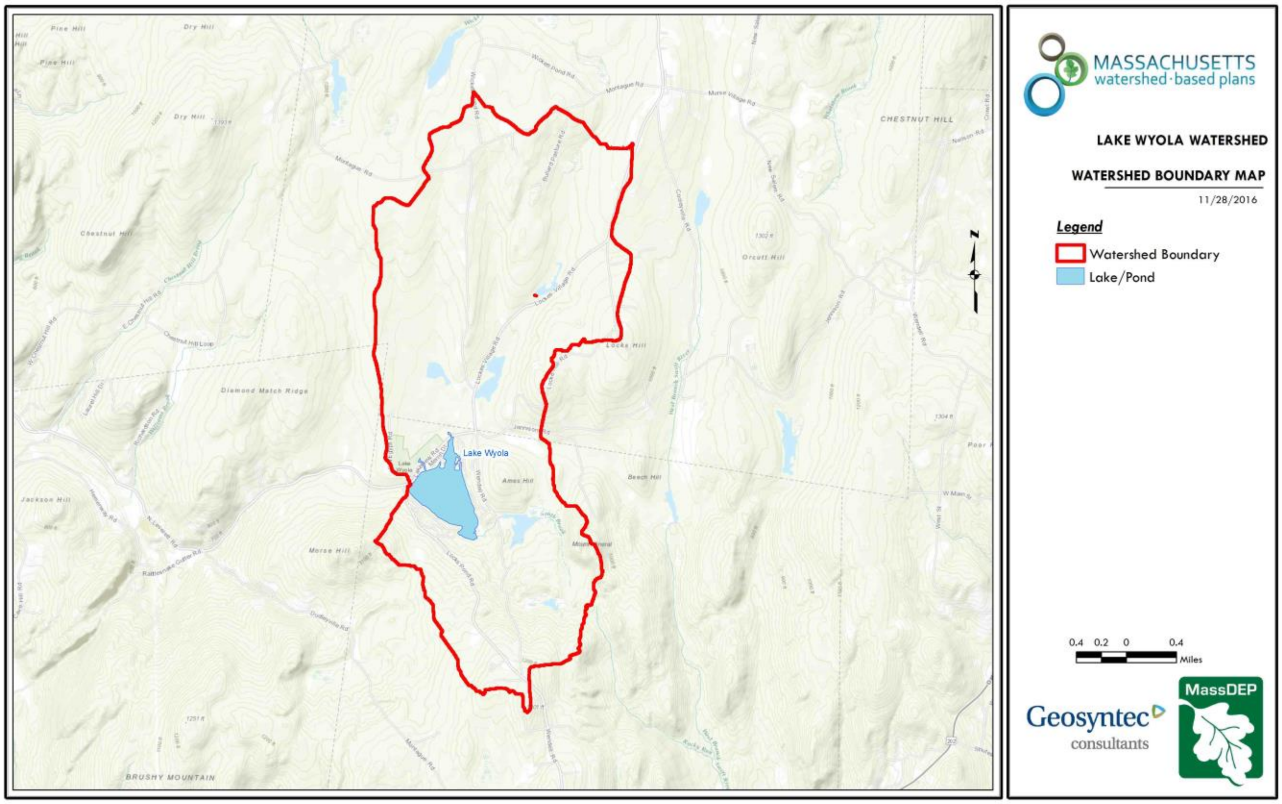

Figure A-1: Watershed Boundary Map (MassGIS, 1999; MassGIS, 2001; USGS, 2016)

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

Lake Wyola is a 128-acre recreational lake located in the northwest corner of Shutesbury (see **Figure A-1**). It is considered a Class B water[5] and a warm water fishery. The lake is relatively densely settled and supports a variety of water and ice-based recreation. The area of the original lake was approximately doubled when the Lake Wyola Dam was constructed in 1883. The lake has a maximum depth of 33 feet, although most of the lake is relatively shallow, averaging only 11 feet (see Figure A-2). The water is typically transparent to roughly 8 feet. The bottom is most often mud, with scattered areas of gravel.[6]

Because Lake Wyola qualifies as a Great Pond, public access is required. A public boat ramp and small park (Elliot Park) at the South Brook Conservation Area provide public access at the southern end of the lake and the small, municipal Top of the Lake Park will one day provide a canoe and kayak launch area at the northern end. The 40-acre Lake Wyola State Park Recreation Area provides public beach access on the northern shore. One additional, very small Town-owned parcel called the Garbiel Gift provides shoreline access in the northeast corner. The LWA maintains three private beaches on the west, north, and east sides of the lake for Association members. See Figure A-3 for a map of locations of important Lake Wyola landmarks.

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[5] According to the Massachusetts Water Quality Standards, the Class B waters are designed as habitat for fish, other aquatic life, and wildlife, and for primary and secondary recreation. Class B waters shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.

[6] MassWildlife 2016

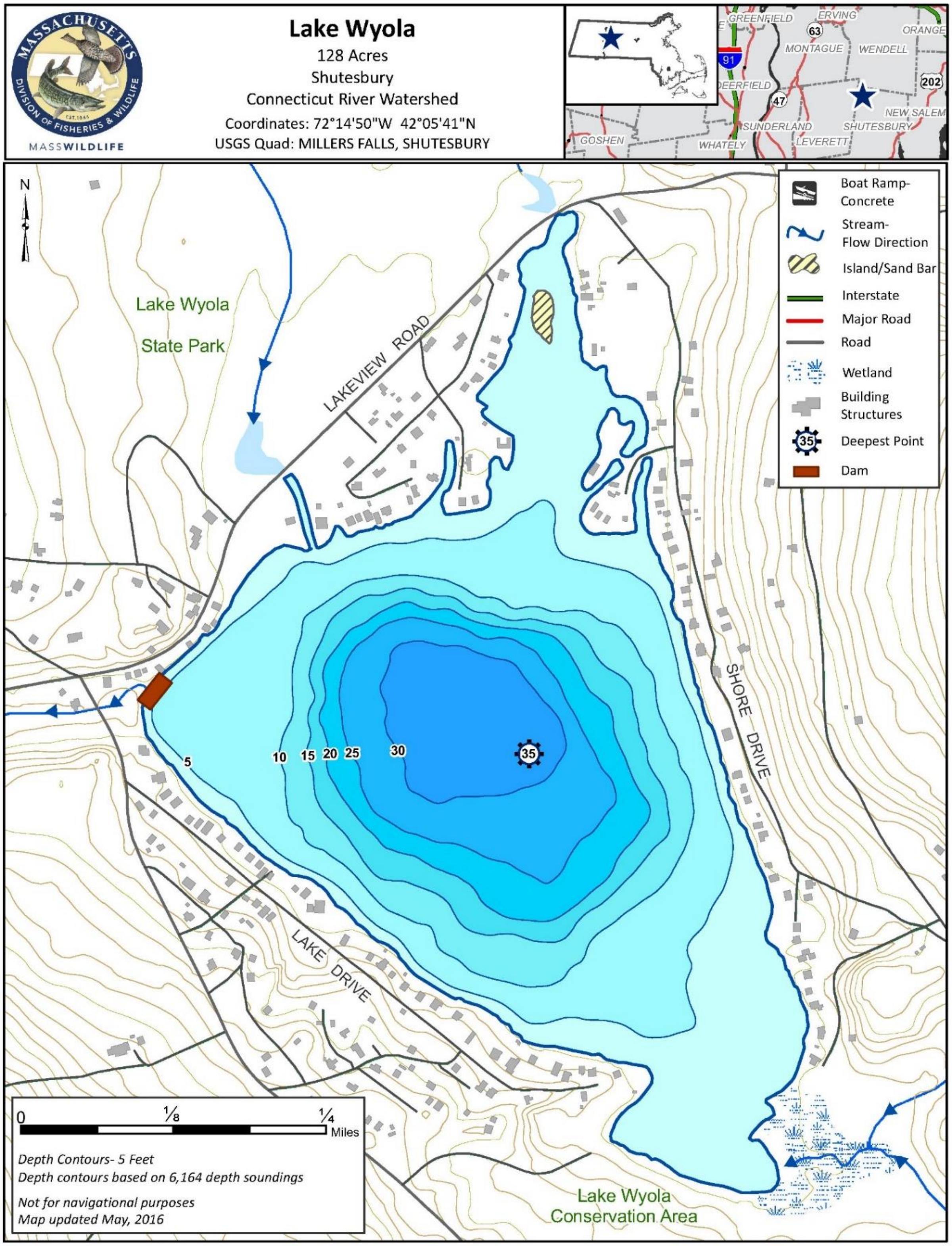

Figure A-2: Lake Wyola Bathometry Map

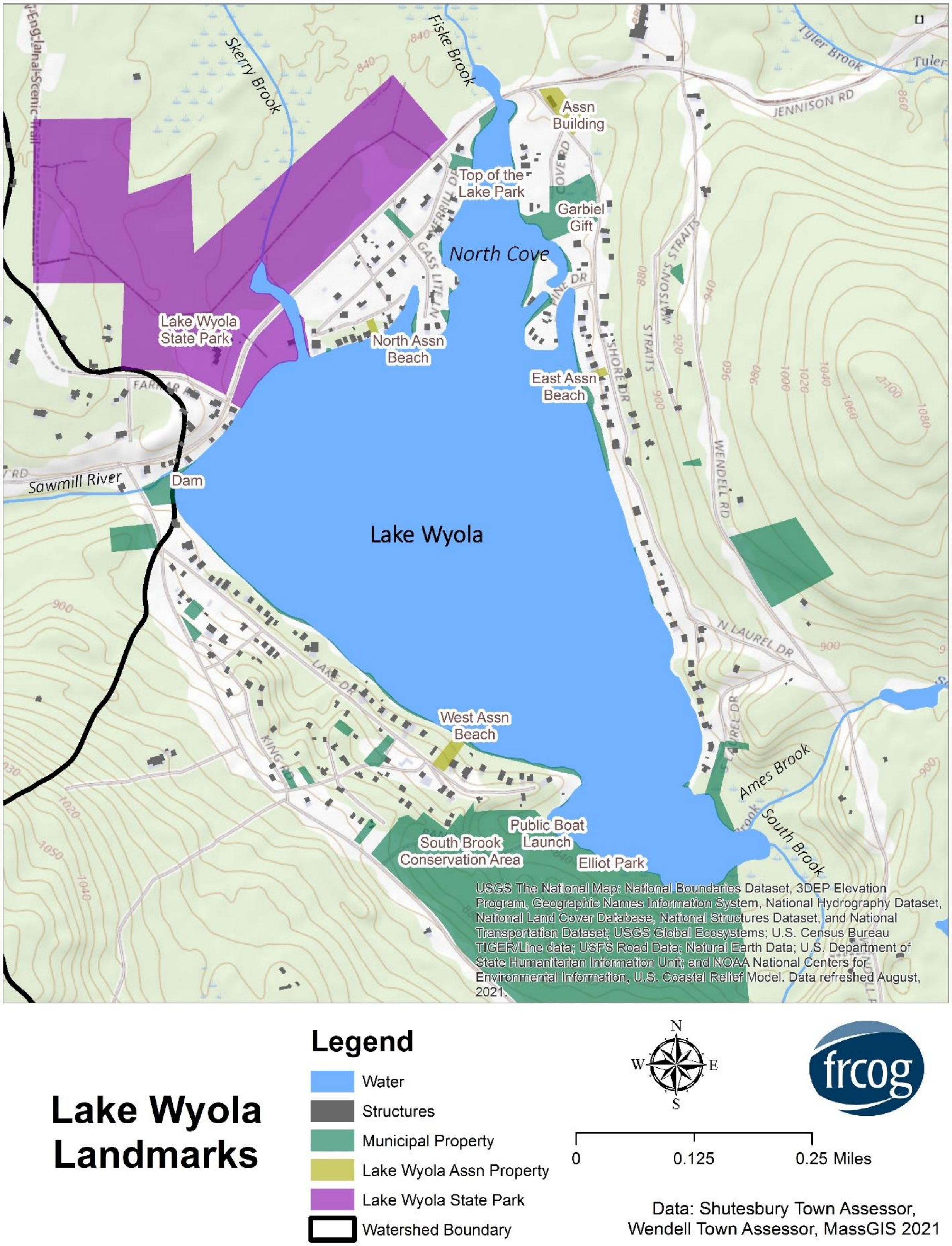

Figure A-3: Lake Wyola Water and Landmarks

The southern half of the watershed is in Shutesbury and the northern half is in Wendell. The lake itself sits just south of the Wendell Town boundary. Medium- and high-density development of year-round homes and summer cottages comprises 80 percent of the shoreline.[7] Beyond the lake's shoreline neighborhoods, the watershed is rural and heavily forested, crossed by a few rural roads and roadside residential development. Approximately 37.6 percent of the watershed land is permanently protected. One state-owned and three Town-owned riverfront properties comprise approximately 140 acres of permanently protected land adjacent to the shore. A high percentage of the wetlands in the watershed are also permanently protected.

Numerous streams and five wetlands drain into Lake Wyola. Skerry Brook discharges into Lake Wyola from the northwest through the Lake Wyola State Park Recreation Area. Fiske Brook feeds Fiske Pond from the north and discharges into the North Cove of Lake Wyola. Just upstream where Fiske Brook enters Lake Wyola, emergent and scrub-shrub wetland vegetation is present. From the Shutesbury portion of the watershed, Ames Pond drains from the east via a small brook into the lake's South Cove. South Brook drains to the same location from Footit's Bog to the southeast. Lake Wyola discharges at the Lake Wyola Dam into the Sawmill River (MA34-40). See Figure A-3 for important waterbodies and waterways in the watershed.

The lake's water level is controlled by a manually activated dam capable of drawing down the lake as much as eight feet. Two-foot drawdowns occur every November 1^{st} – April 1^{st} to protect the shoreline and shoreline infrastructure from ice damage, as well as to inspect the dam. Lake-level drawdown has the added benefit of controlling weeds. The Lake Wyola Advisory Committee also cooperates with the Conservation Commission on a timeline for the lowering of the lake that allows wildlife to move to safety.[8]

Topography, soils, and rare species presence may pose only minor limitations to BMP selection. Shallow depth to bedrock is present along the middle section of the lake's east side, from Ames Hill down to North Laurel and Shore Drives. Soils around the lake are typically loamy sands or sandy loams, well draining, and with a depth to groundwater of nine feet or greater everywhere except the south end of the lake where it is undeveloped and permanently protected. Lake Wyola and many of the other ponds in the watershed are identified as Natural Heritage and Endangered Species Program (NHESP) Priority Habitat of rare species. Those habitat areas are delineated by a small buffer around the water's edge and surrounding wetlands.[9]

Paved roads within the watershed are minimal, taking the form of a handful of two-lane Town-owned roads. The majority of roads in close proximity to Lake Wyola are 1.5-lane roads surfaced with gravel, or in many cases, material with a high content of sand and fine-grained aggregate. Drainage infrastructure within close proximity to the lake is largely nonexistent, with stormwater mostly reaching the lake through pipes or a series of informally constructed swales. The stormwater and erosion control improvements constructed within and around the Lake Wyola State Park with funding from the 2003 s.319 grant were observed by the consulting engineers for this WBP to be in good condition and functioning properly.[10]

[7] MassWildlife 2016; see also Figure A-9: Watershed Land Use Map
[8] Town of Shutesbury 2022
[9] MassGIS 2021
[10] CEI 2022

Description of the Problem

Lake Wyola is listed as a Category 4A water for total phosphorus (TP) and nutrient/eutrophication biological indicators based on data collected by DEP in the summer of 1994.[11,12] Documentation from MassDEP shows, however, that the data serving as the basis for the listing was inaccurate and Lake Wyola has never had phosphorus readings to suggest that it is impaired for phosphorus. The nutrient/eutrophication biological indicators impairment appears to be based on the same 1994 data and assessment, which reported very dense growths of aquatic macrophytes (primarily *Utricularia* sp.) in the north and south ends of the lake. There have been no recent studies of eutrophication biological indicators that would indicate the status of this impairment.

When the draft *Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes* was published for public comment, the following public comment was submitted: "**Comment**: Volunteer monitoring indicates TP in single digit ppb [parts per billion, or 1 mg/L] range. This lake should not be on TMDL list; it is a good quality temperate lake." The DEP responded in the final draft of the TMDL with the following comment and decision:

> **Response:** The Department agrees that the lake has very low TP and should not be listed for nutrients. Earlier total phosphorus measurements by the Department were biased high due to a high detection limit at the laboratory. The lake also has a balanced plant community that is not causing nuisance conditions. In addition, the low dissolved oxygen in the hypolimnion is typical of temperate lakes in the region and should not be viewed as an impairment on the 303d list. We will recommend that it be removed from the next 303d list. Even if removed from the 303d list, this TMDL for phosphorus will continue to be in effect as a protective TMDL to ensure maintenance of good water quality in the lake.[13]

In acknowledgement of the listing error, a "preventative" TMDL for phosphorus was completed for the lake. The TMDL establishes 0.015 mg/L as the total phosphorus criteria.

Community Concerns

The Shutesbury community values Lake Wyola for its beauty, for its importance as an ecosystem, and for the recreation opportunities it provides. Although Lake Wyola is not listed for sediment, there is visual indication and anecdotal evidence that sediment loading to the lake is high and this is of great concern to the lakeside and greater community. Community members have observed that stormwater runoff via surface flow and culverts appears to be transporting sediment.[14] Residents regularly see strong stormwater flow wash out unpaved roads in lakeside neighborhoods, especially on the west and east sides of the lake. Many of these lakeside roads are constructed with a mix of sand and gravel and are owned by the LWA, so all maintenance and repairs are funded by the LWA.

Sediment also appears to be entering the lake from Fiske Brook via the part of the lake called North Cove. The process of sedimentation has been conspicuous to lakeside landowners since the late 1990s.[15] In the process of developing this WBP for Lake Wyola, a representative of LWAC identified the restoration of the lake's North Cove to historical depths as a goal for the watershed, citing that many Lake Wyola-area residents and people who use the lake dislike the aesthetic and recreational conditions created by sedimentation in the cove. In 2018, Community Preservation Act funds were allocated to the "Lake Wyola Silt Removal" project for the

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[11] Category 4A waters are impaired for one or more designated uses but do not require the development of a TMDL because the TMDL has been completed.

[12] MassDEP 2002

[13] MassDEP 2002

[14] Town of Shutesbury 2022

[15] NRCS 2005

creation of a "comprehensive plan for removal of accumulated silt in the North Cove of Lake Wyola and restoration of Cove to historical depths." The project has not yet been implemented because it was identified that the scope of the project should include a system that settles sediment in the wetland upstream of the Lakeview Road culvert, so as to minimize sedimentation in North Cove in the future. The proposal of a dredging project illustrates the degree of concern about and support for addressing sedimentation in the lake.

The 2019 Lake Wyola Wildlife Habitat Assessment noted an absence of freshwater mussels and clams during the 2019 site visits, which would be expected to be present in the lake.[16] The report hypothesized that the timing, depth, and rate of historic drawdown practice may have had an adverse (fatal) effect on the freshwater mollusk population due to their low mobility. The report recommends a water monitoring protocol to further assess the impact of annual dam drawdown.

Summary of Completed and Ongoing Work

This WBP for Lake Wyola builds on 25 years of assessment, planning, and BMP implementation to protect and improve water quality in Lake Wyola.

1997 Management Plan for Lake Wyola

A lake management plan was completed in 1997.[17] The four primary management concerns identified in the plan included the draw down practice and lake level, aquatic vegetation, sediment, and bank stability. The plan identified sediment loading from road management, shoreline erosion, soil erosion on private property, and lack of riparian buffers as major sources of sediment in the lake. Table A-2 lists recommendations from this plan and their completion status.

2002 TMDL and 2003 Lake Wyola TMDL Implementation Project

In 2002, a Total Maximum Daily Load (TMDL) for phosphorus was completed for Lake Wyola as part of the TMDL of phosphorus for selected Connecticut Basin Lakes. The details of the TMDL can be found in the General Watershed Information section and the MassDEP Water Quality Assessment Report and TMDL Review section. Table A-2 lists the phosphorus and bacteria management recommendations that accompanied the TMDL report and their completion status.

In 2003, the Department of Environmental Management (DEM)[18] was awarded an s.319 implementation grant to address phosphorus loading in the watershed. Focused on dense residential land use and septic systems, the grant funded the installation of a number of BMPs on Lakeview Road and at the Lake Wyola State Park public beach, and facilitated multiple residential BMP installation and education projects throughout the Lake Wyola area. Although the neighborhood west of the lake (e.g., Locks Pond Road, Great Pines Drive, and Lake Drive) was identified as a potential focus area for BMPs, the DEM decided to focus on improvements in the beach area instead.

2005 Lake Wyola Inventory and Evaluation, Shutesbury, MA

In 2005, the Natural Resources Conservation Service (NRCS) prepared a report titled *Lake Wyola Inventory and Evaluation, Shutesbury, MA* that identified road sand along Lakeview Drive and erosion from Fiske Brook and Fiske Pond due to beaver activity and hurricanes as the likely sources of sedimentation of the lake's North Cove.

[16] Stockman Associates, LLC 2019.
[17] New England Environmental 1997
[18] Now the Department of Conservation and Recreation (DCR)

As of 2005, sediment had accumulated up to four feet over the cove's estimated baseline. Table A-2 lists recommendations from this plan and their completion status.

2007 Locks Pond Road and Lake Wyola Subwatershed Stormwater Improvement Study, Shutesbury Massachusetts

In January 2007, Department of Conservation and Recreation (DCR) engineer Scott Campbell evaluated stormwater issues on the western side of the lake stemming from surface runoff from the eastern and northeastern slopes of Morse Hill. Uncontrolled stormwater from Morse Hill was flowing over Locks Pond Road and impacting the adjacent residential area, LWA-owned roads in the residential area, and the lake itself. The report proposed specific best management practices along roads and at residences, with diagrams of proposed locations. The 2022 Shutesbury Open Space and Recreation Plan states that these specific measures have proved challenging to implement because they "require regular maintenance to remain effective, some require acquisition of easements on undeveloped private land in order to construct some of the stormwater management structures, and all would require homeowner understanding of the structures' proper functioning."[19] The plan also cites funding as a constraint. Table A-2 lists recommendations from this plan and their completion status.

2019 Wildlife Habitat Evaluation Report, Lake Wyola, Shutesbury, MA

As part of the issuing of the most recent permit for the annual dam-controlled drawdown of the Lake Wyola water level, the Conservation Commission requested a Detailed Wildlife Habitat Evaluation under their authority granted by the Wetlands Protection Act (310 CMR 10.60). In 2019, Stockman Associates, LLC performed a wildlife habitat evaluation that included a Conceptual Wildlife Habitat Assessment Plan depicting potential impact areas and an Adverse Effects Analysis and guidance on how to improve the drawdown procedure to protect wildlife.

[19] Town of Shutesbury 2022

Table A-2: Lake Wyola Proposed Nonpoint Source Pollution Mitigation Projects and Completion Status

LOCATION	NPS ISSUE	PROPOSED PROJECT	COMPLETION STATUS
1997 Management Plan for Lake Wyola LWAC, Town of Shutesbury, New England Environmental, Inc.			
Public boat ramp access road and parking area on Randall Road	Silt/sediment	Dredging	Unknown.
		Siltation barriers	Not completed.
		Regrade and pave parking lot	Completed.
		Install drainage swale or detention basin	Completed: road runoff directed to a swale and detention basin.
Inlet at Fiske Brook	Silt/sediment from a) Fiske Brook, (although this report notes that it is probably normal levels and not the result of erosion) and b) winter sands washing in from Lakeview Road	20-year dredging schedule of North Cove	Dredging schedule not implemented.
		Shallow underwater berm across the inlet of Fiske Brook (south of Riverview Road) with sediment basin	Not completed.
		Installation of catch basins with deep sumps (4') at the intersection of Lakeview Road and Fiske Brook	Not completed, as approval was too complicated. Catch basins with deep sumps installed at Farrar Road intersection instead.
Lake Wyola State Park Beach	Silt/sediment	Pervious pavers in driveways	Not completed; however, DCR installed a detention basin to control stormwater runoff at the beach.
Elliot Park (formerly Town Beach)	Silt/sediment	Construction of a small retaining wall to slow the flow of sand from the beach into lake	Unknown, however the beach is no longer used as a beach and is vegetated to the lake's edge.
	Nutrients	Toilets	Completed; composting Clivus toilets installed.
Various sources of sediment and erosion from roads and houses	Silt/sediment	Road sweeping	Ongoing.
		Water bar maintenance on dirt roads	Ongoing; inconsistent.
		Public education	Some public education completed as part of 2003 319 grant deliverables.

LOCATION	NPS ISSUE	PROPOSED PROJECT	COMPLETION STATUS
Various areas	Bank erosion from a) cutting of vegetation on banks, b) boat wakes, and c) prevailing winds		As of 2003, the boating speed limit on Lake Wyola is 30 mph during the day and 5 mph 150 feet from the shore and at night.
2002 Connecticut River Lakes Phosphorus TMDL MassDEP			
Lakewide	Phosphorus	Public education	Some public education completed as part of 2003 319 grant deliverables.
		NPS survey	NPS survey completed as part of 2003 319 grant deliverables.
		Lake Management Plan	Lake Wyola had an existing LMP from 1997.
		Forest BMPs	Not completed.
		Residential BMPs	Three residential BMP demonstration sites completed as part of 2003 319 grant deliverables.
		Septic System Maintenance	Systems that are failing or are associated with home renovations are upgraded and replaced with tight-tanks and/or on-site processing systems.
		In-Lake Management	Unknown.
	Bacteria from waterfowl	Prevent feeding of wildfowl	Waterfowl managed starting in the 2010s through a contract with the USDA, management is believed to be ongoing.

LOCATION	NPS ISSUE	PROPOSED PROJECT	COMPLETION STATUS
2005 Lake Wyola Inventory and Evaluation, Shutesbury, Massachusetts NRCS			
North Cove and below Lakeview Road	Sediment accumulation in lake from beaver activity in upstream ponds and brooks and from several recent storm events, including microburst in early 2000s, Hurricane Bertha in 1997, Hurricane Floyd in 1999, and annual spring runoff events.	Periodically inspect and remove accumulated debris at spillway outlet structures at Fiske Pond, McAvoy Pond, and Tyler Pond.	Not completed.
		Inspect spillway to ensure water is not flowing around the ends of the spillway and eroding the abutment.	Not completed.
		Install streambank and channel protection measures along the eroded outlet channel below the spillway outlet structure at Fiske Pond.	Not completed.
		Conduct hydraulic analysis of Fiske Pond Dam to evaluate the capacity of the spillway and the safety of the dam from overtopping.	Not completed.
		Install log boom structure upstream of the spillway to prevent the debris dams at the spillway of Fiske Pond and McAvoy Pond.	Not completed.
		Install beaver control measures at the active beaver areas downstream on Fiske Brook.	Not completed.
Lakeview Road and bridge, Locks Pond Road, Shore Drive, Pine Drive, other dirt roads around the lake	Runoff from road sand and salt; street sweeping doesn't capture it all	Minimize amount of sand applied to the road around Lake Wyola during winter months.	Unknown.
		Develop regular road sweeping program for cleaning in the spring and during the summer and fall, as needed; remove excess accumulations of sand along the shoulders of Lakeview Road.	Ongoing.
		Install curbs or berms along the edges of the roads to direct the road runoff into constructed sediment basins, which can be periodically cleaned out.	Partially completed. Some berms have been installed on Lake Drive that have caused runoff to be a problem down the hill, as there is no provision to deal

LOCATION	NPS ISSUE	PROPOSED PROJECT	COMPLETION STATUS
			with the runoff. The Conservation Commission is currently discouraging berms.
Lake community	Sediment from landowners adding sand to their beaches	Minimize the amount of sand used for beach replenishment around the lake.	Completed; sand is only added at Lake Wyola State Park beach.
Lakewide	Bank erosion	Install vegetative and/or structural shoreline protection measures along exposed and eroding shoreline areas to control wave action from boats and reduce the amount of sand washing into the lake.	One demonstration site completed as part of 2003 319 grant deliverables. Bank erosion is reportedly minimal at present. The Conservation Commission strongly encourages a vegetated buffer strip at the lake edge when site work is done on a property under an RDA or NOI and, on a case-by-case basis, may require it
2007 Locks Pond Road and Lake Wyola Subwatershed Stormwater Improvement Study, Shutesbury, Massachusetts Scott Campbell, DCR			
Locks Pond Road and Lake Wyola Association neighborhood	**Locks Pond Road Stormwater Controls** Runoff carried by and across Locks Pond Road is funneled and concentrated by a series of makeshift berms constructed by residents on the east side of the road; pitch of driveways on the	Regulations that require driveway runoff to be directed away from travel lanes of principal roads and into roadside ditches.	Issue has changed, as much of the runoff collected on the west side of the road is now funneled under Locks Pond Road by a series of culverts. Surface flow and erosion along residential driveways and roads still an issue.
		Non-erosive asphalt berm along Locks Pond Road that sends outfall down a paved chute or rock-lined splash pad into vegetated roadside areas.	Berm was constructed but now runoff is directed into culverts rather than rock-lined or vegetated roadside areas.
		Regularly inspect and maintain the small water bars across the LWA's gravel roads.	Occasional inspections completed.
		Develop bioretention areas in small tracts of undeveloped land at the intersection of King Road and Great Pines Road.	Not completed.

LOCATION	NPS ISSUE	PROPOSED PROJECT	COMPLETION STATUS
	west side of Locks Pond Road funnel water directly onto and across the road.		
Two subwatershed areas for Lake Wyola bisected by Locks Pond Road	**Locks Pond Road Stormwater Diversion** Catchment A drains 58 acres via two 18" culverts (perennial and intermittent streams) and a 12" culvert pipe (seasonal flow). Catchment B drains 39 acres via an earthen ditch 5' wide and 8" deep, transitions into two 12" culvert pipes that funnel water across Locks Pond Road above and below the King Road intersection.	Proposal to redirect flow off Morse Hill to Sawmill must establish controls on frequently occurring storms to limit peak flows and quantities (detain for up to 12 to 24 hours the quantity of runoff produced from 2-yr-storm or 3" rainfall). An area of privately held land located above the lower 12-inch culvert pipe is presently undeveloped and has suitable slope and land area to accommodate a small basin; acquiring an easement to construct and maintain a basin on this property would also prove beneficial by settling out suspended solids largely introduced during wintertime road maintenance activities.	Not completed
		Existing earth-lined roadside ditch on west side of Locks Pond Road is not of sufficient size or lined with appropriate cover to receive increased flows. Increase width and armor; this will require reconstruction of driveway culverts to fit the new channel.	Completed in sections.

LOCATION	NPS ISSUE	PROPOSED PROJECT	COMPLETION STATUS
Rooftops/driveways	Stormwater from residences quickly funneled into roads; roads only slightly crowned and lacking roadside ditches.	Generally: exaggerate crown of road, pitch road towards one side, or intercept water inside roadside ditches.	Some Association roads have been crowned.
		Lake Drive: exaggerate crown; install small ditch on west side of road.	Crowned and small ditch established in 2021.
		Capture roof water runoff.	Not widely installed.
		Use pervious pavers in driveways.	Not widely installed.
Intersection of Great Pines Drive and Lake Drive	Stormwater carried by Great Pines Drive is washing out the road as a meandering ditch is forming that carves across Great Pines and spills across Lake Drive before cascading down to the LWA Beach.	Install stone-lined ditches where road is presently washing out.	Not completed.
		Increase crown of road to 9 inches.	Great Pines Drive crowned in 2021 to improve drainage at Kings Road and Lake Drive intersections.
		Install 12-inch cross culverts at the intersection with King Road.	Not completed.
		Place a sunken infiltrating catch basin structure.	Detention basin installed on Lake Association beach off Lake Drive.
		Install rip rap plunge pool and leaching catch basin.	Detention basin installed on Lake Association beach off Lake Drive.
2003 319 Grant DEM			
Watershed	Sheet flow from Farrar Road collected by two standard catch basins at the intersection with Lakeview Road; catch basins are	Replace catch basins with deep sump catch basins.	Completed.
		Install vegetated water quality swale along 300' of north shoulder of the road with two turnouts	Completed.
		Operation and Maintenance Plan for catch basins and swale.	There is no operation and maintenance plan in place with the Lake Association.

LOCATION	NPS ISSUE	PROPOSED PROJECT	COMPLETION STATUS
	piped to discharge onto a grassed picnic area on DEM property that flows directly into the lake. North shoulder of the road is eroded from runoff and consists of unvegetated soils. Catch basins are clogged and during high flow, runoff flows along the side of the road and carries sediment directly to the lake.		
Lake community	General issues; phosphorus	Install up to six demonstration residential LID retrofits around the lake and throughout watershed.	Three residential BMP demonstration sites completed.
		Tour of demonstration homes	Completed.
		Voluntary lawn audit of up to 10 homes	Unknown.
		Flyer of watershed and BMP information	Completed.
		Three workshops on BMPs	Unknown.

LOCATION	NPS ISSUE	PROPOSED PROJECT	COMPLETION STATUS
		Lake Wyola 319 project survey to determine level of knowledge and awareness of watershed and NPS issues before and after the project.	Completed.
	Bacteria	Develop a comprehensive watershed program for inspecting and managing septic systems (quarter time Shutesbury employee to run an inspection and maintenance program). Program includes a brochure.	According to the Board of Health, systems that are failing or are associated with home renovations are upgraded and replaced with tight-tanks and/or on-site processing systems.

Watershed-Based Plan Development

Project Partners and Stakeholder Input

This WBP was developed by the Franklin Regional Council of Governments (FRCOG) with input and collaboration from the Town of Shutesbury, LWAC, Shutesbury Conservation Commission and MassDEP and with technical assistance from Comprehensive Environmental, Inc. (CEI). This WBP was developed using funds from the Section 319 program to assist grantees in developing technically robust WBPs using MassDEP's Watershed-Based Planning Tool. The FRCOG was the recipient of Section 319 funding in Fiscal Year 2020 to serve as the Regional Nonpoint Source Coordinator for Franklin County for the purpose of developing competitive s.319 Nonpoint Source Pollution grant proposals.

Core project stakeholders and their points of contact include:

- Town of Shutesbury
    - Becky Torres, *Town Administrator*
    - Tim Hunting, *Highway Superintendent*
- Lake Wyola Advisory Committee
    - Mark Rivers, *Chair*
- Shutesbury Conservation Commission
    - Miriam DeFant, *Chair*
- MassDEP:
    - Padmini Das, *Nonpoint Source Pollution Section Chief*
    - Malcolm Harper, *319 Grant Program Manager*
    - Judith Rondeau, *Nonpoint Source Pollution Watershed Specialist and Outreach Coordinator*
    - Meghan Selby, *604b Grant Program Manager*
    - Matthew Reardon, *TMDL Program Manager*

While the FRCOG worked with the aforementioned core stakeholders on the drafting of the plan, the FRCOG engaged a broad range of stakeholders during the public review period, including Shutesbury residents, members of the LWA, DCR, and the Wendell Conservation Commission, who owns large parcels in the upper watershed. The Town will want to continue broader outreach and input into the plan and implementation in the future to ensure the support of public and private landowners.

This WBP was developed as part of an iterative process. An initial meeting was held with a representative of the Lake Wyola Advisory Committee in December of 2021. The FRCOG team then collected and reviewed existing data on the watershed to develop a preliminary WBP. In January 2022, FRCOG staff completed a walking and driving tour of the watershed (hereafter referred to as the FRCOG's *Nonpoint Source Field Assessment of the Lake Wyola Watershed*) with the chair of LWAC and a Selectboard member. The areas of concern identified in FRCOG's field assessment were shared with consultant Comprehensive Engineering, Inc., who in April 2022 completed a field inspection of the priority areas with the chair of LWAC. A completed first draft of the WBP was shared with the Conservation Commission and Lake Wyola Advisory Committee for their feedback. A revised public review draft was shared with the community, including the LWA, Wendell Conservation Commission, and DCR in June 2023 to solicit feedback on elements of the plan such as water quality goals, best management practice (BMP) priority implementation locations, and public outreach.

Water Quality Monitoring and NPS Pollution Source Area Data Sources

This WBP was developed using the framework and data sources provided by MassDEP's WBP Tool and supplemented by data from additional studies and a watershed field investigation. The 2003 Lake Wyola s.319 Project Final Report was not available from the DEP, DCR, or the consultant who worked on the project. Sources reviewed included:

- CEI (Comprehensive Environmental Inc.). *Stormwater Improvement Opportunities – Lake Wyola Watershed Technical Memorandum*. May 10, 2022.

  This report was created to support the Lake Wyola WBP and is included in Appendix B.

- FRCOG (Franklin Regional Council of Governments). *Nonpoint Source Field Assessment of the Lake Wyola Watershed.* January 28, 2022.

  This report was created to support the Lake Wyola WBP and is included in Appendix C.

- MassDEP (Massachusetts Department of Environmental Protection). *Underground Storage Tank Facility Search database*. Last accessed 1/4/2021. https://ma-ust.windsorcloud.com/ust/facility/search?1

- MassDEP (Massachusetts Department of Environmental Protection). 2002. *Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes*. DEP, DWM TMDL Report MA34002-2001-4. https://www.mass.gov/doc/final-tmdls-of-phosphorus-for-selected-connecticut-basin-lakes/download

- New England Environmental, Inc. 1997. *Management Plan for Lake Wyola Shutesbury, MA*. Prepared for the Lake Wyola Advisory Committee and the Town of Shutesbury. https://www.shutesbury.org/sites/default/files/offices_committees/lwac/Management%20Plan%20for%20Lake%20Wyola_1997.pdf

- NRCS (Natural Resources Conservation Service). 2005. *Lake Wyola Inventory and Evaluation, Shutesbury, MA.* https://www.shutesbury.org/sites/default/files/offices_committees/lwac/Lake%20Wyola%20Inventory%20and%20Evaluation_2005.pdf

- Campbell, S. 2007. *Locks Pond Road and Lake Wyola Subwatershed Stormwater Improvement Study, Shutesbury, Massachusetts*. Massachusetts Department of Conservation and Recreation, Division of Water Supply Protection Draft Report. https://www.shutesbury.org/sites/default/files/offices_committees/lwac/Stormwater%20Improvement%20Study_2007.pdf

- University of Massachusetts Amherst Environmental Analysis Lab. 2014. "Lake Wyola Analytical Report." Data collected by Mark Rivers, Lake Wyola Association. www.wrrceal.com.

Element A: Identify Causes of Impairment & Pollution Sources

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

Water Quality Impairments

Known water quality impairments, as documented in the MassDEP 2022 Massachusetts Integrated List of Waters, are listed below. Impairment categories from the Integrated List are as follows: [20]

Table A-3: 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-4: Water Quality Impairments

Assessment Unit ID	Waterbody	Integrated List Category	Designated Use	Impairment Cause	Impairment Source
MA34103	**Lake Wyola**	**4A**	Fish, other Aquatic Life and Wildlife	Nutrient/Eutrophication Biological Indicators	Internal Nutrient Recycling
MA34103	**Lake Wyola**	**4A**	Fish, other Aquatic Life and Wildlife	Nutrient/Eutrophication Biological Indicators	Source Unknown
MA34103	**Lake Wyola**	**4A**	Fish, other Aquatic Life and Wildlife	Phosphorus, Total	Internal Nutrient Recycling
MA34103	**Lake Wyola**	**4A**	Fish, other Aquatic Life and Wildlife	Phosphorus, Total	Source Unknown

[20] MassDEP 2022b

Water Quality Goals

A water quality goal is a quantitative or qualitative target pollution level in a water body. Water quality goals may be established for a variety of purposes, including the following:

a.) For **water bodies with known impairments**, a Total Maximum Daily Load (TMDL) is established by MassDEP and the 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.

b.) For **water bodies without a TMDL for total phosphorus** (TP), a default water quality goal for TP is based on target concentrations established in the Quality Criteria for Water[21] (also known as the "Gold Book"). The Gold Book states that TP should not exceed 50 µg/L in any stream at the point where it enters any lake or reservoir, nor 25 µg/L within a lake or reservoir. For the purposes of developing WBPs, MassDEP has adopted 50 µg/L as the TP target for all streams at their downstream discharge point, regardless of which type of water body the stream discharges to.

c.) Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013) prescribe the minimum water quality criteria required to sustain a waterbody's designated uses. Lake Wyola is a Class 'B' waterbody (see Table A-6). The water quality goal for fecal coliform bacteria is based on the Massachusetts Surface Water Quality Standards.

Table A-5: Surface Water Quality Classification by Assessment Unit

Assessment Unit ID	Waterbody	Class
MA34103	Lake Wyola	B

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-6: Water Quality Goals

Pollutant	Goal	Source
Total Phosphorus (TP)	0.015 mg/L (15 µg/L)	Total Maximum Daily Loads of Phosphorus

[21] USEPA 1986

Pollutant	Goal	Source
		for Selected Connecticut Basin Lakes
Total Suspended Solids (TSS)	**Class B Standard** These waters shall be free from floating, suspended and settleable solids in concentrations and combinations that would impair anyuse assigned to this Class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013)

MassDEP Water Quality Assessment Report and TMDL Review

A Water Quality Assessment Report is a detailed report on the condition of a watershed that assesses watershed conditions, perceived problems, and provides recommendations for each MassDEP-defined stream segment of a watershed. The section below summarizes the findings of the Connecticut River Watershed 2003 Water Quality Assessment Report and the Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes that relate to water quality and water quality impairments. Select excerpts from this document 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).

Connecticut River Watershed 2003 Water Quality Assessment Report (MA34103 - Lake Wyola)
PRIMARY AND SECONDARY CONTACT RECREATION AND AESTHETICS USES There are two beaches along the shoreline of Lake Wyola: Lake Wyola State Park Beach and a town beach.[22] No recent data are available for Lake Wyola, thus all uses are not assessed. **CONNECTICUT RIVER WATERSHED – LAKE SEGMENTS ASSESSED** Currently there is uncertainty associated with the accurate reporting of freshwater beach closure information to MA DPH, which is required as part of the Beaches Bill. Therefore, no Primary Contact Recreational Use assessments (either support or impairment) decisions are being made using Beaches Bill data for these waterbodies. Bathing beaches located in this watershed are listed in their respective lake segments. **Report Recommendations:** Conduct water quality monitoring to evaluate designated uses, particularly bacteria monitoring to assess the Primary and Secondary Contact Recreation uses observed in Lake Wyola.

[22] The swimming beaches as of 2022 are the State Park beach and Lake Association beaches. The former Town Beach is now Elliot Park.

Lake Wyola is a Category 4A water. Lake Wyola has a completed "preventative" phosphorus TMDL that sets the TP limit at 0.015 mg/L.[23] The TMDL was changed to "preventative" status in the final draft of the report when the DEP agreed that the listing was based on flawed measurements.[24]

Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes
(MA34103 - Lake Wyola)

Lake Wyola in Shutesbury is a large lake of approximately 129 acres. The area of the original natural lake was approximately doubled as a result of a dam created a century ago. The watershed is 86 percent forested, 6 percent water and wetlands, 6 percent rural and the remainder consists of urban (high density residential) land use. Populations in Shutesbury ranged between 1,049 and 1,561 from 1980 to the 1990 census. Miser predictions on growth are 2,179 for the year 2000 and 2,937 for the year 2010 with an estimated 20-year growth rate of about 88 percent. With such a high population growth rate, and presumably changes in land use, the current loading of phosphorus is probably higher than reported here; however, the target and the TMDL to protect water quality will remain the same. Secchi disk transparency was recorded at 4.2 m in a DEP baseline survey in 1988. Lake Wyola was assessed by DEP in the summer of 1994 and the assessment comments reported: "Moderate total phosphorus levels, oxygen depletion from 6 to 10 meters (< 1 mg./l below 8 meters), and very dense growths of aquatic macrophytes (primarily Utricularia sp.) occur on the north and south ends of the lake." However, recent citizen volunteer data indicate total phosphorus levels are very low, averaging less than 10 ppb with Secchi disk transparency ranging between 4 and 5 meters during July and August with one anomalous reading of 1 m in June. A management plan was developed to address four issues 1) occasional lake drawdown for maintenance of dam and lakeshore areas 2) aquatic vegetation control 3) sediment removal and control and 4) bank stabilization.

The pollutant stressors reported on the 1998 303d list which are related to this phosphorus TMDL are listed in the table below.

Table 1. Pollutant Stressors listed on 1998 303d list.

WBID	Lake Name	Town	Area	303d list pollutant/stressor
MA34002	Aldrich Lake East	Granby	18.5	Noxious plants
MA34106	Aldrich Lake West	Granby	10.7	Noxious plants
MA34042	Leverett Pond	Leverett	65	Noxious plants;Turbidity
MA34045	Loon Pond	Springfield	25.4	Nutrients;Noxious plants
MA34098	Lake Warner	Hadley	68	Nutrients; Low DO;Noxious plants;Turbidity
MA34103	Lake Wyola	Shutesbury	129	Nutrients; Low DO;Noxious plants

Unfortunately, no detailed study of the nutrient sources within the watersheds has been conducted to date. Thus, nutrient sources were estimated based on land use modeling within the DEP's NPSLAKE model. The NPSLAKE model of Mattson and Isaac (1999) was designed to estimate watershed loading rates of phosphorus to lakes. The phosphorus loading estimates from the model are used with estimates of water runoff and these are used as inputs into a water quality model of Reckhow (1979). A brief description of the NPSLAKE model and data inputs is given here. MassGIS digital maps of land use within the watershed were used to calculate areas of land use within three major types: Forest, rural and urban land use. This model takes the area in hectares of land use within each of three categories and applies an export coefficient to each to predict the annual external loading of phosphorus to the lake from the watershed. Because much of the land use data is based on old (1985) aerial photographs, the current land uses within the watershed may be different today. This can be important in the development of the TMDL because different land uses can result in different phosphorus loadings to the waterbody in question. For many rural areas, land use changes often result in conversion of open or agricultural lands to low density housing, in which case, the export coefficients of the NPSLAKE model are the same and no change in loading is predicted to occur. However, in cases where development changes forests to residential areas or rural land uses to urban land uses, phosphorus loadings are predicted to increase. In some cases, loadings are predicted to decrease if additional agricultural land is abandoned and forest regrowth

[23] Category 4A waters are impaired for one or more designated uses but do not require the development of a TMDL because the TMDL has been completed.
[24] MassDEP 2002

occurs. To account for this uncertainty in land use changes, a conservative target is chosen. In addition, the MassGIS land use maps are scheduled to be updated with current aerial photos and the TMDL can be modified as additional information is obtained.

Other phosphorus sources, such as septic system inputs of phosphorus, are estimated from an export coefficient multiplied by the number of homes within 100 meters of the lake. Point sources are estimated manually based on discharge information and site-specific information for uptake and storage. Other sources such as atmospheric deposition to lakes was determined to be small and not significant in the NPSLAKE model, perhaps because lakes tend to be sinks rather than sources of phosphorus (Mattson and Isaac, 1999). For similar reasons wetlands were also not considered to be significant sources of phosphorus following (Mattson and Isaac, 1999). Other, non-land use sources of phosphorus such as inputs from waterfowl were not included, but can be added as additional information becomes available. If large numbers of waterfowl are using the lake the total phosphorus budget may be an underestimate, and control measures should be considered.

Internal sources (recycling) of phosphorus is not included because it is not considered as a net external load to the lake, but rather a seasonal recycling of phosphorus already present in the lake. In cases where this internal source is large it may result in surface concentrations higher than predicted from land use loading models and may contribute to water quality violations during the critical summer period. As additional monitoring data become available, these lakes will be assessed for internal contributions and possibly control of these sources by alum or other means. The major sources according to the land use analysis are shown for the lake in the following table (from “Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes”, 2002).

Table 2f. Lake Wyola MA34103

Total Estimated Nonpoint Source Pollution loads based on GIS Landuse

Watershed Area=	1770.9 Ha (6.8 mi2)
Average Annual Water Load =	10795301.9 m3/yr (12.2 cfs)
Average Runoff=	61.0 cm/yr (24.0 in/yr)
Lake area=	50.4 Ha. (124.6ac)
Areal water loading to lake: q=	21.4 m/yr.
Homes with septic systems within 100m of lake.=	165.0
Other P inputs =	0.0 kg/yr

Estimate of annual Nonpoint Source Pollution Loads by land use

Land use	Area Ha (%)	P Load kg/yr (%)	N Load kg/yr	TSS Load kg/yr
Forest category				
Forest:	1528.4 (86.3)	198.7 (50.4)	3821.1	36682.7
Rural category				
Agriculture:	28.8 (1.6)	8.6 (2.2)	199.1	5696.8
Open land:	16.4 (0.9)	4.9 (1.2)	85.1	2384.5
Residential Low:	63.4 (3.6)	19.0 (4.8)	348.6	24588.9
Urban category				
Residential High:	32.8 (1.9)	80.2 (20.4)	275.6	18694.5
Comm - Ind:	0.0 (0.0)	0.0 (0.0)	0.0	0.0
Other Landuses				
Water:	76.4 (4.3)	0.0 (0.0)	0.0	0.0
Wetlands:	24.7 (1.4)	0.0 (0.0)	0.0	1306.9
Subtotal	1770.9	311.4	4729.6	89354.1
Other P inputs:	NA	0.0 (0.0)		
165.0 Septics:	NA	82.5 (20.9)		
Total	1770.9 (100.0)	393.9(100)	4729.6	89354.1

Summary of Lake Total Phosphorus Modeling Results

Areal P loading L= 0.8 g/m2/yr.
Reckhow (1979) model predicts lake TP = L/(11.6+1.2q)*1000 = 20.9 ppb.
Predicted transparency = 2.3 meters.

If all land were forested, P export would be 217.1 kg/yr,
and the forested condition lake TP would be 11.5 ppb.

The NPSLAKE model assumes land uses are accurately represented by the MassGIS digital maps and that land use has not changed appreciably since the maps were compiled in 1985. The predicted loading is based on the equation:

P Loading (kg/yr)= 0.5* septics + 0.13* forest ha + 0.3* rural ha + 14* (urban ha)0.5

The coefficients of the model are based on a combination of values estimated with the aid of multiple regression on a Massachusetts data set and of typical values reported in previous diagnostic/feasibility studies in Massachusetts.

All coefficients fall within the range of values reported in other studies. Further details on the methods, assumptions, calibration and validation of the NPSLAKE model can be found in Mattson and Isaac (1999). The overall standard error of the model is approximately 172 kg/yr. If not data is available for internal loading a rough estimate of the magnitude of this sources can be estimated from the Reckhow model by substitution of the in-lake concentration for TP. The difference in predicted loadings from this approach and the land use approach is the best estimate of internal loading.

The NPSLAKE model also generates predictions of estimated yearly average water runoff to the lake based on total watershed area and runoff maps of Massachusetts (Mattson and Isaac, 1999). Other estimates of nitrogen and total suspended solid (TSS) loading rates are estimates based on Reckhow et al.(1980), and are provided here for informational and comparison purposes only.

Because of the general nature of the land use loading approach, natural background is included in land use based export coefficients. Natural background can be estimated based on the forest export coefficient of 0.13 kg/ha/yr multiplied by the hectares of the watershed assuming the watershed to be entirely forested. Without site specific information regarding soil phosphorus and natural erosion rates the accuracy of this estimate would be uncertain and would add little value to the analysis.

Mattson, M.D. and R.A. Isaac. 1999. Calibration of Phosphorus Export coefficients for Total Maximum Daily Loads of Massachusetts Lakes. Lake and Reservoir Man. 15(3):209-219.
Reckhow, K.H. 1979. Uncertainty Analysis Applied to Vollenweider's Phosphorus Loading Criteria. J. Water Poll. Control Fed. 51(8):2123-2128.
Reckhow, K.H., M.N. Beaulac, J.T. Simpson. 1980. Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients. U.S.E.P.A. Washington DC. EPA 440/5-80-011.

The final *2018/2020 Integrated List of Waters Appendix 15: Connecticut River Watershed Assessment and Listing Decision Summary* states that there are no new water quality data available for Lake Wyola so the Aquatic Life Use will continue to be assessed as Not Supporting with the Nutrient/Eutrophication Biological Indicators and the total phosphorus impairments being carried forward from the previous Integrated List of Waters.[25] There is no listing information in the 2022 Integrated List of Waters.

Historical and current Technical Memoranda (TM) produced by the MassDEP Watershed Planning Program (WPP) 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.

Water Quality Data

UMass Environmental Analysis Lab Data, 2014[26]

In 2014, an analysis of the total phosphorus content in nine water samples was performed by the Environmental Analysis Lab at UMass (Table A-7), Amherst. This is the only phosphorus monitoring data available since the TMDL was issued in 2002. The average TP value across the eight sampling locations with detectable measurements was 7.57 µg/L.

[25] MassDEP 2022a
[26] UMass 2014

Table A-7: Lake Wyola Phosphorus Monitoring data, 2014

Sample Location	Sample date	Total phosphorus (µg/L or ppb)
Boat Ramp	8/10/14	8.9
West Beach	8/10/14	7.9
North side stream new 42 Lake	8/10/14	BDL*
Dam	8/10/14	7.0
Steam on East Side of State Beach	8/10/14	7.0
North Cove	8/10/14	6.3
East Beach	8/10/14	8.9
East side near 9 North Laurel Drive Extension	8/10/14	4.1
Center of the Lake	8/10/14	10.5

*Below Detection Limit of 3.3 µg/L

The Environmental Analysis Lab at UMass, Amherst, also performed chlorophyll and phaeophytin[27] analysis on four water samples. At that time, the chlorophyll levels < 4 mg/L were considered excellent (Table A-8).

Table A-8: Lake Wyola Chlorophyll and Phaeophytin Monitoring data, 2014

Site Number	Collection Date	Amount Filtered (mL)	Chlorophyll *a* (µg/L)	Phaeophytin *a* (µg/L)
Wyola 1- Dam	9/21/14	500	2	3
Wyola 2- Cove	9/21/14	500	2	4
Wyola 3- Lake Center	9/21/14	500	2	4
Wyola 4- Boat Ramp	9/21/14	500	1	4

[27] One of the breakdown products of chlorophyll.

Lake Wyola Advisory Committee monitoring data[28]

The Lake Wyola Association runs a bacteria-monitoring program at its three Association beaches. Sampling frequency has varied, but samples were generally taken late May through end of August, once a week or once every two weeks. Data is available from 2011. Data from 2016, with the exception of 2020 (first year of COVID-19 pandemic), is shown in Table A-9.

Table A-9: Lake Wyola Bacteria Monitoring data, 2016-2022

Location: Lake Wyola Association Beaches

Year	E. Coli (CFU/100 mL)																Geo Mean (CFU/ 100 mL)
2022	**5/23**	**5/29**	**6/6**	**6/13**	**6/20**	**6/26**	**7/5**	**7/10**	**7/18**	**7/25**	**8/1**	**8/8**	**8/15**	**8/23**			
East Beach	5	82	3		6	5	1	3	28	6	2	41	4	5			
West Beach	20	10	ND		5	8	1	12	66	4	2	4	2	4			
North Beach	14	52	18		1	45	2	2	28	9	6	4	4	2			
2021	**5/25**	**6/1**	**6/7**	**6/15**	**6/22**	**6/30**	**7/6**	**7/12**	**7/19**	**7/21**	**7/26**	**8/2**	**8/9**	**8/16**	**8/25**	**8/30**	
East Beach	2	8	8	4	32	45	10	6	221		4	2	21	>2	39	17	**10.53**
West Beach	<2	13	6	<2	13	32	4	2	232		8	8	8	2	6	<2	**6.78**
North Beach	4	6	2	6	24	4	8	4	288	40	8	4	17	<2	6	15	**8.65**
2019	**5/28**	**6/3**	**6/10**	**6/17**	**6/24**	**7/1**	**7/8**	**7/15**	**7/22**	**7/29**	**8/5**	**8/12**	**8/19**	**8/26**			
East Beach	<2	54	<2	8	2	13	4	<2	2			4	4	2			**5.2**
West Beach	2	8	4	6	4	<2	10	4	4			<2	4	<2			**4.6**
North Beach	<2	5	<2	19	2	4	4	<2	<2			2	2	4			**3.9**
2018	**5/21**	**5/29**	**6/4**	**6/11**	**6/18**	**6/25**	**7/2**	**7/16**	**7/23**	**8/6**	**8/13**	**8/20**					
East Beach	20	41	52	31	10			10	10	20	<10	<10					**20.1**
West Beach	20	31	63	31	41			10	<10	<10	<10	20					**31.6**
North Beach	41	10	30	20	41			<10	<10	10	10	<10					**19.3**
2017	**5/30**	**6/5**	**6/13**	**6/19**	**6/26**	**7/5**	**7/10**	**7/17**	**7/24**	**7/31**	**8/7**	**8/14**	**8/21**	**8/28**			
East Beach	<10	10	<10	<10	<10	41	30	10	2	8	16	7	4	4			**9.0**
West Beach	<10	<10	<10	<10	30	20	20	20	9	3	14	1	8	4			**8.8**
North Beach	<10	<10	10	10	10	10	<10	<10	3	8	21	0	8	2			**8.4**

[28] LWAC, 2001 - 2019

Year	E. Coli (CFU/100 mL)																Geo Mean (CFU/ 100 mL)
2016	**5/23**	**5/31**	**6/6**	**6/13**	**6/20**	**6/27**	**7/5**	**7/11**	**7/18**	**7/27**	**8/1**	**8/8**	**8/17**	**8/22**	**8/29**		
East Beach	12	20	18	6	20	2	10	30	14	56	8	4	48	6	18		**12.8**
West Beach	12	10	10	12	12	2	10	12	6	14	2	20	18	6	1		**7.5**
North Beach	2	6	10	6	12	20	20	10	12	36	2	2	4	1	2		**6.0**

MA water quality standard for public beaches
Not to exceed **126 CFU/100 mL** as the geometric mean of all samples collected within any 90-day or smaller interval
Not to exceed **235 CFU/100 mL** in a single sample

Cells with results in exceedance of water quality standards are highlighted in red

Table A-10: Lake Wyola monitoring data 2001 – 2021

Location: Lake center, 5-meter depth

Year	Date	Temperature (Celsius)	D.O. (mg/L)	D.O. (%)	Conductivity	pH
2021	7/7/21	17.9	5.2	54	36.5	5.51
	8/27/21	20			33.3	5.14
2020	9/26/20	17.3	7.9	83	40.8	6.65
	10/15/20	14.9	8.5	84	38.8	6.66
2019	05/09/19	10.2	9.5	85	26.2	4.87
2016	06/03/16	14.3		9.5	38	4.96
	07/05/16	20.8		7.3	46.5	6.05
	08/21/16	26		7.1	56.3	5.89
2015	08/03/15	20.5	4	4	46	4.31
2011	06/11/11	13	8.35	8.35	33.3	5.45
	07/16/11	15.4	7.32	7.32	35.4	5.62
	08/21/11	20.2	4.9	4.9	40.9	5.76
2010	07/17/10	20	7.9	7.9	44.6	5.95
2008	06/08/08	15.8	9.9	9.9	46.4	4.88
	06/28/08	16.4	8.42	8.42	46.6	4.72
	7/19/08	18.3	10.17	10.17	47	
	08/17/08	19.5	5.82	5.82	46.4	5.31
2007	7/14/07	17	6.97	6.97	37.8	5.67
	09/15/07	20.5	8.52	8.52	45.7	6.45
2006	05/20/06	12.1	8.88	8.88	40.3	5.26
	06/17/06	14.1	8.21	8.21	40.7	5.77
	07/22/06	16.8	7.32	7.32	41.4	5.62
	08/19/06	19.6	5.9	5.9	42	5.62
	09/16/06	18.8	7.75	7.75	46.3	6.61
	10/21/06	12.5	8.33	8.33	44.3	6.44
2005	04/23/05	8.5	9.9	9.9	33.7	
	05/21/05	11.6	9.75	9.75	33.9	
	06/18/05	13.4	9.02	9.02	45.4	
	07/16/05	14.3	6.76	6.76	46.3	
	08/05/21	16.3	5.58	5.58	47.3	
	09/17/05	19	4.28	4.28	47.5	
2004	05/22/04	12.8	9.05	9.05	33.3	
	06/19/04	15.5	7.68	7.68	37.1	
	10/17/04	13.9	8.86	8.86	38.1	

Year	Date	Temperature (Celsius)	D.O. (mg/L)	D.O. (%)	Conductivity	pH
2003	05/17/03	11.5	9.98		40.7	5.22
	06/21/03	13.6	8.88		42.7	3.88
	07/19/03	15.6	7.1		45.2	6.9
	08/09/03	18.2	6.25		47.7	
	09/20/03	20.7	7.16		50.2	
	10/18/03	12.3	8.59		37.3	
2002	07/21/02	20.4	6.02		48.6	
2001	05/19/01	9.7	9.93		29.7	0.7
	07/15/01	13.3	8.92		32.5	5.24

MA water quality standard
Temperature: Not more than 20°C over a 7-day period
Dissolved Oxygen: No less than 5.0 mg/L
pH: 6.5 to 8.3 standard units and not more than 0.5 units outside of the natural background range (background range for Lake Wyola unknown)

Cells with results in exceedance of water quality standards are highlighted in red

The vast majority of pH testing shows levels outside of the standard range (pH is too low), even though MassDEP has not listed the lake as impaired for pH. Imbalance in pH can occur in fresher waters due to acid precipitation or less frequently, naturally occurring organic acids, which can be found in bogs and some wetlands.

Evidence of Sedimentation in Lake Wyola

Watershed residents are concerned about sedimentation in Lake Wyola, with the North Cove and the west side of the lake of particular concern. According to the NRCS 2005 *Lake Wyola Inventory and Evaluation*, one homeowner reported that around 1990 the lake depth near their house was over six feet and by 2005, it was less than two feet.[29] On the west side, photos and anecdotal evidence show the accumulation of sediment at stormwater outfalls. At North Cove, photos likely taken in 2008 when the lake level was lowered 8 feet to accommodate repair of the dam show the relative depth of North Cove to the rest of the lake during a draw down and the remaining channel (**Figure A-4** and **Figure A-5**). The area on the north side of the Lakeview Drive culvert where Fiske Brook meets North Cove has similarly filled in with silt and sediment, as shown in **Figure A-6.** The degree to which sediment accumulation in North Cove is anthropomorphic or part of natural processes is not fully understood, but can be studied by conducting hydraulic and hydrologic (H&H) and a fluvial geomorphic studies of the watershed.

[29] NRCS 2005

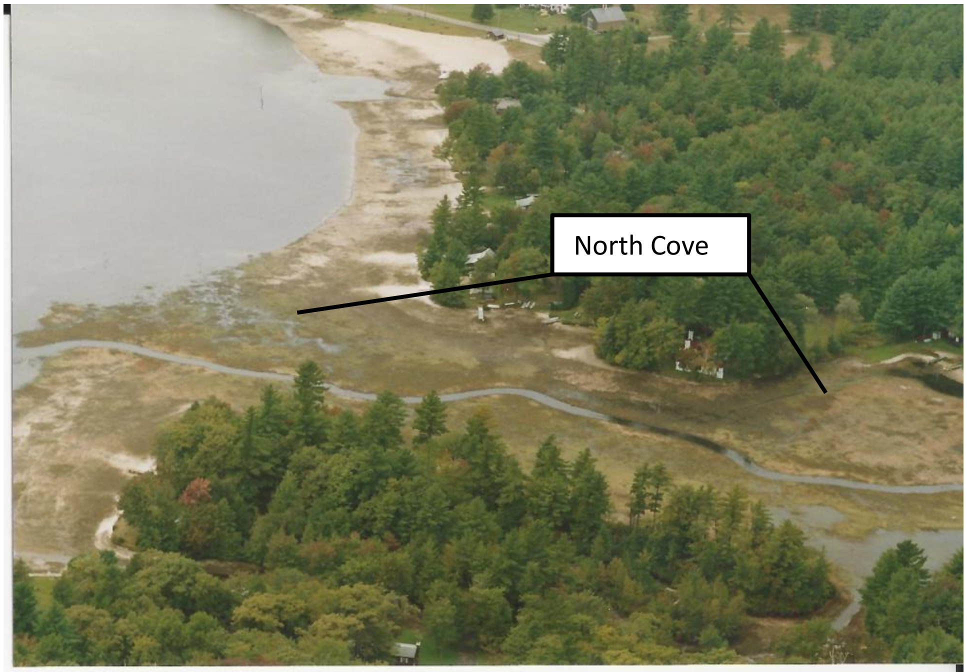

Figure A-4: Sediment in North Cove as seen from the east

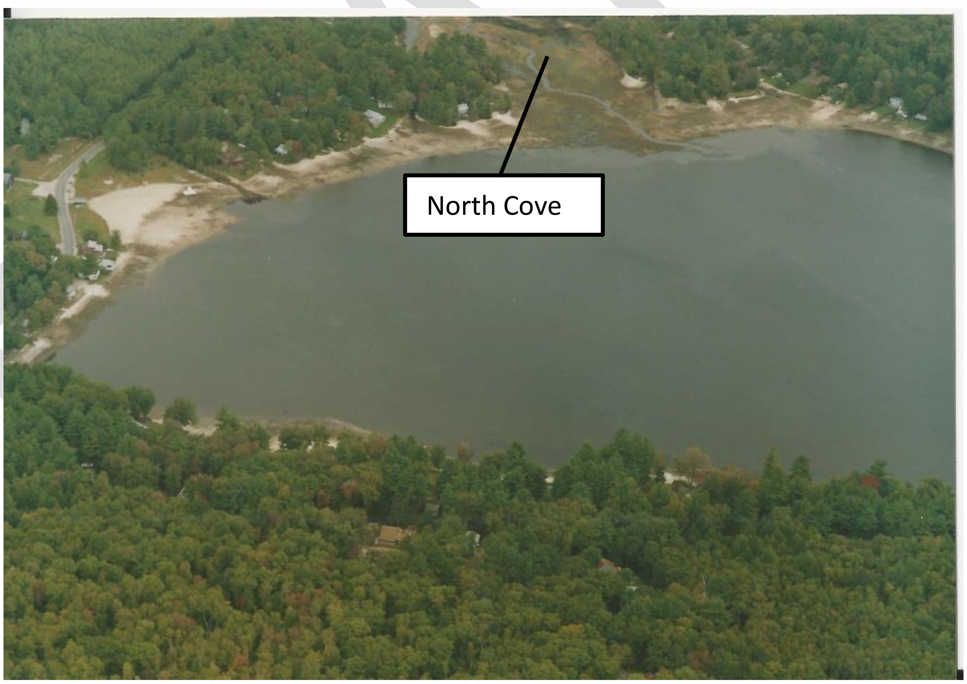

Figure A-5: Sediment in North Cove as seen from the southwest

Figure A-6: Channel of Fiske Brook flowing through area North Cove north of Lakeview Drive, as seen from Lakeview Drive

Data Gaps

Nutrient monitoring data in Lake Wyola is available for a single year (2014) since the issuing of the 2002 TMDL. Phosphorus measurements at the eight 2014 monitoring locations with detectable levels averaged 7.57 µg/L and each of the individual samples met both the TMDL criteria of 15 µg/L and the EPA water quality standards of 25 µg/L. Because there is no biological evidence to suggest that phosphorus levels in Lake Wyola are rising, the 2014 phosphorus data could be sufficient baseline data.

More phosphorus data that includes depth profiles, particularly samples from the hypolimnion at the deep spot, would be helpful in developing/calibrating a trophic response model. It is not expected that internal phosphorus load is a major factor in the lake, but additional data could confirm or refute this assumption.[30]

While sediment loading is a primary concern to the watershed community, there is no TSS monitoring data for Lake Wyola.[31] The Town and Association could collect information about sediment accumulation in existing BMPs around the lake to provide a baseline. Anecdotal evidence for sediment accumulation can also act as a guide.

A study to assess the quantity and quality of sediment loading to the lake from existing sources could help identify sediment management projects for the lake and watershed lands.

[30] CEI 2022

[31] TSS is measured in a lab tests that filters and weighs small particles.

Land Use and Impervious Cover Information

Land use information and impervious cover is presented in the tables and figures below. Land use source data is from 2005 and was obtained from MassGIS (2009b).[32]

[32] 2005 land use data was used in the place of 2016 data because it is the dataset used in the pollutant loading modeling.

Watershed Land Uses

Table A-11: Watershed Land Uses

Land Use	Area (acres)	% of Watershed
Agriculture	32.65	0.8
Commercial	4.35	0.1
Forest	3879.15	90.5
High Density Residential	11.48	0.3
Highway	0	0
Industrial	0.69	0
Low Density Residential	113	2.6
Medium Density Residential	39.43	0.9
Open Land	30.63	0.7
Water	174.04	4.1

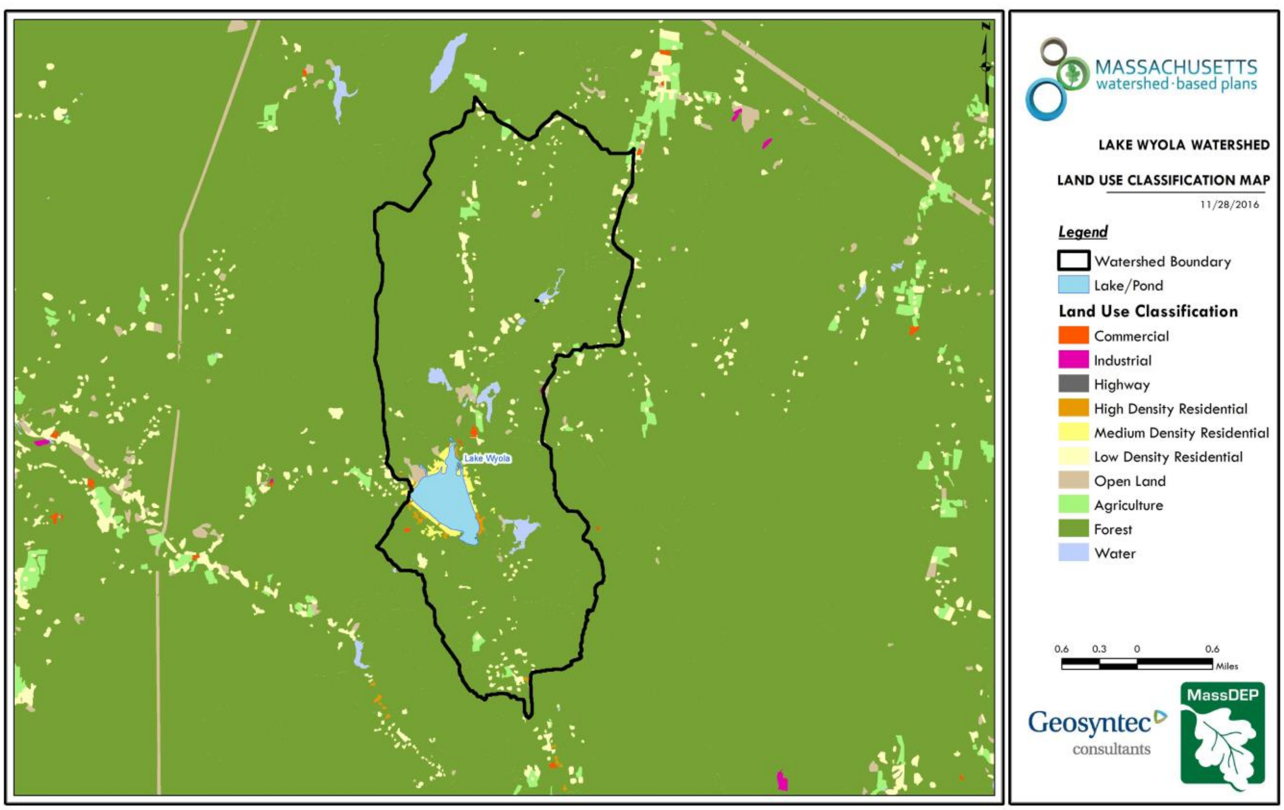

Figure A-7: Watershed Land Use Map (MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

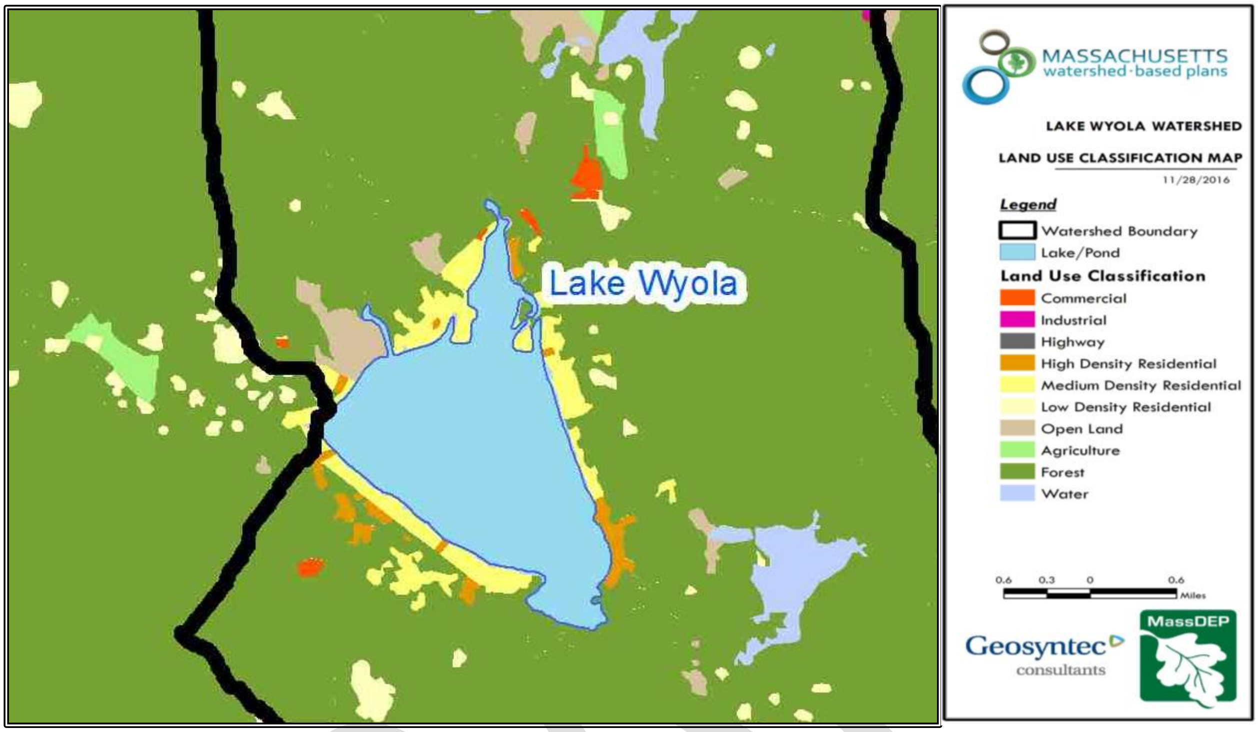

Figure A-8: Land Use Map of Area Immediately Around Lake Wyola (MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Watershed Impervious Cover

There is a strong link between impervious land cover and stream water quality. Impervious cover includes land surfaces that prevent the infiltration of water into the ground, such as paved roads and parking lots, roofs, basketball courts, etc.

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

An estimate of DCIA for the watershed was calculated based on the Sutherland equations. The Sutherland equations estimate the proportion of impervious to pervious surface based on land use classifications for a given area.[33] USEPA provides guidance[34] on the use of the Sutherland equations to predict relative levels of connection and disconnection based on the type of stormwater infrastructure within the total impervious area (TIA) of a watershed. The total land use areas were summed and used to calculate the percent TIA.

[33] Sutherland 1995

[34] USEPA 2010

Table A-12: TIA and DCIA Values for the Watershed

	Estimated TIA (%)	Estimated DCIA (%)
Lake Wyola	2.3	1.8

The relationship between TIA and water quality can generally be categorized as low in impervious cover (0-10%), shown in **Table A-13**, which is characterized by high-quality water and typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and aquatic insects.[35] A significant amount of the watershed's impervious surface is concentrated around the lake, especially on the west side of the lake.

Table A-13: Relationship between Total Impervious Area (TIA) and water quality

% 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. Streams banks become unstable, and physical stream habitat is degraded. Stream water quality shifts into the fair/good category during both storms and dry weather periods. Stream biodiversity declines to fair levels, with most sensitive fish and aquatic insects disappearing from the stream.
26-60%	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.

[35] Schueler et al. 2009

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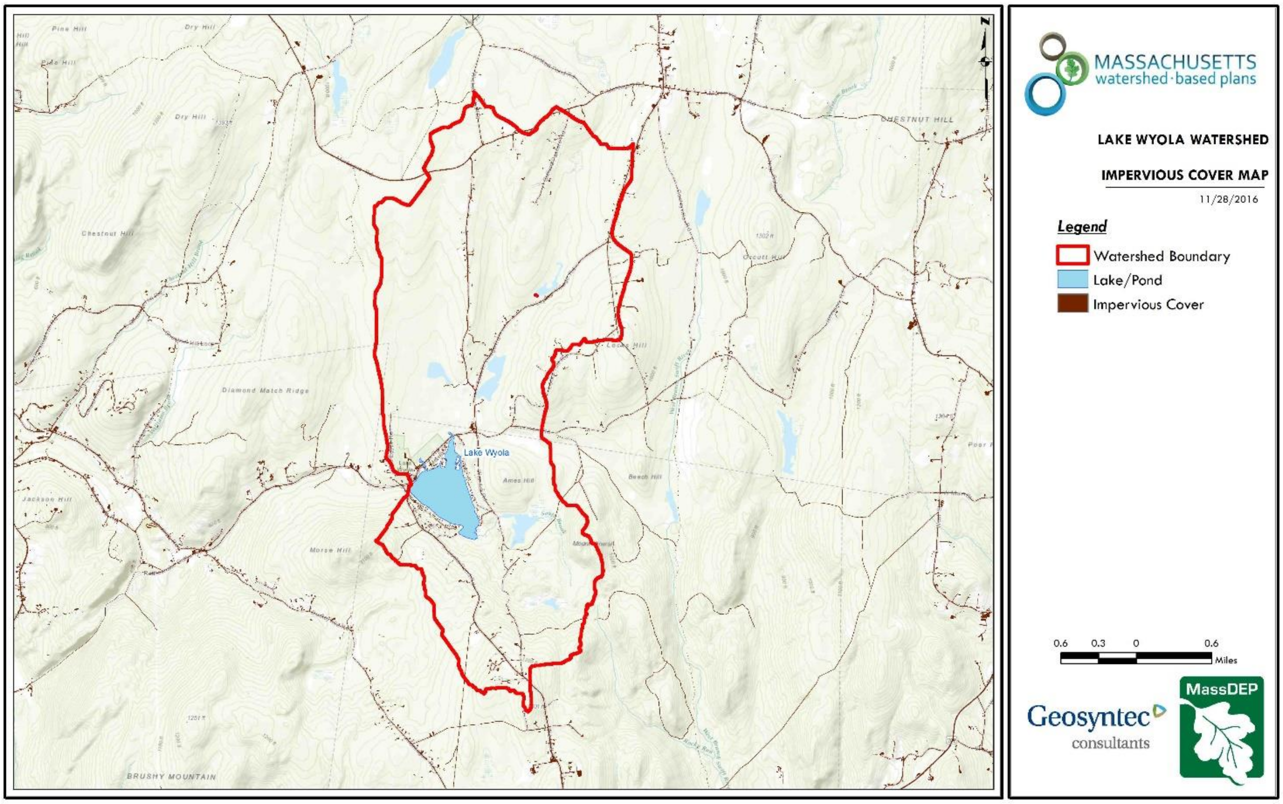

Figure A-9: Watershed Impervious Surface Map (MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

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

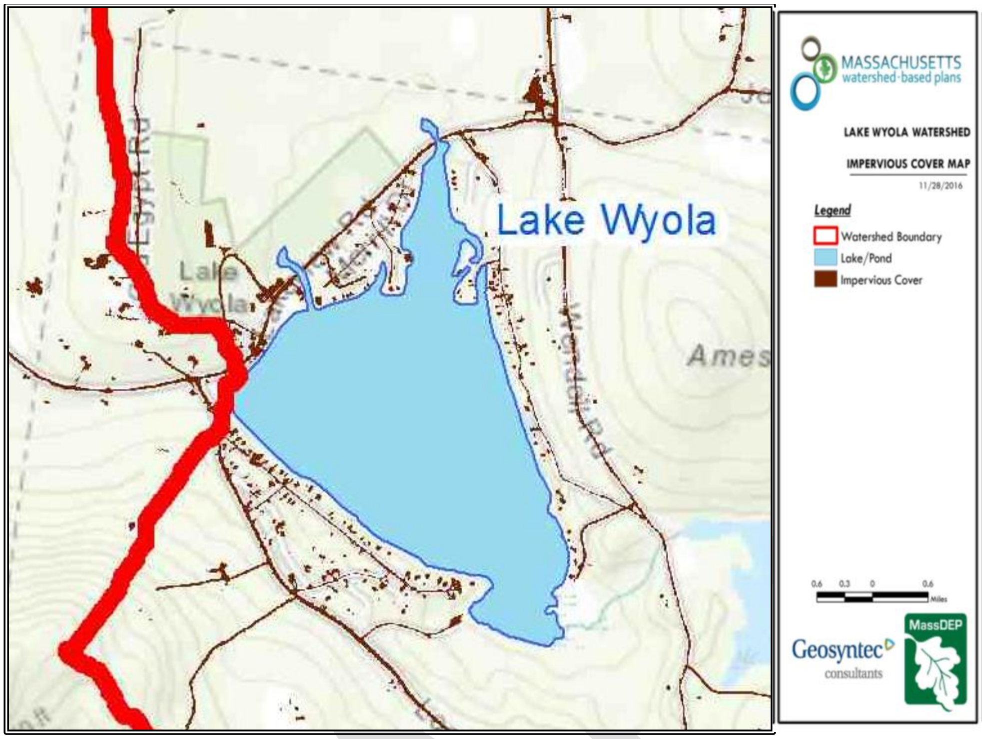

Figure A-10: Watershed Impervious Surface Map (MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Pollution Sources

The majority of the Lake Wyola watershed is undeveloped forest, but the steep slopes, roads, and residential land use directly around Lake Wyola transport high volumes of untreated stormwater runoff directly to Lake Wyola. Over the past 30 years, redevelopment of summer cottages into year-round homes around the lake has steadily increased over time.

Agriculture and Resource Extraction

Based on desktop and field observation, agricultural land use is limited to backyard animals in three or four locations. There are no active mining sites in the watershed. Agriculture, forestry, and mining are not suspected sources of nutrients or sediment.

Forest

Forests are identified in Table A-14 as the primary contributor of TP in the watershed. Forests are a natural source of phosphorus not generally considered a problem. Human-caused sources of phosphorus, such as untreated stormwater runoff from developed land, are where pollutants can best be mitigated.

Groundwater Withdrawal

Groundwater withdrawal can impact streamflow and lake recharge from groundwater: when groundwater withdrawal significantly reduces streamflow and subsurface flow, pollutant levels become more concentrated than under normal flow conditions because there is less water available to dilute the pollutant load. The Lake Wyola watershed does not appear on MassDEP maps as an area of a high groundwater withdrawal or depleted groundwater.[36] This demonstrates that Lake Wyola generally maintains the level of flow expected for a watershed its size, and suggests that groundwater withdrawals are not contributing to elevated pollutant levels, if there were to be any.

Lawns

Lawn fertilizers and dog waste are potential sources of nutrient loading, especially phosphorus. Residential parcels around Lake Wyola are small and yards are often separated by lines of trees. Sandy soil and heavy pine-dominated forest cover may inhibit the growth of a classic lawn look. It is unknown how prevalent the use of lawn fertilizers is in the immediate neighborhood. Shoreline vegetated buffers and diversity are important measures for protecting water quality and habitat value from runoff coming from lawns.

Dog waste may be another potential source of nutrient loading. It is unknown how many dogs use yards or what the sanitation practices of dog owners are. Very few shoreline homeowners have planted buffers along the shoreline, so fertilizers and dog waste could be reaching the lake during storm events.

Roads[37]

The western side of Lake Wyola has the largest number of houses and roads in close proximity to the lake. The majority of the roads that surround Lake Wyola are dirt, sand, or gravel roads in private ownership under the LWA. The Town of Shutesbury does not maintain or repair these roads, maintenance and repair work is funded by the LWA and paid for by dues and fundraising. Membership in the LWA is voluntary, however, with about half of residents in the lake area paying dues, so membership dues do not necessarily represent a significant or reliable funding source. These roads often have steep slopes and limited stormwater infrastructure. Erosion of LWA-owned roads is common around the lake, and road sand deposition has been observed in the lake (Figure A-11a).

The Conservation Commission has observed many locations around the lake where residents have developed and landscaped their properties in ways that alter natural runoff patterns, including adding berms (raised barriers) along the roads that in some cases concentrate runoff and prevent a more dispersed sheet flow of stormwater. Some of the observed berms appear to be within the footprint of the privately owned dirt roads, which may mean they fall under the jurisdiction of the LWA.

Locks Pond Road and west Lake Wyola Area (King Road, Great Pines Drive, Lake Drive, and cross streets)

The 2007 *Locks Pond Road and Lake Wyola Subwatershed Stormwater Improvement Study* notes that at the time of the study, runoff carried by and across the Town-owned Locks Pond Road was a large concern.[38] Steep driveways on the west side (situated on Morse Hill) were the source of the runoff, and makeshift berms constructed by residents on the east side of the road were funneling and concentrating stormwater to discharge points along intersecting roads.

Since the 2007 stormwater improvement study, the Town of Shutesbury Highway Department has crowned Locks Pond Road, installed culverts under some of the west-side driveways, deepened the roadside ditch on the

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[36] MassDEP Sustainable Water Management Initiative (SWMI) Interactive GIS Map

[37] This section on roads contains observations and language from CEI's 2022 *Stormwater Improvement Opportunities – Lake Wyola Watershed Technical Memorandum*.

[38] Campbell 2007

west side (no materials added), and installed additional culverts under Locks Pond Road. The majority of the stormwater flowing off Morse Hill now drains under Locks Pond Road via at least five culverts. During the FRCOG's January 2022 field investigation, it was noted that there is erosion occurring in at least one of the drainage channels.[39]

Despite the improvements in drainage around Locks Pond Road, there are ongoing flooding and erosion problems affecting the LWA roads. A representative of the LWAC stated that there has been an increase in the rate of erosion of LWA roads. The maintenance of a middle section of King Road has been abandoned as a result of ongoing erosion issues, such that a car cannot travel from one end of King Road to the other. According to residents, Great Pines Drive and its intersections with Haskins Way/Birch Drive and Lake Drive frequently experience moderate to severe erosion. Correspondingly, extensive areas of erosion were observed by CEI during their April 2022 site visit along nearly all roads on this side of the lake, including Lake Drive, Great Pines Drive, King Road, and others. In particular, Great Pines Drive runs parallel to the slope and was observed to be highly channelized along it side. Great Pines Drive could be a primary source of sediment running from high points down towards the lake in this area.

There are multiple source outfalls located on the shore of Lake Wyola, two of which are pipes. During the FRCOG field investigation, erosion was noted around the inlet to one of these pipes on the west side of Lake Drive.

Drainage infrastructure such as catch basins, pipes, and formalized swales are largely absent from this area with few exceptions. Recently, the LWA paid for the crowning of Great Pines Drive and Lake Drive and constructed a water bar at the intersection of Great Pines Drive and Lake Drive that diverts water into a newly installed settling basin on the LWA's West Beach property. It is not known if the LWA has a plan for maintaining these installations or other stormwater drainage infrastructure they own.

Based on conversations with stakeholders and field observations, it appears that local residents have attempted to mitigate some erosion problems by creating drainage channels across and adjacent to several roads using materials such as sand and gravel. Channels typically flow off the roads and into the woods where feasible. Some wooded areas appear to be successfully trapping sediment before it reaches the lake, while other areas appear to convey the sediment further down the hill where it likely eventually enters the lake.

Sedimentation and drainage problems in this area are likely due to two things:

- Roads appear to be surfaced in many locations with a layer of loose sand that is highly erodible and readily transported further downgradient during rain events. Some areas with larger stone were observed, and these areas did not appear to be exhibiting the same degree of erosion.
- Roads are typically located at topographic low points. This makes it difficult to convey stormwater to another location (e.g., nearby forest) for pollutant attenuation in many areas, as the road is located at a lower elevation than the surrounding vegetated areas that could allow for stormwater treatment and infiltration.

Based on what is known of the site, possible causes of an increase in erosion include:

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[39] FRCOG 2022

- increased runoff due to changes in precipitation;
- lack of road maintenance and impacts from snow plowing;
- increased driveway area (impervious surface) due to conversion of seasonal homes to year-round homes; and
- increased use of the roads due to conversion of seasonal homes to year-round homes.

Locks Pond Road at Lake Wyola Dam and Sawmill River

According to the Shutesbury Highway Superintendent,[40] there is a small amount of erosion along Locks Pond Road near the Sawmill River culvert. Riprap is currently in place to mitigate the issue. The Superintendent anticipates that the installation of the new Locks Pond-Sawmill River culvert, scheduled for 2023, will resolve this issue.

Farrar Road and Lake Wyola State Park

Stormwater BMPs on Farrar Road and in the Lake Wyola State Park appear to be functioning as intended. The catch basin at the bottom of Farrar Road captures a large amount of sediment, which the Town has to clean out yearly. [41]

Shore Drive and Cover Road

The eastern side of Lake Wyola is somewhat less developed than the western side and has fewer roads. Shore Drive is an Association-owned road that runs parallel to the shore on the east side of the lake. Much of Shore Drive flows off the steep hillside to a swale along the eastern side of the road and away from the lake. However, some areas appear to have either sheet flow or slightly channelized flow towards the lake. Some erosion was observed in the vicinity of the intersection of Shore Drive and Cove Road. The LWA funded the repair and regrading of Shore Drive and Cove Road to construct swales along both sides of the road to collect stormwater runoff and sediment loads before reaching the lake, to clear plugged culverts, and to armor at least one outflow ditch. Drainage infrastructure such as catch basins, pipes, and constructed swales are largely absent from this area with a few exceptions.

North and South Laurel Drives

North and South Laurel Drives are privately owned steep roads owned by the LWA located on the east side of the lake. Some erosion was observed along both North and South Laurel Drives, but according to the representative from LWAC, South Laurel Drive typically experiences more significant erosion. The road material appears to contain more sand than compact gravel. The sand is more easily mobilized during rain events, flowing down the road and eventually towards the lake. Drainage infrastructure such as catch basins, pipes, and formalized swales are largely absent from this area with few exceptions.

North and South Laurel Drives run perpendicular to the lake as they approach the residences along the lakeshore, then turn and run parallel to the shore. Both roads also showed evidence of erosion along the roadside. Both were observed to have some areas regraded to channel stormwater discharges into the woods rather than down the road, however, stormwater from this area still appears to flow down the road towards the lake. Where South Laurel Drive turns to follow the lakeshore, water and sediment cross the road and flow down

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[40] Shutesbury Highway Superintendent, personal communication February 3, 2022
[41] Shutesbury Highway Superintendent, personal communication February 3, 2022

a residential driveway toward the lake. With each of the roads, the sections that run parallel to the shore are sandwiched between the slope and the lakeside residences, making it more difficult to convey stormwater to adjacent vegetated areas for pollutant attenuation.

Wendell Road

Wendell Road is on the lake's east side. Overall, the road material of this road appears to have a higher content of gravel than the roads along the east side and is much more compacted. According to the Highway Superintendent, there is a catch basin at the top of the road that drains very slowly because the planned outfall ran into ledge. In the field investigation, it was noted that there is a soft, wet spot (possibly caused by an underground spring) on the road and erosion in the ditch about 800 feet north of Freeman Road (A-11c). A major culvert over South Brook was replaced on the road several years ago that is working well.

Randall Road

Randall Road is a seasonal Town road that provides access to the public boat launch. The 1997 *Management Plan for Lake Wyola* identified silt and sediment in the lake from erosion around the boat launch, parking lot, and Randall Road. The boat launch has since been paved and Randall Road crowned. The installation of a drainage swale and retention basin appear to have reduced sedimentation in the lake at the end of this road. The Shutesbury Highway Superintendent also reports that the catch basin at the bottom of Randall Road does not fill fast.

Septic

All houses in Shutesbury and Wendell use on-site septic systems for wastewater disposal. Presently, there is no evidence that septic failure is contributing bacteria, nitrogen, or phosphorus to the lake. However, there is potential that septic systems in the shoreline neighborhoods could become a source of pollution due to inadequate maintenance, age, or overuse. The Board of Health reports that they have not seen any evidence that septic failures around the lake have led to the contamination either of the lake water or of drinking water wells.[42] Annual E. coli testing conducted by the Lake Wyola Association at each of the LWA's three beaches predominantly shows very low concentrations of E. coli (see Table A-9). All three beaches are located in areas of concentrated residences, and both are at least 1,000 feet from the lake's major inlet and outlet (see Figure A-3). When failures are detected during Title V inspections, those failures are typically corrected by installing tight tanks, and occasionally conventional systems.[43]

Underground Storage Tanks

There were underground storage tanks in the watershed at the Wendell General Store on Lockes Village Road and another at the AT&T facility on Locke Hill Road that have been removed. There are no underground storage tanks in the Shutesbury portion of the watershed.[44]

Stormwater Outfalls in Lake

According to DCR's 2007 Locks Pond Road and Lake Wyola Subwatershed Stormwater Improvement Study, there are four stormwater outfalls. At least one of these outfalls directs a significant amount of stormwater from Locks

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[42] Shutesbury Board of Health, email communication March 2, 2022
[43] Shutesbury Board of Health, email communication March 2, 2022
[44] MassDEP Underground Storage Tank Facility Search database, accessed 1/4/2022

Pond Road into the lake. These outfalls represent opportunities to reduce sedimentation, either by installing pre-treatment BMPs upstream of these culverts, or by redirecting runoff away from these culverts.

Boat wakes

Anecdotally, increasingly intense motorboat use is creating shoreline erosion and sand bars. Wave action from boats may be contributing to counterclockwise migration of sediments to protected cove areas.[45] Shutesbury bylaws regulate boat speed on the lake, but enforcement of the law is difficult and there are no limits on wakeboards or horsepower. More study may be needed on this topic.

Waterways

Fiske Brook and Pond

Fiske Brook flows into North Cove at the northernmost point of the lake. There is a box culvert where Lakeview Road crosses the very top of the North Cove. The lake and the wetland at the mouth of Fiske Brook have both experienced significant siltation and sedimentation since the late 1990s (see Figures A-11d and A-11e). A 2005 NRCS evaluation[46] posited that the high level of sediment was caused by road sand around the lake area and erosion from banks and streambed of Fiske Brook accelerated by high-powered storms and by intermittent breaching of beaver dams or debris accumulated at the outlet spillway of Fiske Pond and likely other ponds in the watershed (McAvoy Pond, Tyler Pond, and smaller waterbodies). The sedimentation issue appears to be ongoing, though road sand is no longer considered a major source of sediment according to a representative of the LWA and the Shutesbury Highway Superintendent.

An earthen dam on the southernmost edge of the pond impounds the Fiske Pond to a depth of five to ten feet. On their field visit in April 2022, CEI observed some seepage along the base of the dam that flowed into an adjacent forested wetland area. The outlet pipe appears to be located at the top of an approximate 4-foot-high beaver dam (see Figure A-11f) and is equipped with a screen to discourage blockage from debris or beaver activity. The receiving streambed was observed to be stony and free of sediment.

There is concern in the Lake Wyola community that the presence of beaver dams above and below the Fisk Pond Dam could lead to a large amount of sediment entering the lake if they were to fail.[47] Other residents have suggested that beaver populations may add to flood resilience in the Fiske Brook watershed. An H&H study is needed to determine whether and how much risk there is that upstream beaver and manmade dam failures would impact the downstream community. In combination with a fluvial geomorphic assessment, an H&H study would likely also identify what other factors in the Fiske Brook watershed may be contributing to the sedimentation of North Cove.

Waterfowl

Historically, episodic issues with waterfowl have been a source of E. coli in the lake, especially around the state park beach. For many years, geese populations were kept in check with an egg-addling program. In recent years, the nests have been harder to find and the USDA has been involved with managing the live geese population.

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[45] Concern and analysis raised by Conservation Commission in comments submitted on 5/12/2023.
[46] NRCS 2005
[47] Concern raised by LWAC in emails dated 4/27/22 and 5/25/22.

A flock of ducks was noted in the open water under the Lakeview Road culvert during the January 2022 FRCOG field investigation. Community members accompanying FRCOG on the field walk do not know whether feeding of waterfowl occurs. If it does, it should be discouraged.

Figure A-11a:

Waiting on image

Figure A-11b:

Figure A-11c: Wendell Road, roadside erosion

Figure A-11d: Fiske Brook/North Cove, north side of Lakeview Road culvert

Figure A-11e: North Cove, south side of Lakeview Road culvert

Figure A-11f:

Figure A-11 a – f

Pollutant Loading

A Geographic Information System (GIS) was used for the pollutant loading analysis. The land use data was intersected with impervious cover data[48] and United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soils data[49] 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.

Directly connected impervious area was estimated using the Sutherland equation. Any reduction in impervious area due to disconnection—the area difference between total impervious area (TIA) and DCIA—was assigned to the pervious D soil category for that land use to simulate that some infiltration will likely occur after runoff from disconnected impervious surfaces passes over pervious surfaces.

Pollutant loading for key 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 (lb/yr);
A_n = area of land use/cover type n (acres);
P_n = pollutant load export rate of land use/cover type n (lb/acre/yr)

The PLERs are an estimate of the annual total pollutant load exported via stormwater from a given unit area of a particular land cover type. The PLER values for TN, TP and TSS were obtained from USEPA (see values provided in Appendix A).[50] **Table A-14** presents the estimated land-use based TN, TP and TSS pollutant loading in the watershed.

Table A-14: Estimated Pollutant Loading for Key Nonpoint Source Pollutants

Land Use Type	Pollutant Loading[1]		
	Total Phosphorus (TP) (lbs/yr)	Total Nitrogen (TN) (lbs/yr)	Total Suspended Solids (TSS) (tons/yr)
Agriculture	16	100	1.24
Commercial	3	29	0.37
Forest	531	2,700	104.36
High Density Residential	5	35	0.51
Highway	0	0	0.00
Industrial	0	1	0.01
Low Density Residential	31	314	4.20

48 MassGIS 2009a
49 USDA NRCS and MassGIS 2012
50 USEPA 2020; UNHSC 2018, Tetra Tech 2015

Land Use Type	Pollutant Loading[1]		
	Total Phosphorus (TP) (lbs/yr)	Total Nitrogen (TN) (lbs/yr)	Total Suspended Solids (TSS) (tons/yr)
Medium Density Residential	10	92	1.27
Open Land	8	73	1.52
TOTAL	606	3,345	113.47

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

Analysis of Phosphorus Loading

The estimated annual loading of phosphorus-to-receiving-waters within the watershed area is 606 pounds per year, as presented by Table A-14. The largest estimated contributor of the land-use based phosphorus, nitrogen, and TSS are areas designated as forest (88% of TP loading, 81% of TN loading, and 92% of the TSS loading). Nutrients generated from forested areas are a result of natural processes such as decomposition of leaf litter and other organic material. Combined, the residential use areas account for 7.5% of TP loading, 13% of TN loading, and 5% of TSS loading. It is assumed that the TSS and phosphorus loading is higher than estimated in Table A-14 due to ongoing erosion of roads and lack of adequate drainage infrastructure in lakeside neighborhoods. Phosphorus tends to bind to soil particles and therefore is often transported to waterbodies by stormwater runoff carrying sediment.

Loading estimates may also fail to capture high rates of fluvial erosion in forested parts of the watershed, which may elevate the phosphorus and sediment-loading rate. Upland watershed stormwater management practices, including floodplain reconnection and wood loading, could reduce sediment and nutrient loading from Fiske Brook and other streams.

CEI noted that, without the use of a trophic response model to characterize the relationship between P load and in-lake P concentration, goal setting for in-lake P concentration and establishment of a numeric “Required Load Reduction” (lbs of P/year) is arbitrary. CEI noted that the simplest approach to solving this problem is to use existing water quality data, watershed data, and land use data to develop a simple trophic response model (e.g., Vollenweider, Nürnberg).

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

Element B of your WBP should:

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

Estimated Pollutant Loads

Estimated pollutant loads for TP (606 lbs/year), TN (3,345 lbs/year), and TSS (113.47 tons/year) were previously presented in Table A-14 of this WBP.

Water Quality Goals

Pollutant load reduction goals for WBPs can be based on water quality criteria, surface water standards, existing monitoring data, existing TMDL criteria, or other data. Water quality goals for this WBP are focused on reducing TP and TSS loading to Lake Wyola. The most recent (2014) TP monitoring data for Lake Wyola indicates that the phosphorus level is currently below the criteria set by the lake's TMDL, so a protective load reduction goal of simply reducing current phosphorus loading has been set to maintain current good water quality. An annual long-term sediment load reduction goal was calculated using the pre-development land cover (100% forested watershed) load as a target. Sediment load reduction is expected to aid with bacteria and nutrient load reduction. A description of criteria for each water quality goal is described by Table B-1.

The following adaptive sequence is recommended to establish and track water quality goals specific to Lake Wyola:

1. Establish an interim goal to reduce sediment loading by 2.8 tons per year (half of the long-term goal of 5.6 tons per year) and any reduction in phosphorus loading achievable with the installation of management measures.
2. Implement a water-quality monitoring program in accordance with recommendations from Elements H&I. Use monitoring results to perform trend analysis to identify if proposed Element C management measures are resulting in improvements.
3. Establish further goals to meet the long-term sediment load reduction goal of 5.6 tons per year.
4. Meet all applicable water quality standards over the next 10 years, leading to the delisting of Lake Wyola from the 303(d) list and to improved year-to-year conditions of Lake Wyola Association roads.

Table B-1: Pollutant Load Reductions Needed

Pollutant	Existing Estimated Total Load	Water Quality Goal	Required Load Reduction
Total Phosphorus	Table A-14 loading model estimate: 606 lbs/year. Lake Wyola TMDL estimate: 3,880 lbs/yr (1760 kg/yr)	TMDL of 0.015 mg/L	Any reduction is desirable in order to protect existing high-quality waters.
Total Suspended Solids	113 tons/yr	**Class B Standards** These waters shall be free from floating, suspended and settleable solids in concentrations and combinations that would impair any use assigned to this Class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom. Estimated pre-development loading rate is 107.4 tons/year.	5.6 tons/yr (long term goal) (Estimated existing load of 113 tons minus estimated pre-development load of 107.37 tons)

TMDL Pollutant Load Criteria Development

The 2002 *Connecticut River Lakes Phosphorus TMDL* outlines the following pollutant load criteria development (excerpted):

> There are no numeric models available to predict the growth of rooted aquatic macrophytes as a function of nutrient loading estimates, therefore the control of nuisance aquatic plants is based on best professional judgment. However, the goal of the TMDL is to prevent future eutrophication from occurring, thus the nutrient loading still needs to be controlled. To control eutrophication, the Carlson Trophic State Index (TSI) (1977) predicts a lake should have total phosphorus concentrations of about 40 ppb to meet the 4-foot transparency requirement for swimming beaches in Massachusetts and targets are set lower than this. Due to the lack of data on mean depth and other parameters, a simple water quality model was used to link watershed phosphorus loading to in-lake total phosphorus concentration targets. Based on the NPSLAKE model phosphorus loading output and predicted water runoff volumes, an estimated in-lake total phosphorus (TP) concentration was derived based on the Reckhow (1979) model:

$$TP=L/(11.6+1.2*q)*1000$$

where TP= the predicted average total phosphorus concentration (mg/l) in the lake.
L= Phosphorus loading in g/m2/yr (the total loading in grams divided by lake area in meters).
q= The areal water loading in m/yr from total water runoff in m3/yr divided by lake area in m^2.

Similarly, by setting the TP to the target total phosphorus concentration, a target load was estimated by solving the equation above. The Reckhow (1979) model was developed on similar, north temperate lakes and most Massachusetts lakes will fall within the range of phosphorus loading and hydrology of the calibration data set.

[For most lakes], point source wasteload allocation is zero. The margin of safety is set by establishing a target that is below that expected to meet the 4-foot swimming standard (about 40 ppb). Loading allocations are based on the NPSLAKE land use modeled phosphorus budget. The TMDL is the sum of the wasteload allocations (WLA) from point sources (e.g., sewage treatment plants) plus load allocations (LA) from nonpoint sources (e.g., land use sources) plus a margin of safety (MOS). Thus, the TMDL can be written as:

TMDL = WLA + LA + MOS

Seasonality: As the term implies, TMDLs are often expressed as maximum daily loads. However, as specified in 40 CFR 130.2(I), TMDLs may be expressed in other terms when appropriate. For this case, the TMDL is expressed in terms of allowable annual loadings of phosphorus. Although critical conditions occur during the summer season when weed growth is more likely to interfere with uses, water quality in many lakes is generally not sensitive to daily or short term loading, but is more a function of loadings that occur over longer periods of time (e.g. annually). Therefore, seasonal variation is taken into account with the estimation of annual loads. In addition, evaluating the effectiveness of nonpoint source controls can be more easily accomplished on an annual basis rather than a daily basis.

For most lakes, it is appropriate and justifiable to express a nutrient TMDL in terms of allowable annual loadings. The annual load should inherently account for seasonal variations by being protective of the most sensitive time of year. The most sensitive time of year in most lakes occurs during summer, when the frequency and occurrence of nuisance algal blooms and macrophyte growth are usually greatest. Because these phosphorus TMDLs were established to be protective of the most environmentally sensitive period (i.e., the summer season), it will also be protective of water quality during all other seasons. Additionally, the targeted reduction in annual phosphorus load to the ponds will result in the application of phosphorus controls that also address seasonal variation. For example, certain control practices such as stabilizing eroding drainage ways or maintaining septic systems will be in place throughout the year while others will be in effect during the times the sources are active (e.g., application of lawn fertilizer).

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

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

Recent field visits, past studies, and this WBP's loading model suggest that stormwater runoff and sediment from forests, residential areas, and roads around the lake are likely the largest contributors of phosphorus and sediment loading in Lake Wyola. Management measures around Lake Wyola could therefore be selected and designed to stabilize roads, slow stormwater flow, and capture sediment.

Opportunities for Management Measures

The following section outlines general site characteristics and a general proposal for management measures for the Lake Wyola watershed. Recommendations fall into the categories of watershed management/capacity building, structural BMPs, and nonstructural BMPs. *Structural BMPs* are designed to remove pollutants from stormwater runoff or reduce the volume of stormwater runoff. *Nonstructural BMPs* are focused on pollutant reduction, management of pollutants, and preservation of natural features thru management and maintenance practices. Further studies and non-structural BMPs will be essential to solving water quality challenges in this watershed.

This WBP proposes implementation of structural BMPs within seven sites to reduce phosphorus and sediment loading to Lake Wyola (Figure C-1) based on desktop analysis, site visits by the FRCOG (2022) and CEI (2022), and the DCR/Scott Campbell stormwater study published in 2007. Proposed structural BMPs focus on slowing and spreading the flow of surface waters (surface runoff and stream flow) around the lake and reducing any areas of erosion in the uplands. In order to properly design and prioritize these structural measures, it is recommended to fund an engineering study of Sites 1 through 6 and a hydrologic/hydraulic/geomorphic study of Site 7 to identify the location and type of BMPs. BMPs for Sites 1 through 4 and 7 are high priority relative to sites 5 and 6 due to the likely amount of phosphorus and sediment loading and the annual costs incurred by damage to roads in these areas. A number of recommended nonstructural BMPs focus on maintenance of roads and existing structural BMPs and on reducing pollution at its source.

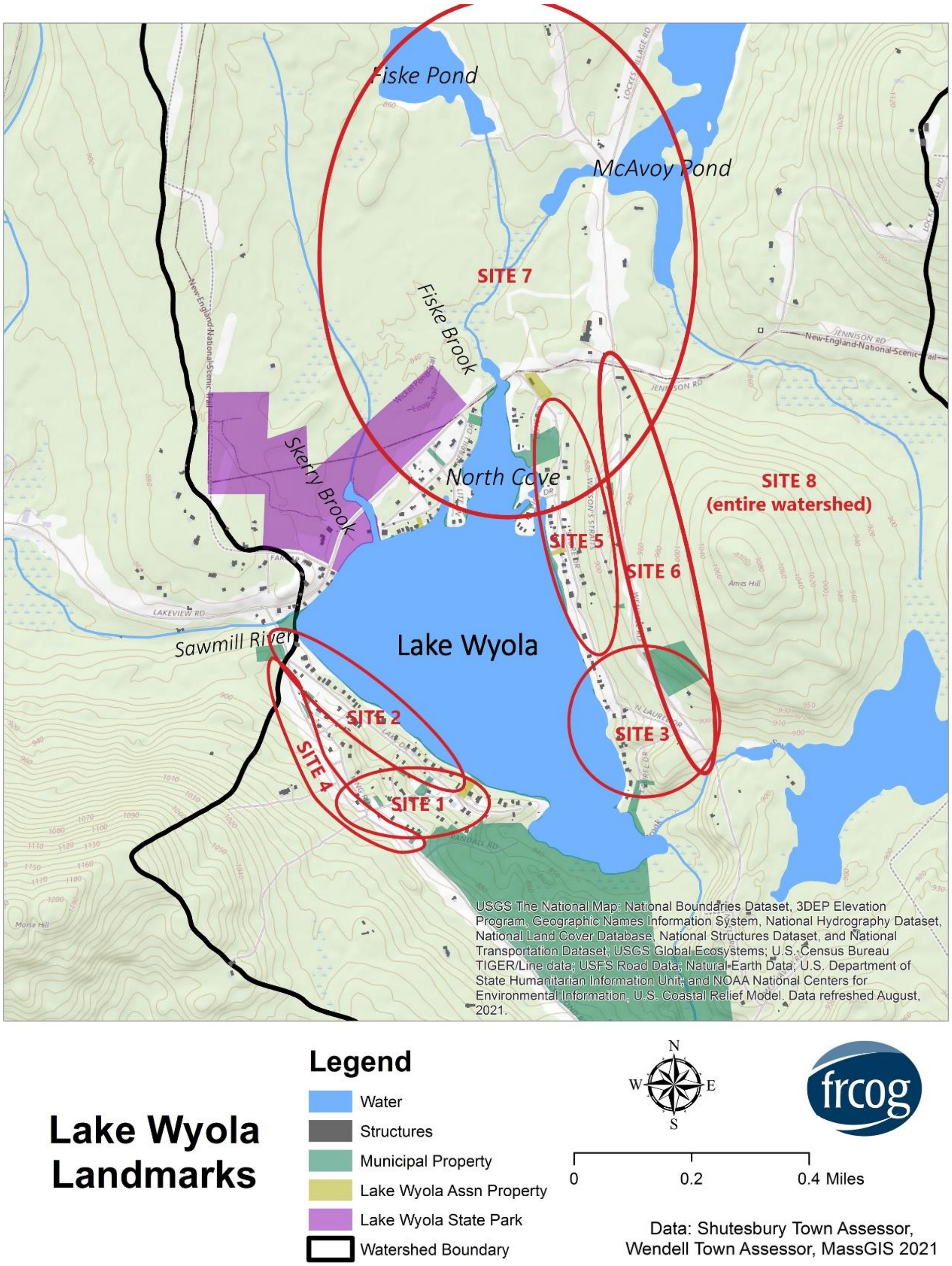

Figure C-1: Proposed BMP implementation sites (approximate)

Structural BMPs

General site characteristics and a general proposal for management measures are listed for each site shown (approximately) in Figure C-1. Recommendations for Sites 1 through 6 were developed by CEI (2022) and Campbell (2007). The recommendations of the 2007 Campbell report were brought forward in general terms because it is assumed that determination of specific BMPs would need to incorporate new climate and precipitation data, design standards, and any changes in hydrology in the 15 years since the report was written. Recommendations for Site 7 were developed by the FRCOG in consultation with CEI. A list of all of the potential BMPs and their pollutant load removal percentage rating is included in Table C-1 at the end of the Structural BMPs section.

In general, funding and constructing water quality improvement and protection projects, such as stormwater BMPs, will happen more readily on Town-owned properties because there are several grants programs Shutesbury can access and the Town has control over site selection, design, construction and maintenance. While some grants will fund these types of projects on private property as part of a public/private partnership, the grant funder will typically require an access agreement (stormwater easement) is negotiated with a willing landowner to ensure the structures can be inspected and maintained. If there are municipally owned parcels located in Sites 1 – 6, these could be considered for BMPs that filter and infiltrate runoff. Otherwise, the Town's options are limited to negotiating easements with private landowners, including LWA, to voluntarily agree to have stormwater BMPs located on their property that are maintained by the Town. The LWA could pursue funding for BMPs on their own property as well, but available funding is more limited for private organizations.

BMPs can be designed for future storm sizes. In 2020, the MassDEP Stormwater Advisory Committee presented recommendations for updating the MassDEP Wetlands Regulations and Stormwater Handbook that included replacing the use of the Rainfall Frequency Atlas (TP40) with NOAA Atlas 14 and calculating stormwater estimates based on 90% of the upper bound of the 90th percentile confidence interval (a method referred to as NOAA14+).[51] Some communities are practicing NOAA14++ as a method by basing stormwater estimates on the upper bound of the 90th percentile confidence interval. Using the New Salem, MA weather station, the NOAA14+ method estimates the following rainfall amounts for 24-hour storms:

100-year interval/24-hour storm:	10.8 inches
10-year interval/24-hour storm:	5.57 inches
2-year interval/24-hour storm:	3.47 inches

NOTE: Some of the sites described below include private property. Discussions with landowners and the identification of landowners willing to have a stormwater BMP on their property will be key to the success of a project that involves private property.

[51] MassDEP Stormwater Advisory Committee 2020

Site 1: Great Pines Drive, King Road, Birch Drive, Haskins Way, and Oak Knoll

Construct a series of water bars, new swales (ditches), and turnouts with sediment-trapping features along these roads to reduce the channelization, erosion and sedimentation from stormwater runoff. Redirect stormwater runoff to wooded areas as best as possible.

The 2007 Campbell report recommends 12-inch drainage cross culverts at the intersection of Great Pines Drive and King Road. Since the Campbell report is now 15 years old and updated precipitation data is available, the recommended size of these culverts (12-inch) should be reevaluated to ensure the structures would be climate resilient. It is likely that the cross culverts would need to have a larger diameter.

Continue to re-crown roads at this site to maintain a proper crown, defined as having a modified "A" cross-section crown with a ½ inch to ¾ inch per linear foot of road width.[52]

The portion of King Road where road maintenance has been discontinued due to perennial erosion could be considered as an area for a multi-BMP treatment train. The Lake Wyola Association owns the former road segment, but the surrounding parcels are privately owned, so the support and participation of the landowners would be needed for this approach.

Conveyances that drain stormwater directly into the lake should be retrofitted with pretreatment BMPs or "treatment trains" that filter out pollutants such as sediment and phosphorus. In cases where these outfalls come from underground pipes, those treatment trains would have to be upstream of the pipe inlet. The Conservation Commission reports that they do not currently know where all of the outfalls cited in the 2007 Campbell report are, so identification of those outfall locations would be a component of an H&H study.

Site 2: Lake Drive

Construct water bars and swales to better control stormwater runoff and erosion throughout the middle section of Lake Drive, where the road is steepest.

Identify willing landowners who are interested in working with the Town of Shutesbury and/or Lake Wyola Association for the placement of BMPs on private property.

Work within this site could also include the study of existing stormwater infrastructure on the LWA Beach to see if there are opportunities for improvement. The 2007 Campbell report recommends a plunge pool and leaching catch basin on the Lake Association beach property, near an existing detention basin.

Site 3: North and South Laurel Drive

Install water bars across driveways in close proximity to Lake Wyola to reduce direct contributions of stormwater runoff to the waterbody.

[52] Vermont gravel road standard for crowns: VTrans 2019

Remove sediment from existing turnouts along North and South Laurel Drive and install additional turnouts (as adjacent grades allow), particularly on the sections of road nearer the lake.

Site 4: Locks Pond Road

Install water bars or similar diversion structures at the intersections with nearby roads, such as Great Pines Drive, Stebbins Pond Road, Dove Lane, King Road, and Randall Road, to reduce concentrated flows down these roads and direct stormwater instead to wooded areas. Install turnouts at the end of water bars to enhance sediment capture. These sediment traps would ideally be rock-lined and flow into naturally vegetated roadside areas.

According to the 2007 Campbell report, the outlets of the culverts that convey water under Locks Pond Road lack armoring and should be considered for BMPs such as rock-lined splash pads or outlet sediment traps. Because many of these culverts convey water that eventually reaches the outfalls along the lake, the culvert outlets and downstream areas are ideal locations for BMPs that slow and infiltrate the flow, such as check dams, and pre-treatment BMPS, such as sand filters.

Site 5: Shore Road and Pine Drive

Install water bars in driveways along the west side of Shore Road to divert stormwater into a vegetated or rock-lined BMP, such as a rain garden or swale, and away from Shore Drive. For efficient and longer-term functioning, waterbars should connect to rock-lined or vegetated turnouts or rain gardens in private yards. Most driveways appeared to be in acceptable condition in 2022, although several could benefit from these low-cost retrofits.

Assess the condition and functioning of existing water bars in this area and design retrofits as needed.

Site 6: Wendell Road

Ensure through proper crowning and grading that road drainage sheet flows off into the woods with minimal channelization. Areas where channelization is occurring could be retrofitted with turnouts designed to capture sediment.

Table C-1: Potential BMPs for Sites 1 – 6

BMP Type	TP Loading Reduction Potential (%)	TSS Loading Reduction Potential (%)[53]
Bioretention basin	30 to 90%	90% with filter strip or equivalent pretreatment
Bioretention/water quality swale	20 to 90%	70% removal when provided with a pretreatment device

[53] Load removal estimates provided by the Massachusetts Clean Water Toolkit and UNH Stormwater Center

BMP Type	TP Loading Reduction Potential (%)	TSS Loading Reduction Potential (%)[53]
		such as a sediment forebay
Culvert	N/A	N/A
Deep sump catch basin	Insufficient data	25%
Leaching catch basin	Insufficient data	80%
Road regrading/crowning	N/A	N/A
Rock-lined splash pad	N/A	N/A
Outlet sediment trap	Insufficient data	25%
Check dam	N/A	N/A
Sediment forebay	Insufficient data	25%
Turnout	N/A	N/A
Waterbar	N/A	N/A

All Sites 1 thru 6

Complete a full engineering study, including any necessary hydraulic and hydrologic (H&H) modeling of anticipated future storm events using NOAA Atlas 14+ design storms to identify and correctly design and size BMPs for Sites 1 thru 6. Evaluate existing structural BMPs for whether they are functioning as designed or need retrofitting.

Encourage appropriately sized and aesthetically pleasing structural BMPs in private residential and public yards to control pollution at the source and reduce runoff:

- Install rain barrels to catch roof runoff
- Install pervious driveways
- Encourage water flow from house and driveway into vegetated areas
- Encourage installation of rain gardens, vegetated swales, and riparian buffers to provide storage, infiltration, and cleansing of stormwater
- Seed bare spots to reduce erosion
- Replace turf grass with native plants and shrubs
- Discourage waterfowl feeding
- Pick up dog waste

Site 7: Fiske Brook Watershed

With the goal of restoring the historical depth of and reducing the rate of sedimentation in Lake Wyola in mind, LWAC asked the FRCOG to consider Fiske Brook and the confluence of Fiske Brook with Lake Wyola as a focus area for nonpoint source pollution BMPs. The FRCOG consulted with CEI, who concluded that from a wetlands permitting perspective, it is explicitly not permissible to put stormwater BMPs in the wetland north of Lakeview

Road. It is possible that with the purchase of land and excavation, there could be an opportunity to create a sedimentation settling/storage BMP adjacent to the wetland north of Lakeview Road. A feasibility study for this kind of project would cost an estimated $15,000 to $20,000 and the installation of the BMP itself over $1 million, according to CEI's estimate. Currently, North Cove functions as a settling basin for the rest of the lake, so dredging North Cove and increasing its storage capacity would serve the same function as creating more sediment storage capacity upstream of North Cove.

An important approach to reducing sedimentation is to better understand and address the various sources of sediment in the Fiske Brook watershed. A comprehensive fluvial geomorphic study would help identify causes of channel instability and erosion, sedimentation, and habitat degradation. It would also assess road-stream crossings for whether these structures are properly sized and designed for their location in the stream. It could also identify projects that use Nature-Based Solutions (sustainable management and use of natural features) for the upland watershed area (entirety of Fiske Brook). These types of projects slow and spread the stormwater runoff and trap sediment, protect and restore water quality, enhance habitat, and provide flood resiliency benefits.

Site 8: General watershed

The entire Lake Wyola watershed could benefit from a Hydrologic and Hydraulic (H&H) study that estimates peak flow, floodwater elevations, flow velocities, and flow paths under current and projected future conditions under climate change and a sediment study that assess the quality and quantity of sediment loading to the lake. The results would inform the sizing and type of stormwater. Done in conjunction with a fluvial geomorphic assessment, an H&H study could project the risk of future storms on the manmade and beaver dams in the Fiske Brook watershed and the potential downstream impact of those storms.

Nonstructural BMPs

A recommendation to modify or develop stormwater regulations was not included in this plan because it is understood that the area directly surrounding Lake Wyola is mostly built out and because stormwater regulations would not apply to the predominantly private roads around the lake. Management measures that could be written into stormwater regulations can alternatively be described and recommended as residential BMPs for residences and dirt road BMPs for public and private road managers.

- As previously mentioned, background engineering studies are needed to better understand the area's hydrology and sediment movement. Prior to selecting and structural BMPs, this plan recommends an H&H study of the whole watershed, a sediment loading study, a study of existing BMPs, and a fluvial geomorphic study of Fiske Brook. Several of these studies could be combined for cost savings.

- The majority of roads in close proximity to Lake Wyola are private (LWA-owned or resident-owned), 1.5-lane gravel, or in many cases surfaced with a material with a high content of sand and fine-grained aggregate. Drainage infrastructure within close proximity to the pond is largely nonexistent, with stormwater mostly reaching the lake through pipes (with not all pipe outlet locations known) or a series of informally constructed swales. Erosion of roads has been identified as a potentially significant source of sediment contribution to Lake Wyola.

Complete a comprehensive road evaluation study to identify road segments that would benefit from installation of road surface material more resistant to stormwater erosion. Road retrofits would be expected to consist of stony material, or possibly pavement in some places. This project would likely include developing a road resurfacing specification and/or detail for use on existing sand and gravel roads, and could be used by both the Town and private entities who maintain private roads. Primary candidate roads include nearly all roads along the western side of the lake (Lake Drive, Great Pines Drive, Oak Knoll, Birch Drive, Haskins Way, King Road, and Stebbins ROW), as well as North and South Laurel Drive on the eastern side of the lake. Although road ownership is complicated in this area, applications for funding are often strengthened by having a number of cooperating stakeholders.

- Provide the most up-to-date best practices information on dirt road maintenance to road maintenance crews (public and private).

- Develop an Operation and Maintenance Plan (O&M Plan) for existing and proposed BMPs and road management on LWA roads to ensure the BMPs function as designed and to identify the responsible parties that have agreed to implement the O&M Plan. For example, water bars on private driveways can be an effective, inexpensive measure but also require regular inspection and frequent cleaning to protect against failure due to overtopping and sediment build-up. Other BMPs will also need regular inspection and maintenance to ensure proper functioning and longevity.

- Consider a beaver management policy or hire a consultant to create a comprehensive beaver management plan for the watershed that is grounded in Nature-Based Solutions. A beaver management plan could help the watershed community better manage flood resiliency and possibly water quality. Given the location of beaver in the Wendell portion of the watershed, the Town of Wendell should be consulted in this action.

- Continue street sweeping, catch basin cleaning, and reduced salt and sand application on applicable roads around the lake (Locks Pond Road and Lakeview Road). Evaluate these road management BMPs to see if potential improvements, such as increased frequency or improved technology, can be implemented to achieve higher pollutant load reductions. For example, if catch basins or culverts are filling more frequently than once or twice a year, the Highway Department could implement a policy to check and clean them more frequently, or if there are improved standards for salt and sand application, or street sweeping, implement the higher standards.

- Expand on the residential education conducted as part of the 2003 s.319 project by providing outreach materials about lake-friendly landscaping, including structural BMPs and practices that property owners can adopt to protect water quality, listed above under All Sites 1 – 6. Residential projects would be very helpful to showcase these practices and increase homeowner interest.

- Conduct educational site visits to State Park beach and residential properties with pre-existing or newly install BMPs.

- Continue Board of Health outreach to landowners on proper septic design, maintenance, and financial assistance opportunities for system owners looking to repair, replace, or upgrade failed septic systems.[54]

- Continue existing waterfowl (geese) control practices. Encourage residents and visitors not to feed waterfowl.

- Develop a water quality monitoring plan for Lake Wyola.

[54] https://www.mass.gov/guides/title-5septic-systems-financial-assistance-opportunities-for-system-owners

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

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

The WBP template includes Table D-1, which presents the funding needed to implement some of 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. Cost estimates for funding needed to implement the management measures have been estimated based on similar projects that FRCOG is familiar with; but these costs could likely increase as time passes. This table will be updated to include further detail once the described studies are completed.

When the Town of Shutesbury is listed as the Relevant Authority, this would include the Highway Department, Conservation Commission, Select Board, Board of Health, and LWAC, as appropriate. The purpose of the LWAC is to serve as a liaison between Town government, the Lake Wyola Association (Association), and the lake community as a whole. It aims to promote the preservation, maintenance, and enhancement of the lake as a natural and recreational resource. Its purview includes protection of water quality from septic systems and other sources of contamination, nuisance weed and sediment removal, erosion and runoff control, and dam safety. Regular water quality assessment and oversight of the dam are also the responsibility of the committee.

Table D-1: Summary of Funding Needed to Implement the Watershed Plan.

Management Measures	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Technical Assistance Needed	Funding Needed	Notes
Structural and Non-Structural BMPs (from Element C)						
Watershed Hydraulic & Hydrologic (H&H) Study	Not applicable	Not applicable	Towns of Shutesbury and Wendell, LWA	Engineering consultant	$30,000	Engineering studies, with the exception of the road surface study, could be combined into single study for cost savings.

Management Measures	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Technical Assistance Needed	Funding Needed	Notes
Sediment loading study	Not applicable	Not applicable	Towns of Shutesbury and Wendell, LWA	Engineering consultant	To be determined	Engineering studies, with the exception of the road surface study, could be combined into single study for cost savings.
Fiske Brook Fluvial Geomorphic Assessment	Not applicable	Not applicable	Towns of Shutesbury and Wendell, LWA	Fluvial geomorphic engineering consultant	$35,000	Engineering studies, with the exception of the road surface study, could be combined into single study for cost savings.
Evaluation of existing structural stormwater BMPs	Not applicable	Not applicable	Town of Shutesbury, LWA	Engineering consultant	To be determined	Engineering studies, with the exception of the road surface study, could be combined into single study for cost savings.
Engineering study of potential stormwater BMPs	Not applicable	Not applicable	Town of Shutesbury, LWA	Engineering consultant	To be determined	Engineering studies, with the exception of the road surface study, could be combined into single study for cost savings.
Road surface study	Not applicable	Not applicable	Town of Shutesbury, LWA	Road engineering consultant	To be determined	
Installation of new structural stormwater BMPs	To be determined	To be determined	Town of Shutesbury, LWA	Engineering consultant, Contractor	To be determined	Stormwater BMPs and costs for design and installation will be determined by future studies.
Lake Wyola Association road and BMP operation and maintenance (O&M) plan	To be determined	To be determined	LWA	Engineering consultant	To be determined	The O&M Plan for the stormwater and road maintenance BMPs would identify capital costs and O&M costs.
Beaver Management Plan	To be determined	To be determined	Town of Shutesbury	Engineering consultants	To be determined	
Shutesbury Highway Department best practices: street sweeping, catch basin cleaning, reduced salt application.	Potentially, if equipment is needed	To be determined	Town of Shutesbury	Engineering consultant	To be determined	An engineering consultant could develop an O&M plan for Town roads.
Waterfowl control practices when needed	Not applicable	Likely minimal	DCR,	None	To be determined	

Management Measures	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Technical Assistance Needed	Funding Needed	Notes
			Town of Shutesbury, LWA			
Information/Education (see Element E)						
Signage	\$3,000 – \$10,000	Not applicable	Town of Shutesbury, LWA	Consultant, FRCOG	\$3,000 – \$10,000	
Project updates (website and social media posts)	Not applicable	To be determined	Town of Shutesbury, LWA	None	Not applicable	
Educational materials and/or presentation for residents	\$1,500	To be determined	Town of Shutesbury, LWA	Consultant, FRCOG	\$1,500	
Public education site visits to demonstration projects	Not applicable	To be determined	Town of Shutesbury, LWA	Consultant, FRCOG	To be determined	
Road management best practices training to private and public road maintenance staff	Not applicable	To be determined	Town of Shutesbury, LWA	Consultant	To be determined	
Monitoring and Evaluation (see Element H/I)						
Sampling QAPP	Not applicable	Not applicable	Town of Shutesbury, LWA	\$6,000	\$6,000	Estimated cost; will vary widely depending on level of detail
Annual water quality sampling	Not applicable	Not applicable	Town of Shutesbury, LWA	\$10,000	\$10,000	Extent of sampling program TBD, this is placeholder estimate
BMP monitoring	Not applicable unless specific equipment was needed as recommended in the O&M Plan	To be determined. Estimates of annual costs would be	Town of Shutesbury, LWA, land owners and volunteers	Training of volunteers might be needed. Town staff might need training on BMPs for stormwater	\$2,500 for annual training and printing of outreach materials	Funding for the O&M Plan implementation could come from the Town's Chapter 90 Program funding and Lake Wyola Association dues

Management Measures	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Technical Assistance Needed	Funding Needed	Notes
		provided in the O&M Plan.		and road maintenance		
				Total Funding Needed	**To be determined**	

Potential Funding Sources:

- 604b Water Quality Management Planning Grant Program
- Section 319 Nonpoint Source Competitive Grant Program
- Municipal Vulnerability Preparedness (MVP) Action Grant Program (only the Town is eligible to apply)
- Long Island Sound Futures Fund (LISFF) through the National Fish and Wildlife Foundation (NFWF)
- Lake Wyola Association Environmental Fund
- Lake Wyola Association dues
- Town Ch. 90 funds
- Town Capital Funds
- Town Wetland Funds (i.e., filing fees to enforce Massachusetts Wetlands Protection Act)
- Town Community Preservation Act Funds
- Massachusetts Environmental Trust
- FEMA Hazard Mitigation Grant
- Volunteer time for public outreach and monitoring

Element E: Public Information and Education

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

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

Step 1: Goals and Objectives

1. Educate Town staff and residents about the health of Lake Wyola, including the potential sources of nonpoint source pollution and geomorphic impairments. Ensure that outreach is inclusive of residents that do not receive information from the Lake Wyola Association and includes renters.
2. Promote a comprehensive approach to ongoing stormwater management, including road BMPs and residential BMPs.
3. Incorporate water quality and stormwater management principles and practices into local school curriculum.

Step 2: Target Audience

1. Lake Wyola Association and Lake Wyola Advisory Committee
2. Lake Wyola-area residents
3. Town of Shutesbury staff, including the Highway Department
4. Shutesbury and Wendell Elementary School students

Step 3: Outreach Products and Distribution

1. Provide general information about nonpoint source pollution, sources, and mitigation in Franklin County via promotion of the Franklin County Healthy and Climate Resilient Rivers online StoryMap.
2. Work with the Lake Wyola Association and Lake Wyola Advisory Committee to develop educational outreach to lake residents about the risk of increased heavy precipitation events and stormwater runoff, and about structural and nonstructural residential BMPs to residents. Use the Lake Association's mailing list and Town newsletter.
3. Conduct one in-person and one virtual educational presentation at the Lake Wyola Association building.
4. Develop and post informational signs at completed BMP locations.
5. Conduct three tours of installed BMPs, open to the public.

6. Post this WBP and project information on the Town of Shutesbury website and on the Lake Wyola Association Facebook page.

7. When completed, provide the Town of Shutesbury Highway Department and Lake Wyola Association with the FRCOG's Dirt Roads Toolkit to inform good dirt road maintenance and stormwater management.

8. When the Toolkit is completed, attend FRCOG workshop to train Highway Departments on dirt road management BMPs and the use of the Dirt Roads Toolkit.

Step 4: Evaluate Information/Education Program

1. Track the number of educational materials distributed in hardcopy or by email.

2. Attach a counter to websites and other social media to evaluate visits and download of materials.

3. Track the number of attendees at educational presentations.

4. Track the number of site visits conducted and attendees.

5. Track the number of informational signs installed.

Elements F & G: Implementation Schedule and Measurable Milestones

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

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

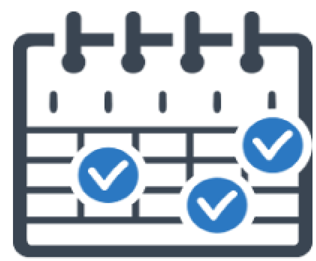

Table FG-1 provides a preliminary schedule for implementation of recommendations provided by this WBP. It is expected that the WBP will be re-evaluated and updated at least once every three (3) years, or as needed, based on ongoing monitoring results and other ongoing efforts.

Table FG-1: Implementation Schedule and Interim Measurable Milestones

Category	Action	Estimated Cost	Year(s)
Monitoring /Evaluation	Write Quality Assurance Project Plan (QAPP) for sampling and establish water quality monitoring program.	$6,000	2025
	Document estimated pollutant removals from existing BMPs in the watershed	TBD	Annual
	Recruit and train volunteers for monitoring program.	$2,500	Annual
	Perform annual water quality sampling and BMP monitoring per Element H&I monitoring guidance.	TBD	TBD

Category	Action	Estimated Cost	Year(s)
	Distribute water quality and BMP monitoring results through annual report card.	TBD	Annual
Structural BMPs	Obtain funding for and implement 3 to 9 BMPs in the four priority areas (average 1 to 3 BMPs per year)	TBD	2026 – 2028
Nonstructural BMPs	Watershed hydraulic and hydrologic engineering study (H&H)	$30,000	2024
	Sediment loading study	TBD	2024
	Fiske Brook geomorphology study	$35,000	2024
	Evaluation of existing structural stormwater BMPs	TBD	2024
	Engineering study of potential stormwater BMPs	TBD	2024
	Road surface study	TBD	2024
	Lake Wyola Association road and BMP Operation & Management (O&M) Plan	TBD	2025
	Ongoing Shutesbury road maintenance BMPs	TBD	2025 and ongoing
	Waterfowl control	TBD	As needed
Public Education and Outreach *(See Element E)*	Signage	$3,000 – $10,00	2026
	Project updates (website posts)	N/A	On-going
	Educational Materials and/or presentation	$1,500	Annual
	Site visits	TBD	2026
	Road management best practices training to private and public road maintenance staff	TBD	2025 – 2026
Adaptive Management and Plan Updates	Charge a group with establishing a working group comprised of stakeholders and other interested parties to implement recommendations and track progress. Meet at least twice per year.	Volunteer	2024
	Re-evaluate Watershed-Based Plan at least once every three (3) years and adjust goals and plan, as needed, based on monitoring results and other observations and experiences.	**TBD**	**Every 3 years from beginning of WBP implementation**
	Delist Lake Wyola from the 303(d) list.	--	**As soon as possible**

Elements H & I: Progress Evaluation Criteria and Monitoring

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

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

The water quality target concentrations are 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 measure the effectiveness of the proposed management measures (described in Element C) in protecting and improving the water quality of Lake Wyola.

Direct Measurements

Direct measurements are generally expected to be performed as described below. Prior to implementing a direct measurement program, a quality assurance project plan (QAPP) and/or Standard Operating Procedures (SOPs) will be established to flesh out details of the program and establish best practices for sample collection and analysis. Water quality monitoring may be performed through a volunteer training program to save on costs in accordance with established practices for MassDEP's environmental monitoring for volunteers; however, it is noted that an organization of volunteers would still require funding.

In-Lake Phosphorus and Water Quality Monitoring

Based on a literature review and communication with stakeholders summarized in Element A of this plan, Lake Wyola does not have a monitoring plan. The most recent known water quality sampling for TP was analyzed by the UMass Amherst Environmental Analysis Lab on behalf of the Lake Wyola Advisory Committee (2014). Regular in-lake phosphorus measurements will provide the most direct means of evaluating the effects of the measures in the plan than have been proposed specifically to reduce phosphorus loading. It is recommended that sampling be performed at the same locations as prior sampling (see Table A-3 in Element A). Additional stations could also be included at locations of interest.

Abiotic and Biotic Monitoring

Water quality monitoring for recreation and to assess the impacts of drawdown are additional goals of the community. If the Town were to move forward with a monitoring program, it may consider consulting the DEP about the creation of a monitoring program that serves multiple community goals and provides reliable data for the state to use in their 303(d) listing process.

It is recommended that water quality testing data be coordinated by a single stakeholder and reported to a single, publicly accessible location.

BMP, TSS, and Flow Monitoring

As feasible, the effectiveness of existing and proposed structural BMPs will be evaluated by routine inspection during and after storm events to measure amounts of sediment collected (i.e., sediment traps, catch basins, etc.). As feasible, TSS and discharge will also be periodically measured at the watershed's major outfalls to the lake in the Lake Drive neighborhood during notable storm events with a goal to capture up to four events per year. TSS and discharge measurements can later be converted to estimates of annual loading to the lake. Results from this monitoring effort will aid in better characterizing base loading to the lake.

Indirect Indicators of Load Reduction

Potential load reductions from non-structural BMPs, such as street sweeping and catch basin cleaning, can be estimated from indirect indicators, such as the number of miles of streets swept or the number of catch basins cleaned. As indicated by Element C, it is recommended that potential pollutant removal from these ongoing activities be estimated, particularly for TSS. Next, it is recommended that ongoing activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions with increased frequency or improved technology.

Additionally, since there is significant erosion of the largely sand-based Lake Wyola Association roads, it is recommended that road condition be tracked. The LWA pays for maintenance (grading and fill) of these roads annually, so these locations and costs can be tracked over time.

Project Specific Indicators

To be determined by the BMP engineering study described in Element C.

TMDL Criteria

Lake Wyola currently meets the TMDL criteria for TP established in the 2002 *Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes*.

Adaptive Management

As discussed by Section 3 of Element B, the baseline monitoring program will be used to establish a long-term (i.e., 10 year) phosphorus load reduction goal (or other parameter(s) depending on results). Long-term goals will be re-evaluated at least once every three years and adaptively adjusted based on additional monitoring results and other indirect indicators. If monitoring results and indirect indicators do not show improvement to the total phosphorus concentrations measured within Lake Wyola, the management measures and loading reduction analysis (Elements A through D) will be revisited and modified accordingly.

The working group charged with stewarding the Lake Wyola WBP will implement recommendations from this WBP and track overall progress. The working group will continue to prepare an annual "snapshot" progress report for dissemination to the public. The progress report will re-iterate goals of this WBP, will summarize indirect indicators, project-specific indicators (once they have been established), and direct measurements as they relate to established water quality goals, and will provide an indication of ongoing outreach efforts and overall next steps.

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Water Quality Assessment Reports

"*Connecticut River Watershed 2003 Water Quality Assessment Report*"

TMDL

"*Total Maximum Daily Loads of Phosphorus for Selected Connecticut Basin Lakes* "

Appendices

Appendix A – Pollutant Load Export Rates (PLERs)

Land Use & Cover[1]	PLERs lb/acre/year)		
	TP)	TSS)	TN)
AGRICULTURE, HSG A	0.45	7.14	2.6
AGRICULTURE, HSG B	0.45	29.4	2.6
AGRICULTURE, HSG C	0.45	59.8	2.6
AGRICULTURE, HSG D	0.45	91	2.6
AGRICULTURE, IMPERVIOUS	1.52	650	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	15.1
FOREST, HSG A	0.12	7.14	0.5
FOREST, HSG B	0.12	29.4	0.5
FOREST, HSG C	0.12	59.8	0.5
FOREST, HSG D	0.12	91	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
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	1.34	1,480	10.5
INDUSTRIAL, HSG A	0.03	7.14	0.3
INDUSTRIAL, HSG B	0.12	29.4	1.2

Land Use & Cover[1]	PLERs lb/acre/year)		
	TP)	TSS)	TN)
INDUSTRIAL, HSG C	0.21	59.8	2.4
INDUSTRIAL, HSG D	0.37	91	3.7
INDUSTRIAL, IMPERVIOUS	1.78	377	15.1
LOW DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.3
LOW DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.2
LOW DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.4
LOW DENSITY RESIDENTIAL, HSG D	0.37	91	3.7
LOW DENSITY RESIDENTIAL, IMPERVIOUS	1.52	439	14.1
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			

Appendix B – CEI *Stormwater Improvement Opportunities* Technical Memorandum

Technical Memorandum

To: Kimberly Noake McPhee, Franklin Regional Council of Governments (FRCOG)
Tamsin Flanders, FRCOG

From: Nick Cristofori, P.E., Comprehensive Environmental Inc. (CEI)
Bob Hartzel, CEI

Date: May 10, 2022

Subject: Stormwater Improvement Opportunities – Lake Wyola Watershed (Shutesbury, MA)

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1. INTRODUCTION

1.1 Project Overview

Lake Wyola is a 124-acre lake located in Shutesbury, MA. Lake Wyola is listed in the Massachusetts 2018/2020 Integrated List of Waters for a Total Phosphorus impairment. A related Total Maximum Daily Load (TMDL) for this Lake was completed and approved by the USEPA in April 2002. Stormwater pollution is a direct source of phosphorus to Lake Wyola. In response, CEI is currently under contract to assist the Franklin Regional Council of Governments (FRCOG) with identifying potential stormwater improvement projects for funding through the Massachusetts 319 Nonpoint Source Competitive Grant Program (319 Program). Stormwater improvement projects are anticipated to consist of structural Best Management Practices (BMPs) such as check dams, rain gardens, water quality swales, etc., which are designed to remove pollutants such as phosphorous, nitrogen, sediment, and bacteria from stormwater prior to discharging into waterbodies. This memorandum summarizes our findings and recommended next steps.

1.2 Field Inspections

In order to better understand the watershed and potential BMP implementation opportunities, Nick Cristofori from CEI conducted field inspections at locations within the Lake Wyola watershed on April 14, 2022. CEI was joined by representatives from the Lake Wyola Association. The purpose of the field inspections was to observe the watershed in general, existing conditions of areas immediately surrounding the lake, and opportunities to provide improved stormwater treatment and/or erosion control. General conditions were documented, such as local topography, available space for retrofits, estimated contributing watershed area, etc. using a combination of field notes, sketches, and photographs. Existing conditions as observed are documented in the following sections.

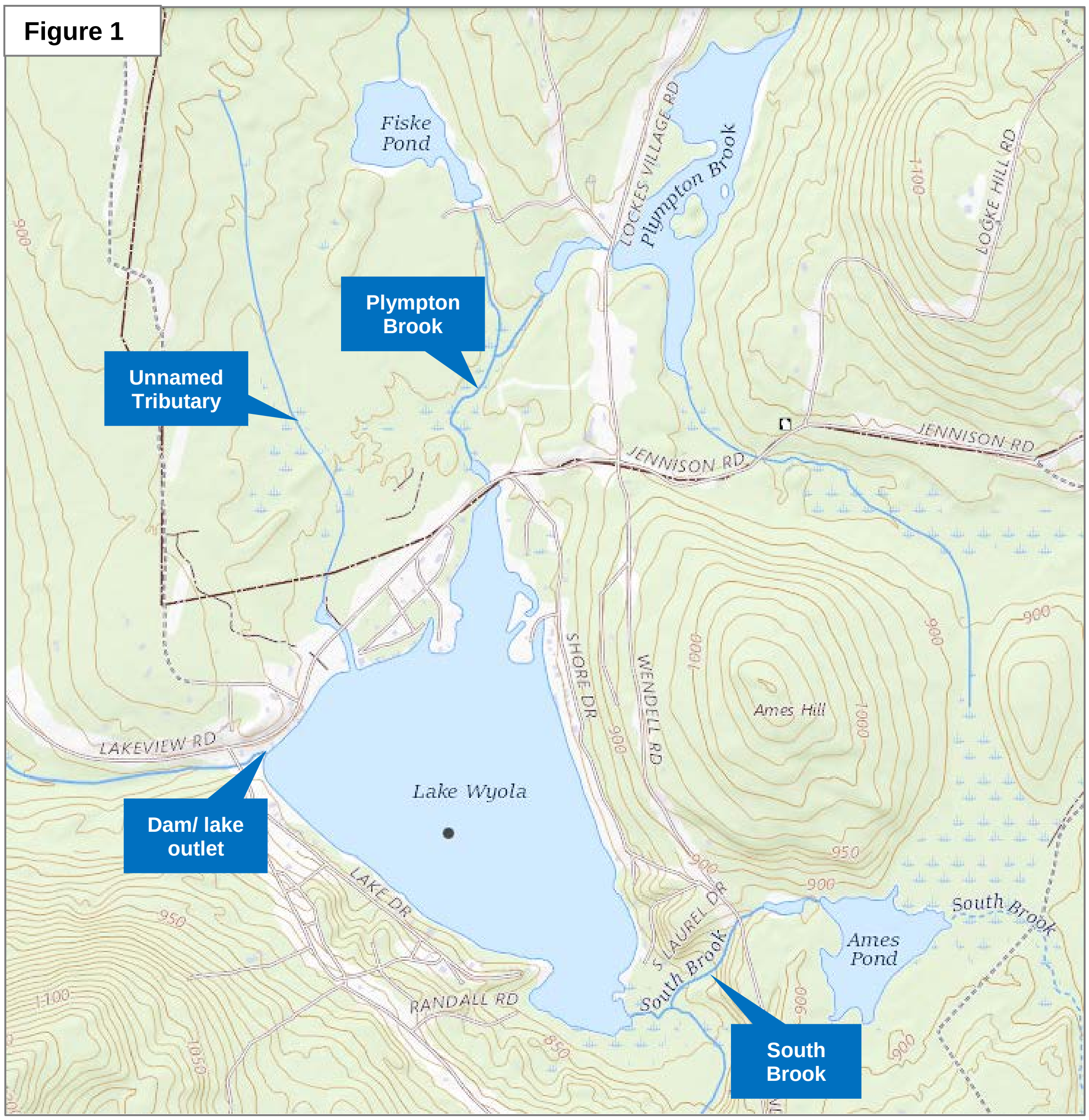
2. EXISTING CONDITIONS

2.1 General

With the exception of the area immediately surrounding the lake, the watershed is heavily forested (61%) with lesser amounts of low density residential (29%). Remaining land cover consists mostly of water (4%) and high density residential (2%). Lake Wyola is fed primarily by Plympton Brook (known locally as Fiske Brook), the watershed for which includes Fiske Pond and its associated unnamed tributary to the north of Lake Wyola (see Figure 1). Plympton Brook flows under Lakeview Road into a cove at the north end of Lake Wyola that has lost depth in during recent years due to (1) the natural process of sediment deposition in lakes from tributary streams and (2) the reported failure of a beaver dam several years ago which released a large volume of sediment that had accumulated behind the dam. Stakeholders indicated that the north cove used to be as deep as 6 feet, but is now has a depth closer to two feet.

The second largest tributary is South Brook, which includes Ames Pond and flows into Lake Wyola's southern tip from the southeast. A smaller, unnamed tributary flows from the northwest and joins Lake Wyola just east of the state park beach. All three tributaries to Lake Wyola drain land that is almost completely forested, with very small quantities of low-density residential area. Most residential areas in the watershed are around the perimeter of Lake Wyola. The lake's water level is controlled by a manually-activated dam capable of drawing down the lake by as much as eight feet. Lake Wyola State Park, including a public beach along the northwest shore of Lake Wyola, is located along Lakeview Road. Several stormwater and erosion control improvements were constructed in this area with funding from a 319 grant in 2007 and were observed to be in good condition and functioning properly.

Figure 1



Impervious roadways within the watershed are minimal, generally limited to two-lane town-owned feeder roads to the lightly developed Lake Wyola area. The majority of roadways in close proximity to Lake Wyola are 1.5-lane gravel, or in many cases surfaced with a material with a high content of sand and fine-grained aggregate. Drainage infrastructure within close proximity to the pond is largely non-existent, with stormwater mostly reaching the lake through a series of informally constructed swales.

2.2 Lake Wyola, West Side

The western side of Lake Wyola has the largest number of houses and roadways in close proximity to the lake. With the exception of Town-owned Locks Pond Road, remaining roadways are privately owned and constructed from a mix of gravel and sand. This area is heavily developed and relatively steeply sloped. Existing roadways are typically located at localized low points and thus serve to channelize stormwater down the slopes and towards the lake. Correspondingly, extensive areas of erosion were observed along nearly all roadways on this side of the lake, including Lake Drive, Great Pines Drive, King Road, and others. In particular, Great Pines Drive runs parallel to the slope and was observed to be highly channelized and is likely the primary source of sediment running from high points down towards the lake in this area. Drainage infrastructure such as catch basins, pipes, and formalized swales are largely absent from this area with few exceptions. Several small streams (shown as intermittent streams on USGS mapping) were also observed in this area.

Based on conversations with stakeholders and field observations, local residents have attempted to mitigate some erosion problems by creating drainage channels across and adjacent to several roadways using materials such as sand and gravel. Channels typically flow off of the roadways and into the woods where feasible. Some wooded areas appear to be successfully trapping sediment before it reaches the lake, while other areas appear to be simply moving the sediment further down the hill where it likely eventually enters the lake.

Sedimentation and drainage problems in this area appear to be two-fold:

1. Roadways appear to be surfaced in many locations with a layer of loose sand that is highly erodible and readily transported further downgradient during rain events. Some areas with larger stone were observed, and these areas did not appear to be exhibiting the same degree of erosion.
2. Roadways are typically located at topographic low points. This makes it difficult to convey stormwater to another location (e.g., nearby forest) for pollutant attenuation in many areas, as the roadway is located lower than the surrounding vegetated areas that could allow for stormwater treatment.

2.3 Lake Wyola, East Side

The eastern side of Lake Wyola is somewhat less developed than the western side and has fewer roads, most of which run perpendicular to the slope. Some erosion was observed, particularly in the vicinity of the intersection of Shore Drive and Cove Road and also along both North and South Laurel Drive. Much of Shore Drive flows to a swale along the eastern side of the road and away from the lake. However, some areas appear to either sheet flow or slightly channelize and flow towards the lake. Stormwater from Wendell Road appears to be mostly contained and channeled away from the lake. The surfacing material of these roads appears to have a higher content of gravel than along the east side, or in the case of Wendell Road, was much more compacted. Drainage infrastructure such as catch basins, pipes, and formalized swales are largely absent from this area with few exceptions.

Stakeholders indicated that much of the more recent work conducted in the watershed has been completed on this side of the lake. For instance, the intersection of Shore Drive and Cove Road was regraded to construct swales along both sides of the roadway to help collect stormwater runoff and sediment loads before reaching the lake. Additionally, North and South Laurel Drive were observed to have some areas regraded to channel stormwater discharges into the woods rather than down the roadways. However, stormwater from this area still appears to flow down the road towards the lake.

The most notable source of sedimentation to the lake on this side is along North Laurel Drive and South Laurel Drive. Similar to Great Pines Drive on the west side, these roadways generally run parallel to the slope and appears to have a larger quantity of sand rather than more compact gravel. The sand is more easily mobilized during rain events where it flows down the roadways and eventually towards the lake. Particularly towards the bottom and closer to the lake, roadways are located at the localized low point, making it more difficult to convey stormwater to adjacent vegetated areas for pollutant attenuation.

2.4 Fiske Pond and Plympton Brook

CEI observed the outlet from Fiske Pond, which flows into Plympton Brook prior to its confluence with Lake Wyola. An earthen dam was observed along the southernmost edge of the dam, which appears to impound the Fiske Pond to a depth of five to ten feet. Some seepage was observed along the toe of slope which flows into an adjacent forested wetland area. The outlet pipe appears to be located at the top of an approximate 4-foot-high beaver dam (see Figure 2) and is equipped with a screen to discourage blockage from debris or beaver activity. The receiving streambed was observed to be stony and free of sediment.

3. RECOMMENDATIONS

It is recommended that the following two project opportunities be combined under a 604b and/or s319 grant:

1. Improve Stormwater Conveyances

Complete a comprehensive roadway evaluation to determine specific locations for installation or retrofitting of swales, water bars, and leak-off areas to better stabilize roadways and adjacent areas. Areas located in close proximity to roads that could potentially receive additional stormwater runoff from stormwater conveyances should also be identified. Several small municipally-owned parcels appear to be located directly adjacent to, or nearby, some areas with erosion and thus these parcels may potentially be utilized for watershed improvements. The following sites are identified as having potential stormwater retrofit opportunities, in order of recommendation:

Site 1: Great Pines Drive, King Road, Birch Drive, Haskins Way, and Oak Knoll

- Construct a series of water bars, new swales, and leak-off sediment traps along these roadways to reduce the heavy stormwater channelizing and sediment erosion of these areas. Redirect stormwater runoff to wooded areas as best as possible and construct leak-offs to capture sediment. Several municipally-owned parcels appear to be present along Great Pines Drive and could be used to construct leak-offs. Additional coordination with the Town of Shutesbury is recommended.

Site 2: Lake Drive

- Construct water bars and swales along the approximate center one-third of Lake Drive where the roadway is steepest to better control stormwater runoff and erosion.
- Install larger diameter stone along the existing privately-owned swale in this area, and convert the existing small yard drain adjacent to Lake Drive to a deep sump catch basin for additional sediment storage.

Site 3: North and South Laurel Drive

- Remove sediment from existing leak-off areas along North and South Laurel Drive.
- Install additional leak-off areas, particularly towards the bottom slope of both roadways as adjacent grades allow.
- Install water bars across driveways in close proximity to the lake to reduce direct contributions to the waterbody.

Site 4: Locks Pond Road

- Install water bars or similar diversion structures at the intersections with nearby roads, such as Great Pines Drive, Stebbins Pond Road, Dove Lane, King Road, and Randall Road to reduce concentrated flows down these roadways and instead direct stormwater to wooded areas.
- Install leak-off sediment traps at the end of water bars to enhance sediment capture.

Site 5: Shore Road and Pine Drive

- Install water bars along the tops of driveways along the west side of the roadway, where stormwater concentrates and flows down to the lake. Most driveways appeared in acceptable condition, although several could benefit from these low-cost retrofits.

Site 6: Wendell Road

- Ensure that roadway drainage sheet flows off into the woods with minimal channelization. Areas where channelization is occurring could be retrofitted with leak-off areas designed to capture sediment before flowing further towards the lake.

2. Improve Roadway Erosion Resiliency

Complete a comprehensive roadway evaluation to determine roadway stretches that would benefit from installation of road surface material more resistant to stormwater erosion. Roadway retrofits are expected to consist of stony material, or possibly in some places, pavement. This project would likely include developing a roadway resurfacing specification and/or detail for use on existing sand and gravel roadways, and could be used by both the Town and private landowners who maintain private roads. Primary candidate roadways include nearly all roadways along the western side of the lake (Lake Drive, Great Pines Drive, Oak Knoll, Birch Drive, Haskins Way, King Road, and Stebbins ROW), as well as North and South Laurel Drive on the eastern side of the lake.

Appendix C – FRCOG Nonpoint Source Field Assessment of the Lake Wyola Watershed, 1/28/22

Nonpoint Source Field Assessment of the Lake Wyola Watershed

FID	Latitude	Longitude	Altitude	CreationDa	Creator	Waypoint_I	Parcel_ID	Address	Public Y/N	Description	BMP potential
1	42.49819469	-72.43157144	249.951889	2022-01-28	rclary	1		Lake Drive	N	Lowpoint of Lake Drive, called a "septic diversion", water coming from patch of woods	Yes
2	0	0	0	2022-01-28	rclary	2		Lake Drive	N	Work done in 2021: crowned Great Pines Road, water bar across Lake Drive at intersection of Great Pines, detention basin on Association beach	Yes
3	42.49765045	-72.43217527	264.5986176	2022-01-28	rclary	3		Great Pines Road	N	Water coming down road being diverted into woods	Yes
4	42.49752786	-72.43260325	265.224411	2022-01-28	rclary	4		Great Pines Road	N	Water coming off of property being seperately diverted to Birch and Haskins	Yes
5	0	0	0	2022-01-28	rclary	5		King Road	N	Work done in 2021: big berm added to divert water into woods; crosses King Road.	Yes
6	42.49692244	-72.43343742	284.3698578	2022-01-28	rclary	6		Locks Pond Road	Y	Culvert	Yes
7	42.49701372	-72.4334401	275.5426483	2022-01-28	rclary	7		Locks Pond Road	Y	Culvert (goes with Waypoint 8 I believe)	Yes
8	42.49769844	-72.43437904	297.493515	2022-01-28	rclary	8		Locks Pond Road	Y	Culvert (goes with Waypoint 7 I believe)	Yes
9	42.4978043	-72.4345792	271.6710663	2022-01-28	rclary	9		Locks Pond Road	Y	Culvert - water flowing at this time	Yes
10	42.49936954	-72.435523	267.646286	2022-01-28	rclary	10		Locks Pond Road	Y	Culvert	Yes
11	42.50031158	-72.43650301	270.9282894	2022-01-28	rclary	11		Locks Pond Road	Y	Culvert - water flowing at this time; more erosion here	Yes
12	42.50183797	-72.43680183	253.0534165	2022-01-28	rclary	12		Locks Pond Road	Y	Dam	
13	42.50041321	-72.43570489	260.311285	2022-01-28	rclary	13		Lake Drive	N	Stormwater drainage point; erosion around pipe	Yes
14	42.50005153	-72.43487583	265.3724422	2022-01-28	rclary	14		Lake Drive	N	Can't see it, but think there's a pipe here	
15	42.49911619	-72.43311396	260.5666351	2022-01-28	rclary	15		Lake Drive	N	Culverted drainage flowing; result of flow from 3 streams	Yes
16	42.50794058	-72.42930765	262.0255184	2022-01-28	rclary	16		Wendell Road	Y	Fiske Brook and North Cove -- sites of heavy sedimentation and potential site of settling basin or other BMPs	Yes
17	42.50647127	-72.42742122	257.3621883	2022-01-28	rclary	17		Shore Drive	N	Culvert?	
18	42.50601857	-72.4275244	282.8096371	2022-01-28	rclary	18		Shore Drive	N	Culvert	Yes
19	42.50516835	-72.42757377	270.1644955	2022-01-28	rclary	19		Pine Drive	N	Water washed out road at this location. Culvert and armored ditch on both sides constructed in 2021; takes a high ratio of Shore Drive water becase people closed off other culverts	Yes
20	42.50454846	-72.42742851	280.7564754	2022-01-28	rclary	20		Shore Drive	N	Culvert; takes a high ratio of Shore Drive water becase people closed off other culverts	Yes
21	0	0	0	2022-01-28	rclary	21		North and South La	N	Water runs down these roads of Wendell Road; three water bars on S Laurel	Yes
22	42.49870544	-72.42455478	250.8831635	2022-01-28	rclary	22	A-23 (maybe)	21 South Laurel Ro	N	Water sheds down driveway; owners often asking for assistance; may have installed a silt fence	Yes
23	42.49969392	-72.4245526	270.8955536	2022-01-28	rclary	23		North Laurel Road	N	Erosion evident along Road	Yes
24	42.49976617	-72.42546489	274.1310272	2022-01-28	rclary	24		North Laurel Road	N	Culvert, rock swale at bottom of hill on North Laurel	
25	42.50497032	-72.43226261	243.6922665	2022-01-28	rclary	25		Merril and Beechwo	N	Road adjacent to wetland often needs additional fill	Yes
0	0	0	0	2022-01-28	rclary	26		Wendell Road	Y	Roadside ditch eroding and some slumping of road	Yes