SHAWS POND

WATERSHED-BASED MANAGEMENT PLAN

PREPARED BY FB ENVIRONMENTAL ASSOCIATES

in partnership with the Friends of Shaws Pond
and the New Durham Water Quality Committee

August 2025

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Funding for this project was provided by the Town of New Durham. NHDES issued guidance pursuant to Executive Order 14154 (90 FR 8353) and Executive Order 14151 (90 FR 8339) to exclude certain language from this and all watershed plans to maintain eligibility for federal funding.

Cover photo: Sunset with smoke from Canadian wildfires over Shaws Pond by Maureen Knepp

ACKNOWLEDGEMENTS

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SPECIAL THANKS

UNH Lakes Lay Monitoring Program
Pat Grant, Water Quality Monitoring Volunteer
Casey Buell, Water Quality Monitoring Volunteer

For questions, comments, or additional information related to the Shaws Pond Watershed-Based Management Plan, please contact the New Durham Water Quality Committee at ndassistant@newdurhamnh.gov or (603)859-2091.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACRONYM	DEFINITION
AC	Assimilative Capacity
AIPC	Aquatic Invasive Plant Control, Prevention and Research Grants
ACEP	Agricultural Conservation Easement Program
ALI	Aquatic Life Integrity
ARM	Aquatic Resource Mitigation Fund
BMP	Best Management Practice
CAGR	Compound Annual Growth Rate
CCCD	Carroll County Conservation District
Chl-a	Chlorophyll-a
CNMP	Comprehensive Nutrient Management Plan
CSP	Conservation Stewardship Program
CUM	Cubic Meters
CWA	Clean Water Act
CWP	Center for Watershed Protection
CWSRF	Clean Water State Revolving Fund
DO	Dissolved Oxygen
DPW	Department of Public Works
EMD	Environmental Monitoring Database
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ESRI	Environmental Systems Research Institute
FBE	FB Environmental Associates
ft	Feet
ha	Hectare
HAB	Harmful Algal Bloom
ILFP	In-Lieu Fee Program
kg	Kilogram
LCHIP	Land and Community Heritage Investment Program
LID	Low Impact Development
LLMP	Lakes Lay Monitoring Program
LLRM	Lake Loading Response Model
LRCT	Lakes Region Conservation Trust
LRPC	Lakes Region Planning Commission
LWA	Lake Winnipesaukee Alliance
LWCF	Land and Water Conservation Fund
m	Meter
NAIP	National Agriculture Imagery Program
NAWCA	North American Wetlands Conservation Act
NERFG	New England Forest and River Grant
NCEI	National Centers for Environmental Information
NFWF	National Fish and Wildlife Foundation
NH GRANIT	New Hampshire Geographically Referenced Analysis and Information Transfer System
NHACC	New Hampshire Association of Conservation Commissions

ACRONYM	DEFINITION
NHD	National Hydrography Dataset
NHDES	New Hampshire Department of Environmental Services
NHFG	New Hampshire Fish and Game Department
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source Pollution
NRCS	Natural Resources Conservation Service
NRI	Natural Resources Inventory
NWI	National Wetlands Inventory
PCR	Primary Contact Recreation
PCS	Potential Contamination Source
PFAS	Per- and polyfluoroalkyl substances
ppb, ppm	parts per billion, parts per million
RCCP	Regional Conservation Partnership Program
RCRA	Resource Conservation and Recovery Act
ROW	Right-of-Way
SCC	State Conservation Committee
SCCD	Strafford County Conservation District
SDT	Secchi Disk Transparency
TP	Total Phosphorus
UNH	University of New Hampshire
USLE	Universal Soil Loss Equation
WBMP	Watershed-Based Management Plan
WQC	Water Quality Committee (of New Durham)
YR	Year

DEFINITIONS

Adaptive management approach recognizes that the entire watershed cannot be restored with a single restoration action or within a short time frame. The approach provides an iterative process to evaluate restoration successes and challenges to inform the next set of restoration actions.

Anoxia is a condition of low dissolved oxygen.

Assimilative Capacity is a lake's capacity to receive and process nutrients (phosphorus) without impairing water quality or harming aquatic life.

Best Management Practices (BMPs) are conservation practices designed to minimize discharge of nonpoint source pollution from developed land to lakes and streams. Management plans should include both non-structural (non-engineered) and structural (engineered) best management practices for existing and new development to ensure long-term restoration success.

Build-out analysis combines projected population estimates, current zoning restrictions, and a host of additional development constraints (conservation lands, steep slope and wetland regulations, existing buildings, soils with low development suitability, and unbuildable parcels) to determine the extent of buildable areas in the watershed.

Chlorophyll-a (Chl-a) is a measurement of the green pigment found in all plants, including microscopic plants such as algae. Measured in parts per billion or ppb, it is used as an estimate of algal biomass; the higher the Chl-a value, the higher the amount of algae in the lake.

Clean Water Act (CWA) requires states to establish water quality standards and conduct assessments to ensure that surface waters are clean enough to support human and ecological needs.

Cyanobacteria are photosynthetic bacteria that can grow prolifically as blooms when enough nutrients are available. Some cyanobacteria can fix nitrogen and/or produce microcystin, which is highly toxic to humans and other life forms.

Dissolved Oxygen (DO) is a measure of the amount of oxygen dissolved in water. Low oxygen can directly kill or stress organisms and stimulate release of phosphorus from bottom sediments.

Epilimnion is the top layer of lake water directly affected by seasonal air temperature and wind. This layer is well-oxygenated by wind and wave action.

Eutrophication is the process by which lakes become more productive over time (oligotrophic to mesotrophic to eutrophic). Lakes naturally become more productive or "age" over thousands of years. In recent geologic time, however, humans have enhanced the rate of enrichment and lake productivity, speeding up this natural process to tens or hundreds of years.

Fall turnover is the process of complete lake mixing when cooling surface waters become denser and sink, especially during high winds, forcing warmer, less-dense water to the surface. This process is critical for the natural exchange of oxygen and nutrients between surface and bottom layers in the lake.

Flushing rate (also called retention time) is the amount of time water spends in a waterbody. It is calculated by dividing the flow in or out by the volume of the waterbody.

Full build-out refers to the time and circumstances in which, based on a set of restrictions (e.g., environmental constraints and current zoning), no more building growth can occur, or the point at which lots have been subdivided to the minimum size allowed.

Hypolimnion is the bottom-most layer of the lake that experiences periods of low oxygen during stratification and is devoid of sunlight for photosynthesis.

Impervious surfaces or cover refer to any surface that will not allow water to soak into the ground. Examples include paved roads, driveways, parking lots, and roofs.

Internal Phosphorus Loading is the process whereby phosphorus bound to lake bottom sediments is released back into the water column during periods of anoxia. The phosphorus can be used as fuel for plant and algae growth, creating a positive feedback to eutrophication.

Low Impact Development (LID) is an alternative approach to conventional site planning, design, and development that reduces the impacts of stormwater by working with natural hydrology and minimizing land disturbance by treating stormwater close to the source, and preserving natural drainage systems and open space, among other techniques.

Nonpoint Source (NPS) Pollution comes from diffuse sources throughout a watershed, such as stormwater runoff, seepage from septic systems, and gravel road erosion. One of the major constituents of NPS pollution is sediment, which contains a mixture of nutrients (like phosphorus) and inorganic and organic material that stimulate plant and algae growth.

Non-structural BMPs, which do not require extensive engineering or construction efforts, can help reduce stormwater runoff and associated pollutants through operational actions, such as land use planning strategies, municipal maintenance practices, and targeted education and training.

Oligotrophic lakes are less productive or have fewer nutrients (i.e., low levels of phosphorus and chlorophyll-a), deep Secchi Disk Transparency readings (8.0 m or greater), and high dissolved oxygen levels throughout the water column. In contrast, **eutrophic** lakes have more nutrients and are therefore more productive and exhibit algal blooms more frequently than oligotrophic lakes. **Mesotrophic** lakes fall in-between with an intermediate level of productivity.

pH is the standard measure of the acidity or alkalinity of a solution on a scale of 0 (acidic) to 14 (basic).

Riparian refers to the areas found along the banks of a lake, river, or stream. Naturally vegetated riparian areas form important wildlife habitat. Not only are these areas ecologically diverse, but they are also critical to protecting water quality by preventing erosion and filtering polluted stormwater runoff.

Secchi Disk Transparency (SDT) is a vertical measure of the transparency of water (ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Transparency is an indirect measure of algal productivity and is measured in meters (m).

Structural BMPs, or engineered Best Management Practices, are often at the forefront of most watershed restoration projects and help reduce stormwater runoff and associated pollutants.

Thermal stratification is the process whereby warming surface temperatures in summer create a temperature and density differential that separates the water column into distinct, non-mixing layers.

Thermocline or **metalimnion** is the markedly cooler, dynamic middle layer of rapidly changing water temperature. The top of this layer is distinguished by at least a degree Celsius drop per meter of depth.

Total Phosphorus (TP) is one of the major nutrients needed for plant growth. It is generally present in small amounts (measured in parts per billion (ppb)) and limits plant growth in lakes. In general, as the amount of TP increases, the number of algae also increases.

Trophic State is the degree of eutrophication of a lake and is designated as oligotrophic, mesotrophic, or eutrophic.

EXECUTIVE SUMMARY

With a 1,125-acre watershed, Shaws Pond is a 70-acre waterbody located within the economically vital Lakes Region of central New Hampshire. Shaws Pond resides completely within the Town of New Durham, while its watershed extends into New Durham, Wolfeboro, and Brookfield. Shaws Pond is fed by a handful of tributaries, some of which flow intermittently. From the small dam on the southwestern side, water from Shaws Pond outlet flows down Beaver Brook and into Wolfeboro Bay of Lake Winnipesaukee.

The Problem

Shaws Pond has experienced generally excellent water quality in the past but has recently seen a rapid degradation in water quality. Shaws Pond is not currently assessed as impaired according to the New Hampshire Department of Environmental Services (NHDES) 303(d) impaired surface waterbodies list. NHDES Lake Trophic Survey Reports (1984, 1999) classify the lake as mesotrophic with depleted dissolved oxygen and aquatic plant abundance. There has also been regular monitoring through a collaboration between the New Durham Water Quality Committee (WQC) and the University of New Hampshire Lakes Lay Monitoring Program (UNH LLMP) since 2017, producing six reports. The 2023 report showed higher chlorophyll-a levels than previous years and assessed the lake as mesotrophic with the risk of becoming eutrophic if chlorophyll-a levels continue to rise. A cyanobacteria bloom in September of 2024 triggered a Cyanobacteria Warning that lasted for 6 days. Cyanobacteria blooms largely occur despite low to moderate nutrient levels in the pond. The blooms caution that anthropogenic inputs to Shaws Pond, such as impacts from stormwater runoff or shoreline erosion from development and increased wave action, can affect the health of the pond, especially as large precipitation events become more frequent and the ice-free period on lakes become longer.

Cyanobacteria blooms are typically spurred by a combination of warming waters and excessive nutrients, in particular phosphorus, to surface waters. Sources of phosphorus in the watershed impacting the pond's water quality include stormwater runoff from developed areas largely from impervious cover, shoreline erosion, erosion from construction activities or other disturbed ground particularly along roads, excessive fertilizer application, failed or improperly functioning septic systems, unmitigated agricultural activities, and pet, livestock, and wildlife waste. Seventeen (17) problem sites were identified in the watershed during a field survey, and the main issues found were road shoulder and ditch erosion, erosion surrounding culverts, and the need for water access point stabilization. Additionally, 21 shorefront properties were identified as having some impact on water quality due to evidence of erosion and lack of vegetated buffer. A lake nutrient loading model revealed changes in phosphorus loading and in-lake phosphorus concentrations over time from pre-development through future conditions, showing that the water quality of Shaws Pond is threatened by current development activities in the watershed and will degrade further with continued development in the future, especially when compounded by the effects of ongoing environmental vulnerability. In the Shaws Pond watershed, the watershed load is the largest source of phosphorus, with runoff from residential/commercial development contributing 76% of the watershed phosphorus load.

The Goal

The goal of the Shaws Pond Watershed-Based Management Plan (WBMP) is to improve the water quality of Shaws Pond such that phosphorus concentrations in the pond are within the assimilative capacity threshold for oligotrophic waterbodies. This change involves decreasing the phosphorus load to the pond, in order to increase water clarity and substantially reduce the likelihood of harmful cyanobacteria blooms in the pond. This goal will be achieved by accomplishing the following objectives over the next 10 years and beyond:

OBJECTIVE 1: Reduce phosphorus loading from existing development by 17% (8.4 kg/yr) to Shaws Pond to improve the average in-lake summer total phosphorus concentration to 7.0 ppb and annual chlorophyll-a concentration to 2.5 ppb.

OBJECTIVE 2: Mitigate (prevent or offset) phosphorus loading from future development by 5.1 kg/yr to Shaws Pond to maintain average the above summer in-lake total phosphorus concentration over the next 10 years (2035).

It is important to note that, while the focus of the plan is phosphorus, the prevention and treatment of stormwater and sediment erosion will result in the reduction of many other kinds of pollutants that may impact water quality. These pollutants would likely include other nutrients (e.g., nitrogen), petroleum products, bacteria, road salt/sand, excessive organic material (raking/blowing leaves and grass cuttings or erosion from boat wakes), and heavy metals (cadmium, nickel, zinc, etc.).

Measures of success include a reduction in phosphorus loading from the tributaries to Shaws Pond and/or from shorefront BMPs and septic system upgrades, and a reduction in the frequency and severity of cyanobacteria blooms in the bay and Lake Winnipesaukee. While any amount of phosphorus load reduction to the lake will be helpful for controlling cyanobacteria blooms, it is important to understand that the dominant cyanobacteria taxa in the pond, *Dolichospermum,* can uptake phosphorus from phosphorus-rich sediments and store phosphorus for later use under more optimal growth conditions. Thus, managing cyanobacteria blooms is not entirely straightforward and depends on additional ecological factors out of our direct control.

The Solution

As part of a campaign to improve the health of Shaws Pond, the New Durham WQC has coordinated the development of the Shaws Pond WBMP, following the pathway of the regional effort of "Our Lake, Our Future," through the Lake Winnipesaukee Alliance (LWA). LWA has been coordinating the development of WBMPs for the entire Lake Winnipesaukee watershed, one sub-watershed at a time. To date, WBMPs have been completed for Meredith, Paugus, and Saunder's Bay (2010), Moultonborough Bay Inlet (2017), Moultonborough Bay and Winter Harbor (2020), and Wolfeboro Bay which includes Shaws Pond (2024). The remaining three major WBMPs for Alton Bay, the Broads, and Center Harbor are expected to be completed by 2026.

As part of the development of the Shaws Pond WBMP, a build-out analysis, land-use model, water quality and assimilative capacity analysis, septic system database development, shoreline survey, and watershed survey were conducted to identify and quantify the sources of phosphorus and other pollutants to the lake. Results from these analyses were used to determine recommended management strategies for the identified pollutant sources in the watershed. An Action Plan (Section 5) was developed in collaboration with an Advisory Committee comprised of key watershed stakeholders (see Acknowledgements). The following actions were recommended to meet the established water quality goal and objectives for Shaws Pond:

WATERSHED STRUCTURAL BMPS: Sources of phosphorus from existing watershed development should be addressed through installation of stormwater controls, stabilization techniques, buffer plantings, etc. for the following: stormwater infrastructure, the high priority sites (and the medium and low priority sites as opportunities arise) identified during the watershed survey, the high and medium impact shoreline properties (and low priority properties as opportunities arise) identified during the shoreline survey, and any new or redevelopment projects in the watershed with high potential for soil erosion. The Town of New Durham has already begun to coordinate the implementation of BMPs at the Shaws Pond Access site.

MUNICIPAL LAND USE PLANNING & ZONING: Additional strategies for reducing phosphorus loading to the lake include revising local ordinances such as setting low impact development (LID) requirements on new development, including setting limits on impervious cover; identifying and replacing malfunctioning septic systems; using best practices for road maintenance and other activities; conserving large or connective habitat corridor parcels; and improving agricultural practices. Future development should also be considered as a pollutant source and potential threat to water quality. Shaws Pond is at risk for greater water quality degradation from new development in the watershed unless environmental resiliency and LID strategies are incorporated into existing zoning standards.

MONITORING: A long-term water quality monitoring plan is critical to evaluate the effectiveness of implementation efforts over time. The WQC, in concert with the UNH LLMP, should continue the annual monitoring program and consider incorporating additional monitoring recommendations laid out in this plan.

EDUCATION AND OUTREACH: The Friends of Shaws Pond, WQC along with partner LWA, Wolfeboro Waters, and other key watershed stakeholders should continue all aspects of their education and outreach strategies and consider developing new ones or improving existing ones to reach more watershed residents. Examples include providing educational materials to existing and new property owners, as well as renters, by distributing them at various locations and through a variety of means, such as websites, newsletters, social media, community events, or community gathering locations. Educational campaigns should raise awareness of water quality concerns, septic system maintenance, fertilizer and pesticide use, pet waste disposal, waterfowl feeding, invasive aquatic species, boat pollution, increasing natural vegetation within shoreline buffers, gravel road maintenance, and stormwater runoff controls.

The recommendations of this plan will be carried out by a diverse stakeholder group in the form of a dedicated committee, including representatives from the Town of New Durham (e.g., WQC, select board, planning board, conservation commission), state and federal agencies or organizations, nonprofits, land trusts, schools and community groups, local business leaders, and landowners. The cost of successfully implementing the plan is estimated at a minimum of $370-$700 thousand over the next 10 or more years in addition to the dedication and commitment of volunteer time and support to manage plan implementation. However, many costs are still unknown or were roughly estimated and should be updated as information becomes available. This financial investment can be accomplished through a variety of funding mechanisms via both state and federal grants, as well as commitments from municipalities or donations from private residents. Of significant note, this plan meets the nine planning elements required by the EPA, and New Durham is eligible for federal watershed assistance grants.

Important Notes

The success of this plan depends on the continued effort of a dedicated committee that meets regularly to coordinate resources for implementation, review progress, and make any necessary adjustments to the plan to maintain relevant action items and interim milestones. A reduction in nutrient loading is no easy task, and because there are many diffuse sources of phosphorus reaching surface waters in the watershed, it will require an integrated and adaptive approach across many different parts of the watershed community to be successful. The recommendations in this plan are idealized and, in some cases, may be difficult to achieve given the physical and political realities of the community dealing with old infrastructure, lack of access to key lakefront areas, and limited funding and volunteer or staff capacity. The water quality goal and objectives are set to meet a desired future water quality condition, which may or may not be accomplished within the 10-year lifespan of this plan.

Finally, we all have a common responsibility to protect our lakes for future generations to enjoy. Private landowners arguably hold the most power in making significant progress toward restoring and maintaining excellent water quality in our lakes; however, engaging private landowners as a single stakeholder group can be difficult. The WQC, Friends of Shaws Pond, and other relevant stakeholders will continue to engage the public as much as possible so that private individuals can help implement the recommendations of this plan and protect the water quality of Shaws Pond long into the future.

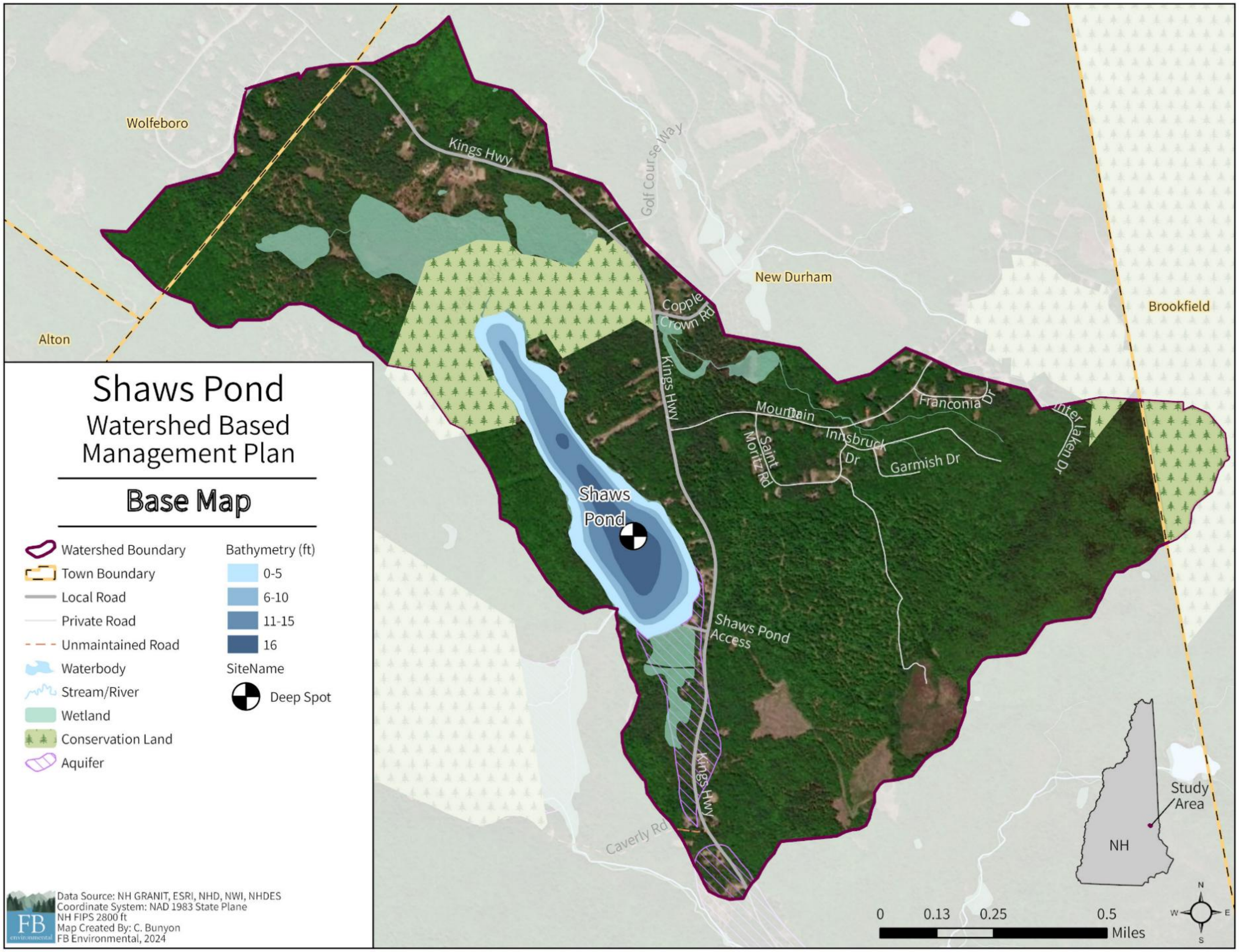

Figure 1. Shaws Pond watershed.

1 INTRODUCTION

1.1 WATERBODY DESCRIPTION AND LOCATION

Shaws Pond is a 70-acre (28-hectare) pond within the greater Lake Winnipesaukee Watershed. The Shaws Pond watershed spans 1,125 acres (455 hectares) within the towns of New Durham (94%), Wolfeboro (4%), and Brookfield (2%) (Figure 1). Shaws Pond is fed by upstream tributaries, not mapped by NHDES. Some tributaries flow intermittently. From the outlet dam of Shaws Pond, water flows as Beaver Brook into Lake Winnipesaukee near the Varney Islands south of Wolfeboro Bay.

The Shaws Pond watershed is situated within a temperate zone of converging weather patterns from the hot, wet southern regions and the cold, dry northern regions, which causes various natural phenomena such as heavy snowfalls, severe thunder and lightning storms, and hurricanes. The area experiences moderate to high rainfall and snowfall, averaging 46.2 inches of precipitation annually. Data were collected for 1993-2022 from the Lakeport 2 weather station (USC00274480), with gaps covered by the following weather stations: New Durham weather station (USC00275783), North Conway (USC00275995), Meredith (US1NHBK0009), Center Harbor (US1NHBK0012), Laconia 2.8 S (US1NHBK0010), Laconia 7.9 E (US1NHBK0007), Tilton Northfield (US1NHBK0001), Tamworth 4 (USC00278614), and Tamworth 3 (USC00278612) (Figure 2). Annual air temperature (from average monthly data) generally ranges from 21 °F to 71 °F with an average of 47 °F (NCEI, 2024).

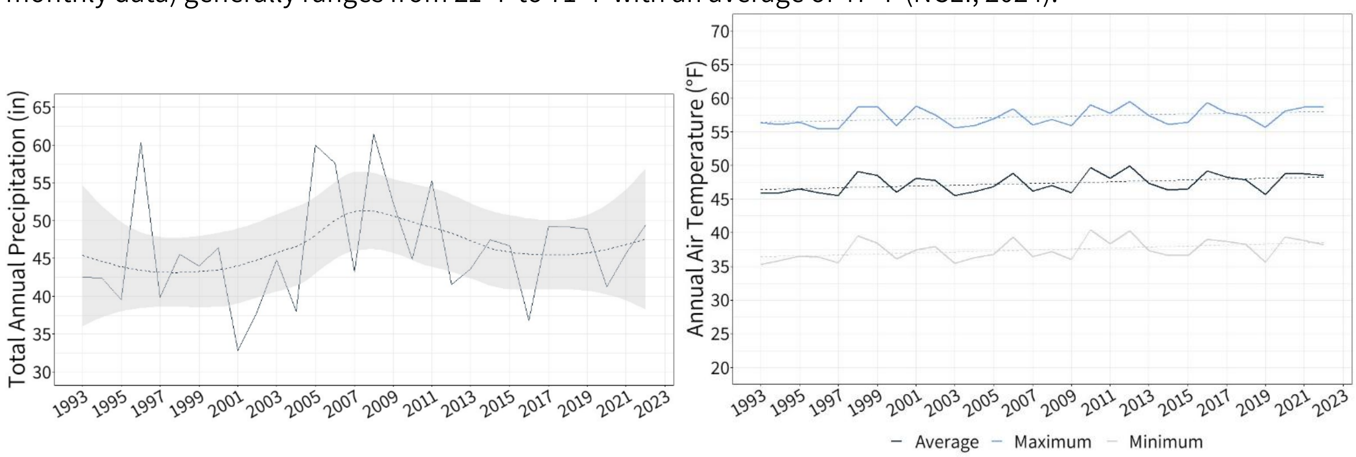

Figure 2. Total annual precipitation (left) and annual max, average, and min of monthly air temperature (right) from 1993 - 2022 for the region. Data collected from NOAA NCEI. The dashed line and grey shaded area for precipitation represents the Locally Estimated Scatterplot Smoothing (LOESS) regression and 95% confidence intervals, respectively. The dashed lines for air temperature indicate a statistically significant trend ($p < 0.05$).

The highest elevation in the watershed (about 534 meters or 1,752 feet above sea level) is located at the summit of Copple Crown Mountain within the Copple Crown Conservation Area of Brookfield in the eastern part of the watershed. Shaws Pond elevation is 235 meters or 771 feet above sea level, based on the USGS National Map.

The watershed is characterized primarily by mixed forest that includes both conifers (e.g., white pine and eastern hemlock) and deciduous (e.g., beech, red oak, and maple) tree species. Fauna within these forested and pond resources include land mammals (moose, deer, black bear, coyote, bobcats, fisher, fox, raccoon, weasel, porcupine, muskrat, mink, chipmunks, squirrels, snowshoe hares, and bats), water mammals (muskrat, otter, and beaver), land and water reptiles and amphibians (turtles, snakes, frogs, and salamanders), various insects, birds (herons, loons, gulls, geese, multiple species of ducks[1], wild turkeys, ruffed grouse, cormorants, bald eagles, and song birds), and fish (largemouth bass, eastern chain pickerel, brown bullhead, and white perch). Loons have been seen using Shaws Pond as a stopping point on their migrations.

1.2 WATERSHED PROTECTION GROUPS

The New Durham Water Quality Committee (WQC) works to maintain a *"high water quality standard for the Town's waterbodies consistent with the standards for the classes and use of each waterbody."*

The Lake Winnipesaukee Alliance (LWA) is a non-profit organization with the mission of "*protecting the water quality and natural resources of Lake Winnipesaukee and its watershed. Through monitoring, education, stewardship, and utilizing science-guided approaches for lake management, LWA works to ensure that Winnipesaukee's scenic beauty, wildlife habitat, water quality, and recreational potential continues to provide enjoyment today and for the future.*" LWA serves the 14 communities located in Belknap and Carroll counties. LWA is led by several paid staff and a volunteer Board of Directors.

Adapted from a letter to NHDES dated February 16, 2023, Wolfeboro Waters is a standing Town of Wolfeboro committee consisting of volunteers appointed by the Wolfeboro Board of Selectmen. The committee was established in response to a local cyanobacteria bloom in Lake Winnipesaukee that lasted for three weeks in August 2018. The committee complements the longer-term protection efforts of the Wentworth Watershed Association (WWA), Rust Pond Association, Mirror Lake Protective Association, and LWA. Wolfeboro Waters focuses on the risk and mitigation of cyanobacteria blooms in local waters.

The Strafford County Conservation District (SCCD) is one of 10 county conservation districts in New Hampshire that operate as resource management agencies and a subdivision of local governments. New Durham is in SCCD's service area. The organization works with farmers, forest owners, landowners, schools, and municipalities to help protect and conserve the area's natural resources through projects such as stream bed restoration, invasive species management, and pollinator plantings. Wolfeboro and Brookfield are part of the Carroll County Conservation District (CCCD).

Lakes Region Conservation Trust (LRCT) is a non-profit organization "*dedicated to the permanent conservation, stewardship, and respectful use of lands that define the character of the Lakes Region and its quality of life.*" Their vision is a "*future where conserved lands support thriving biodiversity, healthy watersheds, and vibrant human communities.*" LRCT has conserved 174 properties totaling over 29,000 acres in the Lakes Region.

The New Hampshire Association of Conservation Commissions (NHACC) works to provide educational assistance to conservation commissions throughout New Hampshire (217 in total). As a non-profit organization, the NHACC's mission is to instill responsible use of the available natural resources by promoting conservation and serving as the communication link between conservation commissions, while providing technical support on the logistics of conservation commission meetings and document writing. Conservation commissions in the Shaws Pond watershed include those of New Durham, Wolfeboro, and Brookfield.

Covering 31 communities, the Lakes Region Planning Commission (LRPC) is a valuable resource to the region. The LRPC aids communities with their local planning services in a targeted approach to protect the environment, while supporting local economies and cultural values.

[1] American black duck, black scoter, canvasback, common goldeneye, hooded merganser, long tailed duck, wood duck, red breasted merganser, northern pintail, and mallard.

The New Hampshire Department of Environmental Services (NHDES) works with local organizations to improve water quality in New Hampshire at the watershed level. NHDES works with communities to identify water resource goals and to develop and implement watershed plans. This work is achieved by providing financial and technical assistance to local watershed management organizations and by investigating actual and potential water contamination problems, among other activities.

1.3 PURPOSE AND SCOPE

The purpose and overarching goal of the Shaws Pond Watershed-Based Management Plan (WBMP) is to guide implementation efforts over the next 10 years (2025-2034) to improve the water quality of Shaws Pond such that it continues to meet state water quality standards for Aquatic Life Integrity (ALI) and Primary Contact Recreation (PCR) and substantially reduces the likelihood of harmful cyanobacteria blooms. *Efforts to protect Shaws Pond will also help protect downstream waterbodies like Wolfeboro Bay of Lake Winnipesaukee.*

As part of the development of this plan, a **build-out analysis**, land-use model, water quality and **assimilative capacity** analysis, and shoreline and watershed surveys were conducted to better understand the sources of phosphorus and other pollutants to the lake (Sections 2 and 3). Results from these analyses were used to establish the water quality goal and objectives (Section 2.4), determine recommended management strategies for the identified pollutant sources (Section 4), and estimate pollutant load reductions and costs needed for remediation (Sections 5 and 6). Recommended management strategies involve using a combination of **structural and non-structural Best Management Practices** (BMPs), as well as an **adaptive management approach** that allows for regular updates to the plan (Section 4). An Action Plan (Section 5) with associated timeframes, responsible parties, and estimated costs was developed in collaboration with the Advisory Committee (Section 1.4). This plan meets the nine elements required by the United States Environmental Protection Agency (EPA) so that communities become eligible for federal watershed assistance grants (Section 1.5).

1.4 COMMUNITY INVOLVEMENT AND PLANNING

The plan was developed through the collaborative efforts of numerous meetings, public presentations, and conference calls between FB Environmental Associates (FBE), the WQC, Friends of Shaws Pond, representatives from the towns of New Durham, and private landowners (see Acknowledgments).

1.4.1 Plan Development Meetings

Several meetings were held over the duration of the plan development. The following list does not include routine annual meetings conducted separately by the WQC, except as they relate to watershed plan development.

- March 28, 2024: WQC and FBE call to organize the kick-off meeting logistics and to schedule the Watershed Survey field day.
- April 22, 2024: WQC and FBE conducted the watershed survey.
- April 23, 2024: Kick-off virtual meeting with the public to introduce the watershed planning process.
- November 25, 2024: Virtual public meeting to review the watershed and shoreline survey results and prioritize sites for remediation.
- May 14, 2025: Public meeting to review the water quality analysis, build-out analysis, modeling results, and set the water quality goal.

1.4.2 Final Public Presentation

A final virtual public presentation was held on July 8, 2025 to summarize the analyses and recommendations detailed in the plan. The presentation was attended by about 11 people. An opportunity for public feedback on the plan was offered. Several written comments were received and incorporated into the final plan.

1.5 INCORPORATING EPA'S NINE ELEMENTS

EPA guidance lists nine components that are required within a WBMP to restore waters impaired or likely to be impaired by **nonpoint source (NPS) pollution**. These guidelines highlight important steps in restoring and protecting water quality for any waterbody affected by human activities. The nine required elements found within this plan are as follows:

A. **IDENTIFY CAUSES AND SOURCES: Sections 2 and 3** highlight known sources of NPS pollution to Shaws Pond and describe the results of the watershed survey and other assessments conducted in the watershed. These sources of pollutants must be controlled to achieve load reductions estimated in this plan, as discussed in item (B) below.
B. **ESTIMATE PHOSPHORUS LOAD REDUCTIONS EXPECTED FROM MANAGEMENT MEASURES:** Sections 2 and 5 describe the calculation of pollutant load to Shaws Pond and the amount of reduction needed to meet the water quality goal, respectively.
C. **DESCRIPTION OF MANAGEMENT MEASURES: Sections 4 and 5** identify ways to achieve the estimated phosphorus load reduction and reach water quality targets. The Action Plan focuses on several major topic areas that address NPS pollution. Management options in the Action Plan focus on non-structural BMPs integral to the implementation of structural BMPs.
D. **ESTIMATE OF TECHNICAL AND FINANCIAL ASSISTANCE: Sections 5 and 6** includes a description of the associated costs, sources of funding, and primary authorities responsible for implementation. Sources of funding need to be diverse and should include local, state, and federal granting agencies, local groups, private donations, and landowner contributions for implementation of the Action Plan.
E. **EDUCATION & OUTREACH: Section 4** describes how the educational component of the plan is already being or will be implemented to enhance public understanding of the project.
F. **SCHEDULE FOR ADDRESSING PHOSPHORUS REDUCTIONS: Section 5** provides a list of action items and recommendations to reduce the phosphorus load to Shaws Pond. Each item has a set schedule that defines when the action should begin and/or end or run through (if an ongoing activity). The schedule should be adjusted by the committee on an annual basis (see Section 4 on Adaptive Management).
G. **DESCRIPTION OF INTERIM MEASURABLE MILESTONES: Section 6** outlines indicators along with milestones of implementation success that should be tracked annually.
H. **SET OF CRITERIA: Sections 2 and 6** can be used to determine whether loading reductions are being achieved over time, substantial progress is being made towards water quality objectives, and if not, criteria for determining whether this plan needs to be revised.
I. **MONITORING COMPONENT: Section 6** describes the long-term water quality monitoring strategy for Shaws Pond, the results of which can be used to evaluate the effectiveness of implementation efforts over time as measured against the criteria in (H) above. The success of this plan cannot be evaluated without ongoing monitoring and assessment and careful tracking of load reductions following successful BMP implementation projects.

2 ASSESSMENT OF WATER QUALITY

This section provides an overview of the past, current, and future state of water quality based on the water quality assessment and watershed modeling, which identified pollutants of concern and informed the established water quality goal and objectives for Shaws Pond.

2.1 WATER QUALITY SUMMARY

2.1.1 Water Quality Standards & Impairment Status

2.1.1.1 Designated Uses & Water Quality Criteria

The **Clean Water Act** (CWA) requires states to determine designated uses for all surface waters within the state's jurisdiction. Designated uses are the desirable activities and services that surface waters should be able to support and include uses for ALI, fish consumption, shellfish consumption, drinking water supply, primary contact recreation (swimming), secondary contact recreation (boating and fishing), and wildlife. Surface waters can have multiple designated uses. **PCR and ALI are the two major uses for lakes.** In New Hampshire, all surface waters are also legislatively classified as Class A or Class B, most of which are Class B (Env-Wq 1700). **Shaws Pond is classified as Class B waters by the State of New Hampshire**. Additionally, from 1984 to 1999, NHDES conducted surveys of lakes to determine **trophic state** (**oligotrophic**, **mesotrophic**, or **eutrophic**). The trophic surveys evaluated physical lake features, as well as chemical and biological indicators. **For Shaws Pond, the trophic state was determined to be mesotrophic in both assessments** due to depleted dissolved oxygen and aquatic plant abundance (NHDES, 1984, 1999). This means that in-lake water quality was consistent with the standards for mesotrophic lakes in terms of dissolved oxygen and aquatic plants, but this doesn't indicate if total phosphorus and chlorophyll-a were in line with oligotrophic or mesotrophic standards.

Water quality criteria are then developed to protect designated uses, serving as a "yardstick" for identifying water quality exceedances and for determining the effectiveness of state regulatory pollution control and prevention programs. Depending on the designated use and type of waterbody, water quality criteria can become more or less strict if the waterbody is classified as either Class A or B or as oligotrophic, mesotrophic, or eutrophic. To determine if a waterbody is meeting its designated uses, water quality criteria for various parameters (e.g., **chlorophyll-a**, **total phosphorus**, **dissolved oxygen**, **pH**) are applied to the water quality data. If a waterbody meets or is better than the water quality criteria, the designated use is supported. The waterbody is considered impaired for the designated use if it does not meet water quality criteria. Water quality criteria for each classification and designated use in New Hampshire can be found in RSA 485 A:8, IV and in the state's surface water quality regulations.

2.1.1.2 Antidegradation Provisions

The Antidegradation Provision (Env-Wq 1708) in New Hampshire's water quality regulations serves to protect or improve the quality of the state's waters. The provision outlines limitations or reductions for future pollutant loading. Certain development projects (e.g., projects that require Alteration of Terrain Permit or 401 Water Quality Certification) may be subject to an Antidegradation Review to ensure compliance with the state's water quality regulations. The Antidegradation Provision is often invoked during the permit review process for projects adjacent to waters that are designated impaired, high quality, or outstanding resource waters. While NHDES has not formally designated high-quality waters, unimpaired waters are treated as high quality with respect to issuance of water quality certificates. Antidegradation requires that a permitted activity cannot use more than 20% of the remaining assimilative capacity of a high-quality water. This is on a parameter-by-parameter basis.

For impaired waters, antidegradation requires that permitted activities discharge no additional loading of the impaired parameter.

2.1.1.3 Waterbody Impairment Status

The assessment unit for Shaws Pond is not formally listed as impaired for ALI or PCR on the 303(d) New Hampshire List of Impaired Waters for the 2024 cycle (NHDES, 2024). However, the pond is considered impaired for fish consumption due to the statewide mercury TMDL (NEIWPCC, 2007).

2.1.2 Water Quality Data Collection

Shaws Pond was monitored as part of the 1984 and 1999 Lake Trophic Surveys and has been monitored since 2017 by the University of New Hampshire (UNH) Lakes Lay Monitoring Program (LLMP) and local volunteers. The annual UNH LLMP water quality reports appear to indicate Shaws Pond has experienced worsening water quality in recent years (Table 1) given that oligotrophic conditions were met only in early years; however, the pond was and still is considered Mesotrophic by NHDES, and the data do not show any statistically significant trends to date (Section 2.1.3). Additional years of data will help better characterize any water quality trends.

Table 1. UNH LLMP report summaryof seasonal averages. **Bold blue text** represents the average value falls within NHDES standards for oligotrophic waterbodies, yellow text indicate values fall within mesotrophic standards, and *italized red text* indicates the value falls within eutrophic standards.

Year	Water Clarity (meters)	Chlorophyll-a (ppb)	Total Phosphorus (ppb)	Dissolved Oxygen (mg/L)
2017	**4.3**	**2.7**	**7.8**	4.6
2018	**4.2**	**2.6**	**6.9**	**6.3**
2019	3.8	4.4	8.8	**6.2**
2021	3.8	3.7	7.4	**6.2**
2022	3.6	*5.8*	9.3	*1.9*
2023	3.3	*6.8*	9.7	2.2
2024	4.0	3.3	8.9	2.3

Water quality data were obtained for this plan from the NHDES Environmental Monitoring Database (EMD) and directly from Bob Craycraft of UNH LLMP (2017-2024). Shaws Pond has one LLMP monitoring site, 1 DEEP, at the pond's deep spot. Data gathered from 1 DEEP included epilimnion composite samples and variable depth grab samples (from the epilimnion and hypolimnion) for total phosphorus, chlorophyll-a, color, total nitrogen, alkalinity, turbidity, chloride, specific conductivity, and pH from 2017-2024. Depth profile data were collected using a YSI EXO2 sonde in 2017 and 2018 for various parameters including temperature, dissolved oxygen, specific conductivity, pH, oxidation reduction potential, turbidity, chlorophyll-a fluorescence, phycocyanin fluorescence, and total dissolved solids. Lastly, data were gathered from three continuous temperature loggers that were deployed at 1, 3, and 4.5-meters in 2024.

Since 2018, samples were collected at tributary sites including the Boat Ramp Stream, Golf Course Brook, Horse Farm Stream, Middle Brook East, South Marsh Stream, South Brook East, South Brook West, and the Washington Road Brook. The South Brook East and West sites are on the same tributary, with samples being collected upstream and downstream of Kings Highway, respectively. South Marsh Stream and Boat Ramp Stream are also collected along the same tributary. Tributary data include total phosphorus, alkalinity, turbidity, pH, chloride, and specific conductance. Total phosphorus data were analyzed as part of this WBMP

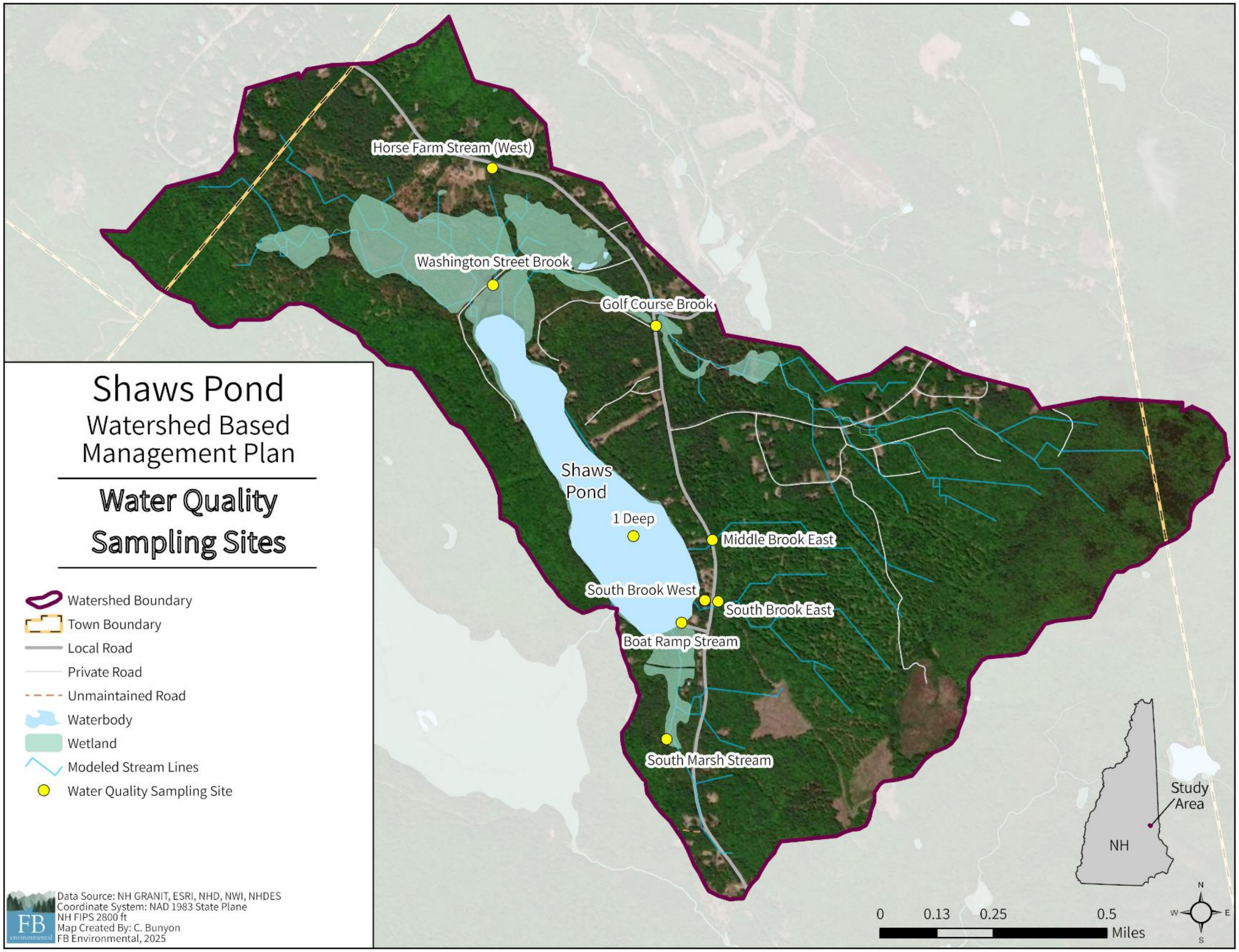

Figure 3. Water quality monitoring sites in the Shaws Pond watershed.

2.1.3 Trophic State Indicator Parameters

Total phosphorus, chlorophyll-a, and Secchi disk transparency are trophic state indicators, or indicators of biological productivity in lake ecosystems. In combination, these parameters help measure the extent and effect of **eutrophication** in lakes and signal changes in lake water quality over time. For example, changes in Secchi disk transparency may be due to a change in the amount and composition of algae communities (typically because of greater total phosphorus availability) or the amount of dissolved or particulate materials in a lake. Such changes are likely the result of human disturbance or other impacts within the lake's watershed.

Generally, higher total phosphorus concentrations in the bottom waters compared to the surface and multi-depth composite samples as occurs in Shaws Pond (Figure 4) suggest that some amount of internal loading is occurring, meaning phosphorus stored in lake bottom sediments is being released into the water column. In shallow lakes, sediment resuspension from wind or wave action, bioturbation from aquatic animals, and increased phosphorus release from organic matter decomposition or low oxygen conditions may occur. Since the beginning of consistent data collection in 2017, no statistically significant trends were observed at the deep spot of Shaws Pond for total phosphorus, chlorophyll-a, or Secchi disk transparency (Figure 5). Future data collection consistent with the most recent years will allow for a better understanding of water quality trends in Shaws Pond.

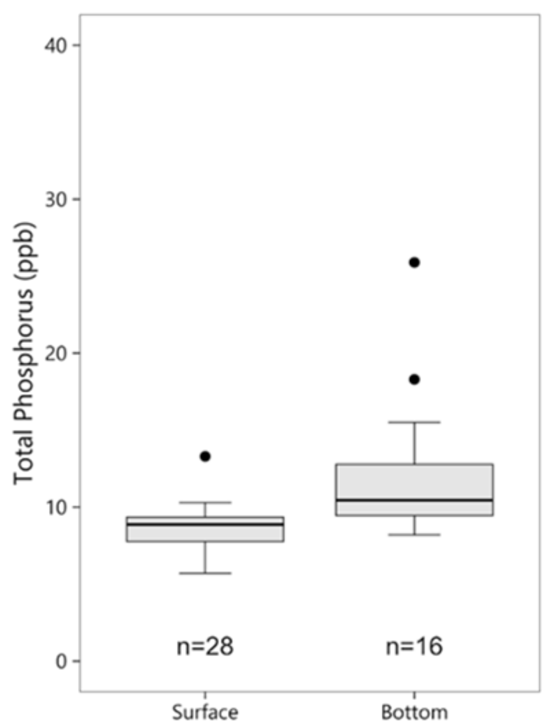

Figure 4. Boxplots showing median total phosphorus concentration in the surface and bottom of the Shaws Pond deep spot [1 DEEP].

Figure 5. Median surface (0-3 meters) or composite total phosphorus (n=28), median composite surface (0-3 meters) chlorophyll-a (n=32), and median water clarity (Secchi Disk depth, methods not recorded) (n=25) measured at the deep spot of Shaws Pond [1 DEEP] largely in June-September from 2017 to 2024. No statistically significant trends were detected from the Mann-Kendall nonparametric trend test using rkt package in R Studio, though 10 or more years of data are preferred to confidently detect trends.

2.1.4 Stream Total Phosphorus

In recent years, the New Durham Water Quality Committee, in collaboration with the UNH LLMP, has collected additional total phosphorus samples from the various tributaries to Shaws Pond. Other parameters that are sampled at a lesser frequency include alkalinity, turbidity, pH, chloride, and specific conductance. The tributaries are unnamed on USGS and NHDES maps but have been assigned their locally-known names for this project. Since 2018, sampling has occurred at the Boat Ramp Stream, Golf Course Brook, Horse Farm Stream, Middle Brook East, South Marsh Stream, South Brook East, South Brook West, and the Washington Road Brook. The South Brook East and West sites are on the same tributary, with samples being collected upstream and downstream of Kings Highway, respectively.

Median total phosphorus levels in the streams are generally low, except for the Boat Ramp Stream. Boat Ramp Stream had the highest median concentration (27.8 ppb) from all years of data collection (Table 2), with phosphorus concentrations of 40.1 ppb on 8/25/2024 and 52.9 on 6/25/2024. These values are generally low for NH tributaries but can be helpful for prioritizing remediation work in subwatersheds to Shaws Pond. This site also has slightly elevated specific conductance levels (maximum recorded value of 208 µs/cm on 10/4/2023) compared to the other streams and should be monitored closely moving forward. Other sites have total phosphorus levels generally on-par with observed concentration in Shaws Pond. Caution should be used when interpreting stream data for total phosphorus and all other parameters due to the limited amount of available data and inconsistencies with sample frequency, timing, and climactic variables.

Table 2. Stream total phosphorus data for Shaws Pond tributaries, presented as summaries for 2023, 2024, and all available years. If only one year of data was available, the "All Years" summary was not presented. "n=_" represents the number of samples used to calculate the median value.

Site	2023 Median TP (ppb)	2024 Median TP (ppb)	All Years Median TP (ppb)
Boat Ramp Stream	18.5, *n=7*	37.1, *n=4*	27.8, *n=11*
Golf Course Brook	9.4, *n=6*	13.3, *n=6*	11.4, *n=16*
Horse Farm Stream	--	9.4, *n=1*	--
Middle Brook East	--	--	--
South Brook East	4.2, *n=3*	6.1, *n=5*	6.1, *n=9*
South Brook West	5.3, *n=7*	--	--
South Marsh Stream	--	11.5, *n=1*	--
Washington Street Brook	12.2, *n=6*	16.6, *n=6*	12.2, *n=17*

2.1.5 Dissolved Oxygen & Water Temperature

A common occurrence in lakes is the depletion of dissolved oxygen in the bottom waters during the summer months. This occurs when **thermal stratification** prevents warmer, less dense, and oxygenated surface waters from mixing with cooler, denser, oxygen-depleted bottom waters. Then, chemical and biological processes occurring in bottom waters, such as decomposition, consume the available oxygen at depth throughout the summer. Because of this separation of water temperatures and densities, also known as thermal stratification, the oxygen at the bottom is not replenished from the surface waters. Dissolved oxygen levels below 5 ppm (and water temperature above 24°C) can stress and reduce habitat for cold water fish and sensitive aquatic organisms. Dissolved oxygen below 2 ppm suggests that the release of sediment-bound phosphorus may occur and be mixed into the water column in a process known as internal loading. Enhanced loading of phosphorus to surface waters, whether from internal or external sources, particularly when compounded by the impacts from environmental variability, can stimulate excessive plant, algae, and cyanobacteria growth and further degrade water quality.

Most lakes in New England are classified as dimictic. This means that they fully mix twice a year when the lake reaches a uniform temperature across the profile, a process termed spring and fall **turnover**. However, because Shaws Pond is relatively shallow, stratification is weaker and the lake may mix during cooler or windy periods during the summer. The pond is therefore classified as polymictic, meaning its waters will stratify and mix many times throughout the year (especially in summer). Figure 6 shows temperature and dissolved oxygen profiles from the Shaws Pond deep spot (1 DEEP) averaged across June through September sampling dates, typically defined as the summer stratification period, in recent years (2019-2024). Profiles for Shaws Pond are typically recorded up to 6 times per season, including profiles in the spring and fall, before and after the summer stratification period.

As a shallow, polymictic lake, Shaws Pond does not fully stratify into the three distinct thermal layers that are typical in deeper lakes (epilimnion, metalimnion, hypolimnion). Instead, Shaws Pond begins stratifying and forms a weak density gradient under calm conditions between the surface (0-3 meters) and bottom (3-5 meters) (Figure 6). Dissolved oxygen in the bottom waters tends to become depleted, reaching levels below 5 ppm around 3.5-4.0 meters and below 2 ppm, defined as anoxic, beginning around 4.5 meters. The deepest oxygen measurements at about 5 meters were consistently close to zero. **Anoxia** in shallow, polymictic lakes can occur throughout the year, particularly during the summer stratification period at the sediment-water interface. Anoxia can be especially pronounced during calm, warm, ephemerally stratified periods, during which decomposition and oxygen demand near the sediment-water interface increase. The data showing a combination of anoxia and higher phosphorus concentrations at depth indicate anoxia-induced **internal phosphorus loading** is occurring in Shaws Pond throughout the summer stratification period.

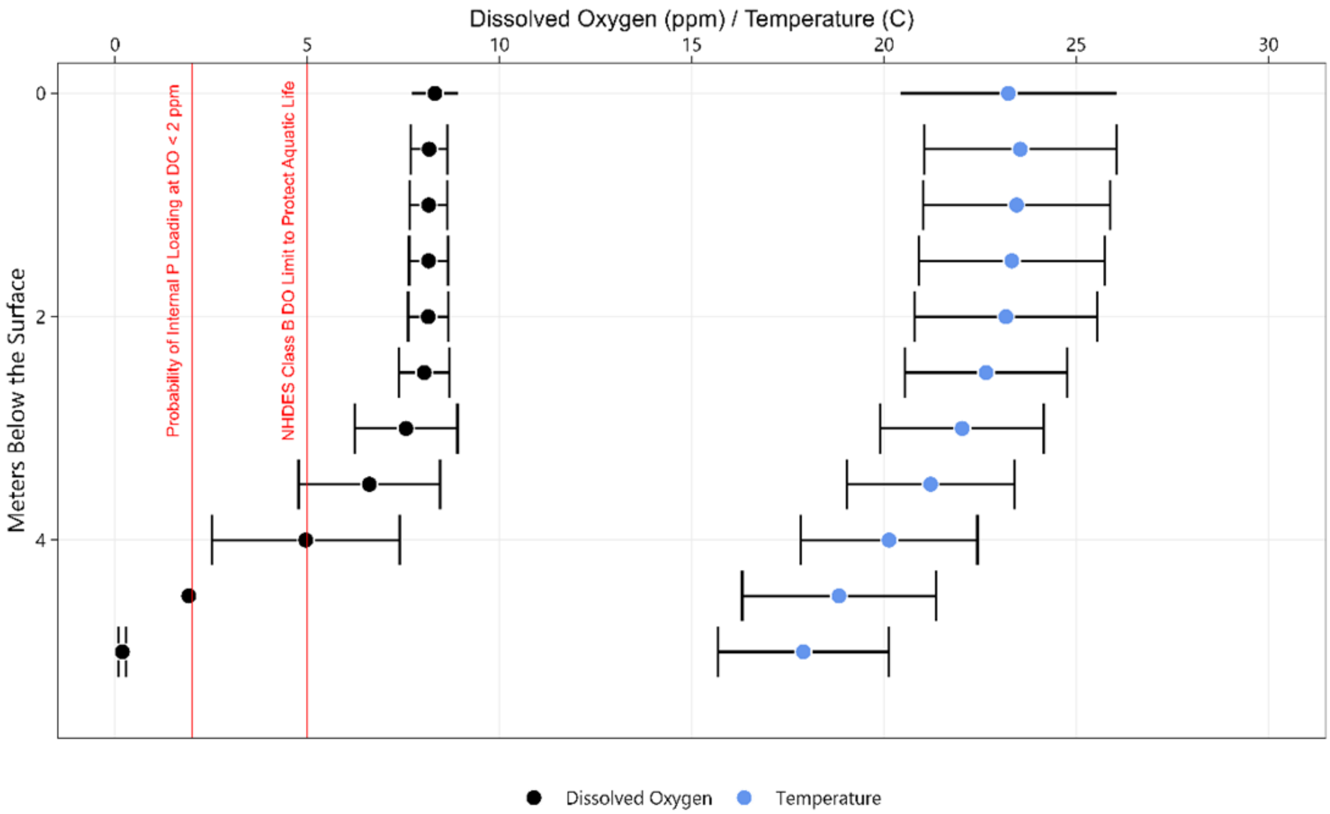

Figure 6. Dissolved oxygen (black) and water temperature (blue) depth profiles for the deep spot of Shaws Pond [1 DEEP] over ten years ago (top) and in 2023 (bottom). Dots represent average values across sampling dates for each respective depth.

Three temperature loggers were deployed in Shaws Pond from 7/9/24 through 10/18/24. These temperature loggers were attached to a vertical line and recorded water temperature at 30-minute intervals at 1-, 3-, and 4.5-meters depth (Figure 7). Data from the temperature loggers showed the periodic stratification and mixing that occurs in Shaws Pond during the summer months.

In early to mid-July, water temperature in the epilimnion was high (reaching 30°C), and the pond was weakly stratified into two thermal layers (surface and bottom). By 7/18/2024, the pond had mixed down to at least 3-meters depth (depicted as the convergence of the data recorded from the 1-meter and 3-meter temperature loggers), likely due to the precipitation experienced from 7/16 through 7/18. The bottom waters (4.5 meters) did not mix into the upper thermal layers until 8/17/2024, at which point the entire pond mixed. Shaws Pond then began a period in which weak thermal stratification and mixing events were common, with mixing notable on 9/1, 9/6, and 9/21. After the 9/21 mixing event, the pond remained fully mixed with near-homogenous temperatures throughout the water column until the end of data collection on 10/18/2024.

Overlaid in Figure 7 are total phosphorus concentrations measured in 2024, symbolized by collection type or location: composite, surface, or bottom. The data indicate total phosphorus concentrations in the bottom samples were higher compared to the surface and composite samples in June and July when the lake was more stratified and internal loading was more apparent. After the lake mixed on 8/17/2024, the total phosphorus concentrations measured in the bottom samples were near equal to the surface and composite samples and lower than earlier in the season, likely due to nutrient uptake by biota at the peak growing period. The increase in total phosphorus concentration measured in the surface sample on 9/23/2024 may be attributed to a small rain event that occurred the day prior after a long period with no rain. Rain events often transport nutrients from the watershed into tributaries to the pond, or directly to the pond, thus increasing surface total phosphorus concentrations.

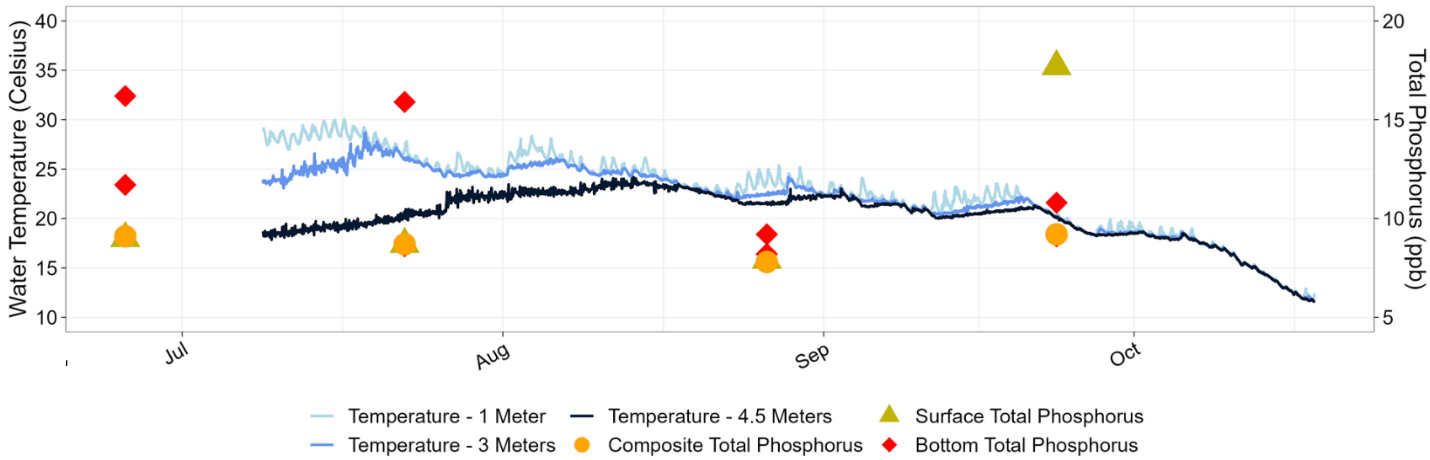

Figure 7. Continuous temperature data collected by a Shaws Pond volunteer at 30-minute intervals at 1-, 3, and 4.5-meters depth at the Shaws Pond deep spot [1 DEEP] from 7/9/2024 to 10/18/2024 (the left axis) and total phosphorus grab and composite sample results from 2024 (excluding April and May for visualization purposes) (the right axis).

2.1.6 Phytoplankton (Cyanobacteria) and Zooplankton

2.1.6.1 Phytoplankton/Zooplankton Surveys

Phytoplankton and zooplankton samples were collected as part of the 1984 and 1999 NHDES Lake Trophic Survey Reports. As noted in these reports, the dominant phytoplankton species were Dinobryon (golden-brown), Tabellaria (diatom), and Rhizosolenia (diatom). The dominant zooplankton species were Nauplius larvae (copepod), Acanthocystis (heliozoa), Calanoid (copepod), Asplancha (rotifer), and Polyarthra (rotifer). Copepods are small crustaceans that eat phytoplankton and provide an important food source to fish. Rotifers are small, inefficient grazers. Daphnia are among the most efficient grazers of phytoplankton but were not found to be among the dominant zooplankton in Shaws Pond.

Samples were collected four times in 2024 for zooplankton and phytoplankton analyses from the deep spot of Shaws Pond (1 DEEP). Samples were analyzed by the UNH LLMP. Shaws Pond had relatively low amounts of phytoplankton and an abundance of rotifers (microzooplankton that often filter feed small phytoplankton) (Figure 8). Early fall samples showed an abundance of golden-browns and diatoms which helps decrease the chance of long-lasting cyanobacteria blooms later in the season. However, Shaws Pond experienced a cyanobacteria bloom containing Dolichospermum on September 12th, 2024. The bloom presented as green ribbons and clouds of material covering an area around the size of a car along the northeast shoreline. The bloom was short lived, small in size, and displaced from the routine sampling location (1 DEEP), further showing the quick growth and subsidence some of these blooms undergo.

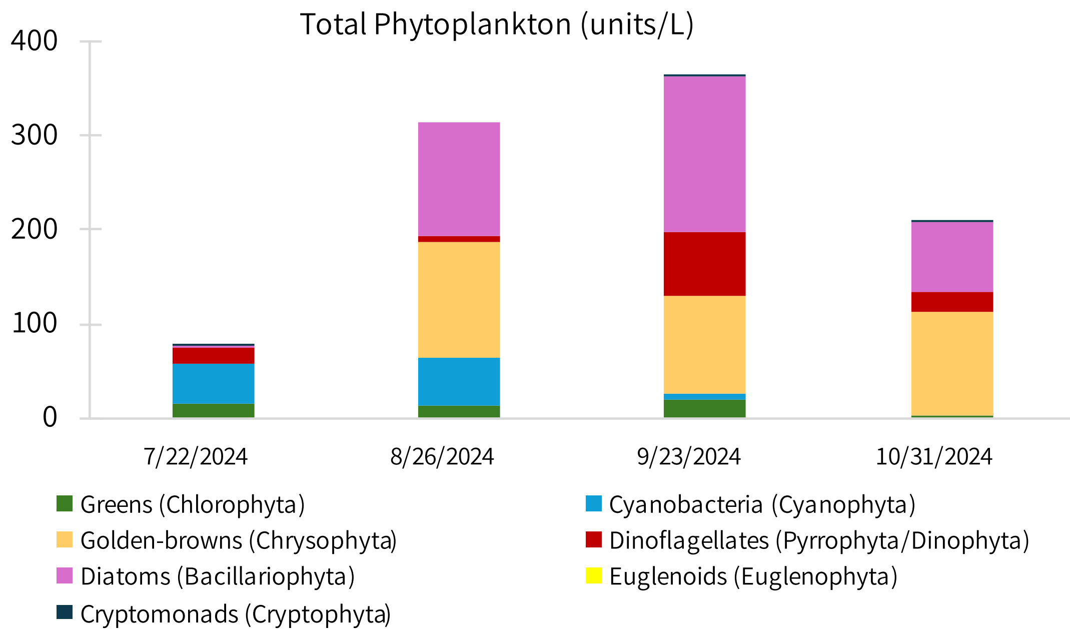

Figure 8. Relative abundance of phytoplankton analyzed from samples collected from 1 DEEP in 2024. Analysis by the UNH LLMP.

Rotifers were most prevalent in Shaws Pond in three of the four sampling events (Figure 9). As filter feeders, rotifers are known to consume phytoplankton and other detritus within the water column. The decrease in total zooplankton from July to August may be attributed to the natural increase in water temperatures, time since spring reproduction and hatching, and/or increased predation.

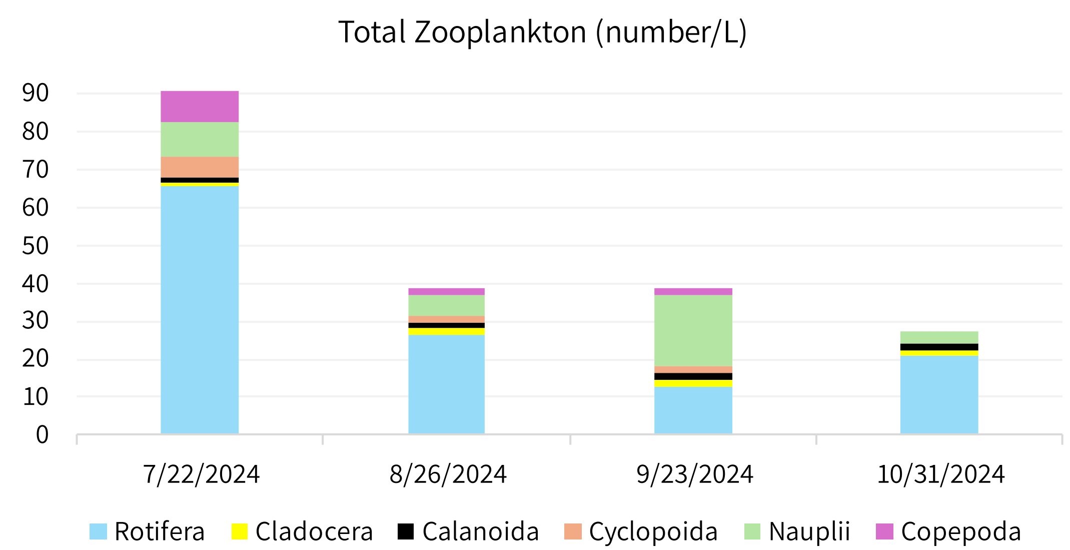

Figure 9. Total number of zooplankton per liter of sample collected from 1 DEEP in 2024. Analysis by the UNH LLMP.

2.1.6.2 Cyanobacteria Bloom History

Nutrients such as phosphorus and nitrogen, as well as algae and cyanobacteria, naturally occur in the environment, including lakes and tributaries and their contributing watersheds, and are essential to lake health. Under natural conditions, algae and cyanobacteria concentrations are regulated by limited nutrient inputs and lake mixing processes that keep them from growing too rapidly. However, human related disturbances, such as erosion, overapplied fertilizers, polluted stormwater runoff, excessive domesticated animal waste, and inadequately treated wastewater, can dramatically increase the amount of nutrients entering lakes and their tributaries. Excess nutrient loading to human-disturbed lake systems, in combination with a warming environment, has fueled the increasing prevalence of Harmful Algal Blooms (HABs) or the rapid growth of algae and cyanobacteria in lakes across the United States.

Cyanobacteria are small photosynthesizing, sometimes nitrogen-fixing, single-celled bacteria that grow in colonies in freshwater systems. Cyanobacteria blooms can (but do not always) produce microcystins and other toxins that pose a serious health risk to humans, pets, livestock, and wildlife, such as neurological, liver, kidney, and reproductive organ damage, gastrointestinal pain or illness, vomiting, eye, ear, and skin irritation, mouth blistering, tumor growth, seizure, or death. Blooms can form dense mats or surface scum that can occur within the water column or along the shoreline. Dried scum along the shoreline can harbor high concentrations of microcystins that can re-enter a waterbody months later. There are several different species of cyanobacteria, such as:

- *Dolichospermum (formerly Anabaena)*: typically observed as filaments, associated with microcystins, anatoxins, saxitoxins, and cylindrospermopsin, *documented in Shaws Pond in 2024.*
- *Gloeotrichia:* typically observed as large, round colonies of filaments, associated with microcystins.
- *Microcystis*: typically observed as variations of small-celled colonies, associated with microcystins and anatoxins.
- *Aphanizomenon*: typically forms rafts of filaments, associated anatoxin-a, anatoxin-a (S), saxitoxins, and possibly microcystins.
- *Woronichinia*: typically forms dense colonies, associated with microcystins.
- *Planktothrix (formerly Oscillatoria)*: typically observed as filaments, associated with microcystins and cylindrospermopsin, can maintain high growth rate at relatively low light intensities when it forms metalimnetic blooms (NHDES, 2020).

Cyanobacteria are becoming more prevalent in low-nutrient lake systems likely due to environmental warming effects (e.g., warmer water temperatures, prolonged thermal stratification, increased stability, reduced mixing, and lower flushing rates at critical low-flow periods that allow for longer residence times) that result in cyanobacteria thriving and outcompeting other phytoplankton species (Przytulska, Bartosiewicz, & Vincent, 2017; Paerl, 2018; Favot, et al., 2019). Many cyanobacteria can regulate their buoyancy and travel vertically in the water column to maximize their capture of both sunlight and sediment phosphorus (even during stratification and/or under anoxic conditions) for growth. In addition, some cyanobacteria can also fix atmospheric nitrogen, if enough light, phosphorus, iron, and molybdenum are available for the energy-taxing process. Some taxa are also able to store excess nitrogen and phosphorus intra-cellularly for later use under more favorable conditions. Because of these traits, the increasing prevalence and dominance of cyanobacteria may enter into a positive feedback with lake eutrophication. This may accelerate eutrophication in low-nutrient lakes and prevent complete recovery of lakes from eutrophic states (Dolman, et al., 2012; Cottingham, Ewing, Greer, Carey, & Weathers, 2015). A better understanding of cyanobacteria's role in lake nutrient feedback will be needed for better and more effective lake restoration strategies.

There has been one NHDES-issued cyanobacteria bloom warning for Shaws Pond, which lasted for 6 days beginning on September 12, 2024. The bloom had 234,200 cyanobacterial cells/mL and was primarily composed of *Dolichospermum. Dolichospermum* is potentially toxin-producing and a nitrogen-fixing species, meaning it can transform nitrogen from the air into a useable aquatic form if it is not already available in the water column. It can also regulate its buoyancy in the water column to outcompete less motile phytoplankton.

It is impossible to eradicate cyanobacteria in Shaws Pond as they are naturally occurring bacteria that have been on the planet for over two billion years and are resilient to environmental changes. Some species of cyanobacteria can become dormant in sediment and then can jump-start cell reproduction once conditions are favorable (warm water temperatures and plenty of sunlight and nutrients). Given the long-term trend of increasing air and water temperatures and increased phosphorus loading from development in the watershed, the likelihood of blooms will continue and possibly accelerate, though year-to-year variability in weather may determine the availability of phosphorus and/or the presence of other oxygen compounds such as nitrates and thus determine the timing, extent, and severity of blooms in any given year. Despite this, conditions favorable for blooms can be substantially minimized by reducing nutrient-rich runoff from the landscape during warm, sunny spells. Water level and flow also helps to either flush out blooms or limit upstream nutrient sources to stymie growth.

2.1.7 Fish

Fish are an important natural resource for sustainable ecosystem food webs and provide recreational opportunities. Shaws Pond is a mesotrophic lake that supports populations of warmwater species including but not limited to largemouth bass, eastern chain pickerel, brown bullhead, and white perch. None of these species are listed as threatened or endangered by the NH Fish and Game Department.

2.1.8 Invasive Species

The introduction of non-indigenous invasive aquatic plant and animal species to New Hampshire's waterbodies has been on the rise. These invasive aquatic plants are responsible for habitat disruption, loss of native plant and animal communities, reduced property values, impaired fishing and degraded recreational experiences, and high removal costs. Once established, invasive species are difficult and costly to remove. NHDES indicates in its Lake Information Mapper that there are no known invasive species in Shaws Pond.

2.2 ASSIMILATIVE CAPACITY

The **assimilative capacity** of a waterbody describes the amount of pollutant that can be added to a waterbody without causing a violation of the water quality criteria. The assimilative capacity is based on a lake's target trophic designation, determined from trophic surveys. Shaws Pond was assessed as mesotrophic in 1984 and 1999 due to depleted dissolved oxygen and aquatic plant abundance, rather than elevated total phosphorus or chlorophyll-a, meaning oligotrophic standards for those parameters may be applicable for this pond for enhanced protection. Both the oligotrophic and mesotrophic designations were selected for running the assimilative capacity analysis for Shaws Pond. For mesotrophic waterbodies, the water quality criteria are set at 12 ppb for total phosphorus and 5.0 ppb for chlorophyll-a, above which the waterbody is considered impaired; the criteria are 8 ppb and 3.3 ppb, respectively, for oligotrophic waterbodies (Table 3). NHDES requires a portion of the difference between the best possible water quality and the water quality standard be kept in reserve as described in the 2024 Section 305(b) and 303(d) Consolidated Assessment and Listing Methodology (CALM); therefore, according to Table 3-17 of the CALM, total phosphorus and chlorophyll-a must be at or below 11.6 ppb and 4.8 ppb, respectively, to achieve Tier 2 High Quality Water status under a mesotrophic designation. Under an oligotrophic designation, the parameters must be at or below 7.2 ppb and 3.0 ppb, respectively, to achieve Tier 2 High Water Quality status. Support determinations are based on the nutrient stressor (phosphorus) and response indicator (chlorophyll-a), with chlorophyll-a dictating the assessment if both chlorophyll-a and total phosphorus data are available and the assessments differ.

Results of the assimilative capacity analysis show that Shaws Pond has total phosphorus and chlorophyll-a levels that exceed the thresholds for the oligotrophic standard, meaning it would be considered impaired based on an oligotrophic designation. For a mesotrophic designation, the pond does not exceed water quality standards and has ample reserve capacity, achieving Tier 2 (High Water Quality) status (Table 4). Though no statistically significant worsening trends have been identified to date (Figure 5), a higher level of protection may be advisable to prevent Shaws Pond from transitioning to a more productive trophic state as development expands within the watershed and as environmental variability progresses (refer to Section 2.4 Water Quality Goals & Objectives).

Table 3. Aquatic life integrity (ALI) nutrient criteria ranges by trophic class in New Hampshire. TP = total phosphorus. Chl-a = chlorophyll-a, a surrogate measure for algae including cyanobacteria.

Trophic State	TP (ppb)	Chl-a (ppb)
Oligotrophic	< 8.0	< 3.3
Mesotrophic	> 8.0 - 12.0	> 3.3 - 5.0
Eutrophic	> 12.0 - 28.0	> 5.0 - 11.0

Table 4. Assimilative capacity (AC) analysis results for Shaws Pond. Existing water quality data truncated to May 24-Sept 15 in the previous 10 years (2015-2024) for composite, epilimnion, or upper samples. Data were summarized by day, then month, then year using the median statistic.

Parameter	AC Threshold (ppb)	Existing Median WQ (ppb)*	Remaining AC (ppb)	Assessment Results
SHAWS POND – 1 DEEP (Oligotrophic Standards)				
Total Phosphorus	7.2	8.7	-1.5	Impaired
Chlorophyll-a	3.0	3.6	-0.6	Impaired
SHAWS POND – 1 DEEP (Mesotrophic Standards)				
Total Phosphorus	11.6	8.7	2.7	Tier 2 (High Water Quality)
Chlorophyll-a	4.8	3.6	1.2	Tier 2 (High Water Quality)

2.3 WATERSHED MODELING

2.3.1 Lake Loading Response Model (LLRM)

Environmental modeling is the process of using mathematics to represent the natural world. Models are created to explain how a natural system works, to study cause and effect, or to make predictions under various scenarios. Environmental models range from very simple equations that can be solved with pen and paper, to highly complex computer software requiring teams of people to operate. Lake models, such as the Lake Loading Response Model (LLRM), can make predictions about phosphorus concentrations, chlorophyll-a concentrations, and water clarity under different pollutant loading scenarios. These types of models play a key role in the watershed planning process. EPA guidelines for watershed plans require that pollutant loads to a waterbody be estimated.

The LLRM is an Excel-based model that uses environmental data to develop a water and phosphorus loading budget for lakes and their tributaries (AECOM, 2009). Water and phosphorus loads (in the form of mass and concentration) are traced from various sources in the watershed through tributary basins and into the lake. The model incorporates data about watershed and sub-watershed boundaries, land cover, point sources (if applicable), septic systems, waterfowl, rainfall, volume and surface area, and internal phosphorus loading. These data are combined with coefficients, attenuation factors, and equations from scientific literature on lakes, rivers, and nutrient cycles to generate annual average predictions of total phosphorus, chlorophyll-a, Secchi disk transparency, and algal bloom probability. The model can be used to identify current and future pollutant sources, estimate pollutant limits and water quality goals, and guide watershed improvement projects. A complete detailing of the methodology employed for the Shaws Pond LLRM is provided in the *Shaws Pond Lake Loading Response Model Report* (FBE, 2025b).

2.3.1.1 Lake Morphology & Flow Characteristics

The morphology (shape) and bathymetry (depth) of lakes and ponds are considered reliable predictors of water clarity and lake ecology. Large, deep lakes are typically clearer than small, shallow lakes as the differences in lake area, number and volume of upstream lakes, and **flushing rate** affect lake function and health.

The surface area of Shaws Pond is 70 acres (1.9 miles of shoreline) with a maximum depth of 16 feet (4.9 meters) and volume of 769,679 m^3 (Appendix A, Map A-1). The **areal water load** is 36 ft/yr (11 m/yr), and the flushing rate is 4 times per year. The flushing rate of 4 means that the entire volume of Shaws Pond is replaced 4 times per year.

2.3.1.2 Land Cover

Characterizing land cover within a watershed on a spatial scale can highlight potential sources of NPS pollution that would otherwise go unnoticed in a field survey of the watershed. For instance, a watershed with large areas of developed land (i.e., impervious cover) and minimal forestland will likely be more at risk for NPS pollution than a watershed with well-managed development and large tracts of undisturbed forest, particularly along headwater streams. Land cover is also the essential element in determining how much phosphorus is contributing to a surface water via stormwater runoff and baseflow.

Current land cover in the Shaws Pond watershed was determined by FBE using a combination of wetlands from the National Wetlands Inventory (NWI), waterbodies from the National Hydrography Dataset (NHD), roads from the New Hampshire Department of Transportation (NHDOT), and building footprints from the publicly available Microsoft building footprints layer. All data were acquired from New Hampshire's data clearinghouse, NH GRANIT. FBE edited the land cover file to add in residential and commercial development, logging, excavation, and other land uses using ESRI World Imagery and Google Earth satellite imagery. For more details on methodology, see the *Shaws Pond Lake Loading Response Model Report* (FBE, 2025b). Refer also to Appendix A, Map A-2.

As of the 2021 NAIP imagery verified with GoogleEarth imagery, development accounts for 7% (29.6 acres) of the watershed, logging accounts for 8% (36.2 acres), and forested and natural areas account for 76% (326.6 acres). Wetlands and open water represent 8% (33.8 acres) of the watershed, not including the surface area of Shaws Pond. Agriculture represents 0.2% (2.16 acres). Figure 10 shows a breakdown of land cover by major category for the entire watershed (not including the area of Shaws Pond), as well as total phosphorus load by major land cover category (refer to Section 2.3.1.4 or FBE, 2025a). Developed areas cover 7% of the entire watershed and contribute 61% of the entire total phosphorus watershed load to Shaws Pond. Development and associated impervious surfaces are most concentrated in the Golf Course Brook sub-watershed with the Village of Copple Crown, and around the eastern shoreline of Shaws Pond.

Developed areas within the Shaws Pond watershed are characterized by **impervious surfaces**, including areas with asphalt, concrete, compact gravel, and rooftops that force rain and snow that would otherwise soak into the ground to run off as stormwater. Stormwater runoff carries pollutants to waterbodies that may be harmful to aquatic life, including sediments, nutrients, salts, pathogens, pesticides, hydrocarbons, and metals. There are documented correlations between the percentage of effective impervious cover in a drainage area and the water quality of the receiving waterbody, with higher percent impervious cover, often greater than 10% as per the NHDES "1065 Rule", causing degradation of water quality and aquatic habitat. While an impervious cover analysis was not completed for this plan, impervious cover in the Shaws Pond watershed is less than 10% since developed land cover (at 7%) reflects all human-impacted areas, including impervious surfaces and non-impervious areas such as lawns.

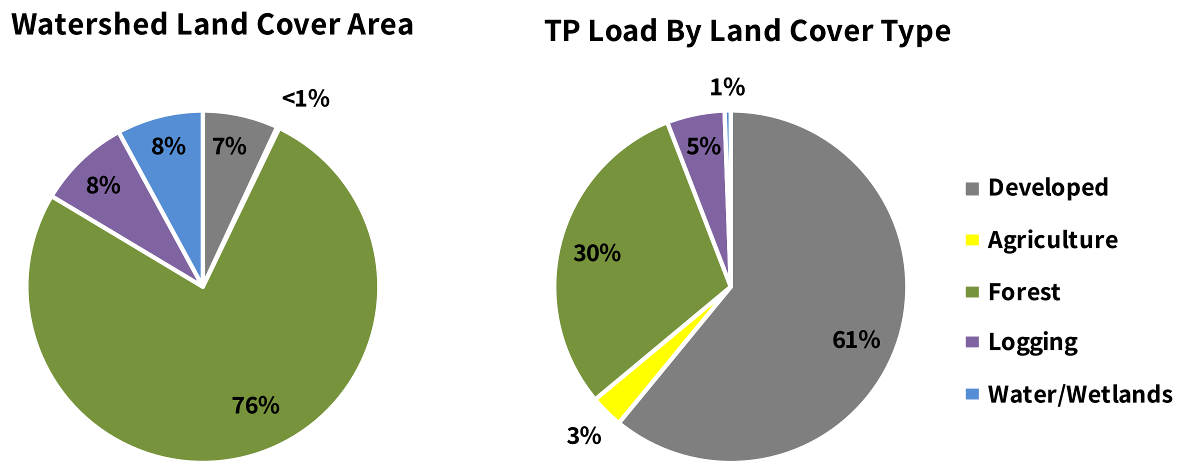

Figure 10. Shaws Pond watershed land cover area by general category (developed, agriculture, forest, and water/wetlands) and total phosphorus (TP) watershed load by general land cover type. This shows that while developed areas cover only 7% of the watershed, they contribute well over half the watershed phosphorus load.

2.3.1.3 Internal Phosphorus Loading

Phosphorus that enters the lake and settles to the bottom can be re-released from sediment under anoxic conditions, providing a nutrient source for algae, cyanobacteria, and plants. Internal phosphorus loading can also result from wind-driven wave action or physical disturbance of the sediment (boat props, aquatic macrophyte management activities). Internal loading estimates were derived from dissolved oxygen and temperature profiles taken at the deep spot of Shaws Pond to determine average annual duration and depth of anoxia defined as <2 ppm dissolved oxygen, and epilimnion/hypolimnion total phosphorus data taken at the deep spot of Shaws Pond to determine average difference between surface and bottom phosphorus concentrations. These estimates, along with anoxic volume and surface area, helped determine rate of release and mass of annual internal phosphorus load. Internal loading, whereby low dissolved oxygen in bottom waters is causing a release of phosphorus from sediments, was estimated as a relatively small source (7%) of phosphorus to the lake (Figure 11).

2.3.1.4 LLRM Results

Overall, model predictions were in good agreement with observed data for total phosphorus (within 2%), chlorophyll-a (within 18%), and Secchi disk transparency (0.1% difference) (Table 5). It is important to note that the LLRM does not explicitly account for all the biogeochemical processes occurring within a waterbody that contribute to overall water quality and is less accurate at predicting chlorophyll-a and Secchi disk transparency. For example, chlorophyll-a is estimated strictly from nutrient loading, but other factors strongly affect algae growth, including transport of phosphorus from the sediment-water interface to the water column by cyanobacteria, low light from suspended sediment, grazing by zooplankton, presence of heterotrophic algae, and flushing effects from high flows. There were insufficient data available to evaluate the influence of these other factors on observed chlorophyll-a concentrations and Secchi disk transparency readings.

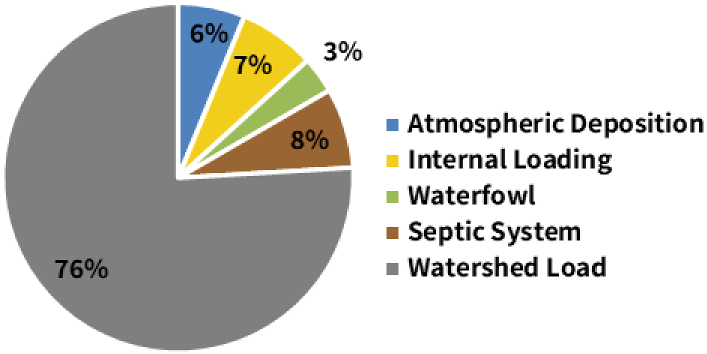

Figure 11. Summary of total phosphorus loading by major source for Shaws Pond. Refer to Table 6 for a breakdown.

Watershed runoff combined with baseflow (76%) was the largest phosphorus loading contribution across all sources to Shaws Pond (Figure 11). The remaining sources contributed less, including shorefront septic systems (8%), internal loading (7%), atmospheric deposition (6%), and waterfowl (3%). Development in the watershed is most concentrated in the Golf Course Brook sub-watershed with the Village of Copple Crown, and around the eastern shoreline where septic systems are located within a short distance to the water, leaving little horizontal (and sometimes vertical) space for proper filtration of wastewater effluent or leaks. Improper maintenance or siting of these systems can cause failures, which leach untreated, nutrient-rich wastewater effluent to the lake. Septic systems are only designed to reduce pathogen loads (and not nutrients like phosphorus), though many siting and design features that reduce pathogens usually (but not always) reduce nutrient loads to some degree. Therefore, even a properly sited, designed, and maintained septic system can occasionally be a source of phosphorus and nitrogen to downgradient streams and lakes. Any errors in siting, design, or installation, or malfunctions due to overuse or lack of maintenance may significantly increase nutrient loading from septic systems to the pond.

Internal loading is currently a relatively minor source of phosphorus to Shaws Pond. The model predicts seven or fewer bloom days (Table 5), which is on par with the actual bloom duration of six days in 2024.

Normalizing for the size of a sub-watershed (i.e., accounting for its annual discharge and direct drainage area) better highlights sub-watersheds with elevated pollutant exports relative to their drainage area. Sub-watersheds with moderate phosphorus mass exported by area (> 0.1 kg/ha/yr) generally had more development. These areas include the direct shoreline areas to Shaws Pond (Figure 12). Drainage areas directly adjacent to waterbodies have direct connection to lakes and are usually prime areas for development, thus increasing the possibility for phosphorus export.

Once the model is calibrated for current in-lake total phosphorus concentration, we can then adjust land use and other factor loadings to estimate historical and future phosphorus loading. Doing so allows us to estimate in-lake total phosphorus concentration prior to human development and future in-lake total phosphorus concentration following **full buildout** of the watershed under current zoning restrictions. A comparison of historical, current, and future water quality for Shaws Pond is shown in Table 6.

Pre-development loading estimation showed that total phosphorus loading to Shaws Pond increased by 187%, from 17.4 kg/yr prior to European settlement to 50 kg/yr under current conditions (Table 6). These additional phosphorus sources are coming from development in the watershed (especially from the direct shoreline drainage to Shaws Pond, and the Golf Course Brook and Boat Ramp Stream subwatersheds), septic systems, internal loading, and atmospheric dust (Table 6). Water quality prior to settlement was predicted to be excellent with extremely low phosphorus and chlorophyll-a concentrations and high water clarity (Table 5).

Future loading estimation showed that total phosphorus loading to Shaws Pond may increase by 116.6%, from 50 kg/yr under current conditions to 108.3 kg/yr at full build-out (anticipated in the year 2138) under current zoning for Shaws Pond (Table 6). Additional phosphorus will be generated from more development in the watershed (especially in the sub-watersheds of Golf Course Brook including the Village of Copple Crown, Washington Street Bridge, and the direct shoreline of Shaws Pond), enhanced internal loading, greater atmospheric dust, and more septic systems (Table 6). The model predicted higher (worse) in-lake phosphorus concentration (21.1 ppb), higher (worse) chlorophyll-a (8.0 ppb), and lower (worse) water clarity (2.2 m) compared to current conditions for Shaws Pond (Table 5). The number of bloom days may increase from an average of 7 days currently to an average of 148 days at full build-out (Table 5).

Table 5. In-lake water quality predictions for Shaws Pond. TP = total phosphorus. Chl-a = chlorophyll-a. SDT = Secchi disk transparency. Bloom Days represent average annual probability of chlorophyll-a exceeding 8 ppb.

Model Scenario	**Mean (Median) TP*** (ppb)	**Predicted Median TP** (ppb)	**Mean Chl-a** (ppb)	**Predicted Mean Chl-a** (ppb)	**Mean SDT** (m)	**Predicted Mean SDT** (m)	**Bloom Days**
Pre-Development	--	4.3	--	0.09	--	7.6**	0
Current (2024)	8.4 (10.0)	10.2	3.9	3.3	3.9	3.9	7
Future (2138)	--	21.1	--	8.0	--	2.2	148

**Mean TP concentration (first value) represents current in-lake epilimnion TP from observed data. Median TP concentration (second value in parentheses) represents 20% greater than the observed mean value as the value used to calibrate the model. Most lake data are collected in summer when TP concentrations are typically lower than annual average concentrations for which the model predicts.*

***Note that the predicted mean Secchi transparency is deeper than the maximum depth of the deep spot (4.9m) identified by NH Fish and Game.*

Table 6. Total phosphorus (TP) and water loading summary by source for Shaws Pond.

Source	**PRE-DEV**			**CURRENT (2024)**			**FUTURE (2138)**		
	TP (KG/YR)	**%**	**WATER (CU.M/YR)**	**TP (KG/YR)**	**%**	**WATER (CU.M/YR)**	**TP (KG/YR)**	**%**	**WATER (CU.M/YR)**
ATMOSPHERIC	2.0	11%	334,958	3.1	6%	334,958	7.0	6%	334,958
INTERNAL	0	0%	0	3.5	7%	0	7.6	7%	0
WATERFOWL	1.7	10%	0	1.7	3%	0	1.7	2%	0
SEPTIC SYSTEM	0.0	0%	0	3.7	8%	3,730	4.5	4%	4,679
WATERSHED LOAD	13.7	79%	2,741,349	38.0	76%	2,735,608	87.5	81%	2,722,781
TOTAL LOAD	17.4	100%	3,076,307	50	100%	3,074,296	108.3	100%	3,062,418

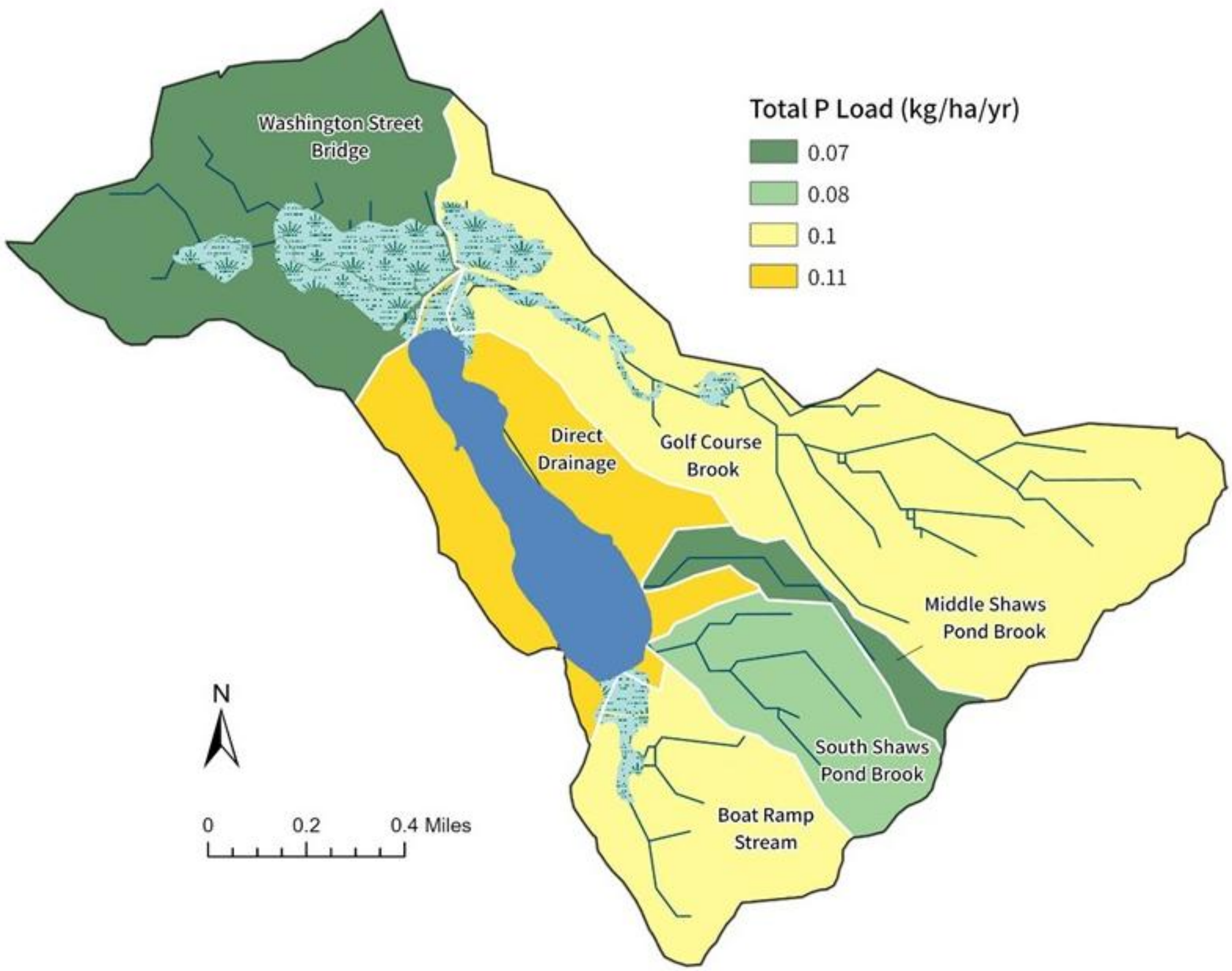

Figure 12. Map of current total phosphorus load per unit area (kg/ha/yr) for each sub-watershed in the Shaws Pond watershed. Higher phosphorus loads per unit area are concentrated in the more developed direct shoreline areas. The "Direct Drainage" subwatershed indicates stormwater flows directly to the lake without first flowing into a tributary.

2.3.2 Build-out Analysis

A full build-out analysis was completed for the Shaws Pond watershed for the municipalities of New Durham, Wolfeboro, and Brookfield (FBE, 2025a). A build-out analysis identifies areas with development potential and projects future development based on a set of conditions (e.g., zoning regulations, environmental constraints) and assumptions (e.g., population growth rate). A build-out analysis shows what land is available for development, how much development can occur, and at what densities. "Full Build-out" is a theoretical condition representing the moment in time when all available land suitable for residential, commercial, and industrial uses has been developed to the maximum capacity permitted by local ordinances and zoning standards. Local ordinances and zoning standards are subject to change, and the analysis requires simplifying assumptions; therefore, the results of the build-out analysis should be viewed as planning-level estimates only for potential future outcomes from development trends.

FULL BUILD-OUT is a theoretical condition representing the moment in time when all available land suitable for residential, commercial, and industrial uses has been developed to the maximum capacity permitted by current local ordinances and current zoning standards.

To determine where development may occur within the study area, the build-out analysis first subtracts land unavailable for development due to physical constraints, including environmental restrictions (e.g., wetlands, conserved lands, hydric soils), zoning restrictions (e.g., shoreland zoning, street Right-of-Ways (ROWs), and building setbacks), and practical design considerations (e.g., lot layout inefficiencies) (Appendix A, Map A-3). Existing buildings also reduce the capacity for new development.

The build-out analysis showed that 50% (512 acres) of the watershed is buildable under current zoning regulations (Appendix A, Map A-4). The Residential/Agricultural zone in New Durham has the most acreage within the watershed, and the most buildable area at 505 acres (Table 7). FBE identified 130 existing buildings within the watershed, and the build-out analysis projected that an additional 290 buildings could be constructed in the future, resulting in a total of 420 buildings in the watershed at full build-out (Appendix A, Map A-5). Currently, existing buildings are the densest along the eastern shore of Shaws Pond, accessed by Kings Hwy, and in the Village of Copple Crown, accessed by Mountain Dr. Though most of the Shaws Pond shoreline parcels are already developed, most of the projected buildings fall within the eastern and northern parts of the watershed. A large number of projected buildings were forecast within New Durham where there is little existing development and lot sizes are relatively small. Additional roadways would need to be built throughout the watershed for these projected buildings to be accessible.

Table 7. Amount of buildable land within the Shaws Pond watershed in New Durham, Wolfeboro, and Brookfield, NH.

Zone	Total Area (Acres)	Buildable Area (Acres)	Percent Buildable Area	Total No. Existing Buildings	Total No. Projected Buildings	Total No. Buildings	Percent Increase
New Durham							
Residential/Agricultural	*964*	*505*	*52%*	*124*	*289*	*413*	*233%*
Wolfeboro							
Rural Residential District (RR)	*47*	*6*	*14%*	*6*	*1*	*7*	*17%*
Brookfield							
Rural Residential/Agricultural	*21*	*0*	*0%*	*0*	*0*	*0*	-
Total	**1,032**	**512**	**50%**	**130**	**290**	**420**	**52%**

Three iterations of the TimeScope Analysis were run using compound annual growth rates (CAGR) for 20-, 30- and 50-year periods from 2000-2020 (1.03%), 1990-2020 (1.52%), and 1970-2020 (1.92%), respectively. Full build-out is projected to occur in 2138 at the 20-year CAGR, 2104 at the 30-year CAGR, and 2098 for the 50-year CAGR. This analysis showed that if the towns within the watershed continue to grow at recent rates identified in the 20-year period, and current zoning and other development constraints remain the same, full build-out could occur within 113 years (Figure 13).

Note that the growth rates used in the TimeScope Analysis are based on town-wide census statistics but have been applied here to a portion of the municipalities. If areas closer to the pond develop faster than more inland areas, watershed full build-out conditions may occur sooner. Also note that the population growth rate in these municipalities is decreasing, so the 20-year estimate is likely more accurate than the 50-year estimate. Using census data to project population increase and/or development has inherent limitations. For instance, the building rate may increase at a different rate than population, due to factors such as commercial versus residential development and number of people per household. As such, the TimeScope Analysis might over or underestimate the time required for the study area to reach full build-out. Numerous social and economic factors influence population change and development rates, including policies adopted by federal, state, and local governments. The relationships among the various factors may be complex and therefore difficult to model.

Table 8. Compound annual growth rates for the municipalities in the Shaws Pond watershed, used for the TimeScope Analysis. Data from U.S. Census Bureau.

Town	50 yr. Avg. 1970-2020	30 yr. Avg. 1990-2020	20 yr. Avg. 2000-2020
New Durham	3.11%	2.08%	1.04%
Wolfeboro	1.51%	1.21%	0.97%
Brookfield	2.71%	1.70%	1.26%
Combined	**1.92%**	**1.52%**	**1.03%**

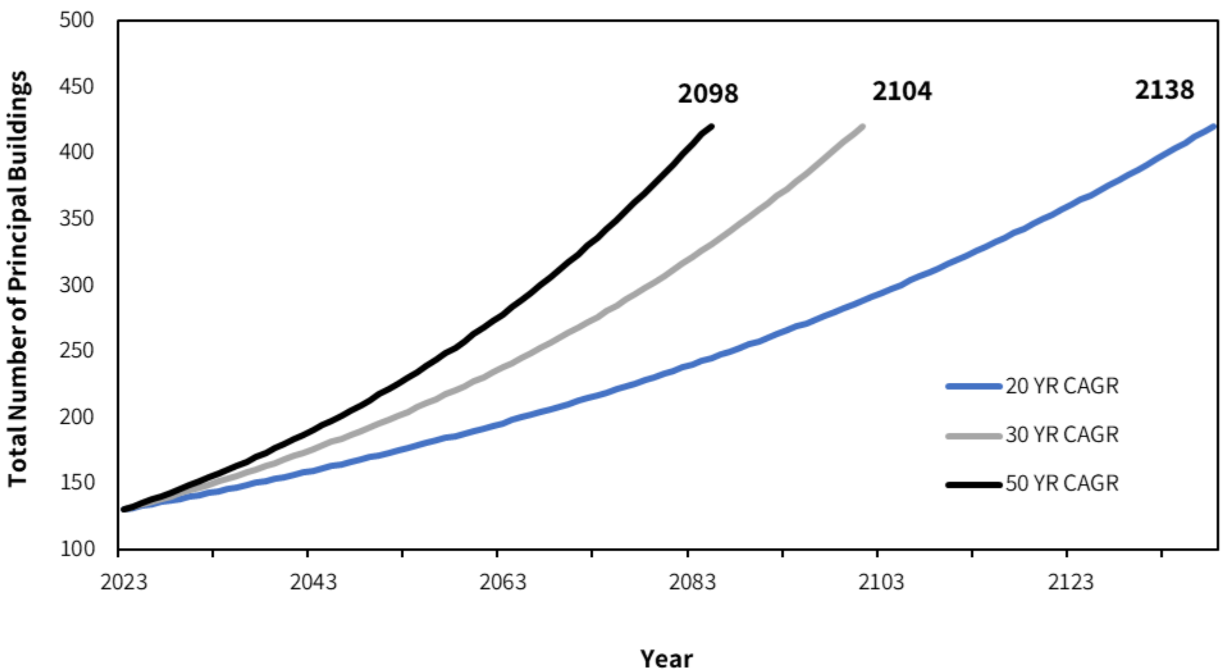

Figure 13. Full build-out time projections of the Shaws Pond watershed in New Durham, Wolfeboro, and Brookfield, NH (based on compound annual growth rates).

The build-out analysis can be combined with a land use model to identify which areas of the watershed are expected to have the greatest pollutant loading in the future and their subsequent impact on water quality, as well as to guide future development and conservation activities in the watershed. For example, conservation measures around the forested and emergent wetlands and headwater streams, in addition to the lakes and ponds, could aim to reduce future development in those critical areas. Increasing the minimum lot size, enacting a setback from wetlands and streams, or encouraging cluster development where development is grouped together to set aside remaining unfragmented land for conservation, are some of the tools that can be strategically used to shape development and protect the water quality of Shaws Pond. Despite the limitations of these spatial and numerical estimates, the build-out analysis serves as a useful planning tool.

2.4 WATER QUALITY GOAL & OBJECTIVES

The model results revealed changes in total phosphorus loading and in-lake total phosphorus concentrations over time from pre-development through future conditions, showing that the water quality of Shaws Pond is threatened by current development activities in the watershed and will degrade further with continued development in the future. We can use these results to make informed management decisions and set an appropriate water quality goal for Shaws Pond.

Although Shaws Pond is currently meeting water quality standards for mesotrophic lakes and has ample reserve capacity, the recent occurrence of a cyanobacteria bloom, the pond's small but established internal phosphorus loading dynamic, and predicted future development in the watershed indicate that there may not be reserve capacity for the lake to assimilate additional nutrients in the future under a "business as usual" scenario. Reducing watershed sources of phosphorus throughout the Shaws Pond watershed will be necessary to protect water quality in the long-term by preventing further accumulation of phosphorus that can feed cyanobacteria blooms. Clear and ambitious objectives are recommended to protect the water quality of Shaws Pond over the long term.

The goal of the Shaws Pond WBMP is to improve the water quality of Shaws Pond such that it exceeds the assimilative capacity threshold for oligotrophic waterbodies, decreases phosphorus load to the pond, increases water clarity, and substantially reduces the likelihood of harmful cyanobacteria blooms in the pond. This goal will be achieved by accomplishing the following objectives.

> **Objective 1:** Reduce phosphorus loading to Shaws Pond from existing development by 17% (8.4 kg/yr) to improve the average in-lake summer total phosphorus concentration to 7.0 ppb and annual chlorophyll-a concentration to 2.5 ppb.
>
> **Objective 2:** Mitigate (prevent or offset) phosphorus loading to Shaws Pond from future development by 5.1 kg/yr to maintain average summer in-lake total phosphorus concentration in the next 10 years (2034).

Measures of success toward achieving the goal and objectives include reduction in phosphorus loading from Shaws Pond tributaries and from shorefront BMPs, septic system upgrades, and reduced frequency and severity of cyanobacteria blooms. While any amount of phosphorus load reduction to the lake will be helpful for controlling cyanobacteria blooms, it is important to understand that the dominant cyanobacteria taxa in the lake can uptake phosphorus from phosphorus-rich sediments and store phosphorus for later use under more optimal growth conditions. Thus, managing cyanobacteria blooms is not entirely straightforward and depends on additional ecological factors out of our direct control. The physiological characteristics of these cyanobacteria taxa also mean that the typical application of the state's water quality standards and assimilative capacity may be somewhat less effective for Shaws Pond.

Reality Check for Meeting Objectives 1 and 2: The watershed survey identified 17 sites impacting the lake. Remediating these sites could prevent up to 13.16 kg/yr of phosphorus from entering Shaws Pond. Treating shoreline sites could reduce the phosphorus load to Shaws Pond by 2.72 kg/yr[2] for the 4 medium impact sites (disturbance score between 9-10), and 5.44 kg/yr[3] for the 16 low impact sites (disturbance score between 7-8) identified from the shoreline survey. The phosphorus load from the "Shaws Pond Access" site is accounted for as part of the watershed survey rather than the shoreline survey here. Upgrading ten shorefront septic systems

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[2] Based on PLET model bank stabilization estimate for fine sandy loams, using 100 ft (length) by 3 ft (height) and moderate lateral recession rate of 0.1 ft/yr.

[3] Based on PLET model bank stabilization estimate for fine sandy loams, using 50 ft (length) by 3 ft (height) and moderate lateral recession rate of 0.1 ft/yr.

most in need based on system type and condition, underlying soil type, and location is estimated to reduce the phosphorus load to Shaws Pond by 1.0 kg/yr. **In sum, treating all existing pollutant sources identified as coming from the external watershed load could reduce the phosphorus load to Shaws Pond by 22.32 kg/yr, meeting 266% of Objective 1 for Shaws Pond.** Non-structural best management practices (BMPs) such as educating homeowners about septic system maintenance, fertilizer use, and residential stormwater management may also contribute to reducing phosphorus loading to Shaws Pond by preventing septic system failures, reducing the amount of fertilizer used on residential lawns, and encouraging stormwater management at the property-scale.

The interim goals for each objective allow flexibility in re-assessing water quality objectives following more data collection and expected increases in phosphorus loading from new development in the watershed over the next 10 or more years (Table 9). Understanding realized water quality improvements due to watershed improvements compared to predicted water quality under a no-action scenario will help guide adaptive changes to interim goals (e.g., actions are meeting goals, or actions are falling short of goals). If the goals are not being met due to lack of funding or other resources for implementation projects versus due to increases in phosphorus loading from new development outpacing achieved phosphorus reductions elsewhere, then this indicates much different conditions from which to adjust interim goals. For each interim goal year, stakeholders should update the water quality data and model, then assess if and why goals are or are not being met. Stakeholders will then decide on how to adjust the next interim goals to better reflect water quality conditions and any practical limitations to implementation.

Table 9. Summary of water quality objectives for Shaws Pond. Interim goals/benchmarks are cumulative.

Water Quality Objective	**Interim Goals/Benchmarks**		
	2027	**2030**	**2034**
1. Reduce phosphorus loading from existing development by 17% (8.4 kg/yr) to improve average in-lake summer total phosphorus concentration to 7.0 ppb and achieve chlorophyll-a of 2.5 ppb for oligotrophic waterbodies.	Achieve 4.25% (2.1 kg/yr) reduction in TP loading to Shaws Pond.	Achieve 8.5% (4.2 kg/yr) reduction in TP loading to Shaws Pond; re-evaluate water quality and track progress	Achieve 17% (8.4 kg/yr) reduction in TP loading to Shaws Pond; re-evaluate water quality and track progress
2. Mitigate (prevent or offset) phosphorus loading from future development by 5.1 kg/yr to maintain average summer in-lake total phosphorus concentration in the next 10 years (2034).	Prevent or offset 1.275 kg/yr in TP loading from new development to Shaws Pond.	Prevent or offset 2.55 kg/yr in TP loading from new development to Shaws Pond; re-evaluate water quality and track progress	Prevent or offset 5.1 kg/yr in TP loading from new development to Shaws Pond; re-evaluate water quality and track progress

3 POLLUTANT SOURCE IDENTIFICATION

This section describes sources of excess phosphorus to Shaws Pond. Sources of phosphorus to lakes include stormwater runoff, shoreline erosion, logging/construction activities, failed or improperly functioning septic systems, leaky sewer lines, boat discharges, fabric softeners and detergents in greywater, fertilizers, and pet, livestock, and wildlife waste. These external sources of phosphorus to lakes can then circulate within lakes and settle on lake bottoms, contributing to internal phosphorus loads over time. Additional phosphorus sources can enter the lake from atmospheric deposition but are not addressed here because of limited local management options. Wildlife is mentioned as a potential source but largely for nuisance waterfowl such as geese or ducks that may be congregating in large groups because of human-related actions such as feeding or having easy shoreline access (i.e., lawns). Environmental variability is also not a direct source but can exacerbate the impact of the other phosphorus sources identified in this section and should be considered when striving to achieve the water quality objectives.

3.1 WATERSHED DEVELOPMENT

NPS pollution comes from many diffuse sources on the landscape and is more difficult to identify and control than point source pollution. NPS pollution can result from contaminants transported by overland runoff (e.g., agricultural runoff or runoff from suburban and rural areas), groundwater flow, or direct deposition of pollutants to receiving waters. Examples of NPS pollution that can contribute nutrients to surface waters via runoff, groundwater, and direct deposition include erosion from disturbed ground or along roads, stormwater runoff from developed areas, malfunctioning septic systems, boat discharges, excessive fertilizer application, pet waste, unmitigated agricultural activities, flooding, potential contamination sources, and wildlife waste.

3.1.1 Historical Development

Before European settlement, the area was inhabited by Native Americans who travelled along well-established trails for hunting, fishing, and crop growing. According to Chester B. Price of New Durham and author of the book titled “Historic Indian Trails of New Hampshire 1756 to 2003,” the trails traversed New Durham in several places. For example, the Ko-KchiKook (Cocheco) Trail (now Old Bay Road and Main Street) in New Durham traveled to Alton Bay at Lake Winnipesaukee, and the Abenaki Trail (now Kings Highway) traveled to Wolfeboro.[4] During this time, the area was mostly forested with minimal human impacts on the environment.

Early settlers began clearing land. The colonists originally farmed for sustenance, and large dairy and poultry farms became common as time progressed. By 1721, the New Hampshire Colonial Assembly voted to cut a road from Dover (Cocheco) to Lake Winnipesaukee to construct a fort at the lake. The road followed the trails used by the Native Americans traveling to Alton Bay and became known as Bay Road. As the trails became roads and a peace treaty between Europeans and Native Americans was signed by 1760, colonial settlement and wood harvesting in the area took root. People settled around the many waterbodies in New Durham, including Shaws Pond, Merrymeeting Lake, Coldrain Pond, Merrymeeting River, March and Chalk Ponds, as well as the Mad, Isinglass, Ela, and Cocheco Rivers. Waterways were used for power, moving goods, and food. Many sawmills were soon erected in the area, most notably the one that created Downing Pond along the Merrymeeting River through a dam constructed in the late 1700’s during which time New Durham was granted its town charter.

[4] Adapted from research documents gathered by former Town Historian Eloise Bickford, current Town Historian Catherine Orlowicz, and author of “The History of New Durham” Ellen Jennings.

Tourism was a large part of the Lake Region's identity and economy early in its history, beginning with Governor Wentworth's seasonal estate and the construction of the first large hotel in 1795. In 1872, the tourist industry began to expand when the Eastern Railroad was extended into Wolfeboro, connecting the region to Boston and Maine (Denu, 2017). The railroad service allowed the region's industries to flourish as it improved the transport of goods, allowed for the creation of summer camps and hotels, and encouraged tourists to purchase lakefront property to build summer cottages (Town of Wolfeboro, 2019).

In the 1960's, tourism increased dramatically, leading to downtown commercial development. Year-round development grew in addition to tourism. The population in New Durham grew from 583 to 1,183 (34%) between 1970 and 1980 according to the U.S. Census. The rapid population growth was sustained though the turn of the century until it slowed in the 2010s.

Present-day New Durham has changed dramatically since its settlement. Areas that were once served by outhouses with no electricity or running water now have septic systems and modern amenities. While shoreline development began with the construction of summer cottages, contemporary summer homes have increasingly large footprints. As new summer homes are built, others are being converted to year-round use. Tourism is still a large industry in the region, with various inns, golf courses, and private rentals.

3.1.2 Watershed Survey

A watershed survey of the Shaws Pond watershed was completed by technical staff from FBE as part of the development of the Wolfeboro Bay WBMP, and again for the Shaws Pond WBMP. For the Shaws Pond Watershed Survey, FBE was accompanied by a representative of the WQC for a more in-depth survey. The objective of the watershed surveys were to identify and characterize sites contributing to NPS pollution and/or providing opportunities to mitigate NPS pollution in the watershed. Prior to the field work, FBE solicited input from WQC about locations with known NPS pollution. FBE also analyzed aerial images and GIS data for land use/land cover, roads, municipal drainage system, public properties, waterbodies, and other features. This information enabled FBE to better plan for the survey (e.g., to target known or likely high-polluting sites, such as unpaved roads, beaches, highly impervious areas, etc.) and to recommend solutions.

FBE conducted the watershed survey of the Shaws Pond portion of the Wolfeboro Bay watershed on July 12, 2023, and identified 12 NPS sites. On April 22, 2024, FBE and the WQC re-surveyed the Shaws Pond watershed and documented an additional four NPS sites. An additional site was added afterward from feedback received during a project meeting.

For each location, field staff recorded site data and photographs on tablets. Information collected included location description and GPS coordinates; NPS problem description and measurements (e.g., gully dimensions); receiving waterbody; discharge type (direct or indirect/limited); and preliminary recommendations to mitigate the NPS problem. Field staff accessed sites from public and private roads and waterfront access points.

In total, 17 NPS sites were identified in the Shaws Pond watershed (Figure 14). The main issues found were road shoulder ditch erosion, unstable water access points, and buffer clearings. FBE estimated the potential pollutant removal that could be achieved by implementing recommendations as 13.16 kg of phosphorus per year. Appendix B summarizes the recommendations, load reduction estimates, and estimated costs for each site. The top five high priority sites (based on lowest impact-weighted cost per mass of phosphorus removed and project engineer/local stakeholder input) are shown below. In addition to these specific sites, managers of both private and public roads should use best practices for road installation and maintenance for water quality protection. The Town of New Durham has already begun working with an engineering firm to mitigate stormwater erosion and improve the stability of the Shaws Pond Access Point (site 1-8). This project represents a great opportunity for the Town and pond community to incorporate green stormwater control designs that are more protective of water quality.

Site 1-8: Shaws Pond Access

Location (latitude, longitude): 43.52920, -71.13875. Impact: High

Observations: The access point for Shaws Pond features a small beach with a boat launch. The entrance road to the access point is slightly sloped and funnels stormwater toward the pond. As a result, numerous gullies have formed along the surface of the path, and sediment has accumulated near the shoreline. No vegetated shoreline buffer is present along the beach. A small wetland to the west of the water access point feeds the pond; the stream connecting the wetland and the beach has the highest specific conductivity and chloride levels in the pond's watershed, according to a local resident. Other residents have mentioned that the prevailing winds on the lake blow towards this site, causing a concentration of pollutants and debris in the vicinity. Many signs exist on the beach urging proper trash disposal, but residents report issues with waste on the beach. No waste or toilet facilities are available on the site. Residents have reported seeing the site being used as a boat launch and public beach, with use is especially high on holidays in the summer, when up to four cars are parked on the site.

Recommendations: It is recommended to partner with an engineering firm to develop a site-specific restoration plan. Preliminary recommendations include stabilizing the accessway by adding additional stony material stabilized by an interlocking grid to prevent the concentrated flow of stormwater toward the shoreline. It is recommended to install runoff diverters so that the stormwater does not follow a direct path to the pond but is instead redirected to a newly vegetated area. We recommend diverting stormwater away from the wetland into a designated infiltration area such as a rain garden or infiltration trench/basin. A shoreline buffer should be established along the pond at the base of the roadway consisting of large native shrubs and trees. Planting shrubs and riparian plants can stabilize the shoreline in areas not used for recreation. Establishing a vegetated buffer prevents erosion by stabilizing the soil and slowing stormwater, which often carries nutrients bound in sediments. Swimming areas can be reestablished to the side if the Town decides to maintain the site's use as a public beach. An additional recommendation is to continue efforts to establish a pond association and engage with the Town of New Durham to gain support in conservation efforts. We also recommend establishing waste facilities near the beach that are to be maintained by the Town, including trash cans and a portable toilet.

(Left) Numerous gullies have formed as stormwater is channeled down the path toward the shoreline. (Right) No shoreline buffer exists even outside of the area used for recreation. Photos taken on 7/12/23.

(Left) Shaws Pond access driveway leading to the beach area (Right) Shoreline of the Shaws Pond access site contains debris carried by stormwater flow. Photos taken in May 2025.

Site 1-9: Kings Hwy near House 274

Location (latitude, longitude): 43.52988, -71.13763.
Impact: High

Observations: The road shoulder on the eastern side of Kings Hwy has eroded to create a few small gullies that funnel stormwater and sediment directly into South Shaw Stream that ultimately flows into Shaws Pond. The culvert flowing underneath the road is unstable, as are the streambanks. The banks are severely down cut and eroding, which is accelerated by large storm events. Erosion from streambanks and the road shoulder can contribute to excessive nutrient loading directly to the stream because nutrients such as phosphorus are held in sediment. The water quality of Shaws Pond has become a point of concern to the Town of New Durham in recent years as the pond has changed from oligotrophic to mesotrophic between 2018 and 2022. Elevated chloride levels are also a concern for Shaws Pond. This site is of additional concern because of the high volume of sediment from South Shaw Stream that has formed a delta in the pond.

Top photos: Road shoulder erosion has caused a gully that flows directly into a stream. Bottom photos: The banks along the stream are unstable and easily eroded.

Recommendations: We recommend that the bank along the shore of the stream be stabilized to prevent excess sediment and nutrient loading to Shaws Pond. It is also recommended that the road shoulder be reshaped and armored with stone or grass and check dams to prevent sediment from being carried into the stream via stormwater runoff. Turnouts may be installed to direct stormwater into forested areas, away from the stream.

1: Facing north along Kings Hwy (4/22/24). 2: The three tributaries that join to form South Shaw Stream (east of Kings Hwy). Photos taken on 4/22/24. 3: The delta that has formed at the outlet of South Shaw Stream in Shaws Pond. 4: A close-up of the fine sediment forming the peninsula.

Site 1-10: Kings Hwy North of Site 1-09

Location (latitude, longitude): 43.53020, -71.13759. Impact: Low

Observations: The road shoulder on the eastern side of Kings Hwy is eroding to create a channel devoid of vegetation which is filling with sediment from stormwater runoff. Large amounts of soil were observed to be eroding from the road shoulder and from the edge of the forest into the ditch that has formed.

Recommendations: We recommend that the road shoulder and ditch be reshaped and stabilized with riprap. The site is gently sloping and is near a highly forested area. If further site evaluation identifies space for turnouts and infiltration, this would be recommended before installing a riprap ditch.

Road surface and shoulder erosion on Kings Hwy (Site 1-10).

Site SP-2: Kings Hwy Near House 290

Location (latitude, longitude): 43.53236, -71.13800. Impact: High

Observations: An erosion gully has formed along the eastern shoulder of Kings Highway to the north of House 290, extending 128 feet and sloping down towards a culvert that channels runoff to the west side (pond side) of the road. Although the gully is relatively shallow, there is noticeable sediment transport.

Recommendations: We recommend armoring the eastern road shoulder with stone and check dams to promote enhanced infiltration of stormwater. Revegetating with native plants will provide additional stabilization and filtering of sediment.



View of the stormwater ditch conveying runoff down the eastern road shoulder (left) to the culvert inlet (center) and to the culvert outlet on the west side of Kings Highway (right).

Site SP-3: Kings Hwy Near Houses 274-280

Location (latitude, longitude): 43.53023, -71.13763. Impact: High

Observations: Erosion is occurring along a 280-foot stretch of the western shoulder of Kings Highway, between Houses 274 and 280. The shoulder consists of exposed sand and loose gravel, with sediment washing onto the road and across driveways. Stormwater runoff flows either down the driveway of House 276 towards the lake or into a catch basin near the garage of House 274, which discharges into South Shaw Stream through an underground pipe. A local resident noted that while dry most of the time, during spring snowmelt and summer storm events, water rushes rapidly down this site.

Recommendations: To address the erosion along the road shoulder, we recommend armoring the shoulder with crushed stone and installing check dams or vegetated bioswales where feasible. Landowners may also consider planting vegetated buffer strips or creating rain gardens to slow and filter runoff at the downhill end of the driveways by the pond. For more immediate stabilization, erosion control mats or wattles could be installed. UNH has developed a helpful resource for choosing species to establish a successful rain garden in New England. We recommend that engineers be consulted for determining the appropriate size, number, and spacing of check dams or design of the bioswale if these options are considered. It is also recommended that the homeowners consider replacing the sandy gravel driveway areas with only crushed stone stabilized by an interlocking permeable grid. Note that implementation on private property requires permission and approval by the landowners.

View of road shoulder erosion from north of House 280 (A) along the road shoulder past the mailbox of House #76 (B), and to the driveway of House #276 (C). Stormwater then either flows down the driveway of House #276 (D) or if it reaches the catch basin at the garage of House 274, it discharges via the pipe indicated in photo E to South Shaw Stream.

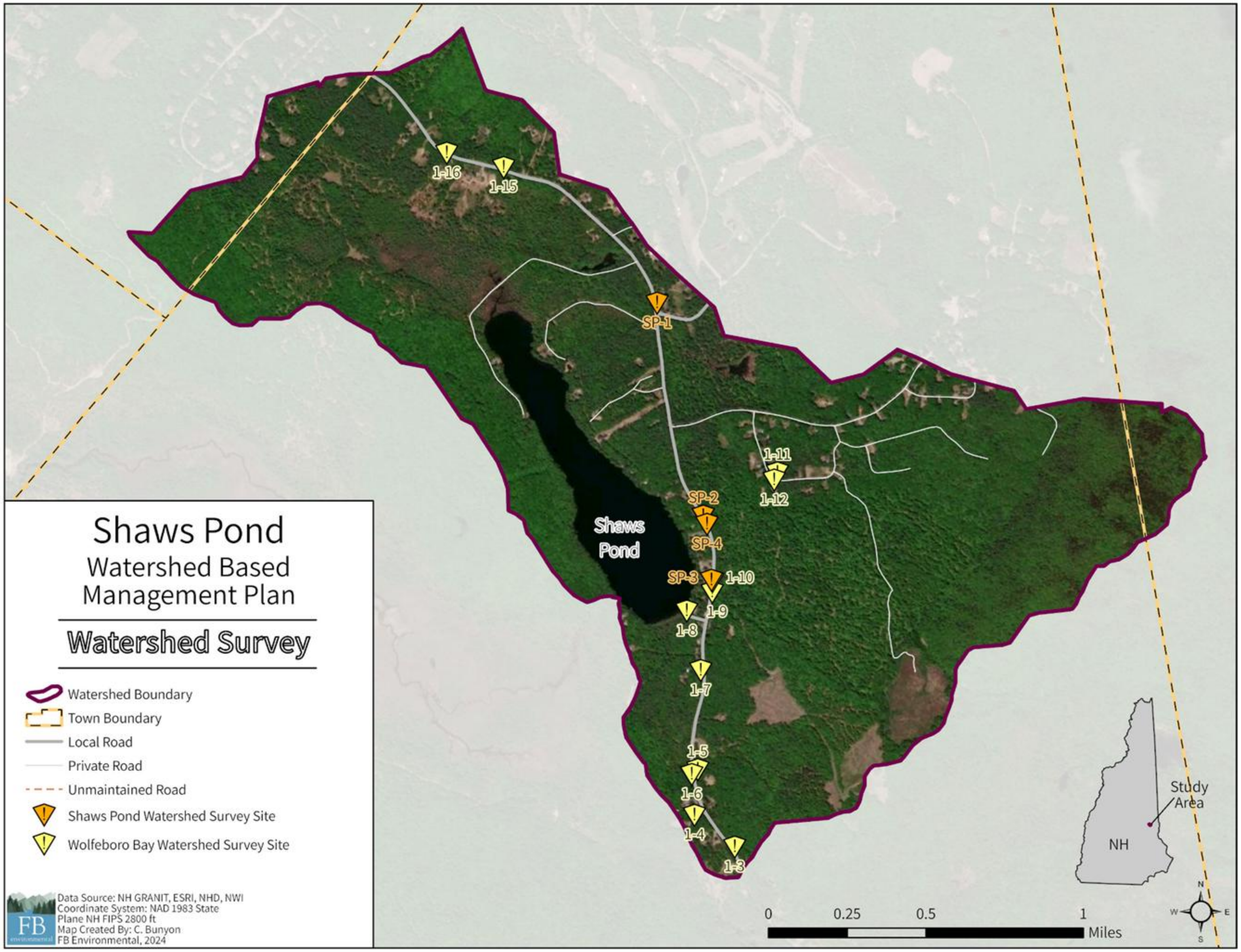

Figure 14. Map of NPS sites identified in both the Wolfeboro Bay watershed survey and the Shaws Pond watershed survey.

3.1.3 Shoreline Survey

Representatives from the WQC conducted a shoreline survey in 2023 following FBE-approved methods. The shoreline survey uses a simple scoring method to highlight shoreline properties around the lake that exhibit significant erosion. This method of shoreline survey is a rapid technique to assess the overall condition of properties within the shoreland zone and prioritize properties for technical assistance or outreach. Volunteers documented the condition of the shoreline for each parcel using a scoring system that evaluates vegetated buffer, presence of bare soil, extent of shoreline erosion, distance of structures to the lake, and slope.[5] These scores were summed to generate an overall "Shoreline Disturbance Score" and "Shoreline Vulnerability Score" for each parcel, with high scores indicating poor or vulnerable shoreline conditions. Photos were taken at each parcel and were cataloged by tax map-lot number. These photos will provide the town with a valuable tool for assessing shoreline conditions over time. It is recommended that a shoreline survey be conducted in mid-summer every five years to evaluate changing conditions.

A total of 44 parcels were evaluated along the shoreline of Shaws Pond. The average Shoreline Disturbance Score (Buffer, Bare Soil, and Shoreline Erosion) for the entire lake was 6.14 (Table 10). About 48% of the shoreline (or 21 parcels) scored 7 or greater. A disturbance score of 7 or above indicates shoreline conditions that may be detrimental to lake water quality. These shoreline properties tended to have inadequate buffers, evidence of bare soil, and shoreline erosion. The average Shoreline Vulnerability Score (Distance and Slope) was 3.68 (Table 10). About 70% (or 31 parcels) scored 4 or greater. A vulnerability score of 4 or greater indicates that the parcel may have a home less than 150 feet from the shoreline and a moderate or steep slope to the shoreline. Parcels with a vulnerability score of 4 or greater are more prone to erosion issues whether or not adequate buffers and soil coverage are present.

Table 10. Average scores for each evaluated condition criterion and the average Shoreline Disturbance Score and average Shoreline Vulnerability Score for Shaws Pond. Lower values indicate shoreline conditions that are effective at reducing erosion and keeping excess nutrients out of the lake. Note: the numbers in parentheses are the range of possible scores for that variable.

Evaluated Condition	Average Score	Total Score
Buffer (1-5)	3.2	Average Shoreline Disturbance Score (3-12) **6.14**
Bare Soil (1-4)	1.7	
Shoreline Erosion (1-3)	1.7	
Distance (0-3)	2.2	Average Shoreline Vulnerability Score (1-6) **3.68**
Slope (1-3)	1.8	

The pollutant loading estimates are based on the Shoreline Disturbance Scores. The 21 parcels with scores 7-12, are contributing approximately **9.53 kg of phosphorus annually**[6]. Remediation efforts on all properties using a 50% Best Management Practices (BMP) efficiency rate could result in an **annual reduction of 4.76 kg of phosphorus**. Note the Shaws Pond Access site was also included in the shoreline survey but was only counted once (as part of the Watershed Survey) for values carried into the Water Quality Goal.

[5] Shoreline erosion can be from or exacerbated by natural phenomena or human-related activities. Natural phenomena typically include the orientation of the parcel to prevailing winds and subsequent greater wave action, composition of the shoreline bank (whether highly erodible soil material or hardened rocky or bedrock outcroppings), and winter ice damage. Human-related activities typically include motorboating (which generate wakes whose wave energy is dissipated by the shoreline) and shoreline development (which includes retaining walls, beaches, access points, etc.).

[6] Based on Region 5 model bank stabilization estimate for fine sandy loams, using 50 ft or 100 ft or 200 ft (length) by 3 ft (height) and moderate lateral recession rate of 0.1 ft/yr.

Certain site characteristics, such as slope, can cause shorelines to be naturally more vulnerable to erosion. Other site characteristics such as structure distance to the lake, are often a direct consequence of the historic development on that parcel and cannot be easily changed. Shoreline buffers and amount of exposed soil are more easily changed to strengthen the resiliency of the shoreline to disturbance in the watershed. In summary, the overall average shoreline condition of Shaws Pond is good, though improvements can be made to combat erosion issues (average disturbance score below 7), with 21 properties (48%) needing to address erosion issues that are impacting the lake. Shaws Pond is also generally more prone to erosion issues because many homes are located close to the shoreline (56%).

Scores should be used to prioritize areas of the shoreline for remediation. Recommendations largely include improving shoreline vegetated buffers. Encouraging landowners to plant and/or maintain vegetated buffers as a BMP along their shoreline, particularly in areas of bare soil, will help mitigate erosion and reduce sediment and nutrient loading to the lake. The New Durham WQC and the Friends of Shaws Pond have been educating shoreline residents on the importance of mitigating residential stormwater runoff, erosion, and maintaining healthy shoreline buffers. Nineteen shoreline properties have completed the Lake Smart survey. Five properties have requested visits from a Lake Smart representative, and three have acquired the Lake Smart certificate. The Friends of Shaws pond will continue to promote this program and educate shoreline residents.

3.1.4 Soil & Shoreline Erosion

Erosion can occur when ground is disturbed by digging, construction, plowing, foot or vehicle traffic, or wildlife. Rain and associated runoff are the primary pathways by which eroded soil reaches lakes and streams. Once in surface waters, nutrients are released from the soil particles into the water column, causing excess nutrient loading to surface waters or cultural eutrophication. Since development demand near lakes is high, construction activities in lake watersheds can be a large source of nutrients. Unpaved roads and trails used by motorized vehicles near lakes and streams are especially vulnerable to erosion. Stream bank erosion can also have a rapid and severe effect on lake water quality and can be triggered or worsened by upstream impervious surfaces like buildings, parking lots, and roads which send large amounts of high velocity runoff to surface waters. Maintaining natural vegetative buffers around lakes and streams and employing strict erosion and sedimentation controls for construction can minimize these effects.

3.1.4.1 Surficial Geology

The composition of soils in the area reflect the dynamic geological processes that have shaped the landscape of New Hampshire over millions of years. Some 300 to 400 million years ago, much of the northeastern United States was covered by a shallow sea; layers of mineral deposition compressed to form sedimentary layers of shale, sandstone, and limestone (Goldthwait, 1951). Over time, the Earth's crust then folded under high heat and pressure to change the sedimentary rocks into metamorphic rocks (quartzite, schist, and gneiss parent material). This metamorphic parent material has since been modified by bursts of molten material intrusions to form igneous rock, including granite for which New Hampshire is famous (Goldthwait, 1951). Erosion has further modified and shaped this parent material over the last 200 million years.

The current landscape formed 12,000 years ago at the end of the Great Ice Age, as the mile-thick glacier over half of North America melted and retreated, scouring bedrock and depositing glacial till to create the deeply scoured basin of the region's lakes. The retreating action also eroded mountains and left behind remnants of drumlins and eskers from ancient stream deposits. The glacier deposited a layer of glacial till more than three feet deep. Glacial till is composed of unsorted material, with particle sizes ranging from loose and sandy to compact and silty to gravely. This material laid the foundation for vegetation and streams as the depression basins throughout the region began to fill with water (Goldthwait, 1951).

The unique geological formation in this area formed the Winnipesaukee River Basin Stratified Drift Aquifers, comprising seventeen of the cleanest and most productive aquifers in the region. A portion of one of these aquifers can be found within the study area beneath the wetland to south of Shaws Pond (Figure 1). This aquifer has a maximum transmissivity of 1,000 ft^2/day. By receiving groundwater from stratified drift aquifers, Shaws pond is a discharge point for the Winnipesaukee River Basin Stratified Drift Aquifer. Any contamination in this aquifer will move quickly due to the high transmissivity of the material and enter Shaws Pond. Therefore, protection of the aquifer is vital to the protection of the bay.

3.1.4.2 Soils and Erosion Hazard

The soils in the Shaws Pond watershed (Appendix A, Map A-6) are a direct result of geologic processes. Of the 14 different soil series present within the Shaws Pond watershed (excluding soils beneath waterbodies), the most prevalent soil group in the watershed is Gloucester extremely stony fine sandy loam (45%), followed by Hollis-Gloucester extremely rocky fine sandy loam (18%), and Gloucester very stony fine sandy loam (18%). Stony or rocky fine sandy loams are all well to excessively drained. The remaining 19% of the watershed (excluding soils under waterbodies) is a combination of 11 additional soil series ranging from 5% to 0.07% of the watershed.

Soil erosion hazard is dependent on a combination of factors, including land contours, climate conditions, soil texture, soil composition, permeability, and soil structure (O'Geen et al., 2006). Soil erosion hazard should be a primary factor in determining the rate and placement of development within a watershed. Soils with negligible soil erosion hazard are primarily low-lying wetland areas near abutting streams. The soil erosion hazard for the watershed was determined from the associated slope and soil erosion factor K_w[7] used in the Universal Soil Loss Equation (USLE). The USLE predicts the rate of soil loss by sheet or rill erosion in units of tons per acre per year. A rating of "slight" specifies erosion is unlikely to occur under standard conditions. A rating of "moderate" specifies some erosion is likely and erosion-control measures may be required. A rating of "severe" specifies erosion is very likely and erosion-control measures and revegetation efforts are crucial. A rating of "very severe" specifies significant erosion is likely and control measures may be costly. Excluding soils under waterbodies, "severe" erosion hazard areas are not present within the Shaws Pond watershed (Appendix A, Map A-7). Moderate erosion hazard areas account for 71% of the watershed land area (803 acres). Slight erosion hazard areas account for 19% (217 acres), and 105 acres or 9% are not rated. Since a highly erodible soil can have greater negative impact on water quality, more effort and investment are required to maintain its stability and function within the landscape, particularly from BMPs that protect steep slopes from development and/or prevent stormwater runoff from reaching water resources. Other areas prone to erosion include steeply sloped areas and areas with roadways within 50 feet of the waterbody (Appendix A; Map A-8).

3.1.4.3 Shoreline Erosion

Water level fluctuations in lakes and ponds can occur on long- and short-term timescales due to naturally changing environmental conditions or as a response to human activity. The small wooden board dam at the outlet of Shaws Pond is on private property and is controlled by the property owner. This dam was removed from the list of inspected dams by the NHDES Dam Bureau. Upon assessment, the NHDES Dam Bureau noted that should the Shaws Pond dam fail, there is no immediate threat to downstream infrastructure. The effect of lake level fluctuation on physical and environmental conditions depends on several factors including the degree of change in water level, the rate of change, seasonality, and the size and depth of the waterbody (Leira & Cantonati, 2008; Zohary & Ostrovsky, 2011). Changes in lake level can impact flora and fauna mainly by altering available habitat, impacting nesting locations, and altering available food sources. In addition to impacts to the biological communities, lakes can experience physical impacts on water quality from changes in lake level. Frequent lake level fluctuations can impact the shoreline, leading to erosion and increased sedimentation in

[7] K_w = the whole soil k factor. This factor includes both fine-earth soil fraction and large rock fragments.

near-shore habitats, inhibiting light penetration and altering water clarity. Exposed shoreline sediment that is inundated at high water levels can release phosphorus, leading to alterations in nutrient accumulation and algae populations. High and low water levels can have detrimental effects on water systems, so finding a balance in managing water level at appropriate times throughout the year is critical to maintaining a healthy waterbody for both recreational enjoyment and aquatic life use. Management strategies become even more challenging when considering the impact of increased wake boating and extreme weather events (droughts and storms) on water level. Residents have expressed concern about enhanced shoreline erosion caused by motor wakes. The Shaws Pond public access location at the southern end of the lake is identified by NHFGD as a cartop gravel launch (NHFGD, 2023). All motorboats on the lake should therefore be those from shoreline residents.

3.1.5 Wastewater

Untreated discharges of sewage (domestic wastewater) are prohibited regardless of source. An example of an NPS discharge of untreated wastewater is from insufficient or malfunctioning subsurface sewage treatment and disposal systems, commonly referred to as septic systems, but which also include holding tanks, grey water tanks, and cesspools. When properly designed, installed, operated, and maintained, most septic systems can retain a very large proportion of phosphorus in sewage in the soils within a short distance of the disposal field (also called leach field). Phosphorus retention in soils depend on the system maintaining an effective biomat layer (except in certain advanced technology systems such as aerated tanks); the porosity and adsorption capacity of the underlying native soils; and adequate vertical separation from groundwater, bedrock, or other restrictive layer. Very porous soils or fill materials such as sands and gravels tend to transmit nutrients rapidly to groundwater, then to surface waters. Soils with shallow groundwater, bedrock, or other limiting factor tend to lack an adequate volume of soil for ample nutrient retention, also allowing phosphorus and nitrogen to move through groundwater toward the pond. Phosphorus retained in soils may still migrate extremely slowly toward surface waters over many decades or centuries (Wang et al., 2024).

Age, overloading, poor maintenance, or damage can result in system failure and the release of nutrients and other pollutants into surface waters (EPA, 2016). Nutrients from underperforming septic systems can enter surface waters through surface overflow or breakout, stormwater runoff, or groundwater. Cesspools are buried concrete structures that allow solid sludge to sink to the bottom and surface scum to rise to the top and eventually leak out into surrounding soils through holes at the top of the structure. Holding tanks are completely enclosed structures that must be pumped regularly to prevent effluent back-up into the home.

The WQC completed an initial review of available data on septic systems within 250 feet of the Shaws Pond shoreline in 2023. The objective of this data survey was to determine the number of septic systems along the shoreline of Shaws Pond and the proportion of older septic systems. The WQC queried the NHDES OneStop online database for subsurface permits and reviewed New Durham tax parcel records. There were 63 properties identified (within 250 feet of the shoreline), 43 of them had dwellings. 11 of the 43 properties (26%) had septic systems older than 25 years, and 11 (26%) had no public information present in terms of the septic system or waste management system present. Local residents expressed concerns about failed septic systems in the southern portion of the watershed draining into the southern wetland, though minimal information was available regarding this possibility.

FBE estimated the pollutant loading from shoreline septic systems using default literature values for daily water usage, phosphorus concentration output per person, and system phosphorus attenuation factors. The number of people using shoreline septic systems was determined by reviewing individual tax records per parcel. As detailed in the *Shaws Pond Lake Loading Response Model Report* (FBE, 2025a), shoreline septic systems contribute 3.7 kg/yr of total phosphorus loading to Shaws Pond, comprising 8% of the total phosphorus load from all sources to the pond. Some septic systems, cesspools, or holding tanks are located within a short distance to the water, leaving little horizontal (and sometimes vertical) space for proper filtration of wastewater effluent. Improper maintenance or siting of these systems can cause failures, which leach untreated, nutrient-rich wastewater effluent directly to the lake. This effluent contains not only nutrients and bacteria but also microplastics, pharmaceuticals, and other pollutants harmful to public health.

3.1.6 Fertilizers

When lawn and garden fertilizers are applied in excessive amounts, in the wrong season, or just before heavy precipitation, they can be transported by rain or snowmelt runoff to lakes and other surface waters where they can promote cultural eutrophication and impair the recreational and aquatic life uses of the waterbody. Many states and local communities are beginning to set restrictions on the use of fertilizers by prohibiting their use altogether or requiring soil tests to demonstrate a need for any phosphate application to lawns. During the shoreline survey, properties with green grass were observed, and it is possible that fertilizer is used on some shoreline properties. The Lake Winnipesaukee Golf Club greens are not within the Shaws Pond watershed.

3.1.7 Pets

In residential areas, fecal matter from pets can be a significant contributor of nutrients to surface waters. Each dog is estimated to produce 200 grams of feces per day, which contain concentrated amounts of phosphorus (CWP, 1999). If pet feces are not properly disposed, these nutrients can be washed off the land and transported to surface waters by stormwater runoff. Pet feces can also enter by direct deposition of fecal matter from pets standing or swimming in surface waters.

3.1.8 Agriculture

Agriculture in the Shaws Pond watershed includes a Stony Pine Farm with stables and paddocks and small hobby-scale practices in residential yards. Agricultural activities, including keeping horses, raising livestock and poultry, growing crops, and other animals for pleasure or profit, involve managing nutrients.

Agricultural activities and facilities with the potential to contribute to nutrient impairment include:

- Fertilizer and manure storage and application;
- Livestock grazing;
- Animal feeding operations and barnyards;
- Paddock and exercise areas for horses and other animals;
- Leachate from haylage/silage storage bunkers; and
- Plowing and earth moving.

Diffuse runoff of farm animal waste from land surfaces (whether from manure stockpiles or cropland where manure is spread), as well as direct deposition of fecal matter from farm animals standing or swimming in surface waters, are significant sources of agricultural nutrient pollution in surface waters. Farm activities like plowing, livestock grazing, vegetation clearing, and vehicle traffic can also result in soil erosion which can contribute to nutrient pollution.

Excessive or ill-timed application of fertilizer or poor storage which allows nutrients to wash away with precipitation not only endangers lakes and other waters, but it also means those nutrients are not reaching the intended crop. The key to nutrient application is to apply the right amount of nutrients at the right time. When appropriately applied to soil, synthetic fertilizers or animal manure can fertilize crops and restore nutrients to the land. When improperly managed, pollutants in manure can enter surface waters through several pathways, including surface runoff and erosion, direct discharges to surface water, spills, and other dry-weather discharges, and leaching into soil and groundwater. We encourage all agricultural operations to ensure they are practicing proper waste management and to connect with the Strafford County Natural Resource Conservation Service office for assistance and resources as needed.

3.1.9 Future Development

Understanding population growth, and ultimately development patterns, provide critical insight to watershed management, particularly as it pertains to lake water quality. According to the US Census Bureau, New Durham, Wolfeboro, and Brookfield have experienced moderate population growth over the last 50 years, increasing from a total of 3,817 people in 1970 to 9,864 people in 2020 (see Section 2.3.2). The Shaws Pond watershed area has long been treasured as a recreational haven for both summer vacationers and year-round residents. The Winnipesaukee Region is among the oldest summer vacation spots in New Hampshire and offers fishing, hiking, boating, sailing, canoeing, kayaking, and swimming in the summer, and ice fishing, cross-country skiing, snowshoeing, and snowmobiling in the winter. The desirability of the greater Lake Winnipesaukee area as a recreational destination will likely stimulate continued population growth in the future. Growth figures and estimates suggest that towns should continue to consider the effects of current municipal land-use regulations, particularly impervious cover limits, on local water resources. As the region's watersheds are developed, erosion from disturbed areas and runoff from impervious surfaces increases the potential for water quality to decline. Refer to section 5.1., the Action Plan for zoning and development-specific action items.

3.2 INTERNAL PHOSPHORUS LOAD

Phosphorus that enters the lake and settles to the bottom can be re-released from sediment under anoxic conditions, providing a nutrient source for algae, cyanobacteria, and plants, otherwise known as internal phosphorus loading. The watershed modeling in Section 2.3 identified internal phosphorus load as a minor portion of the total phosphorus load for Shaws Pond, likely 3.5 kg-P/yr (7%). However, additional monitoring may be conducted to refine the internal loading estimate as the pond experiences many weak stratification and mixing periods through the sampling season because of its relatively shallow depth.

3.3 POTENTIAL CONTAMINATION SOURCES

Point source (PS) pollution can be traced back to a specific source such as a discharge pipe from an industrial facility, municipal treatment plant, permitted stormwater outfall, or a regulated animal feeding operation, making this type of pollution relatively easy to identify. Section 402 of the CWA requires all such discharges to be regulated under the National Pollutant Discharge Elimination System (NPDES) program to control the type and quantity of pollutants discharged. NPDES is the national program for regulating point sources through issuance of permit limitations specifying monitoring, reporting, and other requirements under Sections 307, 318, 402, and 405 of the CWA.

NHDES operates and maintains the OneStop database and data mapper, which houses data on Potential Contamination Sources (PCS) within the State of New Hampshire. Identifying the types and locations of PCS within the watershed may help identify sources of pollution and areas to target for restoration efforts. On June 10, 2023, FBE downloaded datasets for above and underground storage tanks, soil waste facilities, hazardous waste generators, local potential contamination sources, NPDES outfalls, and remediation sites in the Shaws Pond watershed. The only sites present are three remediation sites which are now labeled as "closed" or completed projects.

3.4 WILDLIFE

Fecal matter from wildlife such as geese, ducks, other birds, and beaver may be a significant source of nutrients in some watersheds. This is particularly true when human activities, including the direct and indirect feeding of wildlife and habitat modification, result in the congregation of wildlife (CWP, 1999). Congregations of geese, gulls, and ducks are of concern because they often deposit their fecal matter next to or directly into surface waters. Examples include large mowed fields or lawns adjacent to lakes and streams where geese and other waterfowl gather. Studies show that geese inhabiting **riparian** areas increase soil nitrogen availability (Choi et al., 2020) and gulls along shorelines increase phosphorus concentration in beach sand pore water that then enters surface waters through groundwater transport and wave action (Staley et al. 2018). When submerged in water, the droppings from geese and gulls quickly release nitrogen and phosphorus into the water column, contributing to eutrophication in freshwater ecosystems (Mariash et al., 2019). On a global scale, fluxes of nitrogen and phosphorus from seabird populations have been estimated at 591 Gg N per year and 99 Gg P per year, respectively (with the highest values derived from arctic and southern shorelines) (Otero et al., 2018). Additionally, other studies show greater concentrations of nitrogen, ammonia, and dissolved organic carbon downstream of beaver impoundments when compared to similar streams with no beaver activity in New England (Bledzki et al., 2010). The Shaws Pond LLRM estimated that waterfowl are likely contributing 1.7 kg/yr (3%) of the total phosphorus load to Shaws Pond.

3.5 ENVIRONMENTAL VULNERABILITY

Environmental vulnerability will have important implications for water quality that should be considered and incorporated into WBMPs. In the last century, New England has already experienced significant changes in stream flow and air temperature. Out of 28 rural stream flow stations throughout New England, 25 showed increased flows over the record likely due to the increase in frequency of extreme precipitation and total annual precipitation in the region. In 79 years of recorded flooding in the Oyster River in Durham, NH, three of the four highest floods occurred in the past 10 years (Ballestero et al., 2017). The average annual air temperature in New England has risen by 3.7°C on average from 1985 through 2024. Greater increases are observed with winter air temperature (5.0 °C), than summer air temperature (2.9 °C) (calculated from NOAA monthly air temperatures in the New England Basin). Lake ice-out dates occur earlier as warmer winter air temperature melts the snowpack and lake ice; earlier ice-out allows a longer growing season and increases the duration of anoxia in bottom waters. Increasing storm frequencies will flush more nutrients to surface waters for algae to feed on and flourish under warmer air temperatures.

These trends will likely continue to impact both water quality and quantity. Models predict a 10-40% increase in stormwater runoff by 2050, particularly in winter and spring and an increase in both flood and drought periods as seasonal precipitation patterns shift. Adding to this stress is population growth and corresponding development in New Hampshire. The build-out analysis for the watershed showed that about 512 acres are still developable and approximately 290 new buildings could be added to the watershed at full build-out based on current zoning standards. The Shaws Pond LLRM also showed a 130% increase in watershed load from the current load (2024) to the future load (2138). Shaws Pond is at serious risk of water quality degradation because of new development in the watershed unless environmental resiliency and **low impact development** (LID) strategies are incorporated to existing zoning standards.

4 MANAGEMENT STRATEGIES

The following section details management strategies for achieving the water quality goal and objectives using a combination of structural and non-structural restoration techniques, as well as outreach and education and an adaptive management approach. A key component of these strategies is the idea that existing and future development can be remediated or conducted in a manner that sustains environmental values. All stakeholder groups have the capacity to be responsible watershed stewards, including residents, visitors, municipalities, and other organizations. Specific action items are provided in the Action Plan (Section 5).

4.1 STRUCTURAL NONPOINT SOURCE (NPS) RESTORATION

Structural NPS restoration techniques are engineered infrastructure designed to intercept stormwater runoff, often allowing it to soak into the ground, be taken up by plants, harvested for reuse, or released slowly over time to minimize flooding and downstream erosion. These BMPs often incorporate some mechanism for pollutant removal, such as sediment settling basins, oil separators, filtration, or microbial breakdown. They can also consist of removing or disconnecting impervious surfaces, which in turn reduces the volume of polluted runoff generated, minimizing adverse impacts to receiving waters.

4.1.1 Watershed & Shoreline BMPs

Seventeen (17) NPS sites identified during the 2023 and 2024 watershed surveys and 21 high/medium/low impact rated shoreline properties from the 2023 shoreline survey were documented to have some impact on water quality through the delivery of phosphorus-laden sediment (refer to Section 3.1.1-3.1.2). As such, structural BMPs to reduce the external watershed phosphorus load are a necessary and important component for the protection of water quality in the watershed.

The following series of BMP implementation action items are recommended for achieving Objective 1:

- Address the top five high priority sites (as well as the remaining 4 high and medium impact sites and the 8 low impact sites as opportunities arise) identified during the watershed surveys. The sites were ranked based on phosphorus load reduction and waterbody proximity. The full prioritization matrix with recommended improvements is provided in Appendix B.
- Provide technical assistance and/or implementation cost sharing to one high and one medium impact shoreline property identified during the 2023 shoreline survey. Workshops and tours of demonstration sites can help encourage landowners to utilize BMPs on their own property. Conduct regular shoreline surveys to continue prioritizing properties for technical follow-up.

For the proper installation of structural BMPs in the watershed, landowners should work with experienced professionals on sites that require a high level of technical knowledge or engineering. Whenever possible, pollutant load reductions should be estimated for each BMP installed. More specific and additional recommendations are included in Section 5. For helpful tips on implementing BMPs, see Additional Resources.

Restoration measures have begun at the Shaws Pond Access Site (Watershed Survey site 1-8). The Town of New Durham has hired Horsley Witten Group for conceptual design of the boat launch to mitigate stormwater runoff.

4.2 NON-STRUCTURAL NONPOINT SOURCE (NPS) RESTORATION

Non-structural NPS restoration techniques refer to a broad range of behavioral practices, activities, and operational measures that contribute to pollutant prevention and reduction. The following section highlights important restoration techniques for several key areas, including pollutant reduction best practices, zoning and ordinance updates, land conservation, septic system regulation, sanitary sewer system inspections, boats and marinas, fertilizer use prohibition, pet waste management, agricultural practices, and nuisance wildlife controls.

4.2.1 Pollutant Reduction Best Practices

Pollutant reduction best practices include improving road management and municipal operations for the protection of water quality. Following standard best practices for road maintenance and drainage management protects both infrastructure and water quality through the reduction of sediment and other pollutant transport. Refer to the *New Hampshire Stormwater Manual* (UNH Stormwater Center et al., 2025) for standard road design and maintenance best practices.

Even though none of the watershed towns are required to comply with the six minimum control measures under the New Hampshire Small Municipal Separate Storm Sewer System (MS4) General Permit, each town could consider instituting the permit's key measures, such as street sweeping, catch basin cleaning, and road/ditch maintenance, if not already in place. The MS4 permit also covers illicit discharge detection and elimination plans and including them in ordinance(s), source control and pollution/spill prevention protocols, and education/outreach and/or training for residents, municipal staff, and stormwater operators, all of which are aimed at minimizing polluted runoff to surface waters. New Durham completes street sweeping and catch basin cleaning once per year. Homeowners typically maintain catch basins at the end of their driveways. New Durham also has no municipally maintained gravel roads within 500 feet of waterbodies. However, the New Durham WQC has requested town funds be allocated for annual ditch maintenance for the protection of water quality.

4.2.2 Zoning and Ordinance Updates

Regulations through municipal zoning and ordinances supporting or requiring LID strategies that prevent polluted runoff from impervious surfaces associated with new and re-development projects in the watershed are equally important as implementing structural BMPs on existing development. In fact, local land use planning and zoning ordinances can be the most critical components of watershed protection. FBE completed a preliminary ordinance review of natural resource protections for the towns of Wolfeboro, Alton, New Durham, and Brookfield (Table 11). These towns have already incorporated several important regulations into their ordinances. A more robust review of these ordinances is encouraged for more specific recommendations for improving ordinances and regulations related to natural resource protection (refer to NHDES, 2008). The towns should also consider their staffing capacity to enforce existing and proposed regulations.

Local land use planning and zoning ordinances should consider incorporating environmental resiliency strategies for protecting water quality and improving infrastructure based on temperature, precipitation, water levels, wind loads, storm surges, wave heights, soil moisture, and groundwater levels (Ballestero et al., 2017). There are nine strategies which can aid in minimizing the adverse effects associated with environmental vulnerability and include the following (McCormick and Dorworth, 2019).

- **Installing Green Infrastructure and Nature-Based Solutions**: Planning for greener infrastructure requires that we think about creating a network of interconnected natural areas and open spaces needed for groundwater recharge, pollution mitigation, reduced runoff and erosion, and improved air quality. Examples of green infrastructure include forest, wetlands, natural areas, riparian (banks of a water course) buffers, and floodplains; all of which already exist to various extents in the watershed and have minimized the damage created by intense storms. As future development occurs, these natural barriers must be maintained or even increased to reduce runoff of pollutants into freshwaters. See also Section 4.2.3: Land Conservation.
- **Using LID Strategies**: Use of LID strategies requires replacing traditional approaches to stormwater management using curbs, pipes, storm drains, gutters, and retention ponds with innovative approaches such as bioretention, vegetated swales, and permeable paving or interlocking subsurface stabilizers.

- **Minimizing Impervious Surfaces**: Impervious surfaces such as roads, buildings, and parking lots should be minimized by creating new ordinances and building construction design requirements which reduce the imperviousness of new development. Property owners can increase the permeability for their lots by incorporating permeable driveways and walkways. It is highly recommended that existing impervious surfaces are reduced by incorporating Effective Impervious Cover regulations in zoning codes per NHDES (UNH Stormwater Center et al., 2025). Currently, New Durham's zoning ordinance regulations on lot coverage (20%) exceeds the recommended threshold of 10% or less impervious cover for all zoning districts. Refer to NHDES (2008) for additional recommendations.
- **Encouraging Riparian Buffers and Maintaining Floodplains**: Municipal ordinances should forbid construction in floodplains, and in some instances, floodplains should be expanded to increase the land area to accommodate larger rainfall events. Riparian (vegetated) buffers and filter strips along waterways should be preserved and/or created to slow runoff and filter pollutants. Refer to NHDES (2008) for additional recommendations.
- **Protecting and Re-establishing Wetlands**: Wetlands are increasingly important for preservation because wetlands hold water, recharge groundwater, and mitigate water pollution.
- **Encouraging Tree Planting**: Trees help manage stormwater by reducing runoff and mitigating erosion along surface waters. Trees also provide critical shading and cooling to streams and land surfaces.
- **Promoting Landscaping Using Native Vegetation**: Landowners should promote the use of native vegetation in landscaping, and landscapers should become familiar with techniques which minimize runoff and the discharge of nutrients into waterbodies (Chase-Rowell et al., 2012).
- **Slowing Down the Flow of Stormwater**: To slow and infiltrate stormwater runoff, roadside ditches can be armored or vegetated and equipped with turnouts, settling basins, check dams, or infiltration catch basins. Rain gardens can retain stormwater, while waterbars can divert water into vegetated areas for infiltration. Water running off roofs can be channeled into infiltration fields and drainage trenches.
- **Coordinating Infrastructure, Housing, and Transportation Planning**: Coordinate planning for infrastructure, housing, and transportation to minimize impacts on natural resources. Critical resources including groundwater must be conserved and remain free of pollutants especially as future droughts may deplete groundwater supplies.

Table 11. Ordinance review summary of regulatory and non-regulatory tools for natural resource protection in New Durham which comprises 94% of the Shaws Pond watershed and the entire lake shoreline. For an ordinance refiew of Wolfeboro and Brookfield, please refer to the Wolfeboro Bay WBMP (FBE, 2024)

STRATEGY	NEW DURHAM
Shoreland zoning.	"Shorefront Conservation Overlay District" [Article XIV] applies to a 300ft buffer from each lake or pond greater than 10 acres and a few rivers. It requires a 75ft setback from all structures and the shoreline, except for water related structures, and 125ft setback for septic systems. Permitted uses include shorefront common areas and single-family detached dwellings. Conditional uses must have a stormwater management plan.

STRATEGY	NEW DURHAM
Cluster development and/or open space provisions for subdivisions.	"Open Space Conservation Subdivision" [Article XV] provides an alternative to a typical subdivision with the goal of protecting water quality, agriculture and forestry, wildlife habitat areas, and other natural features. Street designs are regulated to follow natural topography. At least 50% of the buildable area must be permanently designated as open space, recorded at the Registry of Deeds.
Septic pump-out ordinance or regulation of septic and sewer systems.	Septic systems may not be located within 125ft of any wetland or water body [Article XIII, Section H]. As of 2023, "Regulations Pertaining to Certain Subsurface Wastewater Disposal Systems in the Lake Merrymeeting Area and Surrounding Water Bodies in New Durham" apply to all systems within 250 ft of the shorelines of Merrymeeting Lake or any other pond. New regulations require inspections for all systems that do not have design approval on file with NHDES. For expanding a septic system, it prevents the acquisition of a building permit without valid NHDES construction and operation approvals. If there is no ISDS permit on-file and the homeowner seeks to expand the structure, they must provide a NHDES construction approval alongside their building permit application.
Environmental Ordinances (e.g., green building codes, green infrastructure, tree preservation, limits on impervious surface cover)	"Conservation Focus Area Overlay District" [Article X] aims to maintain wildlife habitat, wetlands, and forests on land that has been identified as having significance in protecting living resources and water quality. The Conservation Focus Area District is an overlay district superimposed over the conventional zoning map of the Town. Article XIV, the Shorefront Conservation Overlay District, identifies 20% as the maximum amount of impervious cover a lot may contain.
Zoning districts address environmental protection.	"Aquifer Protection Overlay District," "Water Quality Protection Overlay District," "Shorefront Conservation Overlay District," "Open Space Conservation Subdivision," "Merrymeeting Lake Watershed Overlay District"
Zoning overlay districts that address wetland conservation.	"Water Quality Protection Overlay District" [Article XIII] restricts development adjacent to surface waters and wetlands. Regulates buffer/setback distances for buildings, septic systems, and impervious surfaces. Buffers increase in width if the site is also located on slopes of over 10%.

STRATEGY	NEW DURHAM
Zoning ordinances that address use and density restrictions (e.g., urban growth boundaries)	"Density Control" [Page 39] applies to multi-family developments and restricts the maximum number of dwelling units per multi-family development to six (6) and the maximum number of bedrooms per development to twelve (12). To maintain New Durham's small-town character, the number of adjacent multifamily dwellings may be limited.
Phased Development (growth/development management)	None identified
Transfer of Development Rights (TDR)	None identified
Stormwater treatment practices	"Permanent Stormwater Management Goals" [Article XVII, Section B] outlines that the stormwater treatment plan must abide by regulation and that all stormwater management systems should remove a minimum of 80% of the average TSS annual load, floatables, greases, and soils. Practices that could be used to treat and infiltrate runoff from development areas could include bioretention, infiltration dividers or islands, or planters and rain gardens, and should be used as BMPs to properly manage stormwater [Article XVII, Section E].
Zoning overlay districts that protect groundwater.	"Aquifer Protection Overlay District" [Article XII] includes performance standards for contaminant storage and prohibits multi-family dwellings and the disposal of certain waste products. Prohibits having greater than 205 impervious cover.
Protection of steep slopes.	"Steep Slope Conservation Overlay District" [Article XI] applicable to all areas of 15% slope or greater. Residential development is permitted if less than 10,000 sq. ft. or 25% of lot area is disturbed. Discusses limiting soil erosion and stormwater runoff while maintaining the natural topography of the region. Slopes over 25% may not have more than 500 sq. ft. of disturbance or 12,000 sq. ft. with a conditional use permit.
Nutrient loading analysis required for fresh waterbodies.	None identified.

STRATEGY	NEW DURHAM
Stormwater management for new development / post construction stormwater management controls (consistent with low impact development approaches)	"Design Requirements for All Development Activity" [Article XVII, Section E] requires that all development activity must comply with BMPs. The "Applicability-Stormwater Management and Erosion Control Ordinance" [Article XVII, Section C] outlines that the stormwater management and erosion control applies to any new subdivision, or existing lots where the new disturbance of the land is on slopes greater than 30%, new disturbances of the land greater than 500 square feet on slopes greater than 15% and less than 30%, new disturbances of the land greater than 2000 square feet on slopes of 15% or less, and all new construction or coverage of the land that would result in total impervious coverage of the lot above 20%.
Low impact development requirements and standards.	"Stormwater Management and Erosion Control" [Article XVI] requires the use of BMPs and stormwater management practices for all development activity. Measures to prevent soil erosion during construction are discussed.
Fertilizer and/or pesticide ordinances.	None identified.
Implement and enforce a Stormwater Management Plan.	"All developments subject to the incidental and non-incidental disturbance requirements of this ordinance shall submit a permanent (post construction) Stormwater Management Erosion and Sedimentation Control Plan" [Article XVI]. An incidental disturbance is greater than 2,000 sq. ft. A non-incidental disturbance is greater than 12,000 sq. ft. or will result in more than 5,000 sq. ft. of impervious area. The parameters vary depending on the slope of the site.
Development transfer overlay district.	None identified.
Conservation impact fees.	No conservation impact fee, but "Impact Fee Ordinance" [Zoning and Land Use Ordinance Article XVIII] states that the Planning Board is authorized to assess impact fees for the additional demand that new development creates on public facilities.
Purchase of Development Rights / Land acquisition / Conservation Easements	None identified
Wetland Mitigation Banking	None identified
Wetland mitigation funds.	None identified.
Fee in lieu of land dedication.	None identified.
Stormwater utility district.	None identified.

STRATEGY	NEW DURHAM
Open space or non-lapsing conservation fund.	None identified.
Has a Land Use Change Tax per RSA 79-A:25.	Yes. Landowners are specifically encouraged to participate in the state current use program in the Merrymeeting Lake Watershed Overlay District [Article XVII]. The minimum lot size is 12 acres specifically to allot 2 acres for a dwelling and 10 acres to be placed in Current Use according to RSA79-A.
Participate or collaborate with a local watershed association.	Friend of Shaws Pond.
Participate or collaborate with a local land trust.	Moose Mountain Regional Greenways.
Open space plan.	None identified.
Master plan addresses natural resources and environmental protection.	Yes [2017]. Chapters on Natural Resources and Land Use are relevant to environmental protection. Topics include preserving water quality, low-impact development, identifying wetlands, and maintaining scenic resources.
Conduct a town-wide natural resources inventory.	Yes, completed in 2011.
Stormwater system mapping	None identified
Annual Report on stormwater management and implementation	No, but stormwater management regulations were recently amended in 2024.
Incentive-based programs for voluntary low impact development implementation.	None identified.
Incentive-based programs for stormwater reduction efforts.	None identified.
Consistent Public Outreach and Engagement / Public education programs	None identified.
Have established conservation commission.	Yes.

STRATEGY	NEW DURHAM
Incentivize and/or encourage property owners to implement low impact development stormwater practices.	None identified.
Differential Development Impact Fees	"Impact Fee Ordinance" [Article XIX] assesses the impact fees for public capital facilities and new development.
Encourage property owners to put land into farmland/tree growth programs.	In the Merrymeeting Lake Watershed Overlay District [Article XVII], landowners are encouraged to take advantage of state agricultural and forestry programs.

4.2.3 Land Conservation

Land conservation is essential to the health of a region, particularly for the protection of water resources, enhancement of recreation opportunities, vitality of local economies, and preservation of wildlife habitat. Land conservation is one of many tools for protecting water quality for future generations. Twenty percent (20%, or 212 acres) of the watershed's land area (not including Shaws Pond) has been classified as conservation land (refer to Appendix A, Map A-9). Major conserved areas include the Holm and Mackenzie Lots surrounding the northern end of Shaws Pond, and the Copple Crown Conservation Area and Copple Crown Village District Land Copple Crown Conservation Area.

Local groups should continue to pursue opportunities for land conservation in the Shaws Pond watershed based on the highest valued habitat identified by the New Hampshire Fish & Game (NHFG) (Appendix A, Map A-9). NHFG ranks habitat based on value to the State, biological region (areas with similar climate, geology, and other factors that influence biology), and supporting landscape. These habitat rankings are published in the State's 2015 Wildlife Action Plan (with updated statistics and data layers released in January 2020), which serves as a blueprint for prioritizing conservation actions to protect Species of Greatest Conservation Need in New Hampshire. The Shaws Pond watershed is part of the Sebago-Ossipee Hills and Plains ecoregional subsection of the biological region (NHFG, 2015). Approximately 128 acres (14%) of the Wolfeboro Bay watershed are considered Highest Ranked Habitat in New Hampshire (not excluding the area of Shaws Pond). None of the conserved areas overlap with the Highest Ranked Habitat in New Hampshire, but a portion of the Mackenzie Lot overlaps with an area classified as having the Highest Ranked Habitat in the Biological Region. A map of priority habitats for conservation based on the NH Wildlife Action Plan can be found in Appendix A, Map A-9.

4.2.4 Septic System Regulation

When properly designed, installed, operated, and maintained, septic systems typically treat residential wastewater and reduce the impact of excess pollutants in ground and surface waters. It is important to note, however, that traditional septic systems are designed for pathogen removal from wastewater and not specifically for other pollutants such as nutrients. The phosphorus in wastewater is "removed" only by binding with soil particles or recycled in plant growth but is not removed entirely from the watershed system. Nutrient removal can only be achieved through more expensive, advanced septic system technology. Many advanced septic system types are available for nitrogen removal, but phosphorus removal technologies are not widely available, approved, or deployed.

Proper design, installation, operation, maintenance, and replacement considerations include the following:

- Proper design includes adequate evaluation of soil conditions, seasonal high groundwater or impermeable materials, proximity of sensitive resources (e.g., drinking water wells, surface waters, wetlands, etc.).
- Proper siting and installation mean that the system is installed in conformance with the approved design and siting requirements (e.g., setbacks from waterways).
- Proper operation includes how the property owner uses the system. While most systems excel at treating normal domestic sewage, disposing of some materials, such as toxic chemicals, paints, personal hygiene products, oils and grease in large volumes, and garbage, can adversely affect the function and design life of the system, resulting in treatment failure and potential health threats. Proper operation also includes how the property owner protects the system; allowing vegetation with extensive roots to grow above the system will clog the system; driving vehicles over system components may crush or compact piping or leaching structures.
- Proper maintenance means having the septic tank pumped at regular intervals to eliminate accumulations of solids and grease in the tank. It may also mean regular cleaning of effluent filters, if installed. The frequency of septic pumping depends on the use and total volume entering the system. A typical 3-bedroom, 1,000-gallon tank should be pumped every 3-4 years.
- Proper replacement of failed systems, which may include programs or regulations to encourage upgrades of conventional systems, cesspools, or holding tanks to more innovative alternative technologies.

Management strategies for reducing water quality impacts from septic systems (as well as cesspools and holding tanks) start with education and outreach to property owners so that they are better informed to properly operate and maintain their systems. Other management strategies include setting local regulations for enforcing proper maintenance and inspection of septic systems and establishing funding mechanisms to support the replacement of failing systems (with priority for cesspools and holding tanks). For instance, the Town of New Durham adopted a subsurface ordinance that regulates septic systems within 250 feet of the shoreline of Merrymeeting Lake and ponds within the Town. Regulations include the requirement of homeowners without a valid subsurface system design approval on file and/or who seek a proposed building expansion to submit proof of proper system functioning by a certified septic system inspector within one year of notification.

Additional septic system management includes creating an inventory of all septic systems in a town or watershed. An inventory will record the age, type, exact location of all septic systems, including those for which site evaluation and system design records are missing. Visual inspection for surface breakouts can be conducted periodically for all systems in the shoreland zone and within a certain distance of tributaries or wetlands. Another potential mode of failure or underperformance of septic systems is rapid infiltration of undertreated wastewater due to highly porous soils. In these cases, the septic system may appear to be functioning well from the homeowner's perspective and no surface breakouts appear, but phosphorus is not retained well in the soils due to rapid infiltration and transport to surface waters via groundwater. These conditions can be identified by first accurately mapping soils and groundwater conditions at every septic system location. Data on soil and seasonal high groundwater from test pits recorded on site evaluations can be gathered, and soil texture can be checked at sites where no records exist. The map and data can then be used to identify the highest priority septic systems to upgrade or replace.

4.2.5 Boats

NHDES provides an interactive map of boat pump-out locations, including both public and private boat pump-outs, dump stations for portable toilets, and mobile pump-out vessels. There is not an active pump-out facility in Shaws Pond, though there is one in Wolfeboro Bay at the Wolfeboro Corinthian Yacht Club off Nancy's Way. The following are best practices for boats:

- Target outreach to boat dealers, boat storage facilities, and their consumers regarding State and EPA requirements.
- Educate boat users how to responsibly handle their boats if traveling between waterbodies following NHDES's "Clean, Drain, Dry" protocol.
- All vessels must be checked for aquatic vegetation which must be removed if found upon exiting Shaws Pond.
- All vessels must be checked for aquatic vegetation which must be removed if found and properly disposed of into a waste receptacle before entering Shaws Pond. Note that Shaws Pond Access Point (Watershed Survey site 1-8) is sometimes used as a boat launch but there are no waste receptacles at the site.
- Consider establishing a Weed Watcher Program.
- Provide education signage at the Shaws Pond Access to educate patrons of the BMPs established as part of the ongoing restoration project to help deter parking in non-designated areas.
- Install vegetated buffers between surface waters and upland areas; and
- Do not allow waste that should go to pump-out stations to drain directly into Shaws Pond.

4.2.6 Fertilizer Use Prohibition

Management strategies for reducing water quality impacts from residential application starts with education and outreach to property owners. New Hampshire law prohibits the use of fertilizers within 25 feet of surface waters. Outside of 25 feet, property owners can get their soil tested before considering application of fertilizers to their lawns and gardens to determine whether nutrients are needed and if so in what quantity or ratio. A soil test kit can be obtained through the UNH Cooperative Extension. Many New England communities are starting to adopt local regulations prohibiting the use of both fertilizers and pesticides, most especially near critical waterbodies. The watershed towns could consider a similar prohibition, at the very least for a watershed zoning overlay of major lakes and ponds. In 2024, HB1293 was passed by the legislature to prohibit the sale of fertilizer with a phosphate content level greater than 0.67 percent.

4.2.7 Pet Waste Management

Pet waste collection as a pollutant source control involves a combination of educational outreach and enforcement to encourage residents to clean up after their pets. Public education programs for pet waste management are often incorporated into a larger message of reducing pollutants to improve water quality. Signs, posters, brochures, and newsletters describing the proper techniques to dispose of pet waste can be used to educate the public and create a cause-and-effect link between pet waste and water quality (EPA, 2005). Adopting simple habits, such as carrying a plastic bag on walks and properly disposing of pet waste in dumpsters or other refuse containers, can make a difference. It is recommended that pet owners do not put dog and cat feces in a compost pile because it may contain parasites, bacteria, pathogens, and viruses that are harmful to humans and may or may not be destroyed by composting. "Pooper-scooper" ordinances are often used to regulate pet waste disposal. These ordinances generally require the removal of pet waste from public areas, other people's properties, and occasionally from personal property, before leaving the area. Fines are typically the enforcement method used to encourage compliance with these ordinances. Education and outreach should also emphasize that pet waste should not be left or dumped in private yards near water bodies.

4.2.8 Agricultural Practices

Manure and fertilizer management and planning are the primary tools for controlling nutrient runoff from agricultural areas. Direct outreach and education should be conducted for small hobby farms and any larger-scale operations in the watershed. NRCS is a great resource for such outreach and education to farmers. Larger-scale agricultural operations can work with the NRCS to complete a Comprehensive Nutrient Management Plan (CNMP). These plans address soil erosion and water quality concerns of agricultural operations through setting proper nutrient budgets, identifying the types and amount of nutrients necessary for crop production (by conducting soil tests and determining proper calibration of nutrient application equipment), and ensuring the proper storage and handling of manure. Manure should be stored or applied to fields properly to limit runoff of solids containing high concentrations of nutrients. Manure and fertilizer management involve managing the source, rate, form, timing, and placement of nutrients. Writing a plan is an ongoing process because it is a working document that changes over time.

4.2.9 Nuisance Wildlife Controls

Human development has altered the natural habitat of many wildlife species, restricting wildlife access to surface waters in some areas and promoting access in others. Minimizing the impact of wildlife on water quality generally requires either reducing the concentration of wildlife in an area or reducing their proximity to a waterbody. In areas where wildlife is observed to be a large source of nutrient contamination, such as large and regular congregations of waterfowl, a program of repelling wildlife from surface waters (also called harassment programs) may be implemented. These programs often involve the use of scarecrows, kites, a daily human presence, or modification of habitat to reduce attractiveness of an at-risk area. Providing closed trash cans near waterbodies, as well as discouraging wildlife from entering surface waters by installing fences, pruning trees, or making other changes to landscaping, can reduce impacts to water quality. Public education and outreach on prohibiting waterfowl or other wildlife feeding is an important step to reducing the impact of nuisance wildlife on the lake.

4.3 OUTREACH & EDUCATION

Awareness through education and outreach is a critical tool to protecting and restoring water quality. Most people want to be responsible watershed stewards and not cause harm to water quality, but many are unaware of best practices to reduce or eliminate contaminants from entering surface waters. The WQC and the Friends of Shaws Pond are the primary local entities for education and outreach campaigns in the watershed and for development and implementation of the plan. The WQC and the Friends of Shaws Pond should continue all aspects of their education and outreach strategies and consider developing new ones or improving existing ones to reach more watershed residents. Refer to Section 5: Action Plan. Examples include providing educational materials to existing and new property owners, as well as renters, by distributing them at various locations and through a variety of means, such as websites, newsletters, social media, community events, or community gathering locations. Additionally, the WQC and the Friends of Shaws Pond should continue to engage with local stakeholders such as conservation commissions, land trusts, municipalities, businesses, and landowners. Educational campaigns should include raising awareness of water quality, septic system maintenance, fertilizer and pesticide use, pet waste disposal, waterfowl feeding, invasive aquatic species, boat pollution, shoreline buffer improvements, gravel road maintenance, and stormwater runoff controls.

4.4 ADAPTIVE MANAGEMENT APPROACH

An adaptive management approach, to be employed by a dedicated committee, is highly recommended for protecting Shaws Pond. Adaptive management enables stakeholders to conduct restoration actions in an iterative manner. Through this management process, restoration actions are taken based on the best available information. Assessment of the outcomes following restoration action, through continued watershed and water quality monitoring, allows stakeholders to evaluate the effectiveness of one set of restoration actions and either adopt or modify them before implementing effective measures in the next round of restoration actions. This process enables efficient utilization of available resources through the combination of BMP performance testing and watershed monitoring activities. Adaptive management establishes an ongoing program that provides adequate funding, stakeholder guidance, and an efficient coordination of restoration actions. This approach ensures that restoration actions are implemented and that surface waters are monitored to document restoration over an extended time. The adaptive management components for implementation efforts should include:

- **Maintaining an Organizational Structure for Implementation.** Communication and a centralized organizational structure are imperative to successfully implementing the actions outlined in this plan. A diverse group of stakeholders should be assembled to coordinate watershed management actions. This group can include representatives from state and federal agencies or organizations, municipalities, local businesses, non-profits, and other interested groups or private landowners. Refer to Section 6.1: Plan Oversight.
- **Establishing a Funding Mechanism.** A long-term funding mechanism should be established to provide financial resources for management actions. In addition to initial implementation costs, consideration should also be given to the type and extent of technical assistance needed to inspect and maintain structural BMPs. Funding is a key element of sustaining the management process, and once it is established, the plan can be fully vetted and restoration actions can move forward. A combination of grant funding, private donations, and municipal funding should be used to ensure implementation of the plan. Refer to Section 6.3 for a list of potential funding sources.
- **Determining Management Actions.** This plan provides a unified watershed management strategy with prioritized recommendations for restoration using a variety of methods. The proposed actions in this plan should be used as a starting point for grant proposals. Once a funding mechanism is established, designs for priority restoration actions on a project-area basis can be completed and their implementation scheduled. Refer to Section 5: Action Plan.
- **Continuing and Expanding the Community Participation Process.** Plan development has included active involvement of a diversity of watershed stakeholders. Plan implementation will require continued and ongoing participation of stakeholders, as well as additional outreach efforts to expand the circle of participation. Long-term community support and engagement is vital to successfully implement this plan. Continued public awareness and outreach campaigns will aid in securing this engagement. Refer to Section 4.3: Outreach & Education.
- **Continuing the Long-Term Monitoring Program.** A water quality monitoring program is necessary to track the health of Shaws Pond. Information from the monitoring program will provide feedback on the effectiveness of management practices. Refer to Section 6.4: Monitoring Plan.
- **Establishing Measurable Milestones.** A restoration schedule that includes milestones for measuring restoration actions and monitoring activities in the watershed is critical to the success of the plan. In addition to monitoring, several environmental, social, and programmatic indicators have been identified to measure plan progress. Refer to Section 6.5: Indicators to Measure Progress and Section 2.4: Establishment of Water Quality Goal for interim milestones.

5 ACTION PLAN

5.1 ACTION PLAN

The Action Plan (Table 12) outlines responsible parties, approximate costs[8], an implementation schedule, and potential funding sources for each recommendation within the following major categories: (1) Municipal Land Use Planning & Zoning, (2) Watershed & Shoreline BMPs; (3) Education and Outreach, (4) Septic System Management, (5) Land Conservation, (6) Road and Driveway Management, and (7) Municipal Operations. The plan is designed to be implemented from 2025-2034 and is flexible to allow for new priorities throughout the 10-year implementation period as additional data are acquired. The water quality goal may be achieved by a subset of the action items presented in Table 12, though a multifaceted approach will help increase awareness for the pond and its resiliency for years to come.

Table 12. Action plan for the Shaws Pond watershed. Action items are ordered in a suggested order of prioritization.

Suggested Order of Prioritization	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
1	**Municipal Land Use Planning & Zoning**	Present WBMP recommendations to Select Board/City Council and Planning Board in New Durham and discuss the connection between municipal land use planning and water quality.	Friends of Shaws Pond, Town of New Durham	$1K 2025	Grants (319), CWSRF
2	**Municipal Land Use Planning & Zoning**	Meet with municipal staff to review recommendations to improve or develop ordinances addressing setbacks, buffers, lot coverage, low impact development, and open space.	Friends of Shaws Pond, Town of New Durham	$3K 2025	Town of New Durham, Grants (319), CWSRF
3	**Watershed and Shoreline BMPs**	Complete design and construction of mitigation measures at the top five highest ranked watershed survey sites. **Achieves 101% (8.5 kg/yr P of 8.4 kg/yr P) of Objective 1** for Shaws Pond.	Friends of Shaws Pond, Town of New Durham, private landowners and associations	$64K-$116K 2025-26	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Town of New Durham, private landowners

[8] Cost estimates for each recommendation will need to be adjusted based on further research and site design considerations.

Suggested Order of Prioritization	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
4	Education and Outreach	Create flyers/brochures or other educational materials through printed or online mediums, regarding topics such as stormwater controls, road maintenance, buffer improvements, fertilizer and pesticide use, pet waste disposal, boat pollution, invasive aquatic species, waterfowl feeding, and septic system maintenance. Consider creating a "watershed homeowner" packet that covers these topics and is distributed (mailed separately or in tax bills or posted at community gathering locations or events) to existing and new property owners, as well as renters. Hold 1-2 informational workshops per year to update the public on restoration progress and ways that individuals can help. Cost is highly variable. Share additional/dynamic information on the New Durham Water Quality Committee town webpage or a social media platform for the Friends of Shaws Pond, such as water quality data, loon updates, weather conditions, and webcam, to generate more traffic to the website.	Town of New Durham, Friends of Shaws Pond, SCCD	$20K-$60K 2025-34	Town of New Durham, Grants (319), CWSRF
5	Education and Outreach	Combine education opportunities by the Friends of Shaws Pond and Conservation Commission regarding water quality, and how humans can help the ecosystem through initiating LakeSmart, soak up the rain, municipal regulations, and proper septic practices, to generate larger audiences. Consider repeating workshop topics every few years as new members and new homeowners enter the watershed.	Friends of Shaws Pond, Town of New Durham Conservation Commission	TBD 2025-34	Town of New Durham
6	Septic System Management	Distribute educational materials to property owners about septic system function and maintenance.	Town of New Durham Health Inspector, Friends of Shaws Pond	$3K 2025, 2029, 2034	Town of New Durham, Grant (319), CWSRF
7	Septic System Management	Look into whether any septic pumping companies would give a quantity discount or a discount to members to incentivize septic system pumping.	Friends of Shaws Pond	N/A 2025-26	CWSRF
8	Septic System Management	Inventory and inspect cesspools and lots for which there is no septic system on record to identify any that urgently need upgrading to protect water quality. This would include the 11 systems in the shoreland zone for which there is no information on file. Conduct a septic system risk assessment to identify areas in town which may be more susceptible to septic system malfunction due to high	Town of New Durham Health Inspector	TBD 2025-26	CWSRF, Town of New Durham

Suggested Order of Prioritization	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
		groundwater, soil filtering capacity, risk of flooding, and age of infrastructure.			
9	**Watershed and Shoreline BMPs**	Complete design and construction of mitigation measures at the next four highest ranked watershed survey sites as opportunities arise. **Achieves 30% (2.5 kg/yr P of 8.4 kg/yr P) of Objective 1.**	Friends of Shaws Pond, Town of New Durham, private landowners and associations	\$42.5K-\$85K 2026-29	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Town of New Durham, private landowners
10	**Watershed and Shoreline BMPs**	Provide technical assistance and/or implementation cost sharing to watershed/shoreline property owners to install stormwater and/or erosion controls such as rain gardens and buffer plantings. Prioritize moderate impact properties identified during the shoreline survey. Cost assumes technical assistance and implementation cost sharing provided to the two high impact shoreline properties. **Achieves 16% (1.36 kg/yr P of 8.4 kg/yr P) of Objective 1.** Values exclude the Shaws Pond Access site which is accounted for as the highest ranked site in the watershed survey.	Friends of Shaws Pond, SCCD, Town of New Durham	\$4K 2026-27	Grants (319, Moose plate), CWSRF, Landowners
11	**Municipal Land Use Planning & Zoning**	Incorporate WBMP recommendations into municipal master plans and encourage regular review of the WBMP action plan.	Town of New Durham	N/A 2025-29	Town of New Durham
12	**Municipal Land Use Planning & Zoning**	Adopt/strengthen zoning ordinance provisions and enforcement mechanisms:	Town of New Durham	N/A	Town of New Durham
		1) to promote conservation subdivisions to allow development but also set aside land for conservation.	Town of New Durham	N/A	Town of New Durham
		2) to establish a lake protection overlay zoning ordinance that prohibits erosion from sites in sensitive areas (e.g., lake shorefront, along lake tributaries, steep slopes); and	Town of New Durham	N/A	Town of New Durham
		3) to promote low impact development practices and reduce impervious areas;	Town of New Durham	N/A	Town of New Durham
		4) to require stormwater regulations that align with MS4 Permit requirements;	Town of New Durham	2028-31	Town of New Durham

Suggested Order of Prioritization	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
		5) to promote or require vegetative buffers around lake shore and tributary streams;	Town of New Durham	2028-31	Town of New Durham
		6) to require shorefront "tear down and replace" home construction to be no more non-conforming than existing structures;	Town of New Durham	2028-31	Town of New Durham
		7) to require shorefront seasonal to year-round conversions of homes to demonstrate no additional negative impacts to lake water quality;	Town of New Durham	2028-31	Town of New Durham
		8) to enhance performance standards for unpaved roads to prevent erosion and protect lake water quality.	Town of New Durham	2028-31	Town of New Durham
13	**Municipal Land Use Planning & Zoning**	Increase municipal staff capacity through code enforcers/ building inspectors for inspections and enforcement of stormwater regulations on public and private lands.	Town of New Durham	TBD 2026-34	Town of New Durham
14	**Septic System Management**	Institute a minimum pump-out/inspection interval and ordinance for shorefront septic systems (e.g., once every 3-5 years). Pump-outs (~$250 per system) are the responsibility of the owner. Expand the regulations pertaining to certain subsurface wastewater disposal systems to include regulations for all property sales to have a septic system inspection on file within the past three years. Require upgrades and repairs if needed.	Town of New Durham Health Inspector	N/A 2027-30	Town of New Durham
15	**Septic System Management**	Develop and maintain a town-wide septic inventory database base to facilitate code enforcement of any septic system ordinances.	Town of New Durham Health Inspector	$5k 2030-34	Town of New Durham, CWSRF
16	**Watershed and Shoreline BMPs**	Complete design and construction of mitigation measures at the remaining eight lower ranked watershed survey sites as opportunities arise (refer to Appendix B for complete list). **Achieves 26% (2.2 kg/yr P of 8.4 kg/yr P) of Objective 1.**	Friends of Shaws Pond, Town of New Durham, private landowners and associations	$55K-$85K 2027-34	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Town of New Durham, private landowners

Suggested Order of Prioritization	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
17	**Watershed and Shoreline BMPs**	Continue to promote the LakeSmart program evaluations and certifications through NH Lakes to educate property owners about lake-friendly practices such as revegetating shoreline buffers with native plants, avoiding large grassy areas, and increasing mower blade heights to four inches. Coordinate with NHDES Soak Up the Rain NH program for workshops and trainings. Cost assumes coordination of and materials for up to ten workshops.	Friends of Shaws Pond, SCCD, NH Lakes, NHDES Soak Up the Rain NH, Town of New Durham	$5k 2025-34	NH Lakes, NHDES Soak Up the Rain NH, Grants (319, Moose plate), CWSRF, Town of New Durham
18	**Education and Outreach**	Educate private property owners on questions to ask hired landscaping companies to ensure they are complying with shoreland fertilizer rules.	Friends of Shaws Pond	N/A 2025-34	
19	**Watershed and Shoreline BMPs**	Work with NRCS to implement soil conservation practices such as stormwater control, manure storage, cover crops, no-till methods, timing of manure applications, and others agricultural BMPs which reduce erosion and nutrient pollution to surface waters from agricultural activities.	NRCS, farm owners	TBD 2025-34	Grants, NRCS
20	**Land Conservation**	Inspect wetlands for Prime Wetland Designations and survey for vernal pools within the watershed. Provide greater support to the New Durham Conservation Commission in this endeavor if needed.	Town of New Durham Conservation Commission, Lakes Region Land Trust,	TBD 2027-29	Town of New Durham
21	**Education and Outreach**	Educate contractors and municipal staff about erosion and sediment control practices required on plans. Work with Town of New Durham to ensure that there are sufficient resources to enforce permitting conditions.	Town of New Durham, Friends of Shaws Pond, SCCD	$6K 2025-34	Town of New Durham, Grants (319), CWSRF
22	**Road and Driveway Management**	Contact the Town of New Durham regarding decreasing their road salt usage on town roads within the watershed due to current trends in water quality and discuss reduced salt areas and low-salt approaches.	Town of New Durham	N/A 2025-28	Town of New Durham
23	**Municipal Operations**	Review and update winter operations procedures to be consistent with Green SnowPro best management practices for winter road, parking lot, and sidewalk maintenance. Continue practicing low salt application practices in the watershed.	Town of New Durham (Public Works/Highway)	N/A 2025-28	Town of New Durham

Suggested Order of Prioritization	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
24	**Road and Driveway Management**	Participate in Green SnowPro training. Become Green SnowPro Certified once program rules for Town of New Durham have been adopted by the Joint Legislative Committee on Administrative Rules. The program works to educate, train, and certify "winter maintenance professionals in salt reduction practices that improve water quality while protecting public safety." NHDES Commercial Green SnowPro Certification.	Town of New Durham (Public Works/Highway)	Est. $150-$250/person 2026-30	Town of New Durham
25	**Road and Driveway Management**	Review and optimize MS4 compliance for towns (regardless of MS4 designation), including infrastructure mapping, erosion and sediment controls, illicit discharge programs, and good housekeeping practices such as regular catch basin cleaning. Develop and/or update a written protocol for road maintenance best practices. Incorporate water quality considerations and strategies into roadway evaluations and action plans. (e.g., Sanbornton Roadway Evaluation). Continue providing education and training to contractors and municipal staff on protocols for road maintenance best practices. Assumes one workshop. Consider holding joint workshop with other Town of New Durham or lake associations (or other wider service area) for cost sharing savings. Hold informational workshops on proper road/driveway management and winter maintenance and provide educational materials for homeowners about winter maintenance and sand/salt application for driveways and walkways. Cost assumes up to five workshops.	Town of New Durham, Friends of Shaws Pond, SCCD	$20K 2026-28	CWSRF, Town of New Durham, Grants (Moose Plate, NFWF 5-Star)
26	**Education and Outreach**	Encourage private property and road owners to hire Green SnowPro certified commercial salt applicators.	Friends of Shaws Pond, Town of New Durham	N/A 2027-2034	Grants, Town of New Durham
27	**Road and Driveway Management**	Establish a street sweeping program to sweep municipal paved roads. Consider purchasing a street sweeping machine with neighboring Town of Alton to sweep up road salt and sand in dry weather periods between winter storms as our winters see more rain between snow events. Encourage homeowners to sweep their impervious surfaces after each snowmelt.	Town of New Durham, private landowners	TBD 2030-2034	Town of New Durham

Suggested Order of Prioritization	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
28	**Municipal Operations**	Develop best practice design standards for stormwater control measures, including deep sump catch basins.	Town of New Durham (Public Works/Highway)	N/A 2028-34	Town of New Durham
29	**Septic System Management**	Evaluate locations of near shore and near tributary septic systems to identify systems which require upgrades or areas that might benefit from clustering community septic systems.	Town of New Durham Health Inspector	TBD 2028-30	CWSRF, Town of New Durham
30	**Land Conservation**	Update the Town of New Durham NRI (previously completed in 2011).	Town of New Durham Conservation Commission	$25K 2028-30	Town of New Durham, Grants (NFWF NEFRG), CWSRF
31	**Land Conservation**	Create a priority list of watershed areas that need protection based on the NRI. Refer to Section 2.6 *Areas of Ecological Significance,* and Section 3 *Existing Protections for Natural Resources* to understand current (2011) conservation lands and valuable habitats and wildlife in the watershed that can be used to help identify potential areas to target for conservation. Note: Consider waiting until an NRI update is completed.	Friends of Shaws Pond, Town of New Durham Conservation Commission, Lakes Region Land Trust	$10-15K 2030-34	Grants (NFWF NEFRG, NAWCA), CWSRF, Town of New Durham
32	**Land Conservation**	Maximize conservation of intact forest and other ecologically important properties though education, zoning, and public or private conservation.	Friends of Shaws Pond, Town of New Durham Conservation Commission, Lakes Region Land Trust, private landowners	TBD 2030-34	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP, NFWF NEFRG), Town of New Durham, private landowners
33	**Land Conservation**	Identify potential conservation buyers and property owners interested in easements within the watershed. Use available funding mechanisms, such as the Regional Conservation Partnership Program (RCPP) and the Land and Community Heritage Investment Program (LCHIP), to provide conservation assistance to landowners.	Friends of Shaws Pond, Town of New Durham Conservation Commission, Lakes Region Land Trust or other local land trusts	N/A 2030-34	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP)

Suggested Order of Prioritization	Category	Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
34	**Land Conservation**	The Town of Barnstead's Master Plan identifies developing "collaborative relationships with conservation organizations including non-profit land trusts to encourage acquisition for natural resource preservation." Consider advocating for land protection within the Shaws Pond watershed for its many ecosystem benefits. Enhance community education regarding private land conservation easements. Host workshops educating landowners on the benefits.	Town of New Durham Conservation Commission, Planning Board	TBD 2025-34	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP, NFWF NEFRG), Town of New Durham, private landowners
35	**Education and Outreach**	Offer workshops for landowners with ten acres or more for NRCS assistance with land conservation. Cost assumes up to two workshops.	Friends of Shaws Pond	$5K 2030-34	Grants (RCCP, ACEP, CSP, EQIP)
36	**Education and Outreach**	Consider beginning a Lake Host program at the Shaws Pond boat ramp.	Friends of Shaws Pond	$10K 2025-34	Grants (NHDES AIPC)
37	**Education and Outreach**	Collaborate with NH Lakes on legislative or advocacy issues such as boat speed limits.	Friends of Shaws Pond, NH Lakes	N/A 2025-34	Grants
38	**Watershed and Shoreline BMPs**	Repeat the shoreline surveys in 5-10 years when updating the WBMP. Use the results to target education and technical assistance for high impact sites. Cost assumes hired consultant for survey and summation of shoreline survey results.	Friends of Shaws Pond, Town of New Durham	$7K 2029, 2034	Town of New Durham, Grants (Moose plate), CWSRF

5.2 POLLUTANT LOAD REDUCTIONS

To meet the water quality goal, Objective 1 set a target phosphorus load reduction of 8.4 kg/yr to achieve an in-lake total phosphorus summertime concentration of 7.0 ppb, which exceeds state water quality standards for oligotrophic waterbodies and is anticipated to reduce the likelihood of cyanobacteria blooms in Shaws Pond. The following opportunities for phosphorus load reductions to achieve Objective 1 were identified in the watershed based on field and desktop analyses:

- Remediating the 17 watershed survey sites could prevent up to 13.16 kg/yr of phosphorus load from entering Shaws Pond.
- Treating the 20 low to medium impact shoreline survey sites could reduce the phosphorus load to Shaws Pond by 8.16 kg/yr.
- Upgrading ten shorefront septic systems most in need based on system type and condition, underlying soil type, and location is estimated to reduce the phosphorus load to Shaws Pond by 1.0 kg/yr.

Addressing these field-identified phosphorus load reduction opportunities coming from the external watershed load (i.e., watershed and shoreline sites and shorefront septic systems) could reduce the phosphorus load to Shaws Pond by 22.32 kg/yr, meeting 273% of the needed reductions to achieve Objective 1 (Table 13).

Objective 2 (preventing or offsetting additional phosphorus loading from anticipated new development) can be met through ordinance revisions that implement LID strategies, enhanced limits to impervious cover, and encourage cluster development with open space protection and/or through conservation of key parcels of forested and/or open land.

It is important to note that, while the focus of this plan is on phosphorus, the treatment of stormwater and sediment erosion will result in the reduction of many other kinds of pollutants that may impact water quality. These pollutants would likely include other nutrients (e.g., nitrogen), road salt/sand, petroleum products, bacteria, excessive organic material (raking/blowing leaves and grass cuttings or erosion from boat wakes), and heavy metals (cadmium, nickel, zinc, etc.). Without a long-term monitoring program in place to measure these other pollutants, it will be difficult to track the success of efforts that reduce these other pollutants. However, there are various spreadsheet models available that can estimate reductions in these pollutants depending on the types of BMPs installed. These reductions can be tracked to help assess long-term response.

Table 13. Breakdown of phosphorus load sources and modeled water quality for current and target conditions that meet the water quality goal (Objective 1) for Shaws Pond and that reflect all field identified reduction opportunities in the watershed.

Parameter	Unit	Current Condition	Target Condition	Reduction (Unit, %)
Total P Load (All Sources)[1]	kg/yr	50	41.6	-8.4 (17%)
(A) Background P Load[2]	kg/yr	18.5	18.5	0 (0%)
(B) Disturbed (Human) P Load[3]	kg/yr	31.5	23.1	-8.4 (27%)
(C) Developed Land Use P Load	kg/yr	24.3	16.9	-7.4 (30%)
(D) Septic System P Load	kg/yr	3.7	2.7	-1 (27%)
(E) Internal P Load	kg/yr	3.5	3.5	0 (0%)
In-Lake TP*	ppb	10.2	8.5	-1.7 (17%)
In-Lake Chl-a*	ppb	3.3	2.5	-0.8 (24%)
In-Lake SDT*	meters	3.9	3.9	0 (0%)
In-Lake Bloom Probability*	days	7	2	-7 (71%)

[1] *Total P Load (All Sources) = A + B*

[2] *Sum of forested/water/natural land use load, waterfowl load, and atmospheric load*

[3] *Sum of developed land use load, shorefront septic system load, and internal load (B = C+D+E)*

* *Water quality parameters were sourced from the model and reflect annual average conditions*

6 PLAN IMPLEMENTATION & EVALUATION

The following section details the oversight and estimated costs (with funding strategy) needed to implement the action items recommended in the Action Plan (Section 5), as well as the monitoring plan and indicators to measure progress of plan implementation over time.

6.1 PLAN OVERSIGHT

The recommendations of this plan will be carried out by a diverse stakeholder group in the form of a dedicated committee, including representatives from the WQC, Friends of Shaws Pond, the Town of New Durham (e.g., select boards, planning boards and conservation commissions), state and federal agencies or organizations, nonprofits, land trusts, schools and community groups, local business leaders, and landowners. The committee will need to meet regularly and work hard to coordinate resources across stakeholder groups to fund and implement the management actions. The Action Plan (Section 5) will need to be updated periodically (typically every 2, 5, and 10 years) to ensure progress and to incorporate any changes in watershed activities. Measurable milestones (e.g., number of BMP sites, volunteers, funding received, etc.) should be tracked by the committee.

The Action Plan (Section 5) identifies the stakeholder groups responsible for each action item. Generally, the following responsibilities are noted for each key stakeholder:

- The WQC will conduct water quality monitoring.
- The WQC will be responsible for establishing a dedicated committee and will work to address NPS problems identified in the watershed, including conducting regular best practices maintenance on roads, adopting ordinances for water quality protection, and addressing other recommended actions specified in the Action Plan. Other stakeholder groups can work with the municipality to provide support in reviewing and tailoring the recommendations to fit the specific needs of each community.
- The Conservation Commission should work with municipal staff and boards to facilitate the implementation of the recommended actions specified in the Action Plan.
- Shoreline residents will continue to monitor and report on cyanobacteria blooms and other water quality issues and the Friends of Shaws Pond will provide critical outreach and education on water quality protection needs.
- SCCD can provide administrative capacity and can help acquire grant funding for BMP implementation projects and education/outreach to watershed residents and municipalities.
- NHDES can provide technical assistance, permit approval, and the opportunity for financial assistance through the 319 Watershed Assistance Grant Program and other funding programs.
- Private landowners will seek opportunities for increased awareness of water quality protection issues and initiatives and conduct activities in a manner that minimizes pollutant impact to surface waters.

The success of this plan is dependent on the continued effort of volunteers and a strong and diverse committee that meets regularly to coordinate resources for implementation, review progress, and make any necessary adjustments to the plan to maintain relevant action items and interim milestones. A reduction in nutrient loading is no easy task, and because there are many diffuse sources of phosphorus reaching the rivers, lakes, and ponds from existing development, roads, septic systems, and other land uses in the watershed, it will require an integrated and adaptive approach across many different parts of the watershed community to be successful.

6.2 ESTIMATED COSTS

The strategy for reducing pollutant loading to Shaws Pond to meet the water quality goal and objectives set in Section 2.4 will be dependent on available funding and labor resources but will include approaches that address sources of phosphorus loading, as well as water quality monitoring and education and outreach. Additional significant but difficult to quantify strategies for reducing phosphorus loading to the lake are revising local ordinances such as setting LID requirements on new construction, identifying and replacing malfunctioning septic systems, performing proper road maintenance, and improving agricultural practices (refer to Section 5: Action Plan for more details). With a dedicated stakeholder group in place and with the help of grant or local funding, it is possible to achieve the target phosphorus reductions and meet the established water quality goal for Shaws Pond in the next 10 years. **The cost of successfully implementing the plan is estimated to be at least $370-$700 thousand over the next 10 or more years** (Table 14). However, many costs are still unknown or were roughly estimated and should be updated as information becomes available. In addition, costs to private landowners (e.g., septic system upgrades, private road maintenance, etc.) are not reflected in the estimate, nor were costs associated with purchasing land for conservation.

Table 14. Estimated pollutant reduction (TP) in kg/year and estimated total and annual 10-year costs for implementation of the Action Plan to meet the water quality goal and objectives for Shaws Pond. The light gray shaded planning actions are necessary to achieve the water quality goal. Other planning actions are important but difficult to quantify for TP reduction and costs, the latter of which were roughly estimated here as general placeholders.

Planning Action	TP Reduction (kg/yr)	Estimated Total Cost	Estimated Annual Cost
Watershed & Shoreline BMPs	**7.4**	$177,500 – $302,000	$17,750 – $30,200
Road and Driveway Management	TBD	$43,300 – $48,600	$4,330 – $4,860
Municipal Operations	TBD	TBD	TBD
Municipal Land Use Planning & Zoning	**50.3***	TBD	TBD
Land Conservation		$35,000 – $40,000	$3,500 – $4,000
Septic System Management	**1**	$23,000 – 28,000	$2,300 – $2,800
Agricultural Practices	TBD	TBD	TBD
Education & Outreach	TBD	$41,000 – $81,000	$4,100 – $8,100
Monitoring	*NA*	$50,000 – $200,000	$5,000 – $20,000
Total	**57.8**	**$369,800 – $699,600**	**$36,980 – $69,960**

** Estimated increase in phosphorus load from new development in the next 10 years.*

6.3 FUNDING STRATEGY

It is important that the committee develop a strategy to collect the funds necessary to implement the recommendations listed in the Action Plan (Section 5). Funding to cover ordinance revisions and third-party review could be supported by municipalities through tax collection (as approved by majority vote by town residents). Monitoring and assessment funding could come from a variety of sources, including state and federal grants, municipalities, or donations. Funding to improve septic systems, roads, and shoreland zone buffers would likely come from private landowners. As the plan evolves into the future, the establishment of a funding subcommittee will be a key part in how funds are raised, tracked, and spent to implement and support the plan. Listed below are state and federal funding sources that could assist the committee with future water quality and watershed work for Shaws Pond. Links to each funding source are embedded in the title.

Funding Options:

- EPA/NHDES 319 Grants (Watershed Assistance Grants) – This NPS grant is designed to support local initiatives to restore impaired waters (priorities identified in the NPS Management Program Plan, updated 2024) and protect high quality waters. 319 grants are available for the implementation of watershed-based plans and typically fund $50,000 to $150,000 projects over the course of two years.

- NH State Conservation Committee (SCC) Grant Program (Moose Plate Grants**)** – County Conservation Districts, municipalities (including commissions engaged in conservation programs), and qualified nonprofit organizations are eligible to apply for the SCC grant program. Projects must qualify in one of the following categories: Water Quality and Quantity; Wildlife Habitat; Soil Conservation and Flooding; Best Management Practices; Conservation Planning; and Land Conservation. The total SCC grant request per application cannot exceed $40,000.
- Land and Community Heritage Investment Program (LCHIP) **–** This grant provides matching funds to help municipalities and nonprofits protect the state's natural, historical, and cultural resources.
- Aquatic Resource Mitigation Fund (ARM) – This grant provides funds for projects that protect, restore, or enhance wetlands and streams to compensate for impacted aquatic resources. The fund is managed by the NHDES Wetlands Bureau that oversees the state In-Lieu Fee Program (ILFP) compensatory mitigation program. A permittee can make a payment to NHDES to mitigate or offset losses to natural resources because of a project's impact to the environment.
- New England Forest and River Grant (NFWF NEFRG) – This grant awards $75,000 to $300,000 to projects that restore and sustain healthy forests and rivers through habitat restoration, fish barrier removal, and stream connectivity such as culvert upgrades.
- Aquatic Invasive Plant Control, Prevention and Research Grants (NHDES AIPC) – Funds are available each year for projects that prevent new infestations of exotic plants, including outreach, education, Lake Host Programs, and other activities.
- Clean Water State Revolving Fund (NHDES CWSRF) – This fund provides low-interest loans to communities, nonprofits, and other local government entities to improve and replace wastewater collection systems with the goal of protecting public health and improving water quality. A portion of the CWSRF program is used to fund NPS pollution prevention, watershed protection and restoration, and estuary management projects that help improve and protect water quality in NH.
- Regional Conservation Partnership Program (RCCP) - This NRCS grant provides conservation assistance to producers and landowners for projects carried out on agricultural land or non-industrial private forest land to achieve conservation benefits and address natural resource challenges. Eligible activities include land management restoration practices, entity-held easements, and public works/watershed conservation activities.
- Agricultural Conservation Easement Program (ACEP) - This NRCS grant protects the agricultural viability and related conservation values of eligible land by limiting nonagricultural uses which negatively affect agricultural uses and conservation values, protect grazing uses and related conservation values by restoring or conserving eligible grazing land, and protecting, restoring, and enhancing wetlands on eligible land. Eligible applicants include private landowners of agricultural land, cropland, rangeland, grassland, pastureland, and non-industrial private forestland.
- Conservation Stewardship Program (CSP) - This NRCS grant helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resource concerns. Eligible lands include private agricultural lands, non-industrial private forestland, farmstead, and associated agricultural lands, and public land that is under control of the applicant.
- Environmental Quality Incentives Program (EQIP) - This NRCS grant provides financial and technical assistance to agricultural producers and non-industrial forest managers to address natural resource concerns and deliver environmental benefits. Eligible applicants include agricultural producers, owners of non-industrial private forestland, water management entities, etc.
- National Fish and Wildlife Federation (NFWF) Five Star and Urban Waters Restoration Grants (NFWF 5-Star) - Grants seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development. Eligible projects include wetland, riparian, in-stream, and/or coastal habitat restoration; design and construction of green infrastructure BMPs; water quality monitoring/assessment; outreach and education.

- North American Wetlands Conservation Act (NAWCA) Grants - The U.S. Standard Grants Program is a competitive, matching grants program that supports public-private partnerships carrying out projects in the United States that further the goals of the North American Wetlands Conservation Act (NAWCA). These projects involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats for the benefit of all wetlands-associated migratory birds.
- National Park Service - Land and Water Conservation Fund Grant Program (LWCF) - Eligible projects include acquisition of parkland or conservation land; creation of new parks; renovations to existing parks; and development of trails. Municipalities must have an up-to-date Open Space and Recreation Plan. Trails constructed using grant funds must be ADA-compliant.

6.4 RECOMMENDED MONITORING PLAN

A long-term water quality monitoring plan is critical to evaluate the effectiveness of implementation efforts over time. The WQC with assistance through the UNH LLMP has been monitoring Shaws Pond, providing valuable water quality data to the community that would otherwise not exist. The WQC (with assistance from the Friends of Shaws Pond), in concert with the UNH LLMP, should continue and consider expanding on the following annual monitoring listed below and shown in Table 15 as resources allow:

- Continue annual monitoring through the UNH LLMP. Consider expanding to monthly monitoring from ice-out to October each year for at least total phosphorus (surface and bottom), chlorophyll-a (composite or surface), Secchi disk transparency, and dissolved oxygen-temperature profiles to the pond bottom.
- Collect dissolved oxygen and temperature profiles and Secchi disk transparency readings biweekly from June 1 to September 30 between the hours of 10am and 2pm.
    - For lake assessment purposes, NHDES requires the following criteria for dissolved oxygen: no more than two or 10% of samples (whichever is greater), collected from the epilimnion (defined from the surface to the first 1 or more °C change in temperature) between the days of June 1 and September 30 and the hours of 10am and 2pm in the last 10 years, can be less than 5 mg/L for a Class B waterbody such as Shaws Pond. All 2024 profiles for Shaws Pond were taken between 9am and 10am. We recommend that regular profile data collection be conducted to fulfill NHDES requirements.
- Re-deploy the continuous monitoring equipment (loggers) for 2025 and 2026.
- Establish long-term stream monitoring stations at Washington Street Brook, Golf Course Brook, South Brook, and Boat Ramp Stream.
    - From March through September, collect measurements for water temperature, dissolved oxygen, total phosphorus, and chloride/conductivity grab samples, from the major inflowing tributaries, targeting both wet and dry weather conditions.
- Continue to monitor the lake for cyanobacteria blooms and alert NHDES immediately if a bloom is suspected. Coordinate with NHDES to collect samples for analysis.
    - Consider conducting cyanotoxin testing should another cyanobacteria bloom occur.

Table 15. Recommended monitoring plan by month for Shaws Pond and its primary tributaries. Wet or dry sampling for the tributaries can vary by month depending on the weather. April sampling at 1 DEEP is dependent on the timing of ice out.

Month	Location				
	1 DEEP (Shaws Pond Deep Spot)	Washington Street Brook	Golf Course Brook	South Brook East	Boat Ramp Stream
Mar		Temp, DO, TP, chloride, conductivity (Wet).			
Apr	1 Temp/DO profile, SDT, TP surface, TP bottom, chl-a. Ensure temperature loggers are deployed.	Temp, DO, TP, chloride, conductivity (Dry).			
May	1 Temp/DO profile, SDT, TP surface, TP bottom, chl-a.	Temp, DO, TP, chloride, conductivity (Wet). Check stream gages have not shifted.			
June	1 TP surface, TP bottom, chl-a. 2 Temp/DO profiles, SDT.	Temp, DO, TP, chloride, conductivity (Dry).			
July	1 TP surface, TP bottom, chl-a. 2 Temp/DO profiles, SDT.	Temp, DO, TP, chloride, conductivity (Wet or Dry).			
Aug	1 TP surface, TP bottom, chl-a. 2 Temp/DO profiles, SDT.	Temp, DO, TP, chloride, conductivity (Wet).			
Sept	1 TP surface, TP bottom, chl-a. 2 Temp/DO profiles, SDT.	Temp, DO, TP, chloride, conductivity (Dry).			
Oct	1 Temp/DO profile, SDT, TP surface, TP bottom, chl-a. Prepare temperature loggers for winter.	None			

6.5 INDICATORS TO MEASURE PROGRESS

The following environmental, programmatic, and social indicators and associated numeric targets (milestones) will help to quantitatively measure the progress of this plan in meeting the established goal and objectives for the Shaws pond watershed (Table 16). These benchmarks represent short-term (2026), mid-term (2029), and long-term (2034) targets derived directly from actions identified in the Action Plan (Section 5). Setting milestones allows for periodic updates to the plan, maintains and sustains the action items, and makes the plan relevant to ongoing activities. The committee should review the milestones for each indicator on an ongoing basis to determine if progress is being made, and then determine if the plan needs to be revised because the targets are not being met.

Environmental Indicators are a direct measure of environmental conditions. They are measurable quantities used to evaluate the relationship between pollutant sources and environmental conditions. They assume that recommendations outlined in the Action Plan (Section 5) will be implemented accordingly and will result in an improvement in water quality. Programmatic indicators are indirect measures of watershed protection and restoration activities. Rather than indicating that water quality reductions are being met, these programmatic measurements list actions intended to meet the water quality goal. Social Indicators measure changes in social or cultural practices and behavior that lead to implementation of management measures and water quality improvement.

Table 16. Environmental, programmatic, and social indicators for the Shaws Pond Watershed-Based Management Plan. ** indicators particularly relevant to assessing progress toward achieving the water quality goal and objectives.

Indicators	Milestones*		
	2026	**2029**	**2034**
ENVIRONMENTAL INDICATORS			
Achieve an average summer deep spot epilimnion total phosphorus concentration of 7.0 ppb at the deep spot in Shaws Pond. Existing median total phosphorus is calculated at 8.7 ppb.	<8.5 ppb	<8.0 ppb	<7.0 ppb
Achieve an average summer deep spot epilimnion chlorophyll-a concentration of less than 2.5 ppb at the deep spot in Shaws Pond. Existing chlorophyll-a concentration is calculated at 3.6 ppb.	<3.3 ppb	<3.0 ppb	<2.5 ppb
Eliminate the occurrence of cyanobacteria or algal blooms in Shaws Pond **	5 days/yr	2 days/yr	0 days/yr
Achieve an average summer water clarity to the lake bottom (~4.9m) at the deep spot in Shaws Pond	4.25 m+	4.5 m+	Lake bottom
Achieve a reduction in total phosphorus load from the major tributaries to Shaws Pond. More data are needed to establish a baseline from which to track change over time **	TBD	TBD	TBD
PROGRAMMATIC INDICATORS			
Amount of funding secured from municipal/private work, fundraisers, donations, and grants	$175,000	$350,000	$700,000
Number of NPS sites remediated (17 identified) **	5	11	17
Linear feet of buffers improved in the shoreland zone **	600	1,000	1,400
Percentage of shorefront properties with LakeSmart certification **	25%	50%	75%
Number of watershed/shoreline properties receiving technical assistance visits	5	15	25
Number of workshops and trainings for stormwater improvements to residential properties (e.g., NHDES Soak Up the Rain NH program)	1	2	5
Number of updated or new ordinances that target water quality protection	1	3	5
Number of new municipal staff for inspections and enforcement of regulations	0	1	1
Number of voluntary or required septic system inspections	5	10	25
Number of septic system upgrades **	2	8	15
Number of informational workshops and/or trainings for landowners, municipal staff, and/or developers/landscapers on local ordinances, watershed goals, and/or best practices for road management and winter maintenance	1	4	8
Number of parcels with new conservation easements or number of parcels put into permanent conservation	0	1	3
Number of copies of watershed-based educational materials distributed or articles published	75	250	500
Number of new best practices for road management and winter maintenance implemented on public and private roads by the municipalities	2	5	10

Indicators	Milestones*		
	2026	**2029**	**2034**
Number of municipalities fully implementing key aspects of the MS4 program (Brookfield is not included here because the portion in Shaws Pond is conserved forested land)	1	2	2
Number of meetings and/or presentations to municipal staff and/or boards related to the WBMP	2	5	10
Number of farmers working with NRCS or SCCD or the number of CNMPs completed or NRCS technical assistance provided for farms in the watershed	0	1	2
SOCIAL INDICATORS			
Number of new association members	10	25	50
Number of volunteers participating in educational campaigns	5	10	25
Number of people participating in informational meetings, workshops, trainings, BMP demonstrations, or group septic system pumping	10	20	40
Number of watershed residents installing conservation practices on their property and/or participating in LakeSmart	10	20	40
Number of municipal DPW staff receiving Green SnowPro training	1	2	3
Number of groups or individuals contributing funds for plan implementation	5	10	25
Number of newly trained water quality and invasive species monitors	2	4	6
Percentage of residents making voluntary upgrades or maintenance to their septic systems (with or without free technical assistance), particularly those identified as needing upgrades or maintenance	10%	25%	50%
Number of daily visitors to the New Durham Water Quality Committee Face Book page.	10	15	30

**Milestones are cumulative starting at year 1.*

ADDITIONAL RESOURCES

Buffers for wetlands and surface waters: a guidebook for New Hampshire municipalities. Chase, et al. 1997. NH Audubon Society.

Conserving your land: options for NH landowners. Lind, B. 2005. Center for Land Conservation Assistance / Society for the Protection of N.H. Forests.

Gravel road maintenance manual: a guide for landowners on camp and other gravel roads. Maine Department of Environmental Protection, Bureau of Land and Water Quality. April 2010.

Gravel roads: maintenance and design manual. U.S. Department of Transportation, Federal Highway Program. November 2000. South Dakota Local Transportation Assistance Program (SD LTAP).

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Landscaping at the water's edge: an ecological approach. University of New Hampshire, Cooperative Extension. 2007.

New Hampshire Homeowner's Guide to Stormwater Management: Do-It-Yourself Stormwater Solutions for Your Home. New Hampshire Department of Environmental Services, Soak Up the Rain NH. Revised November 2019.

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Stormwater Manual, Volumes 1-3. New Hampshire Department of Environmental Services. 2008.

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Erosion Control for Construction within the Protected Shoreland. SP-1, 2020.

Lake Eutrophication. WD-BB-3, 2019.

Lawn Care within the Protected Shoreland. SP-2, 2020.

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Phosphorus: Too much of a good thing. WD-BB-20, 2019.

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You and Your Septic System, a Homeowner's Guide to Septic System Maintenance. SSB-13 2020.

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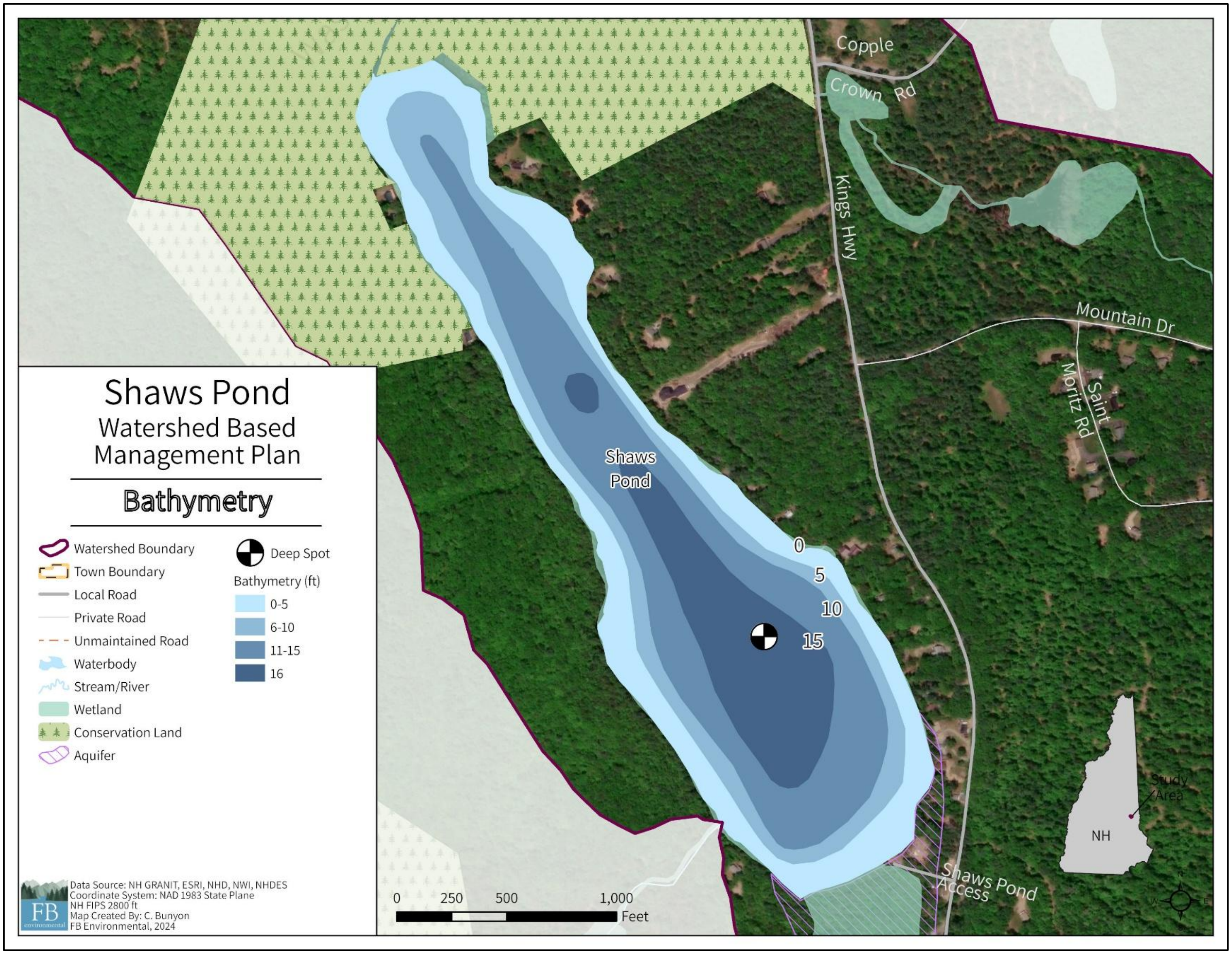
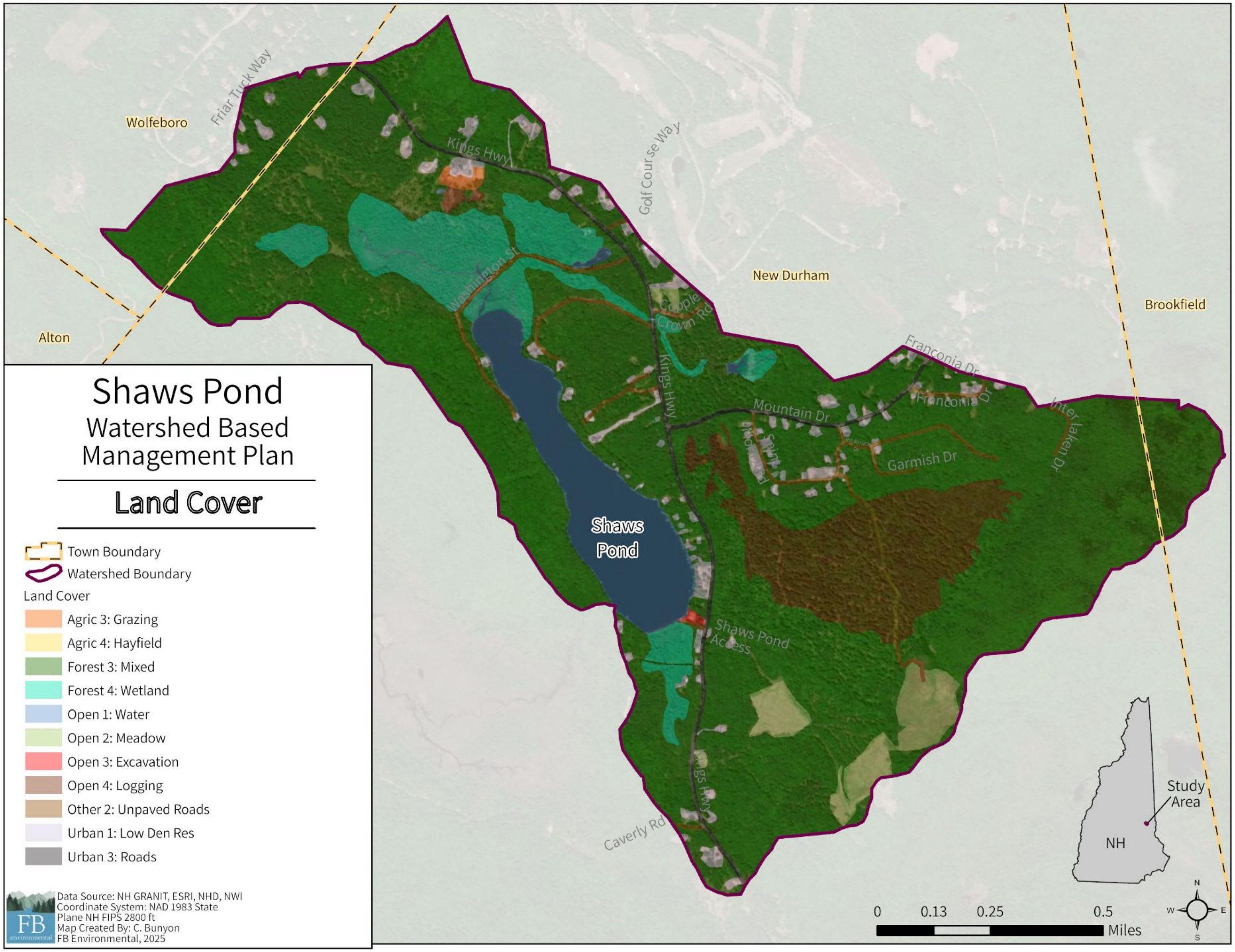
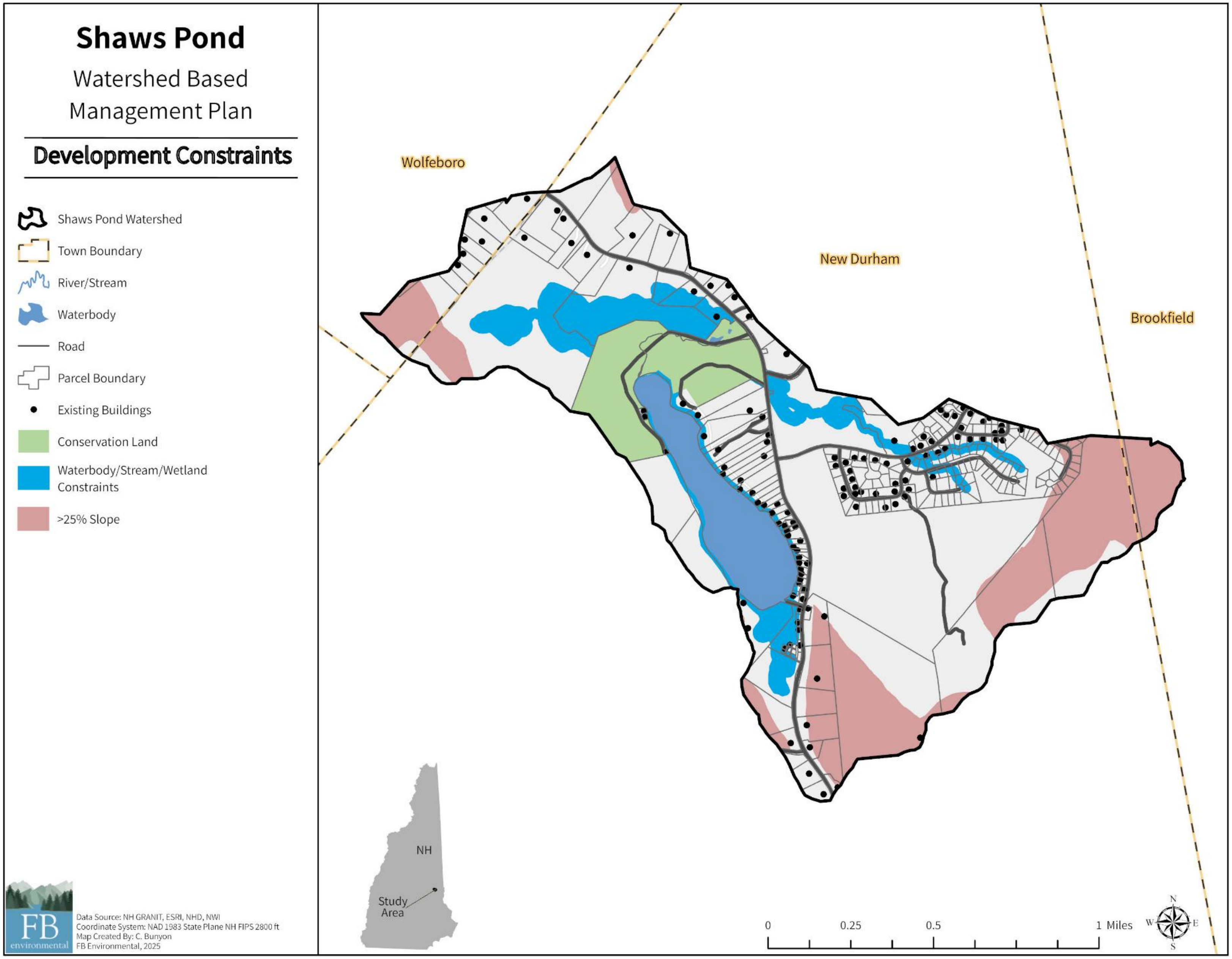
APPENDIX A: SUPPORTING MAPS



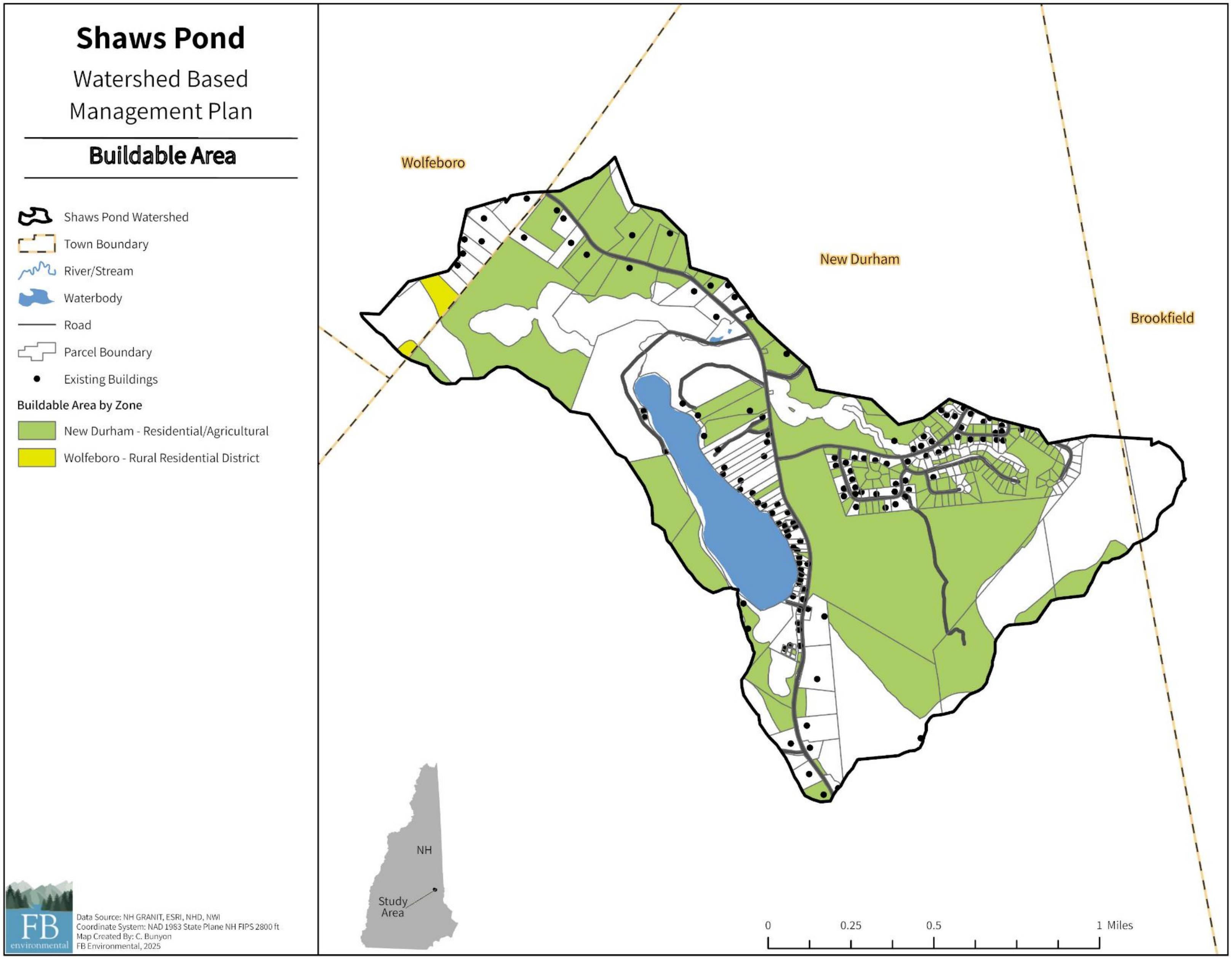
Map A-1. Bathymetry as 5-foot depth contours for Shaws Pond.



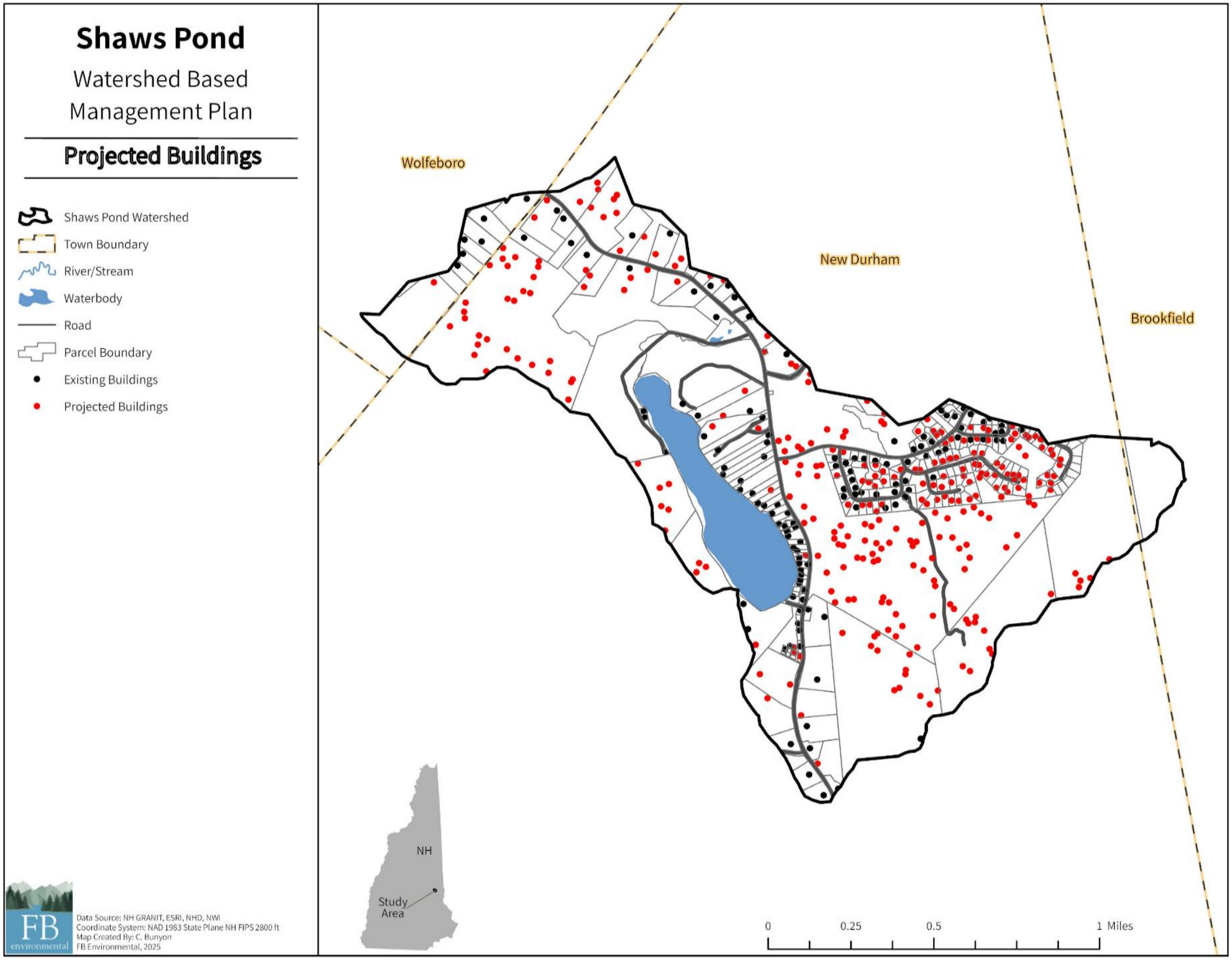
Map A-2. Land cover for the Shaws Pond watershed.



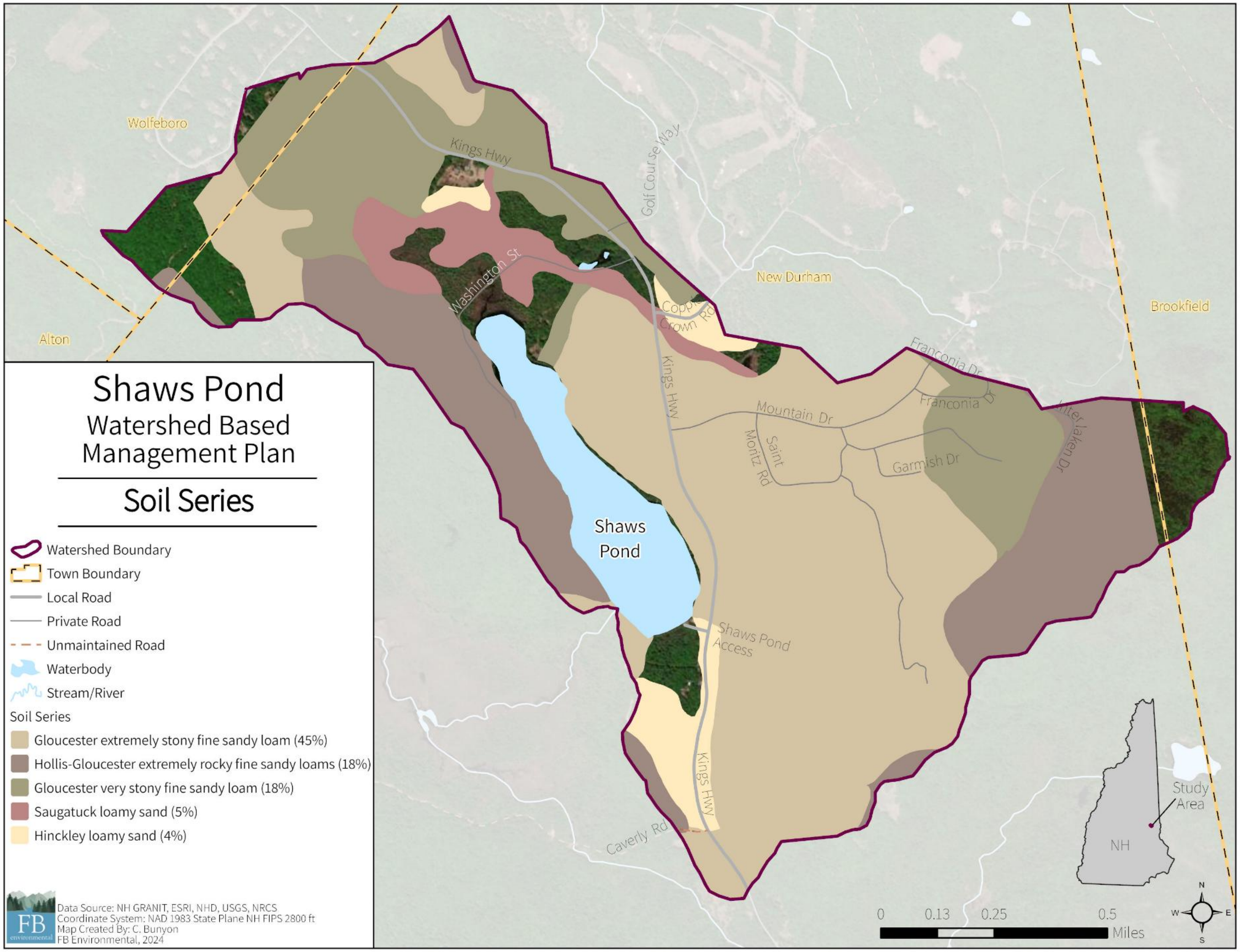
Map A-3. Development constraints in the Shaws Pond watershed in New Durham, Wolfeboro, and Brookfield, NH.



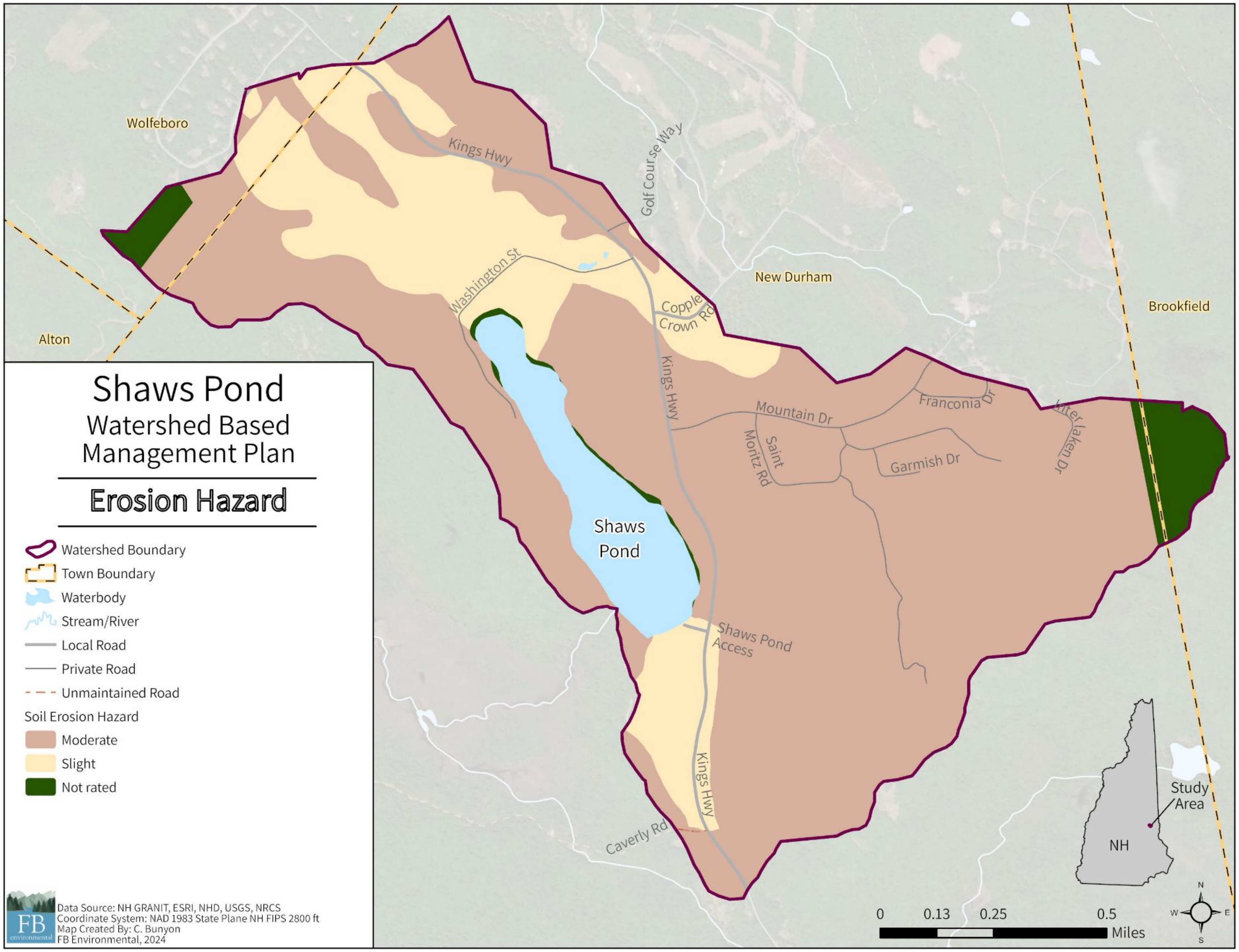
Map A-4. Buildable area by municipal zone in the Shaws Pond watershed in New Durham, Wolfeboro, and Brookfield, NH.



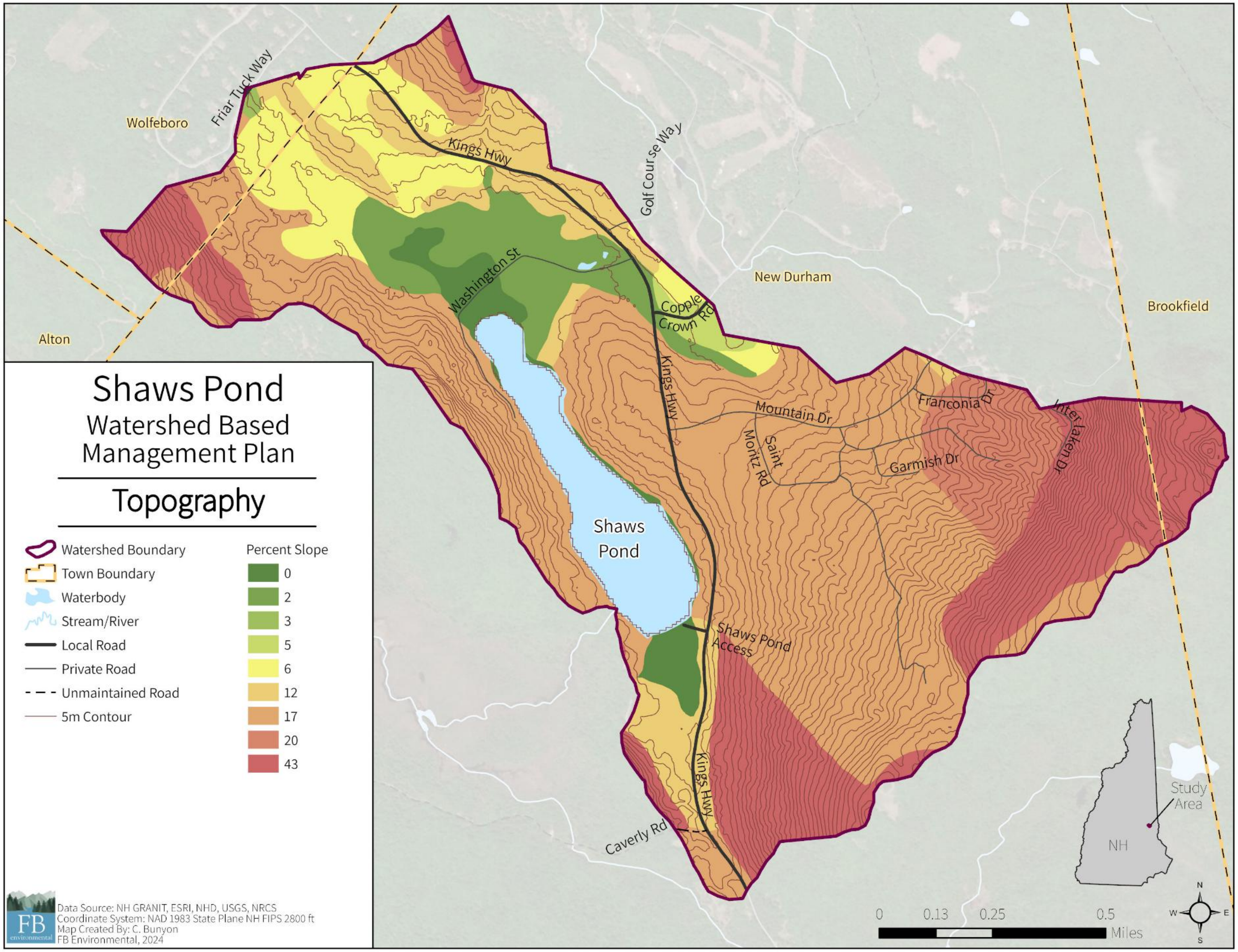
Map A-5. Projected buildings in the Shaws Pond watershed in New Durham, Wolfeboro, and Brookfield, NH.



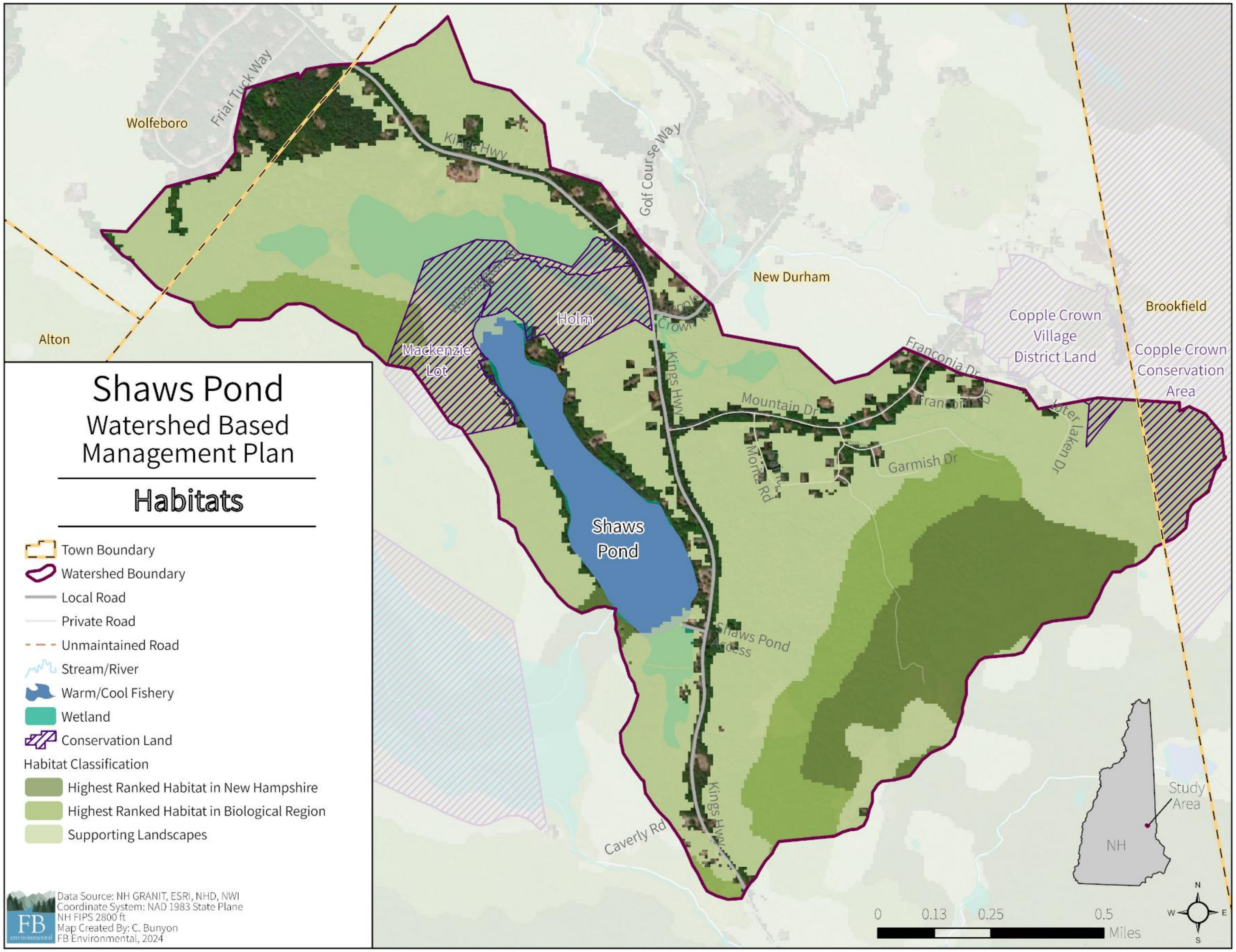
Map A-6. Soil series in the Shaws Pond watershed.



Map A-7. Soil Erosion Hazard in the Shaws Pond watershed.



Map A-8. Topography of the Shaws Pond watershed.



Map A-9. Conservation land and High value habitat according to the 2020 New Hampshire Wildlife Action Plan within the Shaws Pond watershed.

APPENDIX B: BMP MATRIX

Table B-1. Site ID, location description, primary recommended actions, estimated nutrient load reductions, and estimated implementation costs for the 16 NPS sites identified in the Shaws Pond watershed. Pollutant load reductions and cost estimates are preliminary and are for planning purposes only. Cost estimates are based on pre-COVID19 ranges (adjusted for 2024 inflation), and thus actual construction costs could be highly variable at this time. Sites are priority ranked from 1 to 17 for lowest to highest cost per pound of phosphorus load reduced with remediation and then edited based on impact score. Sediment loads are calculated only for stabilization sites using the U.S. EPA's Pollutant Load Estimation Tool (PLET) model. Colored rows group sites according to the Action Plan (Section 5).

Site ID	Location	Impact Score	Primary Recommended Actions	TP (kg/yr)	TN (kg/yr)	Sediment (tons/yr)	Est. Low Cost	Est. High Cost	Est. Avg. Cost	Est. Avg. Cost per kg/yr TP removed	Rank
1-8[1]	Shaws Pond Access	High	Treatment, Stabilization	3.8	8.3	9.6	$15,000	$20,000	$17,500	$4,605	1
1-9	Kings Hwy Near House 274	High	Treatment, Stabilization	0.2	0.6	0.5	$5,000	$10,000	$7,500	$34,091	2
1-10	Kings Hwy North of Site 1-09	Low	Stabilization	2.9	5.8	7.5	$12,000	$16,000	$14,000	$4,844	3
SP-2	Kings Hwy Near House 290	High	Stabilization	1.1	2.8	4.6	$12,000	$20,000	$16,000	$14,545	4
SP-3	Kings Hwy Near Houses 274-280	High	Treatment, Stabilization	0.5	1.4	2.2	$20,000	$50,000	$35,000	$70,000	5
1-5[2]	Kings Hwy Near House 227	Medium	Stabilization	1.6	3.3	4.3	$10,000	$20,000	$15,000	$9,146	6
SP-1	Copple Crown Rd Intersection	Medium	Stabilization	0.3	0.7	1.1	$2,500	$5,000	$3,750	$12,500	7
SP-4	Middle Shaws Brook Crossing at Kings Hwy	High	Treatment	0.5	2.4	-	$20,000	$50,000	$35,000	$70,000	8
1-7	Kings Hwy Near House 250	Medium	Treatment	0.1	0.5	-	$10,000	$10,000	$10,000	$200,000	9
1-15	Kings Hwy Near Horses	Low	Stabilization	0.7	1.5	1.9	$10,000	$15,000	$12,500	$16,892	10
1-3	Kings Hwy Near Caverly Rd	Low	Stabilization	0.6	1.3	1.6	$10,000	$15,000	$12,500	$19,841	11
1-16	Kings Hwy Near House 410	Low	Stabilization	0.1	0.2	0.3	$5,000	$5,000	$5,000	$45,455	12
1-4	Caverly Road Surface	Low	Treatment	0.3	2.6	-	$10,000	$15,000	$12,500	$48,077	13
1-11	St. Moritz Dr - North	Low	Stabilization	0.3	0.7	0.9	$10,000	$25,000	$17,500	$53,030	14
1-6	Kings Hwy Across from Site 1-5	Low	Stabilization	0.1	0.1	0.1	$5,000	$5,000	$5,000	$100,000	15
1-12	St. Moritz Dr - South	Low	Stabilization	0.0	0.1	0.1	$5,000	$5,000	$5,000	$125,000	16
SP-5	SP-5: Washington St Wetlands	Low	Additional Investigations	-	-	-	-	-	-	-	17
TOTAL:				**13.16**	**32.15**	**34.7[3]**	**$161,500**	**$286,000**	**$223,750**		

[1] Load reduction calculations by Horsley Witten Group (7/17/2025) as part of the creation of a conceptual design.
[2] Indicates construction was present at the time of the site visit.
[3] Indicates the value is only a summation of sediment loads from stabilization sites. This is likely an underestimation of the total sediment load within the Shaws Pond watershed.

APPENDIX C: SHAWS POND BOAT RAMP STORMWATER MANAGEMENT CONCEPTUAL DESIGN - DRAFT

Shaws Pond Boat Ramp Stormwater Management Conceptual Design

New Durham, New Hampshire

DRAFT July 2025

PREPARED FOR

Town of New Durham, NH and
New Durham Water Quality Committee

PREPARED BY

Horsley Witten Group, Inc.
112 Water Street | 6th Floor
Boston, MA 02109

INTRODUCTION

The Town of New Durham, with support from the New Durham Water Quality Committee, contracted with the Horsley Witten Group (HW) to develop a conceptual design for stormwater management and erosion control at the Shaws Pond Access Drive and Boat Ramp. The goal of the project is to improve water quality in Shaws Pond, consistent with the Wolfeboro Bay Watershed Management Plan (2024) and Shaws Pond Watershed Management Plan (2025).

Shaws Pond Access Drive and Boat Ramp are situated on the southeast shoreline of Shaws Pond, off Kings Highway in New Durham, NH, and within the Wolfeboro Bay (Lake Winnipesaukee) watershed. Shaws Pond (assessment unit NHLAK700020101-03) is not listed as impaired on the 2024 New Hampshire Department of Environmental Services (NHDES) 303(d) impaired surface waterbodies list. However, the NHDES 2024 watershed assessment identified Shaws Pond as a Category 3-PNS "Likely Bad", with limited data indicating that the water quality is potentially not meeting water quality standards for aquatic life integrity. Water quality sampling indicates that it suffers from depleted dissolved oxygen concentrations during summer months. The pond also experienced a cyanobacteria bloom warning in September 2024. This suggests that anthropogenic inputs of phosphorus to Shaws Pond, such as from stormwater runoff, shoreline erosion, and septic systems, are likely affecting the health of the lake.

The Wolfeboro Bay Watershed Management Plan identified the Shaws Pond Access (Site 1-8 in the BMP Matrix) as a recommended mitigation site to reduce pollutant loading. The planning team recommended stormwater treatment and shoreline buffer restoration and estimated that mitigation would achieve a 0.47 lb/yr (0.21 kg/yr) reduction in Total Phosphorus (TP) loading, at an estimated construction cost of $15,000-$20,000. The Shaws Pond Watershed Survey, conducted in July 2024, further documented erosion and debris at the site and refined the prior recommendations for runoff diversion, shoreline revegetation, waste management, and stakeholder engagement.

HW's team visited the Shaws Pond Access Drive and Boat Ramp on May 5, 2025, during a steady drizzle that allowed our team to observe conditions during rainy weather. We were joined on site by the Town Administrator, DPW Director, Building Inspector, and Chair of the New Durham Water Quality Committee. During the site visit, we gathered information on site uses, preferred practices, and abutter constraints, and collected measurements and photos. We discussed initial ideas for site improvements and received feedback from the Town representatives.

This report presents a conceptual (10% level) design for stormwater management, erosion stabilization, and buffer restoration at the site, along with planning-level estimates of costs[1] and sediment and nutrient load reduction[2]. The goal of the proposed improvements is to reduce sediment and phosphorus loading to Shaws Pond. The design also aims to maintain existing site uses, minimize long-term maintenance requirements, and educate the public about water quality.

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[1] Planning-level construction costs were estimated using NHDOT and MassDOT unit prices, EPA Region 1 (2016) *Methodology for Developing Cost Estimates for Opti-Tool*, and best professional judgement. Costs include 25% contingency and are expressed in 2025 dollars.

[2] Pollutant load reductions were estimated using methodologies from the NH MS4 Permit Appendix F, EPA Region 5 Erosion Control Model, and UNH Stormwater Center (2019) *Pollutant Removal Credits for Restored or Constructed Buffers in MS4 Permits*.

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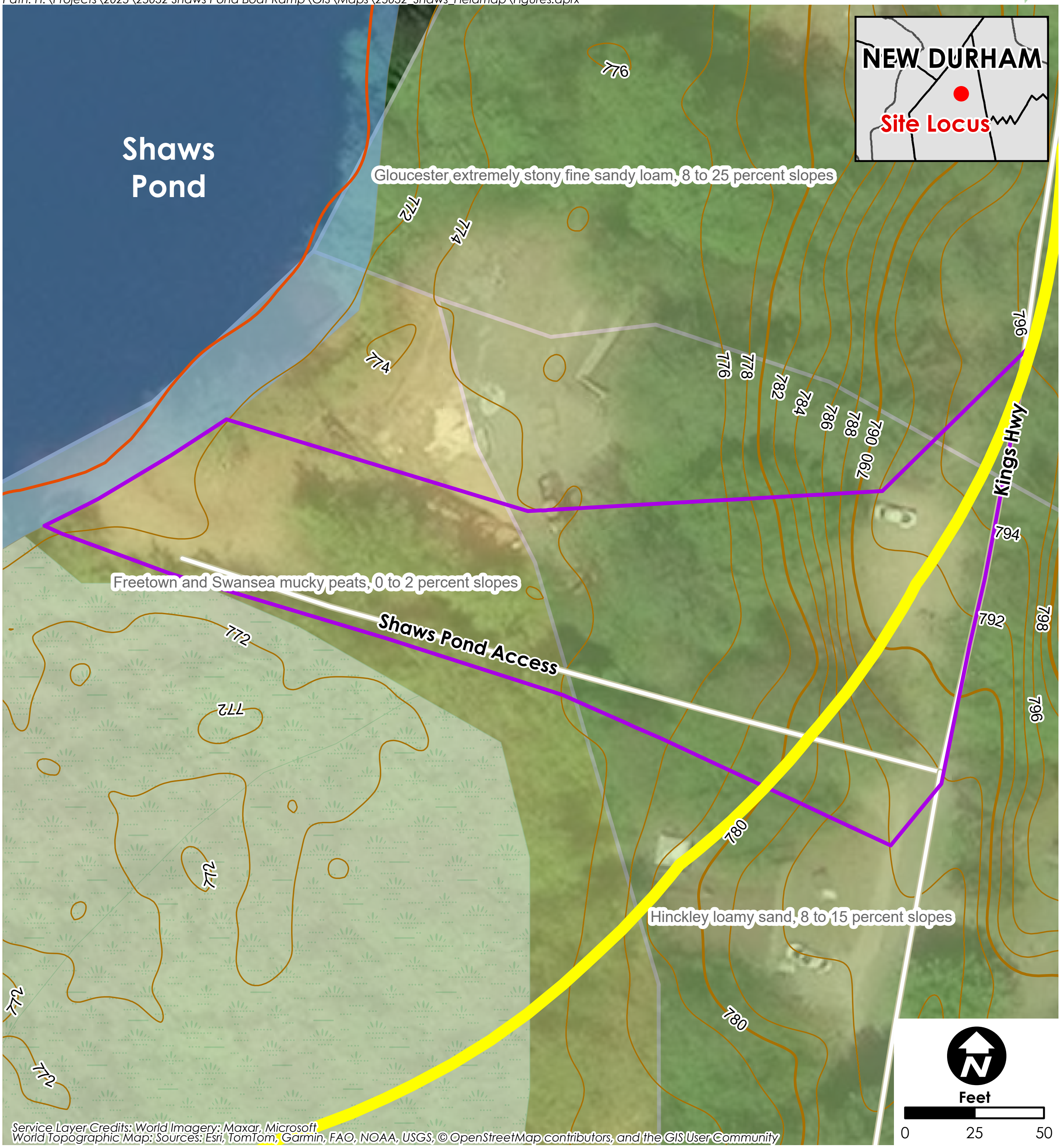
Path: H:\Projects\2025\25032 Shaws Pond Boat Ramp\GIS\Maps\25032_Shaws_Fieldmap\Figures.aprx



Date: 7/18/2025
Data Sources: NHGRANIT, ESRI, New Durham

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

Roads
Contours (2ft)
Reference Elevation*
Drainage Area
Shoreland Protection Zone
Wetlands
Freshwater Forested/Shrub Wetland
Lake
Hydrologic Soil Group
A
B/D

*Reference Elevation of Shaws Pond is 771 feet as designated by NHDES.

Shaws Pond Access Stormwater Management Conceptual Designs
New Durham, NH

Figure 1
Existing Conditions

CONCEPTUAL DESIGN

Existing Site Description

- **Location:** Shaws Pond Boat Ramp is located at the southeast edge of Shaws Pond along Kings Highway, with access between 266 and 270 Kings Highway. The site is bounded by Kings Highway to the East, Shaws Pond to the west, and private properties to the north and south.
- **Ownership:** The public beach and boat ramp are on a narrow right of way owned by the Town of New Durham. The right of way measures approximately 330 ft long by 50 ft wide, with a 60-ft lake frontage. It appears that the northern portion of the access drive crosses onto the private parcel to the north (234 Kings Hwy).
- **Drainage Area:** The drainage area to the boat ramp and adjacent shoreline extends to the crowned centerline of Kings Hwy, with a high point in front of 270 Kings Highway and opposite a wood road. The drainage area for the full project site is approximately 0.6 acres. Existing land cover includes approximately 60% impervious area, consisting of paved and unpaved roads and driveways.
- **Topography:** The access drive slopes down to the boat ramp on a shallow, sandy shoreline. The upper portion of the access drive slopes steeply (approximately 12%) from Kings Hwy to the bottom of the slope where the drive widens into a loop. The lower portion of the access drive flattens out, sloping approximately 1% to the shoreline.
- **Soils:** Soils in the upper portion of the access drive are classified by Natural Resource Conservation Service (NRCS) as Hinckley loamy sand, excessively drained, hydrologic soil group (HSG) A, indicating good infiltration capacity. Soils in the lower portion of the access drive and the boat ramp/beach are classified by NRCS as Freetown and Swansea mucky peats, very poorly drained, HSG B/D, indicating high groundwater and poor infiltration potential.
- **Wetland Resources:** Shaws Pond has an area of approximately 68 acres and a surface elevation "reference line" of 771 ft (based on the NHDES consolidated list). A forested/shrub vegetated wetland abuts the site to the south. The lower portion of the site also lies within the 1% Annual Chance Flood Hazard Zone.
- **Shoreline Buffer:** The shoreline is unvegetated from the edge of the wetlands to the south to the edge of property to the north. Vegetation above the shoreline is comprised primarily of perennial grasses and Pennsylvania sedge, a native grass-like perennial that grows to around 8 inches tall.
- **Site Uses**
  - <u>Pond Access Drive</u>: The access drive splits into two loops, which allow for vehicle turning and backing into the boat ramp/shoreline. There is no formal parking along the access drive. The access drive is used by the abutter to the north (234 Kings Hwy) for access to their property. The private property owner plows the access drive in the winter. A secondary private road (Jackson Dr) transects the main access drive at the base of the slope from Kings Hwy, with a drivable gravel road extending to the north and a narrow unpaved trail extending to the south. The private drive and trail are used for access to surrounding structures and must remain accessible.
  - <u>Beach:</u> Approximately 67 linear ft. of unvegetated sandy beach extends onto private property to the north and back approximately 30 feet from the shoreline across the width of the right of way. According to stakeholders, the beach is not heavily used for swimming.
  - <u>Boat Ramp</u>: The boat ramp is not well defined, and the material blends with the rest of the shoreline/beach. The slope of the ramp is extremely shallow and vehicular access for boat

launching/removal is not currently feasible. During the time of our site visit in early May 2025, the boat ramp was almost entirely submerged.

- **Existing Stormwater Infrastructure:** There is no existing stormwater infrastructure along the west side of Kings Hwy nor within the access drive right of way. Runoff from Kings Hwy flows overland down the sloped access drive and pools in multiple low points along the access drive loops. Most runoff eventually flows into the pond at the boat ramp/shoreline or into the abutting wetland.
- **Erosion:** Intense storms have caused washouts along the access drive and boat ramp. During our visit in May, we observed water flowing through a minor gully on the northeast edge of the access drive to a large, ponded area at the center of the site, which then flowed into a second low spot before flowing into the pond. We also observed shallow erosion along the edge of the shoreline. Based on our observation of the submerged boat ramp and exposed cobbles within the access drive, we estimate an average of approximately 3 inches of gravel and sand has eroded across the width of the drive and ramp surfaces, with small areas of deeper erosion of up to 6 inches. Based on stakeholders' observations, most of the boat ramp erosion occurred during intense storms and flooding in the summer of 2023, and erosion on the loop drive worsened in 2024 due to construction equipment accessing the abutting private property.[3]

Google Streetview image of the approximate drainage area, from a high point along the centerline crown in front of 270 Kings Hwy extending down the slope to Shaws Pond.

[3] Note: For calculation of pollutant loading due to erosion, we assumed an average erosion depth of 3 inches across the surface area of the access drive and boat launch. To be conservative, we assumed that the erosion has occurred gradually over the past 10 years; however, the rate of erosion has likely accelerated in recent years due to degradation of the gravel surface, intense downpours, flooding, and construction traffic.


Photo 1: 270 Kings Hwy, facing south toward Shaws Pond Access Drive.


Photo 2: Top of Shaws Pond Access Drive at Kings Hwy.


Photo 3: Jackson Dr, extending north from Shaws Pond Access Drive, between 270 and 234 Kings Hwy.


Photo 4: Trail extending south from Shaws Pond Access Drive, below 266 Kings Hwy.


Photo 5: Upper portion of access drive, facing southeast toward 266 Kings Hwy.


Photo 6: Lower portion of access drive, facing west. Note the eroding flow paths along the drive. The driveway to 234 Kings Hwy is to the right (north).

Photo 7: First loop on access drive, opposite the driveway to 234 Kings Hwy.

Photo 8: Second loop on access drive.

Photo 9: Unvegetated shoreline and submerged boat ramp below the access drive second loop, facing northeast.

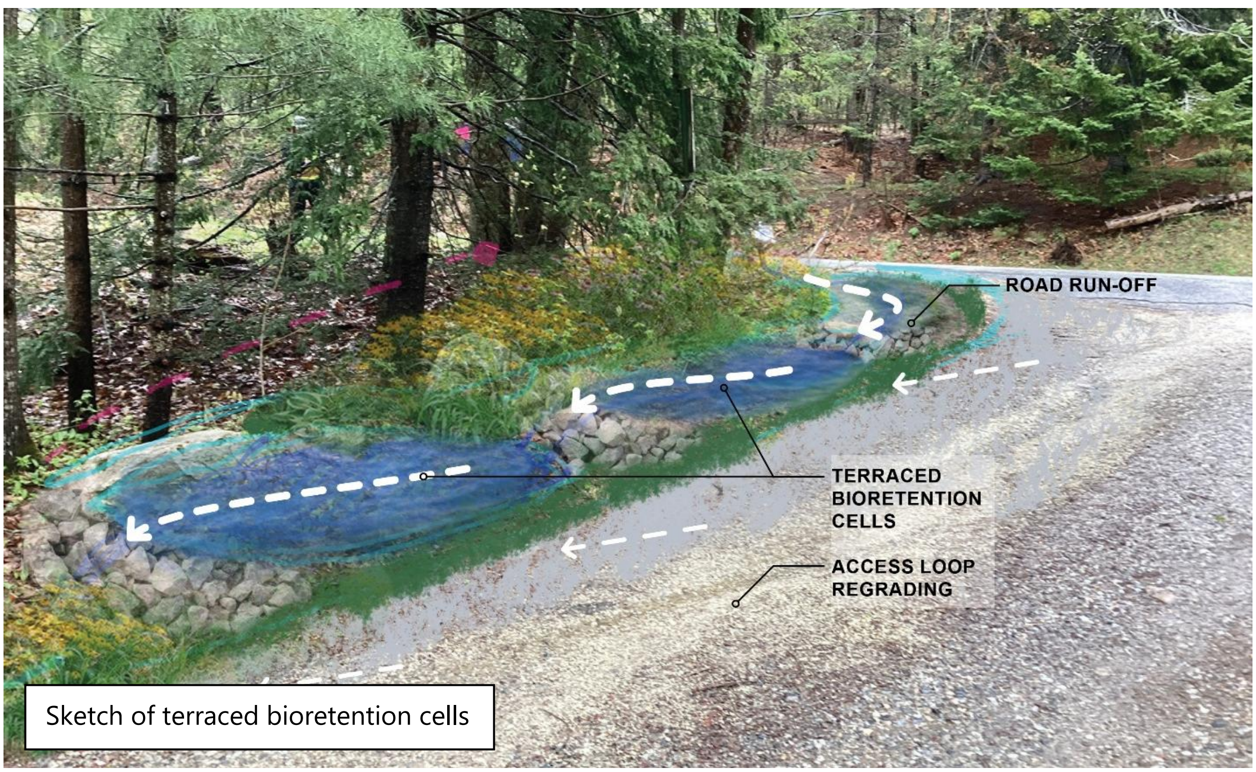
Photo 10: Unvegetated shoreline and submerged boat ramp, facing southwest.

Proposed Improvements

The proposed stormwater control measures include regrading and resurfacing the access drive and boat ramp, diverting runoff into two bioretention facilities, and revegetating the shoreline buffer. The proposed improvements also include an informational sign to educate visitors and encourage lake stewardship. These improvements are described and illustrated in more detail below and in Figure 2.

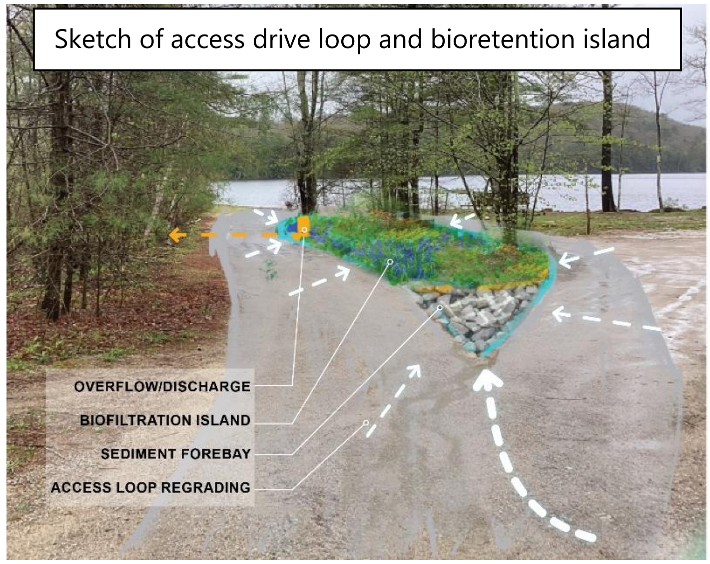
Access drive regrading and resurfacing. Regrade the access drive to increase positive drainage to the bioretention facilities and prevent discharge of untreated stormwater directly into the wetland or pond. Import material to raise the elevation of the lower loop to allow it to slope away from the pond and to create a ramp (rather than a depressed area) at the boat ramp. Resurface the access drive with well-graded aggregate and crushed rock.

Terraced bioretention cells. Along the northern edge of the upper portion of the access drive, construct a terraced bioretention basin. Runoff from Kings Hwy and the upper access drive will be diverted into a sediment forebay and several bioretention cells in series. Waterbars or broad-based dips may be needed to divert runoff from the steeply sloped upper access drive. Within each bioretention cell, runoff will filter through plants, soil, and crushed stone, ultimately infiltrating into the underlying soil. Ponded water from each cell will cascade over a lumber or stone weir into the next cell, with the lowest cell overflowing to a stone-filled infiltration trench.



Sketch of terraced bioretention cells

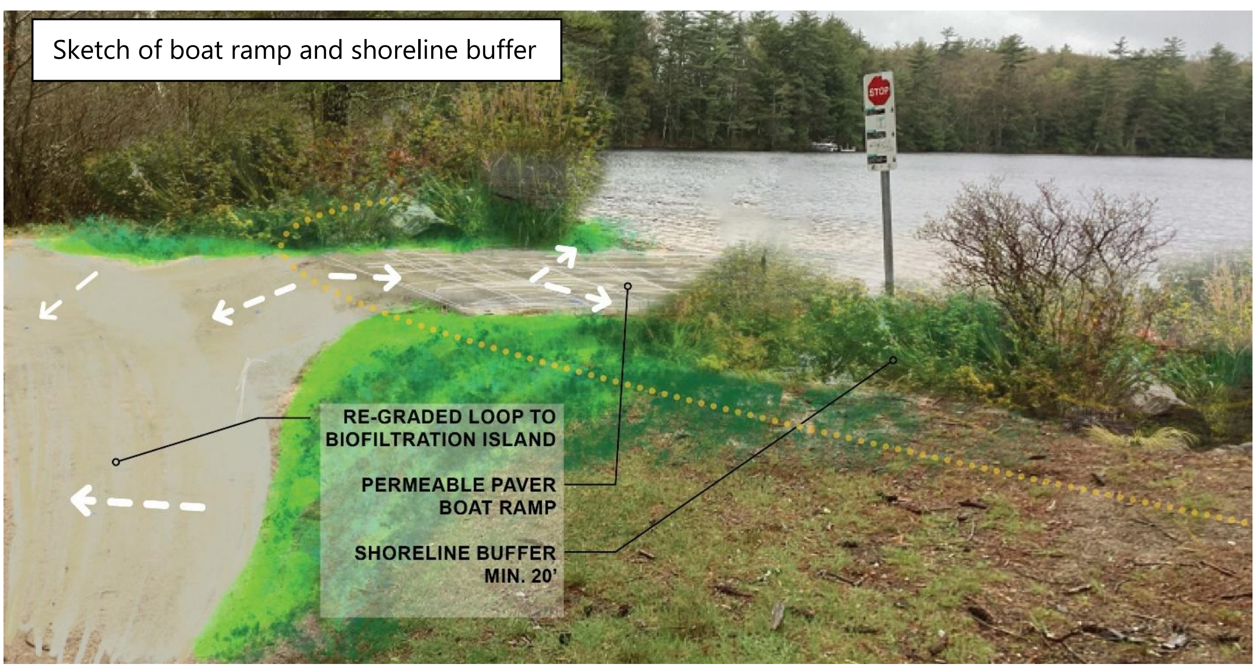
Biofiltration island. Convert the interior "loop" drive area into a biofiltration basin that will receive and filter runoff from the surrounding access drive loop. Since the bioretention island will be in an area with high groundwater, it will be designed with an impermeable liner and an underdrain. Runoff will filter through plants, soil, and stone for pollutant removal before it flows through an area drain and underdrain to a new discharge point near the wetlands to the south.



Boat ramp. Import material to fill in the depressed area and raise the elevation of the boat ramp entrance (where it meets the loop) above the shoreline elevation to achieve the optimal ramp slope. Create defined edges to the boat ramp to establish a 15-ft width. On the boat ramp, install a permeable hardscape surface such as the Drivable Grass concrete paver system, which was recently installed at the Gregg Lake boat launch in Antrim.

Shoreline buffer. Revegetate the shoreline with native grasses and perennials up to the access drive loop on the south side of the boat ramp and on a portion of the north side. Within a small recreational area to the north of the boat ramp, seed with low-growing native grasses.

Educational Signage. Install a kiosk near the recreational area describing the bioretention areas and encouraging lake-friendly behaviors.



Typical Materials and Plant List

Typical materials for the proposed stormwater improvements include the following:

- Temporary erosion and sediment control fencing, silt socks, and stakes
- Crushed stone and Well-graded aggregate
- Bioretention soil
- Lumber or boulders for terracing
- Area drain with grate and frame
- HDPE pipe
- Loam and Plants (containers, plugs, and seed)
- Split rail fence

Typical plants for the bioretention areas may be found in *Native Plants for New England Rain Gardens*[4] and may include the following:

- White turtlehead (*Chelone glabra*)
- Spotted crane's bill (*Geranium maculatam*)
- Blue vervain (*Verbena hastata*)
- Tussock sedge (*Carex stricta*)
- Common or Soft rush (*Juncus effusus*)
- Tussock or Upright sedge (*Carex stricta*)
- Marginal wood fern (*Dryopteris marginalis*)
- Butterfly milkweed (*Asclepias tuberosa*)

Typical plants for the shoreline buffer may be found in *Native Shoreland/Riparian Buffer Plantings for New Hampshire*[5] and may include the following:

- Blueflag iris (*Iris versicolor*)
- Tussock sedge (*Carex stricta*)
- Common or Soft rush (*Juncus effusus*)
- Tussock or Upright sedge (*Carex stricta*)
- Butterfly milkweed (*Asclepias tuberosa*)
- Cinnamon fern (*Osmunda cinnamomea*)
- Hay scented fern (*Dennstaedtia punctiloula*)
- Foamflower (T*iarella cordifolia*)
- Swamp Milkweed (*Asclepias incarnata*)

PERMITTING CONSIDERATIONS

The project site lies within the NH Shoreland Protection Zone (extending 250 feet from the reference elevation) as well as the 1% annual chance flood zone, and it abuts a wetland. For shoreland protection permitting, this project would qualify for a Shoreland Permit-by-Notification as a retrofit proposed for the purpose of stormwater management improvements, erosion control, and environmental restoration. The project site abuts wetlands and may involve work within the lake for the boat ramp installation, as well as

[4] https://www4.des.state.nh.us/SoakNH/wp-content/uploads/2016/03/Native-Plants-for-NH-Rain-Gardens_20160322.pdf
[5] https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/native-shoreland-plantings.pdf

treated-stormwater discharge to the wetlands from the biofiltration island. The project will therefore be subject to NHDES wetland permitting review and approval in accordance with the New Hampshire Fill and Dredge in Wetlands Act (RSA 482-A). The project may be eligible for a Wetland Permit-by-Notification and/or Registration for Routine Roadway Maintenance Activities.

OPERATION AND MAINTENANCE

Operation and maintenance (O&M) for the proposed stormwater improvements is expected to take 20 hours annually. Typical O&M includes routine inspections, preventative maintenance, and corrective actions, such as the following:

1) Clean out trash, debris, and accumulated sediment from the sediment forebays, bioretention areas, infiltration trench, shoreline, and area drain.
2) Inspect and maintain pavers on the boat ramp.
3) Maintain vegetation (weeding, replanting, etc.) and water plants during establishment period.
4) Check for erosion; stabilize areas of erosion, if found.
5) Check for standing water (lack of drainage) in the bioretention areas. Investigate and correct clogging if they do not drain within 48 hours following a rain event.

NEXT STEPS

- Engage with the property owner at 234 Kings Hwy to discuss their willingness to allow regrading and resurfacing on the portion of the access drive that crosses onto their property, as well as shoreline buffer revegetation along a short stretch of waterfront abutting the Town parcel.
- Complete site investigations, including soil evaluation, topographic survey, drainage area assessment, wetland assessment, and property-line survey.
- Consider maintenance needs for the proposed stormwater control measures. Engage with the New Durham DPW, Conservation Commission, Water Quality Committee, and private property owners to explore shared maintenance responsibilities. Refine the design, as needed, to match maintenance capabilities.
- Prepare permit-ready (75% level) design plans.
- Complete shoreland and wetlands permitting through NHDES.
- Develop final design and construction documents.

DESIGN SUMMARY

Owner(s):	Town of New Durham, NH and private owner at 234 Kings Hwy
Receiving water:	Shaws Pond (NHLAK700020101-03)
Drainage area:	0.6 acres
Stormwater control measures:	Erosion stabilization, bioretention, shoreline buffer restoration
Estimated average annual pollutant load reduction:	TP (lb/yr): 8.4 TN (lb/yr): 18.2 Sediment (ton/yr): 9.6
Estimated Costs:	Construction[6]: $100,000-$120,000 Design and Permitting: $40,000 Annual O&M: $3,000

[6] Construction costs include materials and contractor labor with 25% contingency. Costs may be lower with DPW and volunteer labor.

Figure 2. Conceptual Design Plan View and Example Images

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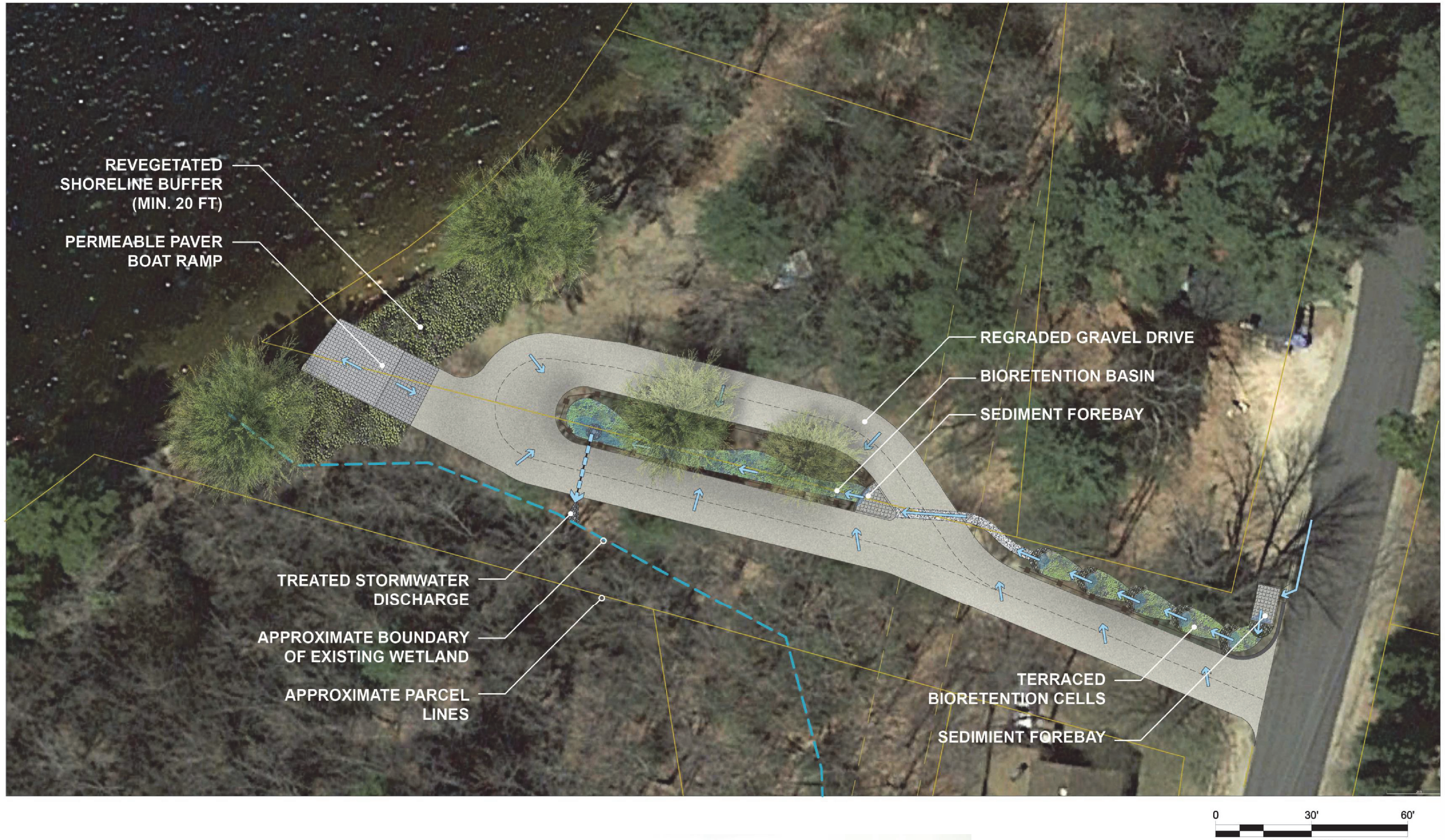

BIORETENTION

- A Inlet
- B Sediment Forebay & Weir
- C Bioretention Basin
- D Bioretention Soil *(loamy sand)*
- E Gravel Reservoir
- F Overflow Structure
- G Outlet Pipe

Bioretention basin with overflow yard drain

Boat ramp with concrete paver mat

Stepped bioretention with lumber weir walls

Sediment forebay with paver mat