Center Harbor Bay

Watershed-Based Management Plan

December 2025 - **DRAFT**

Prepared by
FB Environmental Associates

CENTER HARBOR BAY
WATERSHED-BASED MANAGEMENT PLAN

Prepared by **FB ENVIRONMENTAL ASSOCIATES**
in collaboration with the Lake Winnipesaukee Alliance

December 2025 | **DRAFT**

CONTACT
Pat Tarpey, Former President
Lake Winnipesaukee Alliance
PO Box 1624
Meredith, NH 03253

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ACKNOWLEDGEMENTS

STEERING COMMITTEE

Pat Tarpey, President, Lake Winnipesaukee Alliance
Spencer Joyner, Resident
Don Jutton, Resident
Kevin Kelly, Lake Kanasatka and Moultonborough Cyanobacteria Committee Chair
Marie Samaha, Moultonborough Conservation Commission Chair

ADDITIONAL SUPPORT

Bree Rossiter, Conservation Program Manager, Lake Winnipesaukee Alliance
John Flaherty, Watershed Management and Restoration Specialist, Lake Winnipesaukee Alliance

TECHNICAL CONSULTANT STAFF

Forrest Bell, CEO/Owner, FB Environmental Associates
Margaret Mills, Senior Project Manager/Hydrologist, FB Environmental Associates
Laura Diemer, CLM, Senior Project Manager, FB Environmental Associates
Christine Bunyon, Project Manager/GIS Specialist, FB Environmental Associates
Magdalyn Kosalek, Project Manager, FB Environmental Associates
Evan Ma, Assistant Project Manager, FB Environmental Associates
Tim Kirsten, Project Scientist II, FB Environmental Associates
Amelia Wallis, Project Scientist I, FB Environmental Associates
Don Kretchmer, CLM, DK Water Resource Consulting

SPECIAL THANKS

Bob Craycraft, University of New Hampshire Lakes Monitoring Program Coordinator

For questions, comments, or additional information related to the Center Harbor Watershed-Based Management Plan, please contact the Lake Winnipesaukee Alliance at mail@winnipesaukee.org.

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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
BCCD	Belknap County Conservation District
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
ILF	In-Lieu Fee
KG	Kilogram
LCHIP	Land and Community Heritage Investment Program
LID	Low Impact Development
LLMP	Lay Lakes Monitoring Program
LLRM	Lake Loading Response Model
LRCT	Lakes Region Conservation Trust
RPC	Lakes Region Planning Commission
LWCF	Land and Water Conservation Fund
M	Meter
NAWCA	North American Wetlands Conservation Act
NFRF	Northeast Forests and Rivers Fund
NFWF	National Fish and Wildlife Foundation
NH GRANIT	New Hampshire Geographically Referenced Analysis and Information Transfer System
NHACC	New Hampshire Association of Conservation Commissions
NHD	National Hydrography Dataset
NHDES	New Hampshire Department of Environmental Services
NHFG	New Hampshire Fish and Game Department
NHLCD	New Hampshire Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source Pollution

ACRONYM	DEFINITION
NRCS	Natural Resources Conservation Service
NRI	Natural Resources Inventory
NWI	National Wetlands Inventory
PAS	Potentially Attaining Standards
PCR	Primary Contact Recreation
PCS	Potential Contamination Source
PFAS	Per- and polyfluoroalkyl substances
PNS	Potentially Not Supporting
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
SDT	Secchi Disk Transparency
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
UNH	University of New Hampshire
USLE	Universal Soil Loss Equation
WBMP	Watershed-Based Management Plan
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.

Areal water load (m/yr) is the total annual volume of water (m^3) entering a waterbody from all sources (rain, runoff, groundwater, and streams) normalized to (or divided by) the lake's surface area (m^2). It represents the depth of water added to the lake surface annually if all inflow were evenly distributed over that surface.

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 NPS pollution from developed land to lakes and streams. Management plans should include both non-structural (non-engineered) and structural (engineered) BMPs 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 number 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 sensitive aquatic organisms and stimulate the 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 times, 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 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.

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.

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 wildlife habitat found along the banks of a lake, river, or stream. 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-mixable layers.

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

Center Harbor Bay is an 8,089-acre bay in the northern portion of Lake Winnipesaukee, draining a 20,016-acre watershed within New Hampshire's economically vital Lakes Region. The Lake Winnipesaukee watershed is divided into two primary sub-watersheds: Center Harbor Direct (15,571 acres) and Lake Kanasatka (4,445 acres). Center Harbor Bay and its watershed fall partly within the towns of Meredith, Moultonborough, Center Harbor, and Gilford. Inflows include Lake Kanasatka and Wakondah Pond, while outflow from Center Harbor Bay mixes with the rest of Lake Winnipesaukee through the Broads (the center of Lake Winnipesaukee), Sanders Bay, and Moultonborough Bay.

The Problem

Because of its size and complexity, maintaining the health of Lake Winnipesaukee depends on developing and implementing watershed-based management plans (WMPs) for all contributing watersheds, in collaboration with the many towns they span. Center Harbor Bay is one of the last major Lake Winnipesaukee watersheds still in need of a comprehensive WMP.

According to the 2024 summary report on Center Harbor Bay developed by the UNH Extension Lakes Lay Monitoring Program, the water quality of Lake Winnipesaukee in this bay is excellent (oligotrophic), based on a single sampling event in August 2024 (UNH LLMP, 2024). NHDES Lake Trophic Survey Reports (1979, 1984, 1990, 2001) classified the Center Harbor section of Lake Winnipesaukee as oligotrophic in all survey years.

The Center Harbor watershed contains three lake/pond assessment units: Lake Winnipesaukee, Lake Kanasatka, and Wakondah Pond. Lake Winnipesaukee is formally listed as impaired for aquatic life integrity (ALI), and Lake Kanasatka for primary contact recreation (PCR) on the 303(d) New Hampshire List of Impaired Waters for the 2024 cycle. Lake Winnipesaukee's ALI impairment (4A-M) is due to low pH and the presence of non-native aquatic plants. NHDES also assessed the following ALI parameters as potentially not supporting (3-PNS): alkalinity and non-native fish, shellfish, or zooplankton. Although Lake Winnipesaukee is not listed as impaired for PCR, cyanobacteria hepatotoxic microcystins are potentially not supporting (3-PNS) state thresholds.

NHDES has issued three official cyanobacteria bloom warnings within Center Harbor Bay since 2023. *Dolichospermum* (formally *Anabaena*) is one of the most common toxin-producing cyanobacteria genera in New Hampshire lakes and has been the dominant cyanobacteria genus identified in the Center Harbor Bay blooms. The largest bloom, in August 2023, occurred following record-high precipitation for New Hampshire according to the National Oceanic and Atmospheric Administration. *Dolichospermum* is just one type of cyanobacteria that has presented itself on Lake Winnipesaukee. Four cyanobacteria watches have also been in effect in the bay since 2021; one of these was dominated by *Microcystis* and another by benthic taxa.

Anthropogenic influences such as stormwater runoff, shoreline erosion from increased boat traffic and wave action, and other land use impacts can degrade lake health. Elevated phosphorus loading, from both internal and external sources, especially when combined with longer ice-free periods and more frequent extreme precipitation, can fuel excessive growth of plants, algae, and cyanobacteria, reducing water quality.

Lake Kanasatka, located upstream of Center Harbor Bay, has its own Watershed Management Plan (FBE, 2022), and progress has been made in improving its water quality. In spring 2024, an alum treatment was applied to address internal phosphorus loading, while stormwater best management practices (BMPs) have been installed around the lakeshore, and at least 10 outdated septic systems have been replaced since 2021. Cyanobacteria blooms have been the primary concern for Lake Kanasatka.

Cyanobacteria blooms are typically spurred by a combination of warming waters and elevated nutrient inputs. In the Center Harbor Bay watershed, key phosphorus sources include stormwater runoff from impervious surfaces, shoreline erosion, road and ditch erosion, disturbed soils from construction, excessive fertilizer application, failed or improperly functioning septic systems, unmitigated agricultural activities, and waste from pets, livestock, and wildlife. Thirty-nine (39) problem sites were identified in the watershed during a field survey, and the main issues found were road shoulder and ditch erosion, clogged stormwater infrastructure, and untreated stormwater runoff from impervious surfaces. Additionally, 317 shorefront properties were identified as having some impact on water quality due to evidence of erosion and lack of vegetated buffer. These are in addition to the 22 problem sites and 121 prioritized shoreline properties identified in the Lake

Kanasatka Watershed-Based Management Plan (FBE, 2022), which also fall within Center Harbor Bay's watershed. The lake loading response model results revealed changes in phosphorus loading and in-lake phosphorus concentrations over time from pre-development through future conditions, showing that the water quality of Center Harbor Bay 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 climate change. In the Center Harbor Bay watershed, watershed runoff combined with baseflow is the largest source of phosphorus (56% of the total load), including watershed loads from Lake Kanasatka (5%), the direct land area around Center Harbor Bay (35%), and mixing with other parts of Lake Winnipesaukee (16%).

The Goal

The goal of the Center Harbor Bay WMP is to improve the water quality of Center Harbor Bay such that it continues to meet state water quality standards for the protection of aquatic life integrity (ALI) and primary contact recreation (PCR) and substantially reduces the likelihood of harmful cyanobacteria blooms. This goal will be achieved by accomplishing the following objectives:

> OBJECTIVE 1: Reduce phosphorus loading from existing development by 10.5% (179 kg/yr) to Center Harbor Bay to reduce average in-lake summer total phosphorus concentration to 3.9 ppb.
>
> OBJECTIVE 2: Mitigate (prevent or offset) phosphorus loading from future development by 194 kg/yr to Center Harbor Bay to maintain average summer in-lake total phosphorus concentration in the next 10 years (2035).

The Solution

In collaboration with the Lake Winnipesaukee Alliance (LWA), FB Environmental Associates (FBE) was contracted to develop a WMP to better understand and protect the water quality of the Center Harbor Bay section of Lake Winnipesaukee. As part of the development of the WBMP and according to the Site-Specific Project Plan (SSPP), a build-out analysis, land-use model, water quality and assimilative capacity analysis, septic system database, shoreline survey, and watershed survey were completed 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 the Steering Committee comprised of key watershed stakeholders (see Acknowledgements). The following actions were recommended to meet the established water quality goal and objectives for Center Harbor:

WATERSHED STRUCTURAL BMPS: Sources of phosphorus from watershed development should be addressed through installation of stormwater controls, stabilization techniques, buffer plantings, etc. as recommended for 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 identified during the shoreline survey, and any new or redevelopment projects in the watershed with high potential for soil erosion.

MONITORING: A long-term water quality monitoring plan is critical to evaluate the effectiveness of implementation efforts over time. LWA, in concert with the University of New Hampshire Extension's Lakes Lay Monitoring Program (LLMP), should continue the annual monitoring program and consider incorporating additional monitoring recommendations laid out in this plan. The LLMP should remain the primary lab for processing water quality samples from Lake Winnipesaukee due to their lower method detection limits for total phosphorus.

EDUCATION AND OUTREACH: LWA 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 include raising awareness of water quality concerns, 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.

OTHER ACTIONS: Additional strategies for reducing phosphorus loading to the lake include: revising local ordinances such as setting low impact development (LID) requirements on new construction; identifying and replacing malfunctioning septic systems; inspecting and remediating leaky sewer lines; using best practices for road maintenance and other activities including municipal operations such as infrastructure cleaning; 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. Center Harbor is at risk for greater water quality degradation because of new development in the watershed unless climate change resiliency and LID strategies are incorporated into existing zoning standards.

The recommendations of this plan will be carried out largely by the Lake Winnipesaukee Alliance with assistance from a diverse stakeholder group, including representatives from municipalities (e.g., select boards, planning boards), conservation commissions, state and federal agencies (e.g., NH State Parks) or organizations, nonprofits, land trusts, schools and community groups, local business leaders, and landowners. The cost of successfully implementing the plan is estimated at $2-$3 million 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. Possible sources of funding are listed in section 6.3. Of significant note, this plan meets the nine planning elements required by the EPA, and Center Harbor is now eligible for federal watershed assistance grants.

Important Notes

The success of this plan is dependent on the continued effort of volunteers and a strong and diverse stakeholder group 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 given the old infrastructure, lack of access to key lakefront areas, and limited funding and volunteer or staff capacity.

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 impact to restoring and maintaining excellent water quality in our lakes; however, engaging private landowners as a single stakeholder group can be difficult and outreach efforts often have limited reach, especially to those individuals who may require the most education and awareness of important water quality protection actions. The joint committee will continue to engage the public as much as possible so that private individuals can help review and implement the recommendations of this plan and protect the water quality of Center Harbor long into the future.

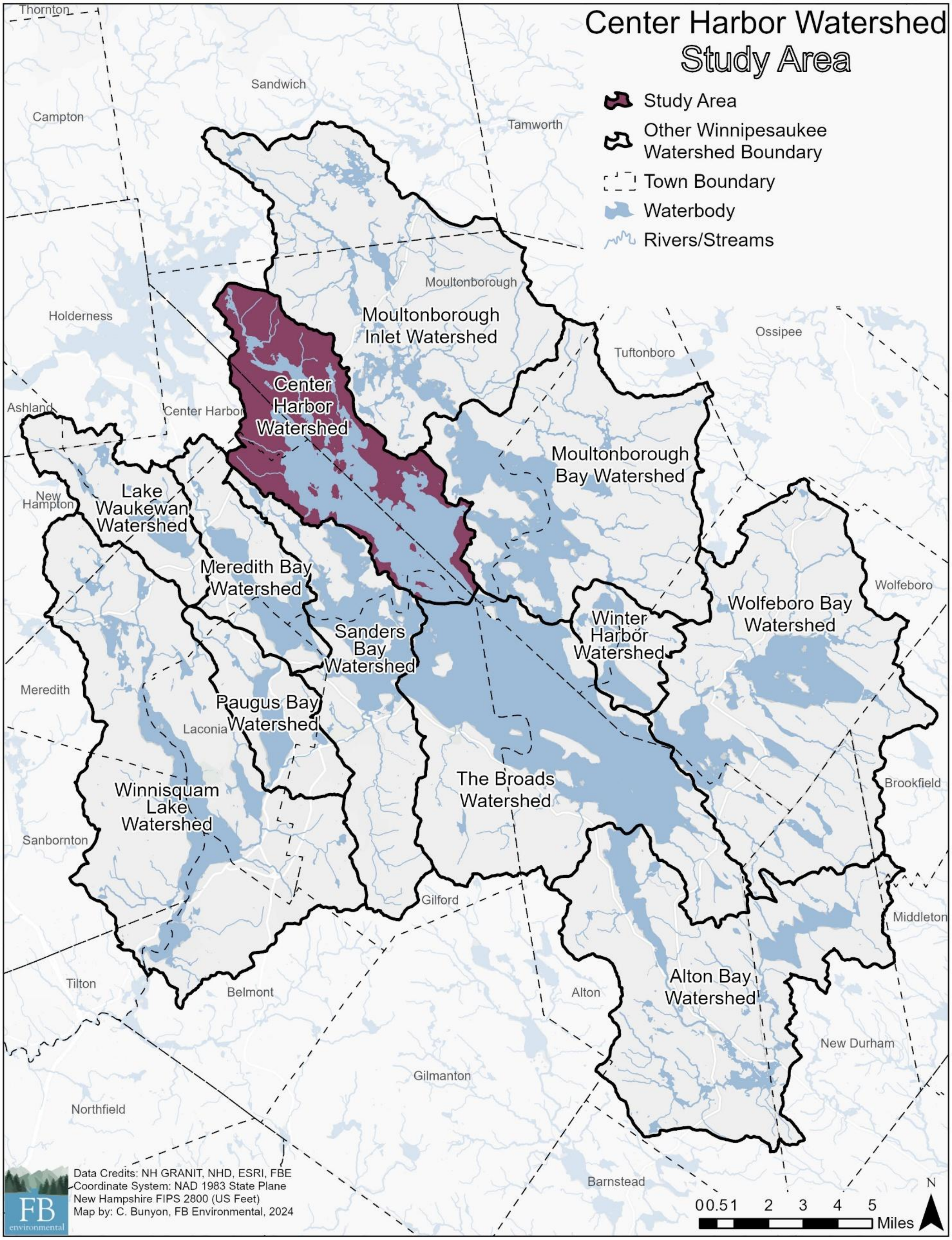


Figure 1. Location of the Center Harbor Bay watershed in relation to the rest of Lake Winnipesaukee's watersheds.

1 INTRODUCTION

1.1 WATERBODY DESCRIPTION AND LOCATION

Center Harbor is an 8,089-acre (3,274-hectare) bay in the northern portion of Lake Winnipesaukee. Including the Lake Kanasatka Watershed, the Center Harbor watershed spans 20,017 acres (8,101 hectares) and extends into the towns of Moultonborough (60% of area), Meredith (29%), Center Harbor (8%), and Gilford (3%). The bay receives inflows from upstream waterbodies, including Lake Kanasatka and Wakondah Pond (Figure 1). Water from the 353-acre Lake Kanasatka flows into Black East Cove in Lake Winnipesaukee via an unnamed stream that passes beneath NH Route 25. Several other small tributaries drain directly to Lake Winnipesaukee as well as to Lake Kanasatka and Wakondah Pond. From the dividing line of Center Harbor, water mixes with the rest of Lake Winnipesaukee before flowing out of the lake via the Winnipesaukee River to join the Pemigewasset River and eventually the Merrimack River.

The Center Harbor Bay watershed is situated within a temperate zone influenced by converging weather patterns— warm, moisture-laden air from the south and cooler, drier air from the north. These interactions give rise to a range of weather events, including heavy snowfall, nor'easters, severe thunderstorms, and the occasional hurricane. The area experiences moderate to high rainfall and snowfall, averaging 49 inches of precipitation annually between 1994 and 2023. Data were collected for this period from Daymet which interpolates weather data at a specific location from nearby weather stations. Annual precipitation has varied over the 30-year period, showing no significant increasing or decreasing trend (using the *rkt* package in R Studio) (Figure 2). Average and minimum annual temperature values have increased during the same time frame ($p < 0.05$), while maximum temperature has not displayed a significant trend (Figure 2).

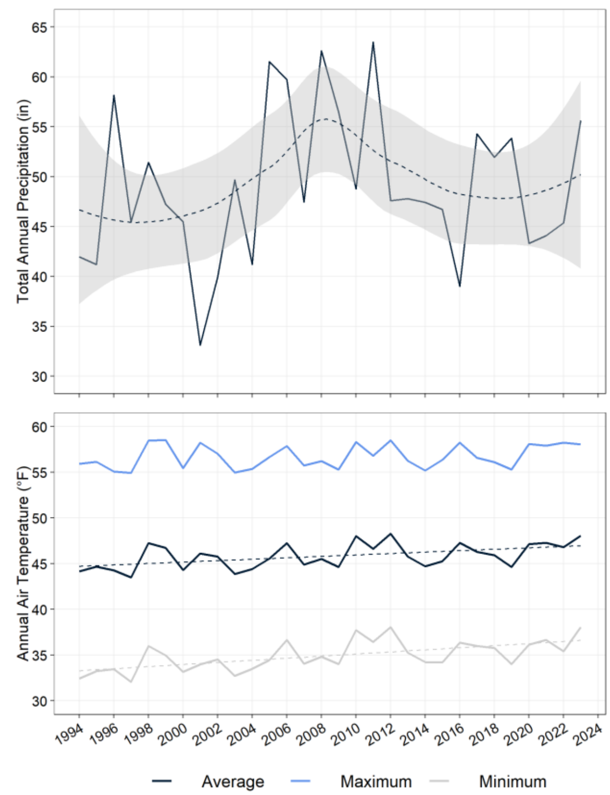


Figure 2. Precipitation and average, maximum, and minimum air temperature for the Center Harbor Bay watershed from 1994–2023. Data retrieved from Daymet (2024). The dashed line and grey shaded area for precipitation represents the Locally Estimated Scatterplot Smoothing (LOESS) regression and 95% confidence intervals, respectively. The dashed lines for air temperature indicate a statistically significant increasing trend ($p < 0.05$).

The highest elevation in the watershed, about 616 feet above sea level, is located northeast of Red Hill Road in Moultonborough. Lake Winnipesaukee's shoreline in Center Harbor Bay is approximately 154 feet above sea level. These elevation measurements were derived from digital elevation models provided by NH GRANIT.

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 that utilize these forested resources include land mammals (deer, black bear, coyote, bobcats, fisher, fox, raccoon, weasel, porcupine, mink, American marten, chipmunks, squirrels, 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. The Towns of Moultonborough, Meredith and Center Harbor are home to a variety of state-listed threatened (T) and endangered (E) wildlife species, including the common loon (T), pied-billed grebe (T), purple martin (T), cliff swallow (T), Blanding's turtle (E), spotted turtle (T), and the bridle shiner (E) (NH NHB, 2020).

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

1.2 WATERSHED PROTECTION GROUPS

The Lake Winnipesaukee Alliance (LWA) is a non-profit organization with a mission "*dedicated to protecting the water quality and natural resources of Lake Winnipesaukee and its watershed now and for the future. Using education and science, we're relentless in our pursuit of the best policies and practices to ensure a healthy, vibrant Lake for residents, business owners, and visitors, today and for generations to come.*" LWA serves the 14 communities located in Belknap and Carroll counties. LWA is led by several paid staff and a volunteer Board of Directors.

The Carroll County Conservation District (CCCD) and the Belknap County Conservation District (BCCD) are two of 10 county conservation districts in New Hampshire that operate as resource management agencies and a subdivision of local governments. CCCD focuses on "*water quality, erosion & sedimentation, wildlife habitats, health of forests & wetlands, non-point source pollution, and storm water & flooding*." BCCD's mission is to "*help landowners and communities conserve the natural resources of Belknap County*." Both organizations work 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. Moultonborough is in the CCCD service area; Center Harbor, Gilford and Meredith are in the BCCD service area.

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.

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 language. Conservation commissions in the Center Harbor Bay watershed include those of Center Harbor, Gilford, Meredith, and Moultonborough.

NH LAKES has the mission to "*restore and preserve the health of New Hampshire's lakes. Our vision is a New Hampshire where all our lakes are clean and healthy, and caring for them is a way of living, doing business, and governing*."

The University of New Hampshire Lakes Lay Monitoring Program engages volunteers and local groups in collecting and analyzing water quality data for lakes across New Hampshire, including Lake Winnipesaukee. The data support informed decision-making for lake management and protection strategies.

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-based management 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 Center Harbor Bay Watershed-Based Management Plan (WBMP) is to guide implementation efforts over the next 10 years (2026-2035) to improve the water quality of the Center Harbor Bay section of Lake Winnipesaukee such that it meets state water quality standards for the protection of aquatic life integrity (ALI) and substantially reduces the likelihood of harmful cyanobacteria blooms in the lake.

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 Steering 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

This plan was developed through the collaborative efforts of numerous meetings, public presentations, and conference calls between FB Environmental Associates (FBE), LWA, representatives from the watershed communities (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 stakeholders.

- **May 21, 2024:** Kick-off meeting with the public to introduce the watershed planning process at the Moultonborough Library.
- **October 20, 2025:** FBE presented the water quality analysis, build-out analysis, modelling results and water quality goal to the Advisory Committee at the Center Harbor Town Hall.
- **November 13, 2025:** FBE presented the draft action plan to the Advisory Committee at the Center Harbor Town Hall.

1.4.2 Final Public Presentation

A final public presentation was held virtually on December 17, 2025, to summarize the analyses and recommendations detailed in the plan. An opportunity for public feedback on the plan was offered.

1.5 INCORPORATING EPA'S NINE ELEMENTS

EPA guidance lists nine components (A-I) that are required within a WMP 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: Section 3** highlights known sources of NPS pollution to Center Harbor Bay and describes 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, 3, and 5** quantify the sources of phosphorus load to Center Harbor Bay, calculate the pollutant load reductions that could be achieved by identified management measures, and determine 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** include descriptions 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: Sections 4 and 5** describe 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 Center Harbor Bay. 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 Center Harbor Bay, 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 Center Harbor Bay.

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. **Primary contact recreation (PCR) and aquatic life integrity (ALI) are the two major uses for lakes – ALI being the focus of this plan.** In New Hampshire, all surface waters are also legislatively classified as Class A (highest quality) or Class B, most of which are Class B (Env-Wq 1700). **Lake Winnipesaukee is classified as Class B in the State of New Hampshire**. Additionally, from 1976 to 2009, 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 Center Harbor Bay, the NHDES Lake Trophic Survey Reports (1979, 1984, 1990, 2001) classify the lake as oligotrophic.

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**, and toxins) 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 Center Harbor Bay watershed contains three lake/pond assessment units: Lake Winnipesaukee, Lake Kanasatka, and Wakondah Pond (Table 1). Lake Winnipesaukee and Lake Kanasatka are formally respectively listed as impaired for ALI and PCR on the 303(d) New Hampshire List of Impaired Waters for the 2024 cycle (NHDES, 2024). Additionally, the NH Statewide Mercury Advisory to limit consumption of fish applies to all assessment units (NHDES, 2021). Although Lake Winnipesaukee is not listed as impaired for PCR, cyanobacteria hepatotoxic microcystins are potentially not supporting state thresholds, and cyanobacteria blooms have recently emerged as a significant concern, as described in Section 2.1.6.

Table 1. NHDES assessment units covering lakes/ponds within the Center Harbor Bay watershed and their associated water quality rating as reported on the NHDES 2024 303(d) list.

Assessment Unit Name	AUID	Impaired Designated Use	Parameter
LAKE WINNIPESAUKEE	NHLAK700020110-02-19	ALI	pH, non-native aquatic plants*
LAKE KANASATKA	NHLAK700020105-02	PCR	Cyanobacteria hepatotoxic microcystins*
WAKONDAH POND	NHLAK700020105-01	None	N/A

** Lake Winnipesaukee is potentially not supporting for alkalinity and non-native fish, shellfish, or zooplankton for ALI, as well as for cyanobacteria hepatotoxic microcystins for PCR. Lake Kanasatka is potentially not supporting for ALI parameters alkalinity, pH, and total phosphorus.*

2.1.2 Water Quality Data Collection

Data were acquired from NHDES's Environmental Monitoring Database in February 2024. Additional data collected by the UNH Center for Freshwater Biology field team and Lakes Lay Monitoring Program (LLMP) volunteers in the Center Harbor Bay watershed were provided by Bob Craycraft in April 2024. As such, this data analysis focuses on the period 2014–2023, the 10 most recent years at the time of assessment. Table 2 summarizes the available data for the Center Harbor Deep Spot and Center Harbor 2 Bay stations for this period. The number of samples for most water quality parameters is relatively low compared to other lakes in New Hampshire, as well as to other parts of Lake Winnipesaukee such as the Broads and Alton Bay. Sample sizes for total phosphorus and chlorophyll-a are especially low, and no dissolved oxygen and temperature profiles were collected in this period (although data has since been collected in 2024 and 2025). No data has been collected at the WCH01DL station since 2011 and it is therefore not summarized in Table 2. Locations of monitoring stations are shown in Figure 3.

Table 2. Summary of recent (2014-2023) sampling data for total phosphorus (TP), chlorophyll-a (Chl-a), Secchi Disk transparency (SDT), dissolved oxygen (DO) and temperature (T) profiles, chloride, and specific conductivity. Sample size (n) refers to the total number of samples collected, not the number of years.

Site Name	Lake Winnipesaukee, Center Harbor - Deep Spot	Lake Winnipesaukee, Center Harbor – 2 Bay
Site ID	WINCEND	WCH02BL
Years Sampled TP *(n)*	2015, 2019 (2)	2019 (2)
Years Sampled Chl-a *(n)*	2019 (2)	2019 (2)
Years Sampled SDT *(n)*	2016-2023 (8)	2019 (2)
Years Sampled DO/T Profile *(n)*	N/A	N/A
Years Sampled Chloride *(n)*	2020-2023 (4)	N/A
Years Sampled Specific Conductivity (*n*)	2020-2023 (4)	N/A

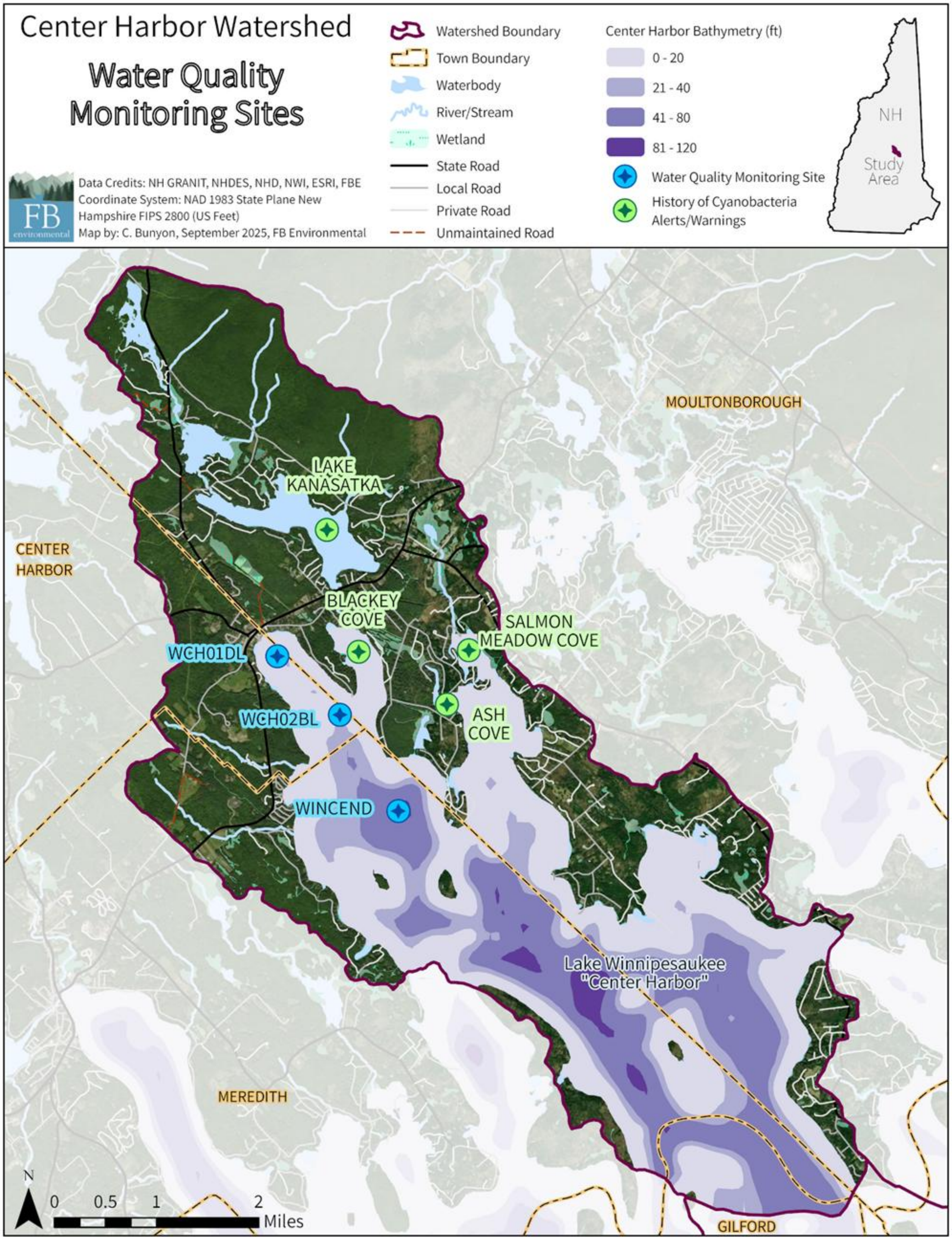


Figure 3. Map of the water quality monitoring sites analyzed in the Water Quality Analysis (blue) with the locations of cyanobacteria advisories/warnings (green). WINCEND is the Center Harbor Deep Spot, WCH01DL is the Center Harbor 1 Deep Spot, and WCH02BL is Center Harbor 2 Bay.

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. The combination of these parameters helps determine the extent and effect of **eutrophication** in lakes and helps 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 to the lake's watershed.

At the WINCEND station, total phosphorus levels have historically been generally similar in the epilimnion, metalimnion and hypolimnion layers (Figure 4). Epilimnetic TP values have been lower in the most recent 10 years compared to the long-term average, however data for this period are very limited to the years 2015 and 2019. Only one TP sample has been collected in each of the metalimnion and hypolimnion layers in the most recent 10 years.

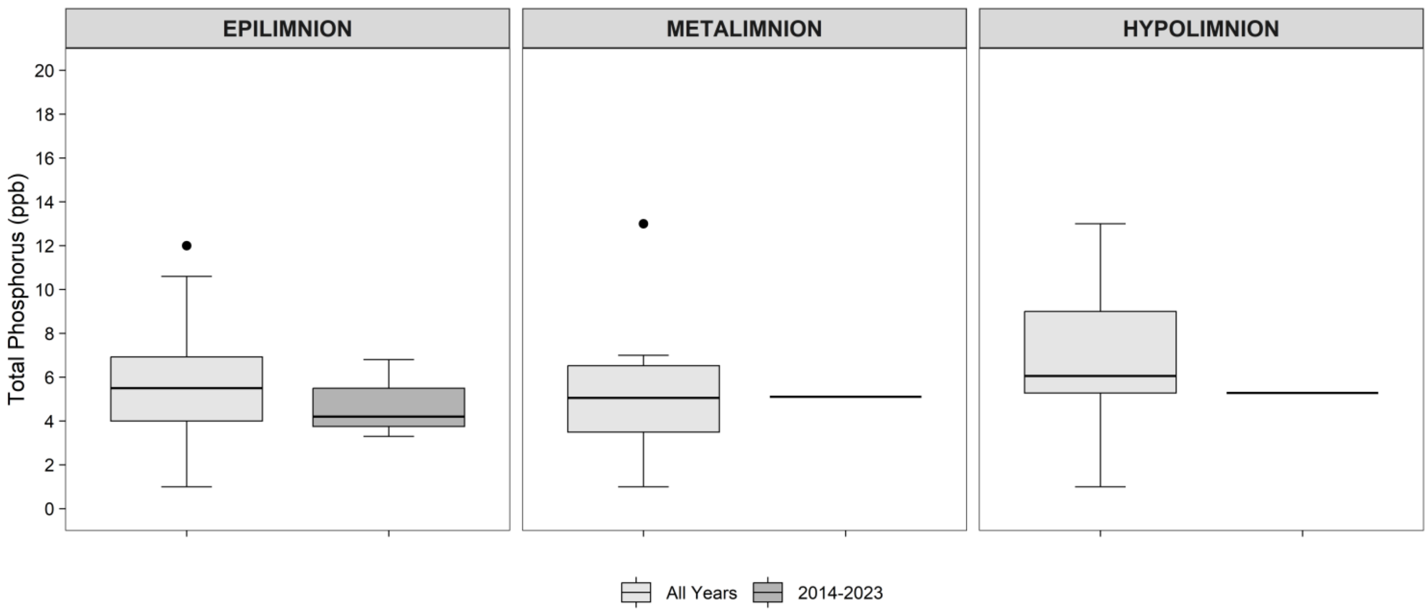


Figure 4. Boxplots showing median total phosphorus concentration in the epilimnion, metalimnion, and hypolimnion of the Center Harbor deep spot of Lake Winnipesaukee (WINCEND). Data are shown for all available years (1979-2023) as well as the most recent 10 years only (2014-2023).

At the shallower station (WCH01DL), generally higher total phosphorus concentrations were measured in the hypolimnion compared to the epilimnion and metalimnion, indicating some amount of internal phosphorus loading was likely occurring in this part of the Lake during the sampling period (Figure 5). One outlier of unusually high total phosphorus was recorded in the epilimnion in July 1995 at WCH01DL. No TP samples have been collected at this station since 2011.

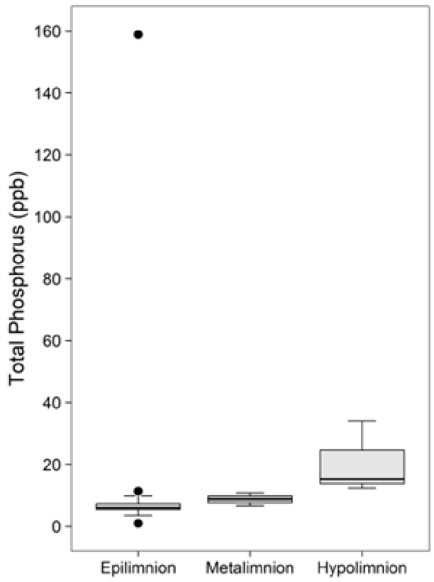


Figure 5. Boxplots depicting median total phosphorus concentration in the epilimnion, metalimnion, and hypolimnion of the Center Harbor 1 deep spot of Lake Winnipesaukee (WCH01DL). Because there is no recent data, data are shown for all available years (1987-2011). Total phosphorus has not been measured at this station in the most recent 10 years. The outlying value in the epilimnion was recorded in July 1995.

No statistically significant trend was found for median epilimnion total phosphorus, chlorophyll-a or Secchi Disk transparency at the WCH01DL Center Harbor deep spot for the available time period of 1986-2011, as well as for the WCH02BL station for 1987-2019, using the Mann-Kendall non-parametric trend test with the *rkt* package in RStudio (Figure 6). At the WINCEND station, median epilimnion total phosphorus has not shown a significant trend between 1976 and 2019. An insufficient number of annual medians for chlorophyll-a and SDT data at WINCEND and total phosphorus at WCH02BL prevents the running of a Mann-Kendall trend analysis for these parameters. Caution should therefore be used when interpreting Figure 3 given its limited availability.

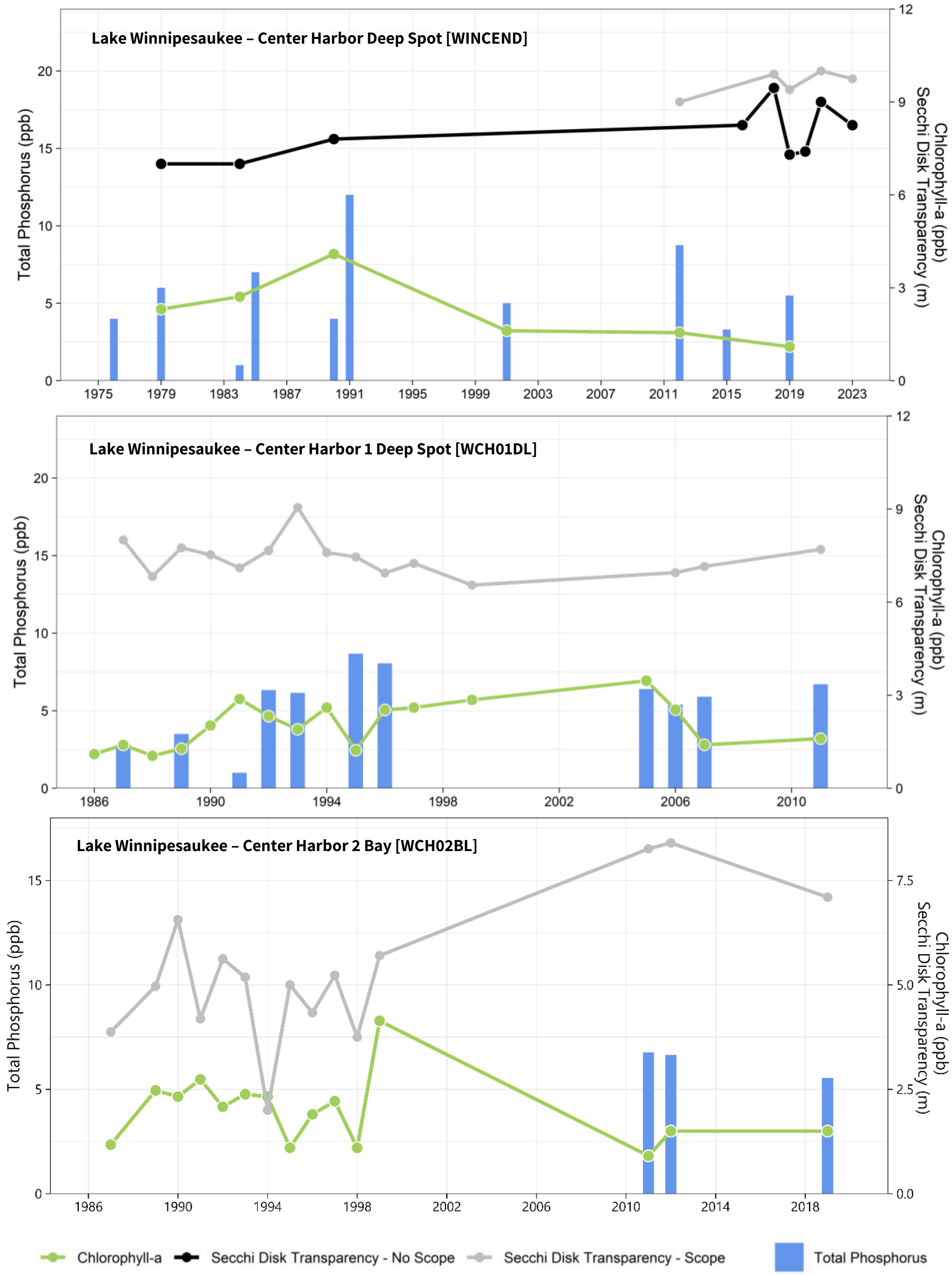


Figure 6. Median epilimnion (2 meters) total phosphorus, chlorophyll-a, and median water clarity (Secchi Disk transparency for scope and no scope methods) measured at WINCEND, top, WCH01DL, middle, and WCH02BL, bottom between May 24th and September 15th. The epilimnion depth was 0-8 m for WINCEND and 0-4 m for WCH01DL but is truncated to 2 m following the methods prescribed in the 2024 Section 305(b) and 303(d) Consolidated Assessment and Listing Methodology (CALM). All WCH02BL data were epilimnion or composite surface grab samples.

2.1.4 Dissolved Oxygen & Water Temperature

Depletion of dissolved oxygen in the deepest part of lakes throughout the summer months is a common occurrence. This process takes place when **thermal stratification** prevents warmer (less dense), oxygenated surface waters from mixing with cooler (denser), oxygen-depleted bottom waters in the lake. Chemical and biological processes occurring in bottom waters deplete the available oxygen throughout the summer, and because these waters are colder and more dense, the oxygen cannot be replenished through mixing with surface waters. Dissolved oxygen levels below 5 ppm (and water temperature above 24°C) can stress and reduce habitat for coldwater fish and other sensitive aquatic organisms. In addition, **anoxia** (low dissolved oxygen) at lake bottoms can result in the release of sediment-bound phosphorus (called **internal phosphorus loading**), which can become a readily available nutrient source for algae and cyanobacteria. While thermal stratification and depletion of oxygen in bottom waters is a natural phenomenon in dimictic lakes (lakes that mix twice a year) such as Lake Winnipesaukee, it is important to track these parameters to make sure the extent and duration of low oxygen does not change drastically because of human disturbance in the watershed resulting in excess phosphorus loading.

Profiles of temperature and dissolved oxygen sampled during thermal stratification (i.e. in summer, between spring and fall **turnover**) have not been taken at the Lake Winnipesaukee Center Harbor Deep Spot (WINCEND) within the last 10 years. The most recent profile was taken in April 2010, which is not within the summer turnover period. The only other two profiles were taken in 1990 and 2001. The median values of these two profiles are displayed in Figure 7. Also depicted in Figure 7 are the median values for profiles taken at the WCH01DL station between 1989-1999, the only years in which temperature and dissolved oxygen profile data were collected.

The change in temperature in Lake Winnipesaukee, seen most dramatically between 8 and 12 m at WINCEND and between 4 and 8 m at the WCH01DL station, indicates thermal stratification in the water column. The average dissolved oxygen of <2 ppm at 34 m depth at the WINCEND station indicates the possibility of internal loading under anoxic conditions, at least in 2001, when this data point was collected.

Historic recording of temperature and dissolved oxygen profiles included only one water column profile per sampling season. While these data are useful in tracking major trends over time, monitoring consisting of several profiles per sampling season can provide better insight to seasonal changes in the lake.

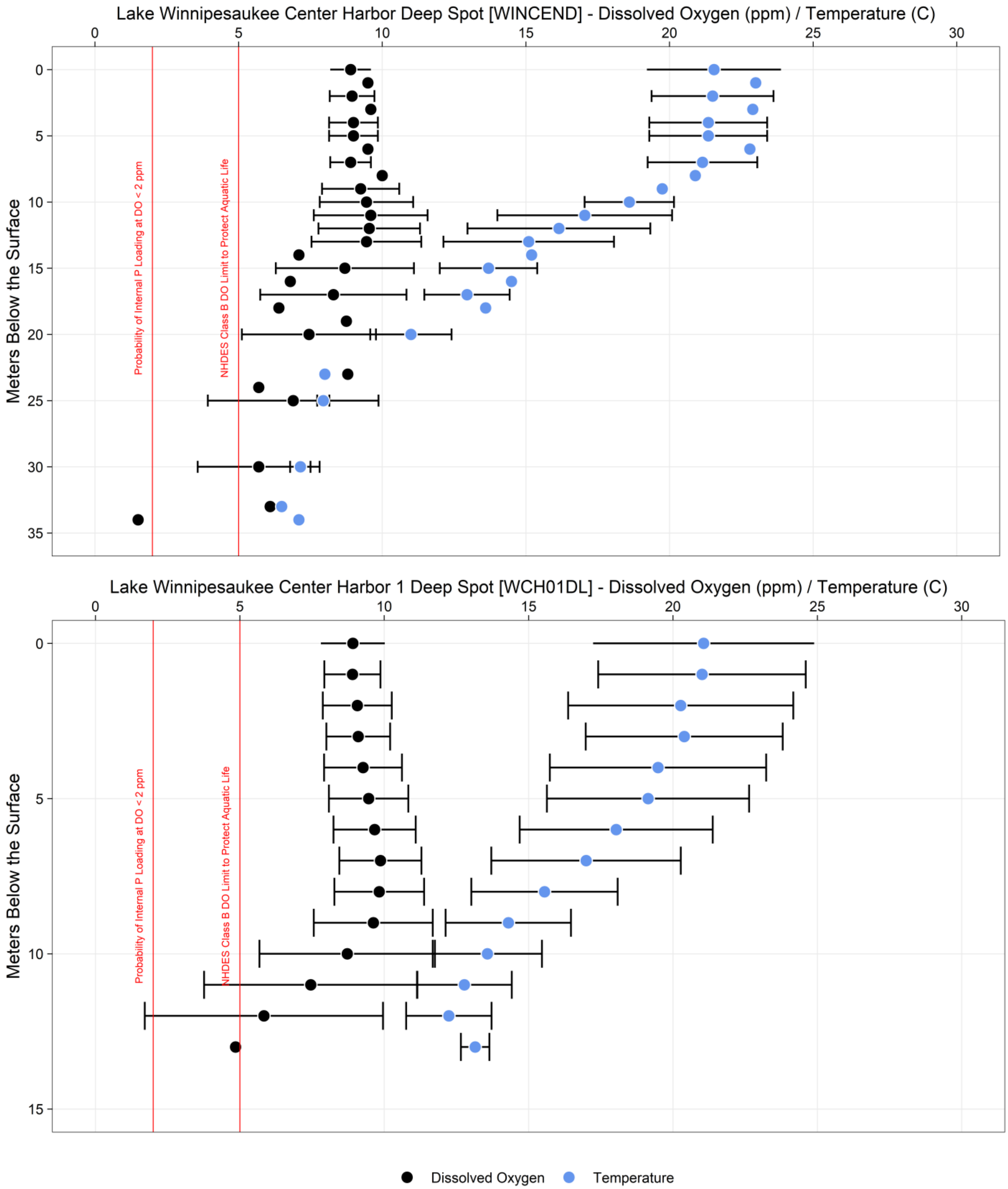


Figure 7. Dissolved oxygen (black) and water temperature (blue) depth profiles for the deep spots of Center Harbor in Lake Winnipesaukee (WINCEND – top and WCH01DL – bottom). Dots represent average values across sampling dates for each respective depth. Error bars represent standard deviation. Profiles for WINCEND were collected in 1990 and 2001 (n=2), with additional DO observations collected in 1979 and 1984. Profiles for WCH01DL were collected every year from 1989-1999 (n=11).

2.1.5 Chloride & Specific Conductivity

Chloride pollution can cause harm to aquatic organisms and disrupt internal mixing processes when concentrations reach toxic levels. Because chloride requires physical grab samples and analysis at a local laboratory, lake managers often use specific conductivity as a rough measure of potential chloride toxicity. Specific conductivity measures the water's ability to conduct an electrical current and gives lake managers a sense of the amount of dissolved material in the water. In the Northeast, chloride from winter salting practices often accounts for increased conductivity of waters. The State of New Hampshire sets a chronic threshold of 230 ppm for chloride (which roughly equates to 835 µS/cm for specific conductivity). Chloride and specific conductance concentrations in the WINCEND Center Harbor deep spot of Lake Winnipesaukee were well below the chronic threshold (17.9 ppm epilimnetic chloride between 2020-2023, and 83.6 µS/cm specific conductance for the same period). However, concentrations of both variables have increased over time, with statistical significance for epilimnetic specific conductivity (Figure 8). There are fewer than 10 data points of epilimnion chloride, so a trend test was not conducted for this parameter. Most New Hampshire lakes are around 4 ppm or 40 µS/cm, but the most recent measurements in Center Harbor Bay show concentrations of chloride and specific conductance above these levels. The increasing trends indicate that chloride from winter salting practices for deicing roads and other surfaces in the watershed may be contaminating the lakes. While not an immediate concern for the health of the lake, chronic chloride toxicity will likely become an issue in the future without a proactive reduction in salt use in the Center Harbor Bay watershed. The WCH01DL deep spot had no chloride and insufficient specific conductance data for trend analysis. Its most recent specific conductivity sample was collected in 2006.

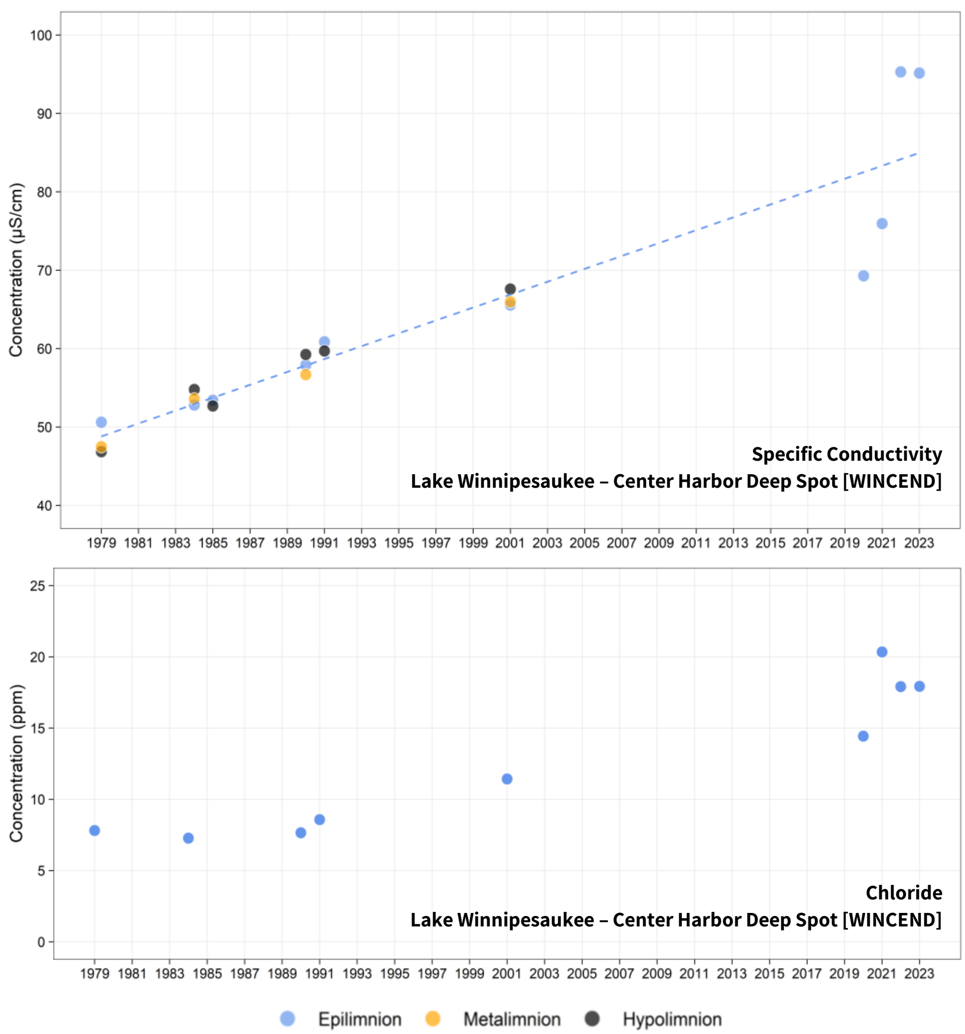


Figure 8. Yearly median of monthly medians for specific conductivity (top) and chloride (bottom) in the Center Harbor deep spot of Lake Winnipesaukee (WINCEND). The dashed line indicates a statistically significant increasing (degrading) trend over time.

2.1.6 Phytoplankton (Cyanobacteria) and Zooplankton

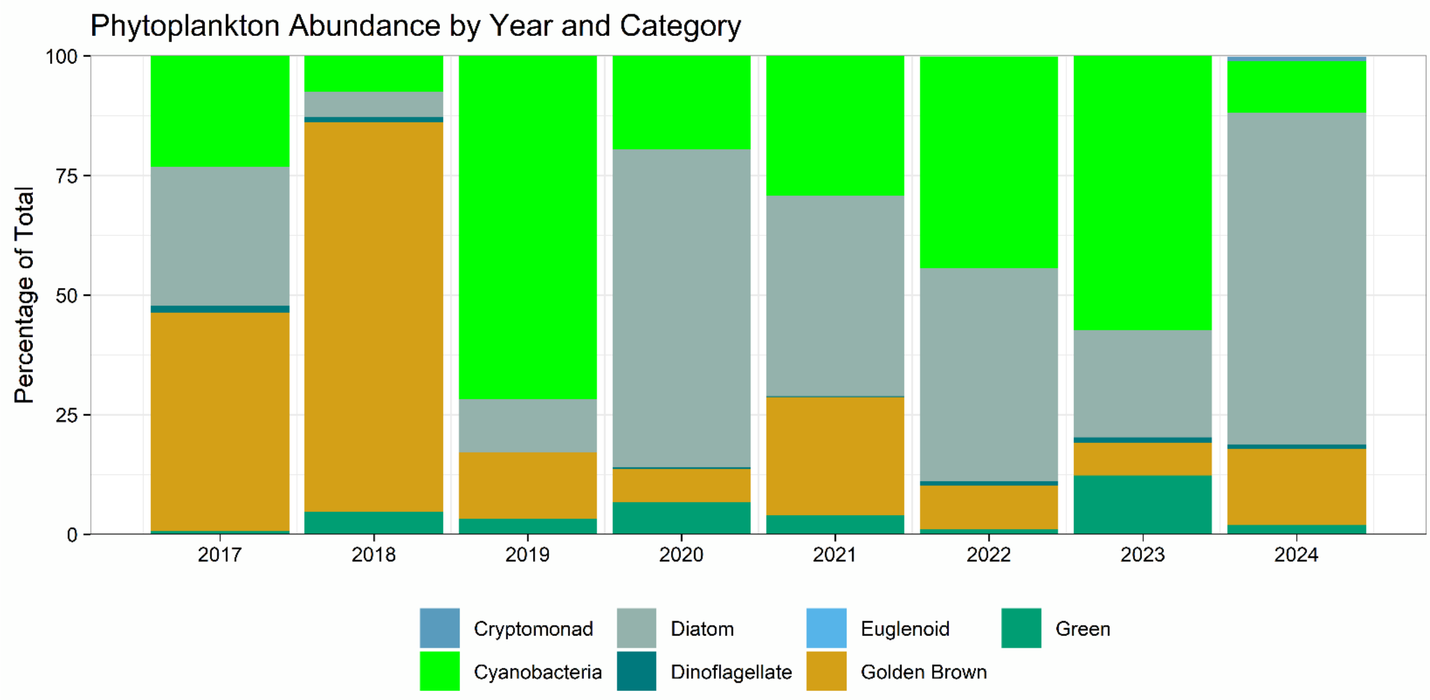
2.1.6.1 Historical Phytoplankton/Zooplankton Surveys

Phytoplankton and zooplankton samples were collected and analyzed during the 1979, 1984, 1990 and 2001 NHDES Trophic Surveys of Center Harbor Bay. The dominant phytoplankton species in summer months were *Chrysosphaerella* (golden-brown), *Tabellaria* (diatom) and *Dinobryon* (golden-brown), *Asterionella* (diatom) while in winter they were *Asterionella*, *Tabellaria* and *Rhizosolenia* (diatom). Zooplankton results indicated *Keratella* (rotifer), *Nauplius* larvae (copepod), *Acanthocystis* (heliozoan), Calanoid copepod (especially in winter months), *Polyarthra* (rotifer), *Vorticella* (ciliate) and an unspecified ciliate species were the dominant taxa at the Center Harbor station. Copepods are small crustaceans that eat phytoplankton and provide an important food source to fish. *Daphnia* are among the most efficient grazers of phytoplankton but were not shown to be a dominant zooplankter in Center Harbor Bay.

2.1.6.2 Recent Phytoplankton/Zooplankton Surveys

In recent years, NHDES has conducted annual phytoplankton and zooplankton surveys throughout Lake Winnipesaukee as part of efforts to monitor for the invasive spiny water flea (see Section 2.1.8). The relative densities of various phytoplankton and zooplankton groups recorded at the WINCEND water quality monitoring station are summarized in Figure 9 below. Although it may be too early to identify clear trends in abundance over time, the introduction of the spiny water flea—first detected in the lake in September 2023—is expected to cause cascading impacts on plankton communities within Center Harbor Bay. Both phytoplankton and zooplankton samples were filtered using an 80 µm mesh net. This small mesh size allows for a representative snapshot of the plankton community.

In most years from 2017 to 2024, cyanobacteria, diatoms and golden-brown algae dominated the phytoplankton community in Center Harbor Bay. While the relative abundance of these groups varies from year to year, no consistent trend over time is evident. Among zooplankton, rotifers were the most abundant group from 2016 to 2024. Cladocerans were observed in relatively low proportions at the Center Harbor deep spot throughout this period, but notably, none were detected in 2024—just one year after the initial detection of the spiny water flea.



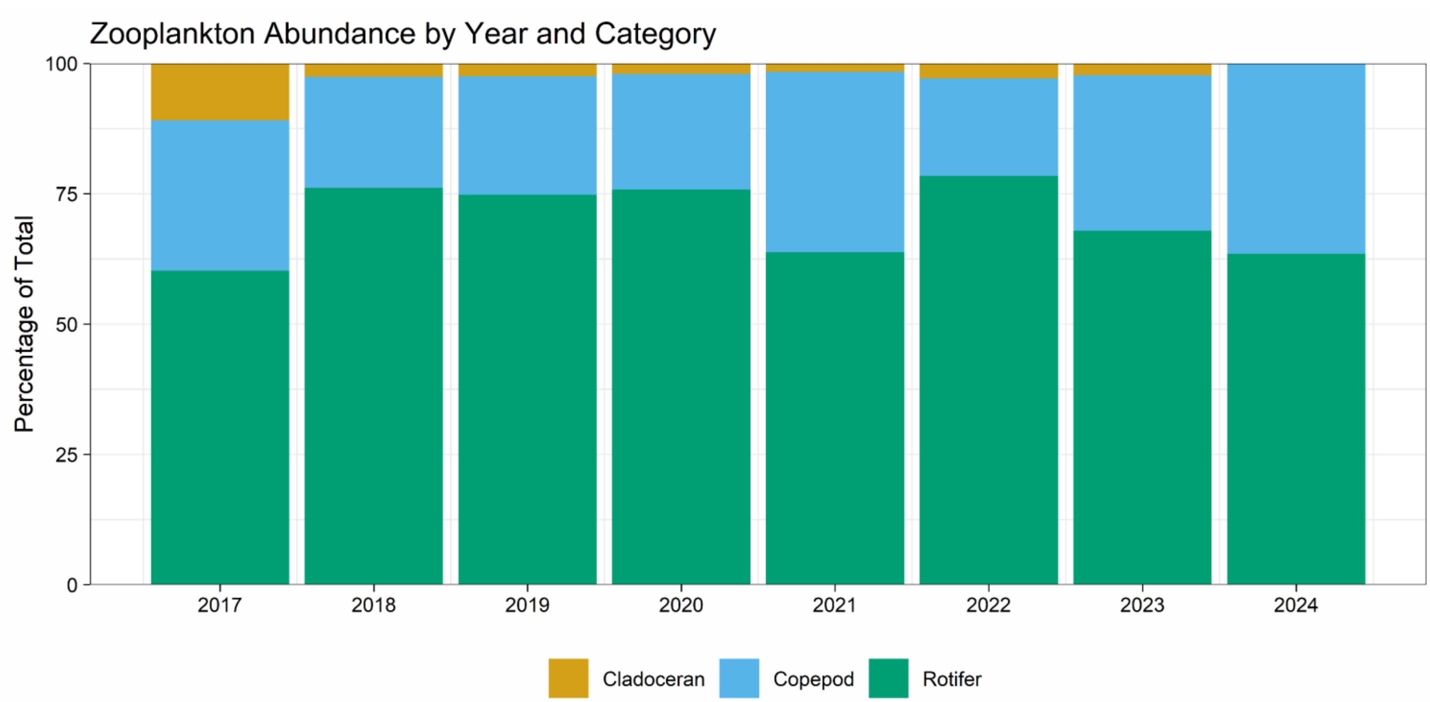


Figure 9. Relative abundance (% of total community) of plankton groups collected by NHDES using an 80 µm mesh net at the Center Harbor deep spot (WINCEND), 2017–2024. The top graph shows phytoplankton results ; the bottom graph shows zooplankton results. Data provided by Kirsten Hugger, NHDES.

2.1.6.3 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 climate, 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 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:

- ***Gloeotrichia:*** typically observed as large, round colonies of filaments, associated with microcystins, documented at Bear, Pine and Threemile Islands in 2022.
- ***Dolichospermum (formerly Anabaena):*** typically observed as filaments, associated with microcystins, anatoxins, saxitoxins, and cylindrospermopsin, documented in Center Harbor Bay in 2022 and 2023 and in Lake Kanasatka in each year between 2020 and 2023.
- ***Microcystis:*** typically observed as variations of small-celled colonies, associated with microcystins and anatoxins, documented in Lake Kanasatka in 2023.
- ***Aphanizomenon:*** typically forms rafts of filaments, associated with anatoxin-a, anatoxin-a (S), saxitoxins, and possibly microcystins.
- ***Woronichinia:*** typically forms dense colonies, associated with microcystins, documented in Lake Kanasatka in 2023.
- ***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).
- ***Pseudanabaena:*** typically observed as filaments, documented in Center Harbor Bay in 2019 and 2021–2024.

Cyanobacteria are becoming more prevalent in low-nutrient lake systems likely due to 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 allow cyanobacteria to thrive and outcompete 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 and as climate warming increases the prevalence and dominance of cyanobacteria, cyanobacteria are one of the major factors driving positive feedbacks with lake eutrophication and may be both accelerating eutrophication in low-nutrient lakes and preventing 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 nutrient feedbacks will be needed for better and more effective lake restoration strategies.

NHDES has issued numerous watches and warnings for cyanobacteria blooms for the Center Harbor Bay area of Lake Winnipesaukee. A bloom of unidentified benthic cyanobacteria was reported in May 2021. *Microcystis* was observed in Salmon Meadow Cove in 2022, while *Dolichospermum* dominated blooms at Ash Cove in October 2022 and at Blackey Cove in June and August 2023. The two Blackey Cove blooms of 2023 had cell counts of 158,000 and 5,900,000, respectively. An additional alert was in place at Blackey Cove for 45 days from October to December 2023. A warning was issued for Bear, Pine and Threemile Islands, which all fall wholly or partially within the watershed, for eight days in September 2022. This bloom was unique for Center Harbor Bay for its dominance of *Gloeotrichia* (alongside *Dolichospermum*), and cell counts reached 116,600 cells/mL. An eight-day warning was issued in June 2024 for *Dolichospermum* (847,000 cells/mL).

Lake Kanasatka has had 16 cyanobacteria bloom alerts and warnings since 2020. *Dolichospermum* was dominant or co-dominant in each bloom where cyanobacteria were identified, with the August 2022 advisory having the highest yet recorded cell count for the lake (> 1 million cells/mL) and lasting longer than all previous advisories (79 days). This was surpassed the following year when a warning was in place from September to December, for 83 days. This bloom also contained *Woronichinia* and *Microcystis*.

Cyanobacteria taxa in Lake Winnipesaukee were identified and enumerated as part of the annual NHDES phytoplankton surveys discussed in Section 2.1.6.2. Figure 10 illustrates the diversity of cyanobacteria present at the Center Harbor deep spot (WINCEND). Since 2022, *Pseudanabaena* has dominated the cyanobacteria community, but at least 12 other species have been identified at this location since 2017.

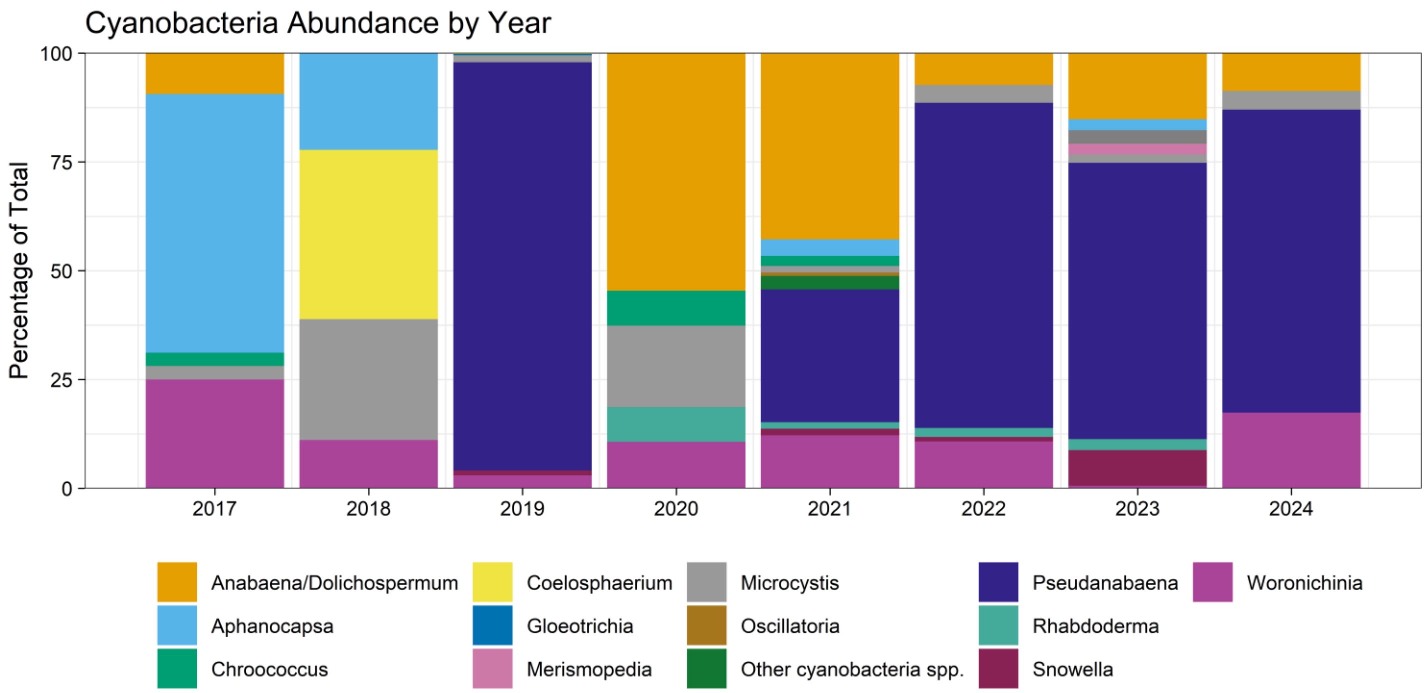


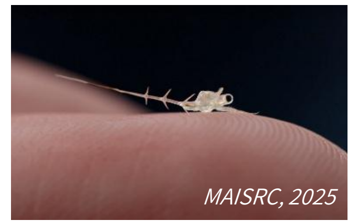
Figure 10. Relative abundance (% of total community) of cyanobacteria taxa sampled by NHDES using an 80 μm mesh net at the Center Harbor deep spot (WINCEND), 2017–2024. Data provided by Kirsten Hugger, NHDES.

2.1.7 Fish

Fish are an important natural resource for sustainable ecosystem food webs and provide recreational opportunities. The 2020 New Hampshire Wildlife Action Plan lists the American eel, burbot and lake whitefish in the Center Harbor Bay portion of Lake Winnipesaukee, as well as bridle shiner in Blackey Cove, Lake Kanasatka, and upstream of Wakondah Pond (Appendix A, Map A-10). Additionally, fish surveys conducted by NH Fish & Game in 2006, 2012, and 2013 in Center Harbor Bay recorded bridle shiner, pumpkinseed (common sunfish), largemouth bass, rock bass, and yellow perch.

2.1.8 Invasive Species

Variable milfoil (*Myriophyllum heterophyllum*) was first discovered in Lake Winnipesaukee in 1965, marking the state's earliest recorded infestation of an aquatic invasive species (NHDES, 2019). Since then, more than 90 waterbodies across New Hampshire have become infested with one or more types of aquatic invasive species (NHDES, 2022a). Although the rate of spread has slowed thanks to statewide prevention and early detection efforts, managing and removing established populations continues to pose significant challenges. disrupt natural habitats, displace native plant and animal communities, lower property values, impair fishing, degrade recreational experiences, and incur high removal costs. There are multiple programs that help prevent the introduction and spread of invasive species in lakes, including the Lake Host Program and the Weed Watcher Program.



A more recent introduction to Lake Winnipesaukee is the spiny water flea (*Bythotrephes longimanus*), a large, predatory zooplankton first detected in Lake Winnipesaukee in 2023 and again in 2024. This invasive species can disrupt lake food webs by competing with native carnivorous and omnivorous zooplankton, such as large-bodied *Leptodora* and cyclopoid copepods, which feed on smaller zooplankton like rotifers. Additionally, the spiny water flea preys directly on native herbivorous, filter-feeding zooplankton, including *Daphnia* and bosminids (both types of cladocerans), and rotifers (Cutter et al., 2023). These groups are essential grazers in lake ecosystems. Declines in *Daphnia* populations resulting from spiny water flea invasion have been linked to increased diatom abundance in two Wisconsin lakes (Walsh et al., 2018). The spiny water flea has fewer predators than native zooplankton because small or juvenile fish are unable to consume their sharp, barbed spine (MAIRSC, 2025). They reproduce rapidly, reaching maturity and producing offspring within a week, and are capable of reproducing asexually. The lack of native predators and fast reproduction cycle enables the species to spread rapidly once introduced to a lake. See Figure 11 for a visual representation of these impacts.

The full impact of the spiny water flea on Lake Winnipesaukee is still being assessed. However, preliminary data collected annually by NHDES suggest a decline in the density of cladoceran taxa (e.g., *Daphnia,* bosminids) across the lake between 2017 and 2024 (Hugger, 2025). Possible impacts could include an increase in diatom densities, a decrease in food sources for native fish (cladocerans), and the clogging of fishing rod eyelets. Continued annual monitoring of phytoplankton and zooplankton communities will help lake managers detect potential impacts, anticipate cascading effects, and implement strategies to prevent issues such as phytoplankton blooms or reduced water clarity.

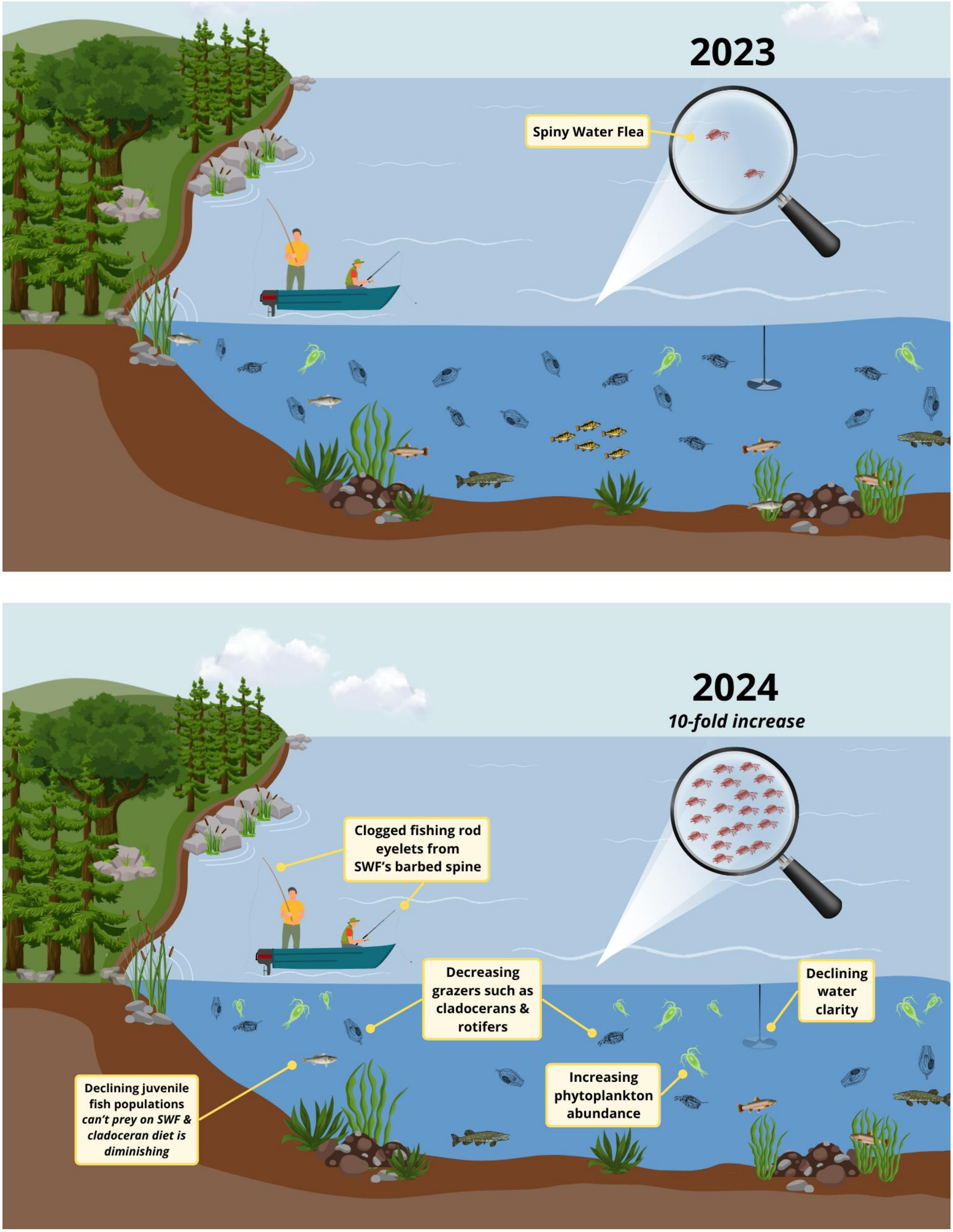


Figure 11. A representation of the impacts of increasing spiny water flea (*Bythotrephes longimanus*) populations in North American lakes.

2.2 ASSIMILATIVE CAPACITY

The assimilative capacity of a waterbody describes the amount of pollutant that can be added without causing a violation of the water quality criteria. The assimilative capacity is based on lake trophic designation. Lake Winnipesaukee is an oligotrophic waterbody, and this designation was selected for running the assimilative capacity analysis for the Center Harbor Bay section of Lake Winnipesaukee. For oligotrophic waterbodies, the water quality criteria are set at 8 ppb for total phosphorus and 3.3 ppb for chlorophyll-a, above which the waterbody is considered impaired (Table 3). According to Table 3-17 in the 2024 Section 305(b) and 303(d) Consolidated Assessment and Listing Methodology (CALM), NHDES requires 10% of the difference between the best possible water quality and the water quality standard be kept in reserve. Therefore, total phosphorus and chlorophyll-a must be at or below 7.2 ppb and 3.0 ppb, respectively, to achieve Tier 2 High Quality Water 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 (Table 4).

For a water quality designation to be determined, NHDES requires a minimum of five samples collected within the critical period (i.e. summer months)[2] and within the most recent 10 years[3]. Since only two epilimnetic total phosphorus and chlorophyll-a samples have been collected at the Center Harbor deep spot within the most recent 10 years, no determination can be made for this part of Lake Winnipesaukee (Table 5).

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.

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. Decision matrix for aquatic life integrity (ALI) assessment in New Hampshire. TP = total phosphorus. Chl-a = chlorophyll-a, a surrogate measure for algae concentration.

Nutrient Assessments	TP Threshold Exceeded	TP Threshold NOT Exceeded	Insufficient Info for TP
Chl-a Threshold Exceeded	Impaired	Impaired	Impaired
Chl-a Threshold **not** Exceeded	Potential Non-support	Fully Supporting	Fully Supporting
Insufficient Info for Chl-a	Insufficient Info	Insufficient Info	Insufficient Info

Table 5. Assimilative capacity (AC) analysis results for deep spots in Lake Winnipesaukee within the Center Harbor Bay watershed, using oligotrophic standards. Chlorophyll-a dictates the assessment results.

Parameter	AC Threshold (ppb)	Existing Median WQ (ppb)*	Remaining AC (ppb)	Assessment Results
LAKE WINNIPESAUKEE – CENTER HARBOR DEEP SPOT [WINCEND]				
Total Phosphorus	7.2	NA	NA	Insufficient data
Chlorophyll-a	3.0	NA	NA	
LAKE WINNIPESAUKEE – CENTER HARBOR 1 DEEP SPOT [WCH01DL]				
Total Phosphorus	7.2	NA	NA	Insufficient data
Chlorophyll-a	3.0	NA	NA	
LAKE WINNIPESAUKEE – CENTER HARBOR 2 BAY [WCH02BL]				
Total Phosphorus	7.2	NA	NA	Insufficient data
Chlorophyll-a	3.0	NA	NA	

* *Existing water quality data truncated to May 24-Sept 15 between 2014-2023 for composite, epilimnion, or upper samples (in order of priority on a given day). N=2 for the WINCEND and WCH02BL stations and n=0 for the WCH01DL station for this period.*

[2] See "Data requirements" section on page 74 of the 2024 New Hampshire Consolidated Assessment and Listing Methodology.
[3] See Table 3-8 on page 24 of the 2024 New Hampshire Consolidated Assessment and Listing Methodology.

2.3 2024 DATA SUMMARY

Water quality data for Center Harbor Bay were collected on August 15th, 2024 by the UNH LLMP volunteers at the WINCEND (deep spot) station. Their results are summarized in the 2024 sampling highlights report (UNH LLMP, 2024). Epilimnion total phosphorus measured 4.5 ppb and the composite chlorophyll-a concentration was 1.9 ppb (n=1 for both). Total phosphorus was 1.0 ppb lower than the 2014-2023 median (n=2) and chlorophyll-a was 0.8 ppb higher than the median for the same period (n=2). No conclusions in long-term trends can be drawn with these low sample sizes, and all values are within expected natural variability for an oligotrophic bay.

UNH LLMP data collected within Center Harbor Bay in 2024 are summarized in Table 6 below. Salmon Meadow Cove measured higher total phosphorus and chlorophyll-a values than all other sites.

Table 6. Summary of trophic state indicator parameters at UNH LLMP stations for data collected in 2024.

LLMP Site Name	Mean Total Phosphorus in ppb (*n*)	Mean Chlorophyll-a in ppb (*n*)	Mean Secchi Disk Transparency in m (*n*)
1 Deep	6.2 (n=1)	2.2 (n=1)	7.1 (n=1)
Ash Cove	6.7 (n=2)	1.8 (n=2)	8.2 (n=2)
Blackey Cove Deep	7.1 (n=2)	1.6 (n=2)	7.3 (n=2)
Braun Bay	5.5 (n=2)	1.5 (n=2)	7.9 (n=2)
Hull Island	6.0 (n=2)	1.4 (n=2)	8.9 (n=2)
WINCEND	4.5 (n=1)	1.9 (n=1)	8.6 (n=1)
Salmon Meadow Cove	12.7 (n=2)	2.9 (n=2)	2.4 (n=1)

Dissolved oxygen levels measured by the LLMP in bottom waters (12.0 to 19.5 m depth) on August 15th averaged 8.7 ppm (range 8.5–9.0 ppm), which are ideal conditions for aquatic life and within oligotrophic levels.

NHDES additionally collected Secchi Disk transparency, chloride, and specific conductivity data at 1 m depth at the WINCEND station on September 11th, as part of its spiny water flea data collection. This data was accessed in September 2025 via the Environmental Monitoring Database maintained by NHDES. Secchi Disk transparency (using a scope) measured 8.5 m, consistent with historic measurements taken at the site. Specific conductance measured 91 µs/cm, consistent with data collected in 2020-2023 and elevated relative to older values. A Mann-Kendall trend test for specific conductance at WINCEND from 1979-2024 shows a significant increase ($p < 0.001$, n = 11). Chloride measured 31.2 mg/L, higher than the previous maximum recorded at this site (20.8 mg/L). Chloride has also significant increased from 1979-2024 ($p < 0.05$, n = 10, Mann-Kendall trend test). Chloride is therefore emerging as a water quality concern for Center Harbor Bay, although levels are still far below NHDES impairment standards.

2.4 WATERSHED MODELING

2.4.1 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[4] of total phosphorus, chlorophyll-a, Secchi

[4] The model cannot simulate short-term weather or loading events.

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 Center Harbor Bay LLRM is provided in the *Center Harbor Lake Loading Response Model Report* (FBE, 2025a).

2.4.1.1 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 Center Harbor Bay is 8,249 acres (48.9 miles of shoreline, including islands) with a maximum depth of 140 feet (42.7 meters) and volume of 447,000,316 m^3 (Appendix A, Map A-1). The **areal water load** is 11 ft/yr (3.5 m/yr), and the flushing rate is 0.26 times per year. The flushing rate of 0.26 means that the entire volume of Center Harbor Bay is replaced approximately once every 3.8 years. Center Harbor Bay has a different flushing rate than Lake Winnipesaukee in aggregate due to the influence of the other bays and their watersheds; the flushing rate of Lake Winnipesaukee is about 0.2, meaning it takes 5 years for the entire volume of Lake Winnipesauke to be replaced.

2.4.1.2 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 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 Center Harbor Bay watershed was determined by FBE using a combination of published datasets on NH GRANIT and ESRI World Imagery from May 26, 2023, and Google Earth satellite imagery from October 10, 2020. For more details on methodology, see the *Center Harbor Lake Loading Response Model Report* (FBE, 2025a). Refer also to Appendix A, Map A-2.

As of the 2023/2020 aerial imagery, development accounts for 22% (665 acres) of the direct drainage area to Center Harbor Bay, while forested and meadow areas account for 69% (2,055 acres; Figure 12). Wetlands and open water represent 6% (180 acres) of the watershed, not including the surface area of Lake Winnipesaukee. Agriculture represents 2% (62 acres). This area does not include the Lake Kanasatka sub-watershed. These areas were previously assessed as part of the *Lake Kanasatka Watershed-based Management Plan* (FBE, 2022).

Developed areas within the Center Harbor Bay 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, 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. A formal impervious cover analysis was not completed for this plan, but impervious cover in the direct watershed to Center Harbor Bay is likely above the 10% threshold. While the 22% developed land cover statistic includes non-impervious surfaces such as lawns, portions of the watershed (particularly downtown Center Harbor) almost certainly exceed 10% imperviousness. These areas contribute contaminated runoff in short, first-flush flow paths to Center Harbor Bay, posing a substantial risk to water quality.

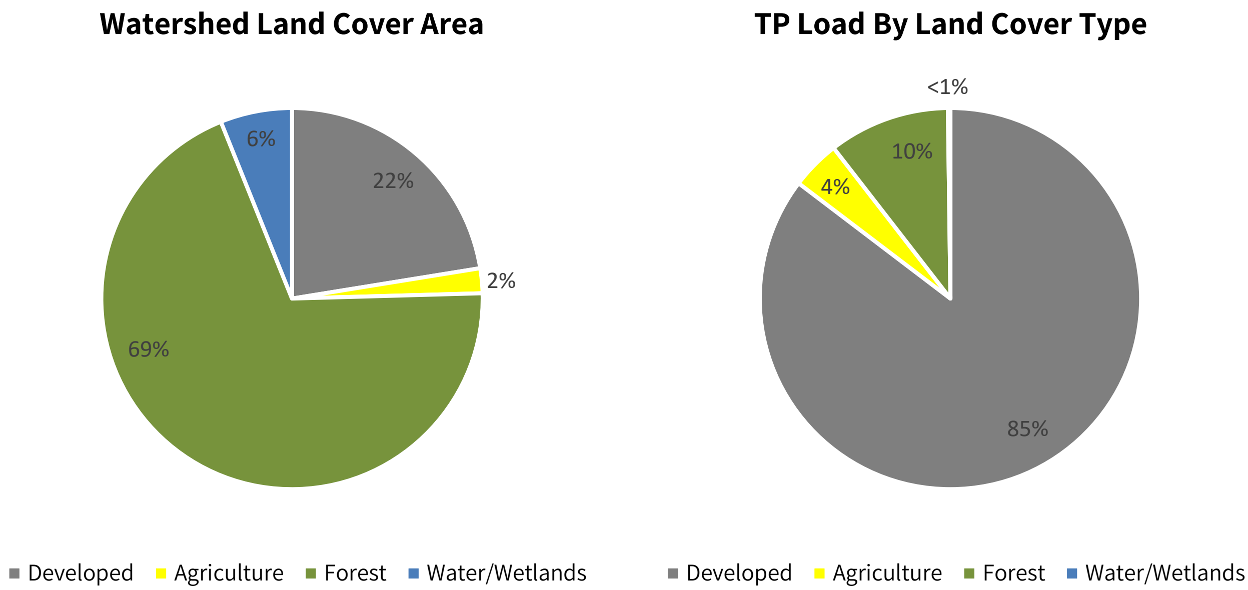


Figure 12. Center Harbor Bay direct drainage land cover area by general category (agriculture, developed, forest, and water/wetlands) and total phosphorus (TP) watershed load by general land cover type. This shows that developed areas cover 22% of the watershed and contribute 85% of the TP watershed load to Center Harbor Bay. The water/wetlands category does not include the lake areas. This area does not include the Lake Kanasatka sub-watershed, only the direct drainage area to Center Harbor Bay.

2.4.1.3 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 spots of Center Harbor Bay from 2015-2024 (to determine average annual duration and depth of anoxia defined as <2 mg/L dissolved oxygen) and epilimnion/hypolimnion total phosphorus data taken at the deep spot from 2015-2024, with some consideration of historical data since recent data were sparse. These estimates, along with anoxic volume and surface area, helped determine the rate of release and mass of annual internal phosphorus load.

The severity of internal loading appears to differ throughout Center Harbor Bay. For example, internal loading appears to be more severe in deep sampling locations closer to the shoreline, likely due to the high phosphorus loads near those deep spots. Internal loading estimates are meant to capture average conditions in the lake. Due to the recent (2024) in-lake treatment in Lake Kanasatka, in which the lake was treated with aluminum sulfate, internal loading has been greatly reduced. In the Lake Kanasatka model, the internal load was reduced by 80% (consistent with observed data from the summer of 2024) to reflect the recent changes in the internal load. Though the in-lake treatment reduced the internal load in Lake Kanasatka, it is unlikely that an immediate impact on the downstream Lake Winnipesaukee was observed.

WHAT IS INTERNAL LOADING?

Over time, as phosphorus enters the lake from the landscape, this phosphorus either stays in the lake (i.e., settles to the bottom or is taken up by plants/algae for growth) or leaves the lake (i.e., get flushed out). The phosphorus that settles on the lake bottom will generally bind with one of two naturally occurring elements that also get flushed into the lake each year from the watershed: aluminum or iron. If phosphorus binds with aluminum, then the bond is permanent, and the phosphorus is sedimented in the lake bottom. If the phosphorus binds with iron, then the bond is non-permanent and in summer when the lake bottom is deprived of oxygen (anoxic), it triggers a chemical reaction that releases phosphorus from iron. This phosphorus is now free to be mixed up into the water column and serve as a nutrient source for plants and algae. Looking at the ratios between aluminum, iron, and phosphorus indicates whether the lake is vulnerable to internal loading or cycling of phosphorus.

2.4.1.4 LLRM Results

Overall, model predictions for Center Harbor Bay were in good agreement with observed data for total phosphorus (2%) and chlorophyll-a (7%), and poor agreement for Secchi disk transparency (33%) (Table 7). 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.

Watershed runoff combined with baseflow (56%) was the largest phosphorus loading contribution across all sources to Center Harbor Bay. The watershed load (56%) includes the watershed loads from Lake Kanasatka (5%), the direct land area to Center Harbor Bay (35%), and mixing with other areas of Lake Winnipesaukee (16%) (Table 8). Other sources of phosphorus are also substantial, including atmospheric deposition (22%), waterfowl (12%), and septic systems (8%). Internal loading was estimated to be minimal (2%). Development in the watershed is most concentrated in the urban downtown area (Center Harbor and Moultonborough) and along the Center Harbor Bay shoreline. Development is also dense around the shoreline where septic systems 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 to the lake. A small portion of the Center Harbor Bay shoreline (particularly the downtown commercial area of Center Harbor) is serviced by sewer systems, which also represent a potential vulnerability if the sewer systems are old or damaged and leaking wastewater into groundwater near the lake. Note that septic systems are a relatively minor load to Center Harbor Bay because 1) the estimate is only for those systems directly along the shoreline and potentially short-circuiting minimally treated effluent to the lake, 2) some of the shoreline area is serviced by sewer which is not accounted for in the model since the assumption is that the sewer lines are not leaking, and 3) shoreline septic systems for Lake Kanasatka are included in its respective watershed load Table 8 for a breakdown). The load from septic systems throughout the rest of the watershed is inherent to the coefficients used to generate the watershed load.

Internal loading is currently a relatively minor source of phosphorus to Center Harbor Bay (and to Lake Kanasatka following the in-lake treatment). Although the model predicts zero bloom days (Table 7) for Center Harbor Bay, numerous bloom warnings and alerts were issued between 2021 and 2024 by NHDES. Bloom warnings and alerts in 2023 spanned 56 days in Center Harbor Bay (*Dolichospermum*) and 122 days in Lake Kanasatka (*Dolichospermum*, *Woronichinia*, and *Microcystis*); blooms in Lake Kanasatka may impact Center Harbor Bay as past blooms have been observed to enter Lake Winnipesaukee through Blackey Cove, meaning blooming cyanobacteria may continue to proliferate in the lake despite the low nutrient levels. Cyanobacteria blooms in Lake Kanasatka are expected to decline in frequency and severity due to the 2024 in-lake treatment. In 2024, bloom warnings/alerts lasted 8 days in Center Harbor Bay (*Dolichospermum*) and 21 days in Lake Kanasatka (*Dolichospermum*, *Microcystis*, and benthic cyanobacteria including *Oscillatoria*). Lake Winnipesaukee also experienced lake-wide blooms of *Gloeotrichia* in 2024, which impacted most areas of the lake.

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-to-high phosphorus mass exported by area (>0.20 kg/ha/yr) generally had more development (i.e., highly developed commercial areas in Moultonborough and Center Harbor, and shoreline areas with small lot sizes; Figure 13). Drainage areas directly adjacent to waterbodies have direct connection to the lakes and are usually targeted for development, thus increasing the possibility for phosphorus export.

Once the model is calibrated for current in-lake phosphorus concentration, we can then manipulate land cover and other loadings factors to estimate pre-development loading scenarios (e.g., what in-lake phosphorus concentration was prior to human development or the best possible water quality for the lake). Refer to FBE (2025a) for details on methodology. Pre-development loading estimation showed that total phosphorus loading to Center Harbor Bay increased by 169%, from 634 kg/yr prior to European settlement to 1,704 kg/yr under current conditions (Table 8). These additional phosphorus sources are coming from development in the watershed (especially from the direct shoreline of Center Harbor Bay and the islands), septic systems, and atmospheric dust (Table 8). Water quality prior to settlement was predicted to be excellent with extremely low phosphorus and chlorophyll-a concentrations and high water clarity (Table 7).

We can also manipulate land cover and other factors to estimate future loading scenarios (e.g., what in-lake phosphorus concentration might be at **full build-out** under current zoning or the worst possible water quality for the lake). Refer to FBE (2025a) and the *Center Harbor Watershed Build-out Analysis Report* (FBE, 2025b) for details on methodology. Note: the future scenario did not assume a 10% increase in precipitation over the next century (NOAA Technical Report NESDIS 142-1, 2013), which would have resulted in a lower predicted in-lake phosphorus concentration; this is because the model does not consider the rate and distribution of the projected increase in precipitation. Climate change models predict more intense and less frequent rain events that may exacerbate erosion of phosphorus-laden sediment to surface waters and therefore could increase in-lake phosphorus concentration (despite dilution and flushing impacts that the model assumes).

The 2024 Lake Kanasatka in-lake treatment reduced internal loading by 80% in the current conditions (2024) model. This 80% adjustment factor was retained for the future load estimation with the assumption that the effectiveness of the in-lake treatment will wane over time, but subsequent in-lake management efforts to control the internal load will be taken in future years.

Future loading estimation showed that total phosphorus loading to Center Harbor Bay may increase by 72%, from 1,704 kg/yr under current conditions to 2,927 kg/yr at full build-out (2087) under current zoning (Table 8). Additional phosphorus will be generated from more development in the watershed (especially in the Inner Bay, Blackey Cove, and Salmon Meadows sub-watersheds), greater atmospheric dust, more septic systems, and enhanced internal loading (Table 8). The Center Harbor Bay model predicted higher (worse) phosphorus (9.4 µg/L), higher (worse) chlorophyll-a (2.9 µg /L), and lower (worse) water clarity (4.1 m) compared to current conditions for the watershed (Table 7). This corresponded with a projected four bloom days per year under future conditions. Future load estimation shows that Center Harbor Bay will be nearing a tipping point at full-build out, where the lake may be at risk of failing to meet the state's criteria for oligotrophic lakes (thus making the lake mesotrophic). Mesotrophic lakes have increased productivity that can reduce water clarity, produce more cyanobacteria blooms, and ultimately begin a shift to a cyanobacteria-dominated steady state.

Table 7. In-lake water quality predictions for Center Harbor Bay. TP = total phosphorus. Chl-a = chlorophyll-a. SDT = Secchi disk transparency. Bloom Days represent average annual probability of chlorophyll-a exceeding 8 µg/L.

Model Scenario	Median TP (µg/L)	Predicted Median TP (µg/L)	Mean Chl-a (µg/L)	Predicted Mean Chl-a (µg/L)	Mean SDT (m)	Predicted Mean SDT (m)	Bloom Days
Center Harbor Bay							
Pre-Development	--	2.0	--	0.2	--	13.3	0
Current (2024)	5.0 (5.6)*	5.5	1.5	1.4	9.3	6.2	0
Future (2087)	--	9.4	--	2.9	--	4.1	4

**Mean TP concentration (first value) represents current summer in-lake epilimnion TP from observed data. Median TP concentration (second value in parentheses) represents the annual median concentration from 2025 ice-out data 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.*

Table 8. Total phosphorus (TP) and water loading summary by model and source for modeled waterbodies in the Center Harbor Bay watershed. Italicized sources sum to the watershed load.

SOURCE	PRE-DEVELOPMENT			CURRENT (2024)			FUTURE (2087)		
	TP (KG/YR)	%	WATER (CU.M/YR)	TP (KG/YR)	%	WATER (CU.M/YR)	TP (KG/YR)	%	WATER (CU.M/YR)
Center Harbor Bay									
ATMOSPHERIC	233.7	23%	40,843,174	367.2	22%	40,843,174	834.6	29%	40,843,174
INTERNAL	0.0	0%	0	40.1	2%	0	68.9	2%	0
WATERFOWL	200.3	20%	0	200.3	12%	0	200.3	7%	0
SEPTIC SYSTEM	0.0	0%	0	143.9	8%	106,881	155.5	5%	121,299
WATERSHED LOAD	199.9	57%	76,143,842	946.0	56%	75,732,220	1,785.0	57%	75,320,931
Lake Kanasatka	19.7	*3%*	*8,427,390*	80.0	5%	8,377,897	*138.4*	*5%*	8,307,229
Direct Land Use Load	84.2	*13%*	*19,716,451*	594.2	35%	19,354,324	1,051.4	*36%*	*19,013,702*
Exchange with Main Lake	96.0	*15%*	*48,000,000*	278.4	16%	48,000,000	476.9	*16%*	*48,000,000*
TOTAL LOAD TO LAKE	**633.9**	**100%**	**116,987,016**	**1,704.2**	**100%**	**116,682,276**	**2,926.0**	**100%**	**116,285,404**

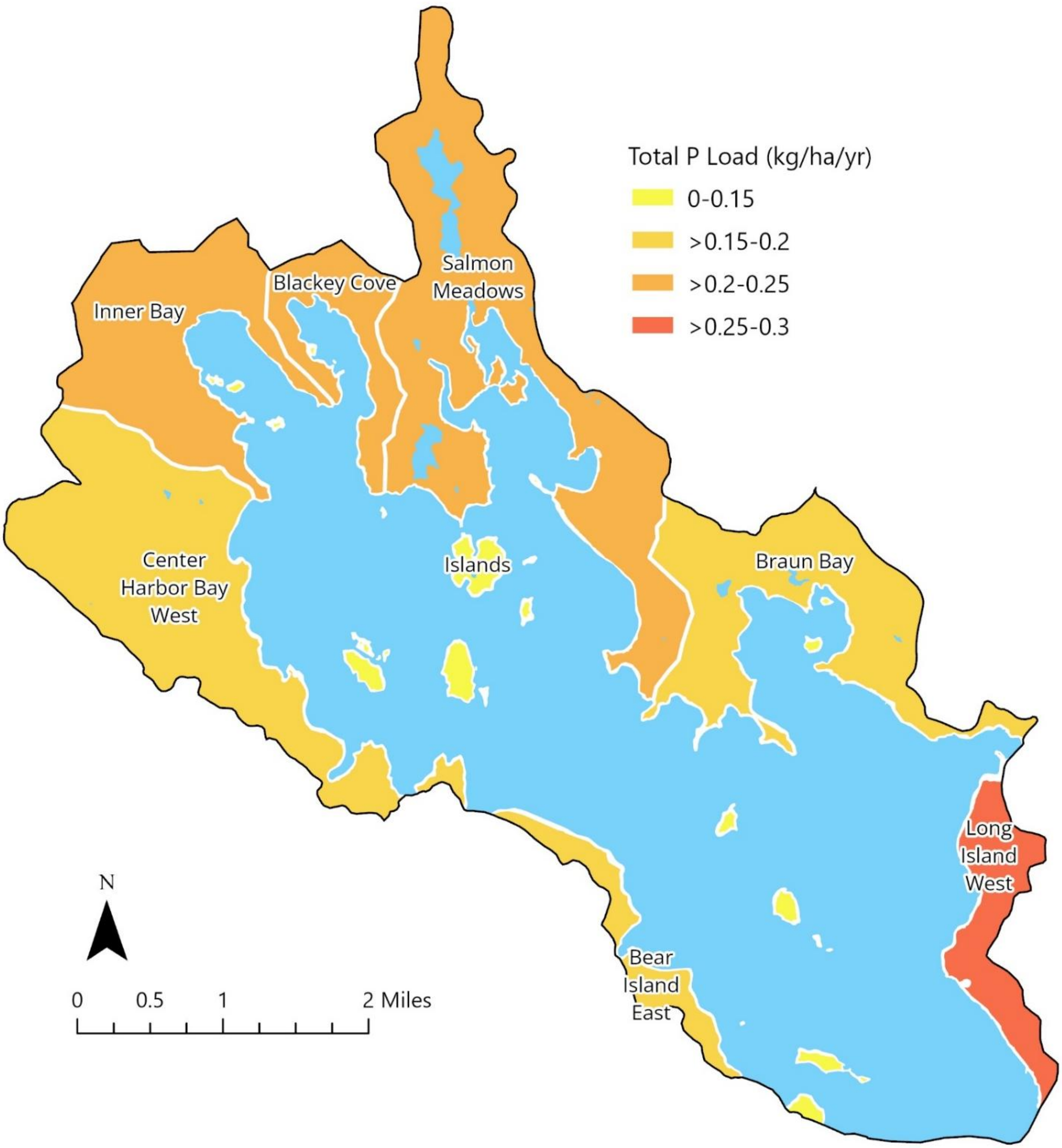


Figure 13. Map of current total phosphorus load per unit area (kg/ha/yr) for each sub-watershed in the Center Harbor Bay watershed. Higher phosphorus loads per unit area are concentrated in the more developed portions of the watershed, particularly the Long Island West subbasin which is relatively small but is highly developed.

2.4.2 Build-out Analysis

A full build-out analysis was completed for the Center Harbor Bay watershed for the municipalities of Center Harbor, Gilford, Meredith, and Moultonborough (FBE, 2025b). 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 39% (4,095 acres) of the study area is buildable under current zoning regulations (Appendix A, Map A-4). As most of the watershed lies within the Town of Moultonborough, most of the buildable area can be found there as well (Table 9). FBE identified 2,523 existing principal buildings within the watershed, and the build-out analysis projected that an additional 2,403 buildings could be constructed in the future resulting in a total of 4,926 buildings in the watershed (Appendix A, Map A-5). Because most of the Lake Winnipesaukee shoreline parcels are already developed, most of the projected buildings fall outside the direct shoreline area. A cluster of buildings were projected in the Center Harbor Residential Class 1 District. There is also a higher density of projected buildings in Moultonborough than in Meredith because Moultonborough determines lot size by soil class and slope rather than set lot sizes per zone. Additional roadways would need to be built throughout the watershed for these projected buildings to be accessible.

Table 9. Amount of buildable land and projected buildings within the Center Harbor Bay watershed, in Center Harbor, Gilford, Meredith, and Moultonborough, NH.

Zone	Total Area (Acres)	Buildable Area (Acres)	Percent Buildable Area	No. Existing Buildings	No. Projected Buildings	Total No. Buildings	Percent Increase
Center Harbor	*1,244*	*749*	*60%*	*167*	*473*	*640*	*283%*
Agricultural and Rural (AR) Class 1 & 2	1,009	570	56%	49	118	167	241%
Commercial Village (CV) Class 2	19	12	63%	18	14	32	78%
Residential (RES) Class 1	115	106	92%	21	269	290	1281%
Residential (RES) Class 2	101	61	61%	79	72	151	91%
Gilford	*44*	*16*	*37%*	*12*	*8*	*20*	*67%*
Island Residential (IR)	44	16	37%	12	8	20	67%
Meredith	*1,808*	*868*	*48%*	*381*	*366*	*747*	*96%*
Forestry and Rural Non-Waterfront Utility Class III	535	357	67%	41	66	107	161%
Meredith Neck Non-waterfront Utility Classes III	273	90	33%	1	21	22	2100%
Residential Non-Waterfront Utility Class III	164	124	76%	12	80	92	667%
Shoreline District Non-Waterfront Utility Class III	206	61	30%	128	43	171	34%
Shoreline District Waterfront Utility Classes III	630	236	37%	199	156	355	78%
Moultonborough	*7,527*	*2,462*	*33%*	*1,963*	*1,556*	*3,519*	*79%*
Commercial Zone A	159	66	42%	85	44	129	52%
Residential/Agricultural	7,151	2,269	32%	1,777	1,433	3,210	81%
West Village Overlay District	216	127	59%	101	79	180	78%
Total	*10,623*	*4,095*	*39%*	*2,523*	*2,403*	*4,926*	*95%*

Three iterations of the TimeScope Analysis were run using compound annual growth rates (CAGR) for 10-, 20- and 50-year periods from 2010-2020 (0.94%), 2000-2020 (1.09%), and 1970-2020 (1.89%), respectively, to project the rate of new development into the future (Table 10). Full build-out is projected to occur in 2097 at the 10-year CAGR, 2087 at the 20-year CAGR, and 2061 for the 50-year CAGR (Figure 14).

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 lake within each municipality 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 10 or 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. Many projected buildings would also require the development of new roadways, which is a factor that would affect the rate of development. 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 10. US Census Bureau population and growth rates for the towns of Moultonborough, Meredith, Gilford, and Center Harbor, NH, 1970-2020. Population estimates obtained from the NH Office of Strategic Initiatives.

	Compound Annual Growth Rate (CAGR)		
Town	**50 Year Avg. (1970-2020)**	**20 Year Avg. (2000-2020)**	**10 Year Avg. (2010-2020)**
Moultonborough	2.68%	0.46%	1.98%
Meredith	1.67%	0.57%	0.65%
Gilford	1.76%	0.62%	0.78%
Center Harbor	1.32%	0.22%	-0.52%
Combined	**1.89%**	**1.09%**	**0.94%**

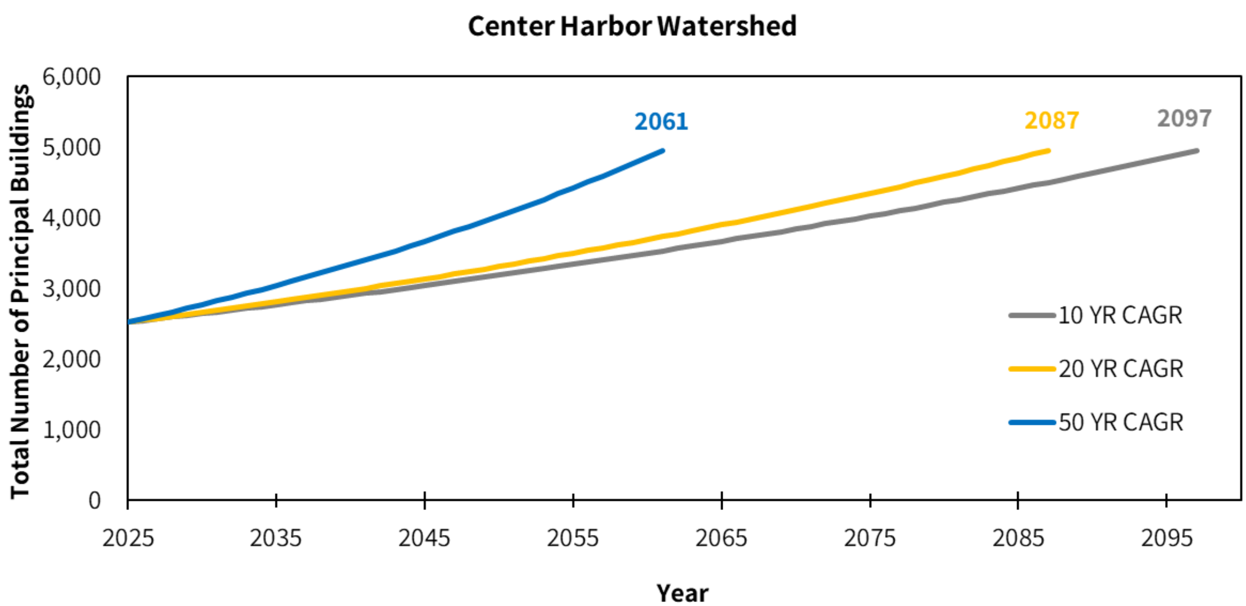


Figure 14. Full build-out time projections of the Center Harbor Bay Watershed in Center Harbor, Gilford, Meredith, and Moultonborough, NH (based on compound annual growth rates).

2.5 WATER QUALITY GOAL & OBJECTIVES

The model estimated changes in total phosphorus loading and in-lake total phosphorus concentrations from pre-development through future conditions. Results show that in-lake concentrations have already more than doubled under current development and are projected to exceed the NHDES oligotrophic reserve capacity threshold if "business-as-usual" development continues, placing the long-term water quality of Center Harbor Bay at risk. Additionally, the increasing prevalence of cyanobacteria blooms indicates that there may not be reserve capacity for Lake Winnipesaukee to assimilate additional nutrients.

Reducing watershed sources of phosphorus throughout the Center Harbor Bay watershed will be necessary to protect water quality in the long-term by preventing the accumulation of phosphorus that can feed cyanobacteria blooms. Given that Center Harbor Bay is experiencing cyanobacteria blooms and is threatened by new development, it is highly recommended that strong objectives be established to protect the water quality of the bay and Lake Winnipesaukee into the future.

The goal of the Center Harbor Bay WMP is to improve the water quality of Center Harbor Bay such that it continues to meet state water quality standards for the protection of aquatic life integrity (ALI) and primary contact recreation (PCR) and substantially reduces the likelihood of harmful cyanobacteria blooms. This goal will be achieved by accomplishing the following objectives:

Objective 1: Reduce phosphorus loading from existing development by 10.5% (179 kg/yr) to Center Harbor Bay to reduce average in-lake summer total phosphorus concentration to 3.9 ppb.

Objective 2: Mitigate (prevent or offset) phosphorus loading from future development by 194 kg/yr to Center Harbor Bay to maintain average summer in-lake total phosphorus concentration in the next 10 years (2035). *Note: excludes phosphorus loading from mixing with the Broads, focusing only on future development within the direct watershed to Center Harbor Bay and Lake Kanasatka.*

Measures of success for achieving the goal and objectives should be based on a reduction in phosphorus loading from the major tributaries to Center Harbor Bay and/or from shorefront BMPs and septic system upgrades, as well as 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 lake can uptake phosphorus from phosphorus-rich sediments and store phosphorus for later use under more optimal growth conditions. Thus, the management implications for minimizing the risk of cyanobacteria blooms is not straightforward and depends on a number of factors out of our direct control. The physiological characteristics of these cyanobacteria taxa also means that the typical application of the state's water quality standards for lakes in the form of the assimilative capacity analysis are less relevant for Lake Winnipesaukee.

Reality Check: The watershed survey identified 39 sites impacting the lake. Remediating these sites could prevent up to 11.4 kg/yr of phosphorus from entering Center Harbor Bay. Treating prioritized shoreline sites (disturbance score between 7–12) could reduce the phosphorus load to Center Harbor Bay by 52.5 kg/yr[5] identified from the shoreline survey. Upgrading the 718 known shorefront septic systems older than 25 years is estimated to reduce the phosphorus load to Center Harbor Bay by 71.8 kg/yr. Additionally, remediating all watershed survey sites, prioritized shoreline survey sites, and shorefront septic systems older than 25 years in the Lake Kanasatka sub-watershed will reduce annual phosphorus loading by an additional 43 kg/yr (FBE, 2024). **In sum, treating all existing pollutant sources identified as coming from the external watershed load could reduce the phosphorus load to Center Harbor Bay by 179 kg/yr, which meets 100% of Objective 1 for Center Harbor Bay.** Note that a 2024 alum treatment in Lake Kanasatka reduced internal loading sources of phosphorus in the system during the first year post-treatment, which will have positive downstream impacts on Center Harbor Bay (FBE, 2025c). 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 Center Harbor Bay beyond what has been identified in Table 11 to meet and exceed the water quality goals. Preventing septic system failures, reducing residential lawn fertilizer use, and improved stormwater management at the property scale were not included in the goal attainment calculations above. Because it is hydrologically connected to the Broads, reducing external watershed loads there would also decrease the load entering Center Harbor Bay; however, these effects were not included in the above calculations.

Objective 2 can be met through ordinance revisions that implement low impact development strategies, encourage cluster development with open space protection, through conservation of key parcels of forested and/or open land, and/or targeted outreach and education.

[5] Based on PLET model bank stabilization estimate for fine sandy loams, using 50–200 ft (length, depending on distance from the shoreline) by 3 ft (height) and moderate lateral recession rate of 0.1 ft/yr.

Table 11. Reality check of the water quality goal based on the identified external watershed loads.

	Center Harbor Bay Watershed	Lake Kanasatka Watershed*
Remediating Watershed Assessment Sites Number of sites and total phosphorus load reduction.	39 sites, 11.4 kg/yr	22 sites, 11.5 kg/yr
Addressing Shoreline Properties Number of prioritized properties (Disturbance Scores 7–12) and total phosphorus load reduction.	317 properties, 52.5 kg/yr	121 properties, 20 kg/yr
Upgrading Shoreland Zone Septic Systems Number of septic systems > 25 years old and total phosphorus load reduction.	~718 systems, 71.8 kg/yr	~115 systems, 11.5 kg/yr
Total Phosphorus Load Reduction Per Individual Watershed Sum of remediating watershed assessment sites, addressing shoreline properties, and upgrading septic systems.	136 kg/yr	43 kg/yr
Modeled Total Phosphorus Summer Concentration Goal, and Load Reduction Needed to Meet the Water Quality Goal	3.9 ppb 136 kg/yr	7.2 ppb 59 kg/yr

* Values come from the 2022 Lake Kanasatka Watershed-Based Management Plan. The values are likely an overestimate as some progress to reducing total phosphorus from the watershed has already been made.

The interim goals for each objective allow flexibility in reassessing 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 12). Understanding predicted water quality following watershed improvements compared to likely water quality following no action will help guide adaptive changes to interim goals (e.g., goals are on track or goals are falling short). If the goals are not being met because of limited funding or other implementation resource constraints, rather than because phosphorus loading from new development is outpacing reductions from improvements to existing development, the conditions for adjusting interim goals are very different. For each interim goal year, stakeholders should update the water quality data and model and assess 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 practical limitations to implementation.

Table 12. Summary of water quality objectives for Center Harbor Bay. Interim goals/benchmarks are cumulative. TP refers to total phosphorus.

Water Quality Objective	Interim Goals/Benchmarks		
	2028	2030	2035
1. Reduce phosphorus loading from existing development to Center Harbor Bay by 179 kg/yr to improve average in-lake summer or annual total phosphorus concentration to 4.1 ppb.			
	Achieve 2.6% (44.75 kg/yr) reduction in TP loading to Center Harbor Bay	Achieve 5.25% (89.5 kg/yr) reduction in TP loading to Center Harbor Bay; re-evaluate water quality and track progress	Achieve 10.5% (179 kg/yr) reduction in TP loading to Center Harbor Bay; re-evaluate water quality and track progress
2. Mitigate (prevent or offset) phosphorus loading from future development by 194 kg/yr to Center Harbor Bay to maintain average summer in-lake total phosphorus concentration in the next 10 years (2035).			
	Prevent or offset 48.5 kg/yr in TP loading from new development to Center Harbor Bay.	Prevent or offset 97 kg/yr in TP loading from new development to Center Harbor Bay; re-evaluate water quality and track progress	Prevent or offset 194 kg/yr in TP loading from new development to Center Harbor Bay; re-evaluate water quality and track progress

3 POLLUTANT SOURCE IDENTIFICATION

This section describes sources of excess phosphorus to Center Harbor Bay. Sources of phosphorus to lakes include stormwater runoff, shoreline erosion, construction activities, illicit connections, failed or improperly functioning septic systems, leaky sewer lines, 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). Climate change 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, excessive fertilizer application, unmitigated agricultural activities, pet waste, and wildlife waste.

3.1.1 Historical Development

The land surrounding Lake Winnipesaukee has a long history of human use. The area has likely been used by Native Americans since approximately 8,000 BCE. The Winnipesaukee group of the Western Abenaki tribe occupied the region when early English settlers arrived in the mid-1600s. (Brames, Inc., n.d.). The Native Americans' impact on the Center Harbor Bay environment would have been minimal. Their livelihoods were based on a mix of hunting, fishing, gathering, and subsistence farming of corn, beans, squash, potato, and tobacco.

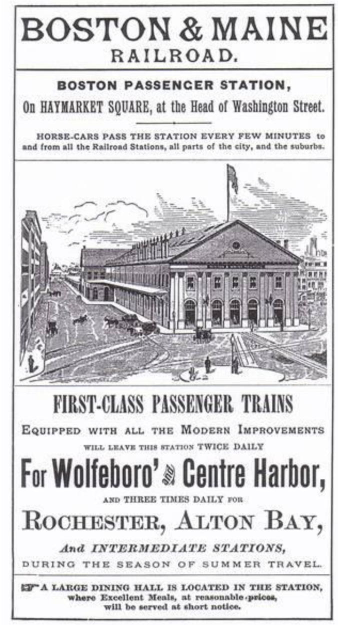
Prior to colonial settlement on Lake Winnipesaukee's shores, Native Americans developed an extensive trail network around the Lake and to villages outside of the region. The largest village in the Northeast, Aquedoctan, was located on the shores of Lake Paugus and Weirs Beach, just west of the Center Harbor Bay watershed (Lake Winnipesaukee Historical Society, n.d. 1). The Aguadak'gan Trail ran along the south-western shore of Lake Winnipesaukee (where Route 11 is today) and connected Aquedoctan to Quannippi, a village in present-day Alton Bay (Indigenous New Hampshire Collaborative Collective, 2024). While the Indigenous people were based in these two villages, setting up weirs in the Weirs Channel to catch migrating shad and mining clay for pottery near Brickyard Mountain, they used trails to utilize the land around the entire shoreline of Lake Winnipesaukee. The Winnipesaukee Trail branched off at several points between Squam Lake and Lake Winnipesaukee, within the northern reaches of the Center Harbor Bay watershed.

The first major shift in land use within Center Harbor Bay occurred in the early colonial period, during the decades following the establishment of the Province of New Hampshire in the 1620s. European settlers that arrived in the area gradually displaced Native Americans and established larger farms and logging operations. Center Harbor was incorporated in 1797, and was initially a small, subsistence farming community (Center Harbor, n.d.). At the time, it was considered a part of Meredith and New Hampton. Some of the islands within the Center Harbor Bay watershed, such as Bear Island, were also settled in the 1790s. These early farmers introduced sheep, planted apple and maple tree orchards, and grew new crops (Lake Winnipesaukee Historical Society, n.d. 2).

The clearing of forested land for farming increased the rates of sedimentation and nutrient runoff into Lake Winnipesaukee and other waterbodies within Center Harbor Bay, such as Lake Kanasatka. One of the more significant impacts on Lake Winnipesaukee in the early colonial period was the construction of the Lakeport dam in Paugus Bay in 1766. Prior to the building of the dam, Lake Winnipesaukee's water level was approximately 5–12 feet lower than it is today (Brames, Inc., n.d.). Nevertheless, the low population density of colonists during the 1600s and 1700s in the Center Harbor Bay watershed meant the impact of land use on water quality was relatively modest compared to later periods.

The "Great Sheep Boom" between 1810 and 1840 led to significant deforestation and building of stone walls in woodlands across New England. By 1840, there were an average of 65 sheep per square mile in New England – more than two sheep for every person.

The clearing of forested land for farming, as well as high sheep density, during this period increased the rates of sedimentation and nutrient runoff into Lake Winnipesaukee and other waterbodies within the Center Harbor Bay watershed. The sheep boom collapsed rapidly after 1840 and many farms were abandoned around this time.



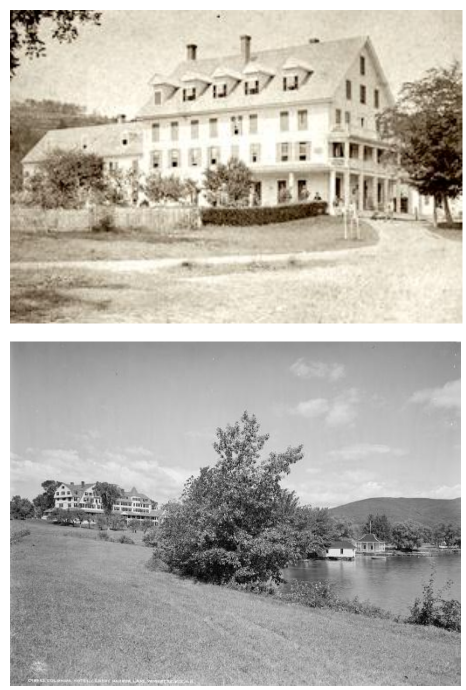
Poster from the late 1800s/ early 1900s advertising tourist destinations including Center Harbor to Boston residents.

Industrialization in the 1800s led to increased development and changing land use patterns around Lake Winnipesaukee. Lumber became the region's most important commodity (along with lake ice). Dams and canals associated with sawmills and gristmills were established along streams and rivers draining into Lake Winnipesaukee. These mills contributed to water pollution through the discharge of untreated waste, as well as runoff from the impervious surfaces of industrial buildings throughout the watershed. The combined impacts of damming and decreasing water quality led to the extirpation of shad in the Merrimack River, and thus Lake Winnipesaukee, by the end of the 19th century. Around 830,000 shad were estimated to be caught in the Merrimack River in 1789, while in 1888, not a single shad was caught (Brames, Inc., n.d.). Nevertheless, Center Harbor village remained relatively small in population compared to other towns around the Lake. Its population peaked at 585 in 1840 and declined each decade until 1940. Only in the 1970s did it surpass this previous population peak, and in 2020 its number of residents stood at 1,040. The impacts of industrialization in Center Harbor were therefore not as pronounced as in other towns in the Lakes Region.

Agricultural productivity also increased in the industrial period as advances in farming techniques and machinery were introduced. After the collapse of the wool industry in New England, dairy farming became prominent in the late 19th century, facilitated by the development of railway networks to Alton and Lakeport, and by steamboats on Lake Winnipesaukee. These transport networks allowed agricultural products to be shipped to outside markets.

Tourism also emerged as an important economic factor in the Center Harbor Bay watershed during the late 19th century. Lake Winnipesaukee was, and remains, a popular vacation spot for visitors from all around the Northeast. The town of Center Harbor, being located roughly halfway between Meredith and Moultonborough, became a major port of lake steamers and a stopping place for stagecoaches (Center Harbor, n.d.). It also provided access to nearby Squam Lake, Lake Kanasatka, and Lake Waukewan. Center Harbor is now the winter home of the paddle steamer MS Mount Washington, the largest boat on Lake Winnipesaukee (Center Harbor, n.d.).

Increasing tourism led to the development of summer cottages, hotels, inns, and recreational facilities, especially concentrated around the shores of Lake Winnipesaukee. It also contributed to further construction of roads, parking lots, and other impervious surfaces, in turn increasing stormwater runoff and pollution into waterbodies. Two of the more prominent seasonal hotels during the mid to late-1800s were the Senter House (later renamed the Colonial Hotel) that stood facing the lake near where the current town office building is located, and the Moulton House that was just north of the Square on the west side of Plymouth Street (Visser, 2020).



The Moulton House (top) and Colonial Hotel (bottom) were popular tourist destinations in Center Harbor in the late 19th century. Source: [Visser (2020)].

By the mid-1800s, Lake Winnipesaukee's summer tourism market was booming as railroads and steamboats provided much easier access for visitors from Boston and beyond. A popular route was to take the train from Boston to the Weirs or Alton Bay, and then to travel to Center Harbor by such lake steamers as The Lady of the Lake, launched in 1849, or on the Mount Washington, launched in 1872 (Visser, 2020). While much of the Lake Winnipesaukee area experienced the same boom in this period, Center Harbor was particularly advertised for its natural beauty and tranquility, and as a retreat for visitors to restore their well-being (Visser, 2020).

By the mid-twentieth century, some of the more notable and grand hotels of the Center Harbor area had been destroyed by fires and were never rebuilt. Center Harbor remained a desirable summer vacation spot, but it was no longer exclusively for the wealthy. The spread of cars also allowed more middle-class vacationers to enjoy the Lake, and many dirt roads and railroads were gradually replaced by macadam and asphalt (Visser, 2020).

Residential, commercial, and recreational development around Lake Winnipesaukee continued to increase throughout the 20th century. Agriculture, especially dairy farming, became more commercialized as better transportation infrastructure allowed access to larger regional markets. This resulted in further conversion of forested lands to hayfields (to provide livestock feed for winter months) and pastures. Farms are still present in parts of the Center Harbor Bay watershed. Along with stormwater runoff from urban development, agricultural runoff is generally an important contributor to water quality changes in waterbodies. Nutrient loading, especially regarding phosphorus, is a primary focus of modern lake management strategies. There have been efforts to implement better stormwater management practices, land conservation initiatives, and regulations aimed at reducing nutrient loading and protecting water quality. This began with the establishment of the Winnipesaukee River Basin Study Commission in the 1960s, which focused on pollution from wastewater discharges (Winnipesaukee Gateway, n.d.). While this study led to the creation of the Winnipesaukee River Basin Program and the construction of public sewage disposal pipeline systems in other parts of the Lake's watersheds, none of these are located within the vicinity of Center Harbor Bay (Winnipesaukee Gateway, n.d.). Most of the properties in the watershed therefore continue to use septic systems and other on-site wastewater disposal systems.

Today, Center Harbor continues as a residential village with small working farms and a robust seasonal population during the summer (Center Harbor, n.d.).

Drainage Infrastructure Assessment – Gilford, NH (2024)

Between June and August 2024, the Lakes Region Planning Commission completed a town-wide inventory of 2,504 culverts and closed drainage system (CCDS) features on municipal roads in Gilford. This effort, guided by the NH SADES protocol, provides critical data on pipe materials, drainage structures, and end treatments. The majority of pipes assessed were plastic, with 84% in "Good" condition—supporting the Town's ongoing transition away from aging metal infrastructure, which showed high rates of deterioration. Key findings also include the dominance of masonry headwalls without wingwalls, and a need to monitor precast concrete structures for early signs of degradation.

This assessment represents a 209% increase in surveyed features since the last CCDS survey in 2016, offering Gilford an expanded, GIS-ready dataset to guide stormwater infrastructure maintenance and planning. The report recommends continued investment in plastic replacements, targeted inspection of concrete components, and adoption of GIS tools to streamline field verification. A follow-up assessment is advised within five years to track changes and ensure system resilience in the face of growing environmental and development pressures.

The 2024 assessment comes at a critical time as the region faces more frequent and intense storms, increasing the volume and impact of stormwater runoff. The significantly improved inventory—documenting 2,504 existing features—provides a much clearer understanding of where vulnerabilities lie. This comprehensive dataset equips the town to prioritize repairs and upgrades that reduce flooding, road damage, and pollutant-laden runoff. Well-maintained drainage infrastructure also helps protect downstream water quality in areas like Center Harbor Bay by minimizing erosion and controlling the flow of stormwater into sensitive waterbodies.

A visual description of headwalls and wing walls from the LRPC 2024 CCDS Report (LRPC, 2024).

3.1.2 Watershed Survey

A watershed survey of the Center Harbor Bay watershed was completed by technical staff from FBE and LWA. The survey area excluded the Lake Kanasatka watershed, for which a watershed survey was conducted in 2021 as part of the Lake Kanasatka Watershed-Based Management Plan. The objective of the survey was to identify and characterize sites contributing NPS pollution and/or providing opportunities to mitigate NPS pollution in the watershed. Prior to fieldwork, FBE analyzed aerial images and GIS data for land use/land cover, roads, 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 inform recommended solutions. Nonpoint source sites identified during the survey require implementation of best management practices (BMPs) due to impacts from stormwater, erosion, lack of infiltration (impervious cover), culvert restrictions, and/or lack of vegetated riparian buffer.

On September 4, 2024, FBE and LWA staff surveyed the watershed, documenting a total of 19 NPS sites. FBE technical staff conducted a follow-up visit on April 28, 2025 during spring wet weather conditions and identified an additional 14 public NPS sites and 6 private NPS sites (Figure 15). Site documentation included describing the problem, making recommendations for fixing the problem, rating the site's impact to water quality, logging the site's geoposition, and taking photographs. Field staff accessed sites from public and private roads and waterfront access points. The main issues found were water access point erosion and road and ditch erosion, and camp and beach runoff.

Following the watershed survey, pollutant load reduction estimates and cost estimates were determined and used to better prioritize implementation at the 39 identified NPS sites (see Appendix B). NPS sites were given an impact score of Low, Medium, or High based on field observations (proximity to surface waters, severity of the NPS problem, habitat connectivity, etc.). The top five ranked sites (based on lowest impact-weighted cost per mass of phosphorus removed) 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.

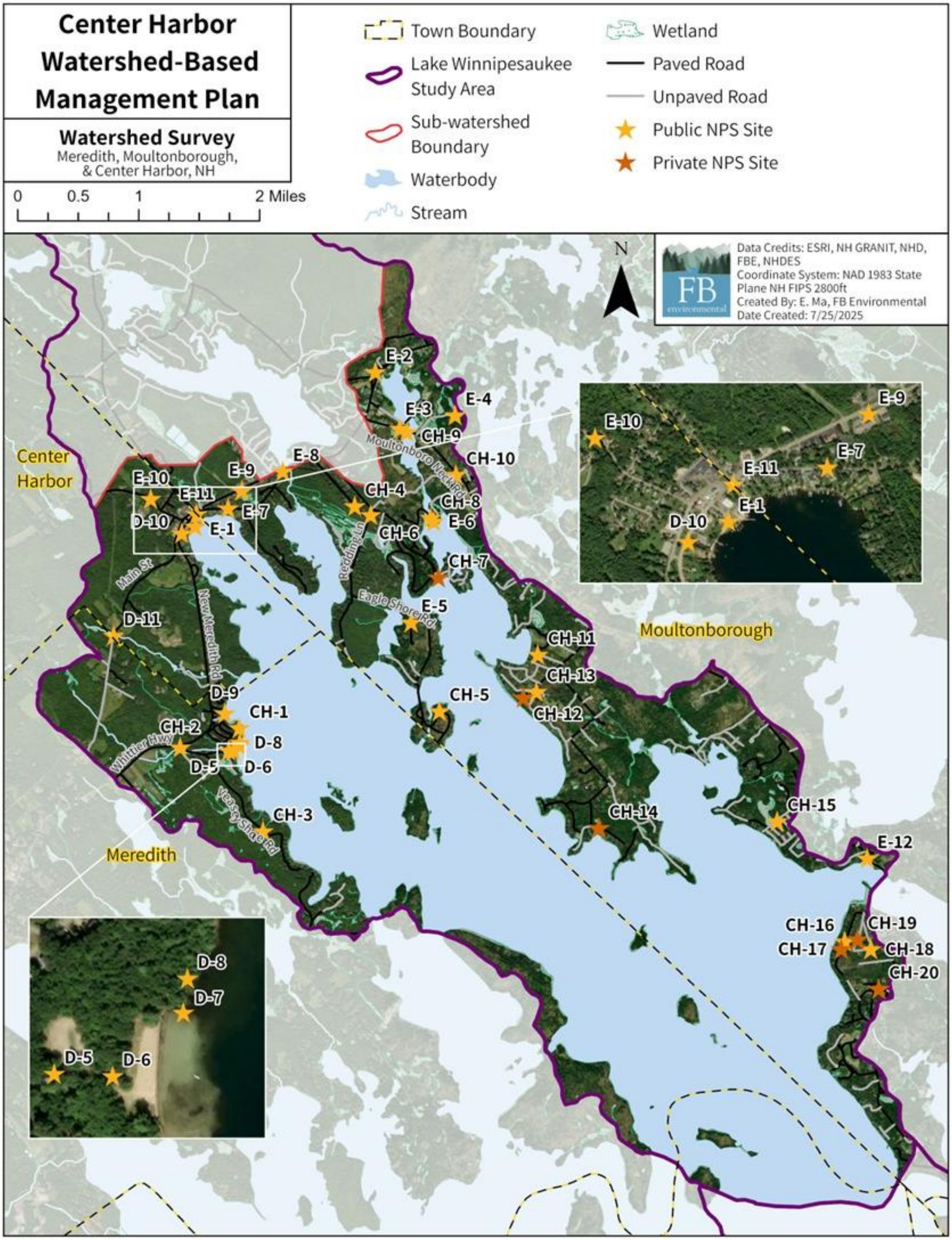


Figure 15. Location of identified nonpoint source sites and points of interest in the Center Harbor Bay watershed.

Site E-4: Greene's Basin Road

Location (latitude, longitude): 43.72141, -71.41755

Impact: High

Observations: A 168-foot-long gully is located on the southern side of the unpaved Greene's Basin Road. The gully extends from the property (east side of gully) to an oak tree with an orange blaze mark (west side of gully). A culvert beneath the road is located within this stretch, marked with metal poles. The gully extends in both directions from the culvert, and the erosion is deepest in the basin immediately around the culvert outlet. Extensive emerging tree roots also indicate the severity of the erosion. Part of this basin may have been purposefully dug, rather than caused by erosion. Sediment from the unpaved road has been deposited in the gully throughout its length. Sand from the driveway is another sediment source. The gully ultimately discharges into a forested wetland along Greene's Basin Road. The basin around the culvert is approximately 8 feet wide.

Recommendations: The accumulated sediment should be cleaned out and the ditch reshaped into a U-shape. The plunge pool area around the culvert outlet should be lined with larger riprap, with regular clean outs in the basin. Smaller (6") riprap should be placed along the length of the road ditch, stabilizing the foreslope, backslope, and bottom.

(Top left) A view of the gully along Greene's Basin Road, facing the driveway. (Top right) A close-up view of the gully showing the accumulation of sand. (Bottom left and right) Two views of the deep basin around the culvert, located within the course of the gully.

Site E-05: Kerrie Court Shoulder

Location (latitude, longitude): 43.69665, -71.42493

Impact: High

Observations: A 313-foot long gully has formed on the eastern shoulder of Kerrie Court, just upslope from its intersection with Eagle Shore Road. The gully was possibly part of a dug ditch in the past and has a relatively flat bottom. Sand has accumulated in the channel. It is estimated the gully has taken up to 10 years to form, with sand building up over the last five years. Some graminoids (grasses and similar plants) were observed growing in the accumulated sediment of the channel, though sparsely. A small plastic pipe culvert was observed at the end of the gully, transporting runoff under Kerrie Court to the west of the road. There is a relatively large pond-wetland complex downslope (west) of Kerrie Court to which water from this gully drains, before ultimately flowing into Lake Winnipesaukee.

Recommendations: The channel should be vegetated with native plants. Woolsedge (*Scirpus cyperinus*) was observed growing in the gully near its terminus on the survey date, and could be a candidate species for re-planting, as it is a wetland species. Revegetation would reduce the runoff flow rate and sediment transport down the road shoulder. Check dams could also be installed, and the road surface crowned so that runoff falling on the opposite side of the road drains directly to the wetland and reduces the volume entering the ditch on the east side of Kerrie Court.

Views downslope (top left) and upslope (top right) of the gully on the eastern shoulder of Kerrie Court. (Bottom left) Sand accumulation and erosion of the adjacent forest area is common throughout its length. (Bottom right) The bottom end of the gully has less sand, with a culvert (circled) conveying water away from the gully beneath Kerrie Ct to the west.

Site D-06: Leavitt Beach Near Parking Lot

Location (latitude, longitude): 43.68135, -71.45427

Impact: High

Observations: Parking lot runoff has formed a gully on Leavitt Beach, spanning from the pavement of the lot directly into the lake. Stormwater originates from the uphill portion of the parking lot and erodes the beach sand, causing it to enter Lake Winnipesaukee.

Recommendations: We recommend installing a settling basin at the beginning of the gully or green infrastructure such as vegetated swales in the parking lot to capture and treat stormwater. A rain garden or stormwater infiltration area may be installed in the grassy area to reduce the volume of stormwater entering the lake through the beach. Repair the gully to prevent the concentrated flow of stormwater through a singular point.


(Left) View of the beginning of the gully from the parking lot to the lake. (Right) The gully leads directly to the water, indicating that untreated stormwater from the parking lot and sediment enter the lake.

Site E-12: Boat Launch Near Trexler's Marina

Location (latitude, longitude): 43.66822, -71.34977

Impact: High

Observations: A sandy gully on the west side of Long Island Road leads down to the boat ramp opposite Trexler's Marina. Some rip rap has been installed near the end of this gully, but the gully continues beyond the rip rap into the sandy boat launch area.

Recommendations: We recommend installing additional rip rap or crushed stone in the road shoulder gully, as well as creating a forebay and rain garden at the receiving end of the existing rip rap, on its lake (south) side. Subsurface stabilizers made of permeable pavers should then be installed at the boat ramp to stabilize the soil and reduce further sediment transport into the lake.

A view of the gully facing uphill (north) (Top Left) and downhill (south) (Top Right) along Long Island Road. Some riprap has been installed at the base of the gully before it reaches the boat ramp opposite Trexler's Marina (Bottom Left). The boat ramp still displays some signs of erosion and sediment movement (Bottom Right).

Site E-10: Dane Road Shoulder

Location (latitude, longitude): 43.71153, -71.46787

Impact: Medium

Observations: A gully has formed along the southern shoulder of Dane Road between the Immaculate Conception Apostolic School and Centre Harbor Historic Society building. The road shoulder is relatively steep and narrow along this section of Dane Road. The gully has two distinct sections. The top part of the gully, starting at the Immaculate Conception building, is unpaved. This section is approximately 215 feet long. The very bottom of the gully, opposite the Historical Society building, is paved, but the tarmac is crumbling and contains accumulated sediment.

Recommendations: We recommend placing crushed stone or riprap along the entire length of the gully. Due to the narrow road shoulder and its position on a blind corner, revegetation is not advised. Sections of the gully may be dug out and reshaped into a U-shaped ditch to spread and slow stormwater flow, if space allows.




(Top left) A view of the bottom section of the gully along Dane Road, opposite the Centre Harbor Historical Society building. (Top right) A view from the top of the gully, immediately east of the driveway for the Immaculate Conception Apostolic School building. (Bottom left and right) Two close-up views of the top end of the gully.

In addition to these 39 problem sites, three other areas in the Center Harbor Bay watershed have been identified as NPS concerns. First, the downtown Center Harbor stormwater infrastructure system was highlighted in the 2012 Center Harbor Master Plan as needing a comprehensive stormwater management plan. Anecdotal reports suggest that deficiencies in the system may be contributing to sandbar formation in Lake Winnipesaukee near the shipyard. In 2025, Center Harbor was awarded a $30,000 Clean Water State Revolving Fund Grant to develop a Stormwater Asset Management Program; the downtown area will be a focus of this project and will help the Town prioritize improvements to its drainage infrastructure. Second, a failing culvert connecting Salmon Meadow Cove to Ash Cove was restricting flow and causing road collapse and bank erosion. The Krainewood Shores Association oversaw its replacement in November–December 2024. This should reduce the volume of sediment-laden runoff entering Center Harbor Bay as banks are stabilized. Third, stormwater flows along both sides of Route 25, in both easterly and westerly directions, into a storm drain on the Lake Kanasatka side of the highway. This drain discharges untreated stormwater into Lake Kanasatka Cove, which ultimately flows into Blackey Cove in Center Harbor Bay. Observations in winter 2024-2025 indicated sediment-laden discharge coming from the drain outlet. With NHDOT planning to add a turning lane for Lake Shore Drive on Route 25, this project presents an ideal opportunity to implement improved stormwater control measures at the site.

3.1.3 Shoreline Survey

LWA staff member John Flaherty conducted a shoreline survey of Lake Winnipesaukee in Center Harbor Bay between August and October 2024, with boating assistance for surveying lakefront parcels provided by Center Harbor Bay residents Randy Perin, Bill Gassman, Bette Higley, Chris Gobeille, Linda Caswell, John Anderson and Don Jutton. 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.

Technical staff 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. The scores were summed to produce two metrics: the "Shoreline Disturbance Score" (ranging from 3 to 12) and the "Shoreline Vulnerability Score" (ranging from 1 to 6). Higher scores reflect poorer or more vulnerable shoreline conditions. Photos were taken at each parcel and were cataloged by tax map-lot number. These photos will provide stakeholders 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 1,095 parcels were evaluated along the shoreline of Center Harbor Bay. The average Shoreline Disturbance Score, which evaluates buffer, bare soil, and shoreline erosion, was 5.5 (**Table 13.** Average Shoreline Disturbance and Vulnerability Scores for Center Harbor Bay. Higher values represent poorer or more vulnerable conditions.Table 13). About 29% of the shoreline, or 317 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 tend to have inadequate buffers, evidence of bare soil or use of lawn fertilizer, and shoreline erosion.

The average Shoreline Vulnerability Score, which evaluates distance and slope, was 4.2 (Table 13). About 86%, or 945 parcels, scored 4 or greater. A vulnerability score of 4 or greater indicates that the parcel may have its residence within 150 feet of the shoreline with 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. The majority of shoreline parcels in Center Harbor Bay (81%, or 886 parcels) are particularly prone to erosion for having homes within 75 feet of the shoreline, receiving the maximum score for distance to shore of 3.

Table 13. Average Shoreline Disturbance and Vulnerability Scores for Center Harbor Bay. Higher values represent poorer or more vulnerable conditions.

Evaluated Condition	Average Score	Total Scores
Buffer (1-5)	3.1	Shoreline Disturbance Score (3-12) **5.5**
Bare Soil (1-4)	1.2	
Shoreline Erosion (1-3)	1.3	
Distance (0-3)	2.6	Shoreline Vulnerability Score (1-6) **4.2**
Slope (1-3)	1.6	

The pollutant loading estimates are based on the Shoreline Disturbance Scores. The 317 parcels with scores 7-12 are contributing approximately 105 kg of phosphorus annually.[6] If shoreline landowners were to create adequate buffers and install other shoreline Best Management Practices (BMPs) on these properties (at a 50% BMP efficiency rate), the annual reduction would be 52.5 kg of phosphorus.

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 Center Harbor Bay is moderate for erosion issues (average disturbance score of 5.5). Center Harbor Bay is also generally more prone to erosion issues because many homes are located close to shore (average distance score is 2.6 out of 3).

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. In 2025, LWA sent postcard mailings to property owners of the 57% of parcels that received scores between 7 and 12 on the Shoreline Disturbance Score with a report of the results for their property and recommendations for getting technical assistance help. Property owners will be invited to participate in the free and voluntary Be Winni Blue/LakeSmart program.

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.

[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.

3.1.4.1 Surficial Geology

The composition of soils in the area reflects 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 for (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. Several of these aquifers surround Lake Winnipesaukee as mapped by the US Geological Survey (Ayotte, 1997), including in Center Harbor and Moultonborough, where deposits are predominantly coarse-grained, or layered coarse-over-fine-grained drifts. The saturated thickness generally ranges from 0 to 40 ft, and the aquifers have a maximum transmissivity of 1,000 ft^2/day.

Lake Winnipesaukee serves as a discharge point for these aquifers, receiving groundwater from the stratified drift deposits. Due to the high transmissivity of the material, contaminants can spread rapidly through the aquifer and into the lake and other surface waters. Therefore, safeguarding the aquifer is essential for protecting the water quality of Lake Winnipesaukee.

3.1.4.2 Soils and Erosion Hazard

The soils in the Center Harbor Bay watershed (Appendix A, Map A-6) are a direct result of geologic processes. Of the 40 different soil series present within the Center Harbor Bay watershed (excluding soils beneath waterbodies), the most prevalent is Henniker fine sandy loam (2,035 acres, 18% of the watershed area), followed by Tunbridge-Lyman-Becket complex (1,828 acres, 16%), Lyman-Berkshire-Rock outcrop complex (1,300 acres, 11%), Metacomet fine sandy loam (1,095 acres, 10%), and Gloucester fine sandy loam (848 acres, 7%). Henniker fine sandy loam, Tunbridge-Lyman-Becket complex, Lyman-Berkshire-Rock outcrop complex, and Metacomet fine sandy loam are well drained, while Gloucester fine sandy loam is excessively well drained. The remaining 37% of the watershed (excluding areas identified with soil as "water") is a combination of 35 additional soil series ranging from 5% to 0.002% 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 is 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. These ratings are derived as part of the Soil Erosion Hazard Off-Road/Off-Trail for each soil series. Excluding soils under waterbodies, "very severe" erosion hazard areas account for 13% (1,510 acres) of the Center Harbor Bay watershed, and "severe" hazard areas account for 10% (1,083 acres). These areas are mostly concentrated in the northeastern portion of the watershed, north of Red Hill Road (Appendix A, Map A-7), an area with steep elevation changes (Appendix A, Map A-8). Moderate erosion hazard areas account for 63% of the watershed land area (7,083 acres) and slight erosion hazard areas account for 13% (1,508 acres). An additional 1% (150 acres) is not rated. Development should be restricted in areas with moderate to more severe hazards due

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

to their inherent tendency to erode at a greater rate than what is considered tolerable soil loss. 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 on the western side of Center Harbor Bay (Appendix A; Map A-7).

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 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 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 of Center Harbor Bay have expressed concern about enhanced shoreline erosion caused by boat wakes. Water level management in Lake Winnipesaukee is complex, requiring a balance between the various environmental and recreational needs of users of both the lake and the downstream Winnipesaukee River. The lake level is controlled at the Lakeport Dam in Laconia.

3.1.5 Wastewater

3.1.5.1 Septic Systems

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 and cesspools. When properly designed, installed, operated, and maintained, septic systems can reduce phosphorus concentrations in sewage within a zone close to the system (depending on the development and maintenance of an effective biomat, the adsorption capacity of the underlying native soils, and proximity to a restrictive layer or groundwater). Age, overloading, or poor maintenance can result in system failure and the release of nutrients and other pollutants into surface waters (EPA, 2016). Nutrients from insufficient 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.

How Old is Your Septic System?

Unsure of the age or status of your septic system? Don't worry! You can investigate the age of your septic system by searching your street address on the NHDES Subsurface Application Status OneStop. We recommend entering the town and street name into the query to pull up your property. The approval date associated with your property should reflect how old the system is. Sometimes there is no data on the State's database. This might mean there was a clerical error, or your system is older than the database itself. In this case, call a licensed septic inspector, who can identify the location and status of your septic system. Inspections should be routinely performed every few years, to inform you of the status of your system and to ensure it is not failing or underperforming. Pumping the septic tank every 1-3 years can also ensure proper function.

Septic systems along the shoreline pose a great risk to water quality due to the proximity of the septic drainfield to the waterbody compared to others in the watershed. In a conventional septic system, household waste is held in a septic tank, which separates liquids, solids, and oils. Wastewater then flows to the drainfield, where it is dispersed into the soil for treatment through natural filtration. Although the primary public health concern in siting and designing septic systems is pathogen treatment, nutrients such as nitrogen and phosphorus are also present in wastewater and pose a risk to water quality if there is inadequate nutrient removal. Since septic systems rely on the soil to treat nutrients, the characteristics of the surrounding soil are incredibly important to the transport of nutrients from septic systems to waterbodies. For example, septic systems in coarse-textured soils, soils with shallow water table, or bedrock tend to have a lower capacity to treat nutrients. Septic systems can also fail as they age, which leads to wastewater ponding at the drainfield surface. This is largely a public health issue, due to the pathogens in the wastewater, but failing septic systems near the shore can also pose significant nutrient loading issues especially if there is a downslope path where the water can be easily transported to a waterbody.

LWA completed an initial review of available data on septic systems within 250 feet of Center Harbor Bay shoreline in 2024. The objective of this survey was to determine the number of septic systems along the shoreline and the proportion of older septic systems. Using GIS and parcel data from the towns of Moultonborough, Meredith, Gilford, and Center Harbor, it was determined that 1,161 parcels of land fall within the 250-foot boundary of the lake. Deductions were made for vacant land, commercial lots, conservation land, sub-parcels, etc. resulting in 1,016 parcels with buildings. Further analysis of the 1,016 parcels indicates that 718 parcels contain buildings built before 1999, the date used to determine the number of systems older than 25 years (the average life span of a septic system). Town tax records were reviewed to gather information on property ownership and the NHDES Subsurface OneStop online database was searched to provide information on the construction or operational approval dates of the septic system. A review of the 310 parcels with lot sizes equal to or under 0.5 acres determined that 239 had buildings built before 1999. The NHDES Subsurface OneStop database indicated that only six systems had been replaced. Refer to the *Septic System Risk Analysis for Center Harbor Bay Watershed* Technical Memorandum (LWA, 2024) for further details on assessment methodology.

LWA then estimated nutrient loading using the LLRM Septic System Nutrient Model, an Excel-based model that uses the following inputs and assumptions to estimate phosphorus loading. Due to the high seasonal use of properties on Lake Winnipesaukee, the number of people per dwelling has been increased to 3.5, rather than the 2.5 value normally used in the LLRM.

As detailed in *Center Harbor Lake Loading Response Model Report* (FBE, 2025a), shoreline septic systems contribute **143.9 kg/yr** of total phosphorus loading to Center Harbor Bay, comprising **8%** of the total phosphorus load from all sources to the lake. Some septic systems, cesspools, or holding tanks are located within a short distance to the water, leaving little horizontal (and sometimes vertical) distance through soil for proper filtration of wastewater effluent. Improper siting, installation, or maintenance 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.

3.1.5.2 Municipal Sewer System

Portions of the Center Harbor Bay watershed are served by the Winnipesaukee River Basin Program (WRBP) sewer system, operated by the NHDES Water Division through the Bay Sewer District. This system begins at the Center Harbor Sewage Lagoons Reservoir in Moultonborough before following NH Route 25 through Center Harbor and Meredith where it exits the watershed and directs wastewater to a treatment facility in Franklin (NHDES, 2022b). It currently serves approximately 300 customers in Center Harbor and Moultonborough. The three sewage lagoons, five acres each, are soon to be decommissioned by NHDES.

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. The New Hampshire Shoreland Water Quality Protection Act (SWQPA) prohibits all fertilizer use within 25 feet of the reference line of public waters, as well as quick-release fertilizers (those containing more than 2% phosphorus and a nitrogen component that is less than 50% slow-release) within 25 to 250 feet of the reference line.

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 Center Harbor Bay watershed is minimal (<1%) and includes some cropland, orchards, grazing areas, and hayfields. Agricultural activities, including dairy farming, raising livestock and poultry, growing crops, and keeping horses and other animals for pleasure or profit, involve managing nutrients.

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

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

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 poorly timed fertilizer application, as well as improper storage that allows nutrients to wash away with precipitation, not only threatens lakes and other water bodies but also prevents nutrients from reaching the intended crops. 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.

3.1.9 Future Development

Understanding population growth, and ultimately development patterns, provides critical insight to watershed management, particularly as it pertains to lake water quality. According to the US Census Bureau, towns in the watershed (Moultonborough, Meredith, Gilford, and Center Harbor) have experienced steady population growth over the last 50 years (see Section 2.4.2). The watershed has experienced consistently higher population growth rates than the statewide average. The Center Harbor Bay area has long been treasured as a recreational haven for both summer vacationers, young campers, and year-round residents. The area 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 Center Harbor Bay and the greater New Hampshire Lakes Region as recreational destinations and full-time residence 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 on local water resources. As the region's watersheds are developed, erosion from disturbed areas increases the potential for water quality decline.

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 2.4.1 identified internal phosphorus load as a relatively minor source of phosphorus to Center Harbor Bay (and to Lake Kanasatka following the in-lake treatment), contributing approximately 2% to the total phosphorus load.

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 January 28, 2025, FBE downloaded datasets for aboveground storage tanks, underground storage tanks, automobile salvage yards, solid waste facilities, hazardous waste sites, local potential contamination sources, NPDES outfalls, and remediation sites in the Center Harbor Bay watershed. Out of the eight possible categories, four occur in the watershed: hazardous waste sites, underground storage tanks, local potential contamination sources, and remediation sites (Appendix A, Map A-9).

3.3.1 Hazardous Waste Sites

Hazardous waste generating facilities are identified through the EPA's Resource Conservation and Recovery Act (RCRA) and require either federal or state regulation. None of the nine hazardous waste generating facilities within the Center Harbor Bay watershed are listed as active; seven are inactive; and two are declassified.

3.3.2 Underground Storage Tanks

Underground storage tanks include permitted containers with oil and hazardous substances such as motor fuels, heating oils, lubricating oils, and other petroleum and petroleum-contaminated liquids. There are 22 underground storage tanks within the watershed. Most of these are located along NH Route 25, with many concentrated around downtown Center Harbor. Additional underground storage tanks are located at Trexler's Marina on Moultonborough Neck. There are no aboveground storage tanks listed within the Center Harbor Bay watershed. Ownership of these tanks can range from commercial industries, gas stations, hospitals, marinas, schools, local government, residential or farms, and utilities.

3.3.3 Local Potential Contamination Sources

Local potential contamination sources are sites that may represent a hazard to drinking water quality supplies due to the use, handling, or storage of hazardous substances. There may be overlap between local potential contamination sources and other PCS identified in this section. Both local potential contamination sources within the watershed are along NH Route 25 in downtown Center Harbor.

3.3.4 Remediation sites

The 68 remediation sites present within the Center Harbor Bay watershed consist of underground injection control sites, leaking storage facilities that contain fuel or oil, initial spill response sites, and submerged vehicles, among others.

3.4 WILDLIFE

Fecal matter from wildlife such as geese, gulls, 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 adjacent to lakes and streams where geese and other waterfowl gather, as well as the underside of bridges with pipes or joists directly over the water that attract large numbers of pigeons or other birds. 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 model estimated that waterfowl are likely contributing 200.3 kg/yr (12%) of the total phosphorus load to Center Harbor Bay.

3.5 ENVIRONMENTAL VARIABILITY

Environmental variability has important implications for water quality that should be incorporated into WMPs. In the last century, New England has already experienced significant changes in stream flow and air temperature. Out of 28 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). Average annual air temperature in New England has risen by 1°C to 2.3 °C since 1895 with greater increases in winter air temperature (IPCC, 2013). Lake ice-out dates are occurring 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 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 up to 2,403 new buildings could be added to the watershed at full build-out based on current zoning standards. Center Harbor Bay is at serious risk for sustained water quality degradation with the possibility for new development in the watershed unless environmetnal 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 citizens, businesses, the government, and others. 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

Thirty-nine (39) NPS sites identified during the 2024/2025 watershed surveys and 317 prioritized shoreline properties from the 2024 shoreline survey were documented to have some impact to 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 (and the remaining 34 sites as opportunities arise) identified during the 2024/2025 watershed surveys. The sites were ranked based on phosphorus load reduction, waterbody proximity, and estimated cost. The full prioritization matrix with recommended improvements is provided in Appendix B.
- Provide technical assistance and/or implementation cost sharing to the 317 prioritized shoreline properties identified during the 2024 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, the committee should work with experienced professionals on sites that require a high level of technical knowledge (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.

(Left) An example of a roadside ditch with riprap and turnout, Center Harbor. (Right) An urban stormwater BMP example in Boston, MA.

Engineered Best Management Practices for Stormwater Runoff & Pollution Prevention

To protect water quality by reducing stormwater runoff and nutrients from entering Center Harbor Bay from more urbanized areas, a suite of engineered Best Management Practices (BMPs) may be considered with routine maintenance. These may include but are not limited to the following:

- **Stormwater Detention Basins** – Temporarily store runoff during storm events to prevent downstream flooding and allow pollutants to settle.
- **Curb Cuts to Detention Areas** – Strategic gaps in curbing direct surface runoff from impervious areas into vegetated or engineered detention zones, promoting infiltration and reducing pollutant loads.
- **Vegetated Swales** – Direct and slow down runoff while promoting natural infiltration and pollutant uptake through vegetation.
- **Rain Gardens & Bioretention Areas** – Designed to capture and treat stormwater onsite using vegetation and soil media to filter pollutants before reaching surface waters.
- **Permeable Pavement** – Reduces runoff volume by allowing stormwater to infiltrate through or between surfaces or pavers in parking areas and walkways.
- **Catch Basins** – Capture and settle out sediments and coarse materials from stormwater before it enters downstream infrastructure or waterbodies.

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, fertilizer use prohibition, pet waste management, agricultural practices, and nuisance wildlife controls.

4.2.1 Pollutant Reduction Best Practices

Pollutant reduction best practices include recommendations and strategies for 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, CEI & NHDES, 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 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 ordinance inclusion), 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.

4.2.2 Zoning and Ordinance Updates

Regulations through municipal zoning and ordinances such as LID strategies that prevent polluted runoff from 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. LWA completed a preliminary ordinance review of natural resource protections for the towns surrounding Lake Winnipesaukee, including Moultonborough, Meredith, Center Harbor, and Gilford (Table 14). These towns have already incorporated several important regulations into their ordinances. A more robust review of these ordinances is encouraged for more specific recommendations on improving ordinances and regulations related to natural resource protection. The towns should also consider their staffing capacity to enforce existing and proposed regulations.

Example Town Ordinances

1. **Shoreland Protection District:** Kingston, NH
2. **Septic pump-out regulations:** Sunapee, NH
3. **Zoning overlay districts for environmental protection:** Kingston, NH**;** Portsmouth, NH
4. **Wetland protection zoning:** Hampton, NH
5. **Zoning for groundwater protection:** Rollinsford, NH
6. **Protection of steep slopes for water quality:** Holderness, NH
7. **Low impact design:** Bedford, NH
8. **Fertilizer and pesticide use:** Portsmouth, NH

Local land use planning and zoning ordinances should consider incorporating climate change 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 climate change 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 freshwater. 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.
- **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.
- **Encouraging Riparian Buffers and Maintaining Floodplains:** Municipal ordinances should forbid construction in floodplains, and in some instances, floodplain protections should be expanded. Riparian (vegetated) buffers and filter strips along waterways should be preserved and/or created to slow runoff and filter pollutants.
- **Protecting and Re-establishing Wetlands:** Wetlands are increasingly important for preservation because wetlands hold water, recharge groundwater, and mitigate water pollution.
- **Encouraging Tree Planting and Conservation:** 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 14. Ordinance review for the towns within the Center Harbor Bay watershed. SF: square feet. (Table produced by staff at LWA.)

Strategy	Moultonborough	Meredith	Center Harbor	Gilford
Aquifer Protection Overlay District	None mentioned so it must follow state regulations.	None mentioned so it must follow state regulations.	None mentioned in the water resource conservation overlay district.	Yes, a boundary of 50 ft outward from the area.
Comprehensive Shoreland Protection	Yes, incorporates the SWQPA into the zoning, with some stronger restrictions.	Follows NH state regulation (300 ft inland)	None mentioned so it must follow state regulations.	Yes, follows NH RSA 483-B, Shoreland Water Quality Protection Act.
Conservation Focus Area Overlay District	None mentioned so it must follow state regulations.	None, but has a forestry and conservation district. In this district a minimum setback of 65 ft from shorelines and 30 ft from the highway.	None mentioned so it must follow state regulations.	None mentioned so it must follow state regulations.
Erosion and Sedimentation Control Ordinance	None mentioned so it must follow state regulations.	>100,000 SF developed or >25,000 SF disturbed requires plan/approval	None mentioned so it must follow state regulations.	None, but mentioned in the Island & Shorefrontage District. Also necessary when creating a site plan to make a sedimentation and erosion control plan.
LID reference	None identified	No, but LID practices must be used in stormwater runoff planning and if not implemented, must document why it's not implemented.	None identified	None identified
Groundwater Protection Ordinance	Yes, for commercial use that renders impervious more than 15% or 2,500 SF of any lot will require a stormwater management plan prepared by a licensed NH engineer.	Follows NH state regulation	Has a groundwater protection district. Any use that renders 15% of any lot in this district impervious will require special exceptions.	Mentioned in Aquifer Protection District; no ordinance of its own.

Strategy	Moultonborough	Meredith	Center Harbor	Gilford
Phosphorus Ordinance	None mentioned so it must follow state regulations.	None mentioned so it must follow state regulations.	Yes, only low phosphorous, slow release nitrogen fertilizer can be used beyond 25 ft of the reference line. Limestone only for first 25 ft.	None. Prohibited the use of phosphorus-containing fertilizers within wetland buffer zones. As well as an ordinance on the sale of phosphorus soaps and detergents.
Shorefront Conservation Overlay District	None mentioned so it must follow state regulations.	Yes, 300 ft boundary/reference line.	Mentioned in Water Resources Conservation Overlay District but none of its own.	Yes, merged with island frontage district.
Site Plan Review Regulations	Yes, last revised April 2020.	Must comply with the town zoning ordinance, subdivision regulations, and any other ordinance which pertains to the development must be submitted 15 days before board meeting. Town specific fees.	Yes, for non-residential sites, but will require a plat and outline.	Yes, the director of planning and land use or his designee shall inspect all site construction subject to the authority of the planning board for compliance with approved site plan designs. The director may allow minor deviations if they don't exceed the dimensional requirements allowed in zoning ordinances and are consistent with the intent of the planning board.
Steep Slope Watershed Overlay	Yes, plans in this area must show site disturbance and adjacent areas within 200 ft of the area subject to site disturbance.	Yes, Management plans required for slopes over 20%.	No overlay but some districts have regulations on slopes like the agriculture district in which slopes >25% cannot be counted toward the minimum lot size under a conventional subdivision is considered the non-buildable area.	Yes, has steep slopes and critical elevation conservation area regulations. Slope > 15% and elevations higher than 1,300 ft.
Sewer Ordinance	Have an ordinance on sewage disposal systems.	No leach field or drywall shall be constructed closer than 125 ft to a body of water or wetland.	In flood management ordinance require plans to ensure no leakage during storms.	Yes, last updated 7-26-2023.

Strategy	Moultonborough	Meredith	Center Harbor	Gilford
Stormwater Management	A Stormwater Management Plan (SMP) is required for developments disturbing 20,000 SF or more and must be prepared by a licensed New Hampshire Professional Engineer following NH Stormwater Manual guidelines. The plan includes drainage and water quality reports, comparing pre- and post-development conditions, and must ensure no negative water quality impacts, maintain pre-development groundwater recharge volumes, and prevent increased runoff rates for a 50-year storm. Sites recently wooded are treated as undisturbed for pre-development calculations, and an Operation & Maintenance Plan must be recorded before occupancy. Engineering peer review fees and additional studies may be required for thorough evaluation, with the ordinance effective since June 30, 2010.	Stormwater management plans must be prepared by a New Hampshire-registered professional engineer and submitted with the site plan review. The requirements vary by the level of land disturbance: larger projects (10,000 square feet or more) require detailed Stormwater Management Plans, and projects disturbing 100,000 square feet or more also need an NH DES Alteration of Terrain (AOT) permit. Plans must include existing and proposed conditions, drainage analyses for multiple storm events, and adherence to design standards such as minimizing site disturbance and using Low Impact Development (LID) strategies where feasible. Post-development runoff must not exceed pre-development levels, and redevelopment projects must meet proportional stormwater management standards based on site constraints. An Operations and Maintenance Manual is mandatory for ongoing system upkeep, with inspections, certifications, and records submitted annually to ensure compliance.	Impervious surfaces in excess of 10 percent requires a stormwater plan.	Follows NH regulations, if a site plan will render more than 15% or 2,500 square feet of any lot, whichever is greater, within the aquifer protection district impervious a stormwater management plan is needed.

Strategy	Moultonborough	Meredith	Center Harbor	Gilford
Subdivision Regulations	Yes, last revised April 2020.	Yes, last updated Feb 2021, specific setup for layout and timeline for process.	Yes, land subdivision regulations.	Yes, subdivision plans must be prepared and stamped by a licensed land surveyor or professional engineer. All subdivisions are reviewed by the planning board in which the person may explain the application.
Washing/Public Waters	None were mentioned so it must follow state regulations.	None were mentioned so it must follow state regulations.	None were mentioned so it must follow state regulations.	Ordinance on the sale of soaps and detergents with phosphorus so as to cut down on pollution in the lakes.
Water Quality Protection Overlay District	Covered in the shoreland water quality protection act (SWQPA).	Follows NHDES regulations.	Incorporated in the water resource conservation overlay district. None of its own.	None, follows NH RSA 483-B, Shoreland water quality protection act.
Water Resources Conservation Overlay District	None were mentioned so it must follow state regulations.	Yes(special exceptions can be allowed for certain uses and permits).	Yes, Protective buffers around water resources. Lake+ponds=250ft, Prime wetlands= 125ft, designated wetlands+ designed streams= 75ft,non-designated wetlands(can become designed with soil scientist approval)+ non-designated streams= 50ft, stratified drift aquifers= land use restrictions only.	None, follows NH RSA 483-B, Shoreland Water Quality Protection Act.
Conservation Subdivision Design Ordinance	None were mentioned so it must follow state regulations.	Yes (they review special exceptions)protected open space has a 50' buffer zone around it.	None mentioned so it must follow state regulations.	No, but the Conservation Commission must review sedimentation plans for site projects.
Watershed Overlay District	None were mentioned so it must follow state regulations.	Has one for lake Waukewan only.	None were mentioned so it must follow state regulations.	None were mentioned so it must follow state regulations.

Strategy	Moultonborough	Meredith	Center Harbor	Gilford
Wastewater/Septics	Septics are not permitted on 25% or greater slopes, otherwise following NHDES regulations.	Adopted 2012. within 250' Lake Waukewan.	None mentioned so it must follow state regulations.	Follows NH regulations
Wetland Resources Conservation Overlay District	Yes, the setback from the wetland will be 50 ft and a naturally vegetated buffer shall be maintained 25 ft immediately adjacent to the applicable wetland.	None were mentioned so it must follow state regulations.	Incorporated in the water resource conservation overlay district. No overlay district for itself.	Has a wetland district that requires a 25 ft buffer around wetlands over an acre. Buildings can be placed on wetlands as long as no digging occurs. Use of phosphorus-containing fertilizer is prohibited in wetland buffer(25ft). But no wetlands resources conservation overlay district

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. For Center Harbor Bay, 20% (2,280 acres) of the watershed's land area has been classified as conservation land (refer to Appendix A, Map A-10). Major conserved areas include the Red Hill Conservation Area, Center Harbor Woods, Pine Hill Conservation Area and Kona Wildlife Management Area. Many of the conservation areas border parts of waterbodies or riverways in the watershed. Several headwater streams draining to Lake Kanasatka and Wakondah Pond are protected within the Red Hill Conservation Area.

Local groups should continue to pursue opportunities for land conservation in the Center Harbor Bay watershed based on the highest valued habitat identified by the New Hampshire Fish & Game (NHFG). 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 Center Harbor Bay watershed is part of the Sebago-Ossipee Hills and Plains ecoregion (NHFG, 2015). Approximately 14,001 acres (70%) of the watershed (including the lake area) are considered Highest Ranked Habitat in New Hampshire. Many of the conserved areas overlap with the Highest Ranked Habitat in the bioregion and with supporting landscapes, though there is less overlap with Highest Ranked Habitat in New Hampshire, as much of this habitat occurs along the shores of Lake Winnipesaukee. A map of priority habitats for conservation based on the NH Wildlife Action Plan can be found in Appendix A, Map A-10.

4.2.4 Septic System Regulation

When properly designed, installed, operated, and maintained, septic systems can 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 to remove pathogens from wastewater and not specifically 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, alternative septic systems, though available systems remove nitrogen and not phosphorus. 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 large vehicles over the system 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 is dependent on the use and total volume entering the system. A typical 3-bedroom, 1,000 gallon tank should be pumped every 3 years or more frequently if within the shoreland zone.
- Proper replacement of failed systems, which may include programs or regulations to encourage upgrades of conventional systems (or cesspools and 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 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. New Hampshire state law requires buyers to obtain a state-licensed septic system evaluator for any part of a septic system within 250 feet of the shoreline (see Statutes § 485-A:39).

4.2.5 Sanitary Sewer System Inspections

It is important for Center Harbor Bay municipalities with sewer infrastructure to develop a program (if not already in place) to inspect and evaluate their sanitary sewer system and address identified leaks and overflows, especially in areas near waterbodies.

4.2.6 Boats & Marinas

NHDES provides an interactive map of boat pump-out locations, including both public and private boat pump-outs facilities dump stations for portable toilets, and mobile pump-out vessels. Within the Center Harbor Bay watershed, there is an active, private pump-out facility at the Quayside Yacht Club off Moultonborough Neck Drive. In addition to this pump-out facility, boaters can access the lake at other public and private boat ramps in the watershed, including the Center Harbor Public Docks and Trexler's Marina. The following are best practices for boats and marinas:

- Target outreach to marina owners, boat dealers, and their consumers regarding State and EPA requirements;
- Encourage marina owners to provide clean and safe onshore restrooms and pump-out facilities;
- Provide an appropriate location for boat washing;
- Do not allow waste from the pump-out stations to drain directly into receiving waters;
- Consider alternatives to asphalt for parking lots and vessel storage areas such as permeable pavement;
- Install infiltration trenches at the leading edge of a boat ramp to catch pollutants in an oil-absorbent barrier or crushed stone before discharge;
- Install vegetated buffers between surface waters and upland areas; and
- Protect storm drains with filters or oil-grit separators. Stencil words (such as "Drains to the Lake") on storm drains to alert customers and visitors that storm drains lead directly to waterbodies without treatment. Contact the appropriate municipal public works department before stenciling any drain.

4.2.7 Fertilizer Use Prohibition

Management strategies for reducing water quality impacts from residential, commercial, and municipal fertilizer application start with education and outreach to property owners. New Hampshire law prohibits the use of fertilizers within 25 ft of a surface water. Outside of 25 ft, 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, 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.

4.2.8 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. Areas close to surface waters in the watershed, such as the beaches and parks along Lake Winnipesaukee, are particularly important to manage effectively.

4.2.9 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.

4.2.10 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.

Beaver dam management may also be necessary in the watershed. Beavers repair their dams if they detect the noise or sensation of flowing water through the dam. If the beaver senses the water level is too low upstream of the dam after constructing a dam, they will abandon the dam and find another suitable site to build a dam. In the context of beaver dam management, this could pose additional issues if beavers relocate to another site along the same stream to build a new dam thus creating additional impoundments and greater flooding potential. Investigating the status of beaver dams in the watershed may be useful to determining if beaver dam management is needed. Options for dam management include installing culverts with beaver exclusion fencing (i.e., the Beaver Deceiver design) and/or other beaver deterrents to maintain a lower water level in the lower dam’s pooling area. If the dam is present and active, a more advanced design such as the Clemson Pond Leveler may be necessary to regulate the water level above and below the dam to prevent washouts. The Clemson Pond leveler deceives beavers by releasing water inconspicuously such that beavers are not triggered to repair the dam (thus impounding more water). Physically maintaining the dams to ensure they are not built too high is also a viable option.

4.3 OUTREACH & EDUCATION

Awareness through education and outreach is a critical tool to protect and restore 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. LWA is the primary entity for education and outreach campaigns in the watershed and for development and implementation of the plan. LWA should continue all aspects of their education and outreach strategies and consider developing new ones or improving existing ones and/or forming new collaborations with other organizations (conservation commissions, neighboring watershed associations, etc.) 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, LWA 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.

Throughout the development of this WBMP (2024–2025), LWA has conducted multiple outreach events to the Lake Winnipesaukee community (Table 15). These include presentations on water quality issues to communities and organizations, and the promotion of the Winni Blue Initiative to businesses and individuals in the lake watershed. LWA conducted and produced reports for 52 LakeSmart visits in 2024–2025. Weekly articles on lake issues are written by LWA and published in the local paper beginning in May and running through Columbus/Indigenous Peoples Day in October—43 articles were published in 2024–2025. A sign campaign promoting support and awareness of the Lake Winnipesaukee Alliance was run through the summer into the fall of 2025, radio spots were run on LAKES 101.5, and public service announcements were run throughout the summer 2025. Additionally, LWA produced printed newsletters, annual reports, social media posts, and electronic newsletters and distributed these to donors and residents throughout the watershed detailing the work of the organization, including updates on the watershed-based management plans.

Table 15. Outreach events hosted by the Lake Winnipesaukee Alliance in 2024 and 2025.

Date	Outreach activity
Presentations on Water Quality Issues	
1/17/24	Fire & Ice at Lake Life Realty
3/7/24	GSRWA Presentation
3/9/24	GIA Presentation
4/12/24	Delta Gamma Kappa Presentation
4/20/24	Water Dance in Meredith
4/25/24	Meredith Democrats Presentation
5/16/24	Source Water Protection Conference
6/1/24	Open House at Cyr Lumber
6/8/24	Water Summit
6/21/24	Radio Spot at Shep Browns with The Pulse of NH
6/29/24	Black Cat Island Presentation
7/6/24	Woodlands Association Meeting
7/13/24	Krainewood Association Meeting
7/17/24	Governor’s Island Presentation
7/31/24	Moultonborough Cyano Presentation
8/1/24	Meredith Cyano Presentation
8/2/24	LRCT Paddle and Talk
8/10/24	Twin Barns Release Party
8/11/24	Lake Winni Day
8/25/24	Bald Peak Event
8/28/24	Meredith Rotary Presentation
9/12/24	Alton Bay Business Association Meeting
10/12/24	Winni Clean Up Days

10/24/24	Cyano Talk at LPC
11/7/24	Tuftonboro Womens Service Organization
12/12/24	Lakes Region Conservation Trust Board of Directors
12/18/24	Presentation of the Wolfeboro Bay Watershed Management Plan
1/6/25	Taylor Community Presentation
1/22/25	Lakes Region Community College meeting with the President
1/30/25	Meredith Community Center tabling event
2/25/25	Meeting with Moultonborough Town Administrator and Town Planner to discuss septic system regulations
2/26/25	Meredith Rotary Club to solicit assistance with ice-out sampling
3/6/25	Belknap County Natural Resource Assessment Workgroup
3/15/25	Gilford Island Association's meeting
3/26/25	Meeting with UNH and NH Department of Environmental Services to discuss issues on Lake Winnipesaukee and monitoring needs
4/3/25	Cherry Valley Road site walk on proposed development project
4/10/25	Radio interview with Lakes 101.5 on ice out story
4/22/25	Meeting with Gilford DPW director to discuss road projects in Gilford
5/8/25	Presentation to the Lakes Region Sail & Power Squadron
Promotion of the Lake Winni Blue Initiative	
5/10/25	Table event at Love Our Earth Day, Laconia
5/15/25	Presentation to the Meredith Garden Club
5/29/25	Presentation on updates to the NH Stormwater Manual, Moultonborough Town Library
6/14/25	Septic System talk held at Moultonborough Public Library
6/18/25	Septic Regulations webinar held for Realtors
6/18/25	Meredith Local Lakes Associations meeting and presentation
6/19/25	Tabling event at Four Your Eyes Only, Moultonborough
6/21/25	Presentation to the Black Point Assn, Alton
6/23/25	Presentation at the annual meeting of Lakes Region Planning Commission
7/12/25	Presentation to Krainewood Association's Annual meeting, Moultonborough
7/12/25	Lake Kanasatka Watershed Assn annual meeting, Moultonborough
7/17/25	Presentation to the members of the Winnipesaukee Golf Club
7/19/25	Varney Point Assn annual meeting, Gilford
7/19/25	Barber Pole Assn. annual meeting, Tuftonboro
7/20/25	Twin Barns public promotion of Keep Winni Blue beer
7/22/25	Podcast with Andy Opel on water quality
7/24/25	Presentation on cyanobacteria at the Loon Preservation Committee, Moultonborough
8/8/25	Tabling event at Lake Winnipesaukee Day, Wolfeboro
8/9/25	Party with a Purpose, Governors Island, Gilford – 100+ in attendance
8/13/25	Landscaping by the Waters Edge Presentation, Moultonborough
8/15/25	Presentation to the Wolfeboro Corinthian Yacht Club
8/30/25	Presentation to the Langdon Cove Assn., Moultonborough
9/10/25	Geology webinar
9/11/25	Presentation to NEPA, Laconia
9/23/25	Laconia High School talk
9/23/25	Gathering at Olcott's home in Wolfeboro to discuss water quality issues – 50 in attendance
10/6/25	Moultonborough's Womens Club

4.4 ADAPTIVE MANAGEMENT APPROACH

An adaptive management approach, to be employed by the Steering Committee, is highly recommended for protecting Center Harbor Bay. 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 features establishing an ongoing program that provides adequate funding, stakeholder guidance, and efficient coordination of restoration actions. Implementation of 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 through LWA should be assembled to coordinate watershed management actions. This group can include representatives from state and federal agencies or organizations, municipalities, local businesses, and other interested groups or private landowners. Refer to Section 6.1: Plan Oversight for additional information on stakeholder recommendations.
- **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 implementing this plan. Continued public awareness and outreach campaigns will aid in securing this engagement. Refer to Section 4.3: Outreach & Education.
- **Continuing and/or Establish Long-Term Monitoring Programs.** A water quality monitoring program is necessary to track the health of surface waters in the watershed. Information from the monitoring programs 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 16) outlines responsible parties, approximate costs[8], an implementation schedule, and potential funding sources for each recommendation within the following major categories: (1) Watershed & Shoreline BMPs; (2) Road Management; (3) Municipal Operations; (4) Municipal Land Use Planning & Zoning; (5) Land Conservation; (6) Septic System Management; (7) Agricultural Practices; and (8) Education and Outreach. The plan is designed to be implemented from 2026-2035 and is flexible to allow for new priorities throughout the 10-year implementation period as additional data are acquired.

Table 16. Action Plan for the Center Harbor watershed. LWA: Lake Winnipesaukee Alliance; BCCD: Belknap County Conservation District; CCCD: Caroll County Conservation District; LRPC: Lakes Region Planning Commission; LKWA: Lake Kanasatka Watershed Association; CWSRF: Clean Water State Revolving Fund; NH ARM: NH Aquatic Resource Mitigation Fund; NFWF: National Fish & Wildlife Foundation; NFRF: Northeast Forests and Rivers Fund; NAWCA: North American Wetlands Conservation Act; LCHIP: Land and Community Heritage Investment Program; RCCP: Regional Conservation Partnership Program; LWCF: Land and Water Conservation Fund; ACEP: Agricultural Conservation Easement Program, CSP: Conservation Stewardship Program; EQIP: Environmental Quality Incentives Program.

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
1. Watershed & Shoreline BMPs			
1.a. Complete design and construction of mitigation measures at the 10 highest ranked sites identified in the watershed survey (refer to Appendix B for complete list). **Achieves a total reduction of 4.3 kg/yr P.**	LWA to coordinate with support from CCCD, BCCD, LRPC, Municipalities, private landowners	$120K-$250K 2026–35	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, NH ARM), Municipalities, private landowners
1.b. Complete design and construction of mitigation measures at the medium priority sites (ranked 11-20) identified in the watershed survey as opportunities arise (refer to Appendix B). **Achieves a total reduction of 6.4 kg/yr P.**	LWA to coordinate with support from CCCD, BCCD, LRPC, Municipalities, private landowners	$600K-$1M 2026–35	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, NH ARM), Municipalities, private landowners

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

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
1.c. Complete design and construction of mitigation measures at the lower priority sites (ranked 21-39) identified in the watershed survey as opportunities arise (refer to Appendix B). **Achieves a total reduction of 0.7 kg/yr P.**	LWA to coordinate with support from CCCD, BCCD, LRPC, Municipalities, private landowners	$125K-$250K 2026–35	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, NH ARM), Municipalities, private landowners
1.d. Promote the Be Winni Blue/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 4 inches. Coordinate with NHDES Soak Up the Rain NH program for workshops and trainings. Cost assumes coordination and materials for up to 10 workshops.	LWA	$15K 2026–35	NH Lakes, NHDES Soak Up the Rain NH, Grants (319, Moose plate)
1.e. 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 high impact properties identified during the shoreline survey. Cost assumes technical assistance and implementation cost sharing provided to the 317 prioritized shoreline properties. With a 50% BMP removal efficiency rate this would amount to an **annual reduction of 53 kg/yr P (achieves 30% of Objective 1).**	LWA, private landowners	$1M-$1.25M 2026–35	Grants (319, Moose plate), CWSRF, private landowners
1.f. Repeat the shoreline survey in 5–10 years to track change over time. 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.	LWA, Municipalities	$25K 2030, 2035	Municipalities, Grants (Moose plate), CWSRF
1.g. Provide technical support to local marinas like Trexler's Marina to ensure proper pump-out facilities and washing stations are preventing contamination of the lake.	LWA	In-house 2026–35	CWSRF, Grants (Moose Plate), Municipalities
1.h. Continue addressing the external load reduction opportunities identified in the Lake Kanasatka WMP, resulting in an **annual reduction to Center Harbor Bay of 43 kg/yr P (achieves 24% of Objective 1).**	LKWA and LWA	$800K-$1.4M 2026-32	Grants (319, Moose Plate), CWSRF, Municipalities

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
1.i. Address recommendations for culverts and closed drainage systems assessed as having 'Poor' condition or identified as needing maintenance within the Center Harbor watershed on the NH Statewide Asset Data Exchange System (SADES), as well as during the ongoing CWSRF Center Harbor Stormwater Asset Management Program.	Municipalities, NHDOT	TBD 2026-2035	Municipalities, CWSRF, NH Aquatic Restoration Fund
1.j. Collaborate with NHDOT to improve stormwater management along Route 25 at the Lake Kanasatka outlet stream crossing. A project is in the planning phase to establish a turning lane for Lake Shore Drive along Route 25, near this crossing.	LWA, LKWA, Municipalities, NHDOT	TBD 2026-2035	Municipalities, CWSRF
1.k. Maintain the new crossing installed by the Krainewood Community to ensure that flow is uninterrupted and the riprap/wingwalls are stable.	Krainewood Shores Association	Annually	Private landowners
2. Road Management			
2.a. Review practices for road and drainage maintenance currently used by public and private entities/groups and determine areas for improvement.	Municipalities, LWA, CCCD, BCCD, LRPC	$10K 2026	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star)
2.b. Provide education and training to contractors and municipal staff on protocols for road maintenance best practices. Assumes one workshop. Consider holding joint workshop with other Lake Winnipesaukee region municipalities (or other wider service area) for cost sharing savings.	Municipalities, LWA, CCCD, BCCD, LRPC	$15K 2026	CWSRF, Municipalities, Grants (319, Moose Plate, NFWF 5-Star)
2.c. Develop and/or update a written protocol for road maintenance best practices.	Municipalities, LWA, CCCD, BCCD, LRPC	$20K 2026	CWSRF, Municipalities, Grants (319, Moose Plate, NFWF 5-Star)
2.d. Incorporate water quality considerations and strategies into roadway evaluations and action plans.	Municipalities, LWA, CCCD, BCCD, LRPC	N/A 2026–35	Municipalities
2.e. Establish inspection and maintenance agreements for private unpaved roads. Cost does not include the implementation of proper road maintenance by private landowners and assumes that municipalities can accommodate this additional effort in current budgets.	Municipalities, private landowners	N/A 2026–35	Municipalities, private landowners

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
2.f. Hold informational workshops on proper road 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.	LWA, CCCD, BCCD, LRPC, Municipalities, private landowners	$10K 2026–35	CWSRF, Municipalities, Grants (319, Moose Plate, NFWF 5-Star), private landowners
3. Municipal Operations			
3.a. 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. Sweep municipal paved roads and parking lots two times per year (spring and fall).	Municipalities (Public Works/Highway)	TBD 2026–35	Municipalities
3.b. Complete Stormwater Asset Management Plans in Center Harbor and Meredith to reduce operating risks and financial costs for infrastructure repairs and replacement. Apply for funding to complete a Stormwater Asset Management Plan in Moultonborough.	Municipalities (Public Works/Planning)	TBD 2026-30	Projects funded and in-progress for Center Harbor and Meredith; CWSRF for Moultonborough
3.c. Participate in the Municipal Green SnowPro Program. Complete training to become Green SnowPro Certified.	Municipalities (Public Works/Highway)	Est. $150-$250/person 2026–35	Municipalities
3.d. Review and update winter operations procedures to be consistent with Green SnowPro best management practices for winter road, parking lot, and sidewalk maintenance.	Municipalities (Public Works/Highway)	N/A 2026	Municipalities
3.e. In Moultonborough, Center Harbor and Meredith, adopt policies to either eliminate fertilizer applications on town properties or implement best practices for fertilizer management (to minimize application and transport of phosphorus). Consider extending these regulations to private properties as well.	Municipalities (Public Works/Highway)	N/A 2026-35	Municipalities
3.f. Develop best practice design standards for stormwater control measures, including deep sump catch basins.	Municipalities (Public Works/Highway)	N/A 2026	Municipalities

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
4. Municipal Land Use Planning & Zoning			
4.a. Present WMP recommendations to Select Boards/City Council and Planning Boards in Moultonborough, Center Harbor, and Meredith. Cost assumes presentations conducted by LWA or volunteers.	LWA	N/A 2026	LWA
4.b. Meet with municipal staff to review recommendations to improve or develop ordinances addressing setbacks, buffers, lot coverage, low impact development, and open space. Cost assumes meetings conducted by LWA.	LWA, Municipalities	N/A 2026-29	LWA, Municipalities
4.c. Incorporate WMP recommendations into municipal master plans and encourage regular review of the WMP action plan.	Municipalities	N/A 2026–35	Municipalities
4.d. Incorporate Low Impact Development standards into Moultonborough's Stormwater Management Ordinance (Section 12.0).	Moultonborough	N/A 2026-2030	Municipalities
4.e. Consider the collection of conservation impact fees or establishment of a non-lapsing conservation fund to support priority conservation projects.	Municipalities	2026-35	Residents
4.f. Pursue an update to the Water Resources Overlay Map to support the Water Resources Conservation Overlay District, including an update to the designated lakes and great ponds, rivers and streams, and wetlands. Existing data was collected between 2009 and 2014.	Center Harbor	2026-28	Center Harbor
4.g. Incorporate climate change into the next Center Harbor Master Plan to address expected changes to the frequency and intensity of storm events. The current Master Plan was written in 2012 with a revised Natural Resources chapter completed in 2014.	Center Harbor	2026-28	Center Harbor

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
4.h. Adopt/strengthen zoning ordinance provisions and enforcement mechanisms (refer to NHDES, 2008): **1)** to promote low impact development practices, particularly impervious cover limits that incorporate Effective Impervious Cover regulations per UNH Stormwater Center, CEI & NHDES (2025); **2)** to require stormwater regulations that align with MS4 Permit requirements; **3)** to promote or require vegetative buffers around lake shore and tributary streams; **4)** to require shorefront "tear down and replace" home construction to be no more non-conforming than existing structures; **5)** to require shorefront seasonal to year-round conversions of homes to demonstrate no additional negative impacts to lake water quality; **6)** 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 **7)** to enhance performance standards for unpaved roads to prevent erosion and protect lake water quality.	Municipalities	N/A 2026–35	Municipalities
4.i. Increase municipal staff capacity for inspections and enforcement of stormwater regulations on public and private lands.	Municipalities	TBD 2026–35	Municipalities
5. Land Conservation			
5.a Update the 2005 Natural Resources Inventory (NRI) for Meredith and the 2014 NRI for Center Harbor (Moultonborough is currently completing an NRI).	Municipalities, Conservation Commissions	\$20K-\$30K per municipality 2026-28	Municipalities, Grants (NFWF NFRF), CWSRF
5.b. Create a priority list of watershed areas that need protection based on NRIs. Refer to Section 4.2.3 to understand current conservation lands and valuable habitats and wildlife in the watershed that can be used to help identify potential areas to target for conservation.	LWA, Municipalities, Conservation Commissions, Lakes Region Conservation Trust or other local land trusts	\$4K-\$8K 2026-28	Grants (NFWF NFRF, NAWCA), CWSRF, Municipalities

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
5.c. 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.	LWA, Municipalities, Conservation Commissions, Lakes Region Conservation Trust or other local land trusts	N/A 2026-28	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP)
5.d. Maximize conservation of intact forest and other ecologically important properties through education, zoning, and public or private conservation.	LWA, Municipalities, Conservation Commissions, Lakes Region Conservation Trust or other local land trusts, private landowners	TBD 2026–35	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP, NFWF NFRF), Municipalities, private landowners
6. Septic System Management			
6.a Distribute educational materials to property owners about septic system function and maintenance. Ensure wide distribution while targeting the 718 Center Harbor Bay shoreline parcels with septic systems older than 25 years. Reducing external load from old septic systems would **achieve 71.8 kg/yr P reduction (achieves 40% of Objective 1).**	Municipalities, LWA	$20K 2026, 2029, 2034	Municipalities, Grant (319), CWSRF
6.b. Look into whether any septic pumping companies would give a quantity discount or a member's discount to incentivize septic system pumping.	LWA	N/A 2026–35	LWA
6.c. Evaluate locations of older and/or noncompliant septic systems (including cesspools or holding tanks) to identify clusters where conversion to community septic systems might be desirable.	LWA, Municipalities	TBD 2026	CWSRF, Municipalities
6.d. Enforce inspection for all home conversions (from seasonal to permanent residences) and property sales to ensure systems are sized and designed properly. Require upgrades if needed. Prioritize shorefront properties around Lake Winnipesaukee.	Municipalities	N/A 2026-35	Municipalities

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
6.e. Develop and maintain a septic system database for the watershed to facilitate code enforcement of any septic system ordinances.	Municipalities	$5K-$10K 2026-35	Municipalities, CWSRF
6.f. Institute a minimum pump-out/inspection interval for shorefront septic systems (e.g., once every 3–5 years). Pump-outs (~$250 per system) are the responsibility of the owner.	Municipalities	N/A 2026-28	Municipalities, private landowners
6.g. Inspect and evaluate sanitary sewer system and address identified leaks and overflows, especially in areas near Lake Winnipesaukee and its tributary streams.	Municipalities	TBD 2026-35	Municipalities
6.h. Undertake a feasibility study to provide cost/benefit analysis of extending the existing Winnipesaukee River Basin Program sewer system in Moultonborough, Center Harbor, and Meredith to connect to additional waterfront homes currently on private septic systems.	Municipalities, NHDES Water Division	TBD 2026-28	Municipalities, CWSRF
7. Agricultural Practices			
7.a. Work with NRCS to implement soil conservation practices such as cover crops, no-till methods, and others which reduce erosion and nutrient pollution to surface waters from agricultural fields.	NRCS, farm owners	TBD 2026–35	Grants, NRCS
8. Education & Outreach			
8.a Share additional/dynamic information on the Lake Winnipesaukee Alliance website, such as water quality data, loon activity, weather conditions, and webcam, to generate more traffic to the website.	LWA	TBD 2026-27	Grants
8.b. Educate managers of private boat launches about invasive species management, in addition to the existing lake host program that operates at public boat launches.	LWA	$10K 2026, 2030, 2035	Grants (NHDES AIPC)
8.c. Offer workshops for landowners with 10 acres or more for NRCS assistance with land conservation. Cost assumes up to two workshops.	LWA	$5K 2026-30	Grants (RCCP, ACEP, CSP, EQIP)
8.d. Encourage private property owners to hire Green SnowPro certified commercial salt applicators.	LWA, CCCD, BCCD, Municipalities, private landowners	N/A 2026–35	LWA, CCCD, Municipalities
8.e. Educate contractors and municipal staff about erosion and sediment control (ESC) practices required on plans. Work with municipalities to ensure that there are sufficient resources to enforce permitting conditions.	Municipalities, LWA, CCCD, BCCD, LRPC	$6K 2026-28	Municipalities, Grants (319), CWSRF

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
8.f. 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. Costs are highly variable depending on level of engagement desired.	Municipalities, LWA, CCCD, BCCD, LRPC	$20K-$60K 2026-35	Municipalities, Grants (319), CWSRF
8.g. Collaborate with NH Lakes on legislative or advocacy issues such as boat speed limits.	LWA, NH Lakes	N/A 2026–35	Grants
8.h. Establish a Weed Watchers team for Lake Winnipesaukee.	LWA, NH Lakes, Municipalities	N/A 2026–35	LWA, NH Lakes, Municipalities
8.i. Secure Lake Host participation at Trexler's Marina. Lake Host volunteers can provide boat inspections and education on invasive plant species.	LWA, Private Landowners, Volunteers	N/A 2026-35	LWA, Municipalities, Private Landowners

5.2 POLLUTANT LOAD REDUCTIONS REAL

To meet the water quality goal, Objective 1 set a target phosphorus (P) load reduction of **179 kg/yr** to achieve a summer in-lake total phosphorus concentration of 3.9 ppb, which meets state water quality standards for oligotrophic waterbodies and is anticipated to reduce the likelihood of cyanobacteria blooms in Center Harbor Bay. The following opportunities for phosphorus load reductions to achieve Objective 1 were identified in the watershed based on field and desktop analyses:

- Remediating the 39 watershed survey sites could prevent up to **11.4 kg/yr** of P load from entering the Bay.
- Treating the 317 prioritized shoreline survey sites could reduce the phosphorus load by **52.5 kg/yr**.
- Upgrading the approximately 718 shorefront septic systems older than 25 years is estimated to reduce the phosphorus load to the Bay by **71.8 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 Center Harbor Bay by **136 kg/yr**, meeting 77% of the needed reductions to achieve Objective 1 (Table 17). Addressing the external load sources identified in the Lake Kanasatka WMP (FBE, 2022) will result in a reduction of an **additional 43 kg/yr** phosphorus to Center Harbor Bay. Together, implementing both sets of recommendations will achieve **100%** of Center Harbor Bay's Objective 1.

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

While the focus of the objectives for 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), 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.). Without a 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 17. Breakdown of phosphorus load sources and modeled water quality for current and target conditions that meet the water quality goal (Objective 1) for Center Harbor Bay and that reflect all field identified reduction opportunities in the watershed, including those for Lake Kanasatka. Reduction percentages are based out of the current condition value for each parameter.

Parameter	**Unit**	**Current Condition**	**Target Condition**	**Reduction** (Amount, % change)
Total P Load (All Sources)[1]	kg/yr	1,713.1	1,534.1	-179 (10%)
(A) Background P Load[2]	kg/yr	767.4	767.4	0 (0%)
(B) Disturbed (Human) P Load[3]	kg/yr	931.1	760.1	-179 (19%)
(C) Developed Land Use P Load[4]	kg/yr	746.1	654.3	-95.4 (13%)
(D) Septic System P Load	kg/yr	152.9	65.7	-83.3 (54%)
(E) Internal P Load	kg/yr	40.1	40.1	0 (0%)
In-Lake TP (summer)*	ppb	4.6	3.9	-0.7 (15%)
In-Lake Chl-a*	ppb	1.4	1.1	-0.3 (21%)
In-Lake SDT*	meters	9.3	9.3	0 (0%)
In-Lake Bloom Probability*	days	0	0	0 (0%)

[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).

[4] Sum of developed land use P load from Center Harbor's direct drainage, Lake Kanasatka, and exchange with Lake Winnipesaukee.

* Water quality parameters were sourced from the model except for SDT, which has a higher observed value than the model predicts.

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 largely by LWA with assistance from a diverse stakeholder group, including representatives from the municipalities (e.g., select boards, planning boards), conservation commissions, state and federal agencies or organizations, nonprofits, land trusts, schools and community groups, local business leaders, and landowners. LWA and an established 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:

- **LWA** will be responsible for plan oversight and implementation. LWA will assist with water quality monitoring, facilitate outreach activities and watershed stewardship, and raise funds for stewardship work.
- **Municipalities** 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. LWA can work with each municipality to provide support in reviewing and tailoring the recommendations to fit the specific needs of each community.
- **Conservation Commissions** will work with municipal staff and boards to facilitate the implementation of the recommended actions specified in the Action Plan.
- **BCCD and CCCD** can provide administrative capacity and 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 Center Harbor Bay to meet the water quality goal and objectives set in Section 2.5 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 Center Harbor Bay in the next 10 years. **The cost of successfully implementing the plan is estimated to be at least $2-$3 million over the next 10 or more years** (Table 18). 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.

Table 18. Estimated pollutant reduction (TP) in kg/yr and estimated total and annual 10-year costs for implementation of the Action Plan to meet the water quality goal and objectives for the Center Harbor Bay watershed. 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[1]	64	$1,885,000–$2,790,000	$188,500–$279,000
Road Management	TBD	$55,000	$5,500
Municipal Operations[2]	TBD	$1,250–$2,500 +	$125–$250 +
Municipal Land Use Planning & Zoning	(194)*	TBD	TBD
Land Conservation	Included in Land Use Planning & Zoning row	$24,000–$38,000	$2,400–$3,800
Septic System Management[3]	72	$25,000–$30,000	$2,500–$3,000
Agricultural Practices	TBD	TBD	TBD
Education & Outreach	TBD	$41,000–$81,000	$4,100–$8,100
Total	**136**	**$2,031,250–$2,994,000**	**$203,125–$299,400**

** Estimated increase in phosphorus load from new development in the next 10 years. Not included in the total load reduction.*

[1] The TP reduction and estimated costs excludes Item 1.h. in the Action Plan, i.e. watershed and shoreline BMP opportunities identified in the Lake Kanasatka WMP. Progress has already been made toward addressing these.

[2] The cost of municipal operations as a planning action only reflects the cost of the Green SnowPro Program course for employees, not other items shown in the Action Plan.

[3] Septic system management only reflects shoreline septic systems, and does not include the cost of inspecting, repairing, or replacing, private septic systems.

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 property owners. 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 in Center Harbor Bay.

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 (ILF) 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.
- **Northeast Forests and Rivers Fund (NFWF NFRF)** – This National Fish and Wildlife Foundation 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.
- **Drinking Water & Groundwater Trust Fund Source Water Protection Program (NHDES DWGTF SWP)** – The SWP program provides grants to permanently protect drinking water supply lands in New Hampshire, including land that falls within wellhead protection areas, hydrologic areas of concern, high-yield stratified drift aquifers classified as GA2, and/or land that the Advisory Commission has determined will likely benefit a future public or community public water system.
- **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 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) U.S. Standard 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 must 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 MONITORING PLAN

A long-term water quality monitoring plan is critical to evaluate the effectiveness of implementation efforts over time. The UNH LLMP has been monitoring the Lakes Region's waterbodies for decades, providing valuable water quality data to communities that would otherwise not exist. LWA, in concert with the LLMP, should continue and consider expanding upon the following annual monitoring:

> NHDES requires **dissolved oxygen** samples to meet stringent requirements to be included in State assessment. These requirements are intended to ensure that dissolved oxygen data is consistent and represents the highest stress periods of the year and time of day (June 1 to September 30 and between 10am and 2pm). Samples also must be collected from the epilimnion (defined as the surface to the first 1 or more ˚C change in temperature). To meet Class B standards, no more than two or 10% of samples (whichever is greater) that meet these requirements can have a dissolved oxygen concentration less than 5 mg/L.

- Continue to monitor the active sites within Center Harbor Bay, prioritizing the deep spot (WINCEND), and at the remaining sites sampled in 2024 (1 Deep, Ash Cove, Blackey Cove Deep, Braun Bay, Hull Island, and Salmon Meadow Cove – See Section 2.3) and previously (2 Bay). Sample for all parameters included in the UNH LLMP protocol. This includes sampling three to five times each summer (June-September or October) for at least total phosphorus (epilimnion, metalimnion, and hypolimnion), chlorophyll-a (composite or epilimnion), Secchi disk transparency, and dissolved oxygen-temperature profiles to the lake bottom.
    - Ensure that dissolved oxygen-temperature profiles are being collected concurrently with sampling of lake deep spot stations and consider collecting profiles at a higher frequency (e.g., every two weeks from May-October).
    - Consider adding total nitrogen and the nitrogen species (total dissolved nitrogen, nitrate-nitrite, and ammonium) to routine lake sampling.
- Continue to monitor Lake Kanasatka as laid out in Section 6.4 its WMP (FBE, 2022).
- Continue to monitor the bay for cyanobacteria blooms and alert NHDES immediately. Coordinate with NHDES to collect samples for analysis.
- Monitor total phosphorus and flow (as well as specific conductance, chloride, temperature, and/or turbidity, if possible) at major tributary inflows to Center Harbor Bay, at least two to five times per year each summer, specifically targeting wet and dry weather conditions.
- Continue monthly samples for speciation and enumeration of phytoplankton and zooplankton in the water column at WINCEND.
- Continue collaboration with NHDES to monitor spiny water flea populations.
- Consider expanding cyanotoxin testing, fluorometry, and picocyanobacteria analysis via e-DNA (through the Bigelow Laboratory for Ocean Sciences) to Center Harbor Bay.

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 Center Harbor Bay watershed (Table 19). These benchmarks represent short-term (2026), mid-term (2030), and long-term (2035) 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 the improvement of 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 19. Environmental, programmatic, and social indicators for the Center Harbor Bay Watershed-Based Management Plan. Milestones are cumulative, starting in Year 1 (2026). ** indicators particularly relevant to assessing progress toward achieving the water quality goal and objectives.

Indicators	Milestones		
	2026	2030	2035
ENVIRONMENTAL INDICATORS			
Achieve an average summer deep spot epilimnion total phosphorus concentration of 3.9 ppb at the deep spot station in Center Harbor Bay	<4.5 ppb	<4.2 ppb	<3.9 ppb
Achieve an average summer deep spot epilimnion chlorophyll-a concentration of 1.1 ppb at the deep spot station in Center Harbor Bay	<1.3 ppb	<1.2 ppb	<1.1 ppb
Eliminate the occurrence of cyanobacteria or algal blooms in Center Harbor Bay (milestones based on observed data from 2024)**	<10 days/yr	<5 days/yr	0 days/yr
Maintain an average summer water clarity of 9.3 m or deeper at the deep spot station in Center Harbor Bay	9.3+ m	9.5+ m	10+ m
Control the proliferation of spiny water flea and variable milfoil in Center Harbor Bay	Invasives Controlled	Invasives Controlled	Invasives Controlled
Prevent the introduction of new invasive aquatic species in Center Harbor Bay	No New Invasives	No New Invasives	No New Invasives
PROGRAMMATIC INDICATORS			
Amount of funding secured from municipal/private work, fundraisers, donations, and grants	$250,000	$1,250,000	$2,500,000
Number of NPS sites remediated (39 identified)**	5	19	39
Linear feet of buffers improved in the shoreland zone**	5,000	25,000	50,000
Percentage of shorefront properties with LakeSmart certification	25%	50%	75%
Number of watershed/shoreline properties receiving technical assistance for implementation cost sharing	30	150	300
Number of workshops and trainings for stormwater improvements to residential properties (e.g., NHDES Soak Up the Rain NH program)	2	5	10
Number of updated or new ordinances that target water quality protection	1	2	5
Number of new municipal staff for inspections and enforcement of regulations	1	1	2
Number of voluntary or required septic system inspections (seasonal conversion and property transfer)	5	10	25
Number of septic system upgrades	15	75	150

Indicators	Milestones		
	2026	2030	2035
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	2	5	10
Number of parcels with new conservation easements or number of parcels put into permanent conservation	3	10	20
Number of copies of watershed-based educational materials distributed or articles published	200	500	1,000
Number of new best practices for road management and winter maintenance implemented on public and private roads by the municipalities	2	5	10
Number of municipalities fully implementing key aspects of the MS4 program	1	2	4
Number of meetings and/or presentations to municipal staff and/or boards related to the WMP	2	10	20
Number of CNMPs completed or NRCS technical assistance provided for farms in the watershed	1	2	4
SOCIAL INDICATORS			
Number of new association members	5	10	15
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	25	50	100
Number of watershed residents installing conservation practices on their property and/or participating in LakeSmart	30	150	300
Number of municipal DPW staff receiving Green SnowPro training	1	3	5
Number of groups or individuals contributing funds for plan implementation	25	50	100
Number of newly trained water quality and invasive species monitors	2	10	15
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 farmers working with NRCS, BCCD, or CCCD	1	2	4
Number of daily visitors to the LWA website	10	25	50

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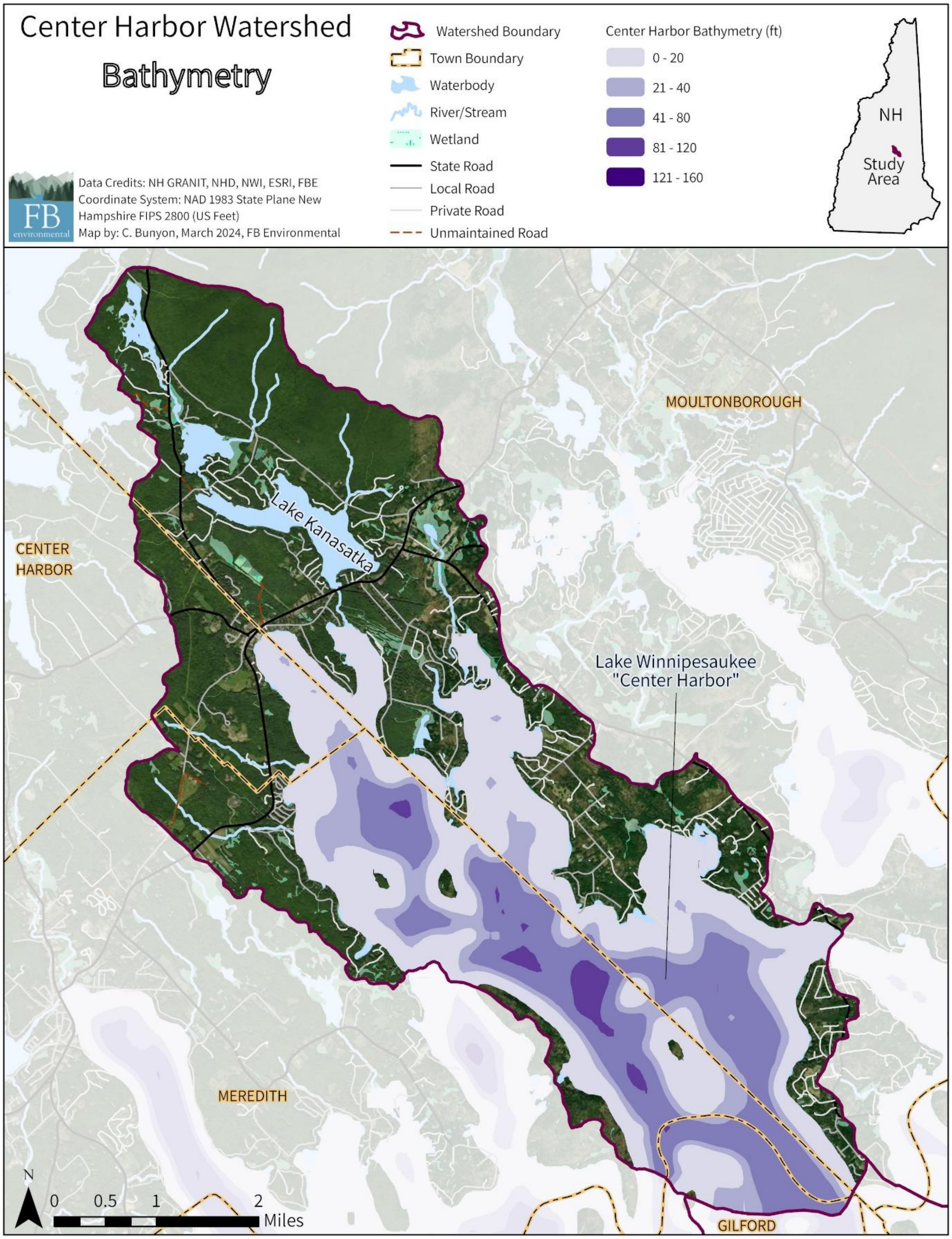
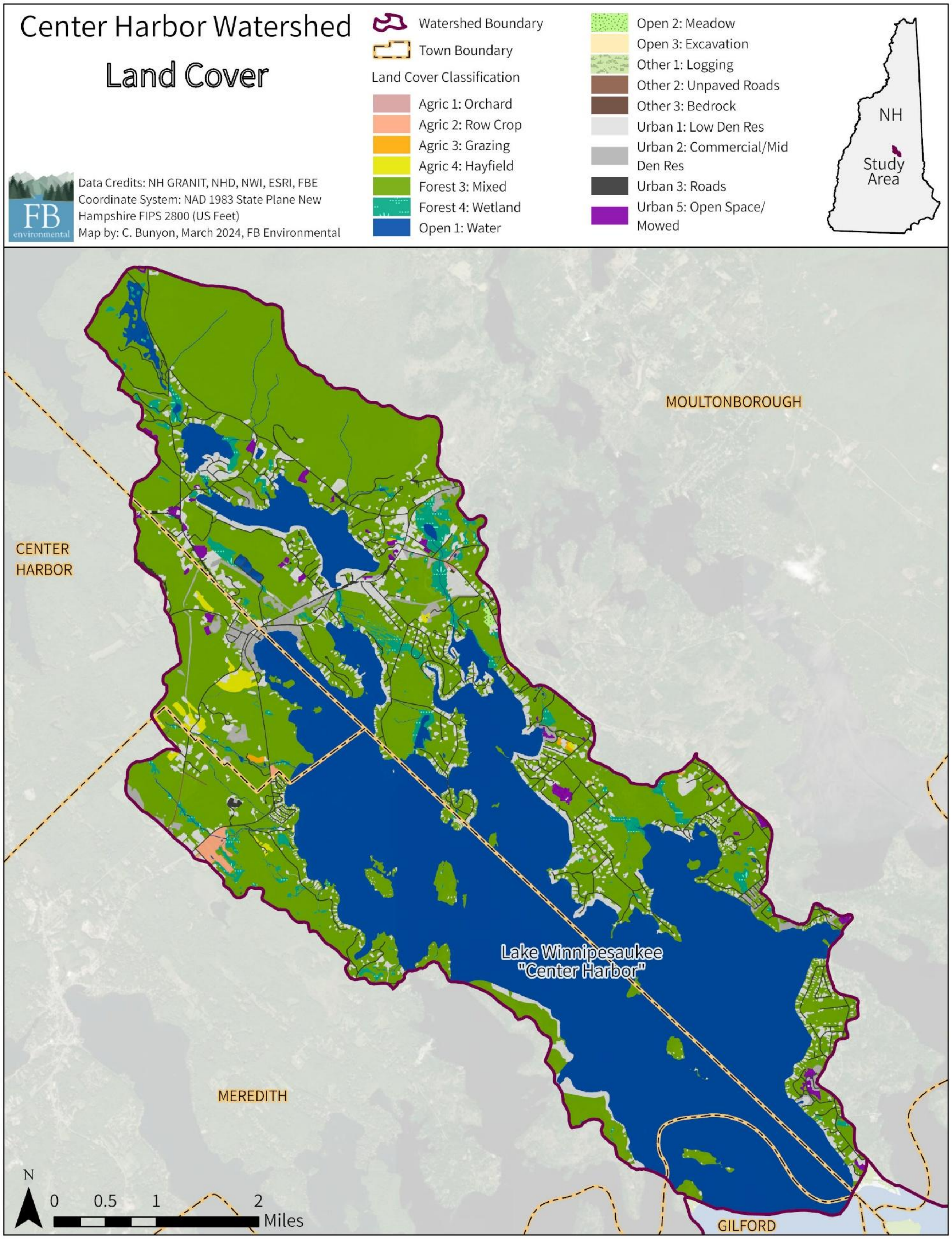
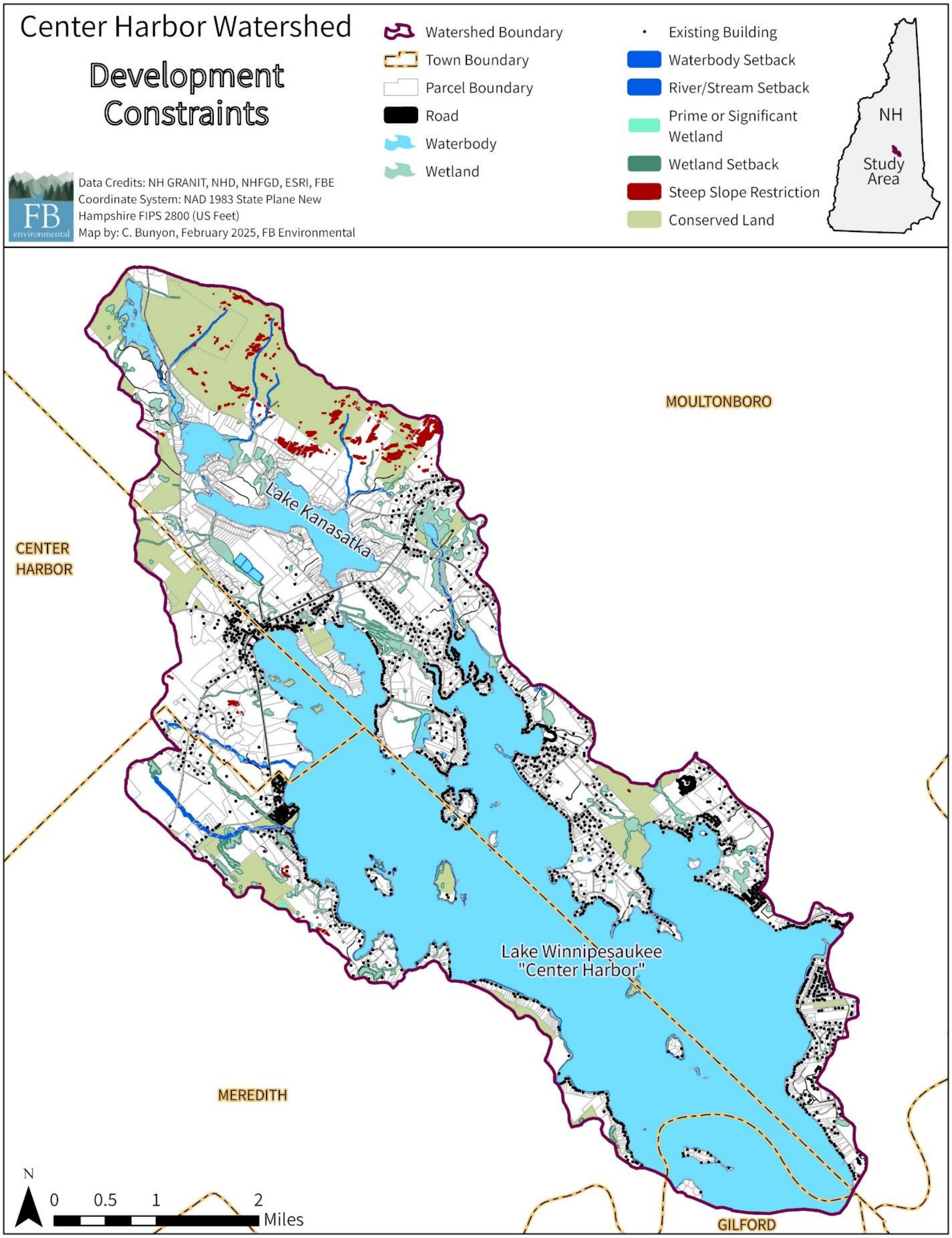
APPENDIX A: SUPPORTING MAPS



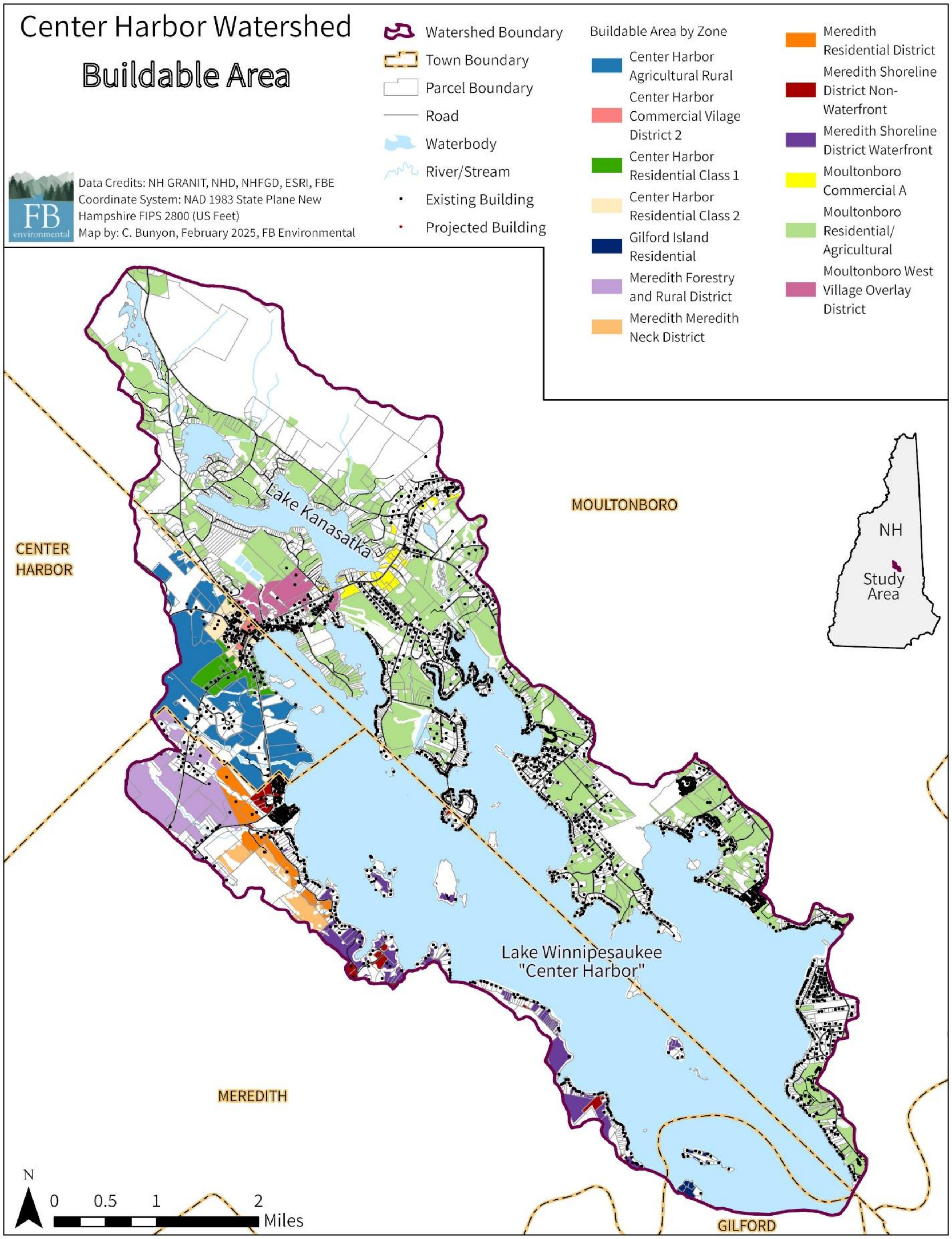
Map A-1. Bathymetry as 20-foot depth contours for Center Harbor Bay (Lake Winnipesaukee).



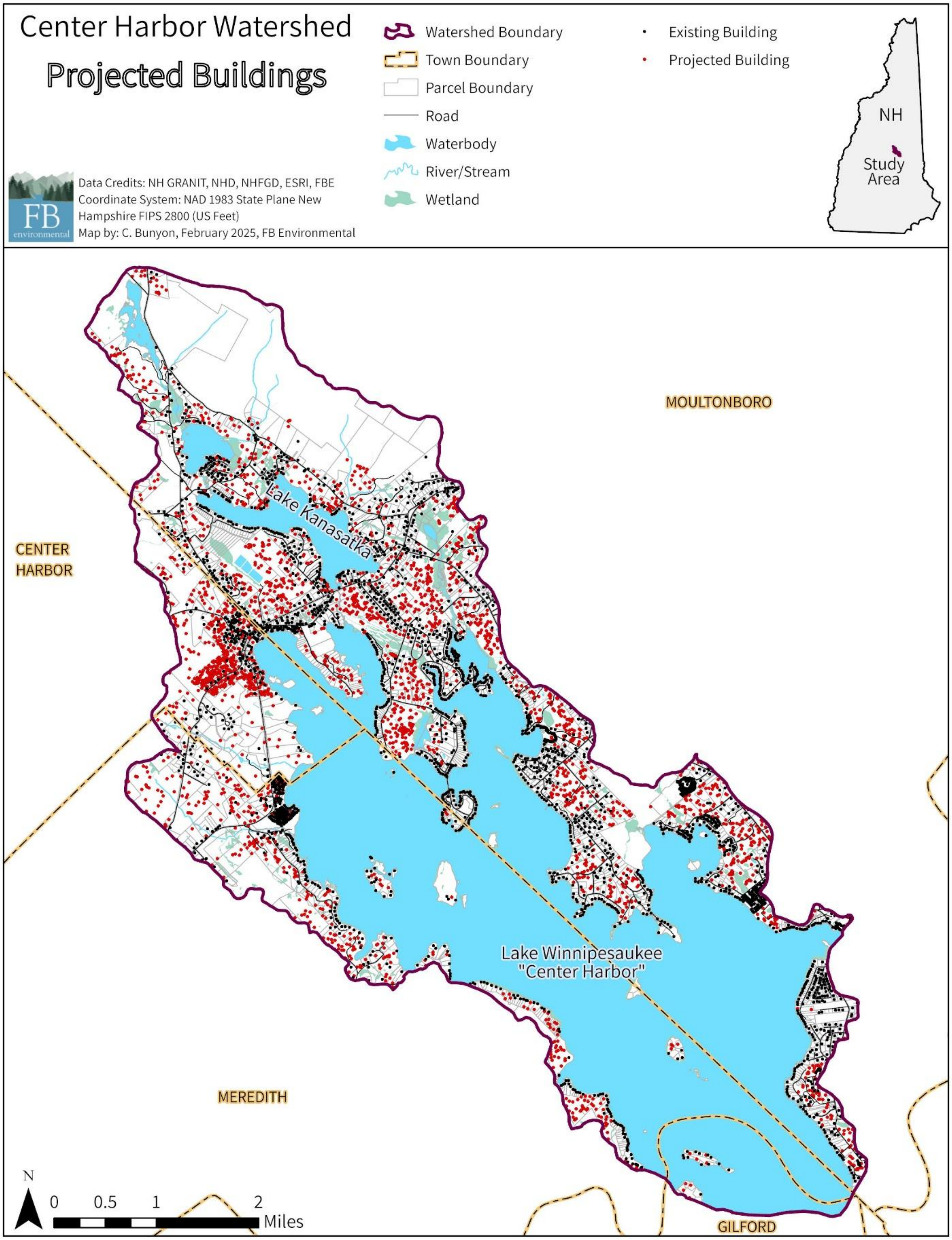
Map A-2. Land cover for the Center Harbor Bay watershed.



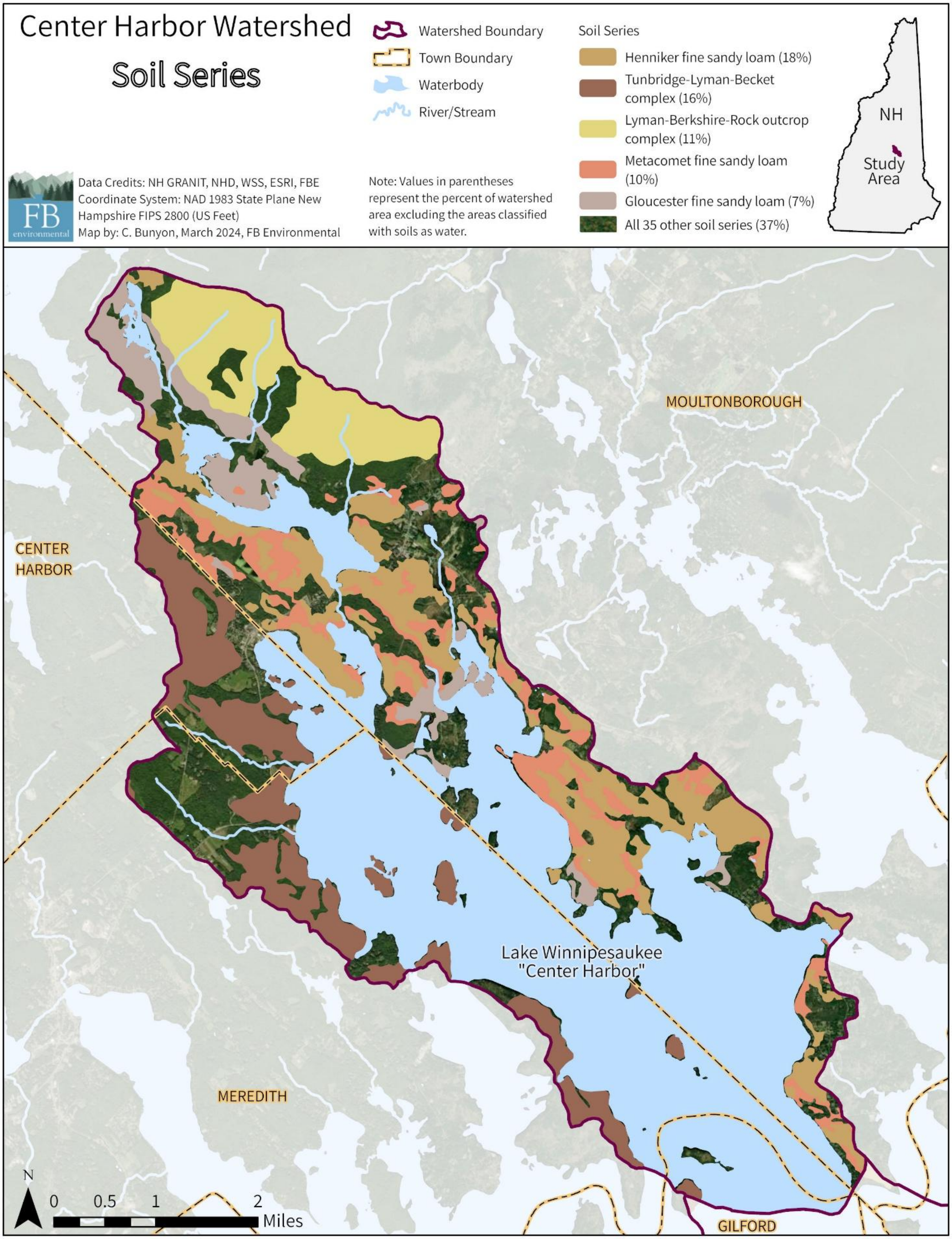
Map A-3. Development constraints (including existing buildings) in the Center Harbor Bay watershed in Moultonborough, Center Harbor, Meredith, and Gilford, New Hampshire.



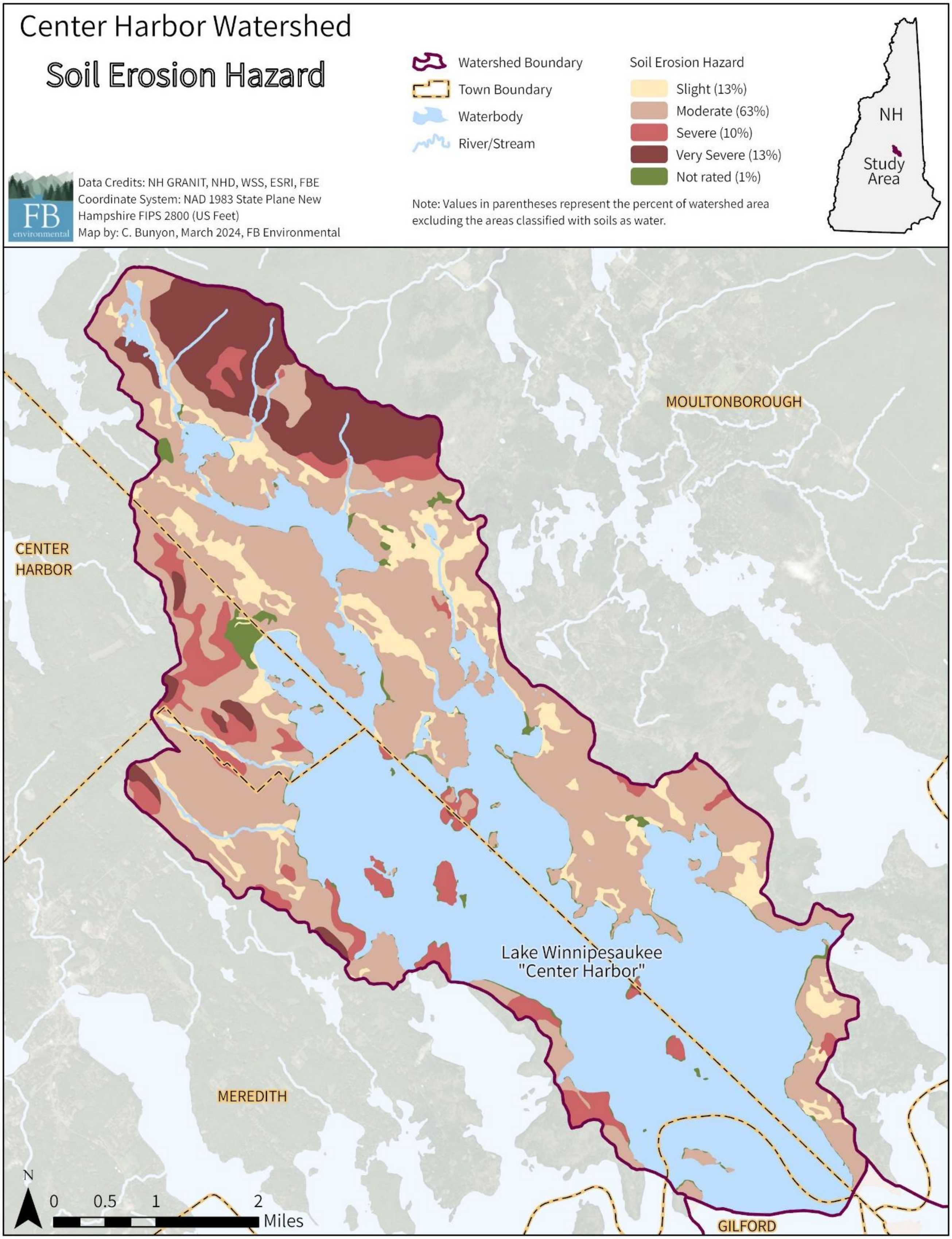
Map A-4. Buildable area by municipal zone in the Center Harbor Bay watershed in Moultonborough, Center Harbor, Meredith, and Gilford, New Hampshire.



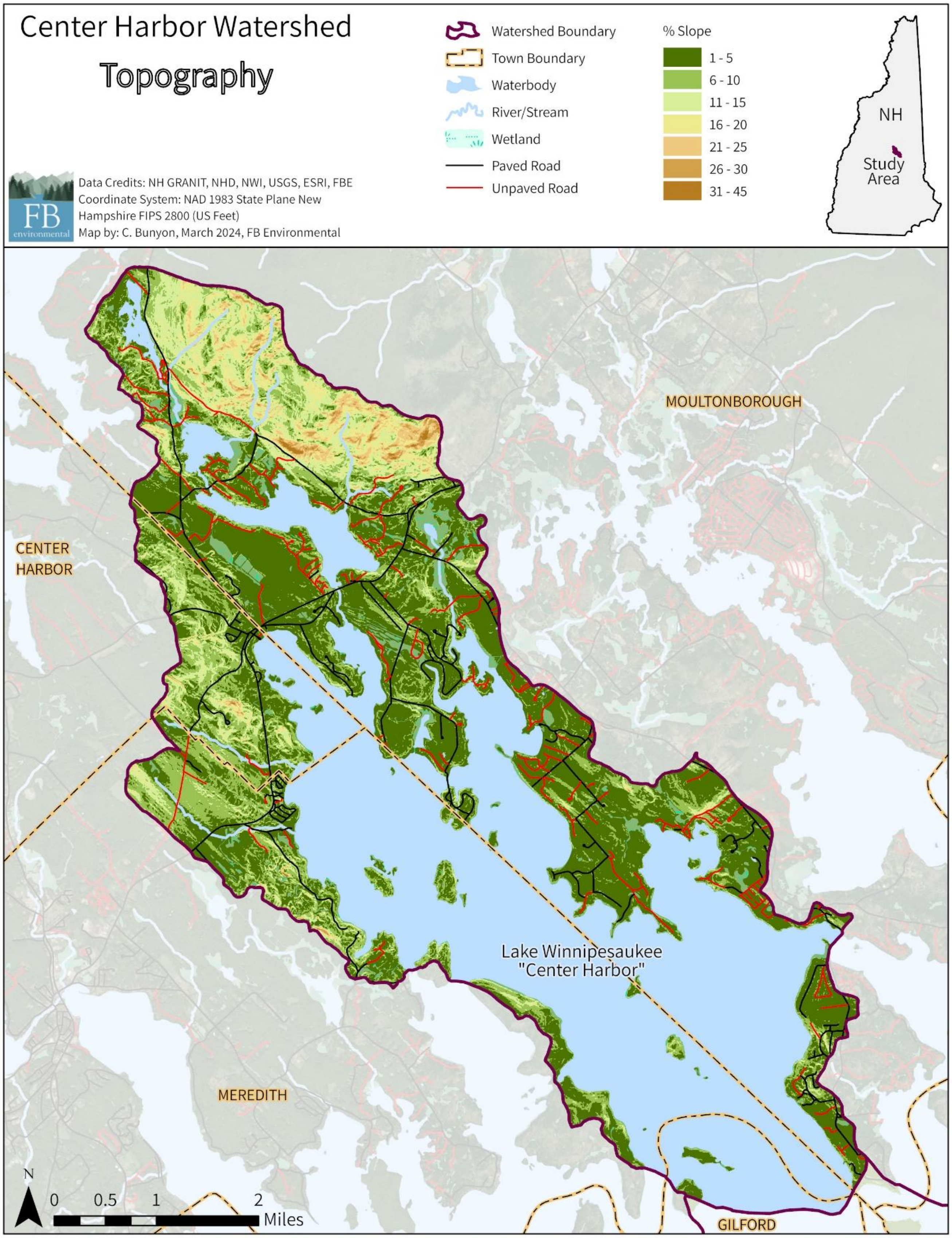
Map A-5. Projected buildings in the Center Harbor Bay watershed in Moultonborough, Center Harbor, Meredith, and Gilford, New Hampshire.



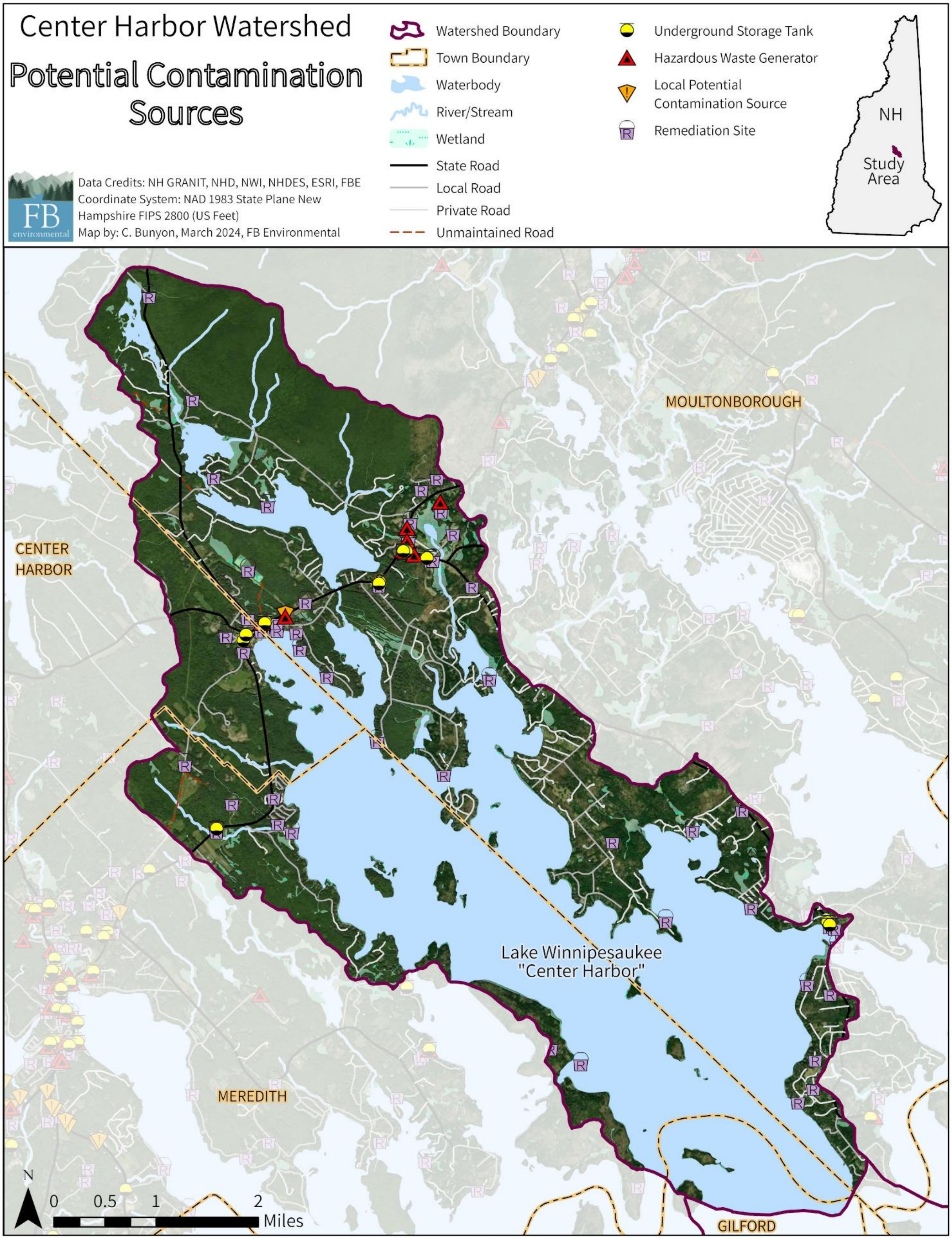
Map A-6. Soil series in the Center Harbor Bay watershed.



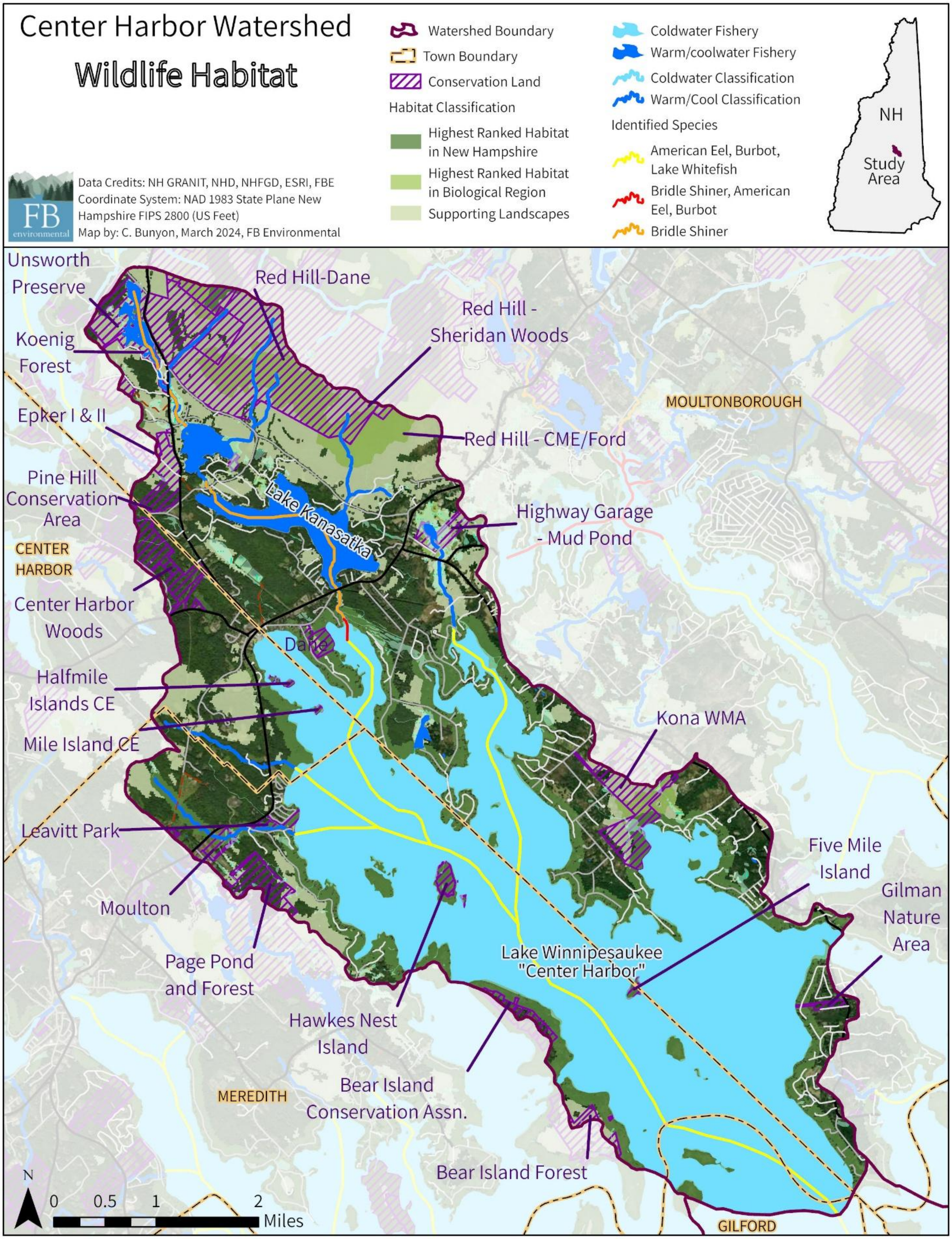
Map A-7. Soil Erosion Hazard in the Center Harbor Bay watershed.



Map A-8. Topography of the Center Harbor Bay watershed.



Map A-9. Potential sources of contamination in the Center Harbor Bay watershed.



Map A-10. Conservation land and high-value habitat according to the 2020 New Hampshire Wildlife Action Plan within the Center Harbor Bay watershed.

APPENDIX B: BMP MATRIX

Table B-1. Site ID, location description, water quality impact, estimated load reduction, and estimated implementation costs for the 39 nonpoint source sites identified in the Center Harbor Bay watershed. **Pollutant load reduction and cost estimates are preliminary and are for planning purposes only**. Some of the 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 1-39 for lowest to highest cost per kilogram of phosphorus load reduced with remediation.

SITE	LOCATION	IMPACT	LOAD REDUCTION			ESTIMATED COST			RANK
			TSS (metric tons/yr)	TP (kg/yr)	TN (kg/yr)	Est. Low Cost	Est. High Cost	Est. Avg. Cost	
E-04	Greene's Basin Road	High	1.80	0.47	1.22	$10,000	$15,000	$12,500	1
E-05	Kerrie Court Shoulder	High	3.01	0.79	2.05	$20,000	$30,000	$25,000	2
D-06	Leavitt Beach Near Parking Lot	High	0.72	0.19	0.49	$5,000	$10,000	$7,500	3
E-12	Boat Launch Near Trexler's Marina	High	0.32	1.62	8.30	$50,000	$100,000	$75,000	4
E-10	Dane Road Shoulder	Medium	1.37	0.36	0.93	$8,000	$12,000	$10,000	5
CH-17	Private NPS site	Medium	1.04	0.27	0.71	$5,000	$15,000	$10,000	6
E-03	Corner of Moultonboro Neck Road & Highway Garage	Medium	0.58	0.15	0.39	$5,000	$10,000	$7,500	7
CH-10	Corner of Blackadar Lane and Moultonboro Neck Road	High	0.04	0.07	0.39	$2,500	$5,000	$3,750	8
E-07	Lake Shore Drive Shoulder Outside House 55	Low	0.80	0.20	0.54	$5,000	$10,000	$7,500	9
CH-18	Tall Pine Road	Medium	0.62	0.16	0.42	$5,000	$15,000	$10,000	10
D-08	Wooded Area North of Leavitt Beach	Low	0.68	0.18	0.49	$5,000	$10,000	$7,500	11
D-10	Whittier Highway South of House 294	High	1.90	1.76	7.12	$200,000	$250,000	$225,000	12
CH-9	Moultonboro Neck Road	Medium	1.08	0.28	0.73	$15,000	$25,000	$20,000	13
CH-11	Lighthouse Lane	High	0.05	0.10	0.50	$10,000	$20,000	$15,000	14
E-09	Road Shoulder Opposite Businesses off Route 25	Medium	2.40	0.63	1.62	$30,000	$60,000	$45,000	15
E-01	Center Harbor Town Beach	Medium	0.26	0.52	1.85	$30,000	$60,000	$45,000	16
E-06	Driftwood Drive Cul-de-sac	Medium	0.05	0.07	0.20	$5,000	$10,000	$7,500	17
D-07	Northern Leavitt Beach	High	2.76	0.72	1.87	$100,000	$250,000	$175,000	18
D-09	Patricia Shores Beach Culverts	Medium	0.49	1.38	7.61	$150,000	$200,000	$175,000	19
D-05	Leavitt Park Road - Stream Crossing	Medium	2.48	0.77	2.76	$60,000	$100,000	$80,000	20
CH-13	Carriage Road	Medium	0.09	0.02	0.06	$2,500	$5,000	$3,750	21
CH-15	Hilltop Road & Spinnaker Drive	Low	0.44	0.12	0.30	$10,000	$20,000	$15,000	22

SITE	LOCATION	IMPACT	LOAD REDUCTION			ESTIMATED COST			RANK
			TSS (metric tons/yr)	TP (kg/yr)	TN (kg/yr)	Est. Low Cost	Est. High Cost	Est. Avg. Cost	
CH-6	Redding Lane	Medium	0.64	0.16	0.43	$30,000	$50,000	$40,000	23
CH-1	Patrician Shores Circle	Low	0.08	0.02	0.06	$2,500	$5,000	$3,750	24
CH-2	Leavitt Park Road entrance	Medium	0.34	0.09	0.24	$20,000	$30,000	$25,000	25
CH-16	West Point Road	Low	0.24	0.06	0.16	$10,000	$20,000	$15,000	26
E-02	Sawmill Way Culvert	Low	0.10	0.03	0.07	$5,000	$10,000	$7,500	27
CH-12	Private NPS site	High	0.01	0.01	0.07	$7,500	$15,000	$11,250	28
E-11	Corner of Wharf Road and Route 25	Low	0.05	0.01	0.03	$2,000	$4,000	$3,000	29
E-08	Corner of Lake Shore Drive and Route 25	Low	0.11	0.12	0.40	$30,000	$60,000	$45,000	30
CH-3	Veasley Road	Low	0.02	0.00	0.01	$2,500	$5,000	$3,750	31
D-11	Coe Hill Road Stream Crossing	Low	0.00	0.00	0.00	$3,000	$6,000	$4,500	32
CH-4	Birch Lane & Redding Lane, Kerrie Court	Low	0.00	0.00	0.00	N/A	N/A	N/A	33
CH-5	Black Cat Island Road	Low	0.00	0.00	0.00	N/A	N/A	N/A	34
CH-7	Private NPS site	High	0.00	0.00	0.00	N/A	N/A	N/A	35
CH-8	Driftwood Drive	Low	0.00	0.00	0.00	N/A	N/A	N/A	36
CH-14	Private NPS site	Medium	0.00	0.00	0.01	$2,500	$10,000	$6,250	37
CH-19	Private NPS site	Medium	0.00	0.00	0.00	N/A	N/A	N/A	38
CH-20	Private NPS site	Low	0.00	0.00	0.00	N/A	N/A	N/A	39
			24.54	**11.36**	**42.01**	**$848,000**	**$1,497,000**	**$1,177,500**	